Hydrobiology Pty Ltd
Environmental Services

NPI Stage 2 EIS

Potential Effects of Water Abstraction on Aquatic MNES Species in the Mary River and Six Mile Creek

January 2008

In Association with Queensland Fauna Consultancy Pty Ltd

ABN	26 096 574 659
GST	The company is registered for GST
Head Office	47 Park Road Milton QLD 4064
Registered Office	Suite 309 Coolangatta Place 87 Griffith Street Coolangatta, QLD 4225
Postal Address	PO Box 2050 Milton QLD 4064
Phone	61 (07) 3368 2133
Fax	61 (07) 3367 3629
Email Contact	info@hydrobiology.biz
Website	http://www.hydrobiology.biz

NPI Stage 2 EIS

Potential Effects of Water Abstraction on Aquatic MNES Species in the Mary River and Six Mile Creek

January 2008

Document Control Information					
Date Printed					
Project Title	NPI Stage 2 EIS: Potential Effects of Water Abstraction on Aquatic MNES Species in the Mary River and Six Mile Creek				
Project Manager	Adrian Flynn				
Job Number	SRW0802				
Report Number	SRW0802_R_1				
Document Title	SRW0802_R_1_v2_JC.doc				
Document File Name	**Document Status**	**Originator(s)**	**Reviewed By**	**Authorised By**	**Date**
SRW0802_R_1_v1_JC.doc	External Draft	Jamie Corfield (Hydrobiology), Bryan Robinson (QFC)	Adrian, Flynn,	Adrian Flynn	18/1/08
SRW0802_R_1_v2_JC.doc	Internal Draft	Jamie Corfield (Hydrobiology), Bryan Robinson (QFC)	Adrian Flynn, Greg Robinson (NRW),	Adrian Flynn	8/2/08

Distribution			
Document File Name	**Description**	**Issued To**	**Issued By**
SRW0802_R_1_v1_JC.doc	Draft 1	Mark Breitfuss	Jamie Corfield
SRW0802_R_1_v2_JC.doc	Draft 2	Mark Breitfuss	Jamie Corfield
SRW0802_R_1_final_JC.doc	Final	Cassandra Arkinstall	Jamie Corfield

EXECUTIVE SUMMARY

Hydrobiology Pty Ltd (Hydrobiology) was commissioned to assess the potential impacts of the water harvesting strategy associated with the Northern Pipeline Inter-connector (NPI) Stage 2 Project on Matters of National Environmental Significance (MNES). Specifically, this study assessed potential impacts on two fish species; Mary River cod (*Macculochella peeli mariensis*) and lungfish (N*eoceratodus forsteri*) and one turtle species (Mary River turtle, *Elusor macrurus*) protected under the *Environmental Protection Biological Conservation Act* (1999).

Based on previous research, all three MNES species are expected to occur in the Mary River, while only Mary River cod and Mary River turtle are expected to occur in Six Mile Creek. The flow-dependent habitat requirements for these species were defined as part of this study. These included flows required to maintain key habitat features such as riffle and deep pool habitat and flows required to stimulate cues for movement at certain times of the year. There was considerable overlap in the flow requirements of the three MNES species.

The assessment focussed on parts of the Mary River catchment between the proposed abstraction point at Coles Crossing and Fishermans Pocket in the Mary River main channel and the reach of Six Mile Creek between Lake Macdonald and the confluence with the Mary River. IQQM modelling was used to compare hydrological responses under the proposed scenario against those under the pre-development and existing entitlement scenarios. The risk assessment carried out for this study was conservative in nature given that it assumed constant take of water rather than periodic takes during drought conditions on a regional scale.

IQQM modelling was used to determine whether or not the proposed scenario meets all the environmental flow objectives (EFOs) outlined in the Mary Basin Water Resource Plan (WRP). These set out to protect the broader aquatic community, including the MNES species addressed as part of this study. Results indicated that the Project satisfied all EFOs except for the '30 cm above cease to flow' EFO. The frequency at which flows are sufficient to maintain this water level under the proposed scenario was outside the target range stated in the WRP. This target range was set out by the WRP Technical Advisory Panel to help protect riffle-run habitat and fauna that rely on these habitats. The maintenance of riffle-run habitat is considered important for all three MNES species in terms of providing breeding and nursery habitat as well as wetted shallow stream corridor facilitating longitudinal movement. It was noted, however, that the 'existing allocation scenario' also falls outside the target range for this EFO and that the proposed scenario represents an improvement on the existing entitlement scenario with respect to this EFO.

High Flow Spell analysis was used to assess the effects of the proposed scenario on critical flow levels based on the flow-dependent habitat requirements of the MNES species. This analysis was more sensitive than the comparison against the WRP EFOs because it compared responses between the proposed scenario and the existing entitlement scenario at key times of the year rather than the entire year. Results of this analysis indicate that the Project will have negligible effect on elevated flows required by the MNES species for habitat maintenance or stimulating the within-channel movement of Mary River cod. However, there was some evidence to suggest that the duration of flows providing for 10cm and 30 cm

above cease to flow levels would decrease during the 'dry' period (August-November)at Dagun Pocket as a result of the project. As a result, the Project may cause interference to lungfish and Mary River turtle breeding and recruitment, restrict Mary River cod movement and / or result in reduced quality of pool habitat for all three MNES species during such times. However, such effects are likely to be minor with mitigation measures in place and even without mitigation, effects would most likely be restricted mainly to the region between the Coles Crossing abstraction point and the confluence of Six Mile Creek and the Mary Rive several kilometeres downstream. Significant impacts associated with low flows are not predicted at or downstream of Fishermans Pocket.

