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**Commonwealth Environmental Water Office  
Long Term Intervention Monitoring Project  
GWYDIR RIVER SYSTEM SELECTED AREA**

Final Plan, 4 September 2018



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# Abbreviations

Abbreviation	Description
ANAE	(Interim) Australian National Aquatic Ecosystems (Classification Framework)
ASL	Above Sea Level
BoM	Bureau of Meteorology
CED	Cause and Effect Diagram
CEWH	Commonwealth Environmental Water Holder
CEWO	Commonwealth Environmental Water Office
EAC OAC	Environmental Contingency Allowance Operations Advisory Committee
ELA	Eco Logical Australia Pty Ltd
EWP	Environmental Watering Plan (Basin Plan)
HSE	Health, Safety and Environment
IMEF	Integrated Monitoring of Environmental Flows
LTIM Project	Long-Term Intervention Monitoring Project
M&E Adviser	Monitoring and Evaluation Adviser
M&E Plan	Monitoring and Evaluation Plan
M&E Provider	Monitoring and Evaluation Provider
M&E Requirements	Monitoring and Evaluation Requirements
MDB	Murray-Darling Basin
MDBA	Murray-Darling Basin Authority
MDFRC	Murray-Darling Freshwater Research Centre
MDMS	Monitoring Data Management System
MERI	Monitoring, Evaluation, Reporting and Improvement Framework
NOW	NSW Office of Water
OEH	(NSW) Office of Environment and Heritage
QA/QC	Quality Assurance / Quality Control
SRA	Sustainable Rivers Audit
STIM	Short-term Intervention Monitoring
SWC	State Water Corporation (NSW)
The Department	Department of the Environment (Commonwealth)
UNE	University of New England



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# 1 Introduction

## 1.1 LTIM context

The Commonwealth Environmental Water Holder (CEWH) is responsible under the *Water Act 2007* for managing Commonwealth environmental water holdings. The holdings must be managed to protect or restore the environmental assets of the Murray-Darling Basin, and other areas where the Commonwealth holds water, so as to give effect to relevant international agreements. The Basin Plan (2012) further requires that the holdings must be managed in a way that is consistent with the Basin Plan's Environmental Watering Plan. The *Water Act 2007* and the Basin Plan also impose obligations to report on the contribution of Commonwealth environmental water to the environmental objectives of the Basin Plan.

Monitoring and evaluation are critical for supporting effective and efficient use of Commonwealth environmental water. Monitoring and evaluation will also provide important information to support the CEWH in meeting their reporting obligations.

The Long-Term Intervention Monitoring Project (LTIM Project) is the primary means by which the Commonwealth Environmental Water Office (CEWO) will undertake monitoring and evaluation of the ecological outcomes of Commonwealth environmental watering. The LTIM Project will be implemented at seven Selected Areas over a five year period from 2014-15 to 2018-19 to deliver five high-level outcomes (in order of priority):

1. Evaluate the contribution of Commonwealth environmental watering to the objectives of the Murray-Darling Basin Authority's (MDBA) Environmental Watering Plan
2. Evaluate the ecological outcomes of Commonwealth environmental watering at each of the seven Selected Areas
3. Infer ecological outcomes of Commonwealth environmental watering in areas of the Murray-Darling Basin not monitored
4. Support the adaptive management of Commonwealth environmental water
5. Monitor the ecological response to Commonwealth environmental watering at each of the seven Selected Areas.

To establish long-term arrangements to undertake intervention monitoring at seven Selected Areas within the Murray-Darling Basin, a Monitoring and Evaluation Plan (M&E Plan) has been developed and will be implemented for each Selected Area. To assist with the development of each M&E Plan, the CEWO engaged the Murray-Darling Freshwater Research Centre (MDFRC) as the Monitoring and Evaluation Advisor (M&E Advisor). As the M&E Advisor, the MDFRC assisted with the planning, consultation and scientific development of each M&E Plan. The MDFRC also developed the following reference documents for the development of the M&E Plans to ensure that a high level scope of intervention monitoring underpins the LTIM Project and was developed in context of Commonwealth environmental water:

LTIM Logic and Rationale document (Gawne et al. 2013a) - sets out the overarching design and framework of the LTIM Project

Monitoring and Evaluation requirements for each Selected Area – developed in line with the LTIM Project framework and links to the Basin Plan

LTIM Evaluation Plan - sets out how the Basin-scale (of outcomes of Commonwealth environmental water) and Selected Area questions will be addressed.

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The LTIM Logic and Rationale document (Gawne et al. 2013a) sets out the scope and monitoring priorities for ecological responses to Commonwealth environmental water. Predicted likely ecological outcomes were based on:

Basin Plan Environmental Water Plan (EWP) objectives  
Cause-effect diagrams that link EWP objectives to flow change  
Major flow types (as described in the Basin Plan)  
Possible water availability scenarios over the 1-5 year timeframe.

This M&E framework identifies priority monitoring indicators (Category I and II) for the Gwydir Selected Area that relate to key objectives for Basin-scale evaluation (Gawne et al. 2013b).

This document is the M&E Plan for the Gwydir Selected Area.

## **1.2 Gwydir M&E Plan**

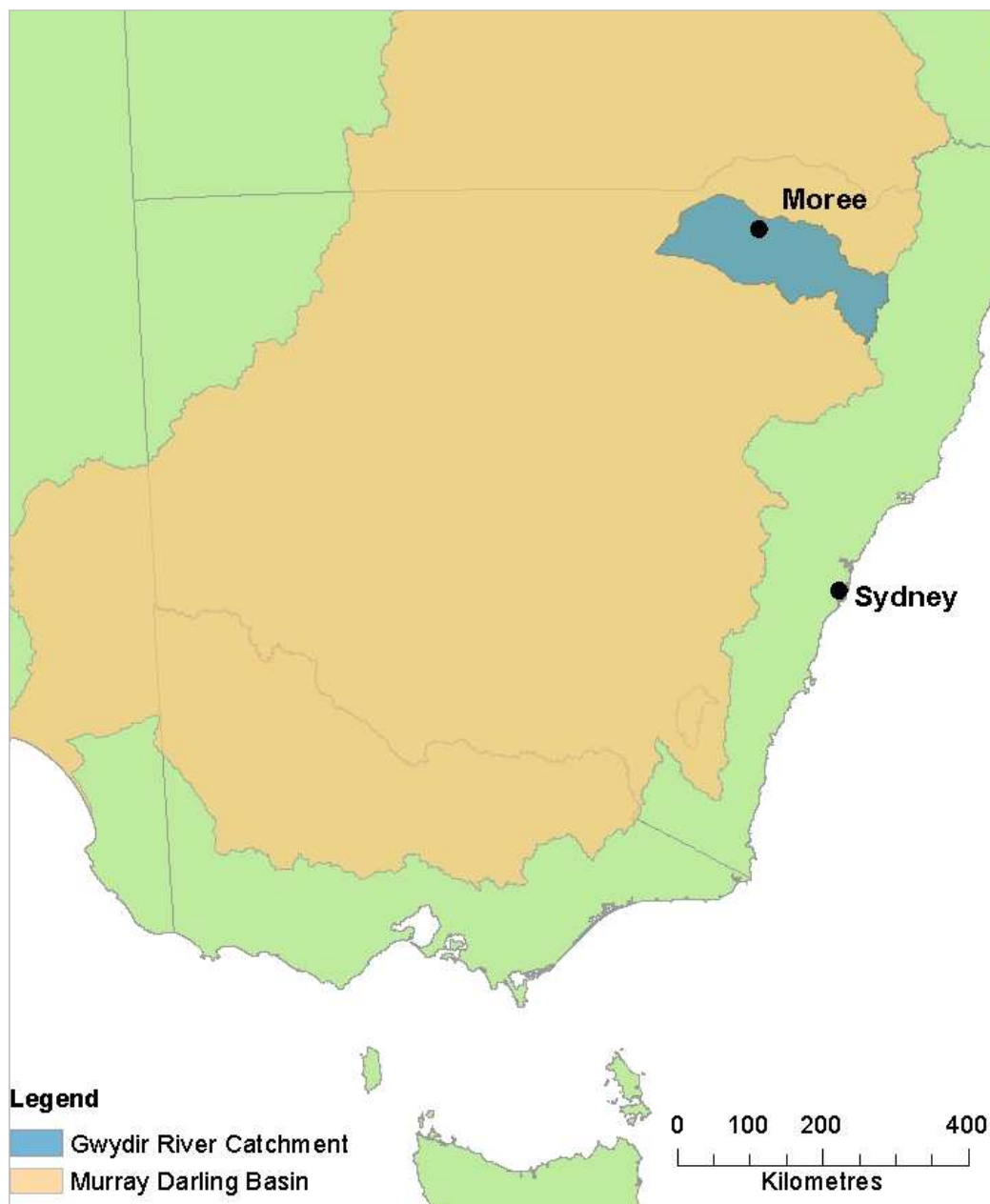
The Gwydir M&E Plan details the monitoring and evaluation activities that will be implemented under the LTIM Project for the Gwydir Selected Area. This M&E Plan includes:

- A brief description of the Gwydir Selected Area (Section 2)
- An overview of environmental watering options in the Gwydir Selected Area (Section 3)
- An overview of the monitoring indicators and the relevant Cause Effect Diagrams (CED) (Section 4)
- The schedule of monitoring (Section 5), including:
  - Evaluation questions (Basin-scale and Selected Area)
  - Monitoring schedule (where, what, when, how)
  - Evaluation approach (Basin-scale and Area)
- A communication and engagement strategy (Section 6; 0)
- A project management plan (Section 7), addressing:
  - Project governance and risk assessment
  - Quality Assurance Plan (0)
- A health, safety and environment (HSE) Plan (0).

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## 2 Gwydir Selected Area

The Gwydir river system is one of seven Selected Areas for monitoring under the LTIM Project. The Gwydir catchment extends from the Great Dividing Range west to the Barwon River, covering an area of 26,600 square kilometres (Green et al. 2011). Downstream of Moree, the system fans out into a broad alluvial near-terminal floodplain (DECCW 2011) (Figure 2-1). Numerous anabranches and distributary channels characterise the lower half of the Gwydir basin, with the Mehi River and Moonin Creek to the south, and the Lower Gwydir River, Gingham watercourse and the Carole-Gil Gil Creek system to the north. Commonwealth environmental watering targets assets with expected outcomes downstream (west) of Tareelaro Weir in the Gwydir floodplain. An overview of the Gwydir catchment, with a focus on the Selected Area, is provided below.



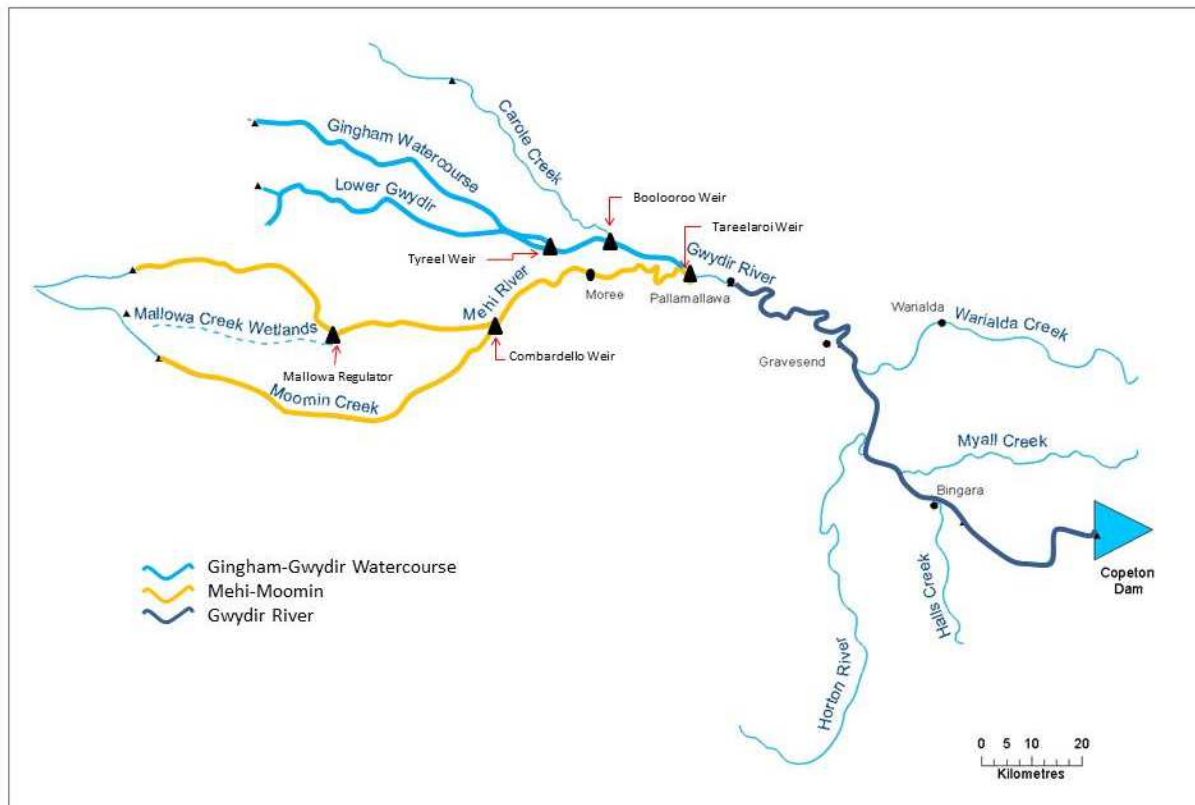
**Figure 2-1: Gwydir catchment within the MDB**

The Gwydir Selected Area focuses on the reaches of the Gwydir Watercourse and distributary channels to the west of Tareelaro Weir. The Gwydir Selected Area (Figure 2-2) includes:

The Gingham-Gwydir Watercourse

Mehi River and Moonim Creek

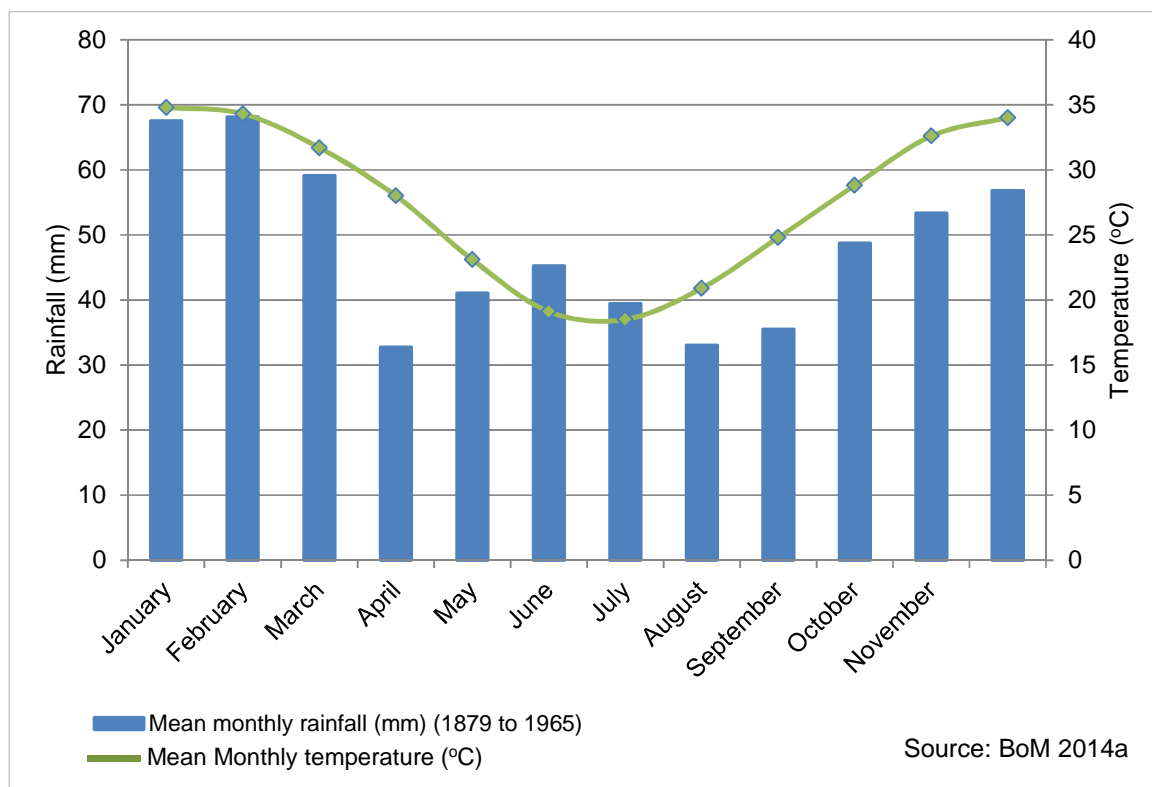
The Gwydir River (downstream of Copeton Dam).



**Figure 2-2: The Gwydir Selected Area**

## 2.1 Climate

Climate across the catchment is sub-tropical in the east to semi-arid in the west. Annual average rainfall varies from around 900 mm at the top of the catchment in the Nandewar Ranges to around 450 mm in the west (Green et al. 2011). The average annual rainfall at Moree is 580 mm (BoM 2014a). Rainfall is summer dominant, with the highest rainfall occurring from October through to March (Figure 2-3). January and February both receive an average monthly total of 68 mm. Monthly winter rainfall varies between 33-45 mm. Monthly evaporation always exceeds rainfall, with an annual average (Class A pan) evaporation of 2328 mm (BoM 2014b). Summer temperatures are warm to hot, with an average daily temperature of 34 °C (Figure 2-3).



**Figure 2-3: Monthly climate averages (Moree Post Office)**

## 2.2 Topography

The headwaters of the Gwydir River are sourced near Uralla in northern NSW at an elevation of approximately 1000 m above sea level (ASL). The upper catchment of the Gwydir River is described as montane, before reaching the plains near Gravesend where the floodplain begins to widen. The Horton River, a major tributary of the Gwydir River that drains to the north from the Nandewar Ranges, enters the Gwydir between Bingara and Gravesend. Almost all runoff for the Gwydir catchment occurs along the 300 km reach upstream of Pallamallawa.

West of Pallamallawa the catchment forms the Gwydir near-terminal floodplain, where the elevation is generally less than 200 m ASL. This area of low relief is crossed by numerous palaeochannels. The Gwydir River and its three main distributary channels (the Mehi River and the Moomin and Carole Creeks) carry the within channel flow across the floodplain. Water also flows through shallow depressions or 'watercourses' in the floodplain. The western floodplains contribute little or no runoff due to low slopes, absorbent soils and high evaporation (DECCW 2011).

## 2.3 Physical environment

The Gwydir River downstream of Copeton Dam flows westward, and links a number of smaller catchments. The major Gwydir River tributary is the Horton River. Upstream of Pallamallawa, the Gwydir River contains large gravel-cobble bars that give way to sand bars and splays (Pietsch 2006 in Gawne et al. 2013b).

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Diversions to the Mehi River are regulated by the Tareelaro Weir upstream of Moree. The Mehi River supports a narrow band of riverine woodland dominated by River Red Gum (*E. camaldulensis*), Coolibah, River Cooba and Lignum (*Muehlenbeckia florulenta*) (Green et al. 2011). At Pallamallawa, a flood channel known as the Biniguy Break carries floodwater through to the Mehi River in higher flows. Whittakers Lagoon is a large semi-permanent wetland that receives floodwater from the Mehi River.

Moomin Creek is an anabranch that leaves the Mehi River west of Moree and re-joins it again just upstream of the confluence with the Barwon River. Mongyer Lagoon is a semi-permanent wetland with a regulated connection to Moomin Creek.

The Gwydir Raft is a unique feature of the Gwydir River. It extends for some 15 km along the river downstream of Moree (DECCW 2011). The Raft is the accumulation, over decades, of timber, debris and sediment deposited in the original channel, causing water pooled behind the deposit to spill north into the Gingham Watercourse, and south into the Tyreel Anabranch (Green et al. 2011).

The Lower Gwydir Wetlands refers to the lower Gwydir catchment downstream of Moree which includes the Gingham Watercourse and the Lower Gwydir Watercourse (or the 'Big Leather Watercourse'). This inland terminal delta forms an alluvial fan of around 20,000 ha. Only during large flood events when the floodplain is inundated does water flow from the wetlands into the Barwon River (Green et al. 2011).

The Gingham Watercourse comprises an area of semi-permanent wetland vegetation as well as extensive areas of floodplain vegetation. The Gingham Waterhole is a permanent lagoon within the main channel. Similar wetland habitats are supported along the Lower Gwydir Watercourse, which is characterised by poorly defined channels and a low gradient (less than one percent).

The Lower Gwydir and Gingham Watercourses contain extensive and significant semi-permanent wetlands, supporting Marsh Club-Rush (*Bolboschoenus fluvialis*), Water Couch (*Paspalum distichum*), River Cooba and Lignum. The less frequently flooded sections of the wetlands are fringed with Coolibah (Gawne et al. 2013b).

The Gingham-Gwydir watercourse complex contains four Ramsar sites: Goddard's Lease, Crinolyn and Windella on the Gingham Watercourse and Old Dromana in the Lower Gwydir.

## **2.4 Hydrology**

The natural hydrology of the Gwydir system has been substantially altered with the construction of storages, weirs and regulators. The major storage is Copeton Dam (1364 GL capacity) which was constructed in the 1970s and controls around 55% of inflows. Upstream of Copeton Dam at Bundarra, the long-term average annual flow is 336,300 ML.

The mean daily flow in the Gwydir River is 2,053 ML/day at Pallamallawa where it reaches maximum capacity (Green et al. 2011) before it loses flow to its anabranches and distributary channels in the lower catchment (Table 2-1). Most flow diversions occur below Pallamallawa where regulation is facilitated by a network of weirs and regulators. Average flows in the Gwydir River and its regulated distributary channels are shown in Table 2-2.

**Table 2-1: Mean daily flow for selected Gwydir River gauging sites**

Gauge site	Catchment area (km <sup>2</sup> )	Mean daily flow (ML/day)	Period of record
Gwydir River (d/s Copeton Dam)	5,240	937	1966-2010
Gwydir River at Gravesend	11,020	2,110	1950-2010
Gwydir River at Pallamallawa	12,300	2,053	1892-2010
Gwydir River at Yarraman Bridge	12,960	1,127	1929-2010
Gwydir River at Brageen Crossing	n/a	183	1982-2010
Gwydir River at Millewa	n/a	71	1988-2010
Gingham Watercourse at Teralba	n/a	221	1997-2010
Carole Creek downstream regulator	n/a	306	1939-2010
Mehi River at Moree	n/a	370	1915-2010
Moomin Creek at Glendello	n/a	287	1984-2010

Reference: Green et al. 2011

**Table 2-2: Major weirs and regulators on the Gwydir River**

Weir	Approximate location	Purpose
Tareelaro Weir	Gwydir River 30 km upstream of Moree	Diversions to the Mehi River
Boooroo Weir	Gwydir River downstream of Moree	Diversions to Carole Creek
Tyreel Regulator	Gwydir River downstream of Moree	Diversions to Tyreel Anabranh and then to the Lower Gwydir Watercourse
Combadello Weir	Mehi River 20 km southwest of Moree	Diversions to Moomin Creek
Gundare Regulator	Mehi River 50 km southwest of Moree	Diversions to Mallowa Creek
Mallowa Creek Regulator	Mallowa Creek 50 km southwest of Moree	Control of stock and domestic flows along Mallowa Creek

Reference: Green et al. 2011

Within channel flows across the Gwydir Selected Area are carried in the Gwydir River, the Mehi River, and the Moomin Creek. Water also flows over the floodplain in the watercourses. The Gwydir river system Selected Area is highly prone to flooding and extended periods of inundation. Regulation of the system has reduced the frequency of moderate to high flows, as well as increasing the average period between large flows.

Flooding in the Lower Gwydir Wetlands occurs at flows between 5,000 and 10,000 ML/d at Yarraman Bridge (Green et al. 2011), depending on extraction rates and antecedent catchment conditions. There is no simple relationship between river flows at gauges and flooding patterns in the Lower Gwydir wetlands; flows of similar magnitude may inundate substantially different areas (Gawne et al. 2013b).

The Gwydir Regulated River Water Source Water Sharing Plan (WSP) is one of two WSPs that guide water management in the Gwydir Catchment under the *Water Management Act 2000*. It applies to regulated rivers in the catchment including the Gwydir River from Copeton Dam to the Gwydir Raft, the Mehi River, Moomin Creek, Carole Creek and the regulated sections of Gil Gil Creek.

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## 3 Commonwealth Environmental Watering

The planning approach for environmental water use options aligns the key aspects of resource availability, expected outcomes from environmental watering actions and the objectives of the Basin Plan. The process aligns water availability with environmental demands in accordance with multi-year ecological and operational considerations (CEWO 2013d).

### 3.1 What types of watering are proposed?

Planning for the use of Commonwealth environmental water is developed with a planning framework that balances water availability with environmental demand according to on-going ecological and operational considerations. Basin-scale environmental watering needs will largely be based on the Basin's annual environmental watering priorities developed yearly by the MDBA (CEWO 2013d).

The Environmental Water Outcomes Framework (CEWO 2013b) was developed by the MDFRC to describe the objectives and outcomes from environmental watering. It underpins environmental water management from the planning and delivery stage through to outcomes and communications.

The Basin Plan identified four key environmental objectives for water-dependent ecosystems to protect and restore water-dependent ecosystem of the Murray-Darling Basin (Gawne et al. 2013a). High level objectives (Level 1 objectives) were identified from the Basin Plan; biodiversity, ecosystem function, resilience and water quality. Within each of these Level 1 objectives, a further set of 'particular' objectives (Level 2 objectives) were identified. Intermediate and long-term targets from the Basin Plan, which are used to measure progress towards Level 1 objectives, have been used to develop Level 3 objectives.

Environmental water can be used to support four environmentally significant flow types (Gawne et al. 2013a). Each flow type provides different functions in the three water-dependent ecosystem types occurring in the Gwydir river system, by influencing biodiversity, ecosystem function, resilience and/or water quality (Table 3-1). Expected ecological outcomes of different flow types that may be derived from Commonwealth environmental watering are summarized in Table 3-2.

Each water year, the CEWO develops a series of water options that may be required in the year to come. Environmental watering actions for the Gwydir river system will be dependent on both the inflow scenarios that aim to meet environmental flow requirements for the Gwydir River, the current availability of Commonwealth environmental water holdings and antecedent conditions. The CEWO planning framework for environmental watering is summarised in Figure 3-1.

Other sources of environmental water in the Gwydir river system include NSW State Water supplementary flows, Environmental Contingency Allowance and Riverbank Environmental Water Licences. The availability of all environmental water types in the Gwydir river system will be considered when developing water use options (Gawne et al. 2013b), including consideration of the release capacities outlined in the WSP for the Gwydir Regulated River Water Source (2004). It is noted that up to 500 ML/day of inflows downstream of Copeton Dam are protected by the WSP for the Gwydir wetlands, as well as 50% of high unregulated flows. Resource availability (e.g. allocations for both the Commonwealth Environmental Water Holder and other environmental water holders and other natural or unregulated flows) may change over the course of a water year. CEWO will regularly assess resource availability.

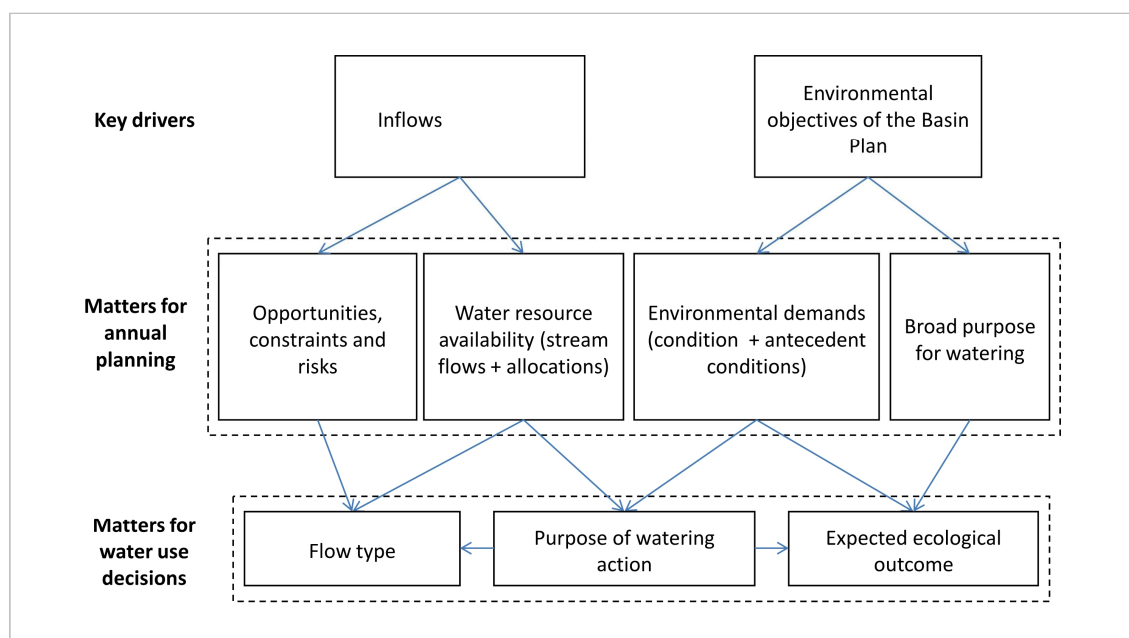


**Table 3-1: Flow type function on rivers, wetlands and floodplains (Gawne et al 2013a)**

Flow type	River	Wetland	Floodplain
Base flow	Flow that protects refugia, sustains water quality, productivity and biodiversity	-	-
Freshes	In-channel disturbance maintains littoral habitat, scours biofilm and provides longitudinal connectivity Will affect water quality and ecosystem functions but the effects vary	-	-
Bankfull	In-channel disturbance Influences in-channel and riparian habitat, provides longitudinal connectivity Sediment transport influences long-term channel form	Only inundates wetlands connected at bankfull, typically those closely connected to parent river  Influence on all water-dependent species habitat, provides some lateral connectivity, major stimulus for primary productivity, decomposition and nutrient cycles  Maintain permanent wetlands as refugia	-
Overbank / terminal wetlands	In-channel disturbance Major influence on in-channel and riparian habitat, provides longitudinal and lateral connectivity, major stimulus for other ecosystem functions Sediment transport influences long-term channel form	Major influence on ecosystem diversity and habitat, provides connectivity, major stimulus for primary productivity, decomposition and nutrient cycles  Maintain permanent wetlands as refugia	Major influence on ecosystem diversity and habitat, provides connectivity, major stimulus for primary productivity, decomposition and nutrient cycles  Maintain permanent wetlands as refugia  Magnitude of flows is important for differentially inundating low lying and higher areas of the floodplain

**Table 3-2: Expected outcomes from different flow types provided by Commonwealth environmental watering (CEWO 2013c)**

Flow type	Expected outcomes (2013-2014)	Long-term contributions	Contribution to Basin Plan objective
Base flow	Refuge	Landscape refuge	Resilience
	Dissolved oxygen	Chemical	Water Quality
Base flows and freshes	Waterbird fledging	Landscape bird diversity	Biodiversity
	Biotic dispersal	Connectivity	Ecosystem function
	Primary production	Nutrient and carbon cycling	
Base flows, freshes and overbank	Within ecosystem diversity	Landscape ecosystem diversity	Biodiversity
	Vegetation condition and reproduction	Vegetation recruitment and extent	
	Fish reproduction Fish condition	Landscape fish diversity	
	Waterbird survival and condition Waterbird reproduction	Landscape bird diversity	
	Other vertebrate condition Other vertebrate reproduction Other vertebrate growth and survival	Other vertebrates	
	Hydrological connectivity End of system flows	Connectivity	Ecosystem function



**Figure 3-1: CEWO environmental watering planning framework**

Water use options that have been developed for the 2013-2014 water year in the Gwydir watering area are summarised in Table 3-3. These are based on water resource availability and flow components (base flows, freshes, overbank/ terminal wetlands) (Gawne et al. 2013b).

**Table 3-3: Summary of watering options for the Gwydir Selected Area (Gawne et al. 2013b; CEWO 2013c)**

Option	Site	Flow Components	Timing	Volume (CEW)	Objective
1	Lower Gwydir and Gingham Watercourses	Base, fresh, over-bank	All year (most likely spring to autumn)	Up to 40 GL (including up to 9.1 GL of supplementary water (if access triggered))	Contribute to base flows and freshes to support connectivity between wetlands, promote recovery of wetland vegetation, provide habitat for threatened species as well as survival and reproduction opportunities for a range of waterbird and native aquatic species (e.g. fish, frogs, turtles, invertebrates)
2	Mallowa Wetlands	Base	All year (most likely spring to autumn)	Up to 10 GL	Contribute to base flows and freshers to support hydrological connectivity between wetlands, promote recovery of wetland vegetation, provide habitat for threatened species as well as survival and reproduction opportunities for a range of waterbird and native aquatic species (e.g. fish, frogs, turtles, invertebrates)
3	Lower Gwydir river channel (downstream of Copeton Dam)	Base	All year (subject to low flow triggers)	Up to 15 GL	Contribute to base flows (i.e. under sustained low inflows provide hydrological connectivity to in-stream habitat), to ensure the persistence of pools as refuge; and to reduce the risk of degrading water quality conditions (particularly low dissolved oxygen levels)
4	Mehi River system	Base, fresh	All year (most likely spring to autumn)	Up to 20 GL (including up to 9 GL of supplementary water (if access triggered))	Contribute to naturally occurring fresh flows to support hydrological connectivity and in-channel flow variability, the health of in-stream habitat, water quality, high primary productivity, native aquatic species condition and reproduction
5	Carole Creek	Base, fresh	All year (most likely spring to autumn)	Up to 5 GL (including up to 1 GL of supplementary water (if access triggered))	Contribute to naturally occurring fresh flows to support hydrological connectivity and allow fish movement, the health of in-stream habitat, water quality, primary productivity, native aquatic species condition and reproduction
6	Gwydir Wetlands TBC (focus on water bird reproduction and fledging contingency)	Base, fresh	Spring /summer /autumn	Up to 5 GL	If required, contribute to base flows to support key species complete life cycles in low lying wetlands (e.g. bird breeding contingency to support waterbird breeding events to successful completion)

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## 3.2 What are the expected outcomes?

### 3.2.1 Expected outcomes from Commonwealth environmental watering

The Environmental Water Outcomes Framework (CEWO 2013b) was developed by the MDFRC and is used to guide environmental watering. Expected outcomes are the likely ecological response from the delivery of Commonwealth environmental water. Outcomes were based on:

Basin Plan Environmental Water Plan (EWP) objectives  
Cause-effect diagrams that link EWP objectives to flow change  
Major flow types (as described in the Basin Plan)  
Possible water availability scenarios over the 1-5 year timeframe.

The Outcomes Framework categorised expected outcomes as the matters that can be achieved from environmental watering within a one year timeframe (1 year expected outcomes) and a one year to five year timeframe (5 year expected outcomes). These timeframes align with the planning hierarchy for Commonwealth environmental water:

Annual water use options  
5 year portfolio management strategies  
The 10 year Basin Plan.

Basin outcomes that relate to environmental watering and other levels under the Basin Plan sit below the four broad objectives. The Outcomes Framework provides a basis for demonstrating how environmental water over successive years accumulates over time to provide Basin-scale outcomes.

Spatio-temporal diagrams have been developed for whole of Basin outcomes that illustrate the links across temporal (1 year, 5 year, > 10 year outcomes) and spatial (site, area, catchment, Basin) scales. Each expected outcome from environmental watering is supported by one or more Cause and Effect Diagrams (CEDs) (Section 4). CEDs explain the interaction between flows and the EWP objectives.

Expected outcomes are those that can be achieved from environmental watering within:

A one-year timeframe  
A one-to-five year timeframe.

Expected outcomes at the one-year timescale are largely reliant on flow type (base, fresh, bankfull, overbank), as well as the ecology of the receiving water-dependent ecosystem (Gawne et al. 2013a). One-to-five year outcomes are influenced by water availability and flow regime. Four water availability classes were defined; extreme dry, dry, median and wet.

### 3.2.2 Expected outcomes in the Gwydir Selected Area

Expected outcomes have been determined for the Gwydir Selected Area (Gawne et al. 2013b) for the Lower Gwydir, Gingham and Mallowa wetlands (Table 3-4) and the Mehi River and Carole Creek (Table 3-5). Note that the expected outcomes for the Lower Gwydir, Gingham and Mallowa wetlands are based on infrastructure assisted flows; this flow component has been nominated as 'discrete wetland inundation'. Watering options for the Gwydir river system will be developed each year by CEWO for the term of the LTIM Project. These options will be developed within the CEWO Outcomes Framework (CEWO 2013b) to ensure that expected outcomes of Commonwealth environmental watering are based around the Basin Plan's environmental watering objectives (CEWO 2013b).

**Table 3-4: Expected outcomes for the Lower Gwydir, Gingham and Mallowa watercourses (Gawne et al. 2013b)**

Flow component	Level 1 objectives	Level 2 and 3 objectives	Suggested < 1 year outcome	Suggested 1- 5 year outcome
Discrete wetland inundation: terminal wetland inundation and infrastructure-assisted bankfull flows in the Gwydir Selected Area	Biodiversity	Ecosystem	Contributes to within ecosystem diversity	Contribute to ecosystem landscape diversity
	Biodiversity	Vegetation	Contributes to within ecosystem riparian, wetland and floodplain native vegetation diversity, extent and condition	Contributed to landscape vegetation diversity and extent
	Biodiversity	Fish	Contributes to fish breeding and recruitment	Contributes to native fish populations and diversity
	Biodiversity	Fish	Recruitment by exotic fish does not increase relative to recruitment by native fish	
	Biodiversity	Waterbirds	Supports colonial waterbirds reaching fledging stage	Maintains waterbird populations and contributes to landscape diversity
	Biodiversity	Waterbirds	Contributes to waterbird condition	Maintains waterbird populations and contributes to landscape diversity
	Biodiversity	Other vertebrates	Contributes to restoration/protection of frog diversity and condition through provision of habitat to support breeding and recruitment	Affects frog populations
	Function	Connectivity	Contributes to breeding and recruitment of native fish by facilitating dispersal (before, during and after breeding)	Contributes to landscape fish diversity
	Water quality	Chemical	Contributes to the maintenance or improvement of water quality to support recruitment, growth and survival of native species (fish, invertebrates, frogs)	Maintains populations of native fish, invertebrates and frogs
	Resilience	Resilience	Contributes to resistance by affecting within ecosystem diversity	Contributes to resistance by affecting landscape ecosystem diversity
	Water quality	Chemical Biological	Contributes to prevention or amelioration of anoxia and algal blooms	Contributes to improved water quality to maintain diversity of key biota (fish, frogs, macroinvertebrates)

**Table 3-5: Expected outcomes for the Mehi River and Carole Creek (Gawne et al. 2013b)**

Flow component	Level 1 objectives	Level 2 and 3 objectives	Suggested < 1 year outcome	Suggested 1- 5 year outcome
Fresh, bankfull	Biodiversity	Vegetation	Contributed to within ecosystem riparian native vegetation diversity, extent and condition	Contributed to landscape vegetation diversity and extent
Base flow, fresh, bankfull	Biodiversity	Fish	Contributed to fish breeding and recruitment	Contributes to native fish populations and diversity
Base flow, fresh, bankfull	Biodiversity	Fish	Recruitment by exotic fish does not increase relative to recruitment by native fish	
Base flow, fresh, bankfull	Biodiversity	Other vertebrates	Contributed to restoration/protection of frog diversity and condition through provision of habitat to support breeding and recruitment	Contributes to frog populations
Fresh, bankfull	Function	Connectivity	Contributed to breeding and recruitment of native fish by facilitating dispersal (before, during and after breeding)	Contributes to landscape fish diversity
Base flow, fresh, bankfull	Water quality	Chemical	Contributed to the maintenance or improvement of water quality to support recruitment, growth and survival of native species (fish, invertebrates, frogs)	Maintains populations of native fish, invertebrates and frogs
Base flow, fresh, bankfull	Resilience	Resilience	Contributed to the maintenance of refugia for aquatic biota	
Base flow, fresh, bankfull	Water quality	Chemical Biological	Contributed to prevention or amelioration of anoxia and algal blooms	Contributes to improved water quality to maintain diversity of key biota (fish, frogs, macroinvertebrates)

### *Water use options 2013-2014 for the Gwydir River Valley*

The CEWO has released the 2013-14 Commonwealth watering options for the Gwydir River system (CEWO 2013c). This document outlines both the expected 2013-14 and longer term outcomes from the use of Commonwealth environmental water in the Gwydir River valley (Table 3-6).

**Table 3-6: Expected outcomes from the 2013-2014 Commonwealth environmental water (CEWO 2013c)**

Flow Type	Expected outcomes (2013-14)	Contributions to longer term outcomes	Contribution to the Basin Plan objective
Base flows	Refuge	Landscape refuge	Resilience
	Dissolved oxygen	Chemical	Water Quality
Base flows and freshes	Waterbird fledging	Landscape bird Diversity	Biodiversity
	Biotic dispersal	Connectivity	Ecosystem function
	Primary production	Nutrient and carbon cycling	
Base flows, freshes and overbank	Within ecosystem diversity	Landscape ecosystem diversity	Biodiversity
	Vegetation condition and reproduction	Vegetation recruitment and extent	
	Fish reproduction Fish condition	Landscape fish diversity	
	Waterbird survival and condition Waterbird reproduction	Landscape bird diversity	
	Other vertebrate condition Other vertebrate reproduction Other vertebrate growth and survival	Other vertebrates	
	Hydrological connectivity End of system flows	Connectivity	Ecosystem function

As part of this process, the Office consulted the following stakeholders:

Environmental Water Scientific Advisory Panel  
Murray-Darling Basin Authority  
New South Wales Office of Environment and Heritage  
New South Wales Office of Water  
New South Wales Department of Primary Industries  
New South Wales State Water Corporation  
Environmental Contingency Allowance Operations Advisory Committee  
North West Local Land Services (LLS).

### **3.3 Practicalities of watering**

The delivery of Commonwealth environmental water in the Gwydir River system is complex, given the context of delivery in a river system that contains public and private storages and developed floodplains (MDBA 2012). Constraints within the system may mean that environmental requirements are not met at all times. Flow capacities are reduced in the downstream direction in the Gwydir system, with the greatest contraction in capacity occurring in the Gwydir River proper. Small flow increases in the Gwydir River at Pallamallawa can cause overbank flows downstream.

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Release capacities for regulated Commonwealth environmental water are provided in the WSP for the Gwydir Regulated River Water Source. Regulated deliveries of environmental water may not reach all of the Selected Area.

The CEWH will enter into arrangements with the NSW state government and other environmental water holders, managers and authorities (delivery partners) to optimise the delivery of environmental water (CEWO 2013d). To inform monitoring activities, a number of documents and range of data will be required. A number of these documents will be produced by CEWO:

Water use minutes (available via the CEWO Project Manager Team Area Leader)

Consolidated decisions and use information (available via the CEWO Project Manager Team Area Leader)

Operational information (planned and actual) and data on water delivery actions (provided by delivery partners).

Access to operational information will be largely via the Selected Area Working Group; it is essential that good working relationships are maintained with the Gwydir Selected Area Working Group, and discussed further in Section 6.



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## 4 Intervention Monitoring Indicators

### 4.1 Monitoring indicators

Intervention monitoring indicators selected for the Gwydir Selected Area were chosen following extensive local area consultation (Gawne et al. 2013a; Gawne et al. 2013b), whole of Basin consideration of scalable indicators and methods of collection and further Selected Area relevant consultation through the Gwydir Selected Area Working Group and Gwydir LTIM Project team. Basin-scale indicators (Category I) were developed to ensure that Basin-scale evaluation needs are met. In addition, Category II and III indicators have been developed for Selected Area and Basin-scale evaluation with the following definitions:

Category I – Mandatory indicators and standard protocols which are required to inform quantitative Basin Evaluation. Indicators have been identified for each Selected Area in this category and must be applied in a consistent manner following standard protocols;

Category II – Optional indicators with mandatory standard protocols which may be used to inform quantitative Basin Evaluation in the future. In the event that any of these indicators are implemented by M&E Providers at the Selected Area, the standard protocol must be followed; and

Category III – Optional indicators with Selected Area specific protocols and mandatory reporting requirements. This includes Selected Area specific monitoring using locally appropriate methods.

Ten indicators relevant to the Gwydir Selected Area and at the Basin-scale have been developed (Table 4-1). For this plan river ecosystem types only were selected.

**Table 4-1: Gwydir Selected Area monitoring indicators**

Monitoring indicator	Category
Ecosystem Type	I
Hydrology (River)	I
Fish (River)	I + III
Waterbird Breeding	I
Vegetation Diversity	II
Waterbird Diversity	II
Water Quality	II
Hydrology (Watercourse)	III
Fish (Movement)	II
Microcrustaceans	III
Macroinvertebrates	III

A matrix of evaluation questions (Basin-scale and Selected Area) and the associated indicators for the Gwydir Selected Area is provided in Table 4-2.

**Table 4-2: Matrix linking evaluation questions and associated indicators for the Gwydir Selected Area**

Evaluation questions	Ecosystem Type	Hydrology (River)	Fish (River)	Waterbird Breeding	Vegetation Diversity	Waterbird Diversity	Water Quality	Hydrology (Watercourse)	Fish (Movement)	Micro-crustaceans	Macro-invertebrates
What did Commonwealth environmental water contribute to sustainable ecosystem diversity?	ST, LT Basin										
Were ecosystems to which Commonwealth environmental water was allocated sustained?	ST, LT Basin										
Was Commonwealth environmental water delivered to a representative suite of ecosystem types?	ST, LT Basin										
What did Commonwealth environmental water contribute to vegetation species diversity?					ST, LT Gwydir			ST, LT Gwydir			
What did Commonwealth environmental water contribute to vegetation community diversity?					ST, LT Gwydir			ST, LT Gwydir			
What did Commonwealth environmental water contribute to native fish community resilience?		LT Basin Gwydir	ST Basin Gwydir								
What did Commonwealth environmental water contribute to native fish survival?		ST Basin Gwydir	ST Basin Gwydir								
What did Commonwealth environmental water contribute to native fish populations?			LT Basin Gwydir						LT Gwydir		
What did Commonwealth environmental water contribute to native fish diversity?		LT Basin Gwydir	LT Basin Gwydir								

Evaluation questions	Ecosystem Type	Hydrology (River)	Fish (River)	Waterbird Breeding	Vegetation Diversity	Waterbird Diversity	Water Quality	Hydrology (Watercourse)	Fish (Movement)	Micro-crustaceans	Macro-invertebrates
What did Commonwealth environmental water contribute to native fish reproduction?		ST Basin Gwydir									
What did Commonwealth environmental water contribute to native larval fish growth?		ST Basin Gwydir									
What did Commonwealth environmental water contribute to native fish dispersal?									ST Gwydir		
Did environmental water stimulate target species to exhibit movement consistent with breeding behaviour?									ST Gwydir		
Did environmental water facilitate target species to move/return to refuge habitat?									ST Gwydir		
What did Commonwealth environmental water contribute to waterbird breeding?				ST, LT Basin Gwydir				ST, LT Gwydir			
What did Commonwealth environmental water contribute to waterbird chick fledging?				ST, LT Basin Gwydir							
What did Commonwealth environmental water contribute to waterbird survival?				ST, LT Basin Gwydir		ST, LT Gwydir					
What did Commonwealth environmental water contribute to waterbird populations?				LT Basin Gwydir		LT Gwydir					

Evaluation questions	Ecosystem Type	Hydrology (River)	Fish (River)	Waterbird Breeding	Vegetation Diversity	Waterbird Diversity	Water Quality	Hydrology (Watercourse)	Fish (Movement)	Micro-crustaceans	Macro-invertebrates
What did Commonwealth environmental water contribute to waterbird species diversity?						LT Gwydir		ST, LT Gwydir			
What did Commonwealth environmental water contribute to patterns and rates of primary productivity?		ST, LT Basin Gwydir									
What did Commonwealth environmental water contribute to temperature regimes?		ST, LT Basin Gwydir					ST, LT Gwydir				
What did Commonwealth environmental water contribute to pH levels?		ST, LT Basin Gwydir					ST, LT Gwydir				
What did Commonwealth environmental water contribute to turbidity regimes?		ST, LT Basin Gwydir					ST, LT Gwydir				
What did Commonwealth environmental water contribute to salinity regimes?		ST, LT Basin Gwydir					ST, LT Gwydir				
What did Commonwealth environmental water contribute to dissolved oxygen levels?		ST, LT Basin Gwydir					ST, LT Gwydir r				
What did Commonwealth environmental water contribute to hydrological connectivity?		LT Basin Gwydir									
What did Commonwealth environmental water contribute to hydrological connectivity of the Gingham-Gwydir Watercourse and Mallowa Creek Wetlands?								ST, LT Gwydir			

Evaluation questions	Ecosystem Type	Hydrology (River)	Fish (River)	Waterbird Breeding	Vegetation Diversity	Waterbird Diversity	Water Quality	Hydrology (Watercourse)	Fish (Movement)	Micro-crustaceans	Macro-invertebrates
What did Commonwealth environmental water contribute to microcrustacean productivity?										ST, LT Basin Gwydir	
What did Commonwealth environmental water contribute to microcrustacean community composition?										ST, LT Basin Gwydir	
What did Commonwealth environmental water contribute to resilience of microcrustacean egg banks?										ST, LT Basin Gwydir	
What did Commonwealth environmental water contribute to the timing of microcrustacean productivity and presence of key species in relation to numbers of larval fish?										ST, LT Basin Gwydir	
What did Commonwealth environmental water contribute to the timing of microcrustacean productivity and presence of key species in relation to growth of larval fish?										ST, LT Basin Gwydir	
What did Commonwealth environmental water contribute to connectivity of microcrustacean and vegetation communities in floodplain watercourses?										ST, LT Basin Gwydir	
What did Commonwealth environmental water contribute to macroinvertebrate diversity?											ST, LT Basin Gwydir

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## 4.2 Indicator priorities

Priority outcomes were initially identified at regional stakeholder workshops in January 2013 based on the values and outcomes presented (Table 4-3). The Gwydir Selected Area Working Group also identified key indicators.

**Table 4-3: Gwydir Selected Area priority monitoring indicators**

Priority monitoring indicator	Identified by
Gwydir, Gingham and Mallowa wetlands - vegetation diversity	Regional stakeholder workshop Jan 2013 (Gawne et al. 2013b)
Gwydir, Gingham and Mallowa wetlands - waterbird survival and condition	
Mehi River and Carole Creek – fish diversity	
Holistic/Functional response of key assets to environmental water	Gwydir Selected Area Working Group (Jan-Feb 2014)
Broader hydrological considerations	
Frogs, turtles, snakes	
Vegetation dynamics	
Sediments	
Fish (abundance/diversity, movement, larvae)	

The Gwydir LTIM Project team in consultation with the Gwydir Selected Area Working Group has evaluated the selected indicators and ranked them (Table 4-4) in terms of relative importance based on:

Potential to meet specified Category I requirements

Relative value for money – linking cost to the likelihood of contributing meaningful monitoring outcomes for the Basin and Selected Area

Importance to the local community (Gawne et al. 2013b) and via the Selected Area Working Group.

**Table 4-4: Indicator priorities for the Gwydir Selected Area**

KEY		Low Return on Investment	Moderate Return on Investment	High Return on Investment
Indicator	Category	Supporting comments		
Ecosystem Type	I	Verifies or describes the ANAE type for each site. The key environmental asset of the Gwydir is the Watercourse, a complex of small channels, floodplains, and closed depressions (wetlands). Most of this environment doesn't fit within the current ANAE mapping. Return on investment (ROI) is moderate.		
Hydrology (River)	I	A key variable for understanding the flow regime. The relatively good network of gauges across the system facilitates this indicator. ROI is high.		
Fish (River)	I	The inclusion of Fish River Category 1 only will provide marginally relevant information at the Selected Area scale due to an absence of comparisons among the distributary network of those channels receiving Commonwealth environmental water and those that do not within a watering year. ROI with Fish River Category I only indicator is moderate. When combined, the Category I and III Fish River indicators can provide Selected Area information on fish populations, diversity and condition that are informative of the value of environmental watering. ROI with these two indicators is high.		
Fish (River)	III			
Waterbird Breeding	I	An iconic part of the Selected Area and an indicator that will provide information that can be directly related to CEWO watering. In addition, the use of real-time monitoring devices (RMCam) will permit real-time adaptive flow management and may facilitate improved successful breeding outcomes. ROI is very high.		
Vegetation Diversity	II	A core target for environmental watering in the Selected Area. Some of the wetland communities are iconic and important nationally and internationally, including 4 Ramsar sites. ROI is very high.		
Waterbird Diversity	II	Linked to Waterbird Breeding this indicator will provide relevant information of bird diversity and response to watering. ROI is high.		
Water Quality	II	Water quality monitoring located only in Gwydir River upstream of Tareelaro providing relevant information on quality of water entering lower Gwydir ecological assets. Location at permanent water and NoW gauged site provides robust data for evaluation questions (including Hydrology River) and security for equipment. ROI is moderate.		
Hydrology (Watercourse)	III	The hydrology/hydrodynamics of the Watercourse area is a critical aspect of understanding the system and the response to flows. The tools and devices for understanding this aspect are now available (several Lidar sets, multiple sources of inundation assessment, hydro-dynamic model) and further work can develop these models and data to improve accuracy and derive meaningful information. This indicator is linked to Microcrustaceans, Waterbird Breeding and Diversity and Vegetation Diversity Dynamics. ROI very high.		

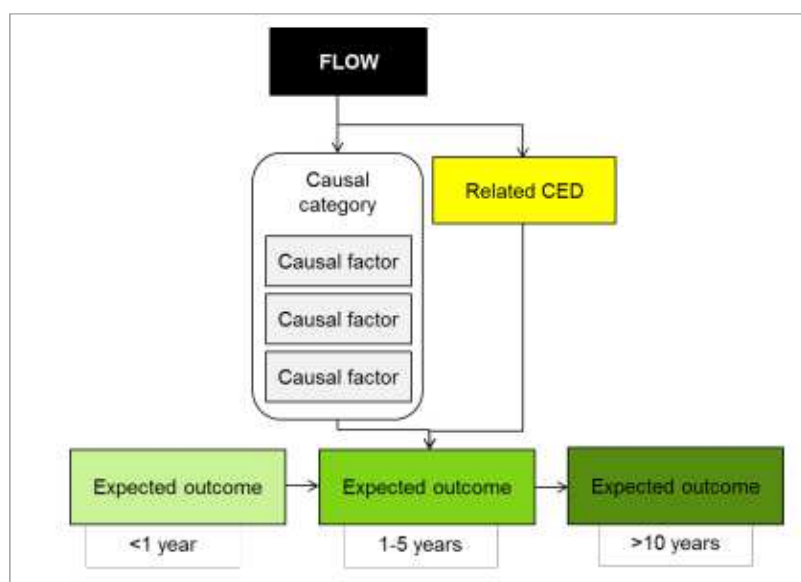
Indicator	Category	Supporting comments
Fish (Movement)	II	<p>This indicator can show fish response as a direct outcome of flow manipulation at short timeframes (annual outcomes). If linked to further understanding of fish behaviour it can contribute significantly to better flow management.</p> <p>This is relatively expensive so ROI is moderate.</p> <p>Co-investment from Fisheries NSW and NoW makes ROI moderate.</p>
Micro-crustaceans	III	<p>This whole of system approach to understanding the response to flow will lead to better understanding of system function, response and resilience. Similar studies are proposed for the southern Selected Areas (Murrumbidgee/Edward-Wakool). Given the nature of the Gwydir watercourse/floodplain systems, environmental water can inundate substantial areas and lead to high rates of primary and secondary productivity that benefit both the environment and agriculture (primarily grazing) and will be linked in this indicator (nutrients-productivity-microcrustaceans- macroinvertbrates-larval fish-waterbirds). The combined knowledge from all of these similar systems will provide substantial synergies in the outcomes from any single Selected Area. This indicator has substantial support from the Selected Area Working Group.</p> <p>ROI is very high.</p>
Macro-invertebrates	III	<p>This whole of system approach to understanding the response to flow will lead to better understanding of system function, response and resilience. Similar studies are proposed for the southern Selected Areas (Murrumbidgee/Edward-Wakool). Given the nature of the Gwydir watercourse/floodplain systems, environmental water can inundate substantial areas and lead to high rates of primary and secondary productivity that benefit both the environment and agriculture (primarily grazing) and will be linked in this indicator (nutrients-productivity-microcrustaceans-macroinvertbrates-larval fish-waterbirds). The combined knowledge from all of these similar systems will provide substantial synergies in the outcomes from any single Selected Area. This indicator has substantial support from the Selected Area Working Group.</p> <p>ROI is very high.</p>



### 4.3 Cause and Effect diagrams

Cause and effect diagrams (CEDs) are simplified conceptual models that link flows to Basin Plan objectives; they do not attempt to explain all possible relationships or causal factors. CEDs for the LTIM Project were developed in line with the objectives hierarchy approach (Gawne et al. 2013a). They link flow through its influence on a range of causal categories (such as habitat, connectivity processes, disturbance and cues) to the objectives hierarchy and expected outcomes (Table 4-5). The LTIM Project CEDs identify two broad types of indicators; effect indicators that support reporting of progress against objectives, and causal indicators that support evaluation and adaptive management.

