Warrego, Paroo, Bulloo and Nebine

Water Resource Plan Review

Risk assessment of insufficient water available for the environment

Queensland Government

This publication has been compiled by Water Policy, Department of Natural Resources and Mines.

Table of contents

Table of tables

Executive summary

An assessment of risks has been undertaken in the Warrego, Paroo, Bulloo and Nebine water resource plan area (the plan area). These risks are associated with the management of water resources resulting in insufficient water availability for the environment and the resulting poor health of water-dependent ecosystems. This assessment does not consider the risks associated with insufficient water availability for surface water and groundwater users which are considered in a separate report.

Outcomes of this assessment will be considered for the review of the Water Resource (Warrego, Paroo, Bulloo and Nebine) Plan 2003 (WPBN WRP) and seek to meet associated accreditation criteria of the Murray Darling Basin Plan (the Basin Plan) for this plan area.

The risk assessment method used for this assessment was provided to the Murray Darling Basin Authority (MDBA) for review and is understood to be consistent with section 10.43 of the Basin Plan. Any risks assessed as having a medium or higher level of risk are described in this report along with any proposed management strategies. Using this method, the level of risk was determined quantitatively using information available from relevant documents and datasets along with expert advice provided by both Department of Natural Resources and Mines (DNRM) and Department of Environment and Heritage (DEHP) Officers and Department of Science, Information Technology, Innovation and the Arts (DSITIA) Scientists.

The assessment considers current and future risks to the continued availability of the water resources of the plan area, with the outcome that only one risk is assessed as medium with all other risks assessed as low. The low risks are consistent with the very low levels of development in the plan areas both for surface and groundwater resources. The only risk assessed as medium relates to the St George Alluvium and highlighted that while growth in take of water from this aquifer is unlikely, it may result in a localised direct impact on the environment and the health of water-dependent ecosystems.

The level of water management implemented to mitigate this medium risk will be determined through the development of the new Warrego, Paroo, Bulloo and Nebine WRP and associated resource operations plan (ROP).

1.0 Introduction

1.1 Purpose and objectives

The purpose of this report is to detail the process and outcomes of the risk assessment conducted for the plan area that meets both the requirements of the WPBN WRP review and of the proposed Basin Plan. The report evaluates risks to the current and future availability of water resources for the environment and the health of water-dependent ecosystems in the plan area. This report will form a component of the WPBN WRP 'package' submitted to the MDBA for accreditation.

The objectives of this risk assessment are to:

- Identify risks, including risks to the environment and the health of water dependent ecosystems if sufficient surface water or groundwater managed by the plan was not available.
- Identify whether management responses to the risk factors should be developed.

1.2 Legislative requirements—*Water Act 2000* (Qld)

The *Water Act 2000* (Qld) provides the legislative framework for the sustainable planning, allocation and management of water resources in Queensland. It requires that all planning, allocation and use of water must 'advance sustainable management and efficient use of water'. Water resource plans provide the principle mechanism for achieving the requirements of the Act, setting out detailed strategies and outcomes for water to be managed between water users, including the environment.

When reviewing an existing WRP, the Minister must act to regulate the taking of groundwater and overland flow if there is a risk that further development of the resource may significantly impact the water requirements of natural ecosystems.

1.3 Proposed Murray-Darling Basin Plan requirements

Section 4.02 of the proposed Basin Plan identifies the following three risks to the condition, or continued availability, of Basin water resources:

- insufficient water available for the environment
- water being of a quality unsuitable for use
- poor health of water-dependent ecosystems.

This assessment focuses on the first and third risks by assessing the risk of insufficient water being available for the environment and the risk of poor health of water-dependent ecosystems.

Chapter 4 of the Basin Plan identifies key risks and proposed strategies to address these risks, and Chapter 10, part 9 details the accreditation requirements relating to risk assessment for basin states.

Key requirements and considerations under Chapter 10, part 9 of the proposed Basin Plan are—

- a water resource plan must be prepared having regard to current and future significant risks to the condition and continued availability of the water resources of the water resource plan area (s 10.41(1))
- the risks are to include (where applicable) risks to environmental watering requirements, risks arising from the matters referred to in subsection 10.20(1), risks arising from potential interception activities and risks arising from salinity or contaminants (s 10.41(2))
- the water resource plan must list and assess each identified risk (s 10.41(4) and (5))
- risks must be identified at least as low, medium or high (s 10.41(6))
- the water resource plan must describe any quantified uncertainties in the level of risk attributed to each risk (s 10.41(8)).

If a WRP defines a risk as having a medium or higher level of risk, it must describe the risk (including associated risk factors) and outline either the management strategy that will address the risk or explain why the risk cannot be addressed by the water resource plan (s 10.43). This risk assessment will contribute to Queensland's accreditation requirements under the Basin Plan.

2.0 Water management in the WPBN

Surface water is managed in the WPBN under the WPBN WRP. The regulation of groundwater will be incorporated into the new draft WRP. Figure 1 shows the WPN plan area.

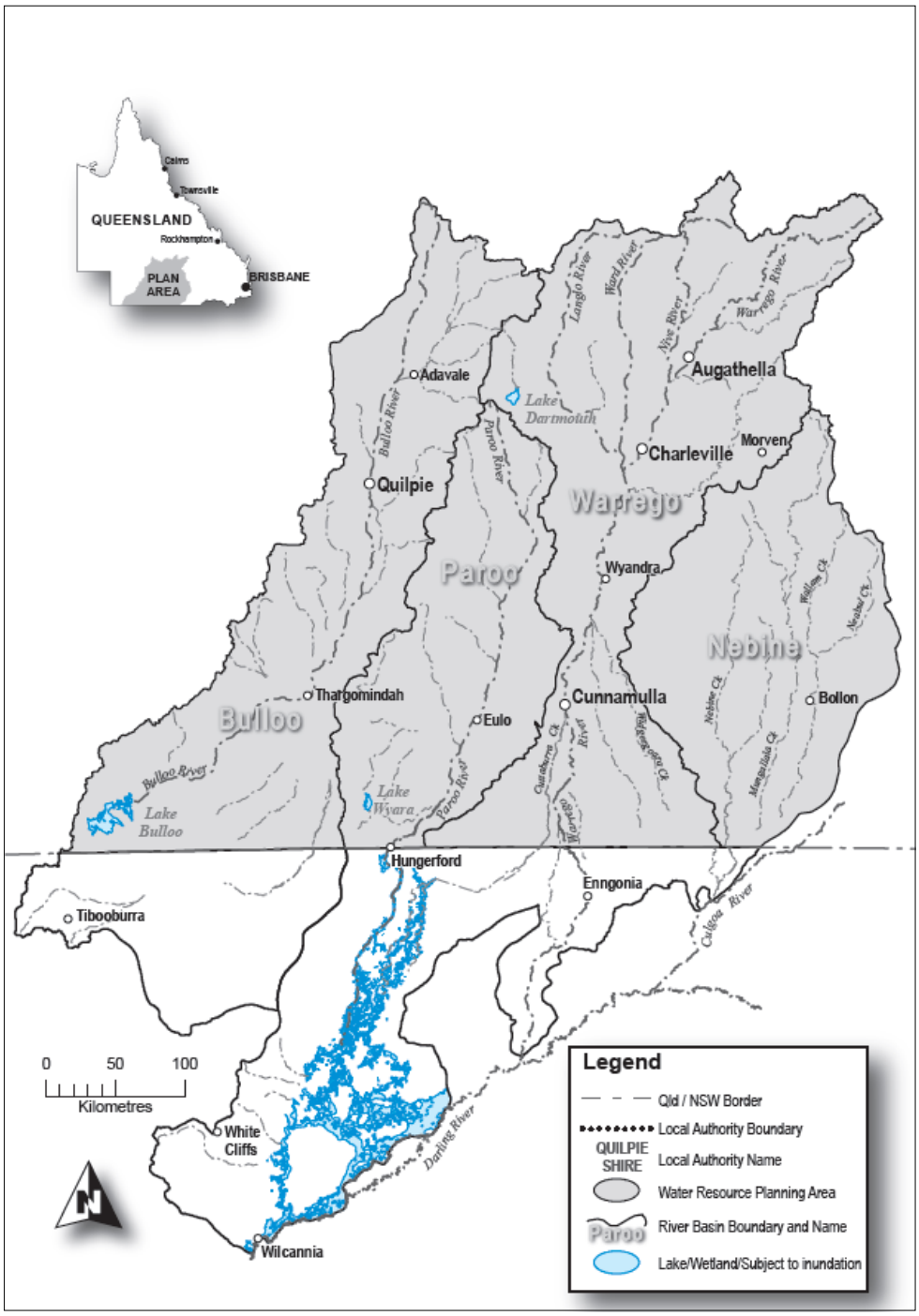

Figure 1: Warrego, Paroo, Bulloo and Nebine Water Resource Plan Area

2.1 Surface water

The plan area is comprised of the surface water catchments of the Warrego, Paroo and Bulloo rivers as well as the Nebine Creek catchment. The combined area of the catchments is approximately 253 000 km^2, 75% of which is located in Queensland with the remainder in New South Wales (refer to Appendix C for a map of the plan area). The Warrego, Paroo and Nebine catchments are also located within the Murray Darling Basin. While a small portion of the Bulloo, the most western of the four catchments, lies within New South Wales, the river itself terminates in Lake Bulloo in Queensland and is not a Murray-Darling Basin catchment.

All four catchments are unregulated (i.e. unsupplemented) with the exception of part of the Warrego catchment which has a small regulated section on the Warrego River (Cunnamulla Water Supply Scheme). Overall, there is very little water resource development in the plan area with most extraction located in the Warrego catchment.

Warrego catchment

There is minimal cropping in the catchment, with some water extraction for cotton. There are 70 privately owned water storages in the Warrego, and the State owned Allan Tannock Weir at Cunnamulla. The catchment has several Nationally Important Wetlands listed: Warrego River Distributary System, Lake Dartmouth, Wyandra-Cunnamulla Claypans Aggregation and “Murrawondah” Lakes (DSITIA 2012a).

Stream flows in the Warrego River catchment are variable and seasonal. The variability is illustrated by the stream flow records from the Wyandra stream gauging station for the period 1967 to 2005 which show that annual discharge for the Warrego River varied from 579 ML in 2003 to more than 84 000 ML in 1990. Most stream flow events tend to occur in summer although significant flows can occasionally occur in the winter months (DSITIA 2012a).