Results of high flow spell analysis also revealed that the Project will not significantly affect the frequency or duration of flows greater than or equal to a 2 m increase above cease to flow level and, hence, is not expected to impact on flows that maintain pool and turtle nest bank habitat through scouring and / or those that stimulate Mary River cod to undertake within-channel movement. Importantly, expected increases in flow in Six Mile Creek associated with the Project will not increase the prevalence of these 'greater than 2 m above cease to flow' or 5 yr average recurrence interval (ARI) types of flows in Six Mile Creek during the typical breeding and recruitment period for Mary River turtle. Hence no significant impacts on Mary River turtle breeding and recruitment success in Six Mile Creek are predicted to be associated with the Project (assuming breeding even takes place in this part of the study reach).

Increased flows entering Six Mile Creek will probably benefit Mary River cod and Mary River turtle in this system by inundating riffle habitat more consistently (and possibly creating new riffle habitat), reducing drawdown and infilling of deep pools and increasing the access of these species to submerged large woody debris. However, there may be some initial drowning of riffles and habitat re-setting at the onset of the increased flow regime, which may cause short-term disturbance to habitat stability, before these benefits are realised. These additional flows may also benefit populations of all three MNES species in the Mary River main channel downstream of the confluence with Six Mile Creek.

A range of mitigation measures and monitoring steps were put forward in this study to reduce potential impacts on MNES species and their flow-dependent habitat requirements. The preferential take arrangement is, in itself, a mitigation strategy that is expected to help avoid significant impacts on populations of MNES species in the Mary River main channel. Monitoring-related mitigation measures put forward focus mainly on the use of flow-dependent habitat surrogates for performance assessment, but this does not preclude baseline studies into population censuses of MNES species or those that explore the depths of their flow-dependent habitat associations in more detail. Nor do they preclude improvements to MNES species' habitat elsewhere in the catchment as compensation for any potential impacts.

NPI Stage 2 EIS

Potential Effects of Water Abstraction on Aquatic MNES Species in the Mary River and Six Mile Creek

January 2008

TABLE OF CONTENTS

TABLE OF TABLES

TABLE OF FIGURES

THIS PAGE DELIBERATELY KEPT BLANK

1 INTRODUCTION

1.1 Background

The Northern Pipeline Interconnector (NPI) is a drought contingency project (referred to herein as the Project) that will provide a bulk fresh water supply in the order of 65 ML/d between the Sunshine Coast and Brisbane. The Project is to be undertaken in several stages and relies on the collection and transportation of available spare capacity from existing water allocations at supply sources throughout the Sunshine Coast as well as accessing some additional flows through new entitlements

The NPI is being constructed in two stages. The first stage (Stage 1) is currently being constructed and will link the main supply line from the Landers Shute Water Treatment Plant (WTP) through to the Morayfield reservoirs. Stage 2 of the NPI will involve the construction of a pipeline between the existing facilities at Cooroy (Noosa WTP) and the termination point of Stage 1 at Eudlo (Landers Shute WTP). Stage 2 also includes a connection with an upgraded Image Flat WTP. Stage 2 is still subject to legislative approval and this report fulfils part of the approval process.

The NPI Stage 2 Project has recently been designated as a controlled action under Commonwealth Government legislation. This is because pipeline crossing construction in Six Mile Creek and planned water abstraction from the Mary River main channel have the potential to impact upon a number of EPBC-listed fish and turtle species. This report deals with issues relating to potential impacts of water abstraction in the Mary River main channel associated with the NPI Stage 2 development on Matters of National Environmental Significance (MNES) fish and turtle species.

Hydrobiology Pty Ltd (Hydrobiology) was commissioned by the Southern Regional Water Pipeline Alliance to provide this report, with support from Bryan Robinson (Queensland Fauna Consultancy Pty Ltd) and Matthew Gooda and Greg Robinson (Natural Resources and Water). This report does not address potential impacts of the Project on other flora or fauna, except with reference to potential indirect impacts on MNES fish and turtle species. Nor does it address potential impacts associated with abstraction from the Traveston Crossing Dam should that project go ahead.

1.2 Scope

Drought contingency water harvesting will make use of existing allocations from Baroon Pocket Dam and the Image Flat and Noosa Water Treatment Plants (WTPs). However, in addition to these existing allocations, the proponent is seeking to extract water from the Mary River at Coles Crossing and access spillover flows at Lake Macdonald under new entitlements. The Department of Natural Resources and Water would assess these applications to ensure consistency with the Mary Basin Water Resource Plan (WRP). The volume of water sought under the new entitlement for water harvesting from the Mary River is 40 ML / day, which equates to around 14600 ML / year. Note, however, that existing entitlements at Coles Crossing and Lake Macdonald will be not be extracted in addition to

the 40ML/d entitlement. A smaller entitlement may also be sought to enable the extraction of water from Lake Macdonald when it is spilling.