Twenty seven generic CEDs were developed for the LTIM Project; each CED follows the same structure (Figure 4-1). A CED may relate to other CEDs; these relationships are also depicted. Each CED has been developed based on evidence from water dependent ecosystems in the MDB or, where there are only limited data available, from further afield. It is noted that the CEDs provided are generic with the purpose of predicting environmental outcomes of Commonwealth environmental water (MDFRC 2013). CEDs may need modifications to be applied to the Gwydir Selected Area, and should form part of the adaptive management process.



**Figure 4-1: Generic CED structure (MDFRC 2013)**

CEDs relevant to the Gwydir Selected Area are highlighted in the Table 4-5 and provided in 0.

**Table 4-5: Summary of objectives hierarchy, expected outcomes and generic CEDS developed for the broader LTIM project across the basin**

Level 1 Objectives	Level 2 Objectives	Level 3 Objectives	Expected outcome (1-5 years)	Expected outcome (<1 year)	Relevant CED (shaded cells relevant to the Gwydir Selected Area)
<b>Biodiversity</b>	Ecosystem diversity				Landscape Ecosystem Diversity
			Species diversity		Within Ecosystem Diversity
	Vegetation	Vegetation	Vegetation diversity		Landscape Vegetation Diversity
				Reproduction Condition	Vegetation Condition and Reproduction
			Growth and survival	Germination Dispersal	Vegetation Recruitment and Extent
		Macro-invertebrates	Macroinvertebrate diversity		Within Ecosystem Macroinvertebrate Diversity
	Fish	Fish	Fish diversity		Landscape Fish Diversity
				Condition	Fish Condition
				Larval abundance Reproduction	Fish Reproduction
			Larval and juvenile recruitment		Fish Larval Growth and Survival
	Waterbirds	Waterbirds	Waterbird diversity		Landscape Waterbird Diversity
			Abundance Population structure	Survival and condition	Waterbird Survival and Condition
				Chicks	Waterbird Reproduction
				Fledglings	Waterbird Recruitment and Fledging
	Other vertebrate diversity	Other vertebrate diversity		Young	Other Vertebrate Reproduction
			Adult abundance		Other Vertebrate Growth and Survival

Level 1 Objectives	Level 2 Objectives	Level 3 Objectives	Expected outcome (1-5 years)	Expected outcome (<1 year)	Relevant CED (shaded cells relevant to the Gwydir Selected Area)
<b>Ecosystem Function</b>	Connectivity			Biotic dispersal Sediment transport Nutrient and carbon cycling Primary productivity Decomposition	Hydrological Connectivity (including end of system flows)
				Movement	Biotic Dispersal
				Sediment transport	Sediment Transport
	Process			Primary productivity	Primary Production
				Decomposition	Decomposition
			Nutrient and carbon cycling		Nutrient and Carbon Cycling
<b>Resilience</b>	Ecosystem resilience		Population condition	Individual survival and condition	Individual Refuges
			Population condition		Landscape Refuges
				Individual condition	Ecosystem Resistance
			Population condition		Ecosystem Recovery
<b>Water quality</b>	Chemical			Salinity	Salinity
				Dissolved Oxygen	Dissolved Oxygen
				pH	pH
				Dissolved organic carbon	Dissolved Organic Carbon
	Biological			Algal blooms	Algal Blooms

Reference Gawne et al. 2013a

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## 5 Monitoring and Evaluation Schedule

This monitoring schedule links the Basin-scale and Selected Area evaluation questions with study design, Standard Methods and Selected Area-specific methods, hypotheses and analytical approach, and where possible shows capacity to scale from site-based to Selected Area/ANAE typology levels.

Hypotheses and analyses included are generalised to address only the evaluation questions for each indicator, and are not exhaustive lists of potential hypotheses for each indicator and interactions among indicators.

Standard Operating Procedures (SOPs) for mandatory and high priority indicators are provided in Appendix B.

### 5.1 Monitoring zones

The Gwydir Selected Area focuses on the reaches of the Gwydir Watercourse and tributary channels to the west of Tareelaro Weir (Table 5-1; Figure 5-1). The monitoring zones have been selected using a hierarchical set of criteria:

- Is the reach a target for CEWO water deliveries?
- Does the reach have uniform hydro-geomorphic characteristics at the reach scale?
- Are there specific environmental assets targeted for the delivery of CEWO water via a watering option?
- Do the reach physical characteristics and infrastructure allow the discrete delivery of CEWO water?
- Does the reach contain an array of gauging stations (two or more) that permit the description of reach hydrology?

Using this set of criteria, three discrete monitoring zones were selected:

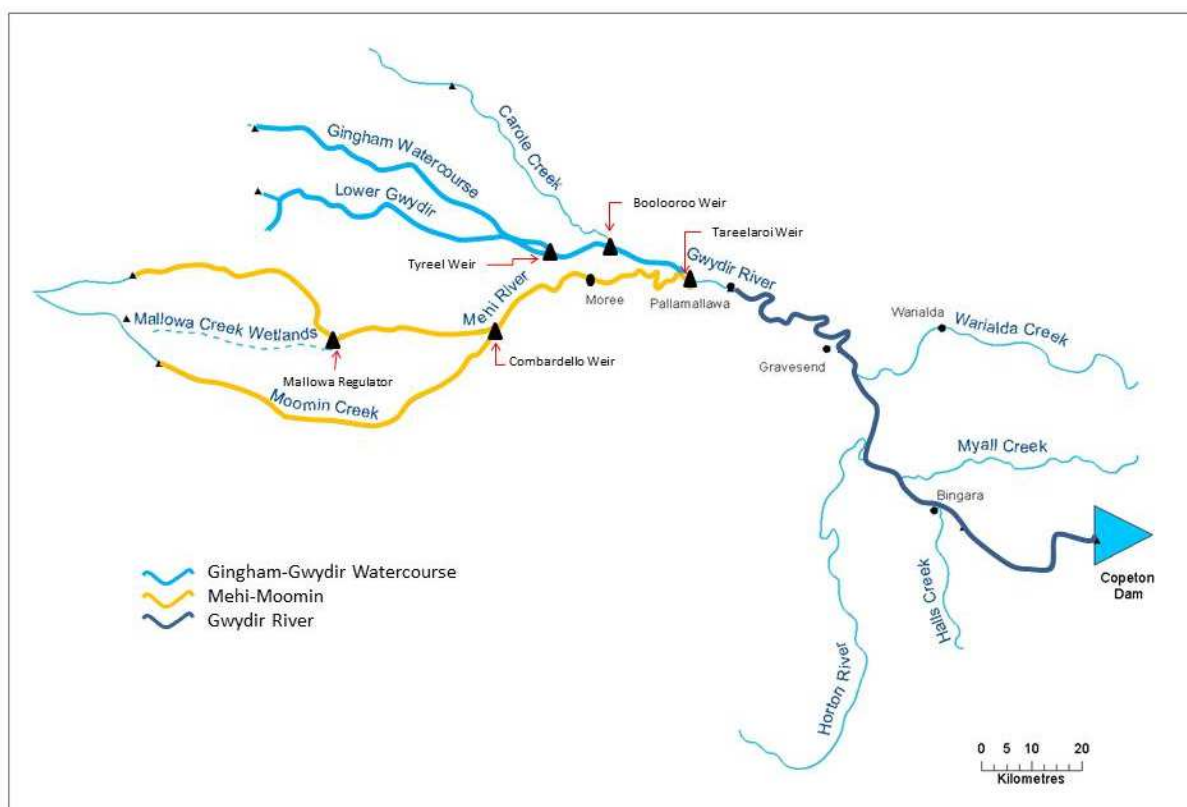
- Gwydir River between Copeton Dam and Tareelaro Weir
- Gingham-Gwydir Watercourse and Channels from Tareelaro Weir to Crinolyn and the Homebush Gauges
- Mehi-Moomin from the Tareelaro d/s to Gundare Regulator and Alma Bridge Gauge.

It should be noted that the infrastructure nominated to define each zone provides a convenient geographic extent for the zone; however, zones also extend laterally from the main mapped channels (Table 5-1; Figure 5-1).

Monitoring zones in the watercourse region (Gingham-Gwydir Watercourse and Mehi-Moomin) are all discrete environmental watering target areas. It is not expected that all of these zones will receive Commonwealth environmental water in any given year. As a result, Category 1 monitoring will be concentrated on the zone (Gingham-Gwydir Watercourse) that has the highest chance of getting water in any given year, given that in dry times, watering priorities are likely to be for water into the terminal wetlands.

**Table 5-1: Gwydir Selected Area monitoring zones**

Zone	Extent	Description
Gwydir River	Copeton Dam to Tareelaro Weir	Single channel meandering river, several tributaries above Gravesend
Gingham-Gwydir Watercourse	Tareelaro Weir to Crinolyn and the Homebush Gauges	Watercourse area consisting of small channels, floodplains and waterholes
Mehi-Moomin	Tareelaro d/s to Gundare Regulator and Alma Bridge Gauge	Small meandering channel and watercourse/floodplain, distributary channel network



**Figure 5-1: Gwydir Selected Area monitoring zones**

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## **5.2 Monitoring schedule - Ecosystem Type**

The SOP for Ecosystem Type is provided in Appendix B.1.

### **5.2.1 Basin-scale evaluation questions**

Short-term (one-year) and long-term (five year) questions:

- What did Commonwealth environmental water contribute to sustainable ecosystem diversity?
- Were ecosystems to which Commonwealth environmental water was allocated sustained?
- Was Commonwealth environmental water delivered to a representative suite of ecosystem types?

### **5.2.2 Where**

At all sites established for all indicators.

### **5.2.3 What**

Validate all ANAE categories for all sites or assign an ecosystem type as per the standard methods. Noting the paucity of mapped ANAE data in the Gwydir Selected Area it is likely that the majority of sites will fall outside of existing mapping.

### **5.2.4 When**

Within 3 months of project commencement. Once only unless new sites are required due to unforeseen circumstances that arise during project operation.

### **5.2.5 How**

As per the LTIM Project Standard Protocol: Section 2 Ecosystem Type (Hale et al. 2014). Existing high resolution imagery (ADS40), Lidar DEM and fine-scale vegetation mapping will be used as key datasets to help define site polygons.

### **5.2.6 Linkages and indicator interactions**

This indicator will help to validate the ANAE mapping.

### **5.2.7 Analytical approach**

Aggregation: list of ecosystem diversity to ensure adequate and representative suite of ecosystems in the Gwydir Selected Area.

Data will be reported following the requirements outlined in the LTIM Project Standard Protocol: Section 2 Ecosystem Type (Hale et al. 2014) and conform to the LTIM Project Data Standard (Brooks & Wealands 2014).

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### **5.3 Monitoring schedule - Hydrology (River)**

The SOP for Hydrology (River) is provided in Appendix B.2.

#### **5.3.1 Basin-scale and Selected Area evaluation questions**

Long-term (five year) questions:

- What did Commonwealth environmental water contribute to hydrological connectivity?
- What did Commonwealth environmental water contribute to native fish species diversity?
- What did Commonwealth environmental water contribute to fish community resilience?

Short-term (one year) questions:

- What did Commonwealth environmental water contribute to native fish reproduction?
- What did Commonwealth environmental water contribute to native larval fish growth and survival?

Short-term (one-year) and long-term (five year) questions:

- What did Commonwealth environmental contribute to patterns and rates of primary productivity?
- What did Commonwealth environmental water contribute to temperature regimes?
- What did Commonwealth environmental water contribute to pH levels?
- What did Commonwealth environmental water contribute to turbidity regimes?
- What did Commonwealth environmental water contribute to salinity regimes?
- What did Commonwealth environmental water contribute to dissolved oxygen levels?

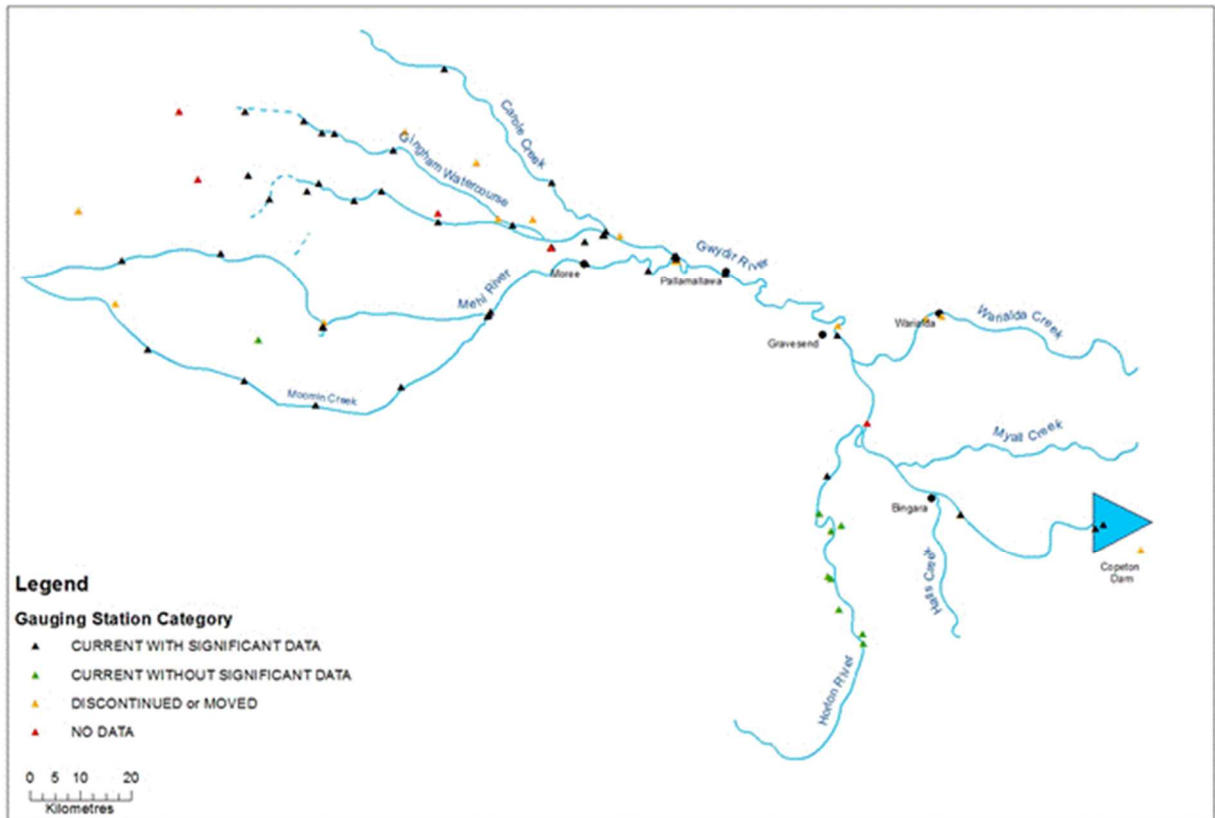
#### **5.3.2 Where**

Across the entire Selected Area. The gauge network maintained by NOW in the Selected Area has sufficient distribution and quality to ensure that no additional gauge stations are required for the delivery of the project (Table 5-2; Figure 5-2).

**Table 5-2: Gauges within zones**

Zone	Gauge no.	Name
Gwydir	418026	D/S Copeton Dam
	418012	Pinegrove
	418013	Gravesend
	418001	Pallamallawa
Gingham-Gwydir	418074	Gingham @ Teralba
	418076	Gingham @ Tillaloo Bridge
	418083	Gingham @ Wetland Rookery
	418077	Gingham @ Gingham Water Hole
	418079	Gingham @ Gingham Bridge
	418063	Gwydir (south arm) DS Tyreel regulator
	418053	Gwydir River at Brageen
	418078	Gwydir @ Allambie Bridge
	418066	Gwydir @ Millewa
	418090	Gwydir @ Old Dromana Regulator
Mehi-Moomin	418044	Mehi River D/S Tareelaroi
	418087	Mehi @ Chinook
	418002	Mehi @ Moree
	418037	Mehi D/S Combadello Weir
	418085	Mehi D/S Gundare Regulator #2
	418048	Moomin @ Combadello
	418060	Moomin @ Glendello
	418067	Moomin @ Clarendon Bridge
	418061	Moomin @ Alma Bridge





**Figure 5-2: Hydrological gauge network**

### 5.3.3 What

Sourcing and analysis of hydrological data to understand the system hydrology and character of Commonwealth environmental water and other environmental water deliveries. This indicator assists with understanding hydrological connectivity and duration for several other indicators.

### 5.3.4 When

On-going for the duration of the project.

### 5.3.5 How

No new gauging stations are to be established. This indicator will require only the standard analysis of system hydrology.

### 5.3.6 Linkages and indicator interactions

This indicator links to Vegetation Diversity, Waterbird Breeding (optional), Waterbird Diversity, Fish (River), Water Quality, Microcrustaceans and Hydrology (Watercourse) indicators.

### 5.3.7 Analytical approach

See individual indicators for short and long term hypotheses and analyses.

Data will be managed following the requirements outlined in the LTIM Project Standard Protocol: Section 14 Hydrology (River) (Hale et al. 2014) and conform to the LTIM Project Data Standard (Brooks & Wealands 2014).

## 5.4 Monitoring schedule - Fish (River)

The SOP for River (River) is provided in Appendix B.3.

### 5.4.1 Basin-scale and Selected Area evaluation questions

Short-term (one-year) questions:

What did Commonwealth environmental water contribute to native fish community resilience?

What did Commonwealth environmental water contribute to native fish survival?

Long-term (five-year) questions:

What did Commonwealth environmental water contribute to native fish populations?

What did Commonwealth environmental water contribute to native fish diversity?

### 5.4.2 Where

The overall design for the Fish (River) indicator has been structured to meet the Category 1 requirements and provide Selected Area specific information. The environmental watering options for the Gwydir system west of Tareelaro Weir are likely to target different zones for different environmental outcomes over a number of years. However, the reach of the Gwydir River between Tareelaro Weir and Tyreel Weir selected for Category 1 Fish (River) sampling will be the most likely reach to receive environmental water each year. Category 3 sampling undertaken in the other three western river reaches will help to inform the Selected Area analysis (Figure 5-3)

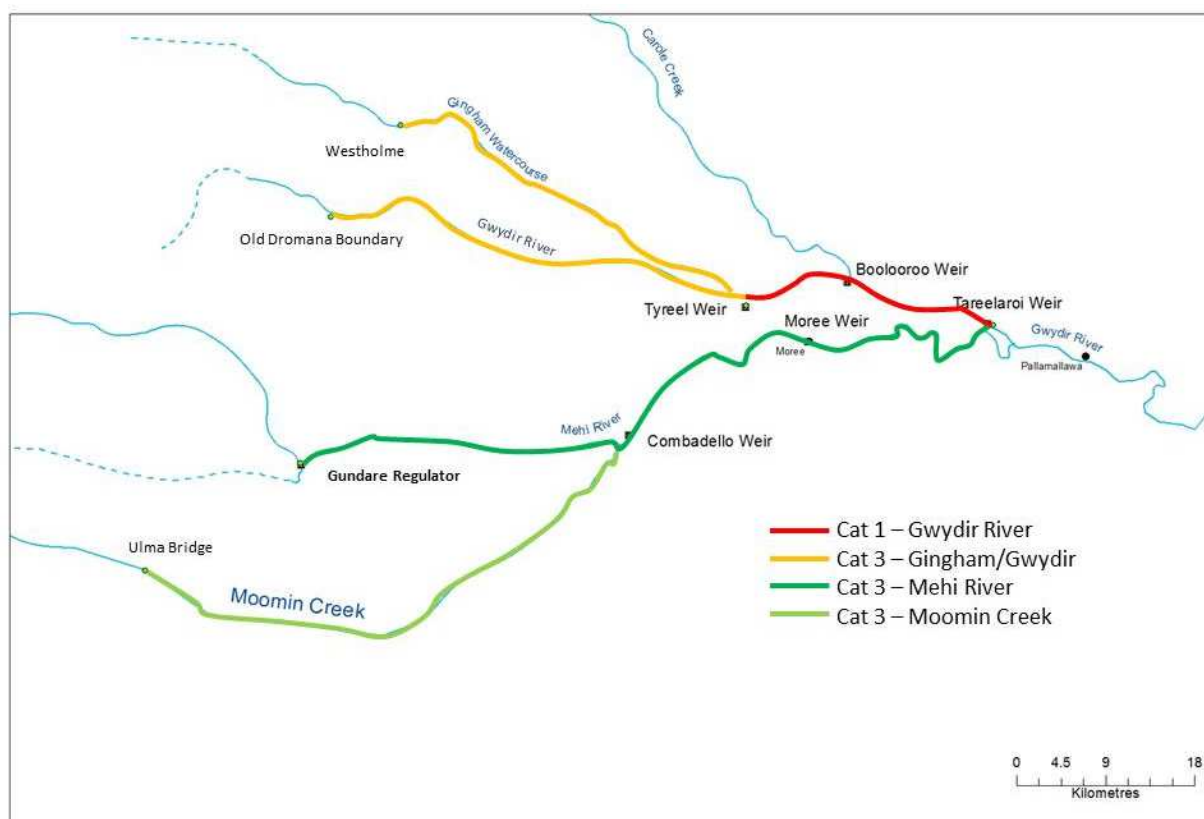


Figure 5-3. Fish (River) to be monitored within the Gwydir River Selected Area

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### 5.4.3 What

In each year, Category 1 Fish (River) monitoring will take place in the priority zone west of Tareelaro Weir following the standard methods (Hale et al. 2014). Otoliths will be collected annually from two opportunistic species within the Category 1 Fish River Selected Area. Otoliths will also be collected in years one and year five from two equilibrium and two periodic species. Equilibrium and Periodic species will be collected within the same zone, but at different locations to the Category 1 Fish River Selected Area so as not to bias the fish community results. In three additional reaches, sampling will be undertaken using Sustainable Rivers Audit (SRA) protocols (Davies et al. 2010). Fish will be sampled at five sites within each zone, using a combination of boat electrofishing (12 x 90 second shots) and un-baited bait traps (n = 10). All fish will be identified, counted, measured and weighed (maximum of 50 individuals per species per electrofishing shot). Although zones are not true replicates (different hydrology, geomorphology), comparisons within and among years of trajectories of change relative to a derived reference condition (SRA metrics) for each zone will provide a robust evaluation of short and long term outcomes from zones receiving Commonwealth environmental water.

Fisheries NSW will be contracted to undertake Fish (River) monitoring.

### 5.4.4 When

March each year for the Category 1 reach. March-April each year for the other zones.

### 5.4.5 How

As per the standard methods. Non-Category 1 sampling zones will use the same methods as those for Category 1 (without otolith sampling) with the site number reduced from 10 to 5 in each zone to facilitate the analytical approach and optimise costs. A total of 25 sites will be sampled annually.

### 5.4.6 Linkages and indicator interactions

This indicator links to Fish (Movement), Hydrology (River) and Microcrustaceans indicators.

### 5.4.7 Selected Area scale hypotheses

Short-term (Annual) responses:

1. Mean Total length, Fork length and Mass for each of the 2 target taxa in each of the 3 life history guilds will be greater in the zone(s) receiving Commonwealth environmental water compared with zones not receiving Commonwealth environmental water.
2. SRA metrics "Expectedness", "Nativeness", and "Recruitment" of native fish communities will be greater in the zone(s) receiving Commonwealth environmental water compared with zones not receiving Commonwealth environmental water.
3. Age of fish (target taxa in each life history guild) will have a greater range (measure of resilience) in the zone(s) receiving annual Commonwealth environmental watering events compared with zones not receiving Commonwealth environmental water.

Long-term (5 year) responses

1. Mean Total length, Fork length and Mass for each of the 2 target taxa in each of the 3 life history guilds will be greatest year-on-year in zones receiving Commonwealth environmental water compared with zones not receiving Commonwealth environmental water.
2. SRA metrics "Expectedness", "Nativeness", and "Recruitment" of native fish communities will be greatest year-on year in zones receiving Commonwealth environmental water.
3. Age of fish (target taxa in each life history guild) will have a greater range year-on year (measure of resilience) in the zone(s) receiving annual Commonwealth environmental watering events.

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#### 5.4.8 Approach to Selected Area scale analyses

Analyses based on Aggregation will be applied at the Basin and Selected Area scales for taxonomic diversity and richness. Additionally, the fish community data will be summarised using the three main SRA Indicators 1) “Expectedness” (a comparison of the existing catch composition with that of historical fish distributions), 2) “Nateness” (the proportion of native versus alien fishes), and 3) “Recruitment” (the recent reproductive activity of the native fish community). Quantitative analyses will then be applied at the Selected Area scale based on annual watering and a counterfactual approach based on an historical ‘reference’ condition represented by a pre-European fish assemblage (developed by Fisheries NSW). Multi-year analyses will be quantitatively analysed based on year-on-year repeat application of annual models outlined in the Selected Area conceptual model (Figure 5-8), and a time-lagged trajectory to a pre-defined condition (Figure 5-9). Uncertainty propagation within and among years will be possible to quantify based on annual comparisons of sites receiving Commonwealth environmental water compared with those sites not watered.

Short-term (Annual) responses:

1. Hypotheses 1, 2 and 3 – Univariate analysis (e.g. ANOVA - main effect – zone) for all taxa, each target taxa, each life history guild, taxa reference richness/diversity.
2. Hypotheses 2 - (diversity-abundance) multivariate analysis (e.g. Permanova, MDS, PCA - factors – zone, target taxa, life history guilds, native/exotic, taxa reference composition).

Long-term (5 year) responses:

1. Hypotheses 4, 5 and 6 – Univariate analysis (main effects – zone, years) for all taxa, each target taxa, each life history guild, taxa reference richness/diversity.
2. Hypotheses 5 - (diversity-abundance) multivariate analysis (factors – zone/years, target taxa, life history guilds, native/exotic, taxa reference composition).

#### 5.4.9 Selected Area scaling

All zones in the lower Gwydir will have representative reaches sampled annually, with 1 priority zone sampled following the delivery of Commonwealth environmental water. Replicate sites in all zones are within defined study reaches of known length (Table 5.1), facilitating outcomes for entire systems to be determined from data scaled from representative reaches (e.g., abundance of native fish/river km scaled to entire channel system of the same ANAE typology).

## 5.5 Monitoring schedule – Vegetation Diversity

The SOP for Vegetation Diversity is provided in Appendix B.4.

### 5.5.1 Selected Area evaluation questions

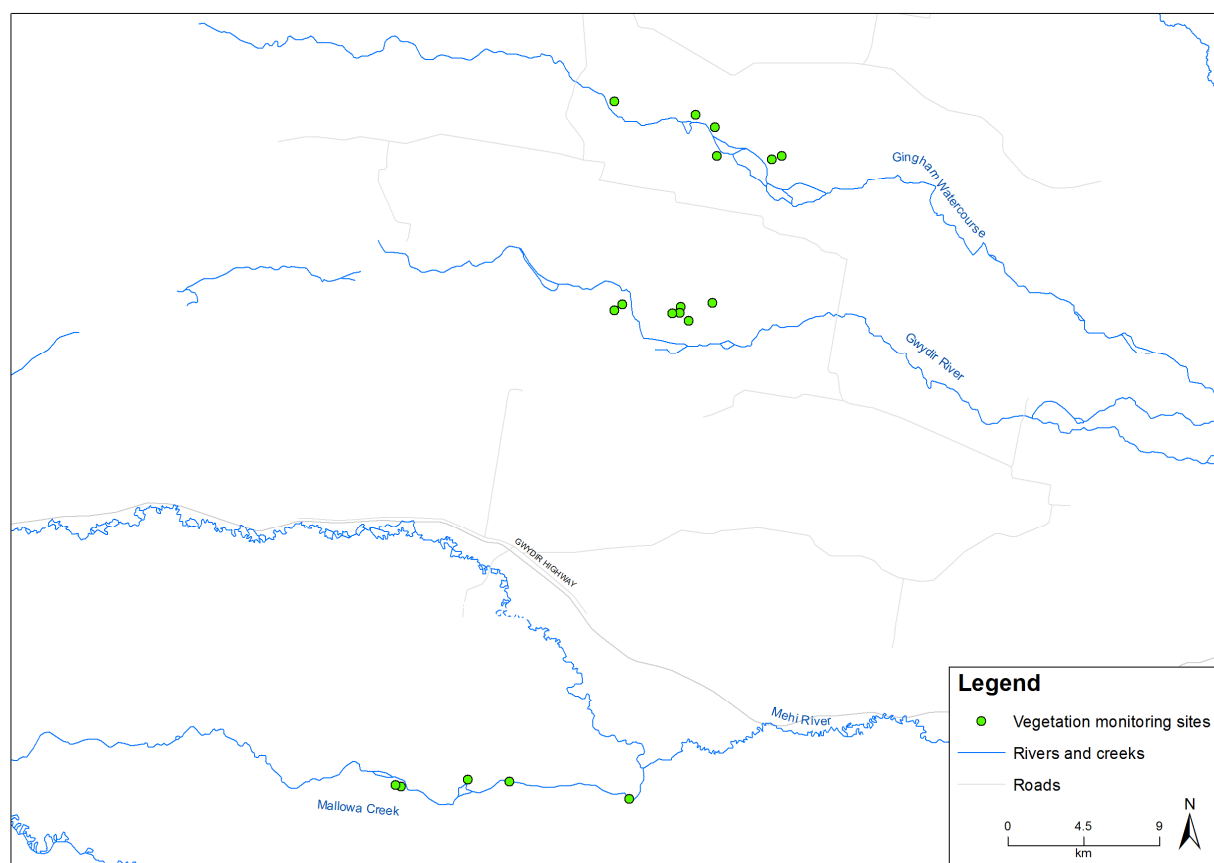
Short-term (one-year) and long-term (five year) questions:

What did Commonwealth environmental water contribute to vegetation species diversity?

What did Commonwealth environmental water contribute to vegetation community diversity?

### 5.5.2 Where

In targeted wetland communities within the Gingham-Gwydir Watercourse and Mehi-Moomin zones (Figure 5-4). These sites are part of an ongoing monitoring program conducted by OEH to monitor the response of vegetation diversity to water. The LTIM Project team will undertake cooperative data collection and sharing with OEH. In these sites Commonwealth environmental water will spill onto the watercourse areas.



**Figure 5-4: Vegetation Diversity Sites**

### 5.5.3 What

Survey and analysis for vegetation diversity responses to inundation.

### 5.5.4 When

Twice annually before and after the watering season: August-October and March-June.

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### 5.5.5 How

Survey methods will comply with the OEH data collection protocols for floodplain wetland vegetation monitoring in the Gwydir watercourse (Bowen 2014; Refer to Appendix B.4, Vegetation Diversity SOP). The methodology aligns with the Standard Methods as a Category 2 indicator (Hale et al. 2014).

Surveys will target 18 existing monitoring sites that incorporate Water Couch communities, River Cooba-Lignum, Marsh Club-rush sedgeland and Coolibah woodlands in the Gingham-Gwydir Watercourse. Depending on the community structure a combination of transects and quadrats will be surveyed (Refer to Appendix B.4, Vegetation Diversity SOP). Sites have been established to directly target zones where environmental watering is likely to be delivered. Links to inundation will be developed through the Hydrology (Watercourse) indicator.

### 5.5.6 Linkages and indicator interactions

This indicator links to Microcrustacean and Hydrology (Watercourse) indicators.

This program links to ongoing vegetation monitoring being undertaken by OEH and will provide for collaborative data sharing.

### 5.5.7 Selected Area scale hypotheses

Short-term (Annual) responses:

1. The delivery of Commonwealth environmental water to wetland and floodplain areas in the Gingham-Gwydir Watercourse will lead to increased cover and/or richness of wetland vegetation communities.

Long-term (5 year) responses:

2. The delivery of Commonwealth environmental water in the Gingham-Gwydir Watercourse will lead to increased year-on-year cover and/or richness of wetland vegetation communities.

### 5.5.8 Approach to Selected Area scale analyses

Analyses based on Aggregation will be applied at the Basin and Selected Area scales for cover and richness of wetland vegetation communities. Quantitative analyses will be applied at the Selected Area scale to document increased cover and richness of wetland vegetation communities at sites receiving Commonwealth environmental water. Multi-year analyses will be quantitatively assessed based on year-on-year repeat application of annual models outlined in the Selected Area conceptual model (Figure 5-8). The placement of survey sites has been strategically undertaken to permit quantification of the hydrologic connection and inundation metrics and lead to reduced uncertainty the delivery of Commonwealth water to these sites.

Short-term (Annual) responses:

1. Hypotheses 1 - univariate analysis (main effect – location, inundation, time) cover and richness and multivariate analysis (factors – location, inundation history, time).

Long-term (5 year) responses:

1. Hypotheses 2 - univariate analysis (main effects – location, inundation history, year, time) and multivariate analysis (factors – location, inundation history, year, time).

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#### **5.5.9 Selected Area scaling**

Each wetland community within the Gingham-Gwydir Watercourse has been mapped at a fine spatial scale. Linking wetland vegetation community extent to Commonwealth environmental water inundation extent should permit extrapolation the response to the Selected Area. The proposed indicator Hydrology (Watercourse) will document the m<sup>2</sup> of inundated ANAE and vegetation hydrology and will facilitate the extrapolation.

## 5.6 Monitoring schedule - Waterbird Diversity

The SOP for Waterbird Diversity is provided in Appendix B.5.

### 5.6.1 Selected Area evaluation questions

Short-term (one-year) and long-term (five year) question:

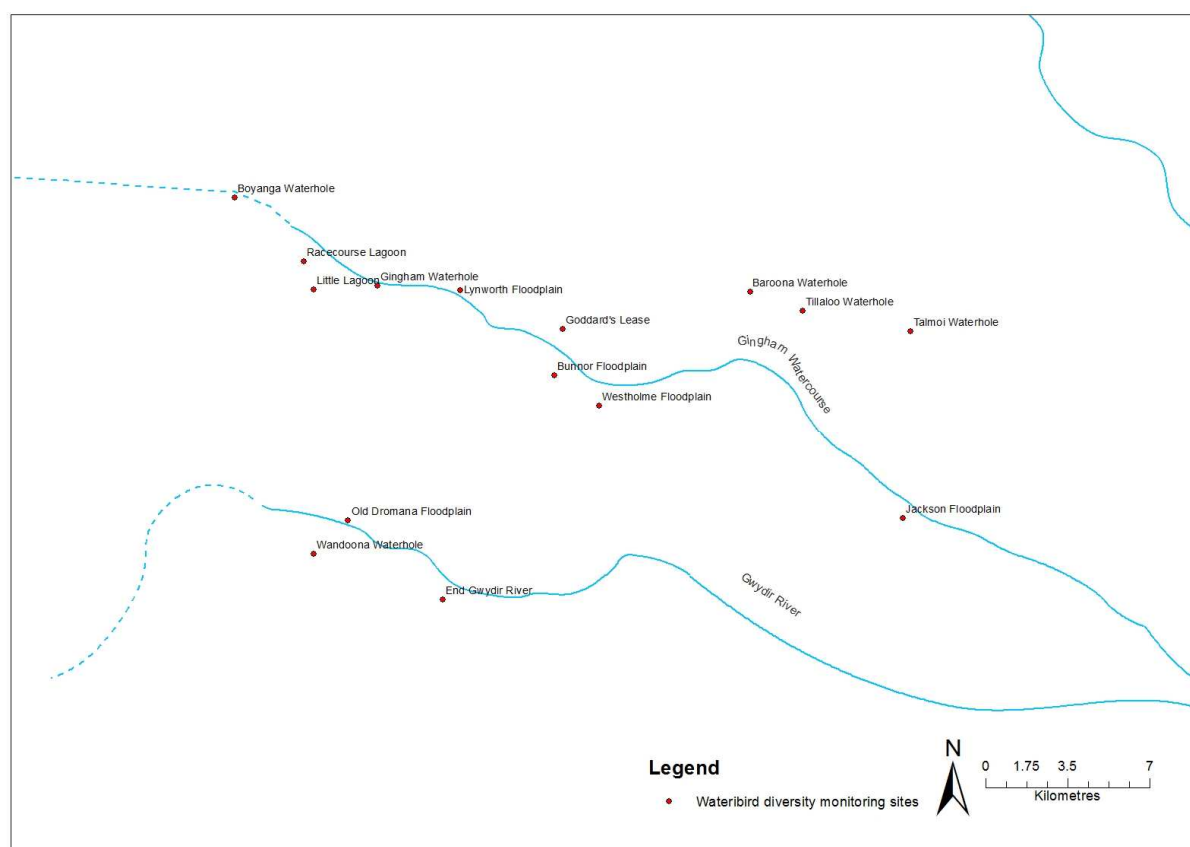
- What did Commonwealth environmental water contribute to waterbird survival?

Long-term (five-year) questions:

- What did Commonwealth environmental water contribute to waterbird populations?
- What did Commonwealth environmental water contribute to waterbird species diversity?

### 5.6.2 Where

A number of sites have been established and monitored in the Gwydir and Gingham Watercourses by OEH staff for a number of years. These areas will be the target of the survey effort (Figure 5-5).



**Figure 5-5. Waterbird Diversity monitoring sites within the Gwydir Selected Area**

### 5.6.3 What

Sampling for waterbird diversity.

### 5.6.4 When

Biannual typically January and April, however, responsive to wetland conditions.



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### 5.6.5 How

Biannual ground surveys will be undertaken, as per the LTIM Standard Methods (Section 10 Waterbird Diversity, Hale et al. 2014). Here, surveys will be undertaken on both foot and from a vehicle using observation points or transects depending on the size and shape of the wetland. Surveys are undertaken for at least 20 minutes but no more than 1 hour at each wetland, in order to gain a representative no necessarily complete, count of all waterbirds in the wetland.

### 5.6.6 Linkages and indicator interactions

This indicator links to Microcrustaceans, Vegetation Diversity and Hydrology (Watercourse) indicators.

### 5.6.7 Selected Area scale hypotheses

Short-term (Annual) responses:

1. The delivery of Commonwealth environmental water will lead to increased waterbird survival?

Long-term (5 year) responses:

1. The delivery of Commonwealth environmental water will lead to larger waterbird populations?
2. The delivery of Commonwealth environmental water will lead to increased waterbird diversity?

### 5.6.8 Approach to Selected Area scale analyses

Analyses based on Aggregation will be applied at the Basin and Selected Area scales for abundance, richness and diversity of waterbirds. Quantitative analyses will be applied at the Selected Area scale to document increased abundance, richness and diversity of waterbirds at sites receiving Commonwealth environmental water. Multi-year analyses will be quantitatively assessed based on year-on-year repeat application of annual models outlined in the Selected Area conceptual model (Figure 5-8). The placement of RMCam devices at each location to quantify hydrologic connection and inundation metrics will improve uncertainty in quantifying the delivery of Commonwealth water to target sites.

Short-term (Annual) responses:

1. Hypotheses 1 and 2 - univariate analysis (main effect – site, time) abundance, richness, diversity.
2. Hypotheses 2 - (diversity-abundance) multivariate analysis (factors – site, time).

Long-term (5 year) responses:

1. Hypotheses 2 and 3 - univariate analysis (main effects – target site, year, time).
2. Hypotheses 3 - (diversity-abundance) multivariate analysis (factors – target site, year, time).

### 5.6.9 Selected Area scaling

The standard method for Waterbird Diversity reports m<sup>2</sup> ANAE area surveyed inundated from Commonwealth environmental water. The proposed indicator Hydrology (Watercourse) will document the m<sup>2</sup> of inundated ANAE and vegetation hydrology and will facilitate the scaling of potential colonial waterbird rookery sites to the lower Gwydir.

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## 5.7 Monitoring schedule - Water Quality

The SOP for Water Quality is provided in Appendix B.6.

### 5.7.1 Selected Area evaluation questions

Short-term (one-year) and long-term (five year) questions:

- What did Commonwealth environmental water contribute to temperature regimes?
- What did Commonwealth environmental water contribute to pH levels?
- What did Commonwealth environmental water contribute to turbidity regimes?
- What did Commonwealth environmental water contribute to salinity regimes?
- What did Commonwealth environmental water contribute to dissolved oxygen levels?

### 5.7.2 Where

At a single station at Pallamallawa near the NOW telemetered gauge in Gwydir River Zone (Copeton Dam to Tareelaro Weir) to allow evaluation of water quality entering the lower Gwydir system.

### 5.7.3 What

*In situ* logging of DO, temperature, EC, pH, turbidity and chlorophyll a at 15 min intervals. The DS5-X multi-probe logger includes a self-cleaning system to reduce fouling of probes and is designed for long-term submersible deployment.

### 5.7.4 When

The logger will be deployed to record continuously at this site as it has permanent surface water flow. Deployment periods will therefore align with the commencement and cessation of Commonwealth environmental water delivery.

### 5.7.5 How

The design, equipment, collection and processing of data, reporting and QA requirements will follow the LTIM Project Standard Protocol: Section 13 Water Quality (Hale et al. 2014).

### 5.7.6 Linkages and indicator interactions

This indicator links to Vegetation Diversity, Waterbird Breeding, Waterbird Diversity, Fish (River) and Hydrology (River and Watercourse) indicators in the lower Gwydir system.

### 5.7.7 Selected Area scale hypotheses

Short-term and long-term responses

1. Mean daily water temperature, and daily range in water temperature will decrease during the delivery of Commonwealth environmental water.
2. Mean daily pH, and daily range in pH will decrease during the delivery of Commonwealth environmental water.
3. Mean daily turbidity will increase during the delivery of Commonwealth environmental water.
4. Mean daily EC will decrease during the delivery of Commonwealth environmental water.
5. Mean daily DO concentrations will decrease during the delivery of Commonwealth environmental water.

### 5.7.8 Approach to Selected Area scale analyses

Quantitative analyses will be applied at the Selected Area scale to test predicted changes in each water quality variable. Multi-year analyses will be quantitatively assessed based on year-on-year repeat application of annual models outlined in the Selected Area conceptual model (Figure 5-8).

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#### Short-term and long term responses

1. Hypotheses 1, 2, 3, 4 and 5. Replication derived from randomised daily means of data periods within/outside delivery of Commonwealth environmental water. One-way Anova (WQ variables as dependant variable) comparing among flow periods, and two-way Anova (flow period, years) for long term dataset.

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## **5.8 Monitoring schedule - Hydrology (Watercourse)**

The SOP for Hydrology (Watercourse) is provided in Appendix B.7.

### **5.8.1 Selected Area evaluation questions**

Short-term (one year) and long-term (five year) questions:

- What did Commonwealth environmental water contribute to hydrological connectivity of the Gingham-Gwydir Watercourse Wetlands?
- What did Commonwealth environmental water contribute to Microcrustaceans?
- What did Commonwealth environmental water contribute to Waterbird Diversity and Breeding?
- What did Commonwealth environmental water contribute to Vegetation Diversity?

### **5.8.2 Where**

In the Gingham-Gwydir Watercourse (Figure 5-7).

### **5.8.3 What**

Map the inundation extent resulting from the delivery of Commonwealth environmental watering using Lidar imaging.

Other data on inundation extent and frequency from previous and ongoing work from OEH (Rachel Thomas et al) and Sue Powell (UC PhD thesis), Lidar captures and hydrodynamic modelling from OEH will be used to assist in developing the known and expected inundation extent and volume from given flow events.

### **5.8.4 When**

Existing sets of Lidar data (already captured) will be used to create an inundation model at targeted areas within the Gingham-Gwydir Watercourse. No new data capture is proposed.

### **5.8.5 How**

Lidar images will be used to create an inundation model and tied to flow/volume data from the nearest gauge.

The inundation layers will be used in conjunction with other locally established gauges to develop location specific knowledge relating flow volume to inundation.

### **5.8.6 Linkages and indicator interactions**

This indicator links to Microcrustaceans, Vegetation Diversity, Waterbird Breeding and Waterbird Diversity indicators.

This project will create data relevant to the hydro-dynamic model built by OEH. It will enable calibration and refinement of this model.

### **5.8.7 Analysis**

GIS based analysis to determine the relationship between inundation event (volume) and inundated area and volume in relation to mapped soil and vegetation regions.

### **5.8.8 Approach to Selected Area scale analyses**

The Hydrology (Watercourse) method reports m<sup>2</sup> ANAE typology and vegetation community inundated from Commonwealth environmental water. The proposed indicator will document the m<sup>2</sup> of inundated

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ANAE and vegetation hydrology and will facilitate the scaling of potential Microcrustaceans, Vegetation Diversity and Waterbird Diversity/Breeding to the Lower Gwydir.

All data provided for this indicator must conform to the data structure defined in the LTIM Data Standard (Brooks & Wealands 2014).

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## 5.9 Monitoring schedule - Fish (Movement)

The SOP for Fish (Movement) is provided in Appendix B.8.

### 5.9.1 Selected Area evaluation questions

Short-term (one-year) questions:

- What did Commonwealth environmental water contribute to native fish dispersal?
- Did environmental water stimulate target species to exhibit movement consistent with breeding behaviour?
- Did environmental water facilitate target species to move/return to refuge habitat?

Long-term (five-year) question:

- What did Commonwealth environmental water contribute to native fish populations?

### 5.9.2 Where

In the first year of monitoring Fish (Movement) (year 2 of the LTIM monitoring), the monitoring team will select the best reach within the target zones to establish the optimal location/s for fish movement array.

### 5.9.3 What

Category II sampling and recording. Fish (Movement) will target movement of one equilibrium species, freshwater catfish (*Tandanus tandanus*) (endangered population Murray-Darling Basin), and one periodic species, spangled perch (*Leiopotherapon unicolor*). Within the Murray Darling Basin, the response of both species to changes in river discharge is poorly understood and to the best of our knowledge neither species is currently being studied elsewhere in the Basin to answer any flow-related questions.

Fisheries NSW in collaboration with NOW will be contracted to undertake Fish (Movement) monitoring.

### 5.9.4 When

Ongoing in Years 2 and 3 only (i.e. 2015-16, 2016-17). Following the collection and analysis of Year 1 Category 1 Fish (River) data, the team will select best reach within the target zone to establish fish movement array.

### 5.9.5 How

As per the LTIM Project Standard Protocol: Section 8 Fish (Movement) (Hale et al. 2014)

### 5.9.6 Linkages and indicator interactions

This indicator links to Fish (River), Water Quality and Hydrology (River) indicators.

### 5.9.7 Selected Area scale hypotheses

Short-term (Annual) responses (for target species *Tandanus tandanus* and *Leiopotherapon unicolor*):

1. Fish movement (metres) and rate of movement (metres/day) is positively correlated to the timing of Commonwealth environmental water delivery.
2. Fish home-range is increased during Commonwealth environmental water delivery.
3. The number of habitats utilised by fish will increase Commonwealth environmental water delivery. Commonwealth environmental water delivery results in breeding of target species.

Long-term (5 year) responses:

1. Fish movement (metres) is greatest in years receiving Commonwealth environmental water delivery
2. Increased breeding activity by target species.

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### 5.9.8 Approach to Selected Area scale analyses

The objective of the Fish (Movement) indicator is to establish an acoustic array to provide 'acoustic recaptures' similar to a mark-recapture study, and to define movement cues and habitat use (including refuge during drought) in response to the delivery of Commonwealth environmental water. Fisheries NSW already has in place a data base to manage the large amounts of data likely to be generated. Techniques such as position averaging (e.g. Simpfendorfer et al. 2010) will be used to reduce data processing where possible. Home-range calculations (kernel utilisation distributions), site fidelity (linearity indices), habitat use and rate of movement will be plotted using Eonfusion® (Fisheries NSW hold multiple licences for the software). Eonfusion® will also be used to generate 'real-time' video to help in visualising fish movements in relation to flow, season, day-night etc. In addition to the above analyses, a model selection approach using linear mixed effect models will be used to determine relationships between movement patterns and environmental variables such as discharge, lagged discharge (number of days since flow event), Julian day, water temperature, sex and length of fish. If breeding related movements do occur, then the locations of fish during this time will be reported as displacement, defined as a representation of the geographical distance and the direction that the fish moved. As freshwater catfish is known to nest on open substrates and in relatively shallow water, we will also attempt to validate nest site locations using underwater cameras.

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## 5.10 Monitoring schedule – Microcrustaceans

The SOP for Microcrustaceans is provided in Appendix B.9.

### 5.10.1 Basin-Scale and Selected Area evaluation questions

Short-term (one-year) and long-term (five year) questions:

What did Commonwealth environmental water contribute to microcrustacean productivity?

What did Commonwealth environmental water contribute to microcrustacean community composition?

What did Commonwealth environmental water contribute to resilience of microcrustacean egg banks? (comparing year 1 to year 5)

What did Commonwealth environmental water contribute to the timing of microcrustacean productivity and presence of key species in relation to numbers of larval fish?

What did Commonwealth environmental water contribute to the timing of microcrustacean productivity and presence of key species in relation to growth of larval fish?

What did Commonwealth environmental water contribute to connectivity of microcrustacean and vegetation communities in floodplain watercourses?

### 5.10.2 Where

Monitoring sites for microcrustaceans will be located in two target areas in the Selected Area, River channels and Watercourse floodplain areas. The application of standard methods to these target areas provides potential for Basin-scale evaluation and comparisons with other Selected Areas.

The first is the River zone receiving Commonwealth environmental water within each watering year, where the river channel sampling protocol for microcrustaceans will occur at the three locations aligned with Fish (River) sampling to provide explicit links among these indicators and provide an assessment of a functional ecosystem response.

The second zone utilises the wetland/floodplain sampling protocol to sample watercourse inundation that is characterised by an extensive floodplain wetland network and will allow an assessment of connectivity. Sampling will occur within representative sites in each of the dominant wetland vegetation communities inundated by Commonwealth environmental water. The Hydrology Watercourse indicator will facilitate the scaling-up of site based Microcrustacean data (density/L/vegetation type) to the entire inundated area of the watercourse. The focus is on the microcrustacean response to the inundation of water couch and Cooba Lignum communities within Goddard's Lease Ramsar site, Westholme, Bunnor and Lynworth in the Gingham systems and Water Couch and Marsh Club-Rush communities on Old Dromana in the Gwydir.

This design will allow Basin-scale reporting with replication (n=3) for each of river channel and watercourse habitats and alignment with Fish (River) and Vegetation Diversity.

River sites:

- The Mehi-Moomin system extends from the upstream site at Tareelaroi Weir to lower sites at Gundare Regulator (Mehi) and Moomin Plains (Moomin Creek) gauges. All these sites have all weather access and established NOW telemetered gauges.

Watercourse sites:

- The Gingham-Gwydir zone extends from Tyreel storage as the confluence of these two systems, to lower sites at Crinolyn (Gingham) and Homebush (Gwydir) gauges both of which have all weather access and established NOW telemetered gauges.



The rationale underlying this approach is to seek as much synergy as possible between the components monitoring other vertebrates and wetland fish that also prey on microcrustaceans. Only a single composite sample (comprised of either 5 benthic cores or 5 pelagic buckets) is taken from each site or flow-habitat within a site. This will reduce the overall number of samples for laboratory processing.

### 5.10.3 What

Sampling of Microcrustacean populations in both pelagic and benthic habitats. Also, the monitoring of nutrients and metabolism.

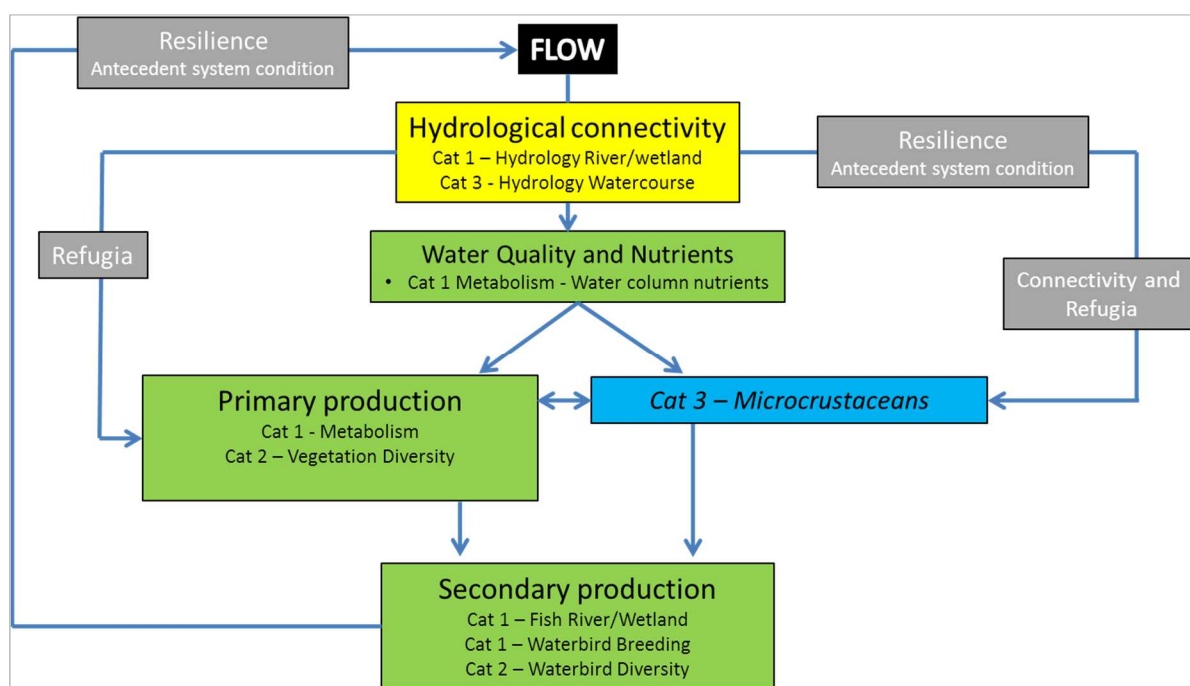


Figure 5-6: CED – microcrustaceans

### 5.10.4 When

At each of the 3 Fish (River) sites, microcrustacean sampling will take place on 4 occasions from October through to April.

At each watercourse site, microcrustacean sampling will take place following watercourse inundation with Commonwealth environmental water, four sample events are planned to follow the inundation and contraction cycle, sampling immediately (days) after inundation, at peak area inundation, and at two times during the drying cycle.

### 5.10.5 How

As per the methodology prescribed in the Microcrustacean SOP (Appendix B.9).

### 5.10.6 Linkages and indicator interactions

This indicator links to Vegetation Diversity, Waterbird Breeding, Fish (River), Hydrology (River) and Hydrology (Watercourse) indicators.

### 5.10.7 Selected Area scale hypotheses

1. The delivery of Commonwealth environmental water will increase the biotic and abiotic resource pools supporting food webs.