Paroo catchment

The primary land use in the Paroo catchment is sheep and cattle grazing with very limited irrigation. The Paroo River is essentially an unregulated stream with no significant in-stream storage, and is considered to be the last unregulated river in the Murray-Darling basin. Based on license information, there are two private water storages in the Paroo.

The catchment has several Nationally Important Wetlands listed: Paroo River Waterholes (“Caiwarro” section of Currawinya National Park), Lake Numalla Aggregation, Lake Wyara, Lake Wombah-Kungi Lake Group and Lakes Bindegolly and Toomaroo. There are also Ramsar listed areas in the catchment including Currawinya National Park (which includes Lakes Numalla and Wyara, and Paroo River Waterholes).

Bulloo catchment

The primary land use in the Bulloo catchment is cattle grazing. There is little to no irrigation. The Bulloo River is essentially an unregulated stream with no significant in-stream storage. There are four privately owned water storages in the Bulloo. The catchment has several Nationally Important Wetlands listed: Bulloo Lake, Lake Bullawarra, Nooyeah Downs Swamps Aggregation, Quilpie (Bulloo River Floodplain) waterholes and Mitchell Swamp.

Nebine catchment

The primary land use in the Nebine catchments is sheep grazing. From existing license information, there are 13 privately owned water storages in the catchment, and a publicly owned weir at Bollon. The Nebine catchment has two nationally Important Wetlands listed: Wyandra-Cunnamulla Claypan Aggregation and “Myola”–“Mulga Downs” Salt Lake and Claypans.

2.1.1 Flow dependent ecosystem components

Floodplain wetlands and vegetation

Floodplain wetlands sustain diverse ecological communities that are adapted to take advantage of the resources that are periodically available (Westlake & Pratt 2012 in DSITIA 2012a). In dryland river landscapes, floodplain wetlands play an important role in the exchange of carbon and nutrients, provide ecosystem services such as water quality buffering, act as refuges during dry spells and provide habitat to a diverse community of plants and animals (Thoms 2003; DSEWPC 2012 in DSITIA 2012a). Patterns of hydrological connectivity and subsequent wetland wetting and drying cycles are important drivers regulating species diversity and richness (Boulton & Brock 1999 in DSITIA 2012a).

The length of time between inundation events and the persistence of water in a wetland are governed by a number of factors including position in the landscape, water source, climate and substrate (Jaensch & Young 2010 in DSITIA 2012a).

The plan area is home to several iconic floodplain plant species including river red gum, black box, coolabah, tangled lignum, river cooba and yapunyah gum, which require riverine flooding for both successful reproduction and recruitment, and to maintain the vigour of adult plants (Roberts & Marston 2001, Rogers 2011, Woods et al. 2012 in DSITIA 2012a). Floodplain wetlands are present in all four plan area catchments and support ecological values including waterbird breeding opportunities and provision of preferred habitat for the eastern snake-necked turtle (*Chelodina longicollis*).

Vertebrates—fish and birds

Flows play a key role in providing habitat for fish, via hydraulic habitat and connectivity, maintenance of channel morphology and substrate and influences on water quality and aquatic vegetation.

Eighteen species of native fish have been recorded in the plan area, including the popular angling fish Yellowbelly, Murray Cod—listed as vulnerable under the EPBC Act, and Eel-tailed catfish which has suffered population declines in southern parts of the Murray-Darling Basin (Rourke & Gilligan 2010 in DSITIA 2012a). Fish of the region tend to be generalists, tolerant of the harsh conditions during dry spells, and possessing life history strategies to take advantage of the intermittent periods of flow (Balcombe et al. 2006 in DSITIA 2012a). Three exotic fish species, European Carp, Goldfish and *Gambusia* are also present in the plan area.

Many species of birds are associated to some degree with riverine and non-riverine wetlands during their life cycle, including waterbirds and species that inhabit riparian zones. Overbank flooding may trigger mass breeding events for some waterbird species.

The Bulloo Floodplain, Paroo Floodplain and Currawinya, Lake Numalla and Lake Bindegolly have been identified as nationally or internationally important bird habitats, supporting significant proportions of the populations of Grey Teal, Australasian Shoveler, Hardhead, Sharp-tailed Sandpiper, Black Swan, Pink-eared Duck, Red-necked Avocet, Caspian Tern, Freckled Duck and Marsh Sandpiper (Watkins 1993; Kingsford & Porter 1994; Birdlife International 2012 in DSITIA 2012a).

Amphibians and Reptiles

Many amphibians and reptiles are associated with aquatic habitats and have specific instream habitat requirements to support critical life history stages. For example, freshwater turtles access areas of exposed sand bars, gravel benches or structures such as large fallen trees to bask. Hence, the flow requirements of these species include flows for the maintenance of hydraulic habitat, water quality and the physical structure of instream habitats. The eastern snake-necked turtle (*Chelodina longicollis)* is the only species known to have specific flow requirements.

Invertebrates

The macroinvertebrate fauna of the plan area is typical of western Queensland arid and semi-arid rivers and as such is numerically dominated by tolerant insect taxa of the orders diptera, coleoptera, odonata, ephemeroptera and hemiptera, bivalve molluscs and crustacean taxa (Marshall et al. 2006a, 2006b in DSITIA 2012a). The shrimp *Macrobrachium australiense* is a conspicuous component of the fauna and important as a source of food for predatory fish (Sternberg et al. 2008, Woods et al. 2012 in DSITIA 2012a). The snail *Notopala* sp. occurs in the Bulloo River and upper Warrego River where invasive carp are absent, but has been driven to extinction or near extinction throughout much of its natural range within the Murray Darling Basin (Sheldon & Walker 1997 in DSITIA 2012a), including the remainder of the plan area, probably as a result of predation by carp in combination with other impacts.

Instream vegetation

Flow regime changes have been associated with changes in the species diversity and abundance of riverine macrophyte assemblages. Flow regime changes are often conducive to macrophyte growth, especially where flow variations or flood magnitudes are reduced. Reductions in flow variability due to water resource development (flow supplementation) often lead to an increase in macrophyte biomass (e.g. Mackay 2006; Mackay & Thompson 2000 in DSITIA 2012a).

In the rivers of plan area, macrophytes are relatively rare. Those that are present, such as *Ludwigia peploides*, *Azolla pinnata* and *Persicaria* spp. are either floating or emergent, allowing them to survive the often high turbidity and fluctuating water levels. A range of planktonic microphytes inhabit the rivers and

again the most common taxa, cryptophytes, chloropytes and euglenophytes, are those that are able to maintain their position near the water surface using buoyancy or motility in order to stay within the shallow photic zone (McGregor et al. 2006 in DSITIA 2012a).

2.1.2 Flow dependent ecosystem processes

Fluvial geomorphology (river landforms) and river-forming processes

The primary drivers of channel morphology are hydrology, the underlying geology of the river channel and sediment availability (Clifford & Richards 1992 in DSITIA 2012b). Geology determines the extent to which flows can alter channel characteristics such as stream bed, bed slope and meander, whereas sediment availability and entrainment processes can determine the development and maintenance of pools and bars.

The Queensland portions of the Murray-Darling Basin and the Bulloo have generally shallow relief and low stream segment slopes resulting in low disturbance intensity from flow events (DEHP 2012 in DSITIA 2012a). Much of the area is depositional valley bottom flat, with silt/clay streambed substrates and development of extensive floodplains (DEHP 2012 in DSITIA 2012a). Some waterholes in the region have experienced fine sediment accumulation (DSITIA 2012a).

2.2 Groundwater

The plan area also overlies three groundwater Sustainable Diversion Limit (SDL) areas:

- Sediments above the Great Artesian Basin Warrego–Paroo–Nebine SDL area
- St George Alluvium Warrego–Paroo–Nebine SDL area
- Warrego Alluvium SDL area.

The water within these SDL areas is generally of poor quality and is largely undeveloped. The vast majority of groundwater development in the plan area is from the Great Artesian Basin (GAB). The GAB is not a resource for the purposes of the proposed Basin Plan and is dealt with under a separate Queensland WRP (and associated resource operation plan) and is therefore not considered in this risk assessment methodology. Figure 2 shows the groundwater alluviums within the plan area.