The water would be extracted under a preferential harvesting arrangement in order to minimise deleterious impacts on downstream water use and ecological values. This preferential harvesting system takes the form of a mutually exclusive and hierarchical take arrangement which is as follows:

- 1st Preference – Water harvested from the Mary River main channel at the Coles Crossing offtake when flow at the pump station is above 90 ML/day **AND** flow at Homepark gauging station is above 20 ML/day;

- 2nd Preference – Taking high priority allocation releases made from existing allocations from Borumba Dam (at the Coles Crossing offtake) at 40 ML/day up to a total of 6500 ML/annum when the first preference is unavailable;

- 3rd Preference – Water harvesting from Lake Macdonald at 40 ML/day when the dam is spilling and preferences 1 and 2 are unavailable;

- 4th Preference – Taking high priority allocation from existing allocations from Lake Macdonald at 40 ML/day up to a total of 5000 ML/annum when preferences 1-3 are unavailable.

In situations associated with the first two preferences, water would be pumped from Coles Crossing to the Noosa WTP, where it would be treated. A proportion of this water (around 19 ML / day) would constitute water supply to Noosa Shire, while the remainder would be fed into the water grid via the NPI. Where flows in the Mary River are below the minimum threshold for abstraction, alternative sources of water would be used. Existing allocations for Six Mile Creek, would be used as a last resort. The result of this strategy is that water is likely to flow over the Lake Macdonald spillway more regularly (i.e. flows in Six Mile Creek would be increased).

Should the proposed Traveston Crossing Dam go ahead, a license for extracting up to 206 ML / day from the dam (at Coles Crossing) would be sought. New pipeline infrastructure would be required to harvest and transport water from the dam to the Noosa WTP. The Traveston Crossing Dam is currently subject to legislative approval pending the outcome of an Environmental Impact Study (EIS) (QWI, 2007), while the construction of a new pipeline and increased levels of water abstraction would be subject to a new and separate EIS process. This study deals only with potential impacts of water abstraction on MNES fish and turtle species based on existing infrastructure and the water abstraction process outlined above.

1.3 Aims

The aim of this study was to provide information that will inform the EIS for the Northern Pipeline Infrastructure Stage 2 Project. Specific objectives included:

- Gathering and presenting evidence as to the likelihood of EPBC-listed fish and turtle species occurring in the study reach (the reaches where MNES species occur that are most exposed to altered flow regimes associated with the Project);
- Defining the flow-dependent habitat requirements of the MNES species potentially affected by the Project;
- Assessing the risks to the MNES species based on the outputs of modelled flow scenarios and benchmarking outputs against guideline environmental flow objectives (EFOs);
- Providing information that informs the development of mitigation options and / or environmental management procedures (EMPs) to reduce risks to MNES species potentially affected by the Project.

2 METHODS

2.1 Study Area

The study area is situated in the Mary River catchment, southeast Queensland. This catchment is already subject to a degree of water resource development, with major water storages on several of the main tributaries (Baroon Pocket Dam on Obi Obi Creek, Borumba Dam on Yabba Creek, Lake Macdonald on Six Mile Creek and Cedar Pocket Dam on Deep Creek) and a number of weir structures in smaller tributaries and the Mary River channel itself. Much of the surrounding land is subject to agricultural production and water is frequently taken from the Mary River main channel for this purpose. In comparison to other large catchments in southeastern Queensland, however, flow in the Mary River catchment is relatively less regulated and, at present, the Mary River is the only system of its size in the region that does not currently feature a large impoundment in its main channel. Infrastructure of this nature (Traveston Crossing Dam) has been proposed and is pending legislative approval (QWI, 2007).

The study reach is defined as the reaches where MNES species are likely to occur that are most exposed to water abstraction-related impacts associated with the Project. Water abstraction at Coles Crossing will not affect reaches upstream of this point. Hence, only reaches of the Mary River main channel downstream of Coles Crossing are considered relevant to this study. Of the remaining downstream reach, it is considered highly unlikely that impacts of water abstraction on flows would be ecologically significant beyond Fishermans Pocket. Results of hydrological modelling carried out as part of the Traveston Crossing Dam EIS (QWI, 2007) indicated that tributaries downstream of Coles Crossing contribute flows to the Mary River main channel, such that flow changes resulting from that project were modelled to be negligible at Fishermen's Pocket and beyond. Changes in flow associated with that project are expected to be far more substantial than those expected to be associated with the NPI Stage 2 Project. In essence, this means that significant impacts of water harvesting associated with the proposed scenario on MNES species downstream of Fishermans Pocket are extremely unlikely. Hence the study reach of interest to the NPI Project is that between Coles Crossing and Fishermans Pocket and it is assumed that no significant impacts of the Project on MNES species will occur downstream of this point. The study reach also comprises Six Mile Creek, because this sub-catchment contains Mary River cod and potentially Mary River turtles, and will likely be subject to increased flows from additional spillway over-topping events if the Project goes ahead. A map of the study area showing the study reach is shown in Figure 2-1.