- 
2. The delivery of Commonwealth environmental water will shift the trophic position of key taxa.
  3. The delivery of Commonwealth environmental water will increase the complexity of food web structure.
  4. The delivery of Commonwealth environmental water will increase whole-of-system trophic dynamics (biological productivity, interaction among species, interaction between the system and its biotic and abiotic surroundings).

#### **5.10.8 Approaches to Selected Area scale analyses**

Data for the Basin-scale will be reported following the requirements outlined in the LTIM Project Standard Protocol: Section 12 Metabolism (Hale et al. 2014) and conform to the LTIM Project Data Standard (Brooks & Wealands 2014).

At the Selected Area scale a number of hypotheses that relate to the outcomes of delivery of Commonwealth environmental water are possible.

In river channel habitats, quantitative analyses will be possible for microcrustacean density and community composition for time since watering, with multivariate analyses such as nMDS (and modules including Simper, BioEnv, DISP, PCA) will be used to explore patterns among dependant and covariate variables such as water column nutrient and carbon concentrations, metabolism and larval and adult fish.

In watercourse habitats, quantitative analyses will be possible for microcrustacean density and community composition for time since watering and vegetation community, with multivariate analyses such as nMDS (and modules including Simper, BioEnv, DISP, PCA) will be used to explore patterns among additional measured variables of water column nutrient and carbon concentrations and metabolism.

Watercourse Hydrology will quantify the area of each vegetation community inundated and the volume of inundation ( $m^3$ ) throughout the delivery cycle of Commonwealth environmental water. Linking microcrustacean density to this indicator will facilitate scaling of response from site based (microcrustacean density/ $m^2$ ) to the inundated vegetation asset scale within the Selected Area.

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### **5.11 Monitoring schedule – Macroinvertebrates**

The SOP for Macroinvertebrates is provided in Appendix B.9.

#### **5.10.9 Basin-Scale and Selected Area evaluation questions**

Short-term (one-year) and long-term (five year) question:

What did Commonwealth environmental water contribute to macroinvertebrate diversity?

#### **5.10.10 Where**

Macroinvertebrates will be sampled at the same locations as described in Section 5.11 for microcrustaceans.

#### **5.10.11 What**

The sampling of macroinvertebrate communities at sites within the river channels and watercourse areas of the Selected Area.

#### **5.10.12 When**

At each of the 3 Fish (River) sites, macroinvertebrate sampling will take place on 4 occasions from October through to April.

At each watercourse site, macroinvertebrate sampling will take place following watercourse inundation with Commonwealth environmental water, four sample events are planned to follow the inundation and contraction cycle, sampling immediately (days) after inundation, at peak area inundation, and at two times during the drying cycle.

#### **5.10.13 How**

As per the methodology prescribed in the Macroinvertebrate SOP (Appendix B.10).

#### **5.10.14 Linkages and indicator interactions**

This indicator links to Vegetation Diversity, Waterbird Breeding, Fish (River), Microcrustaceans, Hydrology (River) and Hydrology (Watercourse) indicators.

#### **5.10.15 Selected Area scale hypotheses**

5. The delivery of Commonwealth environmental water will increase the diversity of macroinvertebrate communities.
6. The delivery of Commonwealth environmental water will increase whole-of-system trophic dynamics (biological productivity, interaction among species, interaction between the system and its biotic and abiotic surroundings).

#### **5.10.16 Approaches to Selected Area scale analyses**

Data for the Basin-scale will be reported following the requirements outlined in the LTIM Project Standard Protocol: Section 11 Macroinvertebrates (Hale et al. 2014) and conform to the LTIM Project Data Standard (Brooks & Wealands 2014).

At the Selected Area scale a number of hypotheses that relate to the outcomes of delivery of Commonwealth environmental water are possible.

In river channel habitats, quantitative analyses will be possible for macroinvertebrate density and community composition for time since watering, with multivariate analyses such as nMDS (and modules including Simper, BioEnv, DISP, PCA) will be used to explore patterns among dependant and covariate variables such as water column nutrient and carbon concentrations, metabolism and larval and adult fish.

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In watercourse habitats, quantitative analyses will be possible for macroinvertebrate density and community composition for time since watering and vegetation community, with multivariate analyses such as nMDS (and modules including Simper, BioEnv, DISP, PCA) will be used to explore patterns among additional measured variables of water column nutrient and carbon concentrations and metabolism.

## 5.12 Monitoring schedule - Waterbird Breeding (optional)

The SOP for Waterbird Breeding is provided in Appendix B.10.

It is noted that monitoring of Waterbird Breeding is an optional monitoring activity and is event driven.

### 5.11.1 Basin-Scale and Selected Area evaluation questions

Short-term (one-year) and long-term (five year) questions:

- What did Commonwealth environmental water contribute to waterbird breeding?
- What did Commonwealth environmental water contribute to waterbird chick fledging?
- What did Commonwealth environmental water contribute to waterbird survival?

Long-term (five-year) question:

- What did Commonwealth environmental water contribute to waterbird populations?

### 5.11.2 Where

There are several well-known colonial bird rookeries within the Gingham-Gwydir Watercourse, these rookery areas will be the target of the survey effort (Figure 5-7).

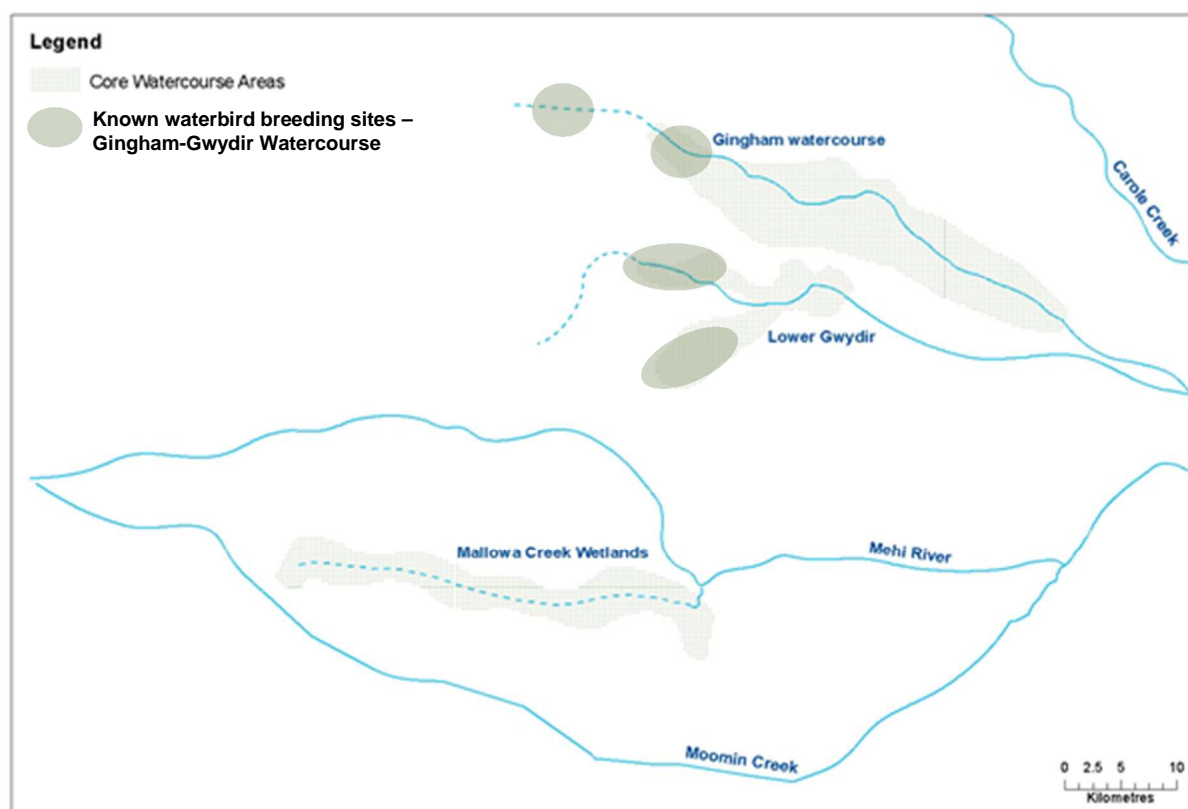


Figure 5-7: Watercourse areas

### 5.11.3 What

Surveys of colonial bird breeding events and fledgling success using standard methods (Hale et al. 2014).

### 5.11.4 When

Monitoring is event driven and will be discussed with CEWO prior being undertaken.

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### 5.11.5 How

The key rookery sites are well-known in the lower Gwydir Watercourse. We will rely on established communication networks with the key stakeholder communities (LTIM survey staff, landholders, birdwatchers and government department/agency staff) to identify bird breeding events or potential events linked to Commonwealth environmental water. Surveys will be initiated by confirmed commencement of bird breeding events.

At key rookery sites remote camera systems (a combination of online ready units and other camera systems) will be established to monitoring a bird breeding event as required. The camera units will be used to provide ongoing photographic monitoring of a minimum of 5 nesting sites in the selected location to assess breeding success.

On-ground surveys will be conducted monthly at a minimum during the event.

Hydrology will be determined via the Hydrology (Watercourse) indicator.

The monitoring design complies with the standard protocol using fixed cameras (Hale et al. 2014).

### 5.11.6 Linkages and indicator interactions

This indicator links to Microcrustacean, Vegetation Diversity and Hydrology (Watercourse) indicators.

### 5.11.7 Selected Area scale hypotheses

Short-term (Annual) responses:

1. The delivery of Commonwealth environmental water to key rookery sites in the lower Gwydir will lead to successful nest establishment by colonial waterbirds.
2. The delivery of Commonwealth environmental water to key rookery sites in the lower Gwydir will lead to the successful fledgling of colonial waterbirds.
3. The delivery of Commonwealth environmental water to key rookery sites in the lower Gwydir will lead to increased diversity and abundance of nesting adult colonial waterbirds (link to Waterbird Diversity Indicator).

Long-term (5 year) responses:

1. The delivery of Commonwealth environmental water to key rookery sites in the lower Gwydir will lead to repeated successful nest establishment by colonial waterbirds.
2. The delivery of Commonwealth environmental water to key rookery sites in the lower Gwydir will lead to the repeated successful fledgling of colonial waterbirds.
3. The delivery of Commonwealth environmental water to key rookery sites in the lower Gwydir will lead to increased Selected Area diversity and abundance of adult colonial waterbirds (link to Waterbird Diversity Indicator).

### 5.11.8 Approach to Selected Area scale analyses

Analyses based on Aggregation will be applied at the Basin and Selected Area scales for taxonomic diversity and richness, and nesting and fledgling success. Qualitative and quantitative analyses will be applied at the Selected Area scale to document nesting and fledgling success of colonial waterbirds. Multi-year analyses will be quantitatively assessed based on year-on-year repeat application of annual models outlined in the Selected Area conceptual model (Figure 5-8). The placement of water level recorders at each location to quantify hydrologic connection and inundation metrics will improve uncertainty in quantifying the delivery of Commonwealth water to rookery sites.

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Short-term (Annual) responses:

1. Hypotheses 1 and 2 - univariate analysis (main effect – rookery site, season), nesting and fledgling success.
2. Hypotheses 3 - (diversity-abundance) multivariate analysis (factors – rookery site /season).

Long-term (5 year) responses:

1. Hypotheses 4 and 5 - univariate analysis (main effects – rookery site /year/season), nesting and fledgling success.
2. Hypotheses 45 and 6 - (diversity-abundance) multivariate analysis (factors – rookery site /year/season).

#### **5.11.9 Selected Area scaling**

The standard method for Waterbird Breeding reports area (m<sup>2</sup>) ANAE typology inundated from Commonwealth environmental water. The indicator Watercourse (Hydrology) will document the area (m<sup>2</sup>) of inundation and vegetation/habitat mapping will facilitate the scaling of potential colonial waterbird breeding sites/success to the lower Gwydir.

### 5.13 Complimentary data

There are a number of complimentary data sets that will be required for the LTIM Project in the Gwydir Selected Area. These data are listed in the individual SOPs developed for each indicator and summarised in Table 5-3 below. It is assumed that where CEWO has access to these data, these data will be made available; other data will be accessed via a license agreement with the appropriate agency. These requirements are detailed further in the Communications Plan (Appendix D).

**Table 5-3: Complimentary data required for the LTIM Project in the Gwydir Selected Area**

Monitoring indicator	Data	Relevant stakeholder
Ecosystem type	Mapping output from Brooks et al. (2013) Regional sources with updated feature mapping and fine-scale resolution vegetation mapping and/or remote sensed data Recently acquired AS40 data Satellite imagery (e.g. SPOT6 – panchromatic resolution 1.5 m, multispectral resolution 8 m) NVIS41_MDB vegetation mapping (NVIS v4.1 updated with CMA mapping by Brooks et al. 2013)	CEWO Other agencies as necessary e.g. LLS, OEH
Fish (River)	SRA data and reporting Integrated Monitoring of Environmental Flows (IMEF) data and reporting	MDBA OEH
Fish (Movement)	Rivers Environmental Restoration Program	
Waterbird Breeding	IMEF	OEH
Waterbird Diversity	Rivers Environmental Restoration Program	
Vegetation Diversity	OEH Environmental Flow Monitoring Program Short-term Intervention Monitoring Project (STIM) data SRA data and reporting IMEF data and reporting Rivers Environmental Restoration Program	OEH CEWO MDBA
Microcrustaceans	IMEF data and reporting Rivers Environmental Restoration Program	OEH
Water Quality	Existing gauging stations and daily river reports IMEF data and reporting	MDBA NOW OEH
Hydrology (River)	Existing gauging stations	
Hydrology (Watercourse)	OEH inundation mapping Watercourse Lidar datasets	MDBA NOW OEH



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## 5.14 Evaluation and analytical approach

The CEWO LTIM Project seeks to quantify the outcomes of the management of Commonwealth environmental water and its contribution to achieving the requirements of the Basin Plan. Basin-scale evaluation is pivotal to the LTIM Project, and is to be informed by monitoring from the Gwydir Selected Area.

All Category 1 and 2 indicators have Standard Methods (Hale et al. 2014) and SOPs that define dependant variables, covariates and units for Basin-scale evaluation.

In addition, the study design allows analyses at the Selected Area scale for a number of Category 1 and 2 indicators. The Category 3 indicators in the Gwydir Selected Area of Hydrology (watercourse) and Microcrustaceans have detailed Selected Area evaluation and analytical approaches (see respective SOPs) with the potential for collaboration to develop a Basin-scale approach should a number of independent Selected Areas monitor these indicators using the Standard Methods.

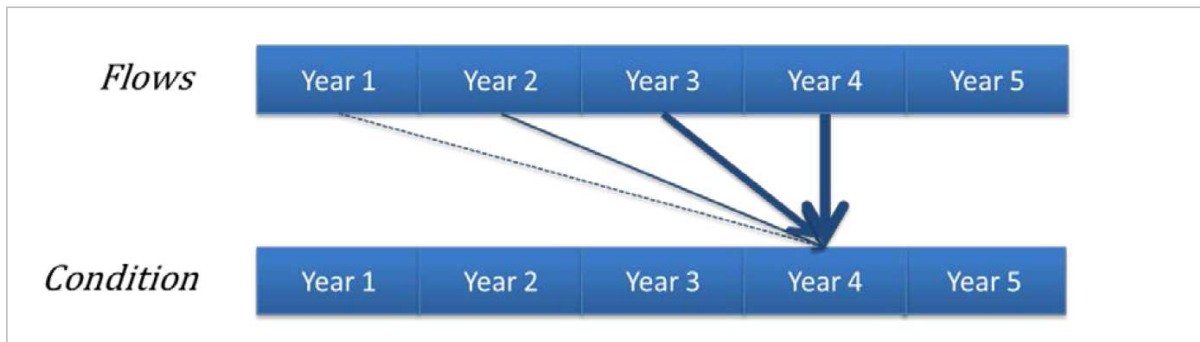
All data will be delivered to the CEWO and Basin to conform to the LTIM Project Data Standard (Brooks & Wealands 2014) and facilitate data management within the LTIM Project Monitoring Data Management System (MDMS).

There are limitations to the analytical approaches for evaluation purposes in response to the Standard Methods applied to Category 1 and 2 indicators in the Gwydir Selected Area. The Selected Area has 3 zones that are spatially independent and geomorphically discrete units, with the evaluation of responses to Commonwealth environmental water often limited to one zone. As such, this design does not generally permit comparisons of outcomes for those sites that receive Commonwealth environmental water compared with those that do not, for indicators of Fish (River) and Vegetation Diversity. This can make short-term (annual) evaluation of outcomes difficult for the Selected Area scale, and may increase the reliance on scientific opinion to assist in the evaluation of Commonwealth environmental water.

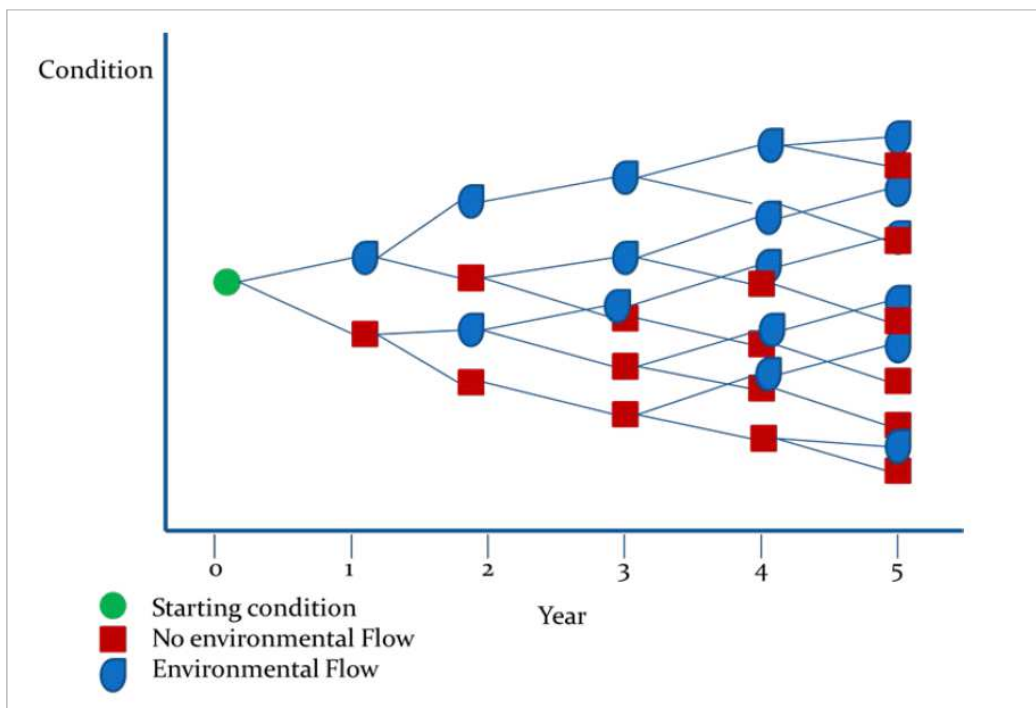
Where possible we will apply a number of broad approaches to short-term (Annual) and long-term (Multi-year) analyses to assess the response of individual or suites of indicators to the delivery of Commonwealth environmental water to ecological assets in the Gwydir Selected Area.

1. For selected indicators (e.g., Fish (River) and Vegetation Diversity) we will develop a 'reference condition' to facilitate predictions that zones receiving Commonwealth environmental water will have a trajectory towards the reference condition (Figure 5-8). For example, a reference condition for Fish River metrics (composition, total length, mass, expectedness, nativeness, and recruitment, and age of target taxa) will be developed in conjunction with DPI Fisheries (SRA) and from existing data (Short Term Intervention Monitoring, OEH monitoring) to set annual and long-term targets. Reference condition may need to be developed specific to antecedent condition, with a dry, average and wet extant reference condition used to determine trajectories of change (see Section 5.15). Evaluation of outcomes from Commonwealth environmental water will be determined by differences between the observed and expected outcomes.
2. Long-term (5 year) outcomes will require quantitative models (Figure 5-8) that define outcomes for each indicator/zone in response to the delivery of Commonwealth environmental water. The repeated application of this model over time seeks to quantify a convergence or divergence in indicator response relative to watering regime (receiving or not receiving Commonwealth environmental water). Statistical approaches for these indicators will be time series-based (space-time substitution), with predicted differences between sites that have received Commonwealth environmental water (and the number of times they have received Commonwealth environmental water) compared with those that do not receive Commonwealth

environmental water at the completion of each annual cycle used to evaluate outcomes. Condition assessment (y-axis on Figure 5-9) is determined from the reference condition approach outlined above).



**Figure 5-8: Hypothetical model of a long-term response to environmental watering based on a created 'reference condition' where the greatest influence is from watering in the most recent year with progressively weaker influence from watering in previous years (Source: Gawne et al. 2014)**



**Figure 5-9: A hypothetical model that will be applied on a year-to-year basis to generate a series of outcomes from different flow regimes over a five year period (Source: Gawne et al. 2014)**

### 5.13.1 Resilience

One of the aims of the LTIM Project is to understand the role of Commonwealth environmental water in promoting the resilience of the entire Gwydir Selected Area. Resilience is the amount of change a system can undergo (its capacity to absorb disturbance) and remain within the same regime that essentially retains the same function, structure and feedbacks (Walker & Salt 2006). A whole-of-system approach to resilience is required for the LTIM Project in the Gwydir Selected Area to link the extensive list of individual indicators within an ecosystem framework, targeted to hydrological and biological connectivity within and

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outside the Gwydir system, variability and heterogeneity in structural and functional elements of ecosystems and the cycling of materials and energy. This framework will be developed with stakeholders as a conceptual diagram of ecosystem components (individual indicators and their links), and their ecological thresholds that act as tipping points between ecosystem states. For example, the CED developed for the Microcrustacean indicator (see Figure 5-6) identifies relationships among hydrologic and watercourse vegetation refuges as key links in the resilience of the system. Building these conceptual models and identifying ecological thresholds through monitoring will form the basis for measuring resilience in the Selected Area.

This framework will outline the adaptive management options that can be taken to manage resilience in the Gwydir system. The Environmental Contingency Allowance Operations Advisory Committee (ECA OAC) for the Gwydir River provides advice to the Commonwealth Environmental Water Office and NSW Office of Environment and Heritage to inform watering decisions. Ryder is an existing member of this Committee and Frazier has requested ex officio membership. This direct contact through the Committee will allow ad hoc and planned changes to the short and long term watering options of the Gwydir system to be responsive to monitoring outcomes such as top-up watering to sustain waterbird breeding events. Membership of this committee also facilitates highly targeted and responsive monitoring to planned Commonwealth environmental watering to ensure all monitoring of events is undertaken.

#### **5.15 Indicator/zone interaction and timing**

The focus of the M&E Plan has been to target planned monitoring in the Gwydir River and distributary channels downstream of Tareelaro Weir (Table 5-4). Sample design has been aligned within each zone based on the expected outcomes of Commonwealth environmental watering options. However, as the delivery of Commonwealth environmental water may target any, all or none of these zones in a given year the M&E Plan has been designed to maximise potential Selected Area and basin-scale outcomes by allowing for the targeting of any individual zone for several indicators in response to the delivery of water.

The Watering Options for the Selected Area are generally for delivery in spring-summer and early autumn, following the broader pattern of pre-regulation watering cycles. Many of the prescribed sampling times for the Category 1 indicators are in summer-autumn. Given the nature of the timing of expected water delivery and Category 1 requirement the sampling effort is heavily weighted to summer-autumn sampling (Table 5-5).

The monitoring design (sites, zones, standard methods) has been developed in the knowledge that the delivery of Commonwealth environmental water may co-occur with other environmental (state) and consumptive water, as well as rainfall driven events and flooding. As such, the evaluation of outcomes from Commonwealth environmental water will need to be made relative to antecedent conditions of inundated zones and the proportion of water delivered that is Commonwealth environmental water. Membership of the ECA OAC will inform the Gwydir LTIM Project team of the planned and delivered proportion of Commonwealth environmental water in any release. Hydrologic gauges nominated for use in Hydrology River and proposed methods for Hydrology Watercourse will both facilitate detailed information on antecedent conditions prior to the delivery of environmental water. For example, a Commonwealth environmental water release to top-up a waterbird breeding event can be hydrologically quantified by discharge, area inundated and linked explicitly to breeding success.

**Table 5-4: Indicator-Zone interactions. SA represents Selected Area.**

Zone		Gwydir Upstream		Gwydir-Gingham				Mehi-Moomin	
Ecosystem Type		River	River	River	Water course	River	Water course	River	
CEW Delivery Option		3 (1,2,4,5,6)		1,6				4	
Reporting		Basin	SA	Basin		SA		Basin	SA
Indicator	Cat.								
Ecosystem Type	1								
Hydrology (River)	1								
Fish (River)	1 + 3								
Waterbird Breeding	1								
Vegetation Diversity	2								
Waterbird Diversity	2								
Water Quality	2								
Hydrology (Watercourse)	3								
Fish (Movement)	2								
Microcrustaceans	3								
Macroinvertebrates	3								

**Table 5-5: Annual field survey cycle**

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Comments
Indicator													
Ecosystem Type													Once only in year 2014
Hydrology (River)													Ongoing, updating regularly from NoW data
Fish (River) (C1)													March Annually
Fish (River) (C3)													In association with C1 sampling
Vegetation Diversity													Twice annually around water season
Waterbird Diversity													Event driven, typically January and April
Water Quality													Continuously, up to 6-weekly maintenance intervals
Hydrology (Watercourse)													Ongoing and following delivery events
Fish (Movement)													Only in year 2015 and 2016
Microcrustaceans													Event driven, likely from October to April annually
Macroinvertebrates													Event driven, likely from October to April annually
Waterbird Breeding (optional)													Event driven, likely summer to autumn

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## 6 Communication and Engagement

### 6.1 Stakeholder engagement

A stand-alone Project Communications Plan has been developed for the Gwydir Selected Area (Appendix D). This Communications Plan has been developed as a stand-alone document that specifies project communication requirements and stakeholder engagement for the duration of the LTIM Project, with the aim of facilitating effective and efficient communication. It describes the schedule of proposed communication and engagement activities, who is involved, who they will talk to, frequency of communications and roles and responsibilities.

It is highlighted that ELA/UNE via CEWO are currently developing a Memorandum of Understanding with OEH for cooperative resource and information sharing. Other necessary license agreements will be entered into with relevant agencies when monitoring indicators have been finalised.

### 6.2 CEWO reporting

There are two forms of reporting requirements by M&E Providers to CEWO for the LTIM Project in the Gwydir Selected Area:

- Project reporting (progress)
- Outcomes reporting.

In addition to formal reporting, ELA will maintain good relationships with the CEWO, M&E Advisors and delivery partners to support evaluation and adaptive management throughout the LTIM Project.

#### 6.2.1 Project progress reporting

Progress reporting requirements for Stage 2 are provided in Table 6-1, including regular forums and teleconferences.

#### 6.2.2 Outcomes reporting

The LTIM Project has a number of reporting and information transfer requirements. Table 6-2 summarises the outcomes reporting and information transfer activities for the LTIM Project, including frequency, timing and responsibility. Note this list covers only operational reporting and information transfer activities only: no external reporting or information transfer activities are specified. It also includes reporting requirements that are the responsibility of the M&E Advisors (being the Annual Basin Evaluation Report).

M&E Providers will also be required to provide other key outputs for monitoring activities in the Gwydir:

- Submit monitoring data in the correct format and according to defined protocols within 1 month of its collection (including the MDMS and the LTIM Project Data Standards (Brooks & Wealands 2014))
- Noting and reporting any incidental observations made during field visits that may contribute to or support Evaluation (Area or Basin) or Adaptive Management. Observations can also include those reported to the M&E Provider by stakeholders. This requirement is ongoing, following observations.

**Table 6-1: Progress reporting requirements for the LTIM Project**

Activity type	What	Frequency	Timing / due date	Responsibility	Description and high level requirements
Project Status Meetings	Phone conference	Monthly	From project inception to submission of final report (October 2019)	M&E Provider	Informal phone catch-up with CEWO Area leader to discuss status of the Gwydir LTIM Project
Information transfer	Monitoring data entry	Monthly	Monthly for the duration of the LTIM Project to the Monitoring Data Management System and Data Standard (Brooks & Wealands 2014)	M&E Providers	Processed monitoring data uploaded to the Monitoring Data Management System in accordance with data management protocols, as outlined in the M&E Plan
Reporting	Project progress reports: 2014-15 onwards	Quarterly	Sep, Dec, Mar and Jun (last business day of month) for the duration of the LTIM Project	M&E Providers	A written progress report, summarising tasks completed since the last report, tasks planned for the upcoming period, emerging issues etc. The CEWO progress report template will be used
Teleconference	Project Leaders Teleconference	Biannual	November and March, each year (3 hours each)	CEWO	Leaders of Project teams
Forum	Annual M&E forum	Annual	July, 2015 –2019 (2 days each)	CEWO	M&E Forum to be held each year (Sydney) Four attendees from each M&E Provider team are to attend to discuss monitoring efforts (issues and solutions), monitoring results and evaluation (Project Director/Manager and three technical leads)

**Table 6-2: Reporting requirements for the LTIM Project**

Activity type	What	Frequency	Timing / due date	Responsibility	Receiver	Description and high level requirements
Reporting	Monitoring and Evaluation Plan	One-off	Draft – Feb 28 2014 Final – 17 Apr 2014	M&E Providers	CEWO	A plan for monitoring and evaluation in each Selected Area over the five-year period from 2014-15 to 2018-19
Work plan	Annual monitoring work plan	Annually	August (2014-2019)	M&E Providers	CEWO	Annual monitoring work plan that outlines which elements will be implemented over the coming water year, based on information available at the time (including Area condition, water availability and water use options)
Annual evaluation plan	Annual evaluation plan	Annually	August (2015-2019)	M&E Providers	CEWO	The annual evaluation plan should outline what evaluation activities will be undertaken over the coming water year, based on anticipated environmental watering actions monitoring data availability
Reporting	Area evaluation report	Annually (October)	(Draft – Aug 30 Final – Oct 31) First report – 2015 Final report – 2019	M&E Providers	CEWO	A cumulative evaluation of the outcomes of Commonwealth environmental water at each Selected Area, prepared in accordance with the M&E Plan The report must be prepared in plain English with simple science and be suitable for publication on CEWO website
Reporting	Basin evaluation report	Annually	Draft – Aug 30 Final – Oct 31 First report – 2015 Final report – 2019	M&E Advisers	CEWO	A cumulative evaluation of the outcomes of Commonwealth environmental water at the Basin-scale, based on the Evaluation Plan The report must be prepared in plain English with simple science and be suitable for publication on CEWO website
Information transfer	Monitoring data entry	Monthly	Monthly for the duration of the LTIM Project	M&E Providers	MDMS	Processed monitoring data is uploaded to the MDMS in accordance with the data management protocols
Information transfer	Information exchange	Ongoing and as required	Ongoing and as required for the duration of the LTIM Project	M&E Providers	Delivery partners / Selected Area Working Group	Information exchange on project activities (monitoring, observations, evaluations) and other information that would support the delivery of environmental water



## 7 Project Management

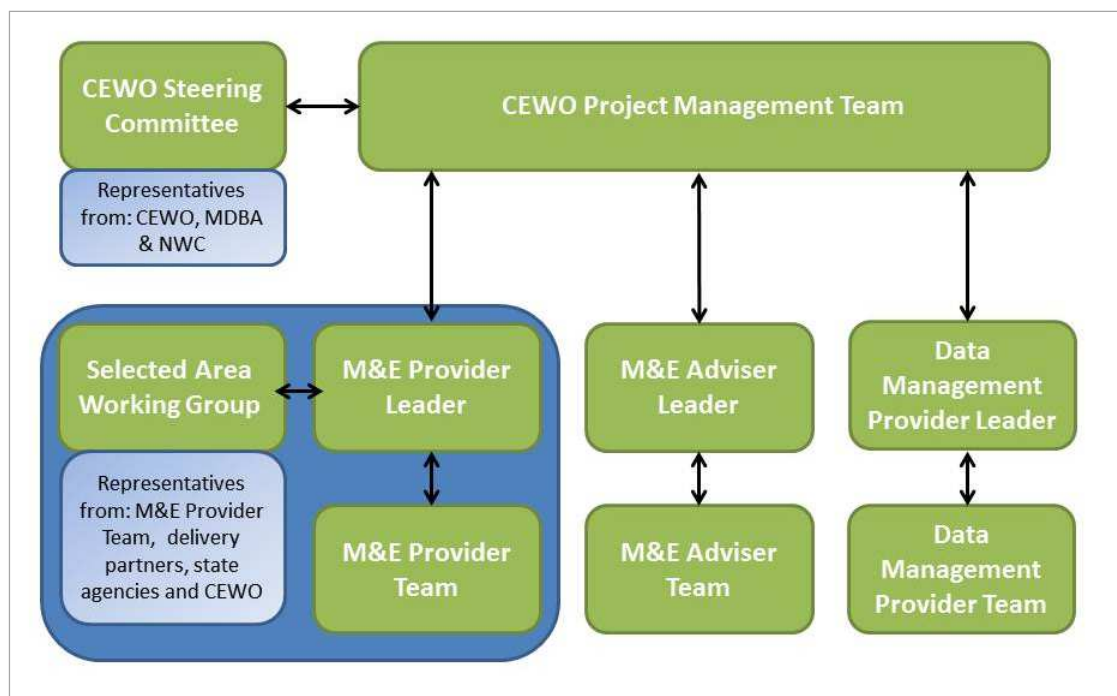
### 7.1 Project governance

The LTIM Project is the primary means for measuring the outcomes of Commonwealth environmental watering in the MDB; as such, a robust framework for ongoing project governance is important for the implementation of the LTIM Project. The LTIM Project governance structure is shown in Figure 7-1.

The primary line of governance between the CEWO, M&E Providers and M&E Advisor is the Project Manager from each lead agent for the Gwydir Selected Area (Table 7-1).

**Table 7-1: Primary governance structure – Gwydir Selected Area LTIM Project**

Project Lead	Agent	Role of Agent
Paul Frazier Darren Ryder	M&E Provider (ELA/UNE) Project Directors	Implement M&E Plan Work with CEWO and delivery partners to demonstrate outcomes and support adaptive management
Jenny Hale	M&E Adviser	Technical coordination and oversight Whole of Basin evaluations of outcomes Support implementation of M&E Plan
Adam Flanagan	CEWO Northern Basin Section	LTIM Project Area lead for the Gwydir



**Figure 7-1: Project governance structure for the LTIM Project (from CEWO n.d.)**

#### 7.1.1 M&E Provider – Project Team

A core project management team has been nominated to coordinate and facilitate delivery of Stage 2 of the CEWO LTIM Project in the Gwydir Selected Area.

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### *Project Directors*

Project Directors (Dr Paul Frazier and Associate Professor Darren Ryder) will provide strategic and technical input to the project, and are alternative points of contact for CEWO.

### *Project Manager*

Mark Southwell is the principal point of contact for the Project and will report to CEWO's LTIM Project manager for the Gwydir Selected Area (Sam Rosenby). The ELA project manager will ensure the M&E Plan meets the requirements of the contract and is responsible for meeting the project budget and work program. The project manager is also responsible for managing accounting, correspondence and meeting coordination.

### *Senior Practitioner Group & Technical Scientists*

The ELA/UNE Project Team will include a team of Senior Practitioners who are recognised experts in their field. This Senior Team will guide the operational monitoring project and undertake aspects of field survey, analysis and reporting. Each member of this team will be assigned a monitoring indicator directly related to their area of expertise.

This team will be supported by a combined ELA/UNE group of technical support scientists, with a range of skills in riverine and floodplain ecology and function. This group will undertake much of the on-ground survey, data handling and some reporting.

## **7.2 Risk assessment**

A risk assessment has been prepared for Gwydir Selected Area LTIM Project, based on this M&E Plan. The purpose of the risk assessment is to identify risks to the successful implementation of the LTIM Project and undertake effective mitigation planning. Three areas of risk were considered:

1. Risks to the success of LTIM Project and the ability to meet project objectives and outcomes (including risks that monitoring activities will not be able to be implemented)
2. Risks to the environment and aquatic ecosystem as a result of LTIM Project activities in the Gwydir Selected Area
3. Risks to the health and safety of personnel undertaking LTIM Project activities in the Gwydir Selected Area.

### **7.2.1 Risk assessment process**

This risk assessment method is compliant with the Australian/New Zealand AS/NZ 31000:2009: Environmental Risk Management – Principles and Process (Standards Australia 2009), and aligns with the principles of Australian Standard AS/NZS 4360:2004 Risk Management (Standards Australia 2004).

Risk is defined as the combination of the likelihood and consequence of an event or outcome, as demonstrated in (Table 7-2).

**Table 7-2: Risk assessment matrix**

LIKELIHOOD	CONSEQUENCE				
	Negligible	Minor	Moderate	Major	Critical
<b>Almost Certain</b>	L16	M10	H5	S2	S1
<b>Likely</b>	L17	M12	M11	H6	S3
<b>Possible</b>	L19	L18	M13	H7	S4
<b>Unlikely</b>	L22	L21	L20	M14	H8
<b>Rare</b>	L25	L24	L23	M15	H9

L= low, M=medium, H=High, S=Severe

The likelihood of a risk refers to the probability of a specific event or outcome actually occurring (Table 7-3); the consequence is the outcome of the action (Table 7-4).

**Table 7-3: Risk likelihood categories**

Likelihood	Description in terms of full operating life of the site
Almost Certain	Consequences expected to occur in most circumstances
Likely	Consequences will probably occur in most circumstances
Possible	Consequences may occur at some time
Unlikely	Consequences are not expected occur within the life of the project
Rare	Consequences may occur in exceptional circumstances

Three key areas of risk were considered. For each of these themes, possible risks were identified by considering project specific issues and the proposed monitoring activities. Potential hazards and their subsequent impact were considered (i.e. what could happen). Using the definitions provided above, the likelihood and consequence of the potential impacts were then applied to assign an inherent risk rating. Management and risk mitigation measures are then recommended, and the risk rating method re-applied.

**Table 7-4: Risk consequence categories**

Possible risks	Consequence				
	Negligible	Minor	Moderate	Major	Critical
Undertaking monitoring activities	Monitoring activities undertaken according to M&E Plan, with data from all planned samples available	Minor disruption to the monitoring program with a small number of planned samples (<10%) not collected or data not available	More than 10% of planned samples not collected / available, however sufficient data available for planned analyses	Data from more than 50% of planned samples not collected /available. Limited monitoring outcomes reported	No useable data collected, analyses not possible, no monitoring outcomes reported
Environment	Negligible environmental damage	Short term, localised, reversible damage to the environment	Short term, widespread damage to the environment reversible to intensive effort	Long-term damage to the environment and/or risk of continuing environmental damage	Long-term, widespread, irreversible damage
Health and safety	Incident requiring first aid treatment	Minor incident requiring treatment by a medical practitioner	Moderate incident requiring short term hospitalisation	Serious incident requiring extensive hospitalisation	A fatality, permanent disability , or multiple people affected by a serious incident
Stakeholders	Short-term, isolated complaints from stakeholders	Sustained but isolated complaints from stakeholders Relationship with stakeholder temporarily affected	Sustained complaints from stakeholders Relationship with stakeholder damaged	Short-term but significant complaints from stakeholders Relationship with stakeholder significantly damaged	Sustained and significant complaints from stakeholder Relationship with critical stakeholder irreversible damaged
Project objectives	Short delay in achievement of project objectives	Delay in achievement of project objectives	Element or project objective not met	Project objectives not met	Project objectives harmed (negative impact)

## 7.2.2 Risks to success of the project

Table 7-5 presents the key risks to success of the LTIM Project in the Gwydir Selected and suggests risk mitigation measures. To assist in the identification of risks to successful implementation of the Gwydir M&E Plan, including the ability to meet the project objectives and outcomes, the risk assessment undertaken in the 2013-14 Gwydir Annual Watering Plan (OEH 2013) together with operational considerations for the Gwydir river system (CEWO 2013c) were reviewed and incorporated.

**Table 7-5: Gwydir M&E Plan risk assessment: successful implementation of the LTIM Project**

Risk	Hazard	Impact	Risk Rating (Inherent)	Risk Mitigation Measures	Risk Rating (Managed)
Unpredictable weather - prolonged natural low flow conditions	Inundation period of system is impacted	Unable to effectively monitor and evaluate LTIM Project objectives	H7	<ul style="list-style-type: none"> <li>Design includes non-event based monitoring to inform the ecological response model and act as pre-flooding data</li> <li>Annual monitoring plan will consider the long range forecast when developing watering options</li> <li>If necessary, review asset condition and future priorities for watering</li> </ul>	L18
Unpredictable weather – extreme flooding following watering event	Inability to collect monitoring data as access limited	Unable to effectively monitor and evaluate LTIM Project objectives Potential risk to crops during pre-harvest period	H7	<ul style="list-style-type: none"> <li>Assess CEWO water availability for additional watering opportunities – opportunity for sustained wetland inundation</li> <li>Survey site design considering flood related accessibility</li> <li>Survey site subset accessible in all conditions to provide a core dataset – design redundancy</li> <li>All condition remote monitoring devices used where possible</li> <li>Local field teams able to respond rapidly to changes in field conditions</li> </ul>	L21
Other extreme weather events, i.e. flooding out of season, bushfires	Extreme weather events not considered in watering options	Negative impact on ecological assets	M14	<ul style="list-style-type: none"> <li>Design includes non-event based monitoring to inform the ecological response model and act as pre-flooding data</li> <li>Annual monitoring plan will consider the long range forecast when developing watering options</li> </ul>	L21
Flooding of commercial crops	Damage to commercial crops	May result in long-term landholder obstruction	H8	<ul style="list-style-type: none"> <li>Risk to be assessed in the annual monitoring plan using the Framework for Determining Commonwealth Environmental Water Use</li> <li>Implement approved communication strategy</li> <li>Manage water deliveries in response to risk and climatic conditions</li> </ul>	L21
Low availability of CEWO environmental water allocations or OEH supplementary flows	Inability to provide environmental watering events outlined in the annual monitoring plan	Short term delay in achieving LTIM Project objectives, mostly in the lower Gwydir system	H7	<ul style="list-style-type: none"> <li>Design includes non-event based monitoring to inform the ecological response model and act as pre-flooding data</li> <li>Annual monitoring plan will confirm availability of CEWO or OEH Environmental Water allocations when developing watering options</li> </ul>	L21

Risk	Hazard	Impact	Risk Rating (Inherent)	Risk Mitigation Measures	Risk Rating (Managed)
Estimated flow target volumes are substantially incorrect	Inundation of system does not occur	Short term delay in achieving LTIM Project objectives	L20	<ul style="list-style-type: none"> <li>Monitor flow delivery daily and seek adjustments</li> <li>Revise flow targets, if necessary</li> </ul>	L20
Landholder obstruction	Inability to collect monitoring data	Unable to effectively monitor and evaluate LTIM Project objectives	H7	<ul style="list-style-type: none"> <li>Adopt the Code of Practice and the Communications Plan</li> <li>Field teams to acknowledge importance of landholder / stakeholder engagement; field teams provided with time during surveys for active engagement with landholders</li> <li>Clear landholder communication plan developed as part of the operational program</li> <li>Understanding of critical times and pressures for all land managers – survey timing and location design in consideration of landholder constraints</li> <li>On-going engagement with landholders from field teams and lead scientific teams</li> <li>Diversified site locations to spread sites across multiple landholder sites – design redundancy</li> <li>Use of publically owned land for a core subset of sites</li> <li>Potential landholder engagement for routine project aspects</li> </ul>	L20
Landholder violence towards field staff	Field Staff being threatened or injured while undertaking field work	Injury to field staff Unable to effectively monitor and evaluate LTIM Project objectives	H9	<ul style="list-style-type: none"> <li>Clear landholder communication plan developed as part of the operational program</li> <li>Understanding of critical times and pressures for all land managers – survey timing and location design in consideration of landholder constraints</li> <li>On-going engagement with landholders from field teams and lead scientific teams</li> <li>Use of publically owned land for a core subset of sites</li> <li>Field staff to exit private land ASAP should they feel threatened by landholder</li> </ul>	L24
State Agency – poor engagement	Possible inefficiencies in collecting monitoring data Poor public image to landholders and the Gwydir community	Unable to effectively monitor and evaluate LTIM Project objectives	M14	<ul style="list-style-type: none"> <li>Communication and data sharing agreement with state agencies</li> <li>On-going high level engagement to share results, methods refinement and scientific approach</li> <li>Gwydir Selected Area Working Group established and relationships maintained</li> </ul>	L24

Risk	Hazard	Impact	Risk Rating (Inherent)	Risk Mitigation Measures	Risk Rating (Managed)
Short-term responsiveness to watering events	Inability to collect monitoring data after a flow event	Unable to evaluate LTIM Project objectives	H7	<ul style="list-style-type: none"> <li>Location of the consortium within three hours of the lower Gwydir system maximises responsiveness to environmental watering</li> </ul>	L20
Equipment operational failure (e.g. weir infrastructure)	Either unexpected flow event at an inappropriate time or impediment to flows	Negative impact on environmental outcomes	H7	<ul style="list-style-type: none"> <li>Diversified site locations to spread sites across multiple sites – design redundancy</li> <li>Potential landholder engagement for quick responses to infrastructure maintenance issues</li> <li>Engagement with infrastructure owners to facilitate quick infrastructure repairs</li> <li>Build in design flexibility to allow changes in monitoring effort so sites and indicators can be exchanged depending on the location and type of flow event</li> </ul>	L20
Unexpected ecological response from environmental watering (e.g. algal blooms, incomplete bird breeding event)	Poor water quality impacts ecological assets i.e. native fish (including threatened species)	Negative impact on ecological outcomes from environmental watering	M13	<ul style="list-style-type: none"> <li>Location of the consortium within three hours of the lower Gwydir system maximises responsiveness to environmental watering</li> <li>Prompt communication and data sharing with the Commonwealth and state agencies</li> <li>ELA/UNE consortium expertise in biology and ecology of indicators to provide sound advice</li> </ul>	L20
Larger germination and spread of weeds (e.g. Lippia and Hyacinth)	Increased spread of Weeds of National Significance	Negative impact on vegetation communities and asset condition	H6	<ul style="list-style-type: none"> <li>Prompt communication with the Commonwealth, state agencies and relevant landholders</li> <li>Develop a targeted response plan for Hyacinth, adhering to Integrated Water Hyacinth Control protocols</li> <li>Discuss voluntary de-stocking to encourage native plant competition in Lippia areas</li> </ul>	L18

Reference: OEH 2013; CEWO 2013c

### 7.2.3 Risks to the environment

On-ground activities have the potential to negatively impact the environment of the Gwydir Selection Area if not managed appropriately. In particular, the following ecological values were considered during the risk assessment (as identified in Gawne et al. 2013b):

- Gwydir River and floodplain are included in the Lowland Darling River Endangered Ecological community, listed under the *Fisheries Management Act 2004* (NSW). This areas also supports several threatened species listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act):
  - Silver perch (*Bidyanus bidyanus*) listed as Critically Endangered under the EBPC Act

- Murray Cod (*Maccullochella peelii*) listed as Vulnerable under the EBPC Act
- 2. The Lower Gwydir and Gingham Watercourses support the largest stand of the threatened marsh club-rush (*Bolboschoenus fluviatilis*) which is listed as Critically Endangered Ecological Community (CEEC) under the NSW *Threatened Species Act 1995* (TSC Act)
- 3. Lower Gwydir wetlands can support a number of threatened fauna species, listed as migratory under the EPBC Act:
  - Eastern Great Egret (*Ardea alba*)
  - Glossy Ibis (*Plegadis falcinellus*)
- 4. The Gwydir Wetlands include nationally and internationally important wetlands
  - Gingham and Lower Gwydir (Big Leather) watercourses are a listed Ramsar site.
- 5. The Mehi River is important for the following native fish:
  - Carp Gudgeon (*Hypseleotris klunzingeri*)
  - Spangled Perch (*Leiopotherapon unicolor*)
  - Bony Bream (*Nematalosa erebi*)
  - Murray Cod (*Maccullochella peelii*) – listed as Vulnerable under the EBPC Act
  - Catfish (*Tandanus tandanus*)
  - Golden perch (*Macquaria ambigua*).

Table 7-6 presents the identified risks to the environment (including ecological values) associated with undertaking monitoring activities in the Gwydir Selected Area and the recommended risk mitigation measures.

**Table 7-6: Gwydir M&E Plan risk assessment: risks to the environment as a result of the LTIM Project**

Risk	Hazard	Impact	Risk Rating (Inherent)	Risk Mitigation Measures	Risk Rating (Managed)
Driving in long, dry grass	Starting bushfires	Loss of or damage to biodiversity and property	H6	<ul style="list-style-type: none"> <li>Safe Work Methods Statement to be completed prior to trip and onsite Toolbox Talks prior to commencing work</li> <li>Contacting relevant landowners prior to fieldwork to identify areas and develop alternative route</li> <li>Arranging long grass to be cut if alternative route cannot be arranged</li> </ul>	M14
Working in threatened ecosystems	Implementing structures in protected areas i.e. National Parks	Loss of or damage to biodiversity and property	M10	<ul style="list-style-type: none"> <li>Identifying areas which will require bathymetric surveys i.e. depth loggers, artificial substrates for stream metabolism</li> <li>REF is required for any structure (including depth loggers) within National Parks estates</li> </ul>	L17



Risk	Hazard	Impact	Risk Rating (Inherent)	Risk Mitigation Measures	Risk Rating (Managed)
	Impacting threatened species and/or habitat in Ramsar wetlands	Loss of or damage to biodiversity and property	H6	<ul style="list-style-type: none"> <li>Standard Operating Procedures for Monitoring Indicators – Vegetation Diversity Fish Larvae</li> <li>Observe quarantine notices (verbal or written) to prevent the spread of animal diseases (e.g. Anthrax, Bovine Johne's Disease, Ovine Johne's Disease, and Equine Influenza)</li> <li>Assess risk of spread of disease. If required provide for protocol of brush down and wash off boots and vehicle</li> <li>Map quad bike routes, or utilise existing quad bike routes, to minimise impact to the environment</li> </ul>	L18
	Field equipment use across the Gwydir Selected Area (e.g. traps used at multiple locations)	Spread of viruses, bacteria (Anthrax), algal spores	H6	<ul style="list-style-type: none"> <li>Standard Operating Procedures for all Monitoring Indicators</li> <li>Drying out nets before use in different area</li> <li>Assess risk of spread of disease through a JSEA</li> <li>If required, provide for protocol of brush down and wash off boots and vehicle</li> <li>All staff to avoid contact with material that could be potentially contaminated with Anthrax</li> <li>In areas known to be habitat for threatened species of frogs, hygiene practices are used to avoid the introduction and/or spread of Amphibian Chytrid Fungus</li> </ul>	M13
Monitoring threatened flora	Impacting threatened species and/or habitat i.e. vegetation assessments in Coolibah-Blackbox Woodlands, Marsh Club-rush areas	Loss of or damage to biodiversity	M13	<ul style="list-style-type: none"> <li>Standard Operating Procedure for Monitoring Indicator – Vegetation Diversity</li> <li>Minimise trampling and avoid areas that do not need surveying. Follow requirements of land owner/ manager, incl. government bodies</li> <li>A scientific licence is required to pick, hold or study native flora</li> <li>Where possible identify flora species in the field. If a sample is required, take only that needed for identification. Take photos where a sample would affect survival of the individual</li> <li>If a new location is discovered for a threatened species, note its position and take care not to unnecessarily disturb its root system or habitat</li> <li>Clean mud and weed propagules off shoes, clothing and vehicle/quad bike tyres prior to leaving an area where possible (particularly where noxious weeds were identified)</li> <li>Works should be programmed to consider seeding periods and weed locations i.e. lippa</li> <li>Field staff to sign off on Environmental Site Inspection for prior to undertaken monitoring activities</li> </ul>	L18

Risk	Hazard	Impact	Risk Rating (Inherent)	Risk Mitigation Measures	Risk Rating (Managed)
Monitoring threatened aquatic fauna	Impacting threatened species or damaging habitat i.e. trapping and electrofishing Silver Perch, Murray Cod	Loss of or damage to biodiversity	H7	<ul style="list-style-type: none"> <li>Standard Operating Procedure for Monitoring Indicators – Fish (River)</li> <li>Ensuring that fish surveys follows the Survey guidelines for Australia's threatened fish. EPBC Act survey guidelines 6.4</li> <li>Use minimum impact survey techniques as per survey procedure and required by animal ethics permit</li> <li>Map quad bike routes, or utilise existing quad bike routes, to minimise impact on the environment</li> <li>Field staff to sign off on Environmental Site Inspection for prior to undertaken monitoring activities</li> </ul>	M14
Monitoring threatened terrestrial fauna	Impacting breeding habitat (waterbirds)	Loss of or damage to biodiversity and property	H6	<ul style="list-style-type: none"> <li>Standard Operating Procedures for Monitoring Indicator – Waterbird Diversity</li> <li>Minimise trampling and avoid areas that do not need surveys</li> <li>Use minimum impact survey techniques as per survey procedure and required by animal ethics permit</li> <li>Field staff to sign off on Environmental Site Inspection for prior to undertaken monitoring activities</li> </ul>	L18

## 7.2.4 Risks to individuals

Table 7-7 presents the potential risks to the health and safety of personnel undertaking monitoring activities within the Gwydir Selected Area and suggested mitigation measures to management them. The development of mitigation measures are in line with ELA's Environment, Safety and Quality framework and the Department's Fieldwork and Safety Guidelines (DSEWPac 2011). Mitigation measures and procedures are described further in the Health, Environment and Safety Plan (Appendix F).