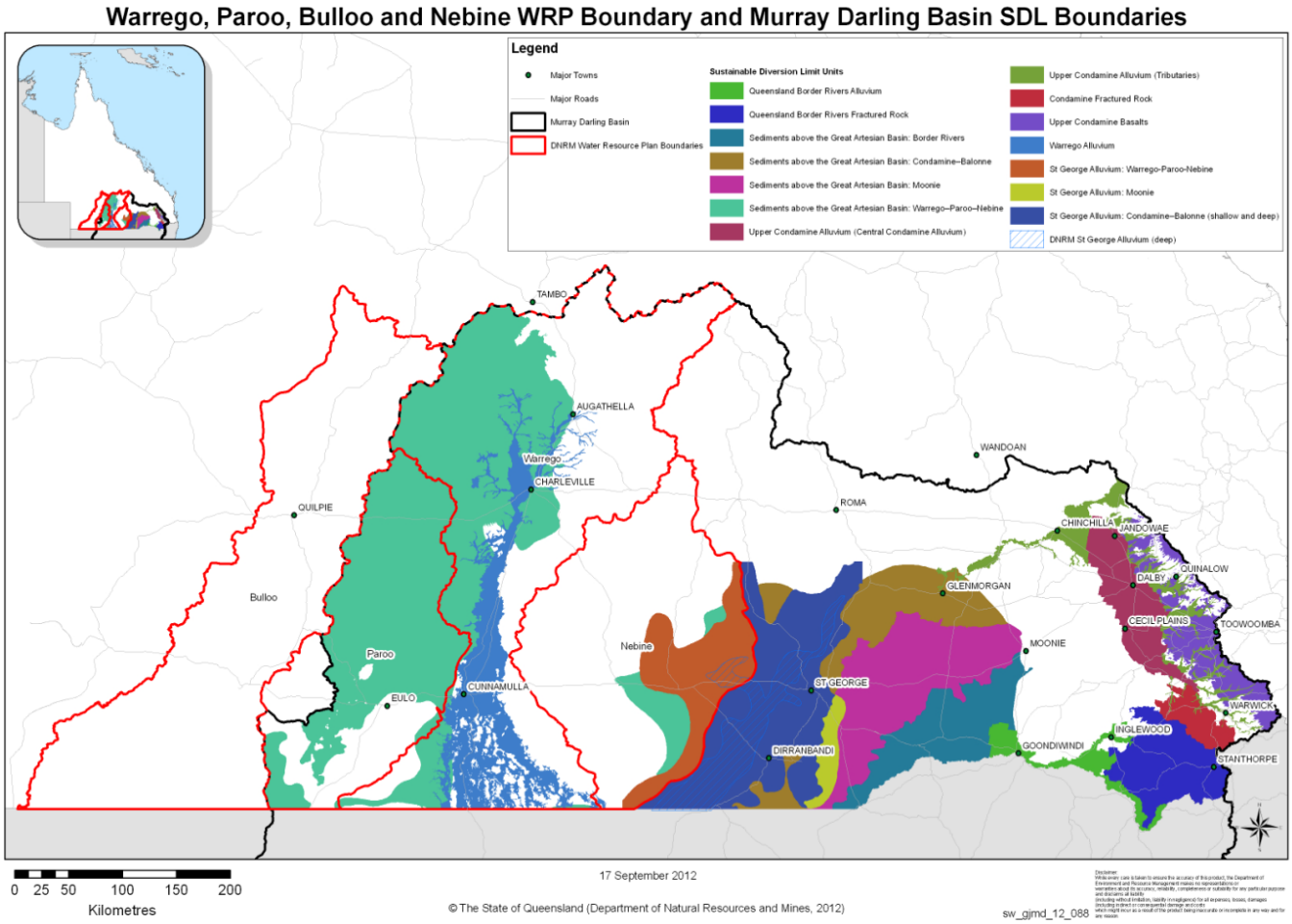

Figure 2 Groundwater alluviums in the WPBN catchment boundaries

Sediments above the Great Artesian Basin Warrego–Paroo–Bulloo–Nebine SDL area

This SDL area is not considered to have good quality groundwater. More reliable groundwater is sourced from the GAB below. Current management arrangements are that water licences are required for all purposes other than stock and domestic purposes and development permits for works are required for all purposes. Metering of bores is not required. Currently there are 6 issued licences with a combined nominal volume of 215 ML/a.

Warrego Alluvium SDL area

The majority of groundwater take in the area of the Warrego alluvium is sourced from the deeper GAB aquifers, where more reliable supplies and better water quality can be achieved. The Warrego Alluvium is separated from other aquifers by thick confining beds. The main use of the groundwater from the Warrego Alluvium is for irrigation and stock and domestic purposes. Current management arrangements are that water licences are required for all purposes other than stock and domestic purposes and development permits for works are required for all purposes

A relatively small number of groundwater licences exist in the Warrego Alluvium, mainly in the vicinity of Charleville. They consist of 10 licences with an overall nominal entitlement of 234 ML. In addition, no multiple formation licences (a license that recognises more than one formation) exist in the area.

St George Alluvium (Warrego-Paroo-Nebine) SDL area

Demand for groundwater from the St George Alluvium in the Warrego-Paroo-Nebine (WPN) area is limited due to poor water quality (DNRM 2012c). Currently water licences are required for all purposes other than stock and domestic use. Development permits are required for all works. There are no licences issued in this area to take groundwater (DNRM 2012c).

The Basin Plan SDL area does not include the deep aquifer of the St George Alluvium, a small part of which extends into the Nebine catchment (see Figure 2). One licence application is held which proposes to take 2000 ML/a from this aquifer within the Nebine catchment. Under the new WRP, the deep and shallow formations of the St George Alluvium will be managed separately primarily because the SDL for the St George Alluvium (deep) is matched by current extractions.

2.2.1 Groundwater dependent Ecosystems

Groundwater dependent ecosystems (GDEs) by definition require access to groundwater to meet all or some of their water requirements, however in many systems groundwater dependence is either subtle or cryptic, extending beyond ephemeral or permanent expressions of groundwater at the surface (Hatton & Evans 1998 in DSITIA 2012a). Following current understanding, GDEs can be categorised into three types (Eamus et al. 2006 in DSITIA 2012a):

- cave and aquifer systems (karstic, fractured rock, alluvial aquifers, hyporheic zone)
- ecosystems dependent on the surface expression of groundwater (baseflow, non-riverine wetlands, and mound springs)
- ecosystems dependent on the sub-surface expression of groundwater, often accessible via the capillary fringe when roots penetrate this zone (terrestrial vegetation).

Cave systems are not present within the plan area. Subterranean aquifers and hyporheic zones (the zone of interaction between river water and the groundwater present in the banks and beds of rivers) are present throughout the plan area and have the potential to support groundwater fauna, or stygofauna, communities within them. The results of extensive aquifer sampling for stygofauna conducted in the Condamine-Balonne and Border Rivers region (DERM, unpublished data), located to the immediate east of the water resource plan area, were evaluated to identify aquifer chemical or morphological attributes associated with the presence/absence and composition of stygofauna assemblages. No meaningful associations were found between aquifer characteristics and stygofauna occurrences.

Ecosystems dependent on the surface expression of groundwater are not well documented within the catchments of the plan area. Non-riverine wetlands in the region have been mapped and these were assessed for possible dependence on groundwater (DSITIA 2012b). As most of these wetlands are shallow—generally less than 2 m (DSITIA 2012a), and therefore do not intersect with aquifers in the region which were recorded to have depth to water table deeper than these wetland bases, it is unlikely that they are groundwater dependent. Mound springs associated with the great artesian basin are also present but are not influenced by shallower aquifers present in the water resource plan area and as such are not within the scope of this assessment.

In the plan area, ecosystems dependent on the sub-surface expression of groundwater are represented by terrestrial vegetation communities that depend on groundwater. This includes deep and/or shallow rooting terrestrial vegetation communities that utilise groundwater in either an obligate or facultative way. It does not include aquatic macrophytes that have an obligate requirement for either partial or complete submergence in water.

As part of the environmental assessment of the plan, groundwater dependent vegetation has been mapped for the Warrego, Paroo, Bulloo and Nebine catchments. In the Warrego, 26% of the area of the Queensland section of the Warrego catchment was occupied by potential groundwater dependent terrestrial vegetation communities dominated by *Acacia aneura*, *A. cambagei*, *A. victoriae*, *Eucalyptus populnea*, *E. ochrophloia*, *E. coolabah* and other low woodland species growing on residuals, alluvial plains and sand plains.

Similarly in the Paroo catchment 38% of the area of the Queensland section of the Paroo catchment was occupied by potential groundwater dependent terrestrial vegetation communities dominated by similar species. For the Bulloo catchment, where groundwater depth data is lacking, assessments could not be made using the methods applied to the other three catchments. Alternatively, distributions of Regional Ecosystem types that had been identified as potential GDEs in the other catchments were used as an indicator GDE distribution (DSITIA 2012c). Using this modified method, 17% of the area of the Queensland

section of the Bulloo catchment was determined to be occupied by potential groundwater dependent Regional Ecosystems. For the Nebine catchment, 31% the area of the Queensland section of the Nebine catchment was occupied by potential groundwater dependent ecosystems.

3.0 Scope of risk assessment

The risk that is assessed in this report is the impact on the environment if insufficient surface water and groundwater is available in the plan area.

3.1 Surface water risk factors

There are seven risk factors that apply when assessing the risk of insufficient water being available for the environment including:

- increased duration of spells between floodplain inundation events
- decreased number of events above bankfull level
- decreased number of bankfull and channel-connecting flow events
- extraction of water from waterholes
- increased duration of spells between flow events
- increased number of spells without flow
- permanence of waterholes affected by water extraction.

An additional risk factor was identified for the Bulloo catchment:

- introduction of alien species to ecologically unique catchments.

Increased duration of spells between floodplain inundation events

Alteration to flood flow resulting in lengthened periods between floodplain wetland inundation has effects on wetland vegetation communities, waterbird breeding opportunities and turtle refuge quality. Increasing the length of high-stress periods for the Eastern Snake-Necked Turtle can lead to the suppression of reproduction and a reduction in population viability. Increased length of dry periods can also lead to the loss of floodplain vegetation condition.

Decreased number of events above bankfull level

Alteration to flood flow resulting in this risk factor reduces the number of recruitment opportunities for flood-spawning fish leading to a reduction in population viability. Decreased number of events above bankfull increases the number of high-stress periods for the Eastern Snake-Necked Turtle. A reduced number of river-forming flow events leads to changes in geomorphology and increased waterhole sedimentation.

Decreased number of bankfull and channel-connecting flow events

Alteration to medium to high flow resulting in a reduction in the number of these events reduces the dispersal opportunities for flood-spawning and migratory fish leading to a reduction in population viability. A reduced number of river-forming flow events leads to changes in geomorphology and waterhole sedimentation.

Extraction of water from waterholes

This low flow risk factor can alter the distribution of refugial waterholes and leads to the risk of small local flows not passing through the system. Additionally, less frequent top-up flows that maintain waterhole water levels result in a reduction in the persistence time and the drying out of some smaller refuges.

Increased number of spells without flow

An alteration to cease-to flow component of the flow regime can result in a no flow spell length that exceeds the persistence time of some waterholes. This can lead to the loss of refuges for aquatic biota and the extinction of local sub-populations.

Alteration to the distribution of refugial waterholes

This risk factor describes water extraction that reduces the permanence of refugial waterholes and alters their distribution. This can reduce spawning and migratory fish dispersal opportunities and can reduce source populations leading to a decrease in population viability for affected species. It can also cause additional stress to Eastern Snake-Necked Turtles. Waterholes are already unfavourable habitat for the species and as the waterholes dry, the conditions become more inhospitable**.**

Permanence of waterholes affected by water extraction

This risk factor describes the effects of a reduced number of permanent waterhole refugia in the catchment. As the distance between refugia increases beyond the dispersal capacity of fish, there is a reduction in distribution, population resilience and viability.

Introduction of alien species or genotype into ecologically unique catchments

This risk factor describes potential transmission of water and aquatic biota between catchments by increased hydrologic connectivity through inter-basin transfer schemes. Competition, predation and cross-breeding with alien species and genotypes leads to loss of diversity and genetic differentiation of aquatic biota in otherwise isolated catchments.