It should be noted that Yabba Creek enters the Mary River within the Project study reach and flows in this tributary are affected by releases from Borumba Dam. These releases are believed to have maintained and possibly promoted the ecological values associated with habitat in the Mary River main channel below the confluence with Yabba Creek (QWI, 2007) at least as far downstream as Coles Crossing. As with Lake Macdonald, the Project is likely to result in increased releases from Borumba Dam into Yabba Creek for much the same reasons as why increased flows are expected from Lake Macdonald into Six Mile Creek (i.e. reduced take of water allocation from this dam = dam level full more often = increased frequency of dam spillovers).

2.2 Approach

2.2.1 Task Ordering

The first step in this study was to gather and present evidence as to the likely presence of various MNES fish and turtles in the study reach and to define the flow-dependent habitat requirements of those expected to occur in the study reach. The second step was to identify the critical flow volumes and / or water levels required to sustain those habitat requirements. From here, impacts were assessed based on modelled flow scenarios based on Integrated Quantity and Quality Modelling (IQQM) outputs. Assessments were made using two main approaches. Firstly, modelled flows were benchmarked against a range of Environmental Flow Objective (EFO) statistics developed for use as part of the Mary River Basin WRP process. Compliance with these EFOs is a legal requirement, but the intent behind the range of EFO set out in the WRP by the Technical Advisory Panel (TAP) was to protect aquatic communities as a whole, incorporating MNES species. Hence, compliance with the WRP EFOs was used as one of the means to assess potential impacts of water harvesting under the NPI Stage scenario on MNES species. Secondly, modelled flows were benchmarked against flow characteristics specific to the requirements of the MNES species covered in this study. These flow characteristics were derived based on the outputs of step 2. Effects of the Project on the seasonality of flows were also assessed, because some of the MNES species rely on flow variation as an environmental cue for movement and / or breeding. Seasonal flow variation is also important in maintaining their habitat and prey species.

Separate assessments were made for the Mary River main channel and Six Mile Creek as these two parts of the study reach host different suites of MNES species. Further, the two reaches are expected to be exposed to opposing flow-changes; the Mary River main channel will be exposed to diminished downstream flows, while Six Mile Creek will be exposed to enhanced flows as a result of the Project going ahead.

The final step in the study process was to identify potential indicators of the status of critical flow-dependent habitat for MNES species that could be used as part of monitoring measures associated with the EMP phase of the Project.

2.2.2 Risk Assessment

Risks to MNES species posed by each potential impact identified in this study were gauged on a qualitative basis. Risk ratings were informed by the following factors:

1. The likely spatial extent of the impact;
2. The likely temporal extent of the impact;
3. The likely relative severity of consequences should a given impact occur: and
4. The likelihood of a given impact occurring at all.

All of these factors, except consequence, were informed by outputs of flow modelling carried out as part of this study.

Risk was rated based on the product of likelihood and consequence (i.e. risk = likelihood x consequence). On this assumption, it is quite possible to achieve a low risk rating for an impact that has moderate to severe impact to MNES species should it occur where that impact has a very low likelihood of occurring.

Risk ratings were given for circumstances with and without mitigation (unless mitigation was expected to not make a significant difference to the outcome) so that the degree to which mitigation could potentially reduce risks to MNES species to an acceptable level was clearly outlined.

It should be noted that not all changes predicted to occur under the proposed scenario are necessarily deleterious. Where predicted changes were expected to benefit MNES species, this was taken into account.

A conservative approach to risk assessment was taken for this study, which should make the conclusions more robust and account for some of the unknowns surrounding the biology of the MNES species. The conservative nature of this assessment is based on the fact that:

- The impacts assessed in this report are those that may occur if the NPI was abstracting 40 ML/day from the Mary River on every day there was sufficient flow, throughout the entire IQQM modelling period (1890 to 1999). However the the Project is to serve as a drought measure and is only expected to be in operation at times of limited water supply in South East Queensland. The actual frequency of use in the future has not been predicted for the purposes of this report; and

- The critical flows identified for MNES species in this study are based on their habitat preferences and not necessarily their obligate requirements. There is some data to suggest that these MNES species are not always found in their preferred habitat conditions and may be more flexible in their habitat requirements than what information on their habitat preferences might suggests. However, for the purpose of this study, we have viewed preferred habitat maintenance as a requirement for their ongoing survival; and

Potential impacts of the NPI Stage 2 have been benchmarked against flows under the existing entitlement scenario. While comparisons with the pre-development scenario would be optimal, given that the MNES species would logically be un-impacted by flow regime modification and probably at their peak abundance, there are no long–term data sets to confirm the latter. While populations of MNES species in the study area under the existing entitlement scenario cannot be necessarily regarded as 'healthy' (indeed their protection status, coupled with recent data for Mary River turtle juvenile recruitment levels (EPA, 2007) might suggest otherwise), benchmarking impacts against the existing entitlement scenario is acceptable because (a) at least there are some abundance and habitat quality and distribution data to assess impacts against for the period for which this scenario applies and (b) the existing entitlement scenario represents an adequate starting point for assuming that any further significant declines in MNES abundance due to the Project are unacceptable.