**Table 7-7: Gwydir M&E Plan risk assessment: risks to individuals and teams undertaking monitoring activities**

Risk	Hazard	Impact	Risk Rating (Inherent)	Risk Mitigation Measures	Risk Rating (Managed)
Adverse weather conditions	Prolonged rain/flooding	Drowning	H7	<ul style="list-style-type: none"> <li>Safe Work Methods Statement to be completed prior to trip and onsite Toolbox Talks prior to commencing work i.e. checking WaterInfo website</li> <li>Undertaking JSEA if river conditions rapidly change.</li> <li>Not entering areas of fast flowing water</li> </ul>	M14
	Extreme heat/cold	Sunburn or skin burn, hyperthermia or hypothermia	H6	<ul style="list-style-type: none"> <li>Safe Work Methods Statement to be completed prior to trip and onsite Toolbox Talks prior to commencing work</li> <li>Appropriate PPE</li> <li>Suitable scheduling &amp; rostering of monitoring activities</li> </ul>	M14

Risk	Hazard	Impact	Risk Rating (Inherent)	Risk Mitigation Measures	Risk Rating (Managed)
Adverse weather activity	Storms-lightning strikes	Burns & shock (potentially fatal)	H9	<ul style="list-style-type: none"> <li>Do not enter site until 1 hour after the storm passes</li> <li>If on-site vacate the area and/or seek shelter immediately</li> </ul>	L23
	High winds	Struck from falling objects and vehicle control	M14	<ul style="list-style-type: none"> <li>Undertaking JSEA before driving if conditions rapidly change</li> <li>Take cover during periods of high winds away from overhead trees/branches</li> <li>Reduce speed if driving in high winds</li> </ul>	L23
Vehicle & driving hazards	Car accident on way to site/onsite	Death, permanent impairment, lost time injury	H8	<ul style="list-style-type: none"> <li>Safe Work Methods Statement to be completed prior to trip and onsite Toolbox Talks prior to driving</li> <li>Site induction in high risk sectors</li> <li>All staff will have current first aid qualifications</li> <li>All vehicles to carry Emergency First Aid Box (includes consumables and bottled water) and sat phone/spot tracker</li> </ul>	M15
	Vehicle breakdown/bogged	Isolation, thermal stress, dehydration, hunger	H7	<ul style="list-style-type: none"> <li>Undertaking JSEA before attempting vehicle recovery</li> <li>4WD training for field staff</li> <li>Safe Work Methods Statement to be completed prior to trip and onsite Toolbox Talks prior to driving</li> <li>All staff will have current first aid qualifications.</li> <li>All vehicles to carry Emergency First Aid Box (includes consumables and bottled water) and sat phone/spot tracker</li> <li>Field staff to sign off on Remote Location Vehicle check list</li> </ul>	M13
	Long distance driving	Wide ranging physical injuries, potentially fatal & vehicle damage	H7	<ul style="list-style-type: none"> <li>Undertaking JSEA Safe Work Methods Statement to be completed prior to trip and onsite Toolbox Talks prior to driving</li> <li>Two person field teams to ensure that there is a break and swap of drivers every 2 hours</li> <li>All staff will have current first aid qualifications.</li> <li>All vehicles to carry Emergency First Aid Box (includes consumables and bottled water) and sat phone/spot tracker</li> </ul>	M13
	Encountering wildlife	Car accident (with either wildlife, or other vehicles)	H7	<ul style="list-style-type: none"> <li>Avoid driving between dusk and dawn where possible. If you must drive during this time keep an eye on the sides of the road and reduce speed to allow brake time if necessary</li> <li>Safe Work Methods Statement to be completed prior to trip</li> <li>All staff will have current first aid qualifications.</li> <li>All vehicles to carry Emergency First Aid Box (includes consumables and bottled water) and sat phone/spot tracker</li> </ul>	M14
Quad-biking	Riding over uneven terrain/marshland	Bike rollover, wide ranging physical injuries, potentially fatal & bike damage	H7	<ul style="list-style-type: none"> <li>Safe Work Methods Statement to be completed prior to trip and onsite Toolbox Talks prior to commencing work</li> <li>Quad bike training for all field staff</li> <li>All staff to wear helmets</li> </ul>	M14

Risk	Hazard	Impact	Risk Rating (Inherent)	Risk Mitigation Measures	Risk Rating (Managed)
	Riding in flooded terrain	Bogging of bike, isolation, thermal stress, dehydration, hunger & bike damage	H7	<ul style="list-style-type: none"> <li>Only one rider per bike</li> <li>All staff will have current first aid qualifications</li> <li>Undertaking JSEA before attempting bike recovery</li> </ul>	M14
Terrain hazards	Bushfires	Burns, smoke inhalation & potentially fatal	H7	<ul style="list-style-type: none"> <li>Safe Work Methods Statement to be completed prior to trip and onsite Toolbox Talks prior to commencing work</li> <li>Field teams to carry Bushfire safety plan</li> <li>Regular updates from BOM website and advice from RFS</li> </ul>	M15
Flora & fauna	Plant & insect allergens	Allergic reactions (skin/eye), Hay Fever, respiratory reactions, anaphylactic shock which can be potentially fatal	H7	<ul style="list-style-type: none"> <li>Ensure staff know who their colleagues are with severe allergic reactions, implement allergy management response plan</li> <li>Be aware of nearest hospital for treatment and have communications available.</li> <li>Don't expose staff with known allergies to projects where these risks are unaccepted [table to their personal health issues</li> <li>Standard Operating Procedures - Wildlife survey procedures</li> <li>Safe Work Methods Statement to be completed prior to trip and onsite Toolbox Talks prior to commencing work</li> <li>First aid kit to be carried at all times and equipped with a snake bandage</li> <li>All staff will have current first aid qualifications.</li> <li>Two persons in the field</li> </ul>	M14
	Venomous fauna	Poisoning, potentially fatal	H7	<ul style="list-style-type: none"> <li>Safe Work Methods Statement to be completed prior to trip and onsite Toolbox Talks prior to commencing work</li> <li>First aid kit to be carried at all times and equipped with a snake bandage</li> <li>All staff will have current first aid qualifications.</li> <li>Two persons in the field</li> </ul>	M14
	Fauna related diseases, including exposure to ticks, mosquitoes, leeches and Anthrax	Bites, Infection & Illness	H7	<ul style="list-style-type: none"> <li>Safe Work Methods Statement to be completed prior to trip and onsite Toolbox Talks prior to commencing work</li> <li>PPE and applying permethrin to field clothing</li> <li>Performing daily tick checks and removing ticks as soon as they are detected</li> <li>First aid kit to be carried at all times and equipped with a snake bandages</li> <li>All staff will have current first aid qualifications</li> <li>All staff to avoid contact with material that could be potentially contaminated with Anthrax</li> </ul>	M14
Remote site hazards	Remote area surveys	Slow response time from external	H7	<ul style="list-style-type: none"> <li>Safe Work Methods Statement to be completed prior to trip and onsite Toolbox Talks prior to commencing work</li> </ul>	M14

Risk	Hazard	Impact	Risk Rating (Inherent)	Risk Mitigation Measures	Risk Rating (Managed)
		source/services to an injury or incident		<ul style="list-style-type: none"> <li>Emergency response procedures developed for remote area surveys</li> <li>Vehicles to be equipped with sat phone/spot tracker, bottled water</li> <li>Field staff to sign off on Remote Location Vehicle check list</li> <li>First aid kit to be carried at all times and equipped with a snake bandage</li> <li>All staff will have current first aid qualifications</li> </ul>	
	Working with others in remote areas	Sexual harassment, bullying, inappropriate behaviour	M15	<ul style="list-style-type: none"> <li>Safe Work Methods Statement to be completed prior to trip and onsite Toolbox Talks prior to commencing work</li> <li>Two person field team</li> <li>Prior discussion with landowners, if required.</li> </ul>	L23
General field work	Field equipment use (e.g. Traps)	Muscle and back strain, joint injury, Lacerations and other injuries from equipment	H6	<ul style="list-style-type: none"> <li>Safe Work Methods Statement to be completed prior to trip and onsite Toolbox Talks prior to commencing work</li> <li>PPE</li> <li>Manual Handling training</li> <li>Complete JSEA if activity is not specified in the Standard Operating Procedures for the relevant Monitoring indicator</li> <li>First aid kit to be carried at all times and equipped</li> <li>All staff will have current first aid qualifications.</li> </ul>	M13
	Long hours/night work	Musculoskeletal injuries, slips, trips, falls	H6	<ul style="list-style-type: none"> <li>Safe Work Methods Statement to be completed prior to trip and onsite Toolbox Talks prior to commencing work</li> <li>Adhere to PPE checklist</li> <li>Wear sturdy shoes, check visibility/take a torch if required</li> <li>First aid kit to be carried at all times and equipped</li> <li>All staff will have current first aid qualifications.</li> </ul>	M13
Aquatic surveys	Boat usage	Hypothermia, become wet during cold conditions, drowning, damage & injuries.	H7	<ul style="list-style-type: none"> <li>Field staff to have boat licence</li> <li>All field staff to wear inflatable vest when operating boat</li> <li>Boat to be equipped with all safety items listed under NSW legislation (Flare/beacon, light, oars, first aid kit)</li> <li>Safe Work Methods Statement to be completed prior to trip and onsite Toolbox Talks prior to commencing work</li> <li>Two person project team, only one person in deep water at any time</li> <li>All staff will have current first aid qualifications.</li> </ul>	M14
	In-stream/wetland/bank surveys	Slip / trip leading to injury, being swept downstream, collision	H7	<ul style="list-style-type: none"> <li>Safe Work Methods Statement to be completed prior to trip and onsite Toolbox Talks prior to commencing work</li> </ul>	M14

Risk	Hazard	Impact	Risk Rating (Inherent)	Risk Mitigation Measures	Risk Rating (Managed)
		with in-stream debris, stuck in mud, drowning.		<ul style="list-style-type: none"> <li>Wear appropriate shoes if working prolonged periods in inundated wetlands</li> <li>Two person project team, only one person in deep water at any time.</li> <li>First aid kit to be carried at all times and equipped</li> <li>All staff will have current first aid qualifications.</li> </ul>	
Hazardous substances	Diesel or Ethanol use and handling	Inhalation, ingestion, contact with skin	Medium	<ul style="list-style-type: none"> <li>Safe Work Methods Statement to be completed prior to trip and onsite Toolbox Talks prior to commencing work</li> <li>MSDS to be carried at all times</li> <li>First aid kit to be carried at all times and equipped</li> <li>Adhere to PPE checklist</li> </ul>	L24
Ergonomic	Manual handling (lifting, bending, reaching, carrying)	Musculoskeletal injuries and back strain, joint injury	H7	<ul style="list-style-type: none"> <li>Safe Work Methods Statement to be completed prior to trip and onsite Toolbox Talks prior to commencing work</li> <li>Job rotation</li> <li>Manual handling training and refresher undertaken</li> </ul>	M15

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### **7.3 Quality Assurance plan**

A stand-alone Quality Assurance Plan (Appendix E) has been developed for the Gwydir Selected Area. This Quality Assurance Plan documents quality control and quality assurance procedures for LTIM activities in the Gwydir Selected Area.

### **7.4 Health, Safety and Environment plan**

A stand-alone Health, Safety and Environment Plan (HSE) Plan (Appendix F) has been developed for the Gwydir Selected Area. This HSE Plan describes the procedures and requirements for minimise the risk of injury to persons and harm to the environment as a consequence of the LTIM Project.

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Ryder D.S., Watts R.J., Nye E., & Burns A. 2006. Can flow velocity regulate epixylic biofilm structure in a regulated floodplain river? *Marine and Freshwater Research*. 57(1); 29-36.

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## Appendix A    Gwydir Selected Area Boundary (Shapefile provided digitally)

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## Appendix B    Standard Operating Procedures

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## B.1 SOP - Ecosystem Type

### 1.1 Objectives

This is a monitoring protocol to validate the interim Australian National Aquatic Ecosystems (ANAE) classification.

### 1.2 Indicators

The monitoring Ecosystem Type will help to validate the interim ANAE mapping.

The interim ANAE framework has been applied to aquatic ecosystems across the Murray Darling Basin using the best available mapping and attribute data (Brooks et al. 2013). The scale and coverage of available mapping and attribute data varied considerably across the Murray Darling Basin and has not yet been validated. There is a need to validate the mapping outputs from Brooks et al. (2013) as they relate to specific sampling sites and the Gwydir Selected Area. The current mapping may be useful within the LTIM project but will not be relied upon until validated.

### 1.3 Locations for monitoring

Validation must be carried out for each ecosystem type that falls within an assessment unit for all other on-ground monitoring indicators completed in the Gwydir Selected Area:

- Fish (River)
- Hydrology (River)
- Vegetation Diversity
- Waterbird Diversity
- Water Quality
- Hydrology (Watercourse)
- Microcrustaceans
- Waterbird Breeding (optional)

Where a site has not been mapped, the typology developed by Brooks et al. (2013) will be used to assign an ecosystem type (see methods below).

### 1.4 Timing and frequency

This validation mapping occurs in Year 1 as a one-off event. Desktop mapping must occur prior to field work. Verification or assignation of a classification will occur after field work.

### 1.5 Responsibilities

The Project Manager of the Gwydir M&E Project Team is responsible for overseeing this procedure. Desktop mapping and updating of any ecosystem type will be undertaken by a GIS Officer. Ground-truthing and validation will be undertaken by an Ecologist.

### 1.6 Complementary monitoring and data

There are a number of complimentary dataset that will be used to aid in identifying aquatic ecosystem types prior to the field validation:

- 
- Mapping output from Brooks et al. (2013)
  - Any regional sources with updated feature mapping
  - Fine-scale resolution vegetation mapping and/or remote sensed data
  - Recently acquired ADS40 data
  - Satellite imagery (e.g. SPOT6 – panchromatic resolution 1.5 m, multispectral resolution 8 m)
  - NVIS41\_MDB vegetation mapping (NVIS v4.1 updated with CMA mapping by Brooks et al. 2013).

It is assumed that where the Commonwealth Environment Water Office has access to these data and that these data will be made available for the purpose of Ecosystem Type assignment in the Gwydir Selected Area. Other data will be accessed via a license agreement with the appropriate agency e.g. the North-West LLS or OEH.

## 1.7 Terminology

For the purposes of the LTIM Project, aquatic ecosystems have been described as rivers, floodplains and wetlands. This is a simplification of four ecosystem classes into three common terms. For the validation protocol the terminology defined by the interim ANAE classification (Aquatic Ecosystem Task Group 2012) is to be applied. The ecosystem classes relevant to the LTIM project are as follows:

- Lacustrine systems (lakes) are open-water dominated systems, characterised by deep, standing or slow-moving water with little or no emergent vegetation (<30% cover) (note this ecosystem class is included as wetlands in LTIM Project Logic and Rational Document, Gawne et al. 2013)
- Palustrine systems are primarily shallow, vegetated, non-channel environments, including billabongs, bogs, swamps, springs, soaks etc. (Included as wetlands in Logic and Rational document)
- Riverine systems are those that are contained within a channel and its associated streamside vegetation. This definition refers to both single channel and multi-channel systems e.g. braided channel networks. The beds of channels are not typically dominated by emergent vegetation, may be naturally or artificially created, periodically or continuously contain moving water, and may form a connecting link between two bodies of standing water (Aquatic Ecosystem Task Group 2012).

## 1.8 Detailed methods

Interim ANAE classification shall be undertaken as per the standard methods described in the LTIM Standard Methods (Section 2 Ecosystem Type, Hale et al. 2014). Field sheets are also provided.

The typology used to assign ecosystem types is described in the LTIM Standard Methods (Hale et al. 2014). A unique number (SYSID) for each polygon (wetland, lake, floodplain) or line (river, creek, stream) will identify each mapped unit (Brooks et al. 2013). On ground validation of the interim ANAE classification is required to confirm the aquatic ecosystem types for use in the LTIM program. Where a site has not been mapped the typology developed by Brooks et al. (2013) should be used to assign an ecosystem type (see below).

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## 1.9 Data analysis

The spatial unit for which data is reported for this validation is an ANAE feature identified by the ANAE SYSID.

No data analysis is required for this indicator. All data provided for this indicator will be reported following the requirements outlined in the LTIM Project Standard Protocol: Section 2 Ecosystem Type (Hale et al. 2014) and must conform to the data structure defined in the LTIM Data Standard (Brooks & Wealands 2014). The data standard provides a means of collating consistent data that can be managed within the LTIM Monitoring Data Management System (MDMS).

## 1.10 Reporting

Each site ANAE classification will be recorded and provided to the CEWO.

## 1.11 Quality assurance/quality control

Quality control and quality assurance protocols are documented in the Quality Plan developed for the M&E Plan (CEWO 2014).

## 1.12 References

Aquatic Ecosystem Task Group. 2012. Aquatic Ecosystems Toolkit: Module 2, Interim Australian National Aquatic Ecosystem Classification Framework. Australian Government Department of Sustainability, Environment, Water, Population and Communities, Canberra.

Brooks S., Cottingham P., Butcher R., & Hale J. 2013. *Murray-Darling Basin aquatic ecosystem classification: Stage 2 report*. Peter Cottingham & Associates report to the Commonwealth Environmental Water Office and Murray-Darling Basin Authority, Canberra.

Brooks S. & Wealands S.R. 2014. *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project: Data Standard*. Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre. MDFRC Publication 29.3/2013 Revised Jan 2014.

Commonwealth Environmental Water Office (CEWO). 2014. *Long Term Intervention Monitoring Project Gwydir River System Selected Area*. Commonwealth of Australia.

Gawne B., Brooks S. Butcher R., Cottingham P., Everingham P., Hale J., Nielson D., Stewardson M. & Stoffels R. 2013a. *Long Term Intervention Monitoring Project: Logic and Rationale Document*. V1.0. MDFRC Publication 01/2013.

Hale J., Stoffels R., Butcher R., Shackleton M., Brooks S. & Gawne B. 2014. *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project – Standard Methods*. Final Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre, MDFRC Publication 29.2/2014, January, 182 pp.



**Table 1: Gauges within zones, Gwydir Selected Area**

Zone	NOW Gauge no.	Name	Latitude	Longitude	Datum
Gingham-Gwydir	418053	Gwydir River at Brageen	-29.3973	149.5465	GDA94
	418063	Gwydir (south arm) DS Tyreel regulator	-29.4379	149.7783	GDA94
	418066	Gwydir @ Millewa	-29.3627	149.3736	GDA94
	418074	Gingham @ Teralba	-29.3995	149.6991	GDA94
	418076	Gingham @ Tillaloo Bridge	-29.2714	149.4526	GDA94
	418077	Gingham @ Gingham Water Hole	-29.2433	149.3062	GDA94
	418078	Gwydir @ Allambie Bridge	-29.3449	149.4307	GDA94
	418079	Gingham @ Gingham Bridge	-29.2233	149.2685	GDA94
	418083	Gingham @ Wetland Rookery	-29.2438	149.3319	GDA94
	418090	Gwydir @ Old Dromana Regulator	-29.3625	149.2018	GDA94
Gwydir	418001	Pallamallawa	-29.477	150.1351	GDA94
	418012	Pinegrove	-29.895	150.6306	GDA94
	418013	Gravesend	-29.5819	150.3666	GDA94
	418026	D/S Copeton Dam	-29.9119	150.9067	GDA94
Mehi-Moomin	418002	Mehi @ Moree	-29.4651	149.8511	GDA94
	418037	Mehi D/S Combadello Weir	-29.5569	149.6582	GDA94
	418044	Mehi River D/S Tareelaro	-29.4532	150.0336	GDA94
	418048	Moomin @ Combadello	-29.5625	149.6543	GDA94
	418058	Mehi @ Bronte	-29.4773	148.9023	GDA94
	418060	Moomin @ Glendello	-29.6942	149.4785	GDA94
	418061	Moomin @ Alma Bridge	-29.6891	149.1565	GDA94
	418067	Moomin @ Clarendon Bridge	-29.7301	149.3047	GDA94
	418068	Mehi @ Ballin Boora Ck	-29.4607	149.1044	GDA94
	418070	Moomin @ Moomin Plains	-29.6352	148.9592	GDA94
	418085	Mehi D/S Gundare Regulator #2	-29.5888	149.315	GDA94
	418087	Mehi @ Chinook	-29.4752	149.977	GDA94

#### 1.4 Timing and frequency

On-going for the duration of the LTIM Project.

#### 1.5 Responsibilities

The Project Manager of the Gwydir M&E Project Team is responsible for overseeing this procedure.

#### 1.6 Complementary monitoring and data

NA



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## 1.7 Detailed methods

No new gauging stations are to be established. Data will be downloaded from the NSW Office of Water hydrological data site (<http://realtime.data.water.nsw.gov.au/water.stm>) or directly from the Office of Water.

## 1.8 Data analysis and reporting

A suitable hydrological modelling package will be used to calculate the following river water regime parameters:

- Daily mean river 'stage' water height (mASL)
- Daily mean river discharge (ML/day)
- Travel time (days).

All data provided for this indicator will conform to the data structure defined in the LTIM Data Standard (Brooks & Wealands 2014).

For the Selected Area analysis, hydrology (River) data will be used to assess the level of Hydrological Connectivity throughout the Selected Area. This will be done by defining relationships between upstream and downstream gauges in each monitoring zone to assess the movement of Commonwealth environmental water flows between these gauges. For flows delivered as specific flow hydrographs (i.e. in-channel fish pulses) the actual flow hydrographs will be compared with the planned flow hydrographs to assess the accuracy of the flow delivery.

## 1.9 Quality assurance/quality control

Quality control and quality assurance protocols are documented in the Quality Plan developed for the M&E Plan (CEWO 2014).

## 1.10 References

Brooks S. & Wealands S.R. 2014. *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project: Data Standard*. Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre. MDFRC Publication 29.3/2013 Revised Jan 2014.

Commonwealth Environmental Water Office (CEWO). 2014. *Long Term Intervention Monitoring Project Gwydir River System Selected Area*. Commonwealth of Australia.

Hale J., Stoffels R., Butcher R., Shackleton M., Brooks S. & Gawne B. 2014. *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project – Standard Methods*. Final Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre, MDFRC Publication 29.2/2014, January, 182 pp.

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## B.3 SOP – Fish (River)

### 1.1 Objectives

To assess the contribution of Commonwealth environmental water to fish survival, resilience and diversity at Basin and Selected Area scales.

### 1.2 Indicators

This Fish (River) indicator links with Fish (Movement), Microcrustaceans and Hydrology (River) indicators.

For Category 1 sampling, Otoliths will be collected annually from two opportunistic species within the Category 1 Fish (River) reach. Otoliths will also be collected in year one and year five from two equilibrium and two periodic species. Equilibrium and periodic species will be collected within the same zone, but at different locations to the Category 1 Fish (River) selected area so as not to bias the fish community results.

Category 3 sampling will be undertaken in each of the other three Gwydir western reaches, using Sustainable Rivers Audit (SRA) protocols (Davies et al. 2010). All fish will be identified, counted, measured and weighed (maximum of 50 individuals per species per electrofishing shot).

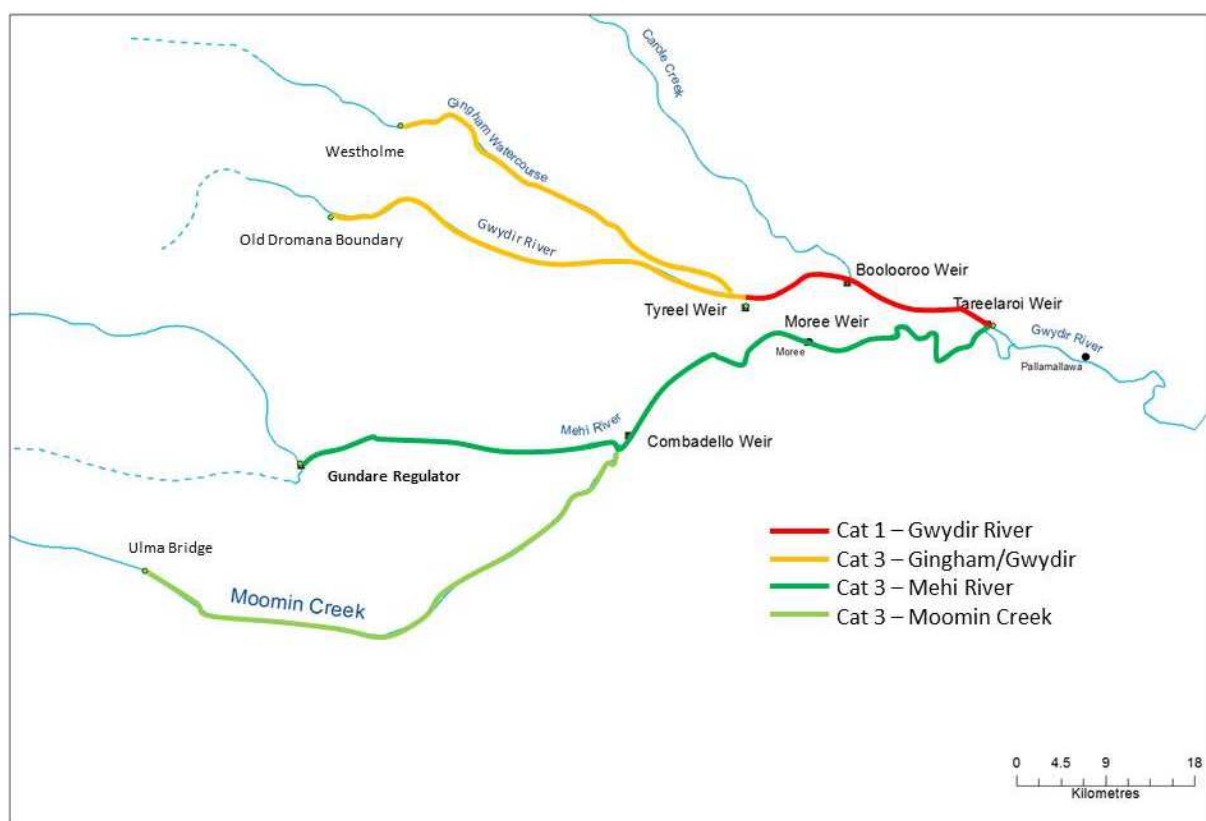
Dependent variables include:

- Relative abundance estimation
- Population structure data for target species
- Additional data is required for target species – total length or fork length , mass (gm)
- Length-age data

### 1.3 Locations for monitoring

In each year Category 1 Fish (River) monitoring will take place in the Gwydir River between Tareelaro weir and Tyreel weir (**Figure 2**), following the standard methods (Hale et al. 2014). The overall design for the Fish (River) indicator has been structured to meet both the Category 1 requirements and provide Selected Area specific information. The extents of each fish sampling reach and how they relate to the broader monitoring zones within the Gwydir River Selected Area is shown in **Table 2**. The environmental watering options for the Gwydir system west of Tareelaro weir are likely to target different zones for different environmental outcomes over a number of years. However, the reach of the Gwydir River between Tareelaro weir and Tyreel weir selected for Category 1 Fish (River) sampling will be the most likely reach to receive environmental water each year. Category 3 sampling undertaken in the other three western river reaches will help to inform the Selected Area analysis (**Figure 2**).

The selection of sites within each of the western Gwydir river reaches will be done following a ‘random’ site selection process which involves breaking each reach up into smaller 1km reaches, and then randomly selecting reaches for sampling. Reaches that are selected first are then visited in the field and assessed as to the suitability of that reach for sampling. If a reach is deemed unsuitable for sampling (no water, restricted access), then the next randomly selected reach is visited. This process continues until the required number of sites is chosen. 10 reaches will be sampled for Category 1 Fish (River), and 5 sites in each reach for the Category 3 sampling. This method has been discussed with, and accepted by the M&E Advisors.



**Figure 2. Location of Fish sampling reaches within the Gwydir River Selected Area**

**Table 2. Fish sampling reach locations within zones and spatial extents**

Target Reach	Category sampling	Zone	Target Reach Extent	Longitude	Latitude
Gwydir River	1	Gingham-Gwydir	Tareelaro to Tyreel	-29.4478 -29.4361	150.037 149.7785
Gingham-Gwydir (west)	3	Gingham-Gwydir	Tyreel to Westholme and Old Dromana	-29.4361 -29.2781 -29.3634	149.7785 149.4144 149.343
Mehi River	3	Mehi-Moomin	Tareelaro to Gundare	-29.4478 -29.5891	150.037 149.6606
Moomin Creek	3	Mehi-Moomin	Combadello to Ulma Bridge	-29.5569 -29.6894	149.6606 149.1566

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## 1.4 Timing and frequency

Fish (River) monitoring will be undertaken in March each year for the Category 1 reach; monitoring in other zones will occur in March-April.

## 1.5 Responsibilities

Fisheries NSW will be sub-contracted by Eco Logical Australia to undertake Fish (River) monitoring.

## 1.6 Detailed methods

Category 1 Fish (River) sampling will be undertaken following the LTIM Standard Methods (Section 5 Fish (River), Hale et al. 2014). Each site will consist of an 800m stretch of channel, be fixed throughout the LTIM Program, and will not be within 1km of a significant tributary or river infrastructure (e.g. weir). At each site, large bodied fish will be sampled using either boat or backpack electrofishing (depending on the depth and accessibility of the site). A total of 2880 seconds of 'on-time' will be undertaken in each reach. Small bodied fish will be sampled using 10 fine-mesh fyke nets set randomly within the site. Detailed methodology is outlined in Hale et al. (2014).

Within the Gwydir River Selected Area, the following species have been targeted for analysis:

- Equilibrium life-history guild – Murray cod
- Periodic life-history guild – golden perch and bony bream
- Opportunistic life-history guild – carp gudgeon and Australian smelt.

For these target species, individuals will be identified, counted, and a random sample of up to 20 individuals will have their total or fork length (mm), and weight (grams) measured. All other species will be identified and counted.

For category 3 reaches sampling will be undertaken using Sustainable Rivers Audit (SRA) protocols (Davies et al. 2010). Fish will be sampled at five sites within each reach, using a combination of boat electrofishing (12 x 90 second shots) and un-baited bait traps (n = 10). All fish will be identified, counted, measured and weighed (maximum of 50 individuals per species per electrofishing shot). Using a subset of the data collected in the Category 1 zone (10 sites) there will be 10 replicate sites within the selected Category 1 reach and 5 sites from each of the remaining 3 reaches.

## 1.7 Data analysis

Please refer to the LTIM Standard Methods (Section 5 Fish (River), Hale et al. 2014) for prescribed data analysis.

### 1.8.1 The Selected Area scale hypotheses

Short-term (Annual) responses:

- Mean Total length, Fork length and Mass for each of the 2 target taxa in each of the 3 life history guilds will be greater in the zone(s) receiving Commonwealth environmental water compared with zones not receiving Commonwealth environmental water
- SRA metrics "Expectedness", "Nativeness", and "Recruitment" of native fish communities will be greater in the zone(s) receiving Commonwealth environmental water compared with zones not receiving Commonwealth environmental water
- Age of fish (target taxa in each life history guild) will have a greater range (measure of resilience) in the zone(s) receiving annual Commonwealth environmental watering events compared with zones not receiving Commonwealth environmental water.

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#### Long-term (5 year) responses

- Mean Total length, Fork length and Mass for each of the 2 target taxa in each of the 3 life history guilds will be greatest year-on-year in zones receiving Commonwealth environmental water compared with zones not receiving Commonwealth environmental water
- SRA metrics “Expectedness”, “Nativeness”, and “Recruitment” of native fish communities will be greatest year-on-year in zones receiving Commonwealth environmental water
- Age of fish (target taxa in each life history guild) will have a greater range year-on-year (measure of resilience) in the zone(s) receiving annual Commonwealth environmental watering events.

#### 1.8.2 The Selected Area scale analyses

Analyses based on Aggregation will be applied at the Basin and Selected Area scales for taxonomic diversity and richness. Additionally, the fish community data will be summarised using the three main SRA Indicators:

- “Expectedness” - a comparison of the existing catch composition with that of historical fish distributions)
- “Nativeness” - the proportion of native versus alien fishes), and
- “Recruitment” - the recent reproductive activity of the native fish community).

Quantitative analyses will then be applied at the Selected Area scale using a counterfactual approach based on an historical ‘reference’ condition represented by a pre-European fish assemblage (developed by Fisheries NSW). Multi-year analyses will be quantitatively analysed based on year-on-year repeat application of annual models outlined in the Selected Area conceptual model (**Figure 3**), and a time-lagged trajectory to a pre-defined condition (Figure 5-8: ). Uncertainty propagation within and among years will be possible to quantify based on annual comparisons of sites receiving Commonwealth environmental water compared with those sites not watered.

#### Short-term (Annual) responses:

- Hypotheses 1, 2 and 3 – Univariate analysis (e.g. ANOVA - main effect – zone) for all taxa, each target taxa, each life history guild, taxa reference richness/diversity
- Hypotheses 2 - (diversity-abundance) multivariate analysis (e.g. Permanova, MDS, PCA - factors – zone, target taxa, life history guilds, native/exotic, taxa reference composition).

#### Long-term (5 year) responses:

- Hypotheses 4, 5 and 6 – Univariate analysis (main effects – zone, years) for all taxa, each target taxa, each life history guild, taxa reference richness/diversity.
- Hypotheses 5 - (diversity-abundance) multivariate analysis (factors – zone/years, target taxa, life history guilds, native/exotic, taxa reference composition).

Two zones in the lower Gwydir will have representative reaches sampled annually, with one priority zone sampled following the delivery of Commonwealth environmental water. Replicate sites in all zones are within defined study reaches of known length, facilitating outcomes for entire systems to be determined from data scaled from representative reaches (e.g., abundance of native fish/river km scaled to entire channel system of the same ANAE typology).

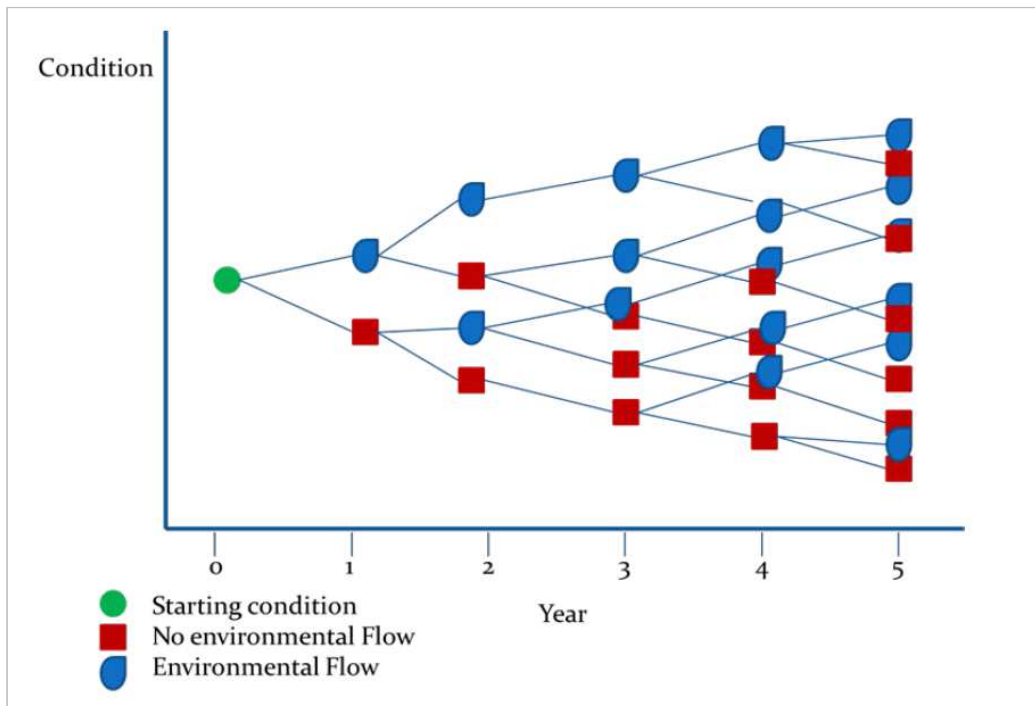


Figure 3: A hypothetical model that will be applied on a year-to-year basis to generate a series of outcomes from different flow regimes over a five year period (Source: Gawne et al. 2014)

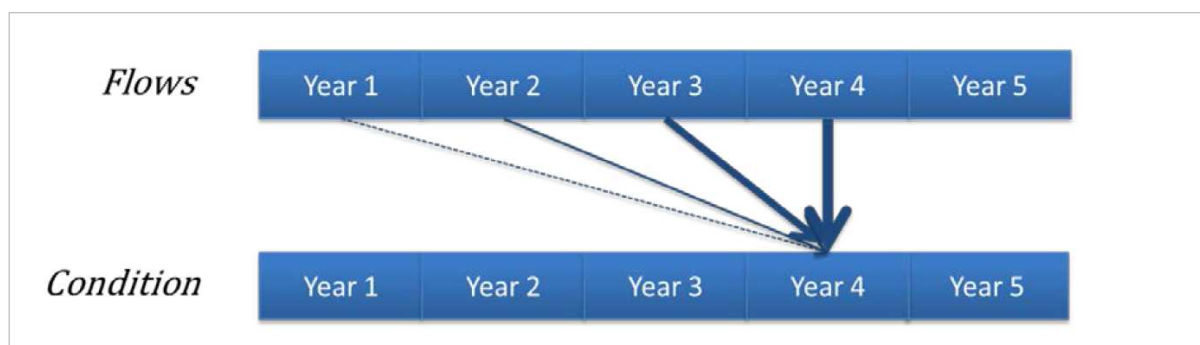


Figure 4: Hypothetical model of a long-term response to environmental watering based on a created 'reference condition' where the greatest influence is from watering in the most recent year with progressively weaker influence from watering in previous years (Source: Gawne et al. 2014).

## 1.8 Reporting

Data for the Basin-scale will be reported following the requirements outlined in the LTIM Data Standard (Hale et al. 2014) and conform to the LTIM Data Standard (Brooks & Wealands 2014).

## 1.9 Quality assurance/quality control

Quality control and quality assurance protocols are documented in the Quality Plan developed for the M&E Plan (CEWO 2014).

QA/QC activities specific to this protocol include:

- Electrofishers must be experienced operators of units. They should be supervised by Senior Operators on-site, and have obtained their electrofishing certificates through a reputable course.
- Monitoring and Evaluation Providers must have relevant boat licenses.
- It is the responsibility of the Monitoring and Evaluation Providers to have specific fisheries and ethics permits with them while sampling.
- Monitoring and Evaluation Providers must also have experience with appropriate PIT implantation procedures.
- Fyke nets should be checked for holes in either wing- or cod-ends prior to every field trip. Any net with a hole should be repaired or replaced.

#### 1.10 Field team

NSW fisheries will provide the field team for this indicator. All staff will be appropriately qualified, licenced and experienced for all aspects of the sampling.

#### 1.11 References

Brooks S. & Wealands S.R. 2014. *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project: Data Standard*. Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre. MDFRC Publication 29.3/2013 Revised Jan 2014.

Commonwealth Environmental Water Office (CEWO). 2014. *Long Term Intervention Monitoring Project Gwydir River System Selected Area*. Commonwealth of Australia.

Davies, P. E., Harris, J. H., Hillman, T. J., & Walker, K. F. (2010). The sustainable rivers audit: assessing river ecosystem health in the Murray–Darling Basin, Australia. *Marine and Freshwater Research*, 61(7), 764-777.

Gawne B., Hale J., Butcher R. Roots J., Brooks S., Cottingham P., Stewardson M. & Everingham P. 2014. *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project: Evaluation Plan*. Final Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre, MDFRC Publication 29/2014.

Hale J., Stoffels R., Butcher R., Shackleton M., Brooks S. & Gawne B. 2014. *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project – Standard Methods*. Final Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre, MDFRC Publication 29.2/2014, January, 182 pp.

## B.4 SOP – Vegetation Diversity

### 1.1 Objectives

This monitoring protocol aims to assess the contribution of Commonwealth environmental water to wetland vegetation diversity, condition and extent.

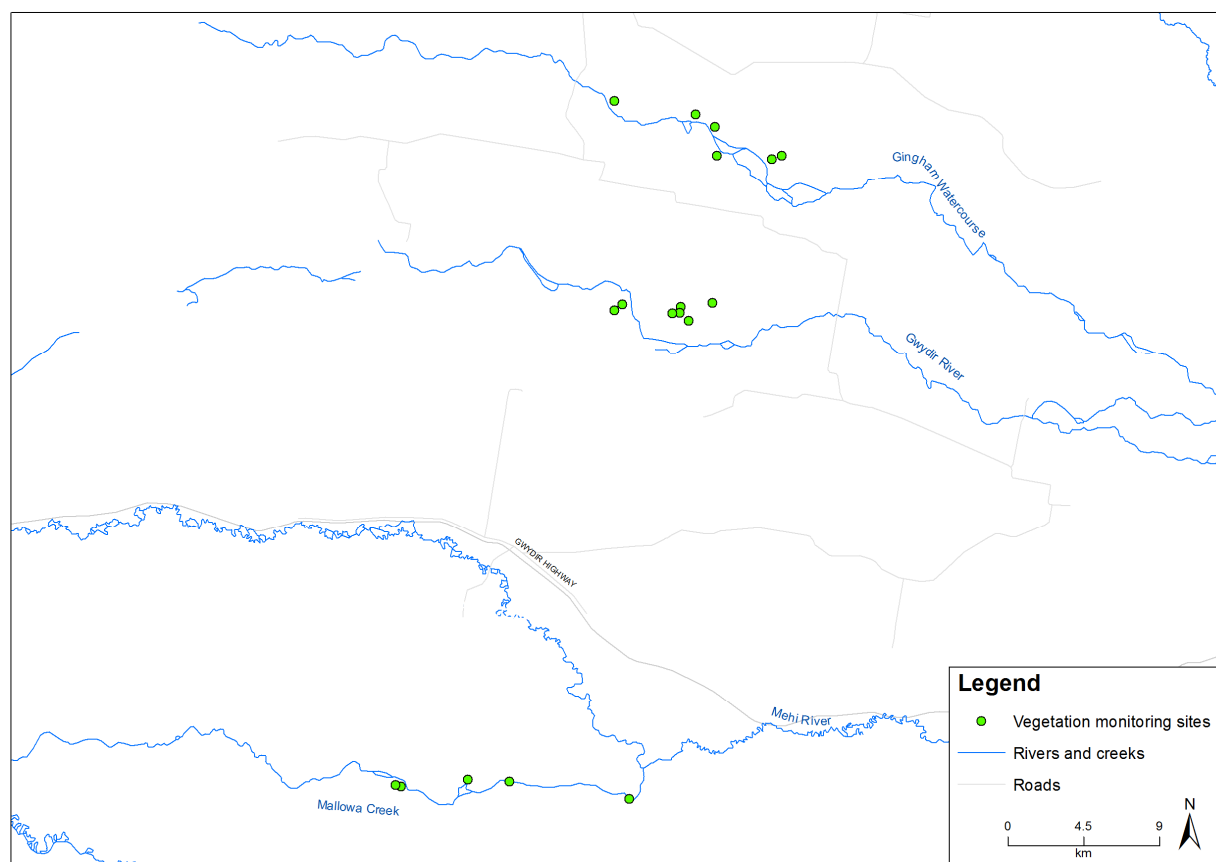
### 1.2 Indicators

This Vegetation diversity indicator links to Ecosystem Type, Microcrustacean, and Hydrology (Watercourse) indicators.

This program links to ongoing vegetation monitoring being undertaken by the NSW Office of Environment and Heritage (OEH) and will provide for collaborative data sharing.

### 1.3 Locations for monitoring

Sites will be located in target wetland communities within the Gingham-Gwydir Watercourse zone (**Figure 5, Table 3**). These sites are linked to an ongoing monitoring program conducted by OEH to monitor the response of vegetation diversity to water. The LTIM Project team will undertake cooperative data collection and sharing with OEH. In these sites Commonwealth environmental water will spill onto the watercourse areas.



**Figure 5 Vegetation Diversity – monitoring sites**



**Table 3 Vegetation Diversity – monitoring site locations**

Site Name	Target vegetation community	Coordinates (zone 55 GDA 94)		Zone	Note
		Easting	Northing		
Bunnor 1	Watercouch marsh grassland	728826	6760771	Gingham Watercourse	NPWS Reserve
Westholme Couch	Watercouch marsh grassland	733507	6759227	Gingham Watercourse	NPWS Reserve
Westholme Coolibah	Coolibah Woodlands	732675	6760769	Gingham Watercourse	NPWS Reserve
Mungwonga 1	Watercouch Marsh grassland	722759	6764005	Gingham Watercourse	NPWS Reserve
Lynworth 1	River Cooba Lignum	727574	6763219	Gingham Watercourse	
Lynworth 3	Watercouch marsh grassland	728716	6762487	Gingham Watercourse	
Old Boyanga	Water couch marsh grassland	716406	6766968	Gingham Watercourse	
Old Dromana Ramsar 1	Eleocharis tall sedgelands	727184	6750992	Lower Gwydir	NPWS Reserve
Old Dromana Ramsar 2	Coolabah Woodland wet understorey	726747	6751789	Lower Gwydir	NPWS Reserve
Old Dromana Ramsar 3	Watercouch Marsh grassland	726641	6751456	Lower Gwydir	NPWS Reserve
Old Dromana Bolboschenus 1	Marsh Club-rush tall sedgeland	723216	6751952	Lower Gwydir	NPWS Reserve
Old Dromana Nursery 1	Coolabah Woodland wet understorey	726223	6751405	Lower Gwydir	NPWS Reserve
Old Dromana Nursery 2	Coolabah Woodland	724473	6751888	Lower Gwydir	NPWS Reserve
Old Dromana Elders 1-1	Water couch marsh grassland	723395	6751952	Lower Gwydir	NPWS Reserve
Bungunya_1	River cooba - lignum	6723793	709823	Mallowa	
Coombah_1	River cooba - lignum	6722614	723849	Mallowa	
Valletta_1	River cooba - lignum	6723629	716519	Mallowa	
Valletta_2	River cooba - lignum	6725026	716262	Mallowa	

#### 1.4 Timing and frequency

Vegetation diversity monitoring shall be undertaken twice annually; before and after the watering season (August-October and March-June). The exact timing of sampling will be largely dependent on the target vegetation communities and expected lag time for response to watering.

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## **1.5 Responsibilities**

The Project Manager of the Gwydir M&E Project Team is responsible for overseeing this procedure. Field surveys will be led by an experienced field botanists.

## **1.6 Complementary monitoring and data**

The selected sites for vegetation diversity monitoring are part of an ongoing monitoring program conducted by OEH to monitor the response of vegetation diversity to water. The Gwydir LTIM Project will undertake cooperative data collection and sharing with OEH.

## **1.7 Detailed methods**

Survey methods will comply with the OEH data collection protocols for floodplain wetland vegetation monitoring in the Gwydir watercourse (Bowen 2013) (Appendix 1, 2). The methodology aligns with the Standard Methods as a Category 2 indicator (Hale et al. 2014).

Surveys will target 14 established monitoring sites that incorporate Water Couch communities, River Cooba-Lignum, Marsh Club-rush sedgelands, and Coolibah woodland. Depending on the community structure a combination of transects and quadrats will be surveyed. Floristics will be undertaken at each site twice annually before and after watering. Measures of Tree condition will be recorded during the post watering sampling trip only. All sites have been established to directly target zones where environmental watering is likely to be delivered. Links to inundation will be developed through the Hydrology (Watercourse) indicator.

## **1.8 Data analysis**

Data analysis methods are provided in Bowen (2013). Refer also to the LTIM Standard Methods (Section 4 Vegetation Diversity, Hale et al. 2014).

The Selected Area scale hypotheses for this indicator are:

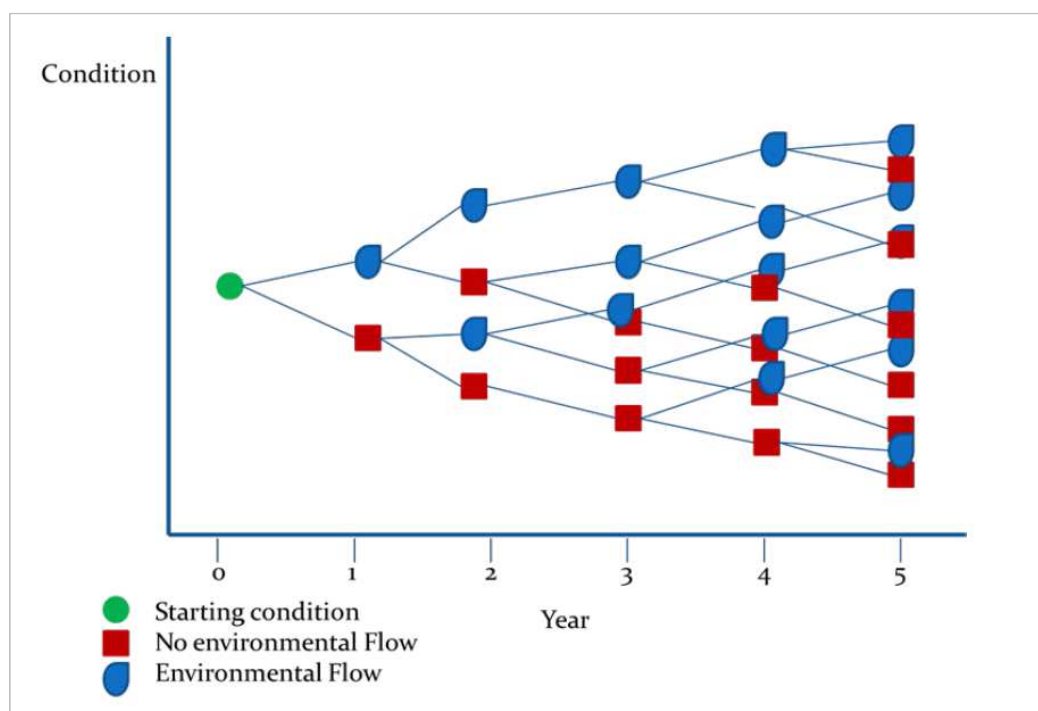
Short-term (Annual) responses:

1. The delivery of Commonwealth environmental water to wetland and floodplain areas in the Gingham-Gwydir Watercourse and Mallowa Creek Wetlands will lead to increased cover and/or richness of wetland vegetation communities.

Long-term (5 year) responses:

2. The delivery of Commonwealth environmental water in the Gingham-Gwydir Watercourse and Mallowa Creek Wetlands will lead to increased year-on-year cover and/or richness of wetland vegetation communities.

Analyses based on Aggregation will be applied at the Basin and Selected Area scales for cover and richness of wetland vegetation communities. Quantitative analyses will be applied at the Selected Area scale to document increased cover and richness of wetland vegetation communities at sites receiving Commonwealth environmental water. Multi-year analyses will be quantitatively assessed based on year-on-year repeat application of annual models outlined in the Selected Area conceptual model (Figure 2). The placement of survey sites has been strategically undertaken to permit quantification of the hydrologic connection and inundation metrics and lead to reduced uncertainty the delivery of Commonwealth water to these sites.



**Figure 2: A hypothetical model that will be applied on a year-to-year basis to generate a series of outcomes from different flow regimes over a five year period (Source: Gawne et al. 2014)**

Short-term (Annual) responses:

1. Hypotheses 1 - univariate analysis (main effect – location, inundation, time) cover and richness and multivariate analysis (factors – location, inundation history, time).

Long-term (5 year) responses:

2. Hypotheses 2 - univariate analysis (main effects – location, inundation history, year, time) and multivariate analysis (factors – location, inundation history, year, time).

Each wetland community within the Gingham-Gwydir Watercourse and Mallowa Creek Wetlands has been mapped at a fine scale. Linking wetland vegetation community extent to Commonwealth environmental water inundation extent should permit extrapolation the response to the Selected Area. The proposed indicator Hydrology (Watercourse) will document the m<sup>2</sup> of inundated ANAE and vegetation hydrology and will facilitate the extrapolation.

## 1.9 Reporting

Data for the Basin-scale will be reported following the requirements outlined in the LTIM Standard Methods (Hale et al. 2014). All data provided for this indicator must conform to the data structure defined in the LTIM Data Standard (Brooks & Wealands 2014).

## 1.10 Quality assurance/quality control

Quality control and quality assurance protocols are documented in the Quality Plan developed for the M&E Plan (CEWO 2014).

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## 1.11 References

Bowen S. 2013. *NSW OEH Environmental Flow Monitoring Program: Methods for survey and monitoring of flood-dependent vegetation communities*. NSW Government.

Brooks S. & Wealands S.R. 2014. *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project: Data Standard*. Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre. MDFRC Publication 29.3/2013 Revised Jan 2014.

Commonwealth Environmental Water Office (CEWO). 2014. *Long Term Intervention Monitoring Project Gwydir River System Selected Area*. Commonwealth of Australia.

Hale J., Stoffels R., Butcher R., Shackleton M., Brooks S. & Gawne B. 2014. *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project – Standard Methods*. Final Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre, MDFRC Publication 29.2/2014, January, 182 pp.

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**Appendix 1 NSW OEH Environmental Flow Monitoring Program: Methods  
for survey and monitoring of flood-dependent vegetation communities**

## Appendix 2 DECC Field Data Sheets

Note – iPads will be used in the field to record all data under the following headings.

### Site floristics

Site Number	Collect	Common name	Scientific name	% Cover	No.	Lower Height	Upper Height	Growth Habits	Strata Type	Exotic	Percent Cover Mid	Percent Cover (Tallest)	waypoint	Photo SW from NE	Photo N from S	Photo NE from SW	Photo S from N	Grazing	Fallen timber (0.04 ha)	Notes

### Community structure

Site Number	Sample date	Veg community	>5m canopy % cover	1-5m understory % cover	<1m ground % cover	Litter % Cover	Lichen/moss % cover	Bare ground % cover	Av length of fallen logs

### Aquatic transect

Point (m)				0				1				2				3				4				5			
	Species Code																										
				HT	FI	Fr	D	HT	FI	Fr	D	HT	FI	Fr	D	HT	FI	Fr	D	HT	FI	Fr	D	HT	FI	Fr	D
Site Number		waypoint	Phot nos																								
	Water depth cm																										

## Tree Health

comment	Tree No	Site No	Date	Plot (0.04 / 0.1ha)	OEI tree number	from north	from east	Species	Stem No	DBH	Canopy Extent (m2)	%foliage cover	%dead canopy	Ht (m)	No. Hollows	No. Nests	No dead limbs /total limbs	Buds/ Flower/ Fruit	Insect damage (L /M / H)	Photo Tree canopy

## Tree Demographics

Site no	Species	No ind. 0.2-0.5m tall (0.04 ha)	No ind. 0.5 1.3m tall (0.04 ha)	No ind. 1.3-3m tall (0.04 ha)	No ind. 0.2-0.5m tall (0.1 ha)	No ind. 0.5 1.3m tall (0.1 ha)	No ind. 1.3-3m tall (0.1 ha)	No dead trees (0.4 ha)	No live trees (0.4 ha)	No dead trees (0.1 ha)	No live trees (0.1 ha)	Fallen timber (0.04 ha)	Fallen Timber (0.01ha)	entry order	comments

## Site flooding data

Site No	Date	% Plot flooded	% Plot wet	% open water	Water depth (cm)	%submerged veg	bare ground submerged (%)	Submerged litter (%)	bare ground (%)	litter (%)	Time since previous flood	Time flooded (weeks)	notes

## B.5 SOP – Waterbird Diversity

### 1.1 Objectives

The Waterbird Diversity monitoring protocol aims to assess the contribution of Commonwealth environmental water contribute to waterbird survival and diversity.

### 1.2 Indicators

This indicator links to Vegetation Diversity, Microcrustaceans and Hydrology (Watercourse) monitoring indicators.

Colonial bird breeding events and fledgling success will be monitored.

### 1.3 Locations for monitoring

There are several well-known waterbird rookeries and wetlands that contain diverse waterbird species including migratory species within the Gingham-Gwydir Watercourse; these sites have been routinely monitored by NSW OEH for a number of years (Figure 1). These sites will be monitored through the LTIM project in association with OEH staff.

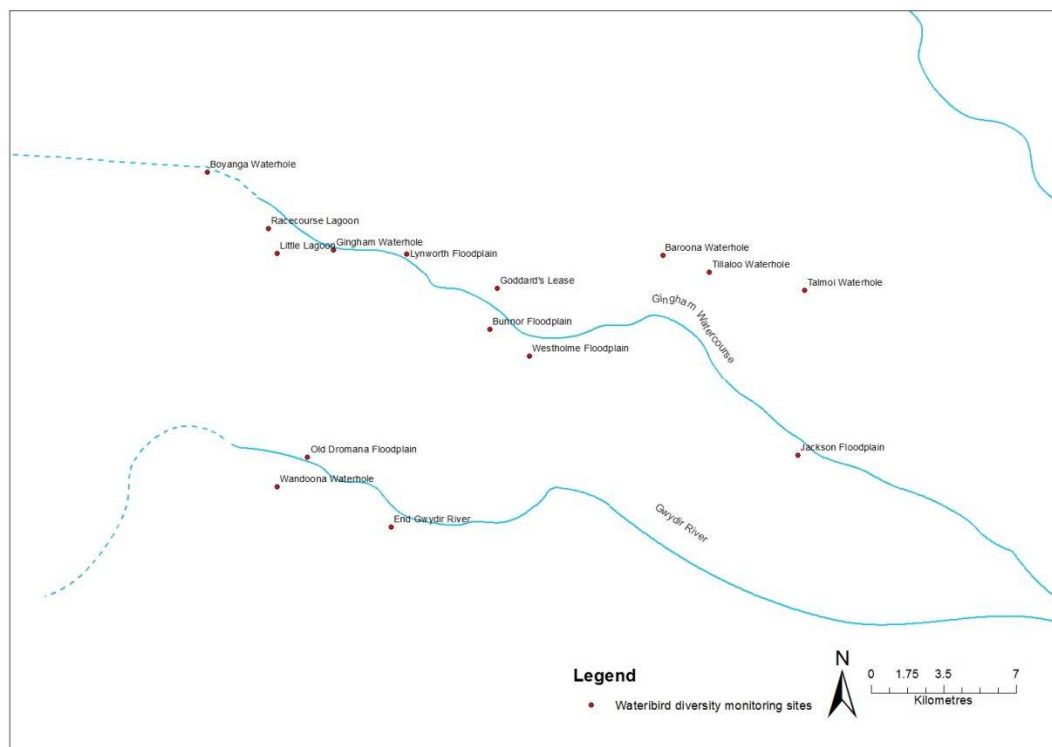


Figure 1: Watercourse areas for Waterbird Diversity monitoring

### 1.4 Timing and frequency

Waterbird Diversity monitoring will be undertaken via two surveys each watering season, however, responsive to wetland conditions.