3.2 Groundwater risk factor

The groundwater risk factor identified was a lowering of groundwater levels. This can lead to a reduction in size and/or number of groundwater dependent ecosystems (GDEs) due to groundwater extraction.

4.0 Risk assessment process

The approach is based on Department of Natural Resources and Mines (DNRM) policy 'DERM Risk Management Policy and Procedure Review: June 2012 Version: 2.0' (departments risk management policy) which is consistent with and AS/NZS ISO 31000:2009 Risk Management – Principles and Guidelines). It is also consistent with of the NWI Policy Guidelines for Water Planning and Management Risk Assessment Module developed by the Department of Sustainability, Environment, Water, Population and Communities.

The risk management process follows 6 steps in a cycle—

1. communicate and consult (i.e. stakeholders' perspectives are considered at each stage to obtain or provide relevant risk information)
2. establish the context (the environment and its boundaries that should be applied when considering risks)
3. identify risks (describing risks in terms of what can happen and the impact that can result)
4. analyse risks (rate each risk in terms of consequences and likelihood to establish the level of risk)
5. evaluate and treat risks (determine which risks require treatment or whether the risk can be tolerated without treatment, then identify the options to treat intolerable risks and implement the most appropriate treatment/s that can be undertaken to reduce the risk level)
6. monitor and review (periodic reporting and review of risks, their level and progress on treatments).

4.1 Step 1: Communicate and consult

The following process was applied to ensure appropriate communication and consultation with internal and external stakeholders—

- desktop assessment of known risks
- preliminary internal workshop to discuss proposed risk assessment methodologies and indentify additional risks with representatives from the former Department of Environment and Resource Management (DERM)
- a risk assessment methodology was developed to meet both the requirements of the proposed Basin Plan and the department
- a final internal workshop to evaluate identified risks and discuss strategies for treatment with representatives from the Departments of Natural Resources and Mines, Environment and Heritage Protection and Science, Information Technology, Innovation and the Arts with areas of expertise including surface and groundwater management and aquatic ecology
- develop a risk assessment report to summarise the process and outcomes of the assessment (this document)
- present outcomes of risk assessment process to external stakeholder forum for feedback
- input the outcomes of the risk assessment process and external consultation into the Implementation Review Report being prepared for the Peak Body Consultative Group
- external consultation through the formal consultation process for the release of the draft water resource plan and resource operations plan.

The Communication Management Strategy includes detailed information on key internal and external stakeholders for the water resource plan area.

4.2 Step 2: Establish the context

The plan area has a low level of development in terms of water extraction with both the Paroo and Bulloo systems delivering almost 100 per cent of pre-development condition end of system mean annual flows. The Warrego provides for 87 per cent and the Nebine 88 per cent of pre-development end of system mean annual flows (a significant proportion of extractive water entitlement in both of these systems is attributed to the CEWH). The catchment also overlies three groundwater SDL areas namely the Sediments above the

Great Artesian Basin Warrego–Paroo–Nebine SDL area, the St George Alluvium Warrego–Paroo–Nebine SDL area and the Warrego Alluvium SDL area. However, the water within these SDL areas is of poor quality and largely undeveloped. The vast majority of groundwater development in the plan area is from the Great Artesian Basin (GAB). The GAB is not a resource for the purposes of the proposed Basin Plan and is dealt with under a separate Queensland water resource plan (and associated resource operation plan) and is therefore not considered in this risk assessment methodology.

The Warrego and Paroo rivers feed various wetlands, including floodplain wetlands, freshwater wetlands and saline lakes (Kingsford & Norman 2002). During large floods, these two rivers also drain into the Darling and Culgoa Rivers of the Murray-Darling Basin in north-west New South Wales.

As the Warrego, Paroo and Nebine catchments (the Queensland Murray Darling Basin catchments) cross the Queensland/New South Wales border, the risk assessment must include consideration of downstream impacts.

4.3 Step 3: Identify risks

This step involves describing risks in terms of what can happen and the impact that can result.

Risks have been identified in Section 3 and are based on the 10 year life span of water resource plan as defined by the *Water Act 2000* (Qld).

4.4 Step 4: Analyse risks

Each risk must be must be rated in terms of consequences and likelihood to establish the risk level—Appendices 1-4 detail the analysis of each risk.

The proposed Basin Plan does not specify detailed requirements for the risk assessment such as a preferred risk analysis matrix. However, section 10.41(6) states that the level of risk defined as the combination of risks, expressed in terms of the combination of consequences and their likelihood (AS/NZS ISO 31000:2009 Risk Management - Principles and Guidelines), must be defined using the following categories—

- low
- medium
- high
- if it is considered appropriate, any additional category.

Section 10.42 of the proposed Basin Plan specifies that a water resource plan must describe each risk identified as having a medium or higher risk and the factors that contribute to the risk.

Section 4.04 of the proposed Basin Plan states that the Authority may publish guidelines setting out specific actions that may be taken in relation to the implementation of the strategies listed in subsection 4.03(3) to deal with the risks identified in section 4.02. These guidelines may include a specific risk assessment tools such as risk analysis matrix however no such guidelines are currently available from the Authority. To meet the 2014 deadline for this water resource plan, the department must undertake its risk assessments in 2012/13. In the absence of specified guidelines, the risk analysis tools identified in the DNRM policy have been adopted. This approach is consistent with recent Queensland water resource planning risk assessments such as the risk assessment for Non-managed Aquifers for the review of the Water Resource (Burnett Basin) Plan 2000.

Defining consequence table

The method for defining consequences of a risk is to categorise each consequence into ecological, economic and social/cultural impacts. This approach is similar to that used for the Burnett WRP review risk assessments.

For a consequence to be assigned it must reflect the impacts for each of these categories. For example, for a risk to be assigned a consequence of ‘insignificant’ the following must apply—

- ecological impacts—impact on aquatic environmental assets is undetectable and will not affect the persistence of the asset in the WRP area
- economic impacts—minimal or no financial losses

- social/cultural impacts—minimal or no impact on Indigenous or non-Indigenous heritage sites or values.

Table 1: Defining consequences

Consequence	Ecological impacts	Economic impacts	Social/cultural impacts	Score
Insignificant	Impact on aquatic environmental assets is undetectable and will not affect the persistence of the asset in the WRP area.	Minimal or no financial losses.	Minimal or no impact on Indigenous or non-Indigenous heritage sites or values.	1
Minor	Minimal impact on asset population in the WRP area, unlikely to affect the persistence of the asset.	Financial loss requiring some reprioritisation and/or restructuring of business.	Minor impact on Indigenous or non- Indigenous heritage sites or values.	2
Moderate	Some impact on asset population, possibly isolated to certain spatial locations or temporal aspects.	Significant individual financial loss with minimal community level impact.	Moderate impact on Indigenous or non-Indigenous heritage sites or a vital community resource.	3
Major	Significant spatial and temporal impact on the asset population, possibly leading to extinction of one or more populations in the WRP area.	Major financial loss with severe individual and some community level impact.	Major disturbances to significant Indigenous or non-Indigenous heritage sites &/or values. Access to resource denied, or vital community resource unavailable, in the medium to long-term.	4
Catastrophic	Disastrous spatial and temporal impact on the asset population resulting in extinction of the asset from the WRP area.	Disastrous long-term financial loss with severe individual and community level impact.	Major disturbances to significant Indigenous or non-Indigenous heritage sites & or values. Site access or vital community resource permanently removed.	5

Important: Where more than one impact category was relevant, the one with the highest consequences was selected to determine the consequence level for the particular risk.

Defining likelihood

The likelihood (chance of something happening) table is based on the department's policy and is consistent with the Risk Assessment undertaken for the Burnett water resource plan review and the state-wide Streams and Estuaries Assessment Program. Table 2 identifies the likelihood categories and their definitions.

Table 2: Likelihood table

Likelihood categories	Definition	Score
Rare	Impact may occur only in exceptional circumstances	1
Unlikely	Impact could occur at some time but it is improbable	2
Possible	Identified factors indicate the impact might occur at some time	3
Likely	Impact will probably occur in many circumstances	4
Almost certain	Impact is expected to occur in most circumstances	5

Level of risk

The level of risk is determined using the definitions identified in the consequence and likelihood tables and the matrix shown in Table 3. The AS/NZS ISO 31000:2009 Risk Management - Principles and Guidelines states that consequences may be expressed qualitatively or quantitatively and the risk can escalate though knock-on effects and likelihood can be defined, measured or determined objectively or subjectively, qualitatively or quantitatively, and described using general terms or mathematically.

Table 3: Consequence and likelihood scoring

	Consequence				
Likelihood	*Insignificant (1)*	*Minor (2)*	*Moderate (3)*	*Major (4)*	*Catastrophic (5)*
Almost certain (5)	Low (5)	Medium (10)	High (15)	Very high (20)	Very high (25)
Likely (4)	Low (4)	Medium (8)	High (12)	High (16)	Very high (20)
Possible (3)	Low (3)	Low (6)	Medium (9)	High (12)	High (15)
Unlikely (2)	Low (2)	Low (4)	Low (6)	Medium (8)	Medium (10)
Rare (1)	Low (1)	Low (2)	Low (3)	Low (4)	Low (5)

Based on Table 3, the level of risk is categorized into the low, medium, high or very high as per the scoring in Table 4.

Table 4: Level of risk

Level of risk	Criteria
Low	Score of 1 to 6
Medium	Score of 8 to 10
High	Score of 12 to 16
Very high	Score of 20 to 25

As per section 10.43 of the proposed Basin Plan, any risk identified as medium or above must be addressed by management strategies within a water resource plan. It is important therefore to clearly explain why a risk would be considered low and therefore tolerable without need for mitigation measures. The identification of the level of risk tolerance equates to determining what defines a 'low' level of risk. Accordingly, the following is the basis for a 'low' level of risk.

Any risk that has a consequence of insignificant is considered a low risk because the consequences of the event occurring, irrespective of the likelihood of occurrence, would have immeasurable impacts (ref to Table 1). Managing such impacts is not practical because of the inability to measure the impact.

A risk that has a consequence of minor and a likelihood of possible or less is considered a low risk because even if the event were to occur the consequences of the event are minimal and are recoverable. This reasoning also applies to a risk that has a consequence of moderate but a likelihood of unlikely.