Produced at the Natural Sciences Precinct
by Natural Resource Information Management,
RSK, **Department of Natural Resources.**

Printed:- December 04, 2000 Current Workspace:- /projects1/mr16224

LEGEND

- 136318A — Gauging Station
- Basin Boundary
- Main Highway
- Main Rivers/Creeks
- Minor Rivers/Creeks
- Kilkivan — Main Towns

Hervey Bay
Howard
Maryborough
Tin Can Bay
Gunalda
Kilkivan
Goomeri
Murgon
Gympie
Amamoor
Pomona
Cooroy
Noosa Heads
Eumundi
Imbil
Yandina
Kenilworth
Nambour
Maroochydore
Caloundra
Maleny
Kilcoy
Tiaro
Bundaberg

MARY RIVER
MARY BARRAGE
TEDDINGTON WEIR
TINANA CREEK
TALLAGALLA WEIR
MIJINA CREEK
BRUCE HIGHWAY
WIDE BAY CREEK
WIDE BAY HIGHWAY
GLASTONBURY
BURNETT HIGHWAY
SIX MILE CREEK
AMAMOOR CREEK
KANDANGA CREEK
COOROY WEIR
YABBA CREEK
BORUMBA DAM
OBI OBI CREEK
BARROON POCKET DAM

138014A Home Park
138004B
138903A
138001A Miva
138002C
138010A
138009A
Fisherman's Pocket
138007A
138020A
138003A
138003D
138003B
138003C
Dagun Pocket
138109A
138107A
Cooran
138102A
138102C
138113A
138108A
138105A
138105D
138111A Moy Pocket
138101A Kenilworth
138104A
Bellbird
138110A
138106A

Location Map

Location of Mary River Basin within Australia

Study Area
- Nodes
- Study Reach
- Coles Crossing (Noosa Pumping station)

Study Area for Water Harvesting Assessment

Northern Pipeline Interconnector (Stage 2)

Queensland Government
Department of Natural Resources

27/02/2001

Mary River Basin
Locality Map

A3-505189

1:500 000

0 10 20 30 40 50 KILOMETRES

0 4 8km
Scale 1:150,000 @ A3

Source: *Base data supplied by Department of Natural Resources and Water*

Projection: *GDA94 (MGA56)*

File Path: *O:\BRS\...\TOC 5 Northern Interconnector\Mapinfo\Workspaces\EIS\Hydrobiology Report\TOC5B\Figure x Mary River Basin & Study Reach Water Harvesting with Nodes.Wor*

Date: *2 April 2008 (Rev C)*

NORTHERN NETWORK ALLIANCE

NORTHERN PIPELINE INTERCONNECTOR

MARY RIVER BASIN & STUDY REACH - WATER HARVESTING ASSESSMENT

2.3 Presence of MNES Species in the Study Area

Four fish species and one species of turtle protected under the *Environment Protection and Biodiversity Conservation Act* (1999) legislation (EPBC Act) occur in the Mary River catchment. These include Mary River cod (*Maccullochella peeli mariensis)*, lungfish (*Neoceratodus forsteri*), honey blue-eye (*Pseudomugil mellis*), Oxyleyan pygmy perch (*Nannoperca oxleyana*) and Mary River turtle (*Elusor macrurus*). Assessments of the likely presence or absence of these species in the study reach were based primarily on a review of the relevant scientific literature, which included the recently completed Traveston Crossing Dam EIS (QWI, 2007) and supporting studies (Ecotone Environmental Services, 2007) as well as primary literature sources such as Simpson (1994); Simpson and Mapleston (2002); Simpson and Jackson (1996), Pickersgill (1998) and Flakus (2002), and review summaries (Kennard, 2003 -Mary Basin Water Resource Plan technical appendix H and Werren and Arthington, 2003 - Mary Basin Water Resource Plan technical appendix I). Recent investigations carried out as part of this EIS were used to assess the likely presence of MNES species in the Six Mile Creek component of the study reach (Hydrobiology, 2008; Queensland Fauna Consultancy, 2007). Direct observations by the authors were also used a basis for performing this task. No field data collection was possible given the timeframe of this study, but available data were considered adequate for the purpose of this study.

2.4 Flow-Dependent Habitat Requirements

The flow–dependent habitat requirements of MNES species considered likely to be present in the study reach were determined based on habitat requirements reported in the literature, including those reviewed and summarised for Mary River cod and lungfish in the QWI (2007) study. Flows required to maintain these habitat features were first defined at a broad level, then required flow volumes were assigned based on ratings tables for relevant nodes. These, in turn, were used as part of the High Flow Spells Analysis (Marsh 2004), performed using the *River Analysis Package*. This analysis was used to assess whether or not critical habitat maintenance flows are likely to be affected significantly by the Project in terms of their frequency, timing and duration.

2.5 Assessment of Modelled Flows against Relevant Guidelines and Species-Specific EFOs

IQQM-modelled pre-development, existing entitlement and proposed development flow scenarios were benchmarked against EFOs outlined in both the final WRP and those put forward in an earlier draft by the Technical Advisory Panel. These include those that should be complied with and those that must be complied with under the WRP. While the Project is only legislatively required to comply with the final WRP EFOs, draft WRP EFOs were included in this assessment for the sake of transparency to address public perceptions about the adequacy of the EFOs in the final WRP for ecosystem protection. Only EFOs for Fishermans Pocket were used for this assessment, because neither of the other two nodes considered as part of this study (Dagun Pocket and Six Mile Creek at Cooran) have EFOs specified in the WRP.