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## **1.5 Responsibilities**

The Project Manager of the Gwydir M&E Project Team is responsible for overseeing this procedure. The field surveys will be led by experienced bird ecologists.

## **1.6 Complementary monitoring and data**

Data from additional sources and monitoring programs may be used to contribute in whole or part to this monitoring protocol. For example, the Eastern Aerial Waterbird Survey (EAWS) may pass over assessment sites and be used to augment ground surveys. There may also be local aerial or ground surveys undertaken under other monitoring programs that should be considered as supplementary data.

## **1.7 Detailed methods**

Biannual ground surveys will be undertaken, as per the LTIM Standard Methods (Section 10 Waterbird Diversity, Hale et al. 2014). Here, surveys will be undertaken on both foot and from a vehicle using observation points or transects depending on the size and shape of the wetland.

Foot surveys will be undertaken by moving around the wetland and observing from various points that are generally spaced so as to be out of sight of each other. At each point all birds are observed and recorded. New birds are recorded enroute to new points and their species and number noted. During the survey, as much of each wetland as possible is accessed, and the percentage of the total wetland observed is recorded. Surveys are undertaken for at least 20 minutes but no more than 1 hour at each wetland, in order to gain a representative no necessarily complete, count of all waterbirds in the wetland.

For large or linear wetlands with good vehicular access, transect surveys will be used. Counts of species observed are recorded as a running tally as the vehicle travels along the transect. The start and end points and times are recorded on the datasheet.

## **1.8 Data analysis**

For ground surveys, the total abundance of each species per wetland and per hectare will be calculated and reported (Section 10, Hale et al. 2014).

### **1.8.1 The Selected Area scale hypotheses**

Short-term (Annual) responses:

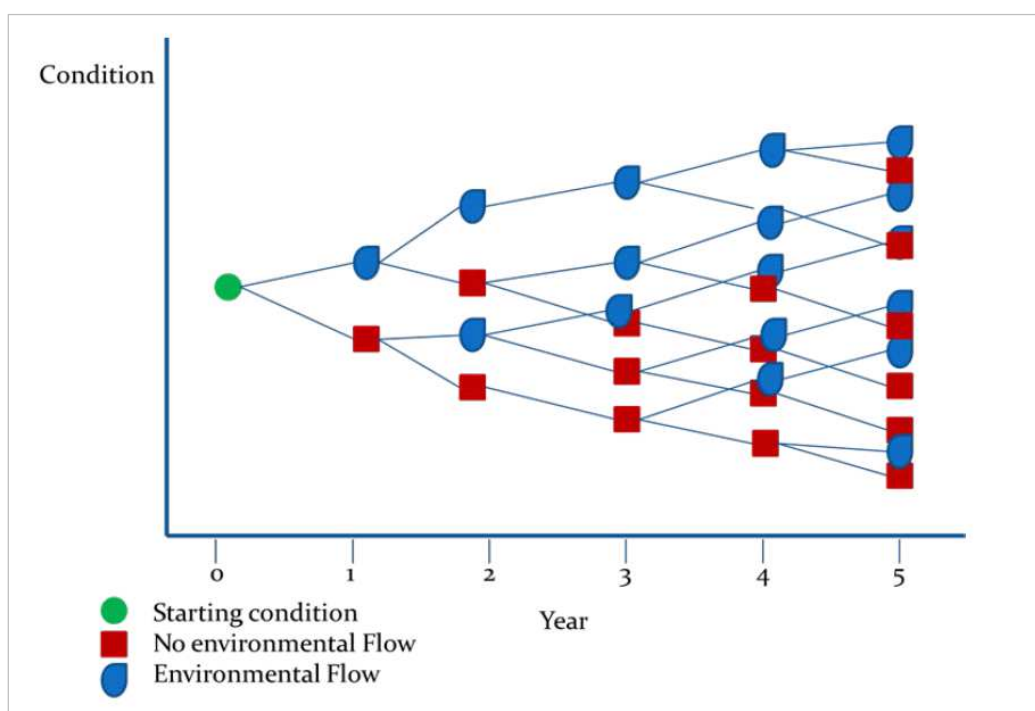
1. The delivery of Commonwealth environmental water will lead to increased waterbird survival?

Long-term (5 year) responses:

2. The delivery of Commonwealth environmental water will lead to larger waterbird populations?
3. The delivery of Commonwealth environmental water will lead to increased waterbird diversity?

### **1.8.2 The Selected Area scale analyses**

Analyses based on Aggregation will be applied at the Basin and Selected Area scales for abundance, richness and diversity of waterbirds. Quantitative analyses will be applied at the Selected Area scale to document increased abundance, richness and diversity of waterbirds at sites receiving Commonwealth environmental water. Multi-year analyses will be quantitatively assessed based on year-on-year repeat application of annual models outlined in the Selected Area conceptual model (Figure 2). The placement of water level devices at key location to quantify hydrologic connection and inundation metrics will improve uncertainty in quantifying the delivery of Commonwealth water to target sites.



**Figure 2: A hypothetical model that will be applied on a year-to-year basis to generate a series of outcomes from different flow regimes over a five year period (Source: Gawne et al. 2014)**

Short-term (Annual) responses:

1. Hypotheses 1 and 2 - univariate analysis (main effect – site, time) abundance, richness, diversity
2. Hypotheses 2 - (diversity-abundance) multivariate analysis (factors – site, time).

Long-term (5 year) responses:

1. Hypotheses 2 and 3 - univariate analysis (main effects – target site, year, time)
2. Hypotheses 3 - (diversity-abundance) multivariate analysis (factors – target site, year, time).

## 1.9 Reporting

The standard method for Waterbird Diversity reports m<sup>2</sup> ANAE area surveyed inundated from Commonwealth environmental water. The proposed indicator Watercourse Hydrology will document the m<sup>2</sup> of inundated ANAE and vegetation hydrology and will facilitate the scaling of potential colonial waterbird rookery sites to the lower Gwydir.

All data provided for this indicator must conform to the data structure defined in the LTIM Data Standard (Brooks & Wealands 2014).

## 1.10 Quality assurance/quality control

Quality control and quality assurance protocols are documented in the Quality Plan developed for the M&E Plan (CEWO 2014).

QA/QC requirements specific to this protocol include:

- 
1. All Waterbird Diversity surveys will be undertaken by the same experienced observers, where possible, over time to maintain consistency
  2. Observers will undergo training prior to undertaking monitoring surveys, including calibration against experienced observers to Measure standardisation of measurements. Training and calibration procedures will be documented in the M&P Plan and relevant records maintained

### 1.11 References

Brooks S. & Wealands S.R. 2014. *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project: Data Standard*. Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre. MDFRC Publication 29.3/2013 Revised Jan 2014.

Commonwealth Environmental Water Office (CEWO). 2014. *Long Term Intervention Monitoring Project Gwydir River System Selected Area*. Commonwealth of Australia.

Gawne B., Hale J., Butcher R. Roots J., Brooks S., Cottingham P., Stewardson M. & Everingham P. 2014. *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project: Evaluation Plan*. Final Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre, MDFRC Publication 29/2014.

Hale J., Stoffels R., Butcher R., Shackleton M., Brooks S. & Gawne B. 2014. *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project – Standard Methods*. Final Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre, MDFRC Publication 29.2/2014, January, 182 pp.

## 1.12 Waterbird Diversity Data sheet

### GWYDIR LTIM WATER BIRD DIVERSITY DATA SHEET

Date:     /     /     Time started(24hr):     Time finished:     Sheet No:     of    

Site name/code:     Survey No:    

Observer name(s):    

Site location, including survey points: (UTM, GDA94 datum)

Survey Point	Zone	EASTING	NORTHING	Photo Numbers

Type of survey:     ☐ Point(s)     ☐ Transect     ☐ Area (100x200m)

#### Survey site description

##### Weather conditions:

Temperature (°C) (est.)    

Rain (circle)      None / Light / Heavy

Cloud cover %    

Wind speed (circle)      Still / Light / Gusty / Gale

Wind direction (from)    

Total size of wetland (ha)    

Site coverage %:      (estimate % of total wetland area surveyed)

Water level: Flooded Area       
(est %)

Gauge height (m)       
(where available)

#### Habitat assessment:

Estimate % coverage of each habitat type that makes up area observed from your survey point (complete for first survey only)

Open water  
Aquatic floating veg  
Mudflat  
Dry bare ground  
Low-growing aquatic veg. eg. nardoo  
Aquatic emergent veg. <1m eg. rushes  
Aquatic emergent veg. >1m eg. reeds  
Terrestrial ground cover

Estimate % total canopy area     Tree canopy

Estimate total number     Dead standing timber

Survey point No:					
Open water					
Aquatic floating veg					
Mudflat					
Dry bare ground					
Low-growing aquatic veg. eg. nardoo					
Aquatic emergent veg. <1m eg. rushes					
Aquatic emergent veg. >1m eg. reeds					
Terrestrial ground cover					
Tree canopy					
Dead standing timber					

Disturbance: (e.g. vehicles, feral species, people, machinery)

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Additional comments:

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## GWYDIR LTIM WATER BIRD DIVERSITY DATA SHEET

Date:    /    /      Site name/code:                                      Sheet No:    of

Date:    /    /      Site name/code:                                      Sheet No:    of

Date:    /    /      Site name/code:                                      Sheet No:    of

[illegible]

<ul style="list-style-type: none"> <li>* Vegetation habitat types include:</li> <li>- Open water (No vegetation) – OW</li> <li>- River red gum forest – RRGF</li> <li>- River red gum woodlands – RRGW</li> <li>- Black box forest – BBF</li> <li>- Black box woodland – BBW</li> <li>- Coolibah – C</li> <li>- River Cooba – RC</li> <li>- Freshwater grasses – FG</li> </ul>	<ul style="list-style-type: none"> <li>- Paperbark - P</li> <li>- Lignum - L</li> <li>- Other Shrub - OS</li> <li>- Saltmarsh - S</li> <li>- Tall emergent aquatic - TEA</li> <li>- Aquatic - A</li> <li>- Sedge/Grass/Forb – S/G/F</li> <li>- Freshwater forb - FF</li> </ul>
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- |  |  |
|--|--|
| <ul style="list-style-type: none"> <li>* Vegetation habitat types include:</li> <li>- Open water (No vegetation) – OW</li> <li>- River red gum forest – RRGF</li> <li>- River red gum woodlands – RRGW</li> <li>- Black box forest – BBF</li> <li>- Black box woodland – BBW</li> <li>- Coolibah – C</li> <li>- River Cooba – RC</li> <li>- Freshwater grasses – FG</li> </ul> | <ul style="list-style-type: none"> <li>- Paperbark - P</li> <li>- Lignum - L</li> <li>- Other Shrub - OS</li> <li>- Saltmarsh - S</li> <li>- Tall emergent aquatic - TEA</li> <li>- Aquatic - A</li> <li>- Sedge/Grass/Forb – S/G/F</li> <li>- Freshwater forb - FF</li> </ul> |
|--|--|

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## B.6 SOP – Water Quality

### 1.1 Objectives

The Water Quality monitoring protocol seeks to assess the contribution of Commonwealth environmental water to improved water quality.

### 1.2 Indicators

Dependant variables:

- Temperature
- pH
- Turbidity
- Salinity
- Dissolved oxygen.

Covariates

- Discharge (ML/day).

### 1.3 Location for monitoring

A single monitoring site for water quality will be located at single site in the Gwydir River zone (Copeton Dam to Tareelaro Weir). This location has permanent surface water connectivity in a defined channel and all Commonwealth environmental water delivered to the Gwydir Selected Area must pass through this reach. Locating a single station at Pallamallawa allows all-weather access to a (NoW) telemetered gauged site and provides data on influent water quality to the Gwydir Selected Area throughout all flow deliveries.

### 1.4 Timing and frequency

Continuous monitoring of dependant variables and covariates (following Section 13 Water Quality, Hale et al. 2014) will occur over a full 12 month cycles. Deployment periods will therefore align with the commencement and cessation of Commonwealth environmental water delivery.

### 1.5 Specific Equipment (in addition to the Standard Methods – Water Quality)

- Hydrolab DS5-X logger. The DS5-X multi-probe logger includes a self-cleaning system to reduce fouling of probes and is designed for long-term submersible deployment

### 1.6 Responsibilities

The Project Manager of the Gwydir M&E Project Team is responsible for overseeing this procedure. A field scientist/technician will be responsible for the monitoring and maintenance of loggers and collation of data under the direction of Project Director (Ryder), who will conduct the analyses and reporting.

### 1.7 Complementary monitoring and data

Hydrological measures of stream discharge are used to inform the interpretation of stream water quality. The existing stream gauge at Pallamallawa (NOW gauge number 418001) will be used to quantify discharge (ML/d).

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## **1.8 Detailed methods**

Measurement of the Water Quality indicator will follow the field and laboratory procedures outlined in the LTIM Standard Methods (Hale et al. 2014).

## **1.9 Data analysis**

### **1.9.1 The Selected Area scale hypotheses**

At the Selected Area scale a number of hypotheses that relate to the outcomes of delivery of Commonwealth environmental water are possible. Selected Area scale hypotheses include:

1. Mean daily water temperature, and daily range in water temperature will decrease during the delivery of Commonwealth environmental water
2. Mean daily pH, and daily range in decrease during the delivery of Commonwealth environmental water
3. Mean daily turbidity will increase during the delivery of Commonwealth environmental water
4. Mean daily EC will decrease during the delivery of Commonwealth environmental water
5. Mean daily DO concentrations will decrease during the delivery of Commonwealth environmental water.

### **1.9.2 The Selected Area scale analyses**

Quantitative analyses will be applied at the Selected Area scale to document temporal shifts in water quality in periods that Commonwealth environmental water is delivered each year. Long-term year on trends can be analysed based on periods with and without the delivery of Commonwealth environmental water.

Short-term and long term responses:

- Hypotheses 1 to 5 – Replication derived from randomised daily means of data periods within/outside delivery of Commonwealth environmental water. One-way Anova (WQ variables as dependant variable) comparing among flow periods, and two-way Anova (flow period, years) for long term dataset.

## **1.10 Reporting**

Data for the Basin-scale will be reported following the requirements outlined in the LTIM Data Standard (Section 13.9 Water Quality – Data analysis and reporting, Hale et al. 2014) and conform to the LTIM Data Standard (Brooks & Wealands 2014).

## **1.11 Quality assurance/quality control**

Quality control and quality assurance protocols are documented in the Quality Plan developed for the M&E Plan (CEWO 2014). In addition, this method requires a number of QA/QC procedures:

- Calibration and maintenance of sensors and loggers is required at a maximum 6 week interval
- Data correction procedures will be used to account for sensor drift or fouling following periodic calibration.

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## 1.12 References

Brooks S. & Wealands S.R. 2014. *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project: Data Standard*. Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre. MDFRC Publication 29.3/2013 Revised Jan 2014.

Commonwealth Environmental Water Office (CEWO). 2014. *Long Term Intervention Monitoring Project Gwydir River System Selected Area*. Commonwealth of Australia.

Hale J., Stoffels R., Butcher R., Shackleton M., Brooks S. & Gawne B. 2014. *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project – Standard Methods*. Final Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre, MDFRC Publication 29.2/2014, January, 182 pp.



## B.7 SOP – Hydrology (Watercourse)

### 1.1 Objectives

The aim of the Hydrology (Watercourse) indicator is to document the extent of inundation caused by Commonwealth environmental watering.

### 1.2 Indicators

Hydrology (Watercourse) monitoring will map the inundation extent resulting from the delivery of Commonwealth environmental watering.

The Hydrology (Watercourse) indicator links to Vegetation Diversity, Waterbird Diversity, Waterbird Breeding, and Microcrustaceans indicators.

### 1.3 Locations for monitoring

Hydrology (Watercourse) monitoring will occur in the Gingham-Gwydir Watercourse (Figure 1).

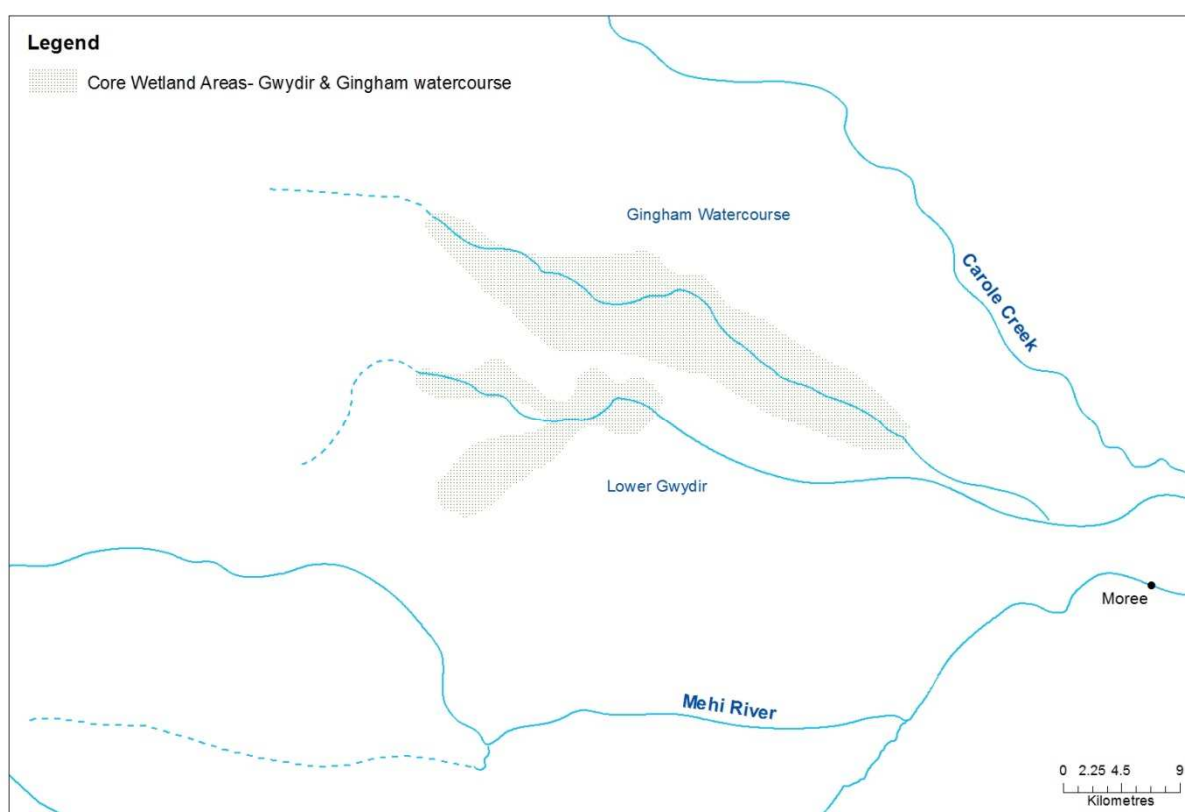


Figure 1: Watercourse areas - Gwydir Selected Area

### 1.4 Timing and frequency

Existing sets of LiDAR data (already captured) will be used to create an inundation model at targeted areas within the Gingham-Gwydir Watercourse. No new data capture is proposed.

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## 1.5 Responsibilities

The Project Manager of the Gwydir M&E Project Team is responsible for overseeing this procedure. A team of GIS officers will complete the data analysis.

## 1.6 Complementary monitoring and data

Data on inundation extent and frequency from previous and ongoing work (e.g. OEH (Rachel Thomas et al.), Powell (2001; University of Canberra, PhD thesis), LIDAR captures and OEH hydrodynamic modelling) will be used to assist in developing the known and expected inundation extent and volume from given flow events.

## 1.7 Detailed methods

At present there are a number of fixed camera sites and gauging stations established within key areas of the Gwydir and Gingham wetlands which can be used to monitor water levels. Several new cameras will be established within the wetlands to allow water level monitoring in the vicinity of the bird hide on Bunnor in the Gingham watercourse and near the eastern extent of Gwydir wetlands on Old Dromana. In addition, a number of water depth recorders will be established in the Gwydir wetlands to increase the coverage of water level monitoring within this system.

Water level information from this network of gauges and cameras will then be linked to the LiDAR imagery to allow for an estimation of the extent and volume of water within the wetlands at any given time.

This project will create data relevant to the hydro-dynamic model built by OEH. It will enable calibration and refinement of this model.

## 1.8 Data analysis and reporting

GIS based analysis to determine the relationship between inundation event (volume) and inundated area and volume in relation to mapped soil and vegetation regions.

The Hydrology (Watercourse) method reports m<sup>2</sup> ANAE typology and vegetation community inundated from Commonwealth environmental water. The proposed indicator will document the m<sup>2</sup> of inundated ANAE and vegetation hydrology and will facilitate the scaling of potential Microcrustacean, Vegetation Diversity and Waterbird Diversity/Breeding to the lower Gwydir.

All data provided for this indicator must conform to the data structure defined in the LTIM Data Standard (Brooks & Wealands 2014).

### 1.8.1 Conceptual definition

This indicator will contain rows of data about a site that is:

*“A defined watercourse potentially inundated by the delivery of environmental water”*

Each row of data will describe:

*“ the extent and volume of inundation by environmental water ”*

### 1.8.2 Site linkages

Sites of Hydrology (Watercourse) require the following linkages to other data (where available):

- ANAE stream identifiers to enable linking with framework datasets for future work
- Gauged flow and stage information from relevant gauges

### 1.8.3 Data definition

Each row of data will contain the following columns of information.

Variable	Description	Type	Req	Range	Example
siteld	A single large wetland or a complex of wetlands represented by either a name or polygon within which observations are made	string	Y		
sampleDate	Start date (inclusive) that these measures were observed	dateTime	Y		
sampleDateEnd	End date (exclusive) that these measures were observed	dateTime	Y		
dailyExtent	m <sup>2</sup>	Number (1 decimals)	N		7 398 765.1
dailyVolume	m <sup>3</sup>	Number (1 decimals)	N		4 897 967.2
percentDry	Percentage of total area that is dry (zero depth)	Integer	N	[0,100]	26
percentDepth020	Percentage of total area that is < 20cm deep	Integer	N	[0,100]	74
percentDepth040	Percentage of total area that is 20 to < 40cm deep	Integer	N	[0,100]	63
percentDepth060	Percentage of total area that is 40 to < 60cm deep	Integer	N	[0,100]	25
percentDepth080	Percentage of total area that is 60 to < 80cm deep	Integer	N	[0,100]	18
percentDepth100	Percentage of total area that is 80 to < 100cm deep	Integer	N	[0,100]	6
percentDeep	Percentage of total area that is >100cm deep	Integer	N	[0,100]	47
percentCEW	Percent of water contributed by CEWO as percent of total area	Integer	N	[0,100]	52

Variable	Description	Type	Req	Range	Example
qualityCode	<p>Data quality codes (1-5) will need to be applied with the following definitions:</p> <p>1: Best quality unedited data. Meets operational standards and is considered a good representation of the true value.</p> <p>2: Good quality. Minimal editing, may include sensor drift correction this is considered a good representation of the true value.</p> <p>3: Modified or transformed data this is considered A reasonable representation of the true value.</p> <p>4: Unreliable data - considered a poor representation (e.g. debris effecting sensor, flat batteries)</p> <p>5: Estimated or modelled data.</p>	Integer	N	[1,5]	2

## 1.9 Quality assurance/quality control

Quality control and quality assurance protocols are documented in the Quality Plan developed for the M&E Plan (CEWO 2014).

## 1.10 References

Brooks S. & Wealands S.R. 2014. *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project: Data Standard*. Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre. MDFRC Publication 29.3/2013 Revised Jan 2014.

Commonwealth Environmental Water Office (CEWO). 2014. *Long Term Intervention Monitoring Project Gwydir River System Selected Area*. Commonwealth of Australia.

Powell S. 2001. *Analysis and modelling of the flood pulse and vegetation productivity response in floodplain wetlands*. PhD Thesis, University of Canberra.

## B.8 SOP – Fish (Movement)

### 1.1 Objectives and hypotheses

The Fish (Movement) monitoring protocol aims to assess the contribution of Commonwealth environmental water to fish population diversity, dispersal and habitat use.

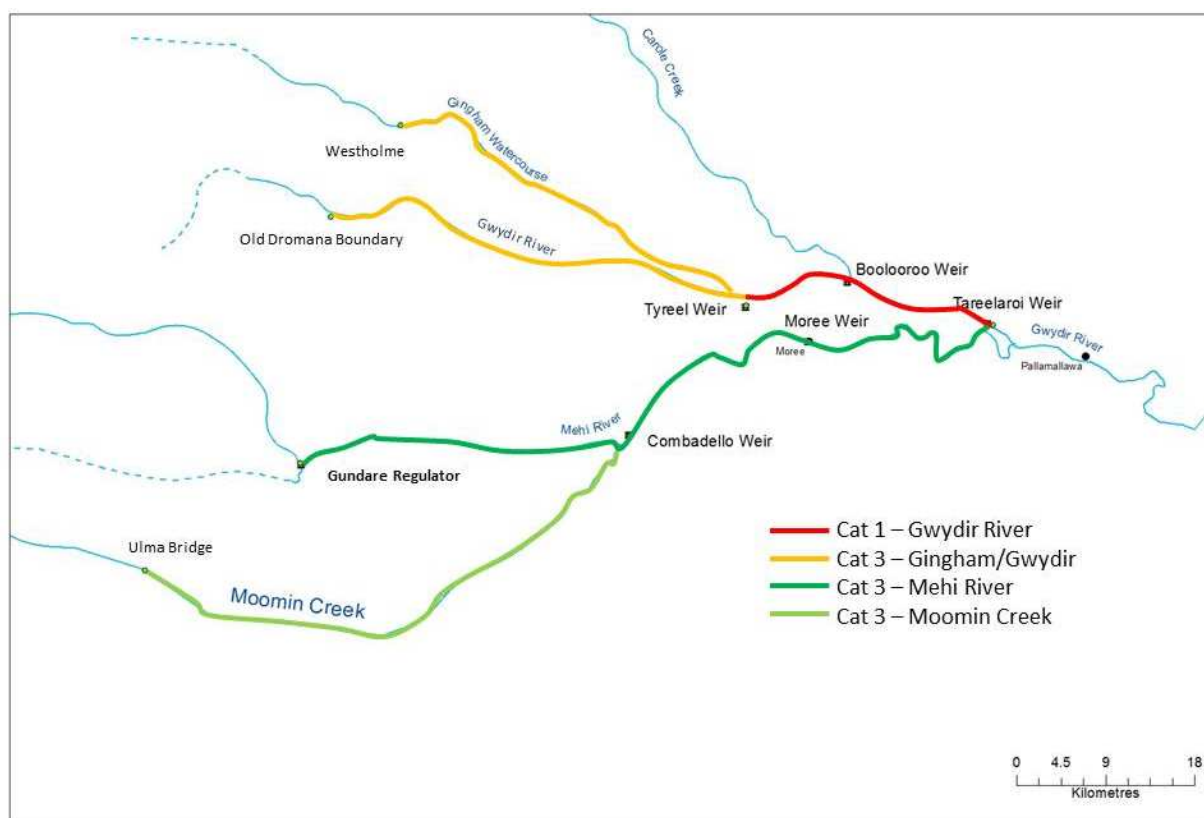
### 1.2 Indicators

Fish (Movement) will target movement of one equilibrium species, freshwater catfish (*Tandanus tandanus*) (endangered population Murray-Darling Basin), and one periodic species, spangled perch (*Leiopotherapon unicolor*).

The Fish (Movement) indicator links to the Fish (River) indicator.

### 1.3 Locations for monitoring

In the first year of monitoring Fish (Movement) (year 2 of the LTIM monitoring), the monitoring team will select the best reach within the target zones (**Figure 6**) to establish the optimal location/s for the fish movement array. The receiver design will be established cognisant of the requirements set out in chapter 8 of Hale et al. (2014).



**Figure 6. Location of fish sampling reaches within the Gwydir River Selected Area. Fish (movement) will be targeted in the Category 1 reach**

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#### **1.4 Timing and frequency**

Fish (Movement) will be undertaken during the second (2015-16) and third (2016-17) years of the project.

#### **1.5 Responsibilities**

Fisheries NSW will be sub-contracted by Eco Logical Australia to undertake Fish (Movement) monitoring.

#### **1.6 Detailed methods**

Methods for sampling fish (movement) will follow those outlines in the LTIM Standard Methods (Hale et al. 2014). Here, individual fish will be tagged using appropriately sized Vemco tags that are less than 2% of individuals total body weight. Tags will be surgically implanted into the coelomic cavity while fish are under anaesthesia. Total length and fork length (mm) as well as mass (g) of each fish will be recorded. Fish are to be fitted with external, individually numbered dart tags in the dorsal musculature to aid angler identification and facilitate tag returns which is important to understand fate of the fish if it is detected in the future. Resident fish will be sourced from the selected channels, and if insufficient numbers are collected, fish may be relocated from Copeton Dam.

Receiver arrays will be set up along the study reach at intervals sufficient to determine the movement of targeted species (1-5km). The spacing of receivers will be determined after a full assessment of the selected reach by field staff.

#### **1.7 Data analysis**

Acoustic receivers will be downloaded quarterly to reduce the possible risk of lost stolen receivers. Data will be analysed following the detailed methods in Hale et al. (2014). Here, movement metrics such as total longitudinal distance (upstream, downstream and total), net longitudinal distance and longitudinal range will be collected for each individual on a monthly basis. The temporal resolution of position collection should be weekly. Home-range calculations (kernel utilisation distributions), site fidelity (linearity indices), habitat use and rate of movement will be plotted using Eonfusion® (Fisheries NSW hold multiple licences for the software). Eonfusion® will also be used to generate 'real-time' video to help in visualising fish movements in relation to flow, season, day-night etc. In addition the above analyses, a model selection approach using linear mixed effect models will be used to determine relationships between movement patterns and environmental variables such as discharge, lagged discharge (number of days since flow event), Julian day, water temperature, sex and length of fish. If breeding related movements do occur, then the locations of fish during this time will be reported as displacement, defined as a representation of the geographical distance and the direction that the fish moved. As freshwater catfish is known to nest on open substrates and in relatively shallow water, we will also attempt to validate nest site locations using underwater cameras.

#### **1.8 Reporting**

All data provided for this indicator must conform to the data structure defined in the LTIM Data Standard (Brooks & Wealands 2014).

#### **1.9 Quality assurance/quality control**

Quality control and quality assurance protocols are documented in the Quality Plan developed for the M&E Plan (CEWO 2014).

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## 1.10 References

Brooks S. & Wealands S.R. 2014. *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project: Data Standard*. Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre. MDFRC Publication 29.3/2013 Revised Jan 2014.

Commonwealth Environmental Water Office (CEWO). 2014. *Long Term Intervention Monitoring Project Gwydir River System Selected Area*. Commonwealth of Australia.

Hale J., Stoffels R., Butcher R., Shackleton M., Brooks S. & Gawne B. 2014. *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project – Standard Methods*. Final Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre, MDFRC Publication 29.2/2014, January, 182 pp.

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## B.9 SOP – Microcrustaceans

### 1.1 Objectives

This Standard Operating Procedure has been developed in line with the Procedure proposed by Jenkins et al. for Selected Areas in the southern MDB. Application of this standard indicator across a broad geographic range of wetland and channel systems throughout the Basin will facilitate comparisons of microinvertebrate and more broadly ecosystem function responses to Commonwealth environmental water.

### 1.2 Indicators

Dependant variables:

- Microinvertebrate relative abundance (density/L)
- Microinvertebrate community assemblage

Covariate Indicators

- Hydrology River
- Hydrology Watercourse
- Fish River
- Fish Larvae
- Metabolism
- Vegetation Diversity
- Waterbird Breeding

### 1.3 Locations for monitoring

Monitoring sites for microinvertebrate will be located in two target areas in the lower Gwydir.

#### *River sites*

The first is the zone between in the Gwydir River between Tyreelaro and Tyreel Weirs that is the target zone for Category 1 fish (river) and will receive Commonwealth environmental water within each watering year. Microinvertebrate sampling using the river channel sampling protocol for will occur at the 3 locations aligned with Fish River sampling (below) to provide explicit links among these indicators and provide an assessment of a functional ecosystem response.

Gwydir			Easting	Northing
	GWR1-C1	56J	209205.00 m E	6740456.00 m S
	GWR2-C1	55J	783417.00 m E	6743136.00 m S
	GWR3-C1	55J	775598.00 m E	6741492.00 m S

#### *Watercourse sites*

The second zone utilises the wetland/floodplain sampling protocol to sample the Gingham watercourse at Bunnor and the Gwydir watercourse at Old Dromana that are characterised by an extensive floodplain wetland network and will allow an assessment of connectivity. Sampling will occur within representative



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sites in each of the dominant wetland vegetation communities inundated by Commonwealth environmental water. In Bunnor sampling will be stratified within water couch, typha and open water habitats. At Old Dromana sampling will be stratified within water couch, marsh clubrush and coolabah sites. Microinvertebrate sample sites in these watercourses will be aligned with the vegetation sample location. The Hydrology Watercourse indicator will facilitate the scaling-up of site based microinvertebrate data (density/L/vegetation type) to the entire inundated area of the watercourse.

This design will allow Basin scale reporting with replication (n=3) for each of river channel and watercourse habitats, and alignment with Fish (River) sites.

The rationale underlying this approach is to seek as much synergy as possible with the fish (river) indicator for channel sites, and the links between watercourse inundation, water chemistry, metabolism and microinvertebrates. Only a single composite sample (comprised of either 5 benthic cores or 5 pelagic buckets) is taken from each site or vegetation habitat within a site. This will reduce the overall number of samples for laboratory processing and align with other Selected Areas.

## **1.4 Monitoring Design**

### *Microinvertebrate River*

Two different microinvertebrate sampling gears will be used within the three river channel sites of the Gwydir River zone targeted for Selected Area scale analyses: benthic corer and a pelagic bucket. Five benthic cores will be randomly allocated within the slackwater habitats along a 150m section of river and placed in a single bucket to yield a single 'benthic' composite sample from the site.

Five pelagic buckets should be randomly allocated within flowing edge habitats along a 150m section of river and then poured through a net to yield a single 'flowing pelagic' composite sample from the site.

Microinvertebrate samples within a site should be collected before the site is disturbed for other sampling.

### *Microinvertebrate watercourse*

Two different microinvertebrate sampling gears will be used where possible within the three vegetation communities of each Bunnor and Old Dromana watercourses: benthic corer and a pelagic bucket.

Five benthic cores will be randomly allocated within shallow-edge (<15cm) of each inundated habitat of each vegetation community and then placed in a single bucket to yield a single 'watercourse benthic' composite sample from the site. Where surface water >15cm depth is present, five pelagic buckets will be randomly allocated within each inundated habitat of each vegetation community and then poured through a net to yield a single 'watercourse pelagic' composite sample from the site.

Microinvertebrate samples within a site should be collected before the site is disturbed for other sampling.

### *Watercourse floodplain wetland metabolism*

To replicate the ecosystem function links between nutrients, carbon, metabolism and microinvertebrates, we will collect metabolism (GPP, R, NPP mg/m<sup>2</sup>/day, Chl a) and water chemistry (DOC, TP, TN, FRP, NOx) metrics in each of the vegetation habitats in each of the 3 watercourse sites. We will follow the standard methods outlined for the indicator Metabolism in the collection and analyses of metabolic and water column nutrient data.

During years 4 and 5 of the project, additional metabolism data will be collected at four of the river channel sites within the Gwydir and Mehi River channels. The same metrics will be calculated for metabolism at these sites as the wetlands sites as outlined above. In addition, a new metric to estimate the amount of organic carbon produced per day per one-kilometre stream reach (kg C/km/day) will be calculated by multiplying the daily rate of GPP (mg O<sub>2</sub>/L/day) by the cross-sectional stream area (m<sup>2</sup>) at the nearest

gauge station with a conversion factor of 12/32 to convert oxygen gas (O<sub>2</sub>) molecular mass to carbon (C) atomic mass. The locations of these sites and the water gauges used to calculate organic carbon production per day per kilometre is presented below.

Site	DPI Water gauge station	Distance from gauge station
GW2	418042 (Gwydir D/S Tareelaroï)	6 km downstream
GW4	418004 (Gwydir @ Yarraman Br)	0 km
GW6	418078 (Gwydir @ Allambie Br)	0 km
ME1	418044 (Mehi D/S Tareelaroï)	3 km downstream

### 1.5 Timing and Frequency

At each of the 3 Category 1 Fish River sites, microinvertebrate sampling will take place on 4 occasions from the commencement to the cessation of environmental water delivery (approx. October through to March).

At each watercourse site, microinvertebrate and metabolism-water chemistry sampling will take place following watercourse inundation with Commonwealth environmental water. Four sample events are planned to follow the inundation and contraction cycle, sampling immediately (days) after inundation, at peak area inundation, and at two times during the drying cycle.

### 1.6 Responsibilities

The Project Manager of the Gwydir M&E Project Team is responsible for overseeing this procedure.

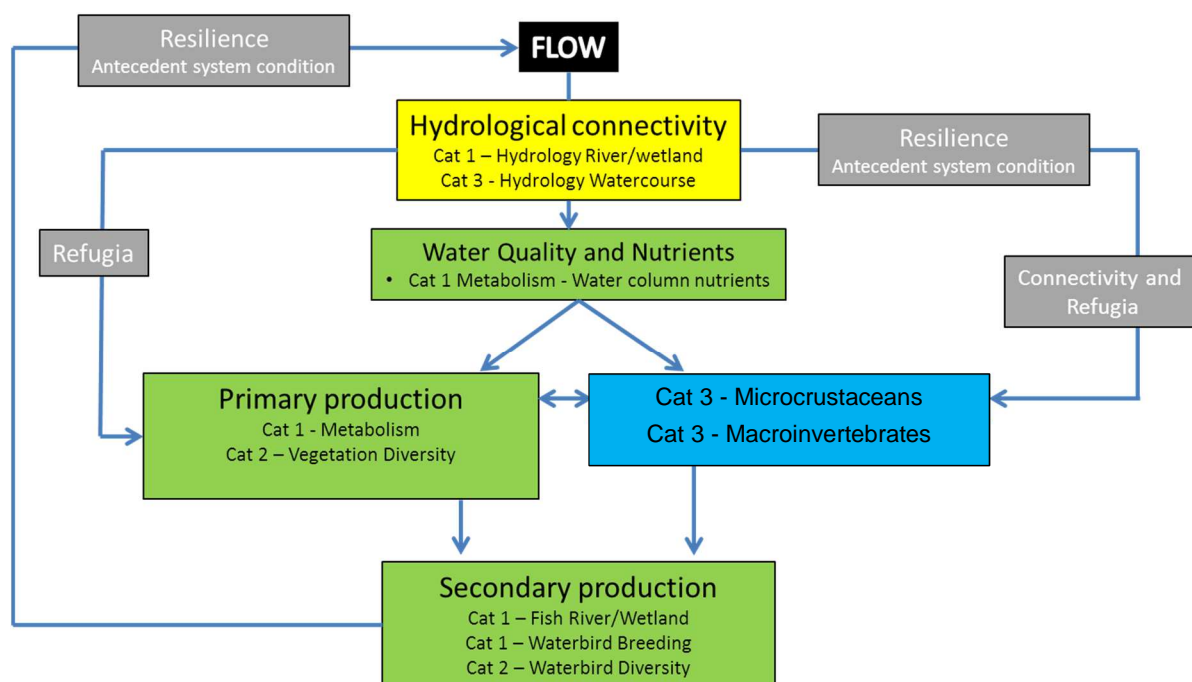
An ecologist will be responsible for the field collation of data and laboratory processing of samples under the direction of Project co-Director (Ryder), who will conduct the analyses and reporting.

Complementary monitoring and data

The following indicators measures in the lower Gwydir will be included as complementary monitoring data to inform the ecosystem function response of each of the river channel and watercourse floodplain wetland systems.

- Hydrology River
- Hydrology Watercourse
- Fish River
- Fish Larvae
- Metabolism
- Vegetation Diversity
- Waterbird Breeding

The cause and effect diagram below demonstrates the functional and food web links provided by microinvertebrate in river channel and floodplain watercourse habitats in the Gwydir Selected Area.



## 1.7 Detailed methods

### 1.7.1 Sampling protocol

The sampling procedure is the same for watercourse and river channels. Benthic corers should be modified slightly from King (2004), the details of which can be found in (Morris 2008). The benthic cores within each site should be collected either in the afternoon or the morning to tie in with other sampling. Collection times should be recorded on the data sheet.

Composite samples (each pelagic and benthic) will be collected at each site. Benthic samples will be collected with a corer (50 mm diameter x 120 mm long, 250 mL volume). At each site, five cores will be collected from random locations within each site with replicates spaced along a 150m transect. The corer is placed onto the sediment surface, the top is then sealed with a plastic cap and the sediment and overlaying water extracted with the aid of a hardened rubber trowel. The contents of the corer are emptied into a 4 litre bucket and allowed to settle for at least one hour. Once settled, the supernatant will be poured through a 63 µm sieve to retain microinvertebrate. The retained sample will be washed into a sample jar and stored in ethanol (70% w/v) with rose bengal. To assess the pelagic microinvertebrate community, a composite sample consisting of 10 x 10 litre buckets will be collected at each site. Each bucket should be poured through a plankton sampler (63 µm mesh). Retained samples are stored in ethanol (70% w/v) with rose bengal until time of enumeration.

Metabolism and water chemistry will follow the Metabolism River SOP. Briefly, loggers will be placed in watercourse locations for a minimum 48h period, with water chemistry samples collected at the commencement and end of incubations.

#### Equipment

- Benthic corer (50 mm diameter x 120 mm long, 250 mL volume) and rubber backed spatula;
- Small (4L) bucket with lid for settling benthic cores;
- 63µm mesh sieve;
- Squirt Bottle

- 
- 70% ethanol with rose bengal stain;
  - Storage jars;
  - Data sheets

Specific Equipment (as per Standard Methods – Metabolism)

1. D-opto temp-oxygen loggers and stakes (calibration, cleaning equipment)
2. Filtration and storage jars for nutrient/carbon samples
3. Data sheets

#### *Laboratory sample processing - microinvertebrate*

Entire samples should be preserved individually in 70% ethanol and returned to the laboratory for microinvertebrate identification and enumeration. Whole samples should be examined in bogorov trays and the contents identified to Class, Order and family level.

Metabolism and water chemistry samples will be processed following the Metabolism SOP.

### **1.8 Data analysis**

At the Selected Area scale a number of hypotheses that relate to the outcomes of delivery of Commonwealth environmental water are possible. We aim to standardise methods and data definitions with the Murrumbidgee and Warrego-Darling Selected Areas to facilitate Basin Scale evaluation.

In river channel habitats quantitative analyses will be possible for microinvertebrate density and community composition for time since watering, with multivariate analyses such as nMDS (and modules including Simper, BioEnv, DISP, PCA) will be used to explore patterns among dependant and covariate variables such as water quality and fish (river).

In watercourse habitats, quantitative analyses will be possible for microinvertebrate density and community composition for time since watering and vegetation community, with multivariate analyses such as nMDS (and modules including Simper, BioEnv, DISP, PCA) will be used to explore patterns among dependant and covariate variables such as water column nutrient and carbon concentrations, metabolism and waterbird breeding/diversity.

Metabolism will be reported in GPP, R, NPP /m<sup>2</sup> vegetation community, facilitating outcomes for entire systems to be determined from scaled data (e.g., microinvertebrate density/m<sup>3</sup>/vegetation community) scaled to entire watercourse systems. Watercourse Hydrology will quantify the area of each vegetation community inundated and the volume of inundation (m<sup>3</sup>) throughout the delivery cycle of Commonwealth environmental water. Linking microinvertebrate density to this indicator will facilitate scaling of response from site based (microinvertebrate density/m<sup>2</sup>) to the inundated vegetation asset scale within the Selected Area.

### **1.9 Reporting**

Basin and Selected Area scale reporting will conform to the LTIM Data Standard (Brooks and Wealands 2014) to facilitate data management within the LTIM Monitoring Data Management System (MDMS).

### **1.10 Conceptual definition**

This indicator will contain rows of data about a site that is:

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*“a River site covers a 100m stretch of channel , within which the diversity of habitats are represented and sampled.”*

*“a Watercourse site covers a 100m stretch of inundated floodplain, within which the diversity of habitats are represented and sampled.”*

Each row of data will describe:

*“the characteristics of microcrustacean assemblages based on density of individuals of a specific taxa at the site in the period defined by the date/time range.”*

### 1.11 Site linkages

Sites of Microcrustaceans require the following linkages to other data (where available):

- site identifiers for representative hydrological indicator data for the river channel
- site identifiers for representative hydrological indicator for the watercourse
- ANAE identifiers to enable linking with framework datasets for future work

### 1.12 Data definition

*Each row of data will contain the following columns of information.*

Variable	Description	Type	Req	Range	Example
siteld	A site that covers a 100m stretch of the channel or watercourse represented by either a name or polygon, within which the diversity of habitats are represented and sampled	string	Y		EDWK04_057
siteType	Channel or Watercourse	category	Y		Channel
sampleDate	Start date (inclusive) that these measures were observed	dateTime	Y		15/05/2014 0:00
sampleDateEnd	End date (exclusive) that these measures were observed	dateTime	Y		15/05/2014 0:00
higherTaxaName	Latin name of order, class, phylum for taxa that cannot be identified to family or below	string	Y		Cladocera
familyName	Latin name of family	string	N		Chydoridae
numberIndividuals	total number of individuals (after multiplying up subsamples)	Integer	N	0 - infinity	1222
densityIndividuals	total density of individuals (after multiplying up subsamples)	Number (2 decimal places)	Y	0 - infinity	12.22

Variable	Description	Type	Req	Range	Example
sampleType	The types of sampling used to determine the total number of individuals	category		Tow net Sediment core Schindler-Patalas trap	Tow net

### 1.13 Quality Assurance/Quality Control

Quality control and quality assurance protocols are documented in the Quality Plan developed as part of the M&E Plan for all Selected Areas. This method requires a number of QA/QC procedures outlined below:

- All staff will follow the Safe Work Method Statement for field and laboratory work
- Standardisation of microinvertebrate sampling equipment
- Sample exchange between Murrumbidgee and Gwydir teams
- Water chemistry samples will have a QA/QC check via 10% sample exchange with NATA laboratory at the NSW OEH Lidcombe laboratories
- Field duplicate and blank samples will be collected following the Standard Method
- Holding times for water quality samples will follow the procedures provided by the processing laboratory
- Preservation and transport of water quality samples will follow the procedures provided by the processing laboratory.
- Data management will follow the Gwydir QA/QC protocols.

### 1.14 References

Brooks S and Wealands S (2014) *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project: Data Standard*. Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre, MDFRC Publication 29.3/2013 Revised Jan 2014, 29pp.

Hale J., Stoffels R., Butcher R., Shackleton M., Brooks S. & Gawne B. 2013. *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project – Standard Methods*. Final Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre, MDFRC Publication 29.2/2014, January, 182 pp.

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## B.10 SOP – Macroinvertebrates

### 1.15 Objectives

This Standard Operating Procedure has been developed in line with the Procedure proposed by Jenkins et al. for Selected Areas in the southern MDB. Application of this standard indicator across a broad geographic range of wetland and channel systems throughout the Basin will facilitate comparisons of macroinvertebrate and more broadly ecosystem function responses to Commonwealth environmental water.

### 1.16 Indicators

Dependant variables:

- Macroinvertebrate relative abundance (density/m<sup>2</sup>)
- Macroinvertebrate community assemblage

Covariate Indicators

- Hydrology River
- Hydrology Watercourse
- Fish River
- Fish Larvae
- Metabolism
- Vegetation Diversity
- Waterbird Breeding

### 1.17 Locations for monitoring

Monitoring sites for macroinvertebrates will be located in the same locations as sampling for macroinvertebrates, in two target areas in the lower Gwydir.

#### *River sites*

The first is the zone between in the Gwydir River between Tareelaro and Tyreel Weirs that is the target zone for Category 1 fish (river) and will receive Commonwealth environmental water within each watering year. Macroinvertebrate sampling using the river channel sampling protocol for will occur at the 3 locations aligned with Fish River sampling (below) to provide explicit links among these indicators and provide an assessment of a functional ecosystem response.

Gwydir			Easting	Northing
	GWR1-C1	56J	209205.00 m E	6740456.00 m S
	GWR2-C1	55J	783417.00 m E	6743136.00 m S
	GWR3-C1	55J	775598.00 m E	6741492.00 m S

#### *Watercourse sites*

The second zone utilises the wetland/floodplain sampling protocol to sample the Gingham watercourse at Bunnor and the Gwydir watercourse at Old Dromana that are characterised by an extensive floodplain wetland network and will allow an assessment of connectivity. Sampling will occur within representative

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sites in each of the dominant wetland vegetation communities inundated by Commonwealth environmental water. In Bunnor sampling will be stratified within water couch, typha and open water habitats. At Old Dromana sampling will be stratified within water couch, marsh clubrush and coolabah sites. Macroinvertebrate sample sites in these watercourses will be aligned with the vegetation sample location.

This design will allow Basin scale reporting with replication (n=3) for each of river channel and watercourse habitats, and alignment with Fish (River) sites.

The rationale underlying this approach is to seek as much synergy as possible with the fish (river) indicator for channel sites, and the links between watercourse inundation, water chemistry, metabolism and macroinvertebrates. Only a single composite sample (comprised of either 5 benthic cores or 5 pelagic buckets) is taken from each site or vegetation habitat within a site. This will reduce the overall number of samples for laboratory processing and align with other Selected Areas.

### **1.18 Monitoring Design**

#### *Macroinvertebrate River and watercourse*

Macroinvertebrate indicator monitoring will be conducted following the Standard Operating Procedures in Hale *et al.* (2013).

### **1.19 Timing and Frequency**

At each of the 3 Category 1 Fish River sites, macroinvertebrate sampling will take place on 4 occasions from the commencement to the cessation of environmental water delivery (approx. October through to March).

At each watercourse site, macroinvertebrate sampling will take place following watercourse inundation with Commonwealth environmental water. Four sample events are planned to follow the inundation and contraction cycle, sampling immediately (days) after inundation, at peak area inundation, and at two times during the drying cycle.

### **1.20 Responsibilities**

The Project Manager of the Gwydir M&E Project Team is responsible for overseeing this procedure.

An ecologist will be responsible for the field collation of data and laboratory processing of samples under the direction of Project co-Director (Ryder), who will conduct the analyses and reporting.

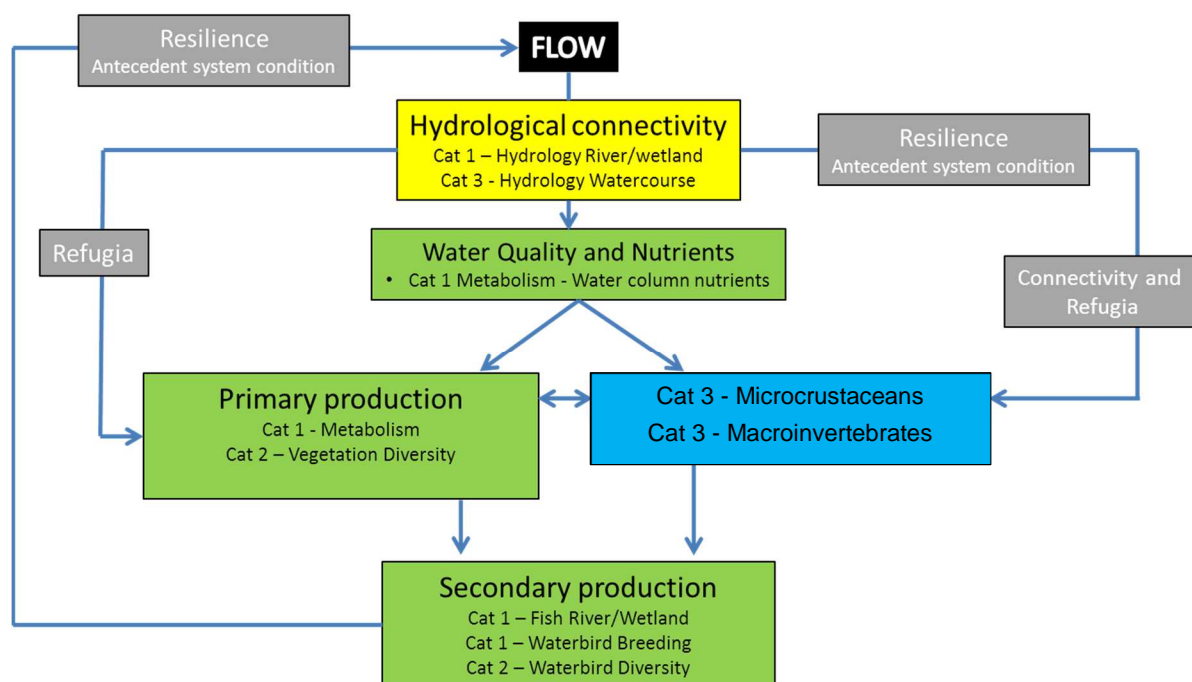
#### *Complementary monitoring and data*

The following indicators measures in the lower Gwydir will be included as complementary monitoring data to inform the ecosystem function response of each of the river channel and watercourse floodplain wetland systems.

- Hydrology River
- Hydrology Watercourse
- Fish River
- Fish Larvae
- Metabolism
- Vegetation Diversity
- Waterbird Breeding



The cause and effect diagram below demonstrates the functional and food web links provided by macroinvertebrates in river channel and floodplain watercourse habitats in the Gwydir Selected Area.



## 1.21 Detailed methods

### 1.21.1 Sampling protocol

This protocol follows the standard AUSRIVAS protocol of sampling every edge habitat that is present in the sampling reach (Hale *et al.* 2013). This modified method is a replicated procedure where each replicate represents a similar sweep length and contains the same percentage of edge habitat type. For this method, four habitat types are recognised: bare edge, macrophyte beds, snags, and leaf packs.

At a site, the major habitat types will be identified within the reach (bare ground, snags, macrophyte beds, leaf litter deposits) and estimate their relative percent cover within the reach (this estimate will determine how much of each habitat type is sampled from). Each habitat should be sampled to a degree dependent on its occurrence, with a full sample spanning a total of 10m of edge habitat. After sampling has been undertaken the sample will be rinsed to reduce fine sediment and coarse leave and twigs will be washed and removed from the sample. The sample will then be transferred to a sample jar and the sample will be preserved with 70% ethanol.

#### Equipment

- Hand sweep net 250 µm mesh, D-opening of 300mm X 300mm with a depth of 500mm.
- Buckets (2 per person)
- Set of 2 Seives – 10 mm, 250 µm mesh (1 per person)
- 500 ml sample jars (3 per replicate)
- labels

#### Laboratory sample processing - macroinvertebrate

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Entire samples should be preserved individually in 70% ethanol and returned to the laboratory for macroinvertebrate identification and enumeration. Whole samples should be examined in bogorov trays and the contents identified to Class, Order and family level.

### **1.22 Data analysis**

At the Selected Area scale a number of hypotheses that relate to the outcomes of delivery of Commonwealth environmental water are possible. We aim to standardise methods and data definitions with the Murrumbidgee and Warrego-Darling Selected Areas to facilitate Basin Scale evaluation.

In river channel habitats quantitative analyses will be possible for macroinvertebrate density and community composition for time since watering, with multivariate analyses such as nMDS (and modules including Simper, BioEnv, DISP, PCA) will be used to explore patterns among dependant and covariate variables such as water quality and fish (river).

In watercourse habitats, quantitative analyses will be possible for macroinvertebrate density and community composition for time since watering and vegetation community, with multivariate analyses such as nMDS (and modules including Simper, BioEnv, DISP, PCA) will be used to explore patterns among dependant and covariate variables such as water column nutrient and carbon concentrations, metabolism and waterbird breeding/diversity.