A risk that has a likelihood of rare is ranked as low because it is only likely to occur in exceptional circumstances that are outside the current basis for planning (i.e. the historical record or the simulation period).

Confidence rating for level of risk

In accordance with section 10.41(8) of the proposed Basin Plan, the risk assessment must describe any quantified uncertainties in the level of risk attributed to each risk. To do so the following confidence scores have been adopted and applied to both the likelihood and consequence ranking.

Table 5: Confidence scores

Confidence	Score
High	3
Medium	2
Low	1

Table 6: Definition of confidence scores

Confidence categories	Definition
High	Strong confidence of the score – able to substantiate with documented and anecdotal evidence to support the scores applicability across the reporting area.
Medium	Reasonable confidence in the score – knowledge may not cover the entire reporting area and the information and other evidence to support this is incomplete.
Low	Are not confident with the score due to a lack of scientific information and other evidence available and/or little expertise on the area of concern

4.5 Step 5: Evaluate risks

This step determines which risks require treatment or whether the risk can be tolerated without treatment and then identifying options to treat intolerable risks and implement the most appropriate treatment/s that can be undertaken to reduce the level of risk.

Section 10.43 of the proposed Basin Plan states that if the level of risk for a risk is medium or higher, the water resource plan must either—

- describe a strategy for the management of the water resources of the water resource plan area that will address the risk

  or

- explain why the risk cannot be addressed by the water resource plan.

The risk register (see Appendix 1 to 4) documents the evaluation of each risk and the information used to determine the level of risk and the level of certainty allocated to each risk assessment.

4.6 Step 6: Monitor and review

Requirements for monitoring, reporting and periodic review to establish whether the WRP is meeting its outcomes and objectives must be detailed in the WRP as prescribed under the *Water Act 2000* (Qld).

5.0 Results and discussion

From the risk assessment undertaken, there was only one risk that has been identified as 'moderate'. The remainder of risks have all been identified as 'low' using the method described in section 4.

5.1 Moderate risk for the lowering of groundwater levels in the St George Alluvium (Nebine catchment)

It is possible that growth in extraction from the St George Alluvium could occur if management arrangements are not put in place. This may result in a lowering of groundwater levels and the possible reduction is size and/or number of GDEs.

Likelihood

The likelihood of reduced groundwater levels and resulting GDE impacts has been determined to be 'possible'. Two key factors influence this rating; historical behaviour reflects a preference for GAB water over that from the shallow aquifers, mainly due to water quality issues; and the SDL for the resource unit is 24.6 GL/a whereas the BDL is only 0.12 GL/a, indicating there is significant scope for water extraction to increase before unacceptable impacts occur.

Consequence

If reduced groundwater levels did result in GDE impacts the consequence was determined to be 'moderate'. The confidence of this 'moderate' rating is limited because the GDE assessment was based on a remote sensing GIS process and did not include on-ground validation. There was also no direct assessment undertaken for stygofauna.

Management Strategies

The department will develop management strategies in the WRP and ROP to mitigate this moderate risk.

5.2 Low risks to the environment from the insufficient availability of surface water

All other risks to the environment in the plan area have been measured to be low. To a great extent this is because water diversion represents a small proportion of overall flow for the plan area. Population forecasts for the plan area project a negligible growth in population to 2031 (DNRM 2013), suggesting that water demand is not expected to increase significantly over this period.

Increased duration of spells between floodplain inundation events

The analysis of this risk utilised IQQM modelling, floodplain assessment and mapping, combined with the presence of well-defined entitlements and low levels of interception activities. Multiple asset responses across a number of floodplain catchments and evidence from neighbouring systems were analysed. NWC farm dams assessments were also utilised. Maximum daily waterharvesting diversions were found to represent a small proportion of flood flow and were spatially confined.

Decreased number of events above bankfull level

The analysis of this risk utilised IQQM modelling, floodplain assessment and mapping, combined with the presence of well-defined entitlements and low levels of interception activities. Multiple asset responses across a number of floodplain catchments and evidence from neighbouring systems were analysed. Maximum daily waterharvesting diversions were found to represent a small proportion of flood flow and were spatially confined. The impact of this risk factor was found to be more significant during drought than flood conditions.

Decreased number of bankfull and channel-connecting flow events

The analysis of this risk utilised IQQM modelling, floodplain assessment and mapping, combined with the presence of well-defined entitlements and low levels of interception activities. Multiple asset responses across a number of floodplain catchments and evidence from neighbouring systems were analysed. Daily waterharvesting diversions were found to represent a small proportion of flood flow and were spatially confined.

The Commonwealth Environmental Water Holder (CEWH) holds allocations totalling 8000ML in the Warrego and 1000ML in the Nebine which are included in the full entitlement models, therefore assessed impacts are conservative as this water is not actually taken. In the Bulloo, some uncertainty was found regarding the geomorphological response and there was also a low level of certainty regarding impacts of low level extraction from take under riparian rights.

Extraction of water from waterholes

Consequences were determined using literature and expert-based conceptual understanding of multiple ecological asset responses combined with evidence from research programs in neighbouring river systems.

Gauge station ability to measure low to very low flows is limited at most stations due to environmental constraints. The limited number and spatial distribution of gauge stations means that some small flow resulting from local rainfall run-off may occur between gauge stations.

Increased duration of spells between flow events

Consequences were determined using literature and expert-based conceptual understanding of multiple ecological asset responses combined with evidence from research programs in neighbouring river systems.

Gauge station ability to measure low to very low flows is limited at most stations due to environmental constraints. The limited number and spatial distribution of gauge stations means that some small flow resulting from local rainfall run-off may occur between gauge stations.

There is a low level of certainty regarding impacts of low level extraction from take under riparian rights.

Increased number of spells without flow

Consequences were determined using literature and expert-based conceptual understanding of multiple ecological asset responses combined with evidence from research programs in neighbouring river systems.

Gauge station ability to measure low to very low flows is limited at most stations due to environmental constraints. The limited number and spatial distribution of gauge stations means that some small flow resulting from local rainfall run-off may occur between gauge stations.

There is a low level of certainty regarding impacts of low level extraction from take under riparian rights.

Permanence of waterholes affected by water extraction

Consequences were determined using literature and expert-based conceptual understanding of multiple ecological asset responses combined with evidence from research programs in neighbouring river systems.

There is a low level of certainty regarding the location of waterholes and the level of extraction under riparian rights.

Introduction of alien species and genotypes to ecologically unique catchments (Bulloo catchment only)

While the consequence of introduction of alien species to the Bulloo catchment was rated as catastrophic due to the significant evidence and understanding of the impacts of competition, predation and cross-breeding by alien species and genotypes, the likelihood of this occurring was deemed rare.

The primary way an aquatic pest species could be introduced is via inter-basin water transfer. No such schemes exist in the WPBN plan area; consequently the only potential mode of water and aquatic biota transfer across catchment boundaries is via water storages near catchment boundaries that could receive water from one catchment and release or use it in another (DSITIA 2012b).

5.3 Low Risk to the environment from the insufficient availability of groundwater

Sediments above the GAB and the Warrego Alluvium

The likelihood of the lowering of groundwater levels due to water extraction was considered to be rare in all areas for sediments above the GAB and in the Warrego alluvium. Historical behaviour reflects a preference for GAB water over that from the shallow aquifers. The proposed Basin Plan identifies the BDLs as well below the SDLs for all catchments within the plan area, therefore there is significant unassigned water

available to mitigate the risk. Future extraction for domestic and irrigation purposes is not expected to increase to 2031 as the average population is not expected to grow significantly over the period, with some areas projected to experience population decline.

6.0 Conclusion

This risk assessment highlighted that growth in take of groundwater in the St George Alluvium may result in localised direct impact on the environment and the health of water-dependent ecosystems. This risk will be managed through strategies and technical management arrangements developed for the new WRP and ROP.

The remaining risk factors were determined to be low for the environment and health of water-dependent ecosystems in the plan area. The main trends that produced this outcome are relatively low levels of resource use, population stability and/or decline in the area and groundwater water quality constraints.

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Appendices

Appendix 1 Warrego catchment surface water and groundwater risk register

Risk identification			Risk analysis			Risk confidence			Comments
						Confidence score			
Risk	Risk factor/source	Effect	Likelihood	Consequence	Level of risk	Likelihood	Consequence	Basis for confidence score	
Insufficient water available for the environment (s4.02(1)(a)) and poor health of water-dependent ecosystems (s4.02(1)(b))	Alteration to flood flow component of flow regime - **increased duration of spells between floodplain inundation events**	Lengthened period between floodplain wetland inundation (effects on wetland vegetation communities, waterbird breeding opportunities, turtle refuge quality); increasing length of high-stress periods for Eastern Snake-Necked Turtle, suppressing reproduction and reducing population viability; increased length of dry periods for floodplain vegetation leading to loss of condition.	Rare	Moderate	**Low (3)**	3	2	Likelihood: IQQM, floodplain assessment and mapping, well defined entitlements, low level of interception activities. NWC farm dams assessment. Consequence: Multiple asset responses across a number of floodplain catchments, evidence from neighbouring systems. NWC farm dams assessment.	Maximum daily water harvesting diversion is a small proportion of flood flow and is spatially confined. The CEWH holds two allocations totalling 8000 ML which are included in the full entitlement model, therefore assessed impacts are conservative as this water is not actually taken. Reference to the NWC farm dams report refers to the 'Improved assessment of the impact of stock and domestic dams in Queensland'.
Insufficient water available for the environment (s4.02(1)(a)) and poor health of water-dependent ecosystems (s4.02(1)(b))	Alteration to flood flow component of flow regime - **decreased number of events above bankfull level**	Reduced recruitment opportunities for flood-spawning fish leading to reduction in population viability; increased number of high-stress periods for Eastern Snake-Necked Turtle; reduced number of river-forming flow events leading to changes in geomorphology and increased waterhole sedimentation.	Rare	Minor	**Low (2)**	3	2	Likelihood: IQQM, floodplain assessment and mapping, well defined entitlements, low level of interception activities. NWC farm dams assessment. Consequence: Literature and expert-based conceptual understanding of multiple ecological asset responses combined with evidence from research programs in neighbouring river systems. NWC farm dams assessment.	Maximum daily waterharvesting diversion is a small proportion of flood flow and is spatially confined. The CEWH holds two allocations totalling 8000ML which is included in the full entitlement model, therefore assessed impacts are conservative as this water is not actually taken. ***The impact of the number and length of spells are more significant when considering the length of inundation (drought more important than flood)***