2.5.1 Assumptions of modelled flow scenarios

The proposed operating arrangements to supply the NPI have been incorporated into the Full Utilisation of Existing Entitlements IQQM scenario. This involved adding a water harvesting extraction node on the Mary River, at the existing pump site for Noosa's Town Water Supply (TWS) at Coles Crossing, and replacing the existing TWS demands at Coles Crossing and Six Mile Creek Dam with extraction nodes that divert water to the NPI at 40 ML/d, up to the licensed volume of each allocation (see below).

The total water requirement for this Project, of 40 ML/d, has been modelled as an extraction from the following sources, in the order of priority listed:

1. Water Harvesting at 40 ML/d from the Mary River at Coles Crossing when flow at the pump site is greater than 90 ML/d and flow at Homepark Gauging Station is greater than 20 ML/d;

2. Accessing Noosa's TWS allocation from Borumba Dam at 40 ML/d up to a maximum annual diversion of 6500 ML;

3. Water harvesting from Lake Macdonald at 40 ML/day when the dam is spilling; and

4. Accessing Noosa's TWS allocation from Lake Macdonald at 40 ML/d up to a maximum annual diversion of 5000 ML.

The modelling undertaken for the NPI Stage 2 has not altered any of the assumptions used in the Full Utilisation of Existing Entitlements scenario except for those mentioned above, and is therefore a suitable tool to assess the relative change in flow conditions caused by the proposed scenario.

The NPI Stage 2 water harvesting case does not include Traveston Dam, nor the 70,000 ML / annum allocation from it. However, the IQQM simulation period was the same as that used for the Traveston Crossing Dam EIS (1 January 1890 to 31 December 1999).

2.6 Development of indicators for monitoring under the EMP

Tasks under the Environmental Management Plan (EMP) component of the Project should include some assessment of the degree to which impacts of the Project on MNES species occur and linkage of the outputs of these assessments to adaptive management measures. It is unlikely that monitoring of MNES species themselves would be practical. On the other hand, assessments of habitat features affected by flow variability offers a good surrogate for determining the impacts associated with the Project on MNES species. For this study, indicators for potential use in EMP–associated monitoring of impacts on MNES fish and turtle species were determined using the information contained in the Ecological Asset–Critical Water Link table produced by Queensland Department of Primary Industry and Fisheries members of the Mary River Basin WRP TAP (NRW, 2003). New indicators were outlined for Mary River turtle in this study based on information regarding flow–dependent habitat requirements of this species presented in the literature.

3 RESULTS AND DISCUSSION

3.1 Background to Aquatic MNES species

Details of the protection status, broad distribution, general habitat requirements and sensitivity to change of the aquatic MNES species at the focus of this study are provided in Hydrobiology and Queensland Fauna Consultancy reports relating to the NPI construction project and the impact assessment relating to the construction and watercourse crossings (Hydrobiology, 2008; Queensland Fauna Consultancy, 2007). Hence, these details are not reproduced for this report.

3.2 Presence of Aquatic MNES Species in the Study Area

3.2.1 Mary River Cod

Mary River cod are certain to be present in all parts of the study reach. A map of the distribution of this species in the catchment is given in Hydrobiology (2008). Discussions of the likely presence of Mary River cod in Six Mile Creek are also presented in that report and are not repeated here. Further evidence supporting the presence of Mary River cod in the study reach between Coles Crossing and Fishermans Pocket includes:

- Three specimens were recorded during the boat-mounted electrofishing sampling associated with the QWI (2007) study, two at Coles Crossing and one near the confluence of the Mary River and Six Mile Creek (between Dagun Pocket and Fishermans Pocket);

- A Mary River cod specimen was observed near Dagun Pocket during the detailed habitat survey and turtle survey components of the QWI (2007) study and several other specimens were observed near Coles Crossing during that same study;

- Habitat immediately downstream of the proposed dam wall classified as 'moderate' to 'good' quality potential Mary River cod habitat as part of the QWI (2007) study, while some habitat in the stretch of river between Coles Crossing and Dagun pocket was rated as 'excellent' quality cod habitat. The latter part of the catchment also contained 'very poor' cod habitat. Pickersgill (1998) classified the part of the catchment containing the study reach as 'cod population in poor habitat', acknowledging the presence of cod in this reach. Her habitat rating was not based on an as detailed survey method as that used for the QWI (2007) study and, consequently, appears to be more conservative; and

- Observations made in the QWI (2007) based on surveys by Hydrobiology and Ecotone Environmental Services (Ecotone) suggest that there are much fewer Mary River cod downstream of Gympie, particularly in the Gundiah –Tiaro section, than in section between Dagun Pocket and Moy Pocket, despite apparent good quality cod habitat in the downstream section. A hypothesis was put forward in the QWI (2007) that this may have been due to increased predation by fork tail catfish (*Arius graeffei*), but this hypothesis has not been tested.