### **1.23 Reporting**

Basin and Selected Area scale reporting will conform to the LTIM Data Standard (Brooks and Wealands 2014) to facilitate data management within the LTIM Monitoring Data Management System (MDMS).

### **1.24 Conceptual definition**

This indicator will contain rows of data about a site that is:

*“a River site covers a 100m stretch of channel , within which the diversity of habitats are represented and sampled.”*

*“a Watercourse site covers a 100m stretch of inundated floodplain, within which the diversity of habitats are represented and sampled.”*

Each row of data will describe:

*“the characteristics of macroinvertebrate assemblages based on density of individuals of a specific taxa at the site in the period defined by the date/time range.”*

### **1.25 Site linkages**

Sites of macroinvertebrates require the following linkages to other data (where available):

- site identifiers for representative hydrological indicator data for the river channel
- site identifiers for representative hydrological indicator for the watercourse
- ANAE identifiers to enable linking with framework datasets for future work

### **1.26 Data definition**

*Each row of data will contain the following columns of information.*

Variable	Description	Type	Req	Range	Example
siteId	A site that covers a 100m stretch of the channel or watercourse represented by either a name or polygon, within which the diversity of habitats are represented and sampled	string	Y		EDWK04_057
siteType	Channel or Watercourse	category	Y		Channel
sampleDate	Start date (inclusive) that these measures were observed	dateTime	Y		15/05/2014 0:00
sampleDateEnd	End date (exclusive) that these measures were observed	dateTime	Y		15/05/2014 0:00
higherTaxaName	Latin name of order, class, phylum for taxa that cannot be identified to family or below	string	Y		Cladocera
familyName	Latin name of family	string	N		Chydoridae
numberIndividuals	total number of individuals (after multiplying up subsamples)	Integer	N	0 - infinity	1222
densityIndividuals	total density of individuals (individuals/m <sup>2</sup> )	Number (2 decimal places)	Y	0 - infinity	12.22 individuals/m <sup>2</sup>

### 1.27 Quality Assurance/Quality Control

Quality control and quality assurance protocols are documented in the Quality Plan developed as part of the M&E Plan for all Selected Areas. This method requires a number of QA/QC procedures outlined below:

- All staff will follow the Safe Work Method Statement for field and laboratory work
- Standardisation of macroinvertebrate sampling equipment
- Sample exchange between Murrumbidgee and Gwydir teams
- Water chemistry samples will have a QA/QC check via 10% sample exchange with NATA laboratory at the NSW OEH Lidcombe laboratories
- Field duplicate and blank samples will be collected following the Standard Method
- Holding times for water quality samples will follow the procedures provided by the processing laboratory
- Preservation and transport of water quality samples will follow the procedures provided by the processing laboratory.
- Data management will follow the Gwydir QA/QC protocols.

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### 1.28 References

Brooks S and Wealands S (2014) *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project: Data Standard*. Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre, MDFRC Publication 29.3/2013 Revised Jan 2014, 29pp.

Hale J., Stoffels R., Butcher R., Shackleton M., Brooks S. & Gawne B. 2013. *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project – Standard Methods*. Final Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre, MDFRC Publication 29.2/2014, January, 182 pp.

## B.11 SOP – Waterbird Breeding (optional)

### 1.1 Objectives

This monitoring protocol aims to understand the contribution of Commonwealth environmental water to colonial waterbird breeding success.

### 1.2 Indicators

The Waterbird Breeding indicator links to the Microcrustaceans, Vegetation Diversity, and Hydrology (Watercourse) indicators.

Colonial bird breeding events and fledgling success will be monitored.

### 1.3 Locations for monitoring

There are several well-known colonial bird rookeries within the Gingham-Gwydir Watercourse; these rookery areas will be the target of the survey effort (Figure 5-71).

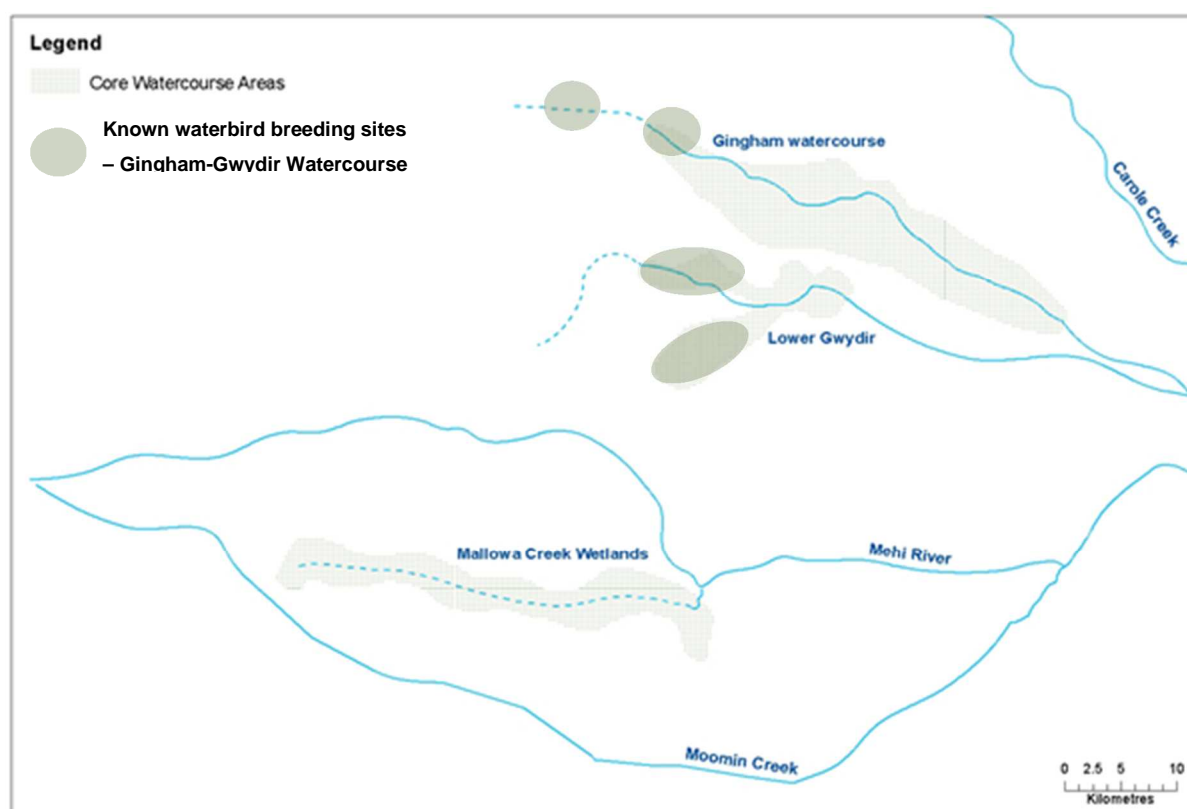


Figure 1: Watercourse areas

### 1.4 Timing and frequency

Monitoring of Waterbird Breeding is event driven. The M&E Plan (CEWO 2014) has provided for monitoring of 2-3 Commonwealth environmental water assisted bird breeding events during the 5 year project.

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## **1.5 Responsibilities**

The Project Manager of the Gwydir M&E Project Team is responsible for overseeing this procedure. The field surveys will be led by experienced bird ecologists.

## **1.6 Complementary monitoring and data**

Existing breeding information for each Selected Area will be used in the first instance to aid in identifying potential monitoring locations (sites). Diversity data for non-breeding birds will be opportunistically collected during waterbird breeding surveys (see Section 10 of the LTIM Standard Methods: Waterbird Diversity, Hale et al. 2014).

## **1.7 Detailed methods**

The key rookery sites are well-known in the lower Gwydir Watercourse area. We will rely on communication networks with the key stakeholder communities (LTIM survey staff, landholders, birdwatchers and government department/agency staff) to identify bird breeding events or potential events linked to Commonwealth environmental water. Survey will be initiated by identified commencement of bird breeding events and agreement with CEWO to undertake targeted monitoring.

At key rookery sites (approximately 5) 10 fixed cameras will be used to sample representative nesting areas across each selected rookery site.

On-ground surveys will be conducted at least monthly during the events.

Hydrology will be determined via the Hydrology (Watercourse) indicator.

The monitoring design complies with the standard methods using fixed cameras (Hale et al. 2014). Waterbird Species and codes as field recording sheets are also provided.

## **1.8 Data analysis**

Please refer to the LTIM Standard Methods (Section 9 Waterbird Breeding, Hale et al. 2014) for prescribed data analysis.

### **1.8.1 The Selected Area scale hypotheses**

Short-term (Annual) responses:

1. The delivery of Commonwealth environmental water to key rookery sites in the lower Gwydir will lead to successful nest establishment by colonial waterbirds
2. The delivery of Commonwealth environmental water to key rookery sites in the lower Gwydir will lead to the successful fledgling of colonial waterbirds
3. The delivery of Commonwealth environmental water to key rookery sites in the lower Gwydir will lead to increased diversity and abundance of nesting adult colonial waterbirds (link to Waterbird Diversity Indicator).

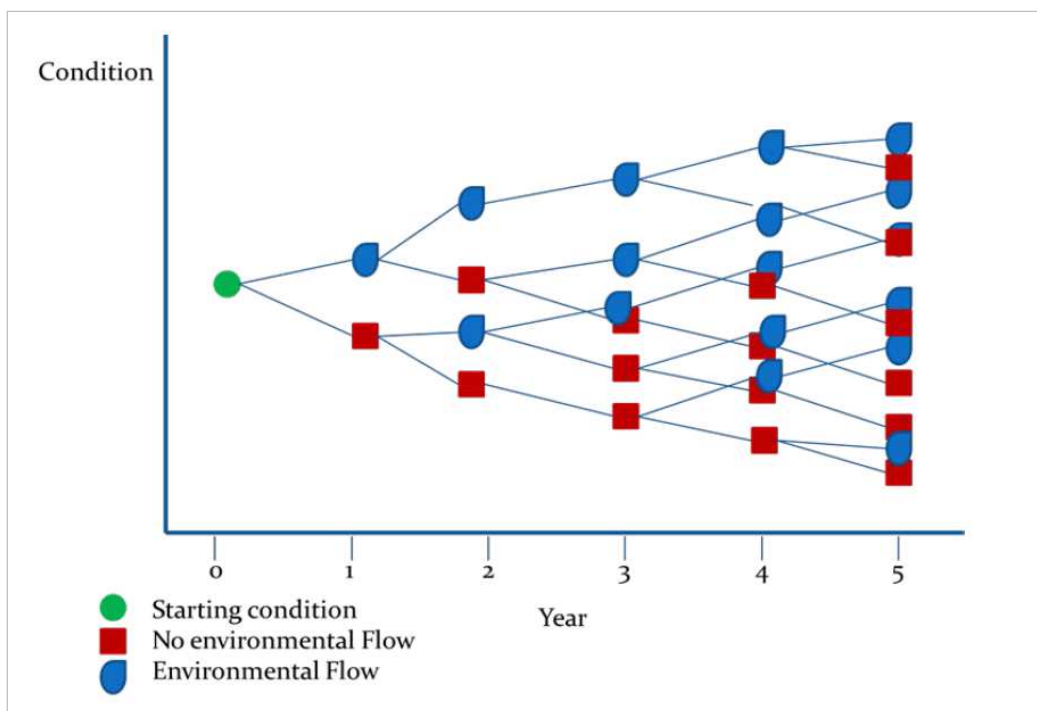
Long-term (5 year) responses:

4. The delivery of Commonwealth environmental water to key rookery sites in the lower Gwydir will lead to repeated successful nest establishment by colonial waterbirds
5. The delivery of Commonwealth environmental water to key rookery sites in the lower Gwydir will lead to the repeated successful fledgling of colonial waterbirds

6. The delivery of Commonwealth environmental water to key rookery sites in the lower Gwydir will lead to increased Selected Area diversity and abundance of adult colonial waterbirds (link to Waterbird Diversity Indicator).

### 1.8.2 The Selected Area scale analyses

Analyses based on Aggregation will be applied at the Basin-scale and Selected Area scales for taxonomic diversity and richness, and nesting and fledgling success. Qualitative and quantitative analyses will be applied at the Selected Area scale to document nesting and fledgling success of colonial waterbirds. Multi-year analyses will be quantitatively assessed based on year-on-year repeat application of annual models outlined in the Selected Area conceptual model (Figure 2). The placement of water level devices at each location to quantify hydrologic connection and inundation metrics will reduce uncertainty in quantifying the delivery of Commonwealth water to rookery sites.



**Figure 2: A hypothetical model that will be applied on a year-to-year basis to generate a series of outcomes from different flow regimes over a five year period (Source: Gawne et al. 2014)**

Short-term (Annual) responses:

1. Hypotheses 1 and 2 - univariate analysis (main effect – rookery site, season), nesting and fledgling success
2. Hypotheses 3 - (diversity-abundance) multivariate analysis (factors – rookery site /season).

Long-term (5 year) responses:

1. Hypotheses 4 and 5 - univariate analysis (main effects – rookery site /year/season), nesting and fledgling success
2. Hypotheses 4, 5 and 6- (diversity-abundance) multivariate analysis (factors – rookery site /year/season).

---

## 1.9 Reporting

The standard method for Waterbird breeding reports area (m<sup>2</sup>) ANAE typology inundated from Commonwealth environmental water. The indicator Watercourse (Hydrology) will document the area (m<sup>2</sup>) of inundation and vegetation/habitat mapping will facilitate the scaling of potential colonial waterbird breeding sites/success to the lower Gwydir.

The variables required to be reported for each colony for each survey conducted for Waterbird Breeding are:

- Location (polygon of the colony)
- ANAE Wetlandid
- Size of wetland surrounding colony (ha)
- Number of nests of each species per vegetation type / structural habitat
- Number of nests in each nesting stage for each species
- Estimate of number of nests successfully fledged for each species (i.e. one or more chicks fledged per nest) since last survey
- Estimate of the mean number of chicks thought to have fledged per successful nest for each species, where possible (for nests fledged since last survey)
- Number of adults of each species
- Vegetation type, condition scores
- Observations of colony level disturbance (e.g. predators, other disturbance agents, or probable causes of colony desertion).

All data provided for this indicator must conform to the data structure defined in the LTIM Data Standard (Brooks & Wealands 2014).

## 1.10 Quality assurance/quality control

Quality control and quality assurance protocols are documented in the Quality Plan developed for the M&E Plan (CEWO 2014).

QA/QC requirements specific to this protocol include:

- All Waterbird Breeding assessments will be undertaken by the same experienced observers, where possible, over time to maintain consistency
- Observers must undergo training prior to undertaking monitoring surveys, including calibration against experienced observers to ensure standardisation of measurements. Training and calibration procedures must be documented in the M&E Plan and relevant records maintained
- A minimum of two staff will be assigned to Waterbird Breeding surveys to minimise the variation associated with different observers. Where there are significant differences in original observer scores, observers will discuss their rationale and where appropriate adjust scores to mutually agreed values.



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## 1.11 References

Brooks S. & Wealands S.R. 2014. *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project: Data Standard*. Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre. MDFRC Publication 29.3/2013 Revised Jan 2014.

Commonwealth Environmental Water Office (CEWO). 2014. *Long Term Intervention Monitoring Project Gwydir River System Selected Area*. Commonwealth of Australia.

Gawne B., Hale J., Butcher R., Roots J., Brooks S., Cottingham P., Stewardson M. & Everingham P. 2014. *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project: Evaluation Plan*. Final Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre, MDFRC Publication 29/2014.

Hale J., Stoffels R., Butcher R., Shackleton M., Brooks S. & Gawne B. 2013. *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project – Standard Methods*. Final Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre, MDFRC Publication 29.2/2014, January, 182 pp.

## Appendix C Cause and Effect Diagrams

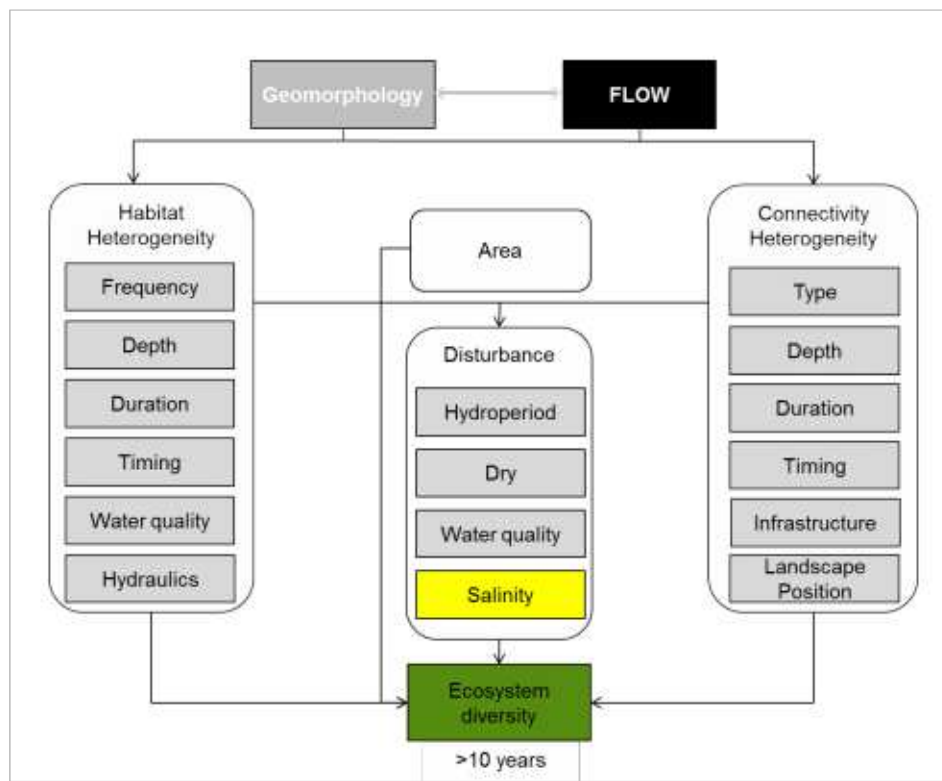


Figure C11-1: Landscape Ecosystem Diversity CED (MDFRC 2013)

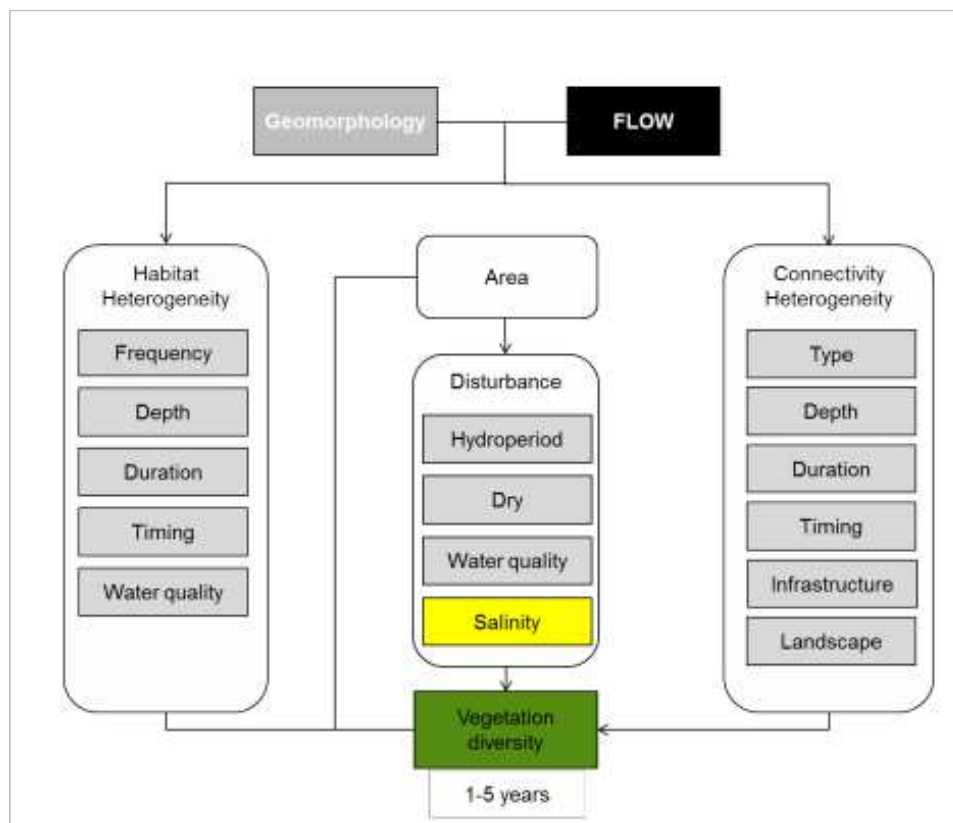


Figure C11-2: Vegetation Diversity CED (MDFRC 2013)

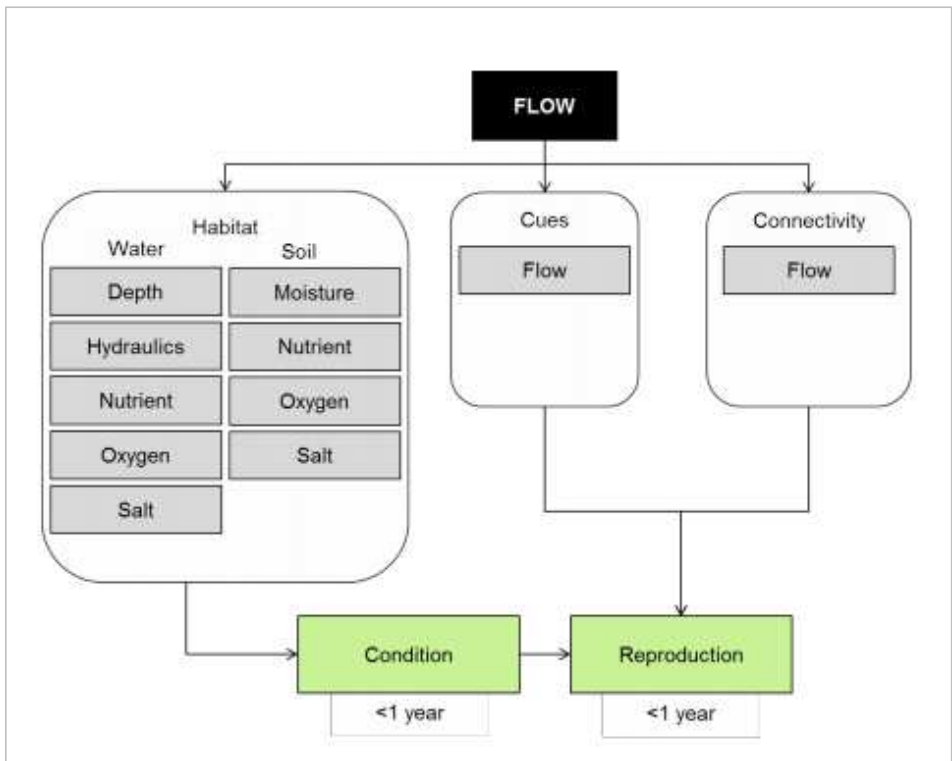


Figure C11-3: Vegetation Condition and Reproduction CED (MDFRC 2013)

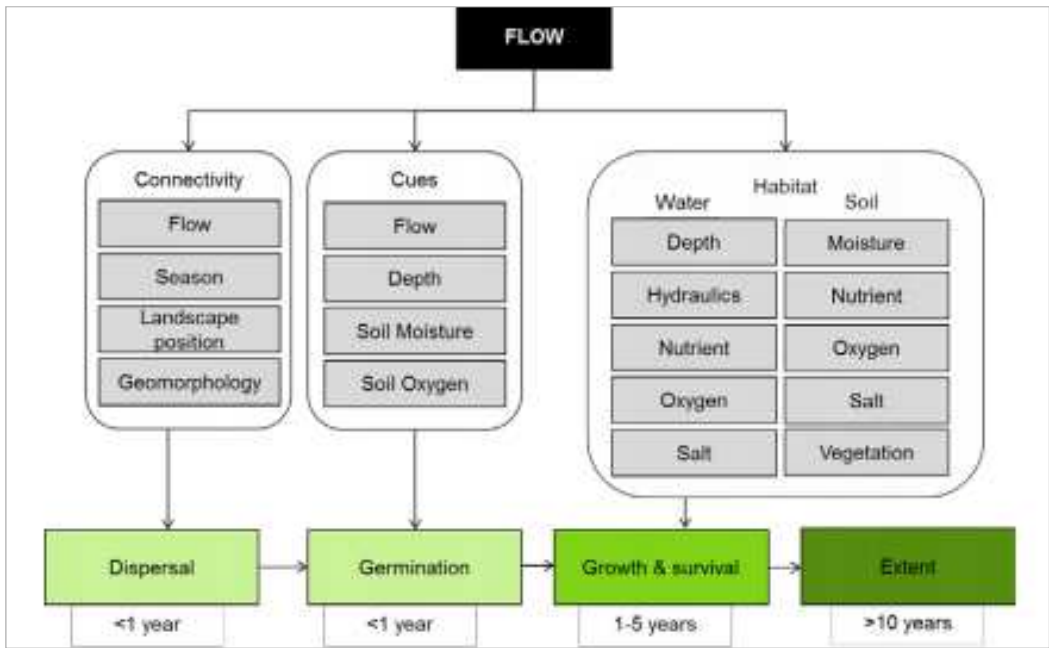


Figure C11-4: Vegetation Recruitment and Extent CED (MDFRC 2013)

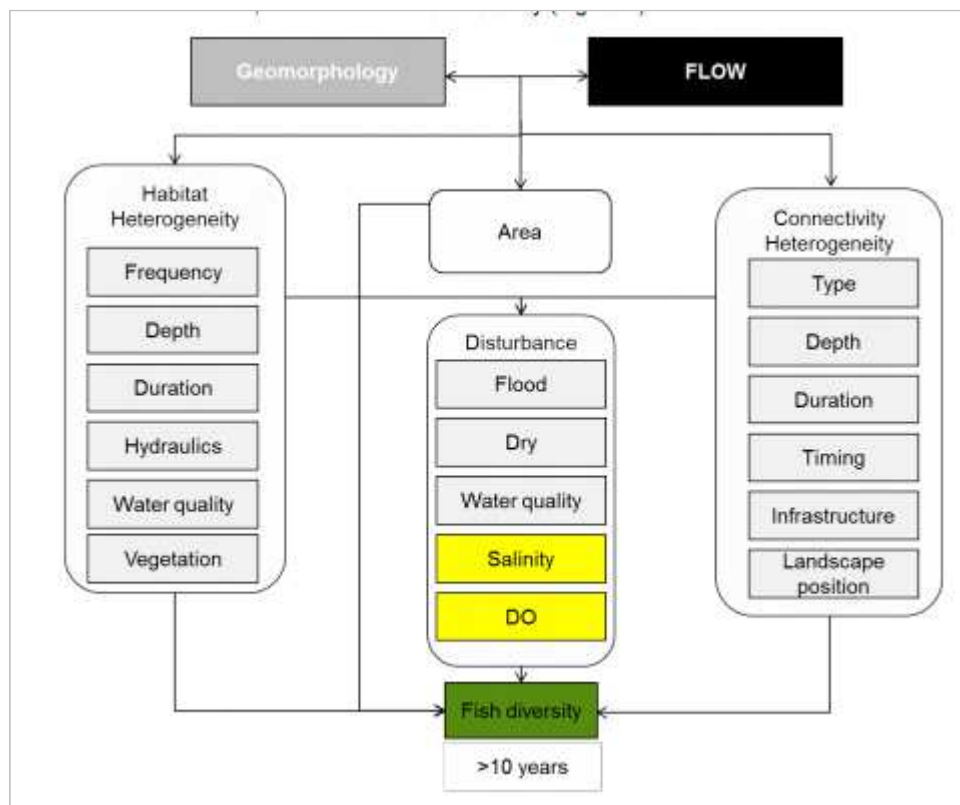


Figure C11-5: Landscape Fish Diversity CED (MDFRC 2013)

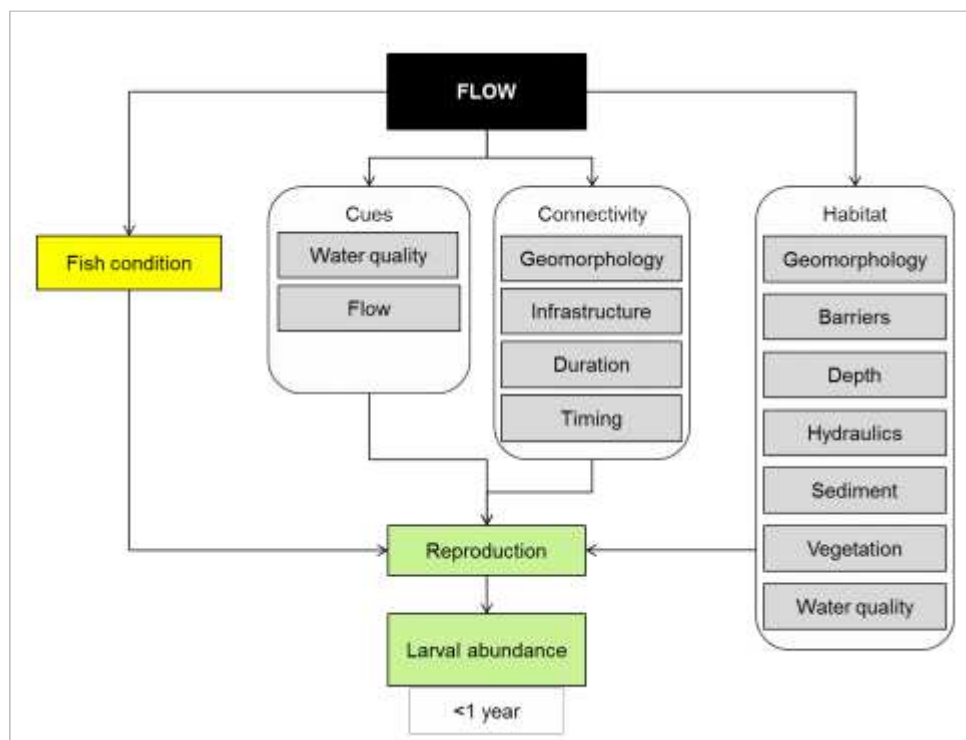


Figure C11-6: Fish Reproduction CED (MDFRC 2013)

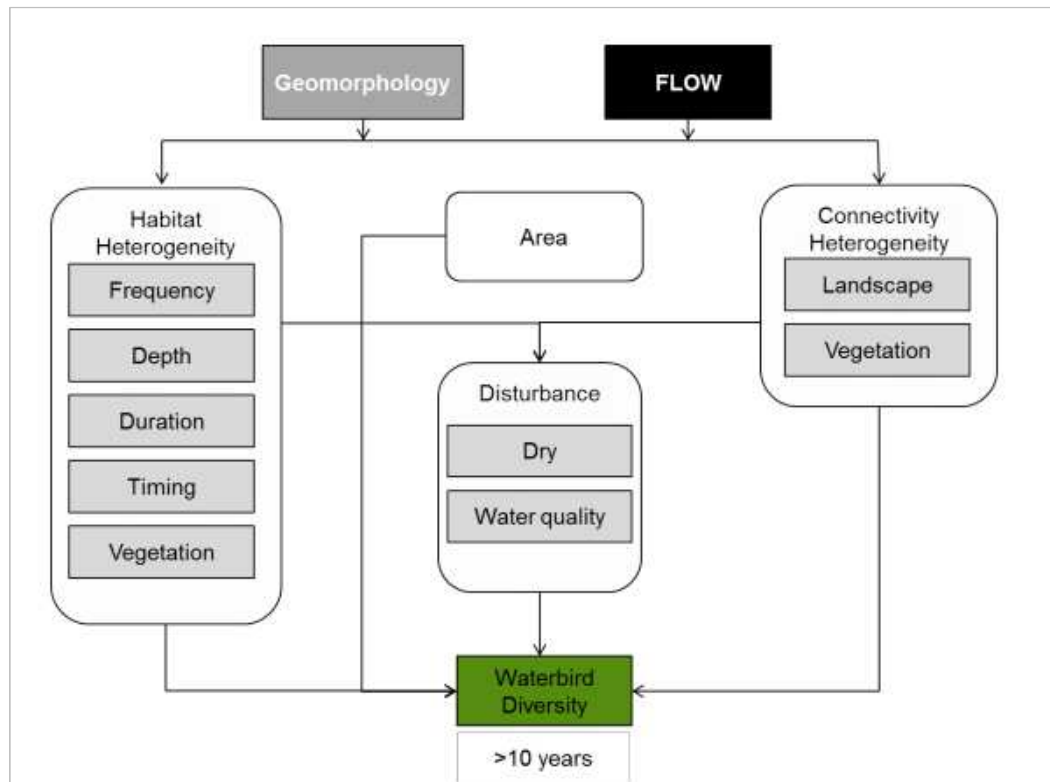


Figure C11-7: Landscape Waterbird Diversity CED (MDFRC 2013)

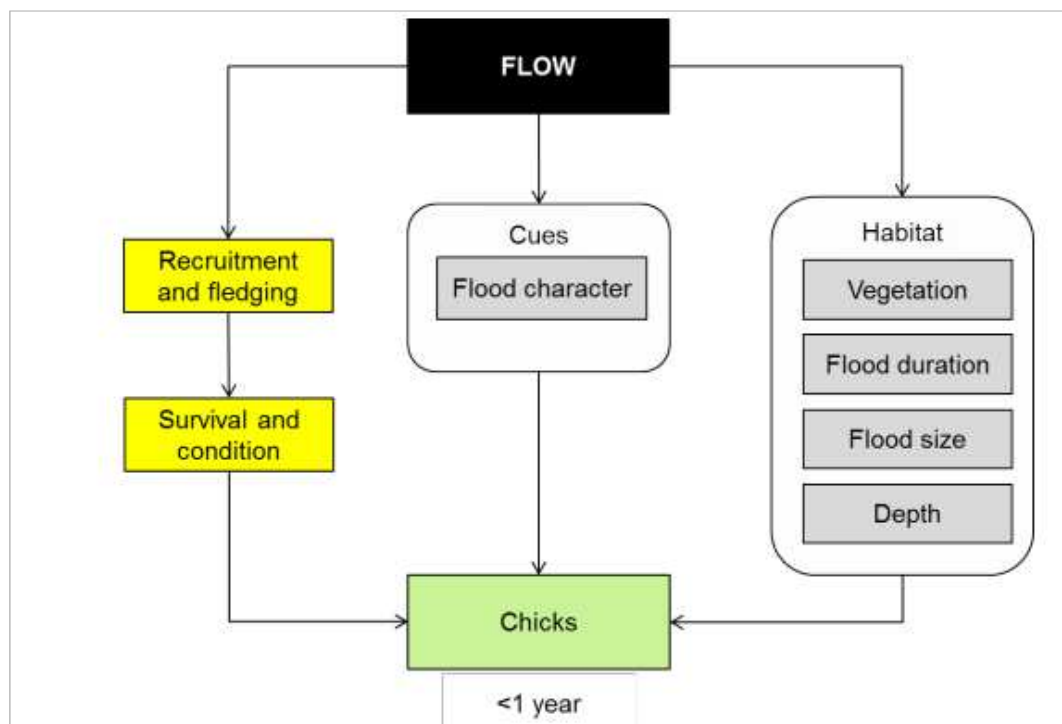


Figure C11-8: Waterbird Reproduction CED (MDFRC 2013)

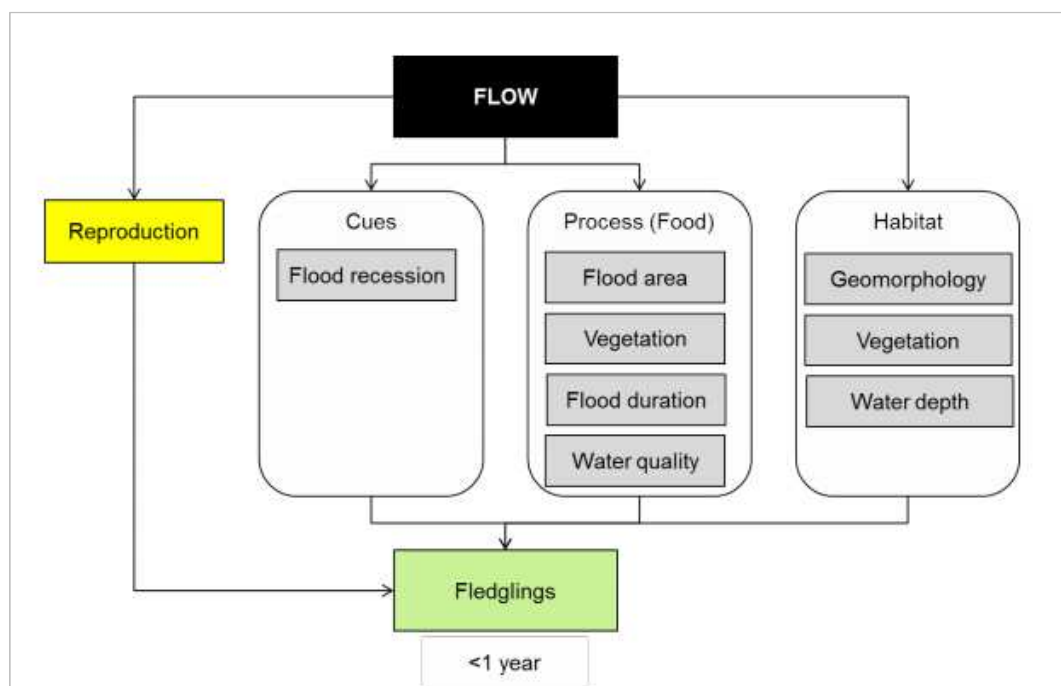


Figure C11-9: Waterbird Recruitment and Fledging CED (MDFRC 2013)

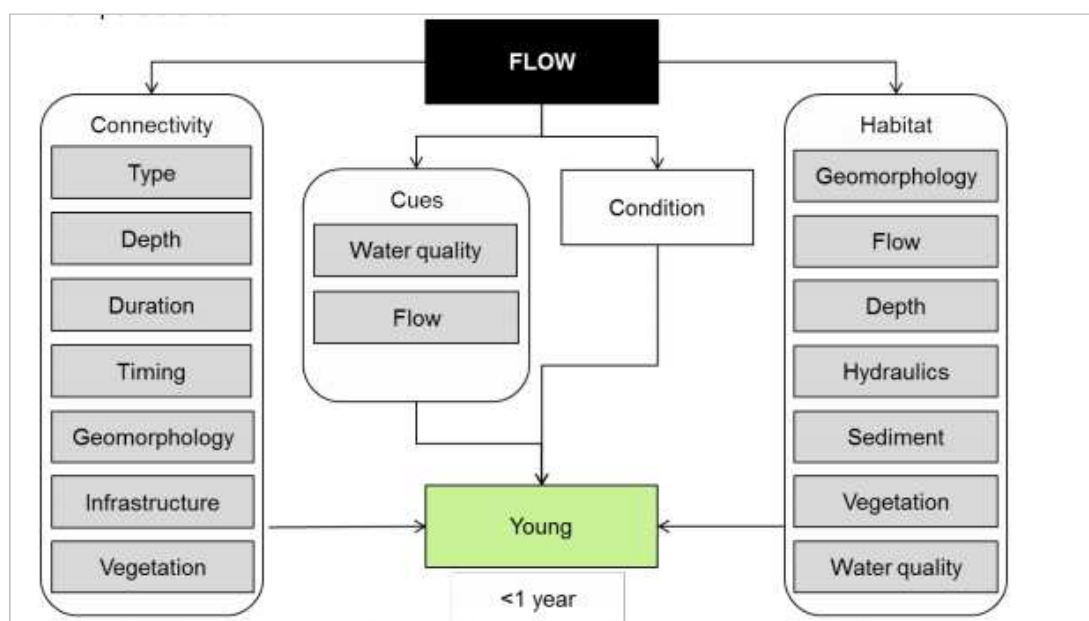


Figure C11-10: Other Vertebrate Reproduction CED (MDFRC 2013)

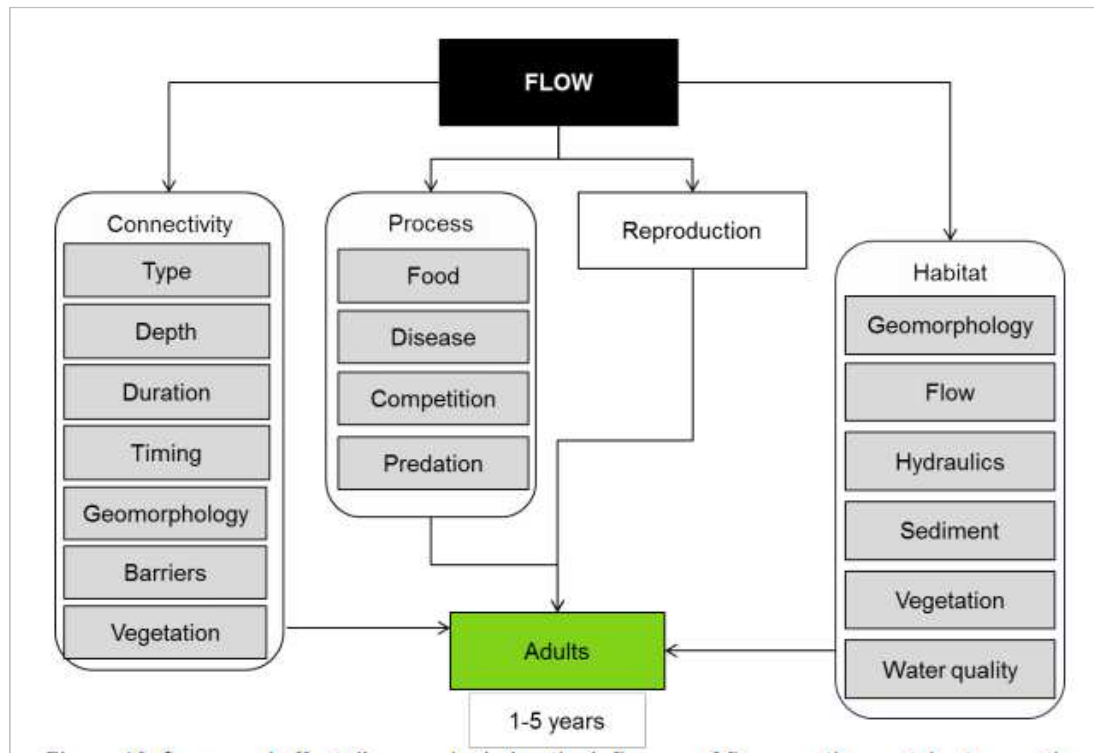


Figure C11-11: Other Vertebrate Growth and Survival CED (MDFRC 2013)

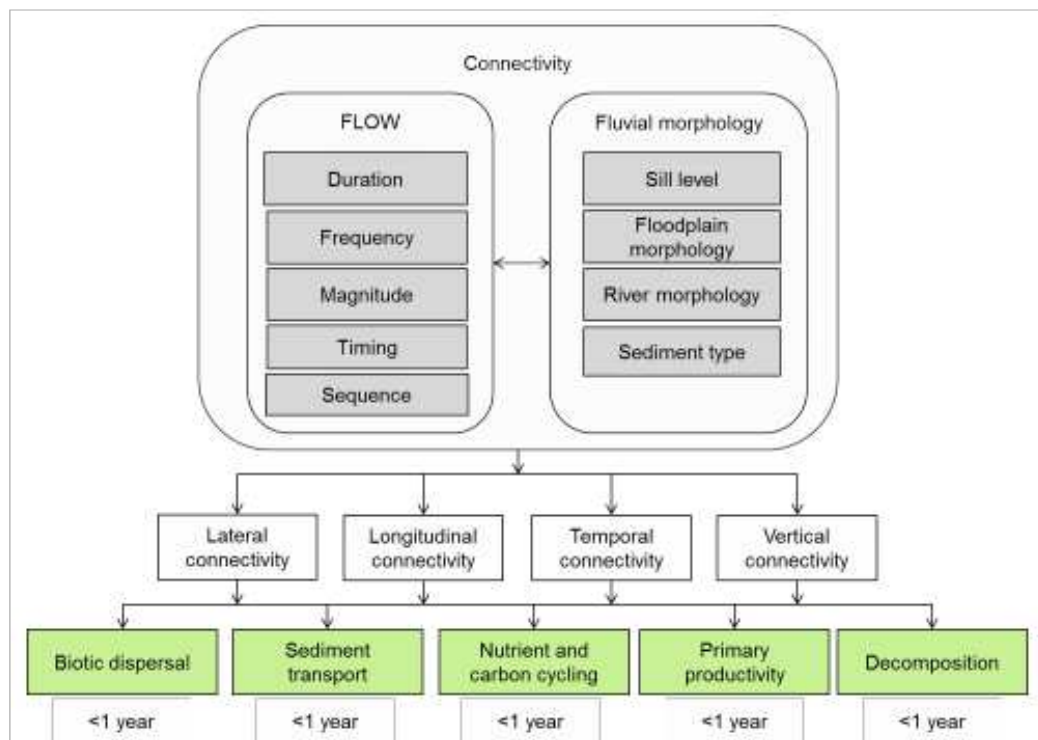


Figure C11-12: Hydrological Connectivity (including end of system flows) CED (MDFRC 2013)

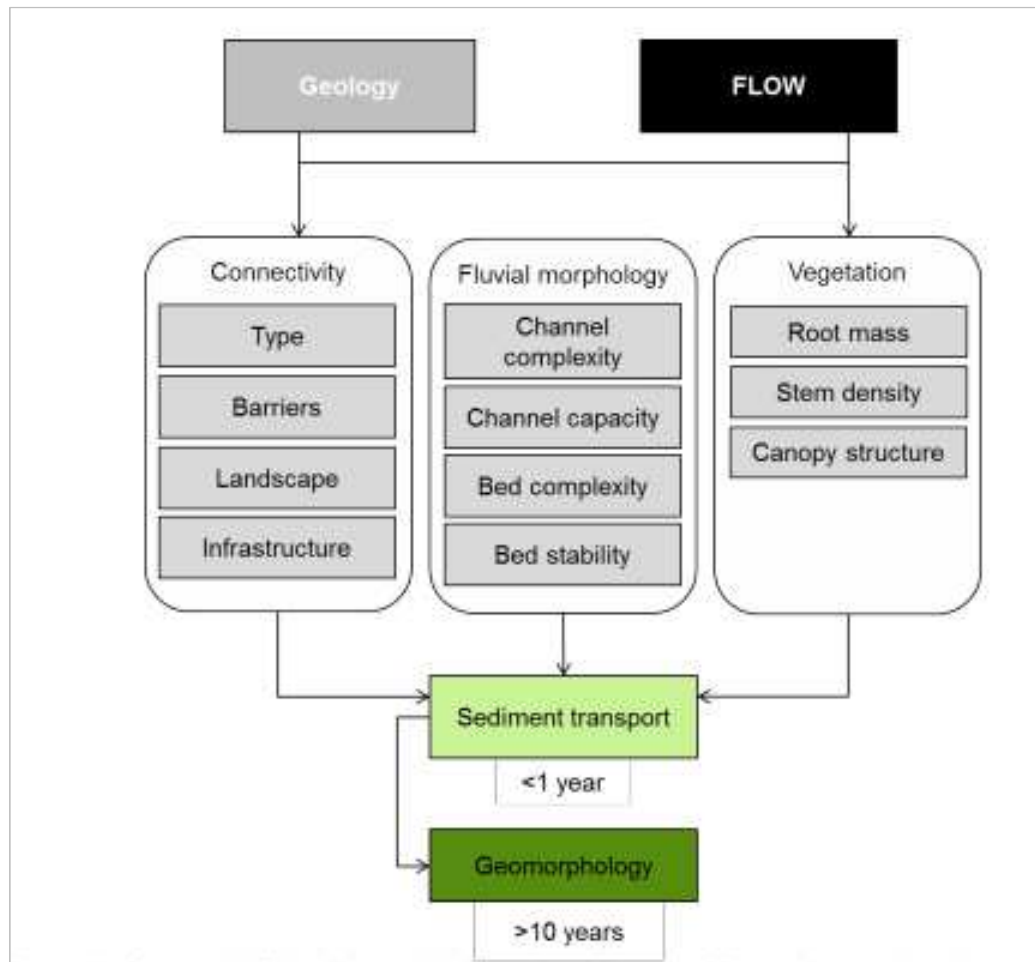


Figure C11-13: Sediment Transport CED (MDFRC 2013)

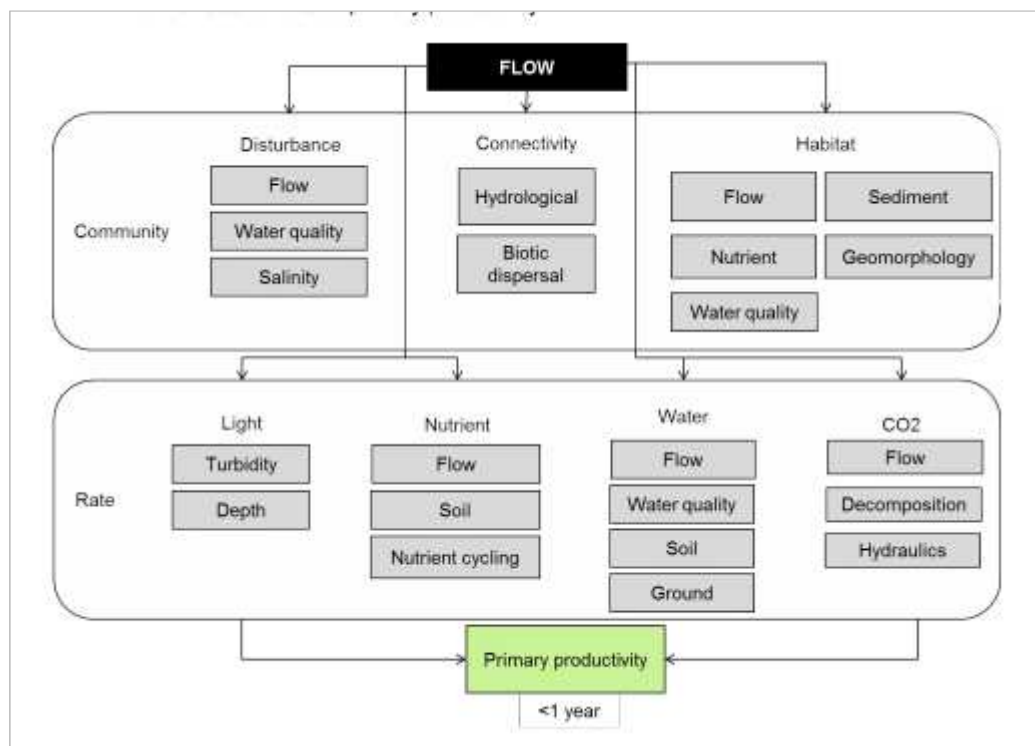


Figure C11-14: Primary Production CED (MDFRC 2013)



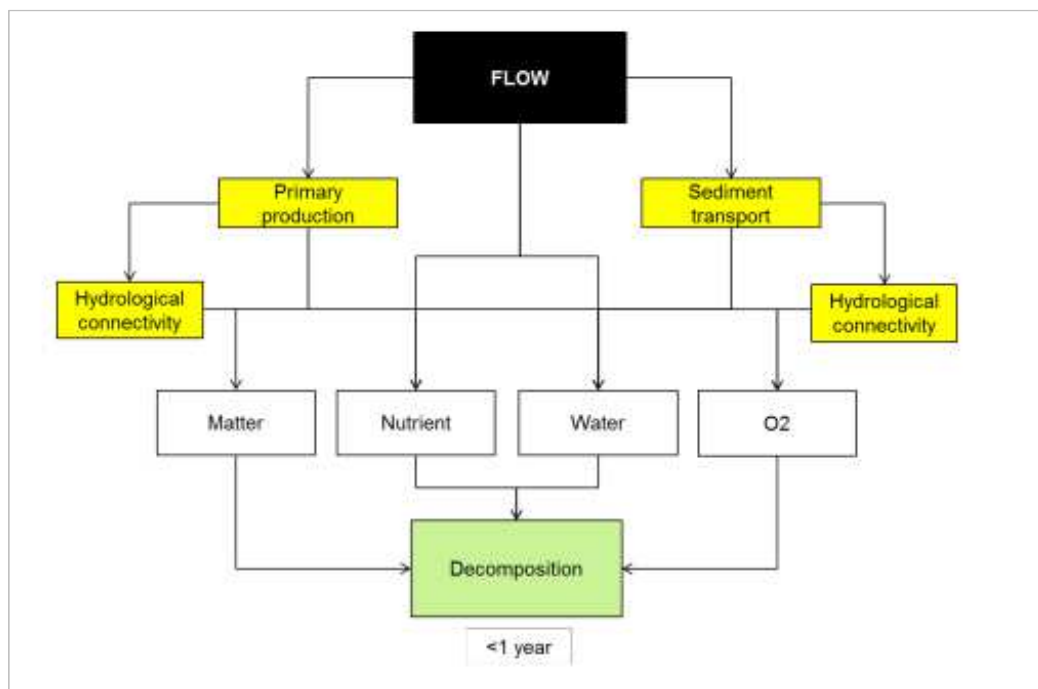


Figure C11-15: Decomposition CED (MDFRC 2013)

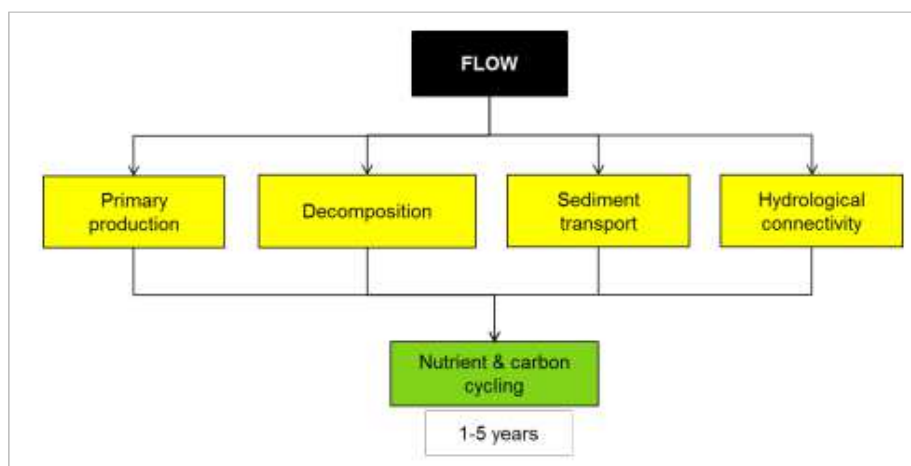


Figure C11-16: Nutrient and Carbon Cycling CED (MDFRC 2013)

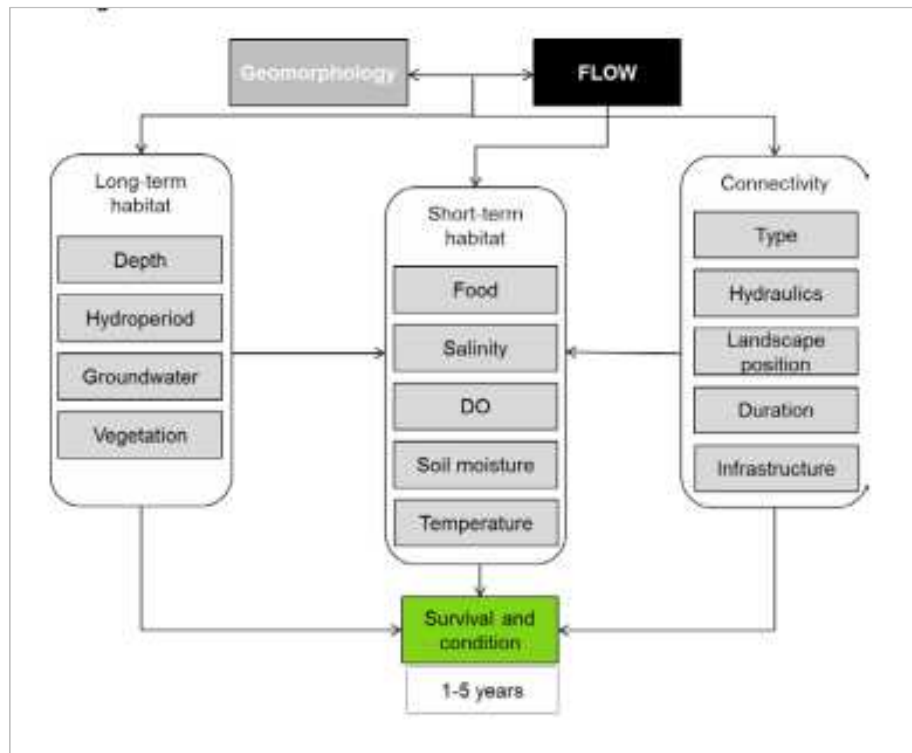


Figure C11-17: Individual Refuges CED (MDFRC 2013)