Risk identification			Risk analysis			Risk confidence			Comments
						Confidence score			
Risk	Risk factor/source	Effect	Likelihood	Consequence	Level of risk	Likelihood	Consequence	Basis for confidence score	
									Reference to the NWC farm dams report refers to the 'Improved assessment of the impact of stock and domestic dams in Queensland'.
	Alteration to medium to high flow component of flow regime - **decreased number of bankfull and channel-connecting flow events**	Reduced dispersal opportunities for flood-spawning and migratory fish leading to reduction in population viability; reduced number of river-forming flow events leading to changes in geomorphology and waterhole sedimentation.	Rare	Moderate	**Low (3)**	3	2	Likelihood: IQQM, channel assessment and mapping, well defined entitlements. Consequence: Literature and expert-based conceptual understanding of multiple ecological asset responses combined with evidence from research programs in neighbouring river systems. Some uncertainty around geomorphological response.	Maximum daily waterharvesting diversion is a small proportion of flood flow and is spatially confined. The CEWH holds two allocations totalling 8000ML which are included in the full entitlement model, therefore assessed impacts are conservative as this water is not actually taken.
Insufficient water available for the environment (s4.02(1)(a)) and poor health of water-dependent ecosystems (s4.02(1)(b))	Alteration to low flow component of flow regime due to **extraction of water from waterholes.**	Small local flows do not pass through system. Less frequent top-up flows to maintain waterhole water levels leading to reduced persistence time and loss of some smaller refuges.	Unlikely	Minor	**Low (4)**	2	2	Likelihood: Gauge stations ability to measure low to very low is limited at most stations due to environmental constraints. The limited number and the spatial distribution of gauge stations means that some small flows resulting from local rainfall run-off, may occur between gauge stations. Consequence: Literature and expert-based conceptual understanding of multiple ecological asset responses combined with evidence from research programs in neighbouring river	There is a low level of certainty regarding impacts of low level extraction from take under riparian rights. Small number of gauging stations (five).

Risk identification			Risk analysis			Risk confidence			Comments
						Confidence score			
Risk	Risk factor/source	Effect	Likelihood	Consequence	Level of risk	Likelihood	Consequence	Basis for confidence score	
								systems.	
	Alteration to cease-to-flow component of flow regime - **increased duration of spells between flow events**	Spell length exceeds persistence time of some waterholes meaning loss of refuges for aquatic biota and extinction of local sub-populations	Rare	Moderate	**Low (3)**	2	2	Likelihood: Gauge stations ability to measure low to very low is limited at most stations due to environmental constraints. The limited number and the spatial distribution of gauge stations means that some small flows resulting from local rainfall run-off, may occur between gauge stations. Consequence: Literature and expert-based conceptual understanding of multiple ecological asset responses combined with evidence from research programs in neighbouring river systems.	There is a low level of certainty regarding impacts of low level extraction from take under riparian rights. Small number of gauging stations (five).

Risk identification			Risk analysis			Risk confidence			Comments
						Confidence score			
Risk	Risk factor/source	Effect	Likelihood	Consequence	Level of risk	Likelihood	Consequence	Basis for confidence score	
Insufficient water available for the environment (s4.02(1)(a)) and poor health of water-dependent ecosystems (s4.02(1)(b))	Alteration to cease-to-flow component of flow regime - **increased number of spells without flow**	Reduced dispersal opportunities and source populations for flood-spawning and migratory fish leading to reduction in population viability; additional stress to Eastern Snake-Necked Turtles as waterholes - already unfavourable habitat - dry and conditions become more harsh.	Unlikely	Minor	**Low (4)**	2	2	Likelihood: Gauge stations ability to measure low to very low is limited at most stations due to environmental constraints. The limited number and the spatial distribution of gauge stations means that some small flows resulting from local rainfall run-off, may occur between gauge stations. Consequence: Literature and expert-based conceptual understanding of multiple ecological asset responses combined with evidence from research programs in neighbouring river systems.	There is a low level of certainty regarding impacts of low level extraction from take under riparian rights. Small number of gauging stations (five).
	Alteration to the distribution of refugial waterholes - **permanence of waterholes affected by water extraction**	Fewer permanent waterhole refugia in the catchment; distance between refugia increased beyond dispersal capacity of fish reducing distribution, population resilience and viability.	Rare	Moderate	**Low (3)**	2	2	Likelihood: There is little information on the location of waterholes and the level of extraction under riparian rights. Consequence: Literature and expert-based conceptual understanding of multiple ecological asset responses combined with evidence from research programs in neighbouring river systems.	There is a low level of certainty regarding impacts of low level extraction from take under riparian rights.

Risk identification			Risk analysis			Risk confidence			Comments
						Confidence score			
Risk	Risk factor/source	Effect	Likelihood	Consequence	Level of risk	Likelihood	Consequence	Basis for confidence score	
Insufficient water available for the environment (s4.02(1)(a)) and poor health of water-dependent ecosystems (s4.02(1)(b))	**Lowering of groundwater levels in sediments above the GAB**	Reduction in size and/or number of GDEs due to groundwater extraction	Unlikely	Moderate	**Low (6)**	2	1	Likelihood: Historical behaviour reflects a preference for GAB water over that from the shallow aquifers. Proposed basin plan identifies BDL as well below SDL therefore significant unassigned water. Consequence: GDE assessment based on remote sensing GIS process with no on ground validation.	No assessment of undertaken for stygofauna.

Risk identification			Risk analysis			Risk confidence			Comments
						Confidence score			
Risk	Risk factor/source	Effect	Likelihood	Consequence	Level of risk	Likelihood	Consequence	Basis for confidence score	
Insufficient water available for the environment (s4.02(1)(a)) and poor health of water-dependent ecosystems (s4.02(1)(b))	**Lowering of groundwater levels in the Warrego Alluvium**	Reduction in size and/or number of GDEs due to groundwater extraction	Unlikely	Moderate	**Low (6)**	2	1	Likelihood: Historical behaviour reflects a preference for GAB water over that from the shallow aquifers. Proposed basin plan identifies BDL as well below SDL therefore significant unassigned water. Consequence: GDE assessment based on remote sensing GIS process with no on ground validation.	No assessment of undertaken for stygofauna.

Appendix 2 Paroo catchment surface water and groundwater risk register

Risk identification			Risk analysis			Risk confidence			Comments
						Confidence score			
Risk	Risk factor/source	Effect	Likelihood	Consequence	Level of risk	Likelihood	Consequence	Basis for confidence score	
Insufficient water available for the environment (s4.02(1)(a)) and poor health of water-dependent ecosystems (s4.02(1)(b))	Alteration to flood flow component of flow regime - **increased duration of spells between floodplain inundation events**	Lengthened period between floodplain wetland inundation (effects on wetland vegetation communities, waterbird breeding opportunities, turtle refuge quality); increasing length of high-stress periods for Eastern Snake-Necked Turtle, suppressing reproduction and reducing population viability; increased length of dry periods for floodplain vegetation leading to loss of condition.	Rare	Moderate	**Low (3)**	3	2	Likelihood: IQQM, floodplain assessment and mapping, well defined entitlements, low level of interception activities. NWC farm dams assessment. Consequence: Literature and expert-based conceptual understanding of multiple ecological asset responses combined with evidence from research programs in neighbouring river systems. NWC farm dams assessment.	Maximum daily waterharvesting diversion is a small proportion of flood flow and is spatially confined. Reference to the NWC farm dams report refers to the 'Improved assessment of the impact of stock and domestic dams in Queensland'.
Insufficient water available for the environment (s4.02(1)(a)) and poor health of water-dependent ecosystems (s4.02(1)(b))	Alteration to flood flow component of flow regime - **decreased number of events above bankfull level**	Reduced recruitment opportunities for flood-spawning fish leading to reduction in population viability; increased number of high-stress periods for Eastern Snake-Necked Turtle; reduced number of river-forming flow events leading to changes in geomorphology and increased waterhole sedimentation.	Rare	Minor	**Low (2)**	3	2	Likelihood: IQQM, floodplain assessment and mapping, well defined entitlements, low level of interception activities. NWC farm dams assessment. Consequence: Literature and expert-based conceptual understanding of multiple ecological asset responses combined with evidence from research programs in neighbouring river systems. NWC farm dams assessment.	Maximum daily waterharvesting diversion is a small proportion of flood flow and is spatially confined. ***The impact of the number and length of spells are more significant when considering the length of inundation (drought more important than flood)*** Reference to the NWC farm dams report refers to the 'Improved assessment of the impact of stock and domestic dams in Queensland'.

Risk identification			Risk analysis			Risk confidence			Comments
						Confidence score			
Risk	Risk factor/source	Effect	Likelihood	Consequence	Level of risk	Likelihood	Consequence	Basis for confidence score	
	Alteration to medium to high flow component of flow regime - **decreased number of bankfull and channel-connecting flow events**	Reduced dispersal opportunities for flood-spawning and migratory fish leading to reduction in population viability; reduced number of river-forming flow events leading to changes in geomorphology and waterhole sedimentation.	Rare	Moderate	**Low (3)**	3	2	Likelihood: IQQM, channel assessment and mapping, well defined entitlements. Consequence: Literature and expert-based conceptual understanding of multiple ecological asset responses combined with evidence from research programs in neighbouring river systems. Some uncertainty around geomorphological response.	There is a low level of certainty regarding impacts of low level extraction from take under riparian rights.
Insufficient water available for the environment (s4.02(1)(a)) and poor health of water-dependent ecosystems (s4.02(1)(b))	Alteration to low flow component of flow regime due to **extraction of water from waterholes.**	Small local flows do not pass through system. Less frequent top-up flows to maintain waterhole water levels leading to reduced persistence time and loss of some smaller refuges.	Rare	Minor	**Low (4)**	2	2	Likelihood: Gauge stations ability to measure low to very low is limited at most stations due to environmental constraints. The limited number and the spatial distribution of gauge stations means that some small flows resulting from local rainfall run-off, may occur between gauge stations. Consequence: Literature and expert-based conceptual understanding of multiple ecological asset responses combined with evidence from research programs in neighbouring river systems.	There is a low level of certainty regarding impacts of low level extraction from take under riparian rights. Small number of gauging stations (one).