3.2.2 Lungfish

A map showing the known distribution of established lungfish populations is shown in the Hydrobiology (2008) report. Discussions of the likely presence of lungfish in Six Mile Creek are also presented in that report and are, therefore, not presented here. Lungfish certainly occur and have established populations in the part of the study reach between Coles Crossing and Fishermans Pocket. Six Mile Creek is unlikely to support established populations of this species given that it lacks suitable breeding and juvenile habitat along much, if not all, of its reach. However, lungfish are occasionally seen upstream near Lake Macdonald after elevated flow events, these individuals most likely representing migrants to this part of the catchment rather than members of an established population. Further evidence supporting the presence of lungfish in the study reach between Coles Crossing and Fishermans Pocket includes:

- A number of lungfish were captured during boat-mounted electrofishing at Coles Crossing and the confluence of Six Mile Creek as part of the QWI (2007) study;
- Two lungfish were captured at a wadeable stream sampling site between Coles Crossing and Dagun Pocket as part of the QWI (2007) study;
- Lungfish were observed at or near Coles Creek and downstream of Dagun Pocket during detailed habitat assessment and turtle survey tasks associated with the QWI (2007) study; and
- Despite the reduced abundance of Mary River cod downstream of Gympie observed during the QWI (2007) study, lungfish remained relatively abundant in these downstream reaches.

Also of relevance to this study was the occurrence and relative abundance of lungfish in Imbil Weir on Yabba Creek (QWI, 2007), a reach exposed to modified flows and habitat conditions due to flow regulation.

3.2.3 Other EPBC-listed fish species

Oxleyan pygmy perch and honey blue-eye are highly unlikely to occur in the study reach based on:

- A lack of any previous records of these species in the study reach;
- A lack of habitat suitability in both the main branch of Six Mile Creek and the Mary River main channel (see habitat descriptions in Hydrobiology (2008) and QWI (2007) and habitat preference requirement details for these species given in Hydrobiology (2008); and
- Locations where these species occur have no direct connectivity with the study reach. Only the Tinana-Coondoo Creek population has connectivity with the Mary River main channel and the confluence of this sub-catchment and the Mary River is well downstream of the study reach.

Oxleyan pygmy perch may occur in the Left Branch of Six Mile Creek based on relatively good overlap between habitat conditions in this creek and the preferences / requirements of this species (Hydrobiology, 2008). However, the Left Branch of Six Mile Creek receives flows from a separate sub-catchment to the main branch of Six Mile Creek and is, therefore, not affected by Lake Macdonald. Hence, any Oxleyan pygmy perch in the Left Branch of Six Mile Creek would not be impacted by changes to flow in Six Mile Creek associated with the Project. The same is true of the known population in Tinana-Coondoo Creek.

For this reason, Oxleyan pygmy perch and honey blue eye are not considered further as part of this component of the NPI Stage 2 EIS study.

3.2.4 Mary River Turtle

Mary River

The Mary River Turtle, *Elusor macrurus,* is confined to the Mary River Catchment, including the main stream of the Mary River and some major tributaries including Tinana Creek and Yabba Creek) and has been recently recorded in suitable localities within Obi Obi Creek (Craig Latta, pers. comm.; Ecotone Environmental Services, 2007). In the Mary River main channel, it occurs as far downstream as the Mary River Barrage at Tiaro and as far upstream as and possibly further than Kenilworth (Cogger et al. 1993; Cann and Legler, 1994; Cann, 1998; Flakus, 2000). Tucker et al. 1999 recorded *Elusor macrurus* at altitudes from 40 to 120 m.

Evidence of the likely presence of Mary River turtle in the Coles Crossing to Fishermans Pocket part of the study reach includes the following:

- During the Ecotone Environmental Services (2007) study, frequency data indicated the reach from Traveston Crossing to 7.6km downstream supported the greatest density of Mary River Turtles currently known for the species, at 7.6 individuals per km. Eighteen adult males, six adult females and thirty four juveniles were recorded within this reach indicating good availability of both adult and juvenile habitat. The reach identified as the Moy Pocket – Traveston Crossing reach in that study, which included the Coles Crossing to Traveston Crossing section, yielded the second highest known density for the species with a frequency of 4.2 individuals per km;

- Potential nest banks were identified as prevalent within the reach from Traveston Crossing to 7.6 km downstream, with additional banks located immediately upstream of this reach (Ecotone Environmental Services, 2007). The abundance of potential nesting sites and the apparent success of nesting within this area as implied by the high proportion of juveniles present, further supports conclusions of the significance of this area to the species;

- Key Mary River turtle habitat components, including riffles, but also including a mosaic of instream habitat such as pool riffle run sequences, were found to be well represented in the Moy Pocket – Traveston Crossing and Traveston Crossing to 7.6 km downstream reaches (Ecotone Environmental Services, 2007). These features are likely to support the large numbers of individuals found in these reaches;