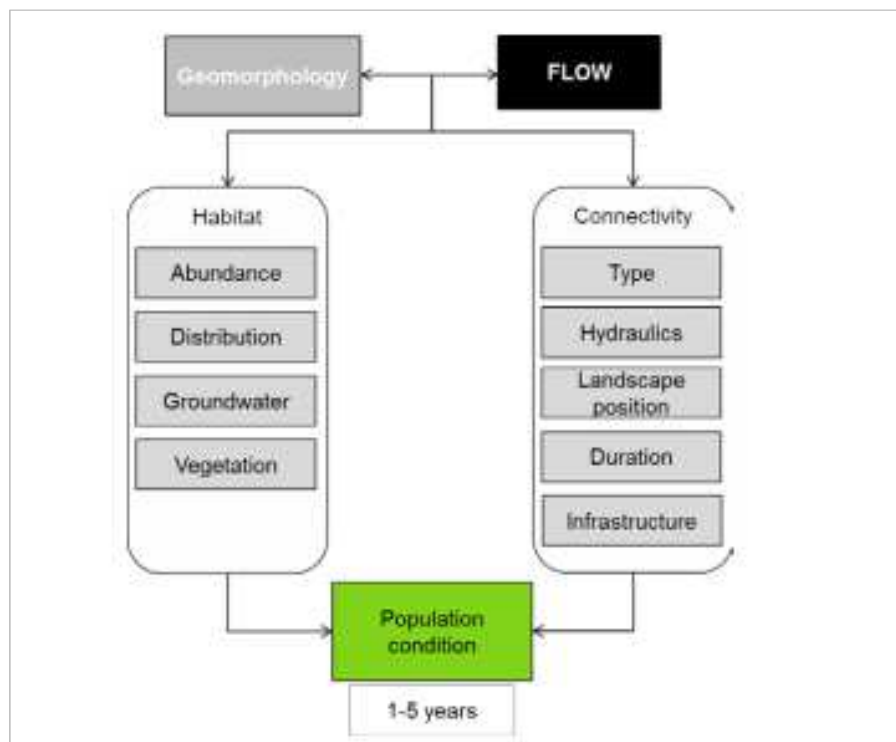


Figure C11-18: Landscape Refuges CED (MDFRC 2013)

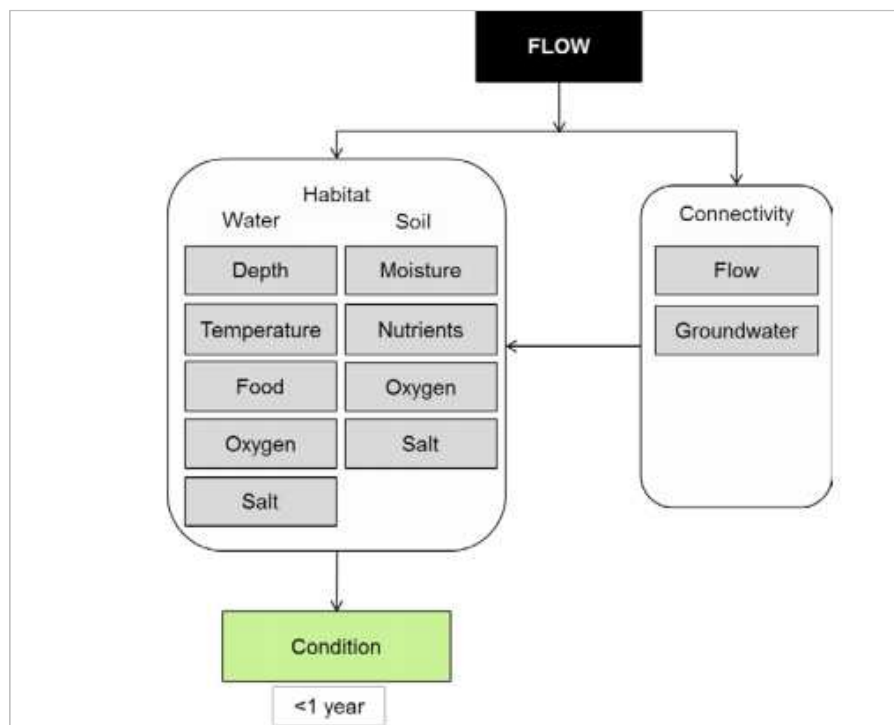


Figure C11-19: Ecosystem Resistance CED (MDFRC 2013)

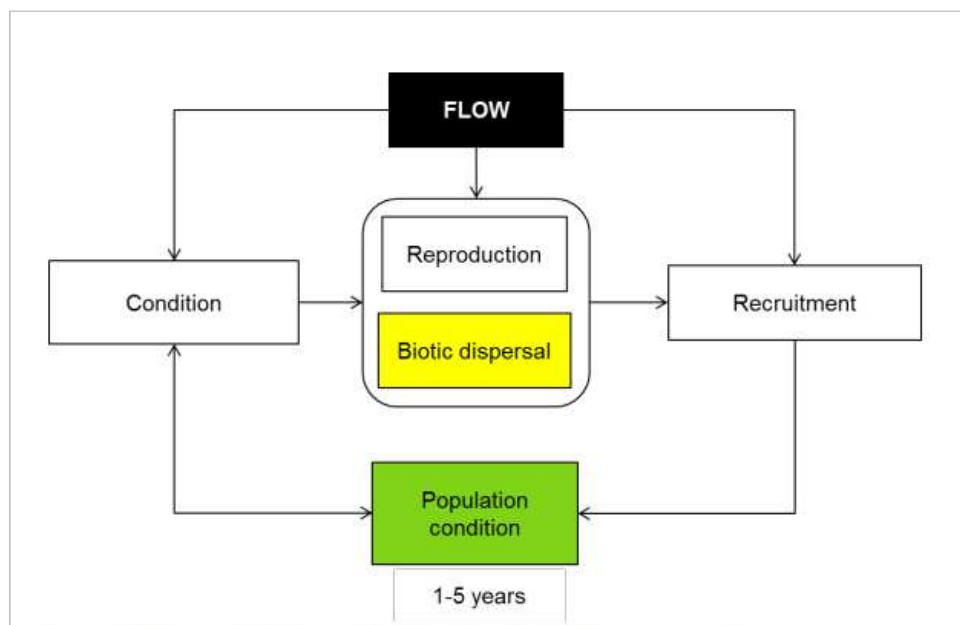


Figure C11-20: Ecosystem Avoidance and Recovery CED (MDFRC 2013)

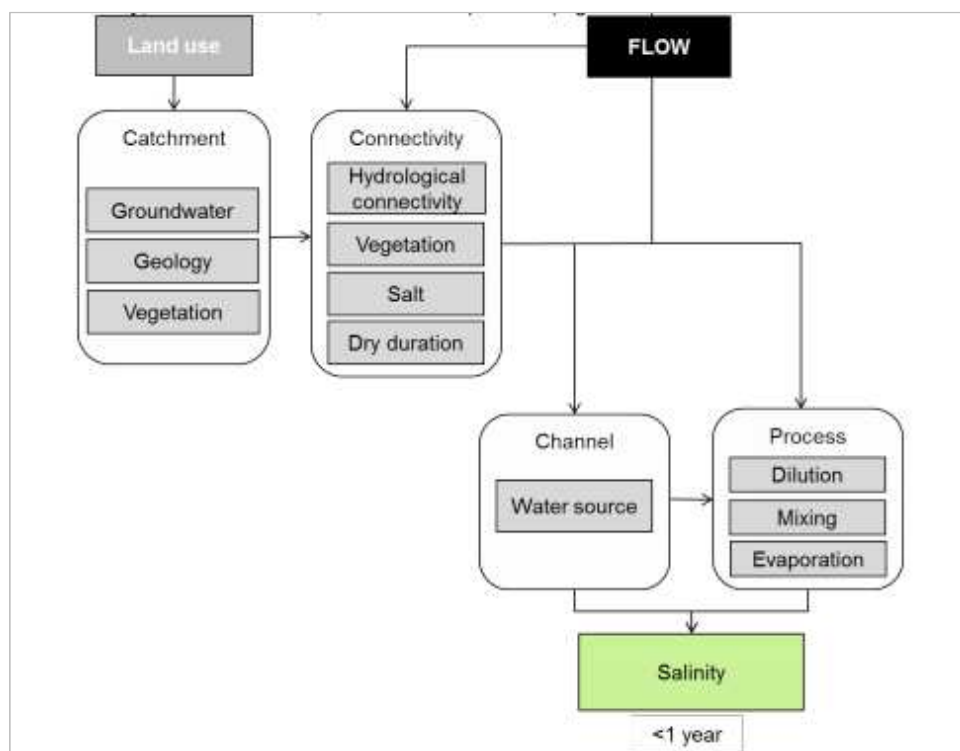


Figure C11-21: Salinity CED (MDFRC 2013)

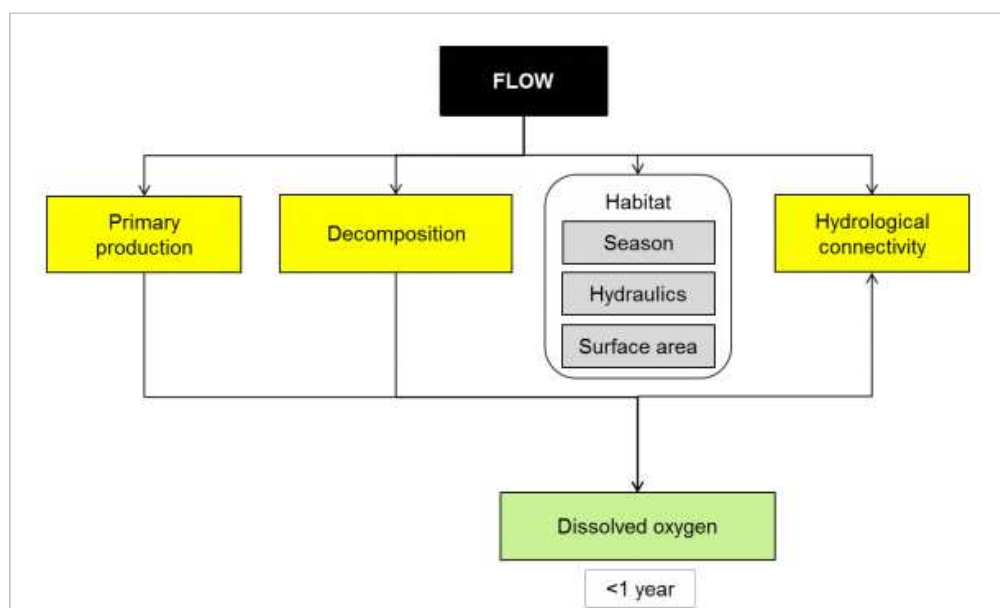


Figure C11-22: Dissolved Oxygen CED (MDFRC 2013)

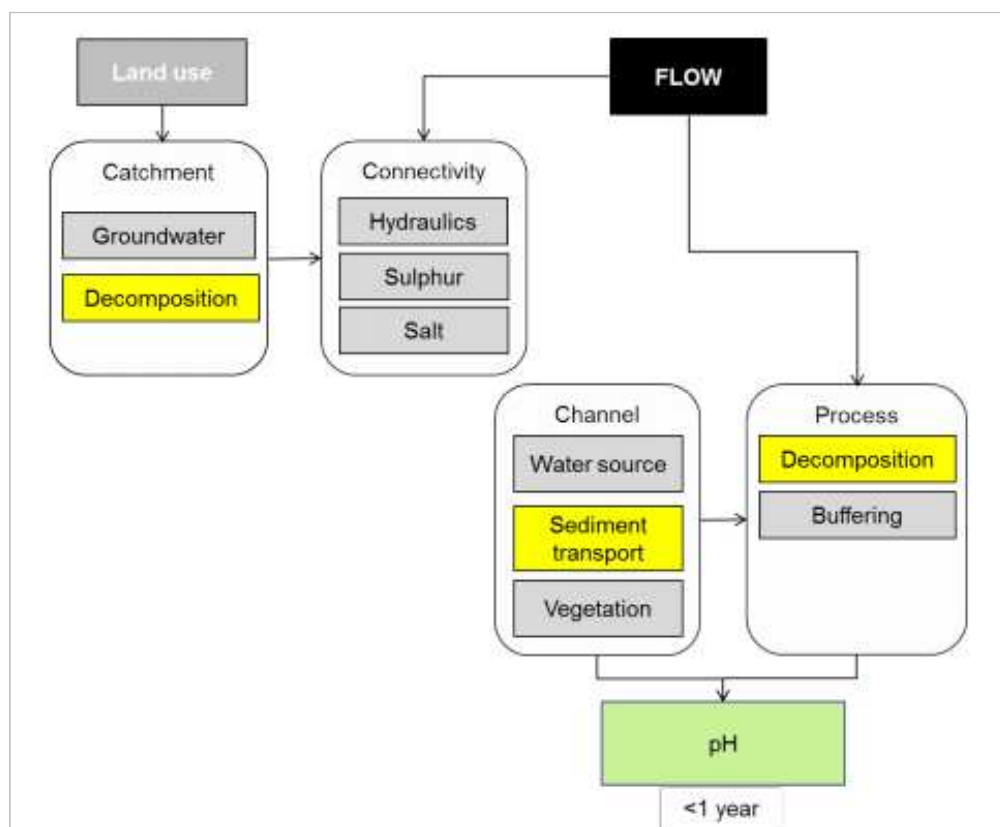


Figure C11-23: pH CED (MDFRC 2013)

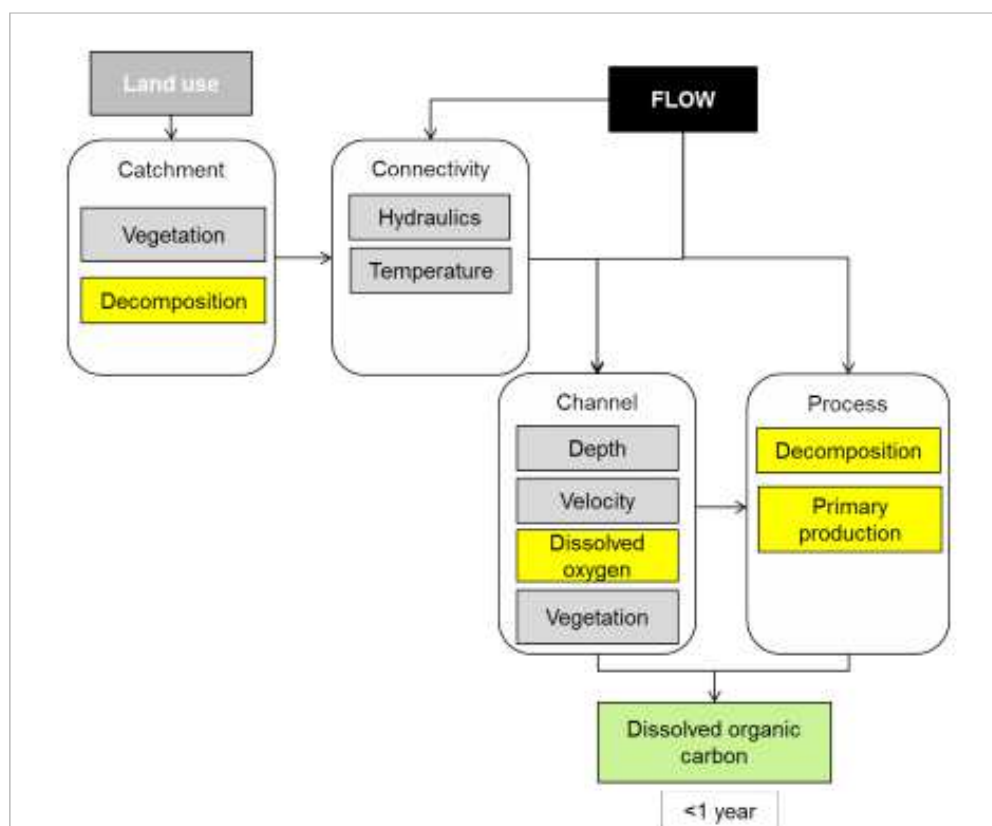


Figure C11-24: Dissolved Organic Carbon CED (MDFRC 2013)

## Appendix D    Communications Plan



Australian Government

Commonwealth Environmental Water Office



**Communications Plan  
Commonwealth Environmental Water Office  
Long Term Intervention Monitoring Project  
Gwydir Selected Area**

Version 2, 23 October 2014



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Item	Detail
ELA Project Number	13ARMNRM-0001
Project Director/s	Paul Frazier, Darren Ryder
Project Manager	Mark Southwell
Prepared by	Emma Garraway

This document is the Communications Plan for the CEWO LTIM Project for the Gwydir Selected Area. It is to be read in conjunction with the Monitoring and Evaluation Plan for the above project.

Any reviews or changes to this Communications Plan must be recorded in the tables below.

#### Document control

Version	Date	Reviewed by	Approved by
1	28 Feb 2014	Paul Frazier	Paul Frazier
2	23 Oct 2014	Paul Frazier, Darren Ryder	Paul Frazier

Version	Change since previous issue
2	Updated to address CEWO comments



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# Abbreviations

Abbreviation	Description
CEWO	Commonwealth Environmental Water Office
EAC OAC	Environmental Contingency Allowance Operations Advisory Committee
ELA	Eco Logical Australia
LLS	Local Land Services
LTIM	Long-Term Intervention Monitoring
M&E Adviser	Monitoring and Evaluation Adviser
M&E Plan	Monitoring and Evaluation Plan
M&E Provider	Monitoring and Evaluation Provider
MDBA	Murray-Darling Basin Authority
MDFRC	Murray-Darling Freshwater Research Centre
NOW	NSW Office of Water
OEH	(NSW) Office of Environment and Heritage
QA/QC	Quality Assurance / Quality Control
SWC	State Water Corporation (NSW)
UNE	University of New England

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# Introduction

This document is the Communications Plan for the CEWO LTIM Project for the Gwydir Selected Area. It is to be read in conjunction with the Monitoring and Evaluation Plan (M&E Plan) for the above project.

## **Objective**

The objective of this Communications Plan is to provide the mechanisms to facilitate effective and efficient communication between LTIM Project partners for the Gwydir Selected Area.

This Communications Plan has been developed by the Monitoring and Evaluation Providers (M&E providers) for the Gwydir Selected Area, being the project consortium (Eco Logical Australia Pty Ltd (ELA) and the University of New England (UNE)).

This Communications Plan has been developed to guide and direct communications between project partners for the Gwydir Selected Area and more broadly (i.e. the LTIM Project), including:

- The M&E providers (i.e. the ELA/UNE consortium and their subcontractors)

- The Commonwealth Environmental Water Office (CEWO)

- The Monitoring and Evaluation Advisors (M&E Advisors) (i.e. the Murray-Darling Freshwater Research Centre (MDFRC))

- State agencies, including NSW Office of Environment and Heritage (OEH) and NSW Fisheries

- Delivery partners, including the NSW State Water Corporation

- Other key stakeholders and groups, including the Gwydir Environmental Contingency Allowance Operations Advisory Committee (EAC OAC).

## **LTIM Project Code of Conduct**

Collaboration and cooperation are vital to the overall success of the LTIM Project (Figure 2-1). A Code of Conduct has been developed to guide the behaviour of individuals and teams when undertaking monitoring and evaluation activities on behalf of the CEWO.

In all communications related to the LTIM Project, including both operation and external communications, the LTIM Project team will comply with Code of Conduct developed by the CEWO.

## LTIM Project Code of Conduct

The CEWO's LTIM Project is a large, long-term, public facing monitoring and evaluation project. Collaborative, cooperative and safe behaviours will be critical to the overall success of the project. This Code of Conduct has been developed to guide the behaviour of individuals and teams when undertaking monitoring and evaluation activities on behalf of the CEWO. It applies to all personnel involved in the LTIM project and applies in addition to any employer imposed codes.

### LTIM Project expected behaviours

- **Be safe** – the LTIM Project will involve significant periods of field work in potentially hazardous situations. The safety goal for the LTIM Project is “Zero Harm”. Project leads are required to develop and regularly review safety plans for their area. Such plans must be compliant with relevant legislation and all guidance provided by CEWO in the Project Operations Manual. All personnel are required to actively contribute to implementation of work health and safety plans and procedures.
- **Be collaborative** – collaboration will promote the achievement of efficient and effective project outcomes. Efficient and effective collaboration is required within and between the CEWO, M&E Advisers, M&E Providers, Data Management Providers and delivery partners. Communication between personnel working on the LTIM Project is expected to be conducted in a professional and courteous manner, even where differences of opinion are apparent. All personnel are required to actively participate in organised collaboration activities and opportunities.
- **Be mindful** – all personnel are required to be mindful of their legal and ethical obligations under the contract. This includes obligations relating to conflict of interest and intellectual property.
- **Be consistent** – consistency with standard methods, QA/QC protocols and data standards at each Selected Area will be critical for the Basin-scale evaluation. All personnel are required to adhere to documented methods, standards and protocols. Project leads are responsible for ensuring all relevant team members have appropriate understanding and training to carry out their duties.
- **Be respectful** – undertaking monitoring activities in some areas will require access to private land. Project leads are responsible for negotiating access to private land, including negotiating any site specific protocols that must be followed (for examples, protocols relating to notification of access, gate conditions and stock presence). All personnel are required to be respectful when conducting activities on private land and follow any agreed protocols.
- **Be a good representative** – all personnel undertaking work as part of the LTIM project will, in effect, be representing the CEWH and the Office more broadly. All personnel are required to be professional and respectful of landholders and community members, taking active steps to listen to their views and where appropriate, relay these back to the Office.

### Breaches of the Code of Conduct

Breaches of the expected behaviours in this Code of Conduct will be treated seriously. All actual or suspected breaches should be reported to the CEWO project management team for investigation.



Commonwealth Environmental Water Office

Figure 11-1: CEWO LTIM Project Code of Conduct

# Operational communications

An overview of the operational communication activities required for the implementation of the M&E Plan in the Gwydir Selected Area is provided in **Table 11-1**. Reporting commitments are detailed in the M&E Plan.

**Table 11-1: Operational communications activities – meetings**

Activity	Purpose	Attendees (indicative)	Frequency	Responsibility	Engagement process
Project Meetings	Project progress and outcomes	CEWO M&E Provider (Project manager plus others as required)	Monthly	M&E Provider	Telephone/Email correspondence
M&E Adviser meetings (to M&E Provider)	Project approach, methods and technical guidance	CEWO M&E Advisers (Project manager plus technical leads) M&E Providers (Project manager plus technical leads)	As required (initial briefing held December 2013)	M&E Advisers	Workshop or teleconference
LTIM Project Managers Group meetings	Collaboration and consistency	CEWO M&E Providers project managers for each Selected Area	Biannually for the life of the LTIM Project	CEWO	Workshop or teleconference
Gwydir Selected Area Working Group meetings	Information and knowledge exchange	Gwydir SAWG	Quarterly for the life of the LTIM Project	M&E Provider for the Gwydir Selected Area	Workshop or teleconference
Annual Discussion Forum – Sydney	Technical Collaboration	CEWO M&E Advisers (Project manager plus technical leads) M&E Providers (Project manager plus three technical leads)	Annually (five in total)	CEWO	Workshop - Sydney

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# Communications requirements

## Gwydir Selected Area Working Group

The Gwydir Selected Area Working Group will provide a platform for the exchange of information and knowledge that supports the implementation of the M&E Plan for the Gwydir Selected Area.

The membership of the Gwydir Selected Area Working Group has been agreed with by CEWO. A Terms of Reference has been developed by CEWO to which the Gwydir Selected Area Working Group will subscribe (Appendix 1). Gwydir Select Area Working Group membership is provided below (**Table 11-2**).

The Gwydir Selected Area Working Group has no executive powers, supervisory functions or decision-making authority in relation to the LTIM Project. It is an operational group tasked with a general support and advisory role. Attendance is at the sole discretion of the nominee.

The Gwydir Selected Area Working Group is required to meet quarterly for the duration of the LTIM Project, commencing in the 2014-2015 water year.

**Table 11-2: Selected Area Working Group membership**

Name	Agency/position/role
Paul Frazier	Gwydir LTIM Project Director (ELA)
Darren Ryder	Gwydir LTIM Project Director (UNE)
Mark Southwell	Gwydir LTIM Project Manager (ELA)
Adam Flanagan	CEWO (Northern Basin Section) LTIM Project Area Lead for the Gwydir
Yoshi Kobayashi	OEH (Scientific Services Division)
Debbie Love	OEH (Environmental Water and Floodplains, North West Region)
Daryl Albertson	OEH (Gwydir Environmental Water Manager)
Jane Humphries	OEH (Wetlands Conservation Officer, Regional Operations Group Moree)
Gavin Butler	DPI Fisheries (Scientific Officer, Aquatic Ecosystems Research)
Neal Foster	NSW Office of Water
Robert Smith	NPWS (NPWS Regional Manager Northern Plains region)
Bronwyn Cameron	North Western LLS/Namoi CMA (Catchment Coordinator M&E)
Sara Foot	North Western LLS/BRG CMA
Paul Hutchings	Gwydir ECA-OAC (current Chair)
Glenn Wilson	Gwydir ECA-OAC (Independent Scientist)

ELA will chair the Gwydir Selected Area Working Group and be responsible for the administration and facilitation of the Group, including providing secretariat duties. All communications to the Gwydir Selected Area Working Group will be via the M&E Provider project manager or directors. Any change to the membership will be agreed between the project manager and CEWO.

## Landholder communications

For the M&E Project, landholders are individuals and/or organisations where access to or through their land is required to undertake monitoring activities.

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Landholder contact details and communications will be established upon approval of final sites. The following principles will be adopted:

- No access to any sites will take place without first contacting the landholder and gaining permission to undertake monitoring activities on their land. Initial access will be sought at least 10 working days before accessing a site for the first time, and then within a timeframe as negotiated with each landholder for subsequent access
- The Project team will invite each landholder to participate in or observe monitoring activities as they chose
- The Project team will discuss with CEWO the availability/accessibility of site specific data for each landholder
- All monitoring activities, including access to sites etc, are to be undertaken so that minimal/nil disturbance to the landholders' activities, livestock and/or cropping practices occur
- Providing ongoing project updates to landholders as requested
- Where possible, existing tracks shall be used
- Vehicles/machinery to be operated so that any damaged is minimised
- Notify the landholder immediately if any damage occurs (to property or livestock)
- Appropriate approvals/licences shall be sought as necessary, including Scientific Licence and Permit to Work in NPWS Reserves. All field teams shall have copies of relevant licences when undertaking field work
- Take all reasonable care to ensure that weeds or pests are not spread
- Return gates to original position after use.

Contact details for landholders will be established in a register (Appendix B, Table B.1 **Landholder contact details register**). Any communications with landholders shall be tracked for the duration of the project, including the date of communications, the project team member and any comment/outcome of the communications (Appendix B Table B.2 **Landholder communications register**). This register will also include a record of any data provided to the landholder. Electronic registers can be maintained.

### **Stakeholder engagement and external communications**

An internal process for conveying consistent messaging about the Gwydir LTIM Project in formal settings will be further developed, including consistent branding, review/sign off by CEWO, and a single point of contact (Project Manager) to be established and implemented.

No media communications shall take place without express permission from the Director, Northern Basin Section within CEWO.

It is noted that ELA/UNE are currently developing a Memorandum of Understanding (MoU) with OEH for cooperative resource and information sharing for the LTIM Project. There are a number of complimentary data sets that will be required for the LTIM Project. When monitoring indicators have been finalised, ELA/UNE will access the necessary data (see Section 5 of the M&E Plan) via the appropriate license agreements with the relevant agencies, including:

CEWO  
LLS  
NSW Fisheries  
Murray-Darling Basin Authority  
OEH.

The primary form of communication with stakeholders and parties external to the Gwydir Selected Area LTIM Project will be via the Gwydir ECA OAC. Membership of the Gwydir ECA OAC includes

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representatives from State and Commonwealth agencies, industry and conservation stakeholders, including the:

- Aboriginal community
- North West Local Land Services (LLS)
- Gingham Watercourse landholders
- Gwydir Valley Irrigators Association
- Independent environmental group
- Independent scientists
- Department of Primary Industries
- Lower Gwydir Water Users Association
- NSW Office of Water
- NSW OEH
- NSW State Water
- Department of Environment (observer status).

ELA are currently discussing opportunities for ELA Project Director (Dr Paul Frazier) to participate in the Group, as either a member or as an observer. UNE Project Director Dr Darren Ryder is currently on the ECA OAC in the role of independent scientist. The participation of the M&E Provider in the group will provide a platform for regular project communication and updates to the Group.

The ECA OAC currently host two phone conferences each year, and one face-to-face meeting in Moree. Reporting commitments and engagement undertaken by the ECA OAC include:

- Provide input and advice to OEH for the development of the Gwydir Valley Annual Environmental Watering Plan - this plan outlines the priority and potential actions for environmental water delivery in the year
- Gwydir Environmental Watering Annual Report – this report summarises environmental water delivered in the water year (including flow and inundation areas) and its outcomes and management implications
- Annual Science Forum
- State of Wetlands seasonal report – published on the LLS website and provided to affected landholders.

Adaptive management is critical to the management of Commonwealth environmental water and aligns with the different levels of evaluation associated with the use of this water at both the Selected Area and Basin-scale levels. The adaptive feedback loop ensures that CEWO has access to the knowledge and data to support environmental water use in the water. Well-established and maintained relationships with delivery partners and all other key stakeholders are vital to the LTIM Project. The ECA OAC for the Gwydir River is the principal authority for the development of annual watering plans for the Selected Area. Existing membership on this committee by the project leads will allow ad hoc and planned changes to the short and long term watering options of the Gwydir system to be responsive to monitoring outcomes. Membership of this committee also facilitates highly responsive monitoring to planned Commonwealth environmental watering to ensure all monitoring of events is undertaken.

#### **1.28.1 Outcomes reporting**

The LTIM Project has a number of reporting and information transfer requirements. Table 6-2 summarises the outcomes, reporting and information transfer activities for the LTIM Project, including frequency, timing and responsibility. It also includes reporting requirements that are the responsibility of the M&E Advisors (being the Annual Basin Evaluation Report).

M&E Providers will also be required to provide other key outputs for monitoring activities in the Gwydir:



- 
- Submit monitoring data in the correct format and according to defined protocols within 1 month of its collection
  - Noting and reporting any incidental observations made during field visits that may contribute to or support Evaluation (Area or Basin) or Adaptive Management. Observations can also include those reported to the M&E Provider by stakeholders. This requirement is ongoing, following observations.

### **Internal communications**

An internal communications procedure will be developed by ELA as part its internal Project Management system. An outline of this internal communications strategy is provided below. The objective of all internal communications is to ensure effective project delivery through timely, transparent and concise dialogue between members of the ELA/UNE project team.

### **Complaints procedure**

In the event of any complaints or concerns raised by stakeholder groups or external parties, including landholders, the following process shall be followed:

Record the date of the complaint and any personal details the complainant wishes to provide together with the nature of the complaint

The respective CEWO Project Management Team area leader will be contacted to ensure the CEWO is aware of, and has the opportunity to contribute to, discussions of relevance to the LTIM Project  
The Gwydir LTIM Project Director (ELA/UNE) shall be contacted to advise them of the complaint

The Project Team shall consider the most appropriate response to address the complaint as soon as practically possible.

**Table 11-3: Reporting requirements and information transfer schedule for the LTIM Project**

Activity type	What	Frequency	Timing / due date	Responsibility	Receiver	Description and high level requirements
Reporting	Monitoring and Evaluation Plan	One-off	Draft – Feb 28 2014 Final – 17 Apr 2014	M&E Providers (UNE/ELA)	CEWO	A plan for monitoring and evaluation in each Selected Area over the five-year period from 2014-15 to 2018-19
Work plan	Annual monitoring work plan	Annually	August (2015-2019)	M&E Providers (UNE/ELA)	CEWO	Annual monitoring work plan that outlines which elements will be implemented over the coming water year, based on information available at the time (including Area condition, water availability and water use options)
Annual evaluation plan	Annual evaluation plan	Annually	August (2015-2019)	M&E Providers (UNE/ELA)	CEWO	The annual evaluation plan should outline what evaluation activities will be undertaken over the coming water year, based on anticipated environmental watering actions monitoring data availability
Reporting	Area evaluation report	Annually (October)	Draft – Aug 30 Final – Oct 31 First report – 2015 Final report – 2019	M&E Providers (UNE/ELA)	CEWO	A cumulative evaluation of the outcomes of Commonwealth environmental water at each Selected Area, prepared in accordance with the M&E Plan  The report must be prepared in plain English with simple science and be suitable for publication on CEWO website
Reporting	Basin evaluation report	Annually	Draft – Aug 30 Final – Oct 31 First report – 2015 Final report – 2019	M&E Advisers	CEWO	A cumulative evaluation of the outcomes of Commonwealth environmental water at the Basin-scale, based on the Evaluation Plan  The report must be prepared in plain English with simple science and be suitable for publication on CEWO website
Information transfer	Monitoring data entry	Monthly	Monthly for duration of the LTIM Project	M&E Providers (UNE/ELA)	MDMS	Processed monitoring data is uploaded to the MDMS in accordance with the data management protocols

Activity type	What	Frequency	Timing / due date	Responsibility	Receiver	Description and high level requirements
Information transfer (including operational information)	Information exchange	Ongoing and as required	Ongoing and as required for duration of the LTIM Project	M&E Providers (UNE/ELA) Delivery partners	Delivery partners / Selected Area Working Group / M&E Providers	Information exchange on project activities (monitoring, observations, evaluations) and other information that would support the delivery of environmental water  Operational information collated by delivery partners and provided to M&E Providers
Review previous actions	Annual Watering Review	Annually	2014 - 2019	CEWO	Delivery partners / / M&E Advisors	Reports that provide a summary of Commonwealth environmental water use throughout the year, the outcomes of the water use and lessons learned, and will incorporate information from delivery partners and M&E Providers

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# Appendix A

## TERMS OF REFERENCE

### GWYDIR SELECTED AREA WORKING GROUP LONG TERM INTERVENTION MONITORING PROJECT

Eco Logical Australia (ELA) with UNE (led by Dr Darren Ryder), have been engaged to prepare and implement the Monitoring and Evaluation Plan for the Gwydir River. For this project ELA is the lead agency. This document provides the Terms of Reference for Stage 1 of the LTIM Project.

#### **Purpose**

The Gwydir Selected Area Working Group will provide a forum for the exchange of information and knowledge that supports the implementation of the LTIM Project, through effective coordination of environmental watering, and monitoring and evaluation.

#### **Objectives:**

The Gwydir Selected Area Working Group will facilitate:

Effective coordination between environmental water delivery partners and other relevant monitoring and evaluation projects

Communication to environmental water managers of any information that would improve environmental water management

Exchange of information and knowledge relevant to improving the implementation of the LTIM Project, as well as improve the efficacy of environmental watering activities to support adaptive management on both a short-term (preliminary observations during watering events) and longer-term (evaluation outcomes)

The identification, communication and management of any issues, risks or opportunities relevant to the LTIM Project.

#### **Membership**

The Gwydir Selected Area Working Group includes agencies involved in the delivery of the Gwydir LTIM Project. It includes organisations directly and indirectly responsible for delivering LTIM Project deliverables and representatives from organisations involved in environmental water planning and delivery.

The Gwydir Selected Area Working Group comprises the following members who have been nominated by ELA (the project lead) and agreed to by the CEWO. M&E Advisers as well as relevant people from the CEWO Water Use Section may be invited by the CEWO to attend meetings.

Name	Agency/position/role
Paul Frazier	Gwydir LTIM Project Director (ELA) Chair
Darren Ryder	Gwydir LTIM Project Director (UNE)
Mark Southwell	Gwydir LTIM Project Manager (ELA)
Adam Flanagan	CEWO (Northern Basin Section) LTIM Project Area lead for the Gwydir
Yoshi Kobayashi	OEH (Scientific Services Division)
Daryl Albertson	OEH (Gwydir Environmental Water Manager)
Jane Humphries	OEH (Wetlands Conservation Officer, Regional Operations Group Moree)
Gavin Butler	DPI Fisheries (Scientific Officer, Aquatic Ecosystems Research)
Neal Foster	NSW Office of Water
Rob Smith	NPWS (NPWS Regional Manager Northern Plains region)
Bronwyn Cameron	North Western LLS/Namoi CMA (Catchment Coordinator M&E)
Sara Foot	North Western LLS/BRG CMA
Paul Hutchings (or new Chair)	Gwydir ECA-OAC (current Chair)
Glenn Wilson	Gwydir ECA-OAC (Independent Scientist)

### Terms of Reference

The Gwydir Selected Area Working Group will be responsible for supporting strategic direction of the LTIM Project and exchanging information and intelligence to support the LTIM Project and adaptive management. It will:

- Actively support and promote the LTIM Project within partner organisations
- Review (where appropriate) key project documentation, including evaluation reports
- Exchange operational intelligence relevant to the LTIM Project, including intelligence on upcoming watering or monitoring activities
- Exchange intelligence relevant to adaptive management of environmental water, including operational observations, monitoring outcomes and evaluation outcomes
- Consider stakeholder expectations (where appropriate) of the LTIM Project
- Exchange intelligence on any risks, actual or perceived, to the LTIM Project
- Communicate key messages of the LTIM Project to organisations involved in environmental water planning and delivery
- Document key discussion points and outcomes of Gwydir Selected Area Working Group meetings and distribute these to members (including the CEWO) in the form of minutes.

### Authority

The Gwydir Selected Area Working Group will be organised, operated and Chaired by ELA.

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The Gwydir Selected Area Working Group has no executive powers, supervisory functions or decision-making authority in relation to the LTIM Project. It is an operational group tasked with a general support and advisory role.

## Operations

The Gwydir Selected Area Working Group will operate in alignment with the following requirements:

### *Meetings*

Selected Area Working Group meetings will be held at least twice during Stage 1 (2013-14) and can be attended either via phone or in person, or via earlier comment.

Meeting schedule	Date	Location
Meeting 1	24 January 2014	Armidale / phone
Meeting 2	TBC	Moree / phone

### *Agendas and Minutes*

ELA will prepare and distribute meeting agendas and minutes. Agendas and minutes from the previous meeting will be distributed no later than five days prior to the meeting.

Where practical, meeting papers will be distributed no later than five days prior to the meeting, and will include:

- Agenda
- Previous meeting minutes
- Any papers for consideration.

Meeting minutes and action items will be distributed within two weeks of the meeting. Immediate actions may be circulated earlier.

### *Agenda items*

The following table lists the standard agenda items for the Selected Area Working Group. Members can submit additional items to be included on the agenda at the discretion of the Chair.

Item	Responsibility
Review and accept minutes from last meeting	ELA (Chair)
Update on action items from last meeting	Chair and members
Update on planned watering activities	Delivery partners, environmental water planning organisations
Update on planned monitoring activities	ELA
Update on monitoring observations and evaluation outcomes to support adaptive management	ELA

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Update on community engagement	ELA
Other business	All
Confirmation of next meeting	ELA (Chair)

**Grievances:**

Grievances identified within the Selected Area Working Group will be mediated by the Chair. Where a grievance is deemed significant, a member or members of the Selected Area Working Group may be removed from the Selected Area Working Group, at the discretion of the CEWO.

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## Appendix B Landholder communication - recording templates

### B.1 Landholder contact details register template

Site	Property name	Landholder contact	Address	Contact number	phone	Preferred contact/timing	method of	Comments



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## B.2 Landholder communications register template

Site	Landholder contact	Date	Summary of communications (including any data transfer etc)

---

# Appendix C    Complaints register

## C.1    Complaints register template

Date	Name	Contact details	Nature of complaint	Action taken	Recorded by



# Appendix E Quality Assurance Plan



Australian Government

Commonwealth Environmental Water Office

eco  
logical  
AUSTRALIA

une  
University of  
New England

**Quality Assurance Plan  
Commonwealth Environmental Water Office  
Long Term Intervention Monitoring Project  
Gwydir Selected Area**

Version 1. 23 October 2014



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Item	Detail
ELA Project Number	13ARMNRM-0001
Project Director/s	Paul Frazier, Darren Ryder
Project Manager	Nathalie van der Veer
Prepared by	Emma Garraway, Darren Ryder

This document is the Quality Assurance Plan for the CEWO LTIM Project for the Gwydir Selected Area. It is to be read in conjunction with the Monitoring and Evaluation Plan for the above project.

Any reviews or changes to this Communications Plan must be recorded in the tables below.

#### Document control

Version	Date	Reviewed by	Approved by
1	23 Oct 2014	Paul Frazier	Paul Frazier

Version	Change since previous issue

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# Abbreviations

Abbreviation	Description
CEWO	Commonwealth Environmental Water Office
ELA	Eco Logical Australia
LTIM	Long-Term Intervention Monitoring
M&E Plan	Monitoring and Evaluation Plan
M&E Providers	Monitoring and Evaluation Providers
NoW	NSW Office of Water
OEH	(NSW) Office of Environment and Heritage
QA/QC	Quality Assurance / Quality Control
UNE	University of New England



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# Introduction

This document is the Quality Assurance Plan for the Commonwealth Environmental Water Office (CEWO) LTIM Project for the Gwydir Selected Area. It is to be read in conjunction with the Monitoring and Evaluation Plan (M&E Plan) for the above project.

This Quality Assurance Plan has been developed by the Monitoring and Evaluation Providers (M&E providers) for the Gwydir Selected Area, being the project consortium (Eco Logical Australia Pty Ltd (ELA) and the University of New England (UNE)). ELA has its own Quality Assurance System (QA System), based on AS/NZS ISO 9001: 2000. This Plan has been developed based on this QA System.

## **Objectives**

This Quality Assurance Plan has been developed in accordance with relevant standards including AS/NZS ISO 10005:2006 and ANZECC (2000). The objective of this Quality Assurance Plan is to document quality control and quality assurance (QA/QC) procedures for monitoring activities in the Gwydir Selected Area, including:

- A table of methods for field equipment
- Data collection QA/QC requirements
- Data storage and management
- Document management
- Training
- Auditing.

# Field Equipment

A table listing field equipment required to collect data relevant to Basin-scale evaluation is provided in Table 2-1, together with specific methods such as calibration requirements and maintenance and calibration logs.

A maintenance log sheet is provided in Appendix D and a Chain-of-Custody Form is provided in Appendix E.

**Table 11-4: Field equipment and methods QA/QC – Gwydir Selected Area**

Monitoring indicator	Field Equipment	QA/QC
Ecosystem Type	GPS and spare batteries Field vegetation guide Maps, including assessment site information SOP Datasheets	
Vegetation Diversity	GPS and spare batteries Compass Maps, including assessment site information 100 m surveyor's measuring tape(s) DBH tape Plastic cattle tags or stamped metal tags pre-prepared as unique identifiers of surveyed trees Permanent marker pens Digital camera, spare battery SOP DECC field data sheets and/or field computer	
Fish (River)	NSW Fisheries are undertaking all field work and data analysis for this indicator. Relevant maintenance records and equipment calibration procedures will be undertaken as per NSW Department of Primary Industries' protocols	
Fish (Movement)	NSW Fisheries are undertaking all field work and data analysis for this indicator. Relevant maintenance records and equipment calibration procedures will be undertaken as per NSW Department of Primary Industries' protocols	
Waterbird Breeding	Field guide Compass Camera (35 mm format camera -SLR or dSLR - with 50–150 mm zoom lens, automatic exposure, auto wind-on, or digital equivalent) Watch Maps of Selected Area including assessment site information 2B pencils, sharpener and eraser Hand held tally counter Binoculars or telescope RMCams and tripods (five) Fix cameras (five) SOP Field note book or datasheets	

Monitoring indicator	Field Equipment	QA/QC
Waterbird Diversity	Field guide GPS Camera Watch Maps of Selected Area including assessment site information 2B pencils, sharpener and eraser Hand held tally counter Binoculars or Telescope and tripod SOP Field note book or datasheets	
Microcrustaceans	Benthic corer (50 mm diameter x 120 mm long, 250 mL volume) and rubber backed spatula Small (4L) bucket with lid for settling benthic cores 63um mesh sieve Squirt Bottle 70% ethanol with rose bengal stain Storage jars Data sheets SOP Data sheets	Consistent make/model of corer/sampler among selected areas using microcrustacean method.  Consistent level of taxonomic identification/keys used among selected areas.
Water quality	Hydrolab DS5-X logger (the DS5-X multi-probe logger includes a self-cleaning system to reduce fouling of probes and is designed for long-term submersible deployment).  Water quality sensors and loggers. Preferably as a multi-parameter probe, but separate probes for each parameter are acceptable. Note that dissolved oxygen probe must have an optical (fluorescence) sensor.  Tool kit and spare parts for the multi-parameter probe; including spare batteries and calibration fluids Metal star pickets and star picket driver or mallet. Means to attach probe to star picket or permanent structure. GPS Probe calibration log Field sheets Laptop and data cables for connecting to probes / logger SOP Data sheets	Sensors placed in location with continuous flow.  Sensor placed at location of NoW Pallmallawa gauge for security.  Calibration and maintenance of sensors and loggers at a maximum 6 week interval.  Data correction procedures will be used to account for sensor drift or fouling following periodic calibration. The initial sensor readings (before cleaning) are compared to a calibrated field meter before removing the monitor sonde for servicing. This initial sensor reading becomes the ending point of the data record since the last servicing, and the field meter reading provides a sense of the reasonableness of the monitor readings and an indication of potential drift and fouling.  If the readings of the monitoring sensor are outside the range of acceptable differences, recalibrating the sensor and/or servicing are required.
Hydrology (River)	n/a	
Hydrology (Watercourse)	This monitoring indicator will be undertaken in conjunction with NSW Office of Environmental and Heritage	

# Data Collection

Specify QA/QC arrangements relating to data collection will ensure that the data collected are of a high quality (**Table 11-5**).

A training log sheet is provided in Appendix F. This training log should be kept with each SOP and a copy provided to the Project Manager.

**Table 11-5: Data collection QA/QC – Gwydir Selected Area**

Monitoring indicator	QA/QC – data collection
Ecosystem Type	GIS analysis by experienced GIS staff Field survey by qualified ecologist/environmental scientist
Vegetation Diversity	All surveys will be led by experienced ecologists. Where possible the same team will be used for each survey to reduce surveyor bias.
Fish (River)	NSW Fisheries are undertaking all field work and data analysis for this indicator. NSW Fisheries will obtain the necessary specific fisheries and ethics permits prior to undertaking any sampling. Copies of these permits shall be provided to the Project Manager prior to any field work taking place.
Fish (Movement)	NSW Fisheries are undertaking all field work and data analysis for this indicator. NSW Fisheries will obtain the necessary specific fisheries and ethics permits prior to undertaking any sampling. Copies of these permits shall be provided to the Project Manager prior to any field work taking place.
Waterbird Breeding	All Waterbird Breeding assessments within a Selected Area, where possible, will be undertaken by the same experienced observers to maintain consistency over time. All observers will undergo training prior to undertaking monitoring surveys, including calibration against experienced observers to ensure standardisation of measurements. Training and calibration procedures must be documented in the M&E Plan and relevant records maintained. Identification of difficult to see species will often differ between observers. To minimise the variance associated with different observers, a minimum of two staff are assigned to Waterbird Breeding assessments, particularly when aerial methods are used. Where there are significant differences in original observer scores, observers will discuss their rationale and where appropriate adjust scores to mutually agreed values. For aerial surveys this should be done immediately after flights to get agreement on species identifications.
Waterbird Diversity	All Waterbird Diversity assessments within a Selected Area, where possible, will be undertaken by the same experienced observers during the LTIM project to maintain consistency over time. All observers will undergo training prior to undertaking monitoring surveys, including calibration against experienced observers to ensure standardisation of measurements. Training and calibration procedures must be documented in the M&E Plan and relevant records maintained. Identification of difficult species will often differ between observers. To minimise the variance associated with different observers, a minimum of two staff are assigned to Waterbird Breeding assessments. Where there are significant differences in original observer scores, observers will discuss their rationale and where appropriate adjust scores to mutually agreed values.
Microcrustaceans	Standardisation of microcrustacean sampling equipment. Requirements for NATA accreditation for water quality sampling – all samples will be processed by the NSW OEH Lidcombe laboratories. Field duplicate and blank samples will be collected following the Standard Method.

Monitoring indicator	QA/QC – data collection
	<p>Preservation and transport of water quality samples will follow the procedures provided by the processing laboratory.</p> <p>Entire samples should be preserved individually in 70% ethanol.</p>
Water quality	<p>Calibration and maintenance of sensors and loggers is required at a maximum 6 week interval</p> <p>Data correction procedures will be used to account for sensor drift or fouling following periodic calibration</p>
Hydrology (River)	Data will be sourced from existing NoW gauging stations
Hydrology (Watercourse)	The data from this monitoring will enable calibration and refinement of the existing hydro-dynamic model built by OEH

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# Data Storage and Management

The Commonwealth Environmental Water Office (CEWO) has developed the LTIM data standard to ensure that data collected for the LTIM Project is done so in a structured and consistent manner. The LTIM data standard defines the specific data requirements for the LTIM Project that will be managed by the LTIM Monitoring Data Management System (MDMS) (Brooks & Wealands 2014).

ELA/UNE will store and manage access to primary data for the duration of the LTIM project.

## **Confidentiality and Intellectual Property**

The UNE/ELA consortium will align and comply with CEWO's contract and requirements for confidentiality. All personnel will be aware of confidentiality and communication management requirements.

Ownership of information generated for this project belongs to CEWO.

ELA will develop and maintain an intellectual property register for the duration of the project.

ELA will obtain and abide by all licences and agreements for all complimentary data obtained and used for the LTIM Project. This will also be tracked in the Intellectual Property register.

## **Document and Data Management**

All data will be entered onto ELA's server as soon as practically possible upon return from the field. All computer data is backed up to a server on a daily basis. ELA utilises a common data backup rotation scheme. Backup rotation schemes allow immediate storage of data in a secure location.

Copies of data sheets will also be scanned onto the server and hard copy records kept. At a minimum, 5% of all data entered will be checked for consistency and accuracy.

As much as possible, data storage will be undertaken in a way to be complimentary to the CEWO MSDS.

All files will be stored according to ELA's existing file naming protocol (see below).

All derived data submitted for shared evaluation needs will adhere to LTIM data standards and be traceable to raw data. Data that supports shared evaluation needs will be submitted/uploaded within one month of collection, and according to the protocols established by CEWO.

# Document Management

The document control processes outlined below are based on ELA's Quality Control Process, which confirms to the requirements of the AS/NZS ISO 9001:2008 Quality management system.

A document control process has been developed for both internal and external LTIM documents (Table 11-6). Internal documents will primarily relate to the project and outcomes reporting requirements to CEWO. Each document will follow the specified CEWO reporting templates. All external documents will follow the process outlined below, and in addition:

All external written documentation to be submitted to CEWO (not including emails) will be reviewed by the M&E Adviser (Director) prior to submission

The Approved Branding specification will be adhered to

The delivery of external documents will align and comply with CEWO's contract and requirements for confidentiality

**Table 11-6: Document management procedures**

Step	Description
1. When to make changes	<b>LTIM Reporting Documents</b> <ul style="list-style-type: none"> <li>Changes to a document will be made in response to an audit or request by CEWO Project Management Team or M&amp;E Advisers</li> <li>The M&amp;E Provider Team will refer to the Document &amp; Authority Register to determine who is responsible for document changes and approval</li> <li>Changes cannot be made until a new copy of the document is saved. The current version will be retained until changes are finalised (and approved, if required)</li> <li>HSE Documentation (includes Safety procedures, plans, registers and forms) are only undertaken by the M&amp;E Provider team, in collaboration with their HSE Manager to ensure compliance with relevant legislation</li> </ul>
2. Changing and approving changes to a document	<p>All members of M&amp;E Provider Team can make changes to a document.</p> <p>Approval of changes to a document can only be undertaken by the M&amp;E Provider Leads (UNE/ELA)</p> <p>Any major changes will be discussed with CEWO Project Management Team.</p>
3. Control versions at point of use	<p>The M&amp;E Provider Team will save all new versions of a document using the file naming system outlined in Step 4</p> <p>Document required by CEWO will follow the relevant CEWO reporting templates and include a version control register</p> <p>Communicate changes to relevant project personnel and re-issue documents, if required</p> <p>Printed copies of documents are uncontrolled and should be treated as non-current</p>
4. Legible and readily identifiable	<p>The M&amp;E Provider Team will initiate a project folder and file naming system</p> <ul style="list-style-type: none"> <li>Documents for internal use should be in the form "Brief name of document]_[date]_[initials]", e.g. "Draft M&amp;E Plan_172014_XX"</li> <li>Version number – this is shown in the Document Tracking box of the report and in the file name: <ul style="list-style-type: none"> <li>Use v0, v1, v2 etc to indicate changes in report versions that are sent to the client. Use v0 for the first draft before it goes to the client as v1. Do not restart the numbering when you change from draft to final report status</li> <li>Use an alphabetical suffix for internal revisions e.g. v1a, v1b, v1c. Do not send files that have the alphabetical suffix to the client</li> <li>If there are a number of people working on a document simultaneously, add the initials of the author to differentiate documents e.g. v1a_el</li> </ul> </li> </ul>

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Step	Description
5. Review of documents	A record of the review will be documented on a <b>Document Register</b> within the document
6. Archival documents & data	All archival documents & data to be retained for legal or knowledge preservation purposes are to be identified (Archival file) and stored on under nominated folder i.e. driver:\LTIM project\OLD.

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The M&E Providers will develop and maintain an intellectual property register for the duration of the LTIM project.



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# Training

Training logs will be maintained for all training undertaken as required for monitoring indicators. These logs will be provided in each SOP as required, and copies maintained by the Project Manager. Any training required under the HSE Plan will also be logged.

A training log template is provided in Appendix C.

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# Self-Auditing

CEWO will be developing and implement an LTIM Project Audit Plan. ELA/UNE will comply and adhere to procedures within that Plan.

The following self-auditing procedures will also be adopted for the LTIM Project (Table 11-7).

**Table 11-7: Document management procedures**

What	When	Who	Auditing procedure
Review monitoring schedule (including SOPs)	At the completion of the first round of monitoring (for each indicator)	Lead technical expert for each indicator	<ul style="list-style-type: none"><li>• Review data collected against evaluation questions and overall LTIM Objectives</li><li>• Identify any deficiencies in data</li><li>• Discuss with Project Director/s and raise with CEWO as necessary</li></ul>
Review M&E Plan (including sub-plans)	At the end of the first year of monitoring	Project Manager	<ul style="list-style-type: none"><li>• Identify any deficiencies in data</li><li>• Discuss with Project Director/s and raise with CEWO as necessary</li><li>• Update plans as necessary</li></ul>
	Receipt of feedback (CEWO, Landholders, Stakeholders etc)	Project Manager	<ul style="list-style-type: none"><li>• Discuss with Project Director/s</li><li>• Notify CEWO Area Leader</li><li>• Determine appropriate action</li><li>• Update plans as necessary</li></ul>
	Receipt of non-conformances, complaints etc	Project Manager	<ul style="list-style-type: none"><li>• Discuss with Project Director/s</li><li>• Notify CEWO Area Leader</li><li>• Determine appropriate action</li><li>• Update plans as necessary</li></ul>

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# References

AS/NZS ISO 10005:2006 Quality management systems - Guidelines for quality plans.