Risk identification			Risk analysis			Risk confidence			Comments
						Confidence score			
Risk	Risk factor/source	Effect	Likelihood	Consequence	Level of risk	Likelihood	Consequence	Basis for confidence score	
Insufficient water available for the environment (s4.02(1)(a)) and poor health of water-dependent ecosystems (s4.02(1)(b))	Alteration to cease-to-flow component of flow regime - **increased duration of spells between flow events**	Spell length exceeds persistence time of some waterholes meaning loss of refuges for aquatic biota and extinction of local sub-populations	Rare	Moderate	**Low (3)**	2	2	Likelihood: Gauge stations ability to measure low to very low is limited at most stations due to environmental constraints. The limited number and the spatial distribution of gauge stations means that some small flows resulting from local rainfall run-off, may occur between gauge stations. Consequence: Literature and expert-based conceptual understanding of multiple ecological asset responses combined with evidence from research programs in neighbouring river systems.	There is a low level of certainty regarding impacts of low level extraction from take under riparian rights. Small number of gauging stations (one).
	Alteration to cease-to-flow component of flow regime - **increased number of spells without flow**	Reduced dispersal opportunities and source populations for flood-spawning and migratory fish leading to reduction in population viability; additional stress to Eastern Snake-Necked Turtles as waterholes - already unfavourable habitat - dry and conditions become more harsh.	Rare	Minor	**Low (2)**	2	2	Likelihood: Gauge stations ability to measure low to very low is limited at most stations due to environmental constraints. The limited number and spatial distribution of gauge stations means that some small flow resulting from local rainfall run-off, may occur between gauge stations. Consequence: Literature and expert-based conceptual understanding of multiple ecological asset responses combined with evidence from research programs in neighbouring river systems.	There is a low level of certainty regarding impacts of low level extraction from take under riparian rights. Small number of gauging stations (one).

Risk identification			Risk analysis			Risk confidence			Comments
						Confidence score			
Risk	Risk factor/source	Effect	Likelihood	Consequence	Level of risk	Likelihood	Consequence	Basis for confidence score	
Insufficient water available for the environment (s4.02(1)(a)) and poor health of water-dependent ecosystems (s4.02(1)(b))	Alteration to the distribution of refugial waterholes - **permanence of waterholes affected by water extraction**	Fewer permanent waterhole refugia in the catchment; distance between refugia increased beyond dispersal capacity of fish reducing distribution, population resilience and viability.	Rare	Moderate	**Low (3)**	2	2	Likelihood: There is little information on the location of waterholes and the level of extraction under riparian rights. Consequence: Literature and expert-based conceptual understanding of multiple ecological asset responses combined with evidence from research programs in neighbouring river systems.	There is a low level of certainty regarding impacts of low level extraction from take under riparian rights.
	Lowering of groundwater levels in sediments above the GAB	Reduction in size and/or number of GDEs due to groundwater extraction	Rare	Moderate	**Low (3)**	2	1	Likelihood: Historical behaviour reflects a preference for GAB water over that from the shallow aquifers. Proposed basin plan identifies BDL as well below SDL therefore significant unassigned water. Consequence: GDE assessment based on remote sensing GIS process with no on ground validation.	No assessment of undertaken for stygofauna.

Appendix 3 Nebine catchment surface water and groundwater risk register

Risk identification			Risk analysis			Risk confidence			Comments
						Confidence score			
Risk	Risk factor/source	Effect	Likelihood	Consequence	Level of risk	Likelihood	Consequence	Basis for confidence score	
Insufficient water available for the environment (s4.02(1)(a)) and poor health of water-dependent ecosystems (s4.02(1)(b))	Alteration to flood flow component of flow regime - **increased duration of spells between floodplain inundation events**	Lengthened period between floodplain wetland inundation (effects on wetland vegetation communities, waterbird breeding opportunities, turtle refuge quality); increasing length of high-stress periods for Eastern Snake-Necked Turtle, suppressing reproduction and reducing population viability; increased length of dry periods for floodplain vegetation leading to loss of condition.	Rare	Moderate	**Low (3)**	3	2	Likelihood: IQQM, floodplain assessment and mapping, well defined entitlements, low level of interception activities. NWC farm dams assessment. Consequence: Literature and expert-based conceptual understanding of multiple ecological asset responses combined with evidence from research programs in neighbouring river systems. NWC farm dams assessment.	Maximum daily waterharvesting diversion is a small proportion of flood flow and is spatially confined. The CEWH holds two allocations totalling 1000ML which is included in the full entitlement model, therefore assessed impacts are conservative as this water is not actually taken. Reference to the NWC farm dams report refers to the 'Improved assessment of the impact of stock and domestic dams in Queensland'.
Insufficient water available for the environment (s4.02(1)(a)) and poor health of water-dependent ecosystems (s4.02(1)(b))	Alteration to flood flow component of flow regime - **decreased number of events above bankfull level**	Reduced recruitment opportunities for flood-spawning fish leading to reduction in population viability; increased number of high-stress periods for Eastern Snake-Necked Turtle; reduced number of river-forming flow events leading to changes in geomorphology and increased waterhole sedimentation.	Rare	Minor	**Low (2)**	3	2	Likelihood: IQQM, floodplain assessment and mapping, well defined entitlements, low level of interception activities. NWC farm dams assessment. Consequence: Literature and expert-based conceptual understanding of multiple ecological asset responses combined with evidence from research programs in neighbouring river systems. NWC farm dams assessment.	Maximum daily waterharvesting diversion is a small proportion of flood flow and is spatially confined. The CEWH holds two allocations totalling 1000ML which is included in the full entitlement model, therefore assessed impacts are conservative as this water is not actually taken. **The impact of the number and length of spells are more significant when considering the length of inundation (drought more important than flood)**

Risk identification			Risk analysis			Risk confidence			
						Confidence score			
Risk	Risk factor/source	Effect	Likelihood	Consequence	Level of risk	Likelihood	Consequence	Basis for confidence score	Comments
									Reference to the NWC farm dams report refers to the 'Improved assessment of the impact of stock and domestic dams in Queensland'.
	Alteration to medium to high flow component of flow regime - **decreased number of bankfull and channel-connecting flow events**	Reduced dispersal opportunities for flood-spawning and migratory fish leading to reduction in population viability; reduced number of river-forming flow events leading to changes in geomorphology and waterhole sedimentation.	Rare	Moderate	**Low (3)**	3	2	Likelihood: IQQM, channel assessment and mapping, well defined entitlements. Consequence: Literature and expert-based conceptual understanding of multiple ecological asset responses combined with evidence from research programs in neighbouring river systems. Some uncertainty around geomorphological response.	Maximum daily waterharvesting diversion is a small proportion of flood flow and is spatially confined. The CEWH holds two allocations totalling 1000ML which is included in the full entitlement model, therefore assessed impacts are conservative as this water is not actually taken.

Risk identification			Risk analysis			Risk confidence			Comments
						Confidence score			
Risk	Risk factor/source	Effect	Likelihood	Consequence	Level of risk	Likelihood	Consequence	Basis for confidence score	
Insufficient water available for the environment (s4.02(1)(a)) and poor health of water-dependent ecosystems (s4.02(1)(b))	Alteration to low flow component of flow regime due to **extraction of water from waterholes.**	Small local flows do not pass through system. Less frequent top-up flows to maintain waterhole water levels leading to reduced persistence time and loss of some smaller refuges.	Rare	Minor	**Low (4)**	2	2	Likelihood: Gauge stations ability to measure low to very low is limited at most stations due to environmental constraints. The limited number and spatial distribution of gauge stations means that some small flow resulting from local rainfall run-off, may occur between gauge stations. Consequence: Literature and expert-based conceptual understanding of multiple ecological asset responses combined with evidence from research programs in neighbouring river systems.	There is a low level of certainty regarding impacts of low level extraction from take under riparian rights. Small number of gauging stations (two).

Risk identification			Risk analysis			Risk confidence			Comments
						Confidence score			
Risk	Risk factor/source	Effect	Likelihood	Consequence	Level of risk	Likelihood	Consequence	Basis for confidence score	
Insufficient water available for the environment (s4.02(1)(a)) and poor health of water-dependent ecosystems (s4.02(1)(b))	Alteration to cease-to-flow component of flow regime - **increased duration of spells between flow events**	Spell length exceeds persistence time of some waterholes meaning loss of refuges for aquatic biota and extinction of local sub-populations	Rare	Moderate	**Low (3)**	2	2	Likelihood: Gauge stations ability to measure low to very low is limited at most stations due to environmental constraints. The limited number and the spatial distribution of gauge stations means that some small flows resulting from local rainfall run-off, may occur between gauge stations. Consequence: Literature and expert-based conceptual understanding of multiple ecological asset responses combined with evidence from research programs in neighbouring river systems.	There is a low level of certainty regarding impacts of low level extraction from take under riparian rights. Small number of gauging stations (two).

Risk identification			Risk analysis			Risk confidence			Comments
						Confidence score			
Risk	Risk factor/source	Effect	Likelihood	Consequence	Level of risk	Likelihood	Consequence	Basis for confidence score	
Insufficient water available for the environment (s4.02(1)(a)) and poor health of water-dependent ecosystems (s4.02(1)(b))	Alteration to cease-to-flow component of flow regime - **increased number of spells without flow**	Reduced dispersal opportunities and source populations for flood-spawning and migratory fish leading to reduction in population viability; additional stress to Eastern Snake-Necked Turtles as waterholes - already unfavourable habitat - dry and conditions become more harsh.	Rare	Minor	**Low (2)**	2	2	Likelihood: Gauge stations ability to measure low to very low is limited at most stations due to environmental constraints. The limited number and the spatial distribution of gauge stations means that some small flows resulting from local rainfall run-off, may occur between gauge stations. Consequence: Literature and expert-based conceptual understanding of multiple ecological asset responses combined with evidence from research programs in neighbouring river systems.	There is a low level of certainty regarding impacts of low level extraction from take under riparian rights. Small number of gauging stations (two).
	Alteration to the distribution of refugial waterholes - **permanence of waterholes affected by water extraction**	Fewer permanent waterhole refugia in the catchment; distance between refugia increased beyond dispersal capacity of fish reducing distribution, population resilience and viability.	Rare	Moderate	**Low (3)**	2	2	Likelihood: There is little information on the location of waterholes and the level of extraction under riparian rights. Consequence: Literature and expert-based conceptual understanding of multiple ecological asset responses combined with evidence from research programs in neighbouring river systems.	There is a low level of certainty regarding impacts of low level extraction from take under riparian rights.

Risk identification			Risk analysis			Risk confidence			Comments
						Confidence score			
Risk	Risk factor/source	Effect	Likelihood	Consequence	Level of risk	Likelihood	Consequence	Basis for confidence score	
Insufficient water available for the environment (s4.02(1)(a)) and poor health of water-dependent ecosystems (s4.02(1)(b))	**Lowering of groundwater levels in sediments above the GAB**	Reduction in size and/or number of GDEs due to groundwater extraction	Unlikely	Moderate	**Low (6)**	2	1	Likelihood: Historical behaviour reflects a preference for GAB water over that from the shallow aquifers. Proposed basin plan identifies BDL as well below SDL therefore significant unassigned water. Consequence: GDE assessment based on remote sensing GIS process with no on ground validation.	No assessment undertaken for stygofauna.
	Lowering of groundwater levels in the St George Alluvium	Reduction in size and/or number of GDEs due to groundwater extraction	Possible	Moderate	**Medium (9)**	2	1	Likelihood: Historical behaviour reflects a preference for GAB water over that from the shallow aquifers. Proposed basin plan identifies BDL as well below SDL therefore significant unassigned water. Consequence: GDE assessment based on remote sensing GIS process with no on ground validation.	No assessment undertaken for stygofauna.

Appendix 4 Bulloo catchment surface water and groundwater risk register

Risk identification			Risk analysis			Risk confidence			Comments
						Confidence score			
Risk	Risk factor/source	Effect	Likelihood	Consequence	Level of risk	Likelihood	Consequence	Basis for confidence score	
Insufficient water available for the environment (s4.02(1)(a)) and poor health of water-dependent ecosystems (s4.02(1)(b))	Alteration to flood flow component of flow regime - **increased duration of spells between floodplain inundation events**	Lengthened period between floodplain wetland inundation (effects on wetland vegetation communities, waterbird breeding opportunities, turtle refuge quality); increasing length of high-stress periods for Eastern Snake-Necked Turtle, suppressing reproduction and reducing population viability; increased length of dry periods for floodplain vegetation leading to loss of condition.	Rare	Moderate	**Low (3)**	3	2	Likelihood: IQQM, floodplain assessment and mapping, well defined entitlements, low level of interception activities. NWC farm dams assessment. Consequence: Literature and expert-based conceptual understanding of multiple ecological asset responses combined with evidence from research programs in neighbouring river systems. NWC farm dams assessment.	Maximum daily waterharvesting diversion is a small proportion of flood flow and is spatially confined. Reference to the NWC farm dams report refers to the 'Improved assessment of the impact of stock and domestic dams in Queensland'.
Insufficient water available for the environment (s4.02(1)(a)) and poor health of water-dependent ecosystems (s4.02(1)(b))	Alteration to flood flow component of flow regime - **decreased number of events above bankfull level**	Reduced recruitment opportunities for flood-spawning fish leading to reduction in population viability; increased number of high-stress periods for Eastern Snake-Necked Turtle; reduced number of river-forming flow events leading to changes in geomorphology and increased waterhole sedimentation.	Rare	Minor	**Low (2)**	3	2	Likelihood: IQQM, Floodplain assessment and mapping, Well defined entitlements, low level of interception activities Consequence: Literature and expert-based conceptual understanding of multiple ecological asset responses combined with evidence from research programs in neighbouring river systems.	Maximum daily waterharvesting diversion is a small proportion of flood flow and is spatially confined. **The impact of the number and length of spells is more significant when considering the length of inundation (drought more important than flood).** Reference to the NWC farm dams report refers to the 'Improved assessment of the impact of stock and domestic dams in Queensland'.

Risk identification			Risk analysis			Risk confidence			Comments
						Confidence score			
Risk	Risk factor/source	Effect	Likelihood	Consequence	Level of risk	Likelihood	Consequence	Basis for confidence score	
	Alteration to medium to high flow component of flow regime - **decreased number of bankfull and channel-connecting flow events**	Reduced dispersal opportunities for flood-spawning and migratory fish leading to reduction in population viability; reduced number of river-forming flow events leading to changes in geomorphology and waterhole sedimentation.	Rare	Moderate	**Low (3)**	3	2	Likelihood: IQQM, channel assessment and mapping, well defined entitlements. Consequence: Literature and expert-based conceptual understanding of multiple ecological asset responses combined with evidence from research programs in neighbouring river systems. Some uncertainty around geomorphological response.	There is a low level of certainty regarding impacts of low level extraction from take under riparian rights.

Risk identification			Risk analysis			Risk confidence			Comments
						Confidence score			
Risk	Risk factor/source	Effect	Likelihood	Consequence	Level of risk	Likelihood	Consequence	Basis for confidence score	
Insufficient water available for the environment (s4.02(1)(a)) and poor health of water-dependent ecosystems (s4.02(1)(b))	Alteration to low flow component of flow regime due to **extraction of water from waterholes.**	Small local flows do not pass through system. Less frequent top-up flows to maintain waterhole water levels leading to reduced persistence time and loss of some smaller refuges.	Rare	Minor	**Low (4)**	2	2	Likelihood: Gauge stations ability to measure low to very low is limited at most stations due to environmental constraints. The limited number and spatial distribution of gauge stations means that some small flow resulting from local rainfall run-off, may occur between gauge stations. Consequence: Literature and expert-based conceptual understanding of multiple ecological asset responses combined with evidence from research programs in neighbouring river systems.	There is a low level of certainty regarding impacts of low level extraction from take under riparian rights. Small number of gauging stations (two).

Risk identification			Risk analysis			Risk confidence			Comments
						Confidence score			
Risk	Risk factor/source	Effect	Likelihood	Consequence	Level of risk	Likelihood	Consequence	Basis for confidence score	
Insufficient water available for the environment (s4.02(1)(a)) and poor health of water-dependent ecosystems (s4.02(1)(b))	Alteration to cease-to-flow component of flow regime - **increased duration of spells between flow events**	Spell length exceeds persistence time of some waterholes meaning loss of refuges for aquatic biota and extinction of local sub-populations	Rare	Moderate	**Low (3)**	2	2	Likelihood: Gauge stations ability to measure low to very low is limited at most stations due to environmental constraints. The limited number and the spatial distribution of gauge stations means that some small flows resulting from local rainfall run-off, may occur between gauge stations. Consequence: Literature and expert-based conceptual understanding of multiple ecological asset responses combined with evidence from research programs in neighbouring river systems.	There is a low level of certainty regarding impacts of low level extraction from take under riparian rights. Small number of gauging stations (two).
the environment (s4.02(1)(a)) and poor health of water-dependent ecosystems (s4.02(1)(b))	Alteration to cease-to-flow component of flow regime - **increased number of spells without flow**	Reduced dispersal opportunities and source populations for flood-spawning and migratory fish leading to reduction in population viability; additional stress to Eastern Snake-Necked Turtles as waterholes - already unfavourable habitat - dry and conditions become	Rare	Minor	**Low (2)**	2	2	Likelihood: Gauge stations ability to measure low to very low is limited at most stations due to environmental constraints. The limited number and spatial distribution of gauge stations means that some small flow resulting from local rainfall run-off, may occur between gauge stations. Consequence: Literature and expert-based conceptual understanding of multiple ecological asset	There is a low level of certainty regarding impacts of low level extraction from take under riparian rights. Small number of gauging stations (two).

Risk identification			Risk analysis			Risk confidence			Comments
						Confidence score			
Risk	Risk factor/source	Effect	Likelihood	Consequence	Level of risk	Likelihood	Consequence	Basis for confidence score	
		more harsh.						responses combined with evidence from research programs in neighbouring river systems.	
	Alteration to the distribution of refugial waterholes - **permanence of waterholes affected by water extraction**	Fewer permanent waterhole refugia in the catchment; distance between refugia increased beyond dispersal capacity of fish reducing distribution, population resilience and viability.	Rare	Moderate	**Low (3)**	2	2	Likelihood: There is little information on the location of waterholes and the level of extraction under riparian rights. Consequence: Literature and expert-based conceptual understanding of multiple ecological asset responses combined with evidence from research programs in neighbouring river systems.	There is a low level of certainty regarding impacts of low level extraction from take under riparian rights.

Risk identification			Risk analysis			Risk confidence			Comments
						Confidence score			
Risk	Risk factor/source	Effect	Likelihood	Consequence	Level of risk	Likelihood	Consequence	Basis for confidence score	
Insufficient water available for the environment (s4.02(1)(a)) and poor health of water-dependent ecosystems (s4.02(1)(b))	**Introduction of alien species** or genotypes into ecologically unique catchments - transmission of water and aquatic biota between catchments by increased hydrologic connectivity, inter-basin transfer schemes, water storage and subsequent use.	Competition, predation and cross-breeding by alien species and genotypes leads to loss of diversity and genetic differentiation of aquatic biota in otherwise isolated catchments.	Rare	Catastrophic	**Low (5)**	2	3	Likelihood: There is some knowledge of development applications in those areas and good knowledge of the water resources within the catchment. Consequence: Significant evidence and understanding of the impacts of competition, predation and cross-breeding by alien species and genotypes.	This risk centres on inter basin transfers rather than flooding. A possible driver for the introduction of alien species would be mining activities where water is brought in from another catchment (possibly a northern catchment). Inter-basin transfers are predominately an issues that would be addressed under any environmental authority issued under the Environmental Protection Act 1994 (Qld) or addressed through the Environmental Protection and Biodiversity Conservation Act 1999 (Cwlth).
	Lowering of groundwater levels in sediments above the GAB	Reduction in size and/or number of GDEs due to groundwater extraction.	Unlikely	Moderate	**Low (6)**	2	1	Likelihood: Historical behaviour reflects a preference for GAB water over that from the shallow aquifers. Consequence: GDE assessment based on remote sensing GIS process with no on ground validation.	No assessment of undertaken for stygofauna.