- In the study by Ecotone Environmental Services (2007), Mary River turtle were less abundant in the downstream reaches of the Mary River, particularly between Gympie and Netherby, than in the lower end of the Traveston Crossing - Moy Pocket and Traveston Crossing to 7.6 km downstream reaches, despite the intermittent occurrence of apparently suitable habitat in this river section. Furthermore, no juvenile turtles were recorded further than 7.6 km downstream during that study. However, the Ecotone Environmental Services, (2007) was a short-term study and did not sample in areas further downstream near the Mary River Barrage at Tiaro. In addition, reduced visibility in the reach between Gympie and Netherby may also have been a factor in the reduced number of Mary River turtle observations in this reach compared to upstream reaches (although this seems unlikely given that a relatively large number of other turtle species were caught in this reach at the time). Longer term data sets held by the Queensland Environmental Protection Agency (EPA) indicate that Mary River turtle are relatively abundant further downstream near the Mary River Barrage at Tairo and that both adults and juveniles were present, with juveniles making up around 35% of the population in that lower reach (EPA, 2007). Nonetheless, given assumptions about the limited extent to which flows are likely to be affected by the proposed scenario downstream of Fishermans Pocket, the most critical part of the study reach for Mary River turtle is the reach between Coles Crossing and 7.6 km downstream of Traveston Crossing identified as part of the Ecotone Environmental Services (2007) study; and

- Mary River turtle have been observed within Yabba Creek downstream of Borumba Dam – a reach subject to modified flow regimes (EPA, 2007).

Six Mile Creek

No records exist for the Mary River turtle within Six Mile Creek. Habitat assessment in a previous investigation downstream of Lake MacDonald showed usable deep pool habitat but lacked the connective habitat required by the species (Queensland Fauna Consultancy, 2007). Occurrence within these upstream localities was deemed unlikely.

The mid reach of Six Mile Creek through to the confluence of the Mary River contain variable habitat (i.e. pool-riffle-run sequences) more indicative of that utilised by the Mary River turtle (Simpson and Jackson, 1996; R. Manning, pers. comm.). Other tributaries of the Mary River also contain apparent usable pool habitat, but the species does not occur in them all, perhaps due to a lack of connective instream habitat.

Mary River cod are known to exist in Six Mile Creek and this fish species has similar habitat requirements to Mary River turtle. These two species are often observed occurring together in certain habitats. Therefore, this may point to the potential existence of Mary River turtle in Six Mile Creek. Further investigations would be required to accurately determine the presence of the species in Six Mile Creek but Mary River turtle are assumed to occur in this sub-catchment for the purpose of this study.

3.3 Flow-dependent Habitat Requirements

Flow-dependent habitat requirements were identified for Mary River cod, lungfish and Mary River turtle. This information was obtained mainly from information presented in the literature. Flow-dependent habitat requirements comprise both physical habitat affected by flow variation and flows of certain timing or volume required to stimulate movement and /or breeding activity. It should be noted that there are some instances where the flow requirements of one species conflicts with those of other species. An example of this is where Mary River cod require elevated flows during the spring–summer period to stimulate movement, while lungfish and Mary turtles require more stable baseflows during his period to ensure successful breeding and recruitment. As discussed in Section 2.2.2, we have assumed preferred habitat features of the MNES to be pre-requisite to the maintenance of their population, although we acknowledge that these species may have some flexibility in terms of their actual habitat requirements. This issue is discussed in relation to each species below.

3.3.1 Mary River Cod

.

Table 3-1 outlines the flow-dependent habitat requirements for Mary River cod with an indication of what types of flows are required to maintain these features and the preferred timing of these critical flows. It should be noted that Mary River cod are not always found in their preferred habitat, as evidenced in studies by Pickersgill (1998) and QWI (2007). This may reflect a wider habitat tolerance than the habitat requirements listed in the table below suggest. Equally, however, it may also reflect observations of cod moving between preferred habitat, or the limited availability of preferred habitat in some sections of river at the time of such observations. There is also a possibility that juvenile cod may use sub-optimal habitat to avoid predation by adults (QWI, 2007; Hydrobiology, 2008).

With respect to the maintenance of riffle habitat to allow longitudinal movement of adults along the river channel, it should be noted that flows providing water levels of less than 30 cm above cease to flow level may still allow juveniles and smaller individuals to undertake longitudinal within-channel movement.

With respect to the requirement for stable flow to maintain pool depth, it should be assumed that wherever conditions for allowing water levels to reach 10 cm above cease to flow level or above, that pool depth should also be maintained through water top up (assuming no pool infilling is occurring at the same time due to sedimentation). This assumption holds for the habitat requirements of all three MNES species

With respect to flows to stimulate movement cues, we acknowledge that the weight of evidence suggest that cod do not need these cues to breed (cod readily breed in tanks in the absence of flow (QWI, 2007) and that movement appears unrelated to breeding (movement is not undertaken at the same time in the same direction (Simpson and Jackson, 1996; Simpson and Mapleston, 2002). Thus flows that stimulate movement cues may not be essential to the long term survival of Mary River cod. Nonetheless, the fact remains that cod continue to move large distances as part of their life cycle and this may offer an evolutionary advantage to them in terms of increasing their chances of finding prey and / or potential mates. Hence, such flows were considered as a habitat requirement for Mary River cod for the purpose of this study.

With respect to flows equivalent to a typical 'fresh' event in autumn-winter to stimulate cod movement in tributaries to