Australian and New Zealand Environment and Conservation Council (ANZECC). 2000. *Australian guidelines for water quality monitoring and reporting*. Australian and New Zealand Environment and Conservation Council, Canberra, Australia.

Brooks S. & Wealands S. 2014. *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project: Data Standard*. Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre, MDFRC Publication 29.3/2013 Revised Jan 2014, 29pp.

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## Appendix D Meter Maintenance Log

This Log Sheet to be kept with Meter at all times.

Owner of Meter:	Serial number:
Make and model:	Date of Last Service:
Date of purchase (if known):	

Date	Time	Field Officer	Standard/Reagent Expiry date or lot number	Calibration 1 (auto or manual; one or multi- point)	Parameters calibrated	Comments (variation in values/drift)

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## Appendix E Chain-of-Custody Form

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Field sampling staff:

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Project name/ID and location:

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Sample dates included:

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Sample sites included:

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**SAMPLES SENT BY:**

Date: Time: am/pm

---

Location:

---

Sample quantity: Samples unaltered: yes/no

---

Signed:

---

Courier company:

**RECEIVING LABORATORY**

Receipt of sample by laboratory from sampling officer or courier:

---

Date: Time: am/pm

---

Location:

---

Sample quantity: Samples unaltered: yes/no

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## Appendix F Training log

[illegible]

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## Appendix F Health, Safety and Environment Plan (HSE Plan)



Australian Government

Commonwealth Environmental Water Office



**Health, Safety and Environment Plan  
Commonwealth Environmental Water Office  
Long Term Intervention Monitoring Project  
Gwydir Selected Area**

Version 1, 23 October 2014





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Item	Detail
ELA Project Number	14ARMNRM-0001
Project Director/s	Paul Frazier, Darren Ryder
Project Manager	Nathalie van der Veer
Prepared by	Emma Garraway

This document is the Health, Safety and Environment Plan for the CEWO LTIM Project for the Gwydir Selected Area. It is to be read in conjunction with the Monitoring and Evaluation Plan for the above project.

Any reviews or changes to this Health, Safety and Environment Plan must be recorded in the tables below.

#### Document control

Version	Date	Reviewed by	Approved by
1	23 Oct 2014	Paul Frazier	Paul Frazier

Version	Change since previous issue

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# Abbreviations

Abbreviation	Description
CEWO	Commonwealth Environmental Water Office
ELA	Eco Logical Australia
JSEA	Job Safety and Environment Assessment
LTIM	Long-Term Intervention Monitoring
M&E Plan	Monitoring and Evaluation Plan
M&E Providers	Monitoring and Evaluation Providers
NoW	NSW Office of Water
OEH	(NSW) Office of Environment and Heritage
PPE	Personal Protective Equipment
QA/QC	Quality Assurance / Quality Control
SOP	Standard Operating Procedure
UNE	University of New England

## Induction Register

All field team members are to sign below acknowledging they have read and understood their roles and responsibilities as documented within this HSE Plan.

[illegible]

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## 2 Introduction

This document is the Health, Safety and Environment Plan (HSE Plan) for the Commonwealth Environmental Water Office (CEWO) LTIM Project for the Gwydir Selected Area. It is to be read in conjunction with the Monitoring and Evaluation Plan (M&E Plan) for the above project.

This HSE Plan has been developed by the Monitoring and Evaluation Providers (M&E providers) for the Gwydir Selected Area, being the project consortium (Eco Logical Australia Pty Ltd (ELA) and the University of New England (UNE)).

### Plan Objectives

The objectives of this HSE Plan are to:

- Identify and address risks to health, safety and the environment that may arise from monitoring activities undertaken during the LTIM Project in the Gwydir Selected Area (Contract 1213-0427), including the provision of job safety and environment assessments (JSEAs)
- Identify roles and responsibilities
- Provide emergency preparedness and response procedures, including incident reporting
- Detail communication and consultation processes as they related to HSE
- Describe the process for the review of this HSE Plan and subsequent reporting.

### Scope

The scope of this HSE Plan is to address activities that will be undertaken for all monitoring indicators as part of the Gwydir LTIM Project, including travelling to and from site.

Locations for field work are nominated in the Standard Operating Procedures (SOPs) prepared for each monitoring indicator, and are not replicated in this document.

### Identifying Legal & Other Requirements

This HSE Plan has been developed in accordance with the Commonwealth *Work Health and Safety Act 2011*, *Work Health and Safety Regulations 2011* and the Work Health and Safety Codes of Practice 2011, and the relevant NSW legislation.

### Related documents

This HSE Plan is supported by ELA's Environment, Safety and Quality Management System (ESQMS) that conforms to:

- AS/NZS ISO 14001: 2004 Environmental management systems – Requirements with guidance for use
- AS/NZS 4801:2001 Occupational Health & Safety management systems – Requirements with guidance for use
- AS/NZS ISO 9001:2008 Quality management system – Requirement.

Where existing ELA procedures and documents are referred to, these documents are provided as an attachment to this HSE Plan.

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# HSE Risks

Risk management is an integral part of this HSE Plan and good management practice. It is an iterative process consisting of steps, which, when undertaken in sequence, enable continual improvement in decision-making.

ELA has established, implemented and maintained documented procedures for the identification, assessment and control of hazards and risks (Operational Control ESQ\_20PR & Risk Management ESQ\_21PR procedures). The process for analysing and managing hazards and risks includes:

Establishing the context, including acceptability criteria for the risk analysis

Hazards/aspects identification to determine risk scenarios and select a suitable level of risk evaluation

Evaluating risks by qualitative or quantitative assessment(s) and assigning risk ownership

Recording the risk analysis in the ELA ESQ Risk Register (ESQ\_01R)

Managing risks according to their classification of High to achieve levels that are deemed to be as low as reasonably practicable

Utilising the following hierarchy of control:

- Eliminate the risk scenario
- Substitution
- Engineering and process controls
- Administrative controls or management strategies
- The use of personal protective equipment (PPE)

Developing and agreeing on further actions or monitoring of the risks, taking into account the hierarchy of controls

Verifying the completion of actions

Re-evaluating the risk and classification as appropriate

Reviewing and updating the ELA ESQ Risk Register (ESQ\_01R) over time

Documenting, reporting and communicating the risk information.

## **Risk Identification & Assessment**

The risk management process, including the identification of risks and the risk assessment/control process, is outline above and in Chapter 7 of the M&E Plan.

The risk assessment method undertaken for the LTIM Project is compliant with the Australian/New Zealand AS/NZ 31000:2009: Environmental Risk Management – Principles and Process (Standards Australia 2009), and aligns with the principles of Australian Standard AS/NZS 4360:2004 Risk Management (Standards Australia 2004).

Risk is defined as the combination of the likelihood and consequence of an event or outcome, as demonstrated in (Table 7-2).

**Table 11-8: Risk assessment matrix**

LIKELIHOOD	CONSEQUENCE				
	Negligible	Minor	Moderate	Major	Critical
Almost Certain	L16	M10	H5	S2	S1
Likely	L17	M12	M11	H6	S3
Possible	L19	L18	M13	H7	S4
Unlikely	L22	L21	L20	M14	H8
Rare	L25	L24	L23	M15	H9

L= low, M=medium, H=High, S=Severe

The likelihood of a risk refers to the probability of a specific event or outcome actually occurring (Table 7-3); the consequence is the outcome of the action (Table 7-4).

**Table 11-9: Risk likelihood categories**

Likelihood	Description in terms of full operating life of the site
Almost Certain	Consequences expected to occur in most circumstances
Likely	Consequences will probably occur in most circumstances
Possible	Consequences may occur at some time
Unlikely	Consequences are not expected occur within the life of the project
Rare	Consequences may occur in exceptional circumstances

Possible risks were identified by considering project specific issues and the proposed monitoring activities. Potential hazards and their subsequent impact were considered (i.e. what could happen). Using the definitions provided above, the likelihood and consequence of the potential impacts were then applied to assign an inherent risk rating. Management and risk mitigation measures are then recommended applying the hierarchy of controls, and the risk rating method re-applied.

**Table 11-10: Risk consequence categories**

		Possible risks to	
		Environment	Health and safety
Consequences	Negligible	Negligible environmental damage	Incident requiring first aid treatment
	Minor	Short term, localised, reversible damage to the environment	Minor incident requiring treatment by a medical practitioner
	Moderate	Short term, widespread damage to the environment reversible to intensive effort	Moderate incident requiring short term hospitalisation
	Major	Long-term damage to the environment and/or risk of continuing environmental damage	Serious incident requiring extensive hospitalisation
	Critical	Long-term, widespread, irreversible damage	A fatality, permanent disability , or multiple people affected by a serious incident



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## Risk Register

A risk register has been developed for monitoring and evaluation activities to identify potential project risks (0). This risk register identifies key personnel responsible for control measures to ensure that the register and associated controls are current, implemented and communicated.

Potentially high risk activities associated with the LTIM Project are listed below (Table 2-1). Further details are provided in 0.

**Table 11-11: Potentially high risk activities identified for the LTIM Project – Gwydir Selected Area**

Potential risk	Site/activity specific
Exposure to the elements, weather conditions	Generic
Vehicles and driving hazards (including remote access, fatigue, towing etc)	Generic
Terrain hazards and general site hazards (e.g. slips, trips and falls)	Generic
Hazards from flora and fauna, including dead livestock	Generic
Hazards to flora and fauna	Generic
Water borne illnesses	Generic
Manual handling and lifting	Generic
Handling and storage of chemicals and equipment	Activity specific
Remote surveys	Generic – limited coverage at most sites in the Gwydir Selected Area
Bushfire hazards	Generic

## Safe Work Procedures

Safe work procedures have been provided for potentially high risk activities and form part of this HSE Plan. Safe work procedures provide directions on how a particular aspect of work is to be carried out safely. They identify hazards and clarify what must be done to eliminate or minimise risks.

Written work safe procedures should be prepared for all potentially hazardous tasks performed and must list any required PPE. The process of developing a written safe work procedure for a hazardous task includes the following four steps:

- Determine the overall task that requires a safe work procedure

- Break down the task into its basic steps

- Identify the hazards associated with each step, and ways to eliminate or minimise the risk to workers from these hazards

- Write the safe work procedure – the list of actions that workers must do when performing the task.

Safe work procedures and protocols have been developed for the following activities and provided in 0:

- Fatigue management

- Manual handling

- Bogged vehicle retrieval

- Heat/cold induced illnesses and injuries

- Hazard chemicals

- Fauna related diseases

- Bushfire safety

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Personal protective equipment  
Safe driving.

These procedures will be updated or added too, should any deficiencies or non-conformances be identified during the project (see Section 0).

### **Procedure for Site Visits**

Prior to any field-based activities, a review of HSE risks shall be carried out.

A copy of this HSE Plan will be carried by all field teams, and is to be used in conjunction with the SWMS – High Risk ESQ\_05F (0) and SWMS - Toolbox Talk ESQ\_05cF (0).

The SWMS – High Risk ESQ\_05F will be completed and reviewed prior to undertaking any fieldwork by all personnel including consultants and sub-contractors. The SWMS shall include call-in/call-out procedures, emergency contacts,

Toolbox talks must be completed daily on-site. Any new risks identified as part of the Toolbox Talks are to be sent to the Project Manager for inclusion on the risk register.

The following standard practices shall be applied prior to undertaking any fieldwork:

1. All vehicles should be checked for serviceability prior to leaving (ESQ\_09F – Remote Location Vehicle Checklist). Vehicle Emergency box & First Aid Kits are to be carried in company & non-company vehicles at all times during field trips.
2. Fit for Work Policy & Procedures (ESQ\_04P), Safe Driving Policy (ESQ-7P) and Fatigue Management Plan (ESQ\_03PL) are to be adhered to at all times.
3. First Aid Kit must be carried by an individual at all times when away from the vehicle.
4. One member of the team undertaking site visit or field trip must be senior first aid qualified.
5. Drivers must have a current drivers' licence eligible in Australia.
6. The most recent update of this HSE Plan must be carried in the consultant's field folder.
7. The completed SWMS – High Risk ESQ\_05F and blank copies of the SWMS - Toolbox Talk ESQ\_05cF must be carried in the consultant's field folder. Completed copies must be scanned and electronically saved in project file and hard copies placed on the project folder.

A list of first aid equipment is contained in each first aid kit. The field team leader or designated project officer will be responsible for checking the first aid supplies of each kit prior to field work.

All field vehicles carry a Field based First Aid Kit and also an emergency equipment box which includes various supplies and consumables (Bottled water, and non-perishable food) in the event of an emergency.

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# Emergency Responses & Reporting

## Emergency Response

The safety of all persons is the immediate priority.

All members of the Project Team must report all injuries or incidents (inclusive of lost time and no lost time) to the Project Manager and ELA's HS&E Manager within 24 hours and fill in an Injury / Incident Report ESQ\_03F (0).

Hazards and near miss incidents are to be reported on the Hazard Form ESQ\_06F within one business day to the appropriate ELA Office Manager and ESQ Reps for an investigation to be undertaken. Serious hazards or near miss incidents should be reported immediately to the Office Manager and HS&E Manager (refer to the Risk Management Procedures ESQ\_21PR). For environmental incidents (where there was no incident, hazard or near miss to persons), refer to the Non-conformance Procedures ESQ PR46.

## Notifiable Incidents

The Work Health and Safety (WHS) Act requires that ELA must notify the regulator of any notifiable incidents that arise out of the conduct of the business or undertaking. The primary purpose of incident notification is to enable the regulator to investigate serious incidences and potential contraventions of the WHS Act, as soon as possible.

In the event of a notifiable incident it is the responsibility of the person with management or control of the workplace to ensure, so far as is reasonably practicable, that the site is not disturbed until an inspector arrives or otherwise directs.

The HS&E Manager is to be notified immediately following a notifiable incident. The HS&E Manager will notify the relevant agency of the incident within the required timeframe for notification.

## What is a notifiable incident

A notifiable incident is an incident involving the **death of a person, serious injury or illness of a person or a dangerous incident**. To assist in determining what type of incident must be notified, 'serious injury or illness' and 'dangerous incident' are defined in the *WHS Act*.

A **serious injury or illness** is one that requires a person to have:

- Medical treatment within 48 hours of exposure to a substance

- Immediate treatment as an in-patient in a hospital

- Immediate treatment for a serious injury or illness such as a serious head injury, a serious burn or a spinal injury and a number of other injuries listed in the WHS Act.

Importantly, it does not matter whether a person actually received the treatment referred to in this definition, just that the injury or illness could reasonably be considered to warrant such treatment.

A **dangerous incident** is an incident in a workplace that exposes a worker or any other person to a serious risk to their health or safety emanating from an immediate or imminent exposure to a number of risks. These risks include an uncontrolled escape, spillage or leakage of a substance, an electric shock, a fall from a height or the collapse of a structure.

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### **Notification to Regulator**

Immediately after the occurrence of a notifiable incident, the HS&E Manager must notify the regulator (relevant State/Territory) by telephone or in writing, by fax or email, whichever is faster. The notification must provide the information required by the regulator. If telephone notification is made, the regulator may request written notice to be provided within 48 hours.

### **Incident Site Preservation**

In the event of a notifiable incident, it is the responsibility of the person with management or control of the workplace to ensure, as far as is reasonably practicable, that the site (including any plant, substance, structure or thing associated with the incident) is not disturbed until an inspector arrives or otherwise directs.

This does not prevent the person taking any action to assist an injured person, remove a deceased person, take action that is essential to make the site safe or to minimise the risk of a further notifiable incident occurring, or any action associated with a police investigation or action for which an inspector or the regulator has given permission.

### **Non-Notifiable/First Aid Incidents**

Personnel must report all injuries/incidents and near misses to their Manager and the HS&E Manager within 24 hours and fill in an Injury / Incident Report ESQ\_03F. Ensure that all first aid treatment is recorded on a First Aid Treatment Log ESQ\_25F (refer to the First Aid Procedures ESQ\_23PR).

### **Incident Investigation and Reporting**

All accidents and dangerous events will be investigated. Investigations must however, be kept objective, factual and free from any attempt to assign blame. The principal benefit of incident investigation is the prevention of a further accident, but there are other advantages such as:

- Improved morale by corrective actions that may be implemented
- Reduction in lost time, delays and business interruption
- Reduction in damage to product and plant
- Good documentation as legal preparation.

Carrying out an investigation aimed at identifying the underlying causes of an accident or near miss will require the asking of some basic questions. The importance of concentrating upon the underlying cause(s), rather than the outcome is important. An examination of the workplace and its work procedures and methods will be required as well as the collection of background information. All investigations will be documented on the Incident Investigation Report RSQ\_04F and added to the Incident Investigation Register ESQ\_04R. The Incident Investigation Register ESQ\_04R will be reviewed and any outstanding actions completed by the HS&E Manager monthly and reported to the Board of Directors.

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# HSE Roles & Responsibilities

## **Project Manager**

The Project Manager (of the UNE/ELA consortium) is responsible for the safety relating to all personnel (including sub-contractors/ sub-consultants) engaged in the LTIM Project for the Gwydir Selected Area.

The Project Manager is responsible for ensuring that the following conditions are met by any sub-contractors/ sub-consultants:

- A Sub-consultant Contract and Subcontractor's Statement is provided for the duration of the LTIM Project
- The sub-contractor / sub-consultant are competent for the tasks to be undertaken, suitably trained, licensed and experienced
- The sub-contractor / sub-consultant and their employees carry out the work in a safe manner, using proper and safe plant and substances, employing systems of work that are safe and environmentally sound, and in which there has been adequate instruction, training and supervision.
- The sub-contractor / sub-consultant are able to demonstrate an awareness of the relevant WHS legislative requirements appropriate to the work to be undertaken and commit to this.

Any sub-contractors/ sub-consultants engaged on the project must submit to the Project Manager, for review and approval, a project-appropriate Safe Work Method Statement (SWMS) (and safe work procedures). Certificates of Currency for all relevant insurances must also be provided.

The Project Manager must monitor the performance of any sub-contractors / sub-consultants against their SWMS and any safe work procedures and work practices.

## **Field staff**

All personnel undertaking any field-based activities for the LTIM Project in the Gwydir Selected Area are responsible for:

- Understanding and agreeing to comply with the requirements of this HSE Plan, including wearing of PPE as nominated
- Advising the Project Manager as they become aware of any hazards/risks
- Comply with any actions required to reduce risks, taking into account the hierarchy of controls.

## **Sub-contractors / Sub-consultants**

Sub-contractors / sub-consultants are responsible for the management of their employees and the implementation of their HSE Plans. Sub-contractors / sub-consultants must prepare an appropriate HSE Plan and/or SWMS and submit to Project Manager for their review and approval. Alternatively, sub-contractors / sub-consultants may agree to operate under this HSE Plan and associated safe work procedures.

Sub-contractors / sub-consultants must attend a project start-up meeting with Project Manager to ensure all the HSE issues have been communicated and are understood.

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# Training & Competency

Training needs, and evidence of completion, will be documented and appropriate records maintained for the duration of the LTIM Project. This training needs assessment is to ensure that training required for the safe working of the project is provided to enable field personnel to competently undertake monitoring activities in a safe manner.

## **HSE Induction**

All project staff visiting or working on site are required to be provided with induction training prior to commencing work. This induction will be undertaken by the Project Manager or their nominated representative.

Induction training should be documented and appropriate records maintained (see Induction Register, page vi of this HSE Plan).

## **Skills & Competency**

Project personnel either visiting or working on site shall be provided with appropriate HSE skills training. Where activities with potentially significant safety or environmental risk are to be undertaken, specialised training in accordance with the Job Safety Environment Analysis (JSEA) shall be provided.

All project staff will have the necessary licences to drive, operate equipment and undertake specialised work as required by law.

Training conducted and training certificates, licences etc shall be documented and appropriate records maintained (0).

## **Sub-contractors**

Sub-contractors are responsible for the communication of the HSE Plan and safe work methods to their employees. Sub-contractors shall ensure appropriate records are kept of all inductions, training etc.

Copies of training records and induction logs shall be made available to the Project Manager upon request.

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# Monitoring & Reviews

The HSE Plan should be reviewed regularly to ensure its currency, that any new risks are captured and adequate mitigation measures provided and existing controls evaluated. Scheduled reviews are nominated in Table 11-7; however, a review can take place at any time.

If this HSE Plan is reviewed, the document shall be controlled, and all staff previous inducted shall be provided with a copy of the new HSE Plan.

**Table 11-12: HSE Plan Review**

What	When	Who	Audit/review procedure
Review HSE Plan	At the completion of the first round of monitoring	Project Manager (with Team Leader for each indicator as required)	<ul style="list-style-type: none"><li>• Review risks and controls</li><li>• Review incidences or non-conformances</li><li>• Identify any deficiencies in existing controls</li><li>• Discuss with CEWO as necessary</li></ul>
	Receipt of feedback (CEWO, Landholders, Stakeholders etc)	Project Manager	<ul style="list-style-type: none"><li>• Identify any deficiencies in data</li><li>• Discuss with Project Director/s and raise with CEWO as necessary</li><li>• Update plans as necessary</li></ul>
	Receipt of non-conformances, complaints etc	Project Manager	

# Risk Register

Mechanism	Risk Title	Hazards	Occurrence Likelihood	Consequences	Inherent Risk Class	Control measures	Responsibility for control actions	Due Date	Sign off	Residual risk class	JSEA Number
Weather Conditions	Thermal risk-Extreme Heat	Sunburn, skin cancers, hyperthermia	Likely	Fatality/serious illness/injuries	HIGH	Refer to GSA 1- 1B controls. Appropriate PPE, suitable scheduling & rostering of activities	Project Director, Project Manager, Project staff			MODERATE	Working in extreme conditions
	Thermal risk-Extreme Cold	Hypothermia, skin burns & frost bite.	Likely	Fatality/serious illness/injuries	HIGH	Refer to GSA 1C- 1E controls. Appropriate PPE, suitable scheduling & rostering of activities	Project Director, Project Manager, Project staff			MODERATE	
	Prolonged Heavy Rain / Flash flooding	Drowning & physical injury from debris slips & falls.	Likely	Fatality/serious illness	HIGH	Refer to GSA 1F. Record any areas of potential flash flooding on the SWMS_Toolbox Talk. Check for any flooding alerts prior to entering site	Project Director, Project Manager, Project staff			LOW	
	Storms-lightning strikes	Burns & Shock, (potentially fatal)	Very unlikely	Fatality/serious illness/injuries	MODERATE	Refer to GSA 1G. Do not enter site until 1 hour after the storm passes If on-site vacate the area and/or seek shelter immediately.	Project Director, Project Manager, Project staff			MODERATE	
	High winds	Struck from falling objects and vehicle control.	Very unlikely	Fatality/serious illness/injuries	MODERATE	Refer to GSA 1H. Take cover during periods of high winds away from over head trees/branches. Reduce speed if driving in high winds	Project Director, Project Manager, Project staff			LOW	
Vehicles & Driving hazards	Vehicle Accident on way to survey	Death, Permanent impairment, lost time injury	Unlikely	Fatality/serious illness/injuries	HIGH	Refer to GSA 2H. Safe Driving Policy, *Safe Work methods statements, * prior risk analysis of each project, *4WD first Aid Kit, *All field staff have current First Aid qualifications. *Emergency First Aid Box	Project Director, Project Manager, Project staff			MODERATE	Vehicle recovery
	Vehicle accident on site	Permanent impairment, Death, injury, isolation	Unlikely	Fatality/serious illness/injuries	HIGH	Refer to GSA 2D-2G. Sat phone, 4WD Car First Aid Kit, Emergency First Aid Box, All staff have current first aid qualifications. Site induction in high risk sectors. SWMS and onsite Toolbox Talks prior to commencing work	Project Director, Project Manager, Project staff			MODERATE	
	Vehicle breakdown/ bogged	Isolation, thermal stress, dehydration, hunger	Unlikely	Fatality/serious illness/injuries	HIGH	Refer to GSA 2 - 2B. Safe Operating Procedures- Vehicle recovery, 4 WD recovery Kit in all Field based 4WD's, 4WD training for field staff, Safe Driving Policy, Emergency First Aid Box (includes consumables and bottled water, Sat phones, trialling Spot tracker, Safe Work Methods Statement (SWMS) on site Toolbox Talks	Project Director, Project Manager, Project staff			MODERATE	
	Driving long distances - Fatigue	Wide ranging physical injuries, potentially fatal & vehicle damage	Likely	Fatality/serious illness/injuries	HIGH	Refer to GSA 2I - 2J. Safe Operating Procedures- Vehicle recovery, 4 WD recovery Kit in all Field based 4WD's, 4WD training for field staff, Safe Driving Policy, Emergency First Aid Box (includes consumables and bottled water, Sat phones, trialling Spot tracker, Safe Work Methods Statement (SWMS) on site Toolbox Talks	Project Director, Project Manager, Project staff			MODERATE	



Mechanism	Risk Title	Hazards	Occurrence Likelihood	Consequences	Inherent Risk Class	Control measures	Responsibility for control actions	Due Date	Sign off	Residual risk class	JSEA Number
	Towing trailers & boats	Injury, accident, Collision, Loss of trailer equipment	Unlikely	Short term illness/injury/First Aid	MODERATE	Refer to GSA 2M-2N. Safe Driving Policy, Emergency First Aid Box (includes consumables and bottled water, Sat phones, Safe Work Methods Statement (SWMS)	Project Director, Project Manager, Project staff			LOW	Manual Handling, Operating a Boat
	Encountering wildlife e.g. kangaroos	Car accident (with either wildlife, or other vehicles)	Unlikely	Fatality/serious illness/injuries	HIGH	Refer to GSA 2R. Safe Driving Policy, Emergency First Aid Box (includes consumables and bottled water, Sat phones, Safe Work Methods Statement (SWMS)	Project Director, Project Manager, Project staff			MODERATE	
Terrain hazards	Rocky, Uneven or slippery Terrain resulting in falls/trips.	Injury – musculoskeletal / soft tissue injury (sprains etc)	Unlikely	Short term illness/injury/First Aid	MODERATE	Refer to GSA 3. Emergency First Aid Box (includes consumables and bottled water)mob/sat phones, Safe Work Methods Statement (SWMS)	Project Director, Project Manager, Project staff			LOW	
	Bushfires	Burns, Smoke inhalation, potentially fatal	Unlikely	Fatality/serious illness/injuries	HIGH	Refer to GSA 3A-3E. SWMS, regular updates from BOM website and advice from RFS, field work policy. Bush regen staff undertaken first response Fire awareness training with annual refresher training	Project Director, Project Manager, Project staff			MODERATE	Bushfire Management
Flora & Fauna	Plant & Insect Allergens and poisons	Allergic reactions (skin/eye) Hay Fever, respiratory reactions, Anaphylactic shock	Unlikely	Fatality/serious illness/injuries	HIGH	Refer to GSA 4D. Ensure staff know who their colleagues are with severe allergic reactions, implement allergy management response plan, ensure epipen or other relevant medication is on hand at all times, be aware of nearest hospital for treatment and have communications available. Don't expose staff with known allergies to projects where these risks are unacceptable to their personal health issues	Project Managers, theme team managers and staff			MODERATE	
	Venomous Fauna	Poisoning, potentially fatal	Unlikely	Fatality/serious illness/injuries	HIGH	Refer to GSA 4. SWMS, Wildlife survey procedures, onsite Toolbox talks, Snake bandages, All staff are qualified in first aid, 2 persons in the field, PPE.	Project Director, Project Manager, Project staff			MODERATE	
	Bats / flying foxes	Australian Bat Lyssavirus (ABL)	Very unlikely	Fatality/serious illness/injuries	MODERATE	Refer to GSA 4C. Ensure you are vaccinated if you are required to work with flying-foxes/bats regularly. Avoid handling flying-foxes/bats or coming into close contact with them. Suitable clothing & PPE.	Project Director, Project Manager, Project staff			MODERATE	
	Ticks, mosquitoes & leeches	Bites, Infection & Illness	Likely	Short term illness/injury/First Aid	MODERATE	Refer to GSA 4A-4B. SWMS, proper clothing and applying permethrin to clothing, performing daily tick checks and removing ticks as soon as they are detected	Project Director, Project Manager, Project staff			MODERATE	

Mechanism	Risk Title	Hazards	Occurrence Likelihood	Consequences	Inherent Risk Class	Control measures	Responsibility for control actions	Due Date	Sign off	Residual risk class	JSEA Number
	Walking through vegetated areas	Trampling of flora & fauna, Potential weed spread, Potential spread of soil fungus	Likely	Minor environmental damage	<b>MODERA</b>	Avoid trampling areas that do not need inspection. Clean mud and weeds off shoes, clothing, bags, and the gear and vehicle tyres prior to leaving an area.	Project Director, Project Manager, Project staff			<b>MODERATE</b>	
	Loss of or damage to biodiversity	Impacts on flora	Likely	Minor environmental damage	<b>MODERATE</b>	Minimise trampling and avoid areas that do not need survey. Follow requirements of land owner/ manager, incl. government bodies.  A scientific licence is required for the picking or possession of protected flora, incl. marine plants. Where possible identify flora species in the field. If a sample is required, take only that needed for identification. Take photos where a sample would affect survival of the individual.  If a new location is discovered for a threatened species, note its position and take care not to unnecessarily disturb its root system or habitat.  Clean mud and weed propagules off shoes, clothing and vehicle tyres prior to leaving an area (particularly where noxious weeds were identified).  Works should be programmed to consider seeding periods and weed locations. This is particularly important when weeds such as Giant Parramatta Grass, St John's Wort, Fireweed, African Lovegrass, and Chilean Needle Grass are seeding.	Project Director, Project Manager, Project staff			<b>MODERATE</b>	
	Fish survey work	Ecological impacts	Likely	Environmental damage	<b>MODERATE</b>	Ensure field staff are listed either on the NSW DPI Scientific Collection Permit or a project specific fisheries permit. Ensure field staff are trained in trapping and handling aquatic fauna. In NSW, additional approvals are required for fish survey works in all Marine Parks or Aquatic Reserves. Conduct works per permit requirements. Ref to Aquatic Section: 8	Project Director, Project Manager, Project staff, subcontractors			<b>MODERATE</b>	
<b>General Site Hazards</b>	Site security - intruders	Physical harm - assault	Very unlikely	Long term illness or serious injury	<b>MODERATE</b>	WMS, Toolbox talks, engagement of security, client representation where required, emergency procedures	Office Managers, staff			<b>LOW</b>	

Mechanism	Risk Title	Hazards	Occurrence Likelihood	Consequences	Inherent Risk Class	Control measures	Responsibility for control actions	Due Date	Sign off	Residual risk class	JSEA Number
	Community consultation	Aggressive behaviour from people, assault	Very unlikely	Long term illness or serious injury	MODERATE	SWMS, Toolbox talks, engagement of security, client representation where required, emergency procedures	Project Director, Project Manager, Project staff			LOW	
	Dumped rubbish - asbestos & needles	Inhalation of asbestos fibres & needle stick injuries	Very unlikely	Long term illness or serious injury	MODERATE	Refer to GSA 5A-5B. SWMS, PPE.	Project Director, Project Manager, Project staff			LOW	
	Working with others in remote areas	Harassment-sexual, bullying, inappropriate behaviour	Very unlikely	Long term illness or serious injury	MODERATE	Refer to GSA 5C. SWMS, 2 person project team, Toolbox talks, spot tracker, mob/sat phone. Prior discussion with client if required.	Project Director, Project Manager, Project staff			LOW	
	Working in Isolation / Remote area surveys	Injury to personnel due to no access to emergency contacts or first aid. Slow response time from external source/services to an injury or incident	Unlikely	Fatality/serious illness/injuries	HIGH	Refer to GSA 5E. SWMS, 2 person project team, Toolbox talks, spot tracker, mob/sat phone. Prior discussion with client if required. Call in/out procedure.	Project Director, Project Manager, Project staff			MODERATE	
	Field Equipment use (e.g. Traps)	Muscle and back strain, joint injury, Lacerations and other Injury from equipment	Unlikely	Long term illness or serious injury	MODERATE	Safe operating procedures, Risk assessment, PPE, Tool box talks, regular, scheduled equipment servicing, Manual Handling training.	Site Manager, Site ESQ rep, staff			LOW	Manual Handling
	Heavy machinery operating on site	Injury/ potentially fatal	Unlikely	Fatality/serious illness/injuries	MODERATE	Refer to GSA 7 . SWMS, ELA 2 person project team, Toolbox talks, signage, mob/sat phone.	Project Director, Project Manager, Project staff			MODERATE	
	Boat usage, Debris Shoreline, Sand bars, Exposure, Sinking, Accidental collision.	Hypothermia, Become wet during cold conditions. Drowning, Explosion, damage & Injuries.	Very unlikely	Fatality/serious illness/injuries	MODERATE	Refer to GSA 8A . SWMS, ELA 2 person project team, Toolbox talks, mob/sat phone.	Project Director, Project Manager, Project staff			LOW	To be addressed under subcontractor HSE Plan
	In-stream/on Bank aquatic surveys	Slip / trip leading to injury, Being swept downstream, Collision with in-stream debris, Drowning.	Unlikely	Fatality/serious illness/injuries	HIGH	Refer to GSA 8C-8D. SWMS, ELA 2 person project team, Toolbox talks, mob/sat phone.	Project Director, Project Manager, Project staff			MODERATE	Working around water
	Aquatic animals	Sting or bite e.g. fish, platypus	Unlikely	Fatality/serious illness/injuries	HIGH	Refer to GSA 8F. SWMS, ELA 2 person project team, Toolbox talks, mob/sat phone.	Project Director, Project Manager, Project staff			MODERATE	
	Fatigue: Field Survey work-Long hours/night work	Musculoskeletal injuries , slips, trips, falls	Likely	Short term illness/injury/First Aid	MODERATE	Effective rostering, maximum work hours. Additional rest breaks. Fatigue Management Plan	Project Manager, Workplace participants,			LOW	
Hazardous substances	Chemicals use & handling	Inhalation	Likely	Short term illness/injury/First Aid	MODERATE	Refer to GSA 9E-9F. Purchasing procedure, Safe Operating procedures- safe use, handling and storage of chemicals, SWMS, Chemicals register, MSDS on site, Tool box talks, First Aid Kits, spill	Project/Site Manager, ESQ Rep, Staff			LOW	
		Ingestion	Unlikely	Short term illness/injury/First Aid	MODERATE					LOW	

Mechanism	Risk Title	Hazards	Occurrence Likelihood	Consequences	Inherent Risk Class	Control measures	Responsibility for control actions	Due Date	Sign off	Residual risk class	JSEA Number
		Contact with skin	Likely	Short term illness/injury/First Aid	MODERATE	kits, PPE, All staff have Chem. Cert III qualifications				LOW	
	Chemical storage	Explosion, spills	Unlikely	Short term illness/injury/First Aid	MODERATE					LOW	
Ergonomic, Manual Handling & Vibration	Manual handling -(lifting, bending, reaching, carrying)	Musculoskeletal injuries and back strain, joint injury	Unlikely	Fatality/serious illness/injuries	HIGH	Refer to GSA 5G. Safe Operating procedures for use of equipment, SWMS, pre start checklist, ensure machinery is regularly serviced, PPE, Job rotation, manual handling training and refresher undertaken	Project/Site Manager, ESQ Rep, Staff			MODERATE	Manual Handling
	Vibration	Use of Quad bike etc	Unlikely	Fatality/serious illness/injuries	HIGH	Safe Operating procedures for use of equipment, WMS, pre start checklist, ensure machinery is regularly serviced, PPE, Regular Job rotation with maximum use limits imposed, Manual handling policy, manual handling training and refresher undertaken	Project/Site Manager, ESQ Rep, Staff			MODERATE	
	Over use of field equipment	Hand injury /strains-use of nets	Unlikely	Long term illness or serious injury	MODERATE	Safe operating procedures developed for all of this equipment, job rotation, work at own pace, SWMS, PPE, tool box talks, Manual Handling training	Project/Site Manager, ESQ Rep, Staff			LOW	
Employee Selection, Training and Competence	Selection and engagement of employees or sub-contractors who are unsuitable for the position or do not appropriate skills, experience and qualifications to undertake tasks	Potential injury to employees, others sub -contractors or others	Unlikely	Long term illness or serious injury	MODERATE	Position descriptions accurately reflecting skills, experience , qualifications required. Merit based EEO selection process undertaken with reference checking. Pre placement medical examinations where required. Annual performance reviews undertaken, Individual and corporate training plan developed annually , staff and subcontractors participate in induction on 1st day of employment. Subcontractor Management Plan and induction process, Project scope accurately identifies tasks and requirements	Employees-Direct Manager, Human Resources Manager, ESQ rep, Consultant Dr (where required), Directors, CSO. Sub -contractors-Project Director, Project Manager, staff, CSO			LOW	
Noise	Use of equipment and machinery -	Noise from quad bike - potential hearing loss	Likely	Long term illness or serious injury	HIGH	SWMS, Risk assessment prior to commencing work, Tool box talks, PPE, job rotation, Chain saw certs of competency, audio testing and health surveillance, pre -employment medical. PPE examinations	Site Manager, ESQ rep, staff			LOW	
	Climbing/Falling from a ladder	Musculoskeletal injuries, Slip/trip/fall from height, Eye injury from vegetation / branches, Ladder collapsing / falling over Electric shock from lightning	Unlikely	Fatality/serious illness/injuries	HIGH	Refer to GSA 6A. Conduct toolbox talk before commencing the task. Ensure that work is carried out in accordance with the Working at Heights Procedure ESQ_30PR and Working at Heights SOP ESQ_10S.	Project Director, Project Manager, Project staff			MODERATE	

Mechanism	Risk Title	Hazards	Occurrence Likelihood	Consequences	Inherent Risk Class	Control measures	Responsibility for control actions	Due Date	Sign off	Residual risk class	JSEA Number
		Interaction with ladder									
	Carrying a ladder	Musculoskeletal injury – carrying ladder	Unlikely	Long term illness or serious injury	MODERATE	Refer to GSA 6A. Conduct toolbox talk before commencing the task. Ensure that work is carried out in accordance with the Working at Heights Procedure ESQ_30PR and Working at Heights SOP ESQ_10S	Project Director, Project Manager, Project staff			LOW	
	Falling branches or nest boxes - striking support staff below	Head injuries, scratches , broken limbs	Unlikely	Long term illness or serious injury	MODERATE	Wear hard hats - PPE, maintain communications with team, risk assess the tree prior to work being undertaken. Ensure nest boxes are secured to rope .	Project Director, Project Manager, Project staff			LOW	

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# Job Safety Environmental Analysis (JSEA)

The purpose of the Job Safety Environmental Analysis (JSEA) is to assess the work tasks and consider what the safest way to complete it is. It is a documented process of risk management.

A JSEA is a systematic examination of each job step to identify potential hazards, assess risks and evaluate control measures. It integrates safety, health and the environment into the planning of work and work related activities.

Conducting JSEAs allows the team to gather information to identify hazards associated with each job step, to determine what could potentially go wrong, what are the controls that are currently in place (if any), and what is the level of risk associated with the identified hazards. In addition, preparing a JSEA will determine if safe work procedures are required.

When conducting/preparing a JSEA the following process should be adopted:

- Break the activity down into logical steps that are required to complete the job
- Consider what may cause injury - identify the hazards
- Document controls currently in place to manage the identified hazards
- Calculate RISK based on existing controls in place
- Consider each hazards and ascertain the consequence of an incident
- Determine the likelihood of the consequence occurring (based on existing controls in place)
- Calculate the risk of each hazard (combination of consequence and likelihood)
- Establish new controls (if required) appropriate for the risk determined
- Calculate residual risk based on new and existing controls
- Establish additional or supplementary controls (where required) to achieve appropriate level of risk.

A template for preparing a JSAE is provided below.

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## A.1 JSEA Template

JOB SAFETY ENVIRONMENT ANALYSIS (JSA) TEMPLATE					
Company name:		Date:		JSA Number:	
Site name:		Supervisor name:		Permit to work required?	Yes / No
Plant / Area:			Location:		
Scope of JSA:					
JSA team member names:					
Overall risk associated with JSA:					
<i>Highest residual risk – this can only be determined after the rest of the JSA is complete</i>					
Approved by: <i>Have the appropriate approval levels been obtained?</i>		Position of approving person:		Date:	

### JOB SAFETY ANALYSIS (JSA) TEMPLATE

<b>Activity</b> <i>Provide a step-by-step breakdown of the task</i>	<b>Hazards</b> <i>List all hazards associated with each step</i>	<b>Inherent Risk</b> <i>Risk associated with each hazard before any control measures are put in place</i>	<b>Controls</b> <i>Measures that need to be taken to eliminate or minimise the risk associated with each hazard</i>	<b>Residual Risk</b> <i>Remaining risk associated with each hazard once the control measures have been put into place</i>

Source: Training Services Australia



# Fieldwork Checklist

When	Action	Responsibility	Completed (y/n)
Fortnight prior to Fieldwork	Landholder/s contacted (as required)	Project Manager or their delegate	
Day Before Fieldwork	<b>Daily Weather / Bushfire Checklist (Form 2)</b> Bureau of Meteorology 1900 969 900 OR <a href="http://www.bom.gov.au">www.bom.gov.au</a> OR <a href="http://www.eldersweather.com.au">www.eldersweather.com.au</a> AND Rural Fire Service 1800 679 737 OR <a href="http://www.rfs.nsw.gov.au">www.rfs.nsw.gov.au</a>	Team Leader or their delegate	
	<b>Daily Trip Plan and Contact Sheet</b> Email to _____	Team Leader or delegate	
	Check all gear is packed	Team Leader or delegate	
Day of Fieldwork	Vehicle inspection	Designated driver	
ON SITE	<b>Complete</b> Toolbox Talk prior to undertaking site work <b>Monitor</b> site conditions (weather, fire, hazards). Cease work if dangerous or no suitable control measures <b>Report</b> near miss/safety incidents/accidents to <b>Complete First Aid Record Form for first aid incidents</b>	Team Leader or delegate	
POST-FIELDWORK	<b>Contact</b> Project Manager to inform team has left site, daily update (new hazards, incidents, site details)	Team Leader or delegate	
	<b>Report</b> incidents or near missed (with 24 hours)	Team Leader or delegate	
	<b>Update</b> JSEA if required	Project Manager	
	<b>Check</b> equipment and batteries – charge if required	Team Leader and all team members	

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# SWMS

	SWMS – High Risk		Document No. ESQ_05F
	Version No: 2	Date Approved: 1 Feb 2012	Approved By: HS&E Manager

*Note: Fill in these sections & communicate with field staff prior to any field work as part of the SWMS - Toolbox Talk process and take a copy into the field*

<b>Project #:</b>		<b>Project Title:</b>	
<b>Description of Task:</b>			
<b>Date:</b>		<b>Project Manager:</b>	

PPE Requirements (Please List)	Training/ Licences/ Permits Required	Special Tools or Equipment Required
Hazardous Materials	Reference Documents	Fire/ Emergency Equipment
	TBO- Legal & Other requirements Register – Work Health & Safety Act 2011 and Regulations, ELA ESQMS and Safe Operating Procedures	

#### PROJECT TEAM

Personnel Name	Project Role


<b>Client Terms and Conditions</b>	<input checked="" type="checkbox"/>	<b>Subcontractor Terms and Conditions</b>	<input checked="" type="checkbox"/> or n/a	<b>Subcontractor Work Method Statement</b>	<input checked="" type="checkbox"/> or n/a
<b>Licences/Approvals/Permits</b>	<input checked="" type="checkbox"/> or n/a	<b>Survey in line with ELA ecological survey procedures</b>	<input checked="" type="checkbox"/> or n/a	<b>Consistent with ELA Project Management Procedures</b>	<input checked="" type="checkbox"/> or n/a

I confirm the above documents have been reviewed, understood and are signed and in the project file.

I agree this project team is competent and trained to complete this project and this form will be used in conjunction with the Generic Site Assessment ESQ\_05bF and SWMS-Toolbox Talk ESQ\_05cF by the team in the field.

This form has been prepared & all team members have been informed of the project planning requirements:

<b>Project Manager/ Project Director Name:</b>	<b>Signature and Date:</b>
--	----------------------------

	SWMS- Desktop Template		Document No. ESQ_05F
	Version No: 2	Date Approved: 1 Feb 2012	Approved By: HS&E Manager

## NEAREST HOSPITAL

The nearest hospital is XX km to the north south east west of the site.

Hospital Name: Phone:

Street Address:


<http://www.truelocal.com.au/search.do?clickToCallAccount=off&geoCodeState=off&term=public+hospital&type=keywords&location=australia&includeSurrounding=on&x=19&y=12> OR  
<http://www2.health.nsw.gov.au/services/>

Insert a map showing route between site and hospital (if required)

## EMERGENCY CONTACTS

ELA Office Manager	0438 647 236 – Nathalie van der Veer
ELA HR Manager	0448 247 828 – Sue Nichols
ELA HSE Manager	0412 071 732 – Leanne Pacemski
ELA Project Manager	
Client Project Manager	
ELA Directors	
0416 093 353 – Andrew Morison	0402 054 751 – Rod Rose
0405 125 701 – Steve House	0437 509 851 – Mark Adams
Police/Ambulance/Fire	000
Rural Fire Service	1800 679 737 (press '2' for current fire information)
Local Council	
Country Energy (Emergencies)	13 23 56
Telstra (Faults and Service)	13 22 03
OEH (Environment Protection)	02 9995 5000
NSW Department of Lands	<a href="http://www.nsw.gov.au">www.nsw.gov.au</a>
Namoi Catchment Authority	Gunnedah: 02 6742 9220 Tamworth: 02 6764 5907
Local Land Services	02 6742 9220
WIRES	02 6778 4994 (New England)
Others	

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	<b>SWMS- Desktop Template</b>		Document No. ESQ_05F
	Version No: 2	Date Approved: 1 Feb 2012	Approved By: HS&E Manager

**RISK ASSESSMENT MATRIX** – Use this matrix to assess the level of WHS and Environmental risk.

MATRIX	LIKELIHOOD				LEGEND	RISK ASSESSMENT MATRIX
	Very Likely (could happen at any time)	Likely (could happen sometime)	Unlikely (could happen but very rarely)	Very Unlikely (could happen but generally never will)		
Fatality or permanent disability. Or property, or environmental damage over \$50,000	<b>H</b> <b>1</b>	<b>H</b> <b>2</b>	<b>H</b> <b>3</b>	<b>M</b> <b>7</b>	<b>1-6</b> <b>H</b>	Top priority– deal with the hazard immediately. Must deal with the cause(s) now.
Long term illness or serious injury. Or property, or environmental damage between \$5,000 and \$50,000	<b>H</b> <b>4</b>	<b>H</b> <b>5</b>	<b>M</b> <b>8</b>	<b>M</b> <b>9</b>	<b>7-13</b> <b>M</b>	Deal with the hazard as soon as possible. Must fix the cause(s) in 1 month. Regularly monitor the cause(s) and hazard until rectified.
Short term illness or injury. Or property, or environmental damage between \$500 and \$5,000	<b>H</b> <b>6</b>	<b>M</b> <b>10</b>	<b>M</b> <b>11</b>	<b>L</b> <b>14</b>	<b>14-16</b> <b>L</b>	Must fix the hazard and cause(s) when time and resources permit but within 3 months. Regularly monitor the cause(s) and hazard until rectified.
First aid needed. Or property, or environmental damage up to \$500	<b>M</b> <b>12</b>	<b>M</b> <b>13</b>	<b>L</b> <b>15</b>	<b>L</b> <b>16</b>		

Source: Workcover- AS/NZS 4360

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	<b>SWMS- Desktop Template</b>		Document No. ESQ_05F
	Version No: 2	Date Approved: 1 Feb 2012	Approved By: HS&E Manager

**DESKTOP RISK ASSESSMENT** – Project Manager to complete **prior** to works.

Step In Process	Hazard Identified (potential source of harm)	Risk Analysis (what could happen)	Risk Rating*	Solution/ Control Measure (consider hierarchy of control)	New Risk Rating*
1. Driving to and from site				•	
2. Conduct field work				•	
3. Surveys				•	
4. Ergonomic, Manual Handling and Vibration				•	
5. Other				•	

\*See Risk Matrix at the beginning of this document.

#### RISK ASSESSMENT & WORK METHOD STATEMENT ACCEPTANCE

I have read and understood and agree to comply:

Name: \_\_\_\_\_

Signature: \_\_\_\_\_

Date: \_\_\_\_\_

I have read and understood and agree to comply:

Name: \_\_\_\_\_

Signature: \_\_\_\_\_

Date: \_\_\_\_\_

I have read and understood and agree to comply

Name: \_\_\_\_\_

Signature: \_\_\_\_\_

Date: \_\_\_\_\_

I have read and understood and agree to comply:

Name: \_\_\_\_\_

Signature: \_\_\_\_\_

Date: \_\_\_\_\_

I have read and understood and agree to comply:

Name: \_\_\_\_\_

Signature: \_\_\_\_\_

Date: \_\_\_\_\_

I have read and understood and agree to comply:

Name: \_\_\_\_\_

Signature: \_\_\_\_\_

Date: \_\_\_\_\_

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# SWMS – Toolbox Talks

	SWMS –Toolbox Talk		Document No. ESQ_05cF
	Version No: 1	Date Approved: 01 Feb 2013	Approved By: HS&E Manager

*Step 1: To be completed daily with all staff in the field prior to commencing work. Also discuss work, conditions & hazards from the SWMS – Desktop Template ESQ\_05F or Project Planning Sheet ESQ\_05aF.*

*Step 2: Identify, discuss & document in the table below any hazards (ID) relevant to the site, any hazards that were not identified in the SWMS – Desktop Template ESQ\_05F or Project Planning Sheet ESQ\_05aF & any relevant additional controls not included in the Generic Site Assessment (GSA) ESQ\_05bF (Additional Controls). Use more than one page if required.*

*Step 3: Assess the risk of any additional controls with the controls in place (Risk Rating) using the Risk Matrix in the back of the Generic Site Assessment (GSA) ESQ\_05bF. Comment section (below) used for addition information.*

*Step 4: All field staff are to sign to say that they have read & agree to comply with this document.*

Project #:		Site:		Date:	
Category (Refer to the GSA)	ID (Refer to the GSA)	Additional Controls (Any additional controls not listed in the GSA for this Category)	Risk Rating (additional controls in place - refer to GSA – Risk Matrix)		
Comments:					
Note: Scan & add to project folder when you return from the field. Notify HS&E Manager of any new Hazards identified.					

I have read, understood and agree to comply with this SWMS:

Name: \_\_\_\_\_ Sign: \_\_\_\_\_ Date: \_\_\_\_\_

Name: \_\_\_\_\_ Sign: \_\_\_\_\_ Date: \_\_\_\_\_

Name: \_\_\_\_\_ Sign: \_\_\_\_\_ Date: \_\_\_\_\_

Name: \_\_\_\_\_ Sign: \_\_\_\_\_ Date: \_\_\_\_\_

Name: \_\_\_\_\_ Sign: \_\_\_\_\_ Date: \_\_\_\_\_

# Injury/Incident Report Form

	Injury / Incident Report		Document No. ESQ_03F
	Version No: 2	Date Approved: 12 Dec 2012	Approved By: HS&E Manager

Refer to the Incident & Accident Management Procedures ESQ\_24PR in TBO • ESQ Corporate

**Eco Logical Australia (ELA) employees must report all injuries/incidents (inclusive of lost time and no lost time) to their Manager and the HS&E Manager within 24 hours.**

## Details of Injured person / person involved in the Incident

Name \_\_\_\_\_

Office \_\_\_\_\_

Address \_\_\_\_\_

DOB: \_\_\_\_/\_\_\_\_/\_\_\_\_ Sex: Male ☐ Female ☐

Employer (if not Employed with ELA) \_\_\_\_\_

## Injury/Incident Details

Date of Injury/Incident \_\_\_\_/\_\_\_\_/\_\_\_\_ Time of Injury/Incident \_\_\_\_:\_\_\_\_ am/pm

Task/Operation undertaken at the time: \_\_\_\_\_

Location where injury/incident occurred \_\_\_\_\_

If Injury, what type of injury (e.g. broken arm etc) \_\_\_\_\_

Part of body injured (e.g. Torso, head, arm etc) \_\_\_\_\_

Cause of injury/incident \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Treatment being undertaken by doctor/hospital \_\_\_\_\_

\_\_\_\_\_

## Person completing this form

Name \_\_\_\_\_

Relationship to injured worker/incident \_\_\_\_\_

Date \_\_\_\_/\_\_\_\_/\_\_\_\_ Time \_\_\_\_:\_\_\_\_ am/pm

Did the injured person cease work: Yes ☐ No ☐ N/A ☐

Has a referral for further treatment been issued: Yes ☐ No ☐ N/A ☐

Signature of person completing this form \_\_\_\_\_

**All incidents/injuries must be reported to your manager or the HS&E Manager within 1 business day.**



# Vehicle Inspection Checklist

Vehicle Make		Registration No.	
Odometer		Date of Inspection	
Inspection by:			
NAME (print)		SIGNATURE	
<b>Tick Box Applicable</b>	<b>YES</b>	<b>NO</b>	<b>Comments</b>
1. Brakes:			
- Foot brake operating			
- Hand brake operating			
2. Light operating and clean			
3. Indicators working and clean			
4. Steering – excessive play/vibration			
5. Windscreen wipers operating			
6. Windscreen washers operating			
7. Windscreen/windows damaged			
8. Windscreen/windows clean			
9. Horn operating			
10. Seat belts satisfactory			
11. Mirrors in good condition			
12. Tyres:			
- Correctly inflated			
- Sufficient tread			
- Damaged			
13. Body damage			
14. Jack and handle			
15. Wheel brace			
16. Spare wheel			
17. Fire extinguisher fitted and charged			
18. Engine Oil/Hydraulic Oil at Correct Level			
- Water – Radiator Full			
- Battery- Secure and water level OK			
19. Windscreen Washers water containers full			
20. First Aid Kit Provided and In Good Condition			
21. Registration Current			
22. Petrol			
<b>Comments</b>			

# Training log

Monitoring indicator	Training undertaken	Date	Trainer		Trainee		Comments
			Name	Signature	Name	Signature	



#### **HEAD OFFICE**

Suite 4, Level 1  
2-4 Merton Street  
Sutherland NSW 2232  
T 02 8536 8600  
F 02 9542 5622

#### **SYDNEY**

Level 6  
299 Sussex Street  
Sydney NSW 2000  
T 02 8536 8650  
F 02 9264 0717

#### **ST GEORGES BASIN**

8/128 Island Point Road  
St Georges Basin NSW 2540  
T 02 4443 5555  
F 02 4443 6655

#### **CANBERRA**

Level 2  
11 London Circuit  
Canberra ACT 2601  
T 02 6103 0145  
F 02 6103 0148

#### **NEWCASTLE**

Suites 28 & 29, Level 7  
19 Bolton Street  
Newcastle NSW 2300  
T 02 4910 0125  
F 02 4910 0126

#### **NAROOMA**

5/20 Canty Street  
Narooma NSW 2546  
T 02 4476 1151  
F 02 4476 1161

#### **COFFS HARBOUR**

35 Orlando Street  
Coffs Harbour Jetty NSW 2450  
T 02 6651 5484  
F 02 6651 6890

#### **ARMIDALE**

92 Taylor Street  
Armidale NSW 2350  
T 02 8081 2681  
F 02 6772 1279

#### **MUDGEES**

Unit 1, Level 1  
79 Market Street  
Mudgee NSW 2850  
T 02 4302 1230  
F 02 6372 9230

#### **PERTH**

Suite 1 & 2  
49 Ord Street  
West Perth WA 6005  
T 08 9227 1070  
F 08 9322 1358

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Suite 204, Level 2  
62 Moore Street  
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T 02 4201 2200  
F 02 4268 4361

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1-5 Baker Street  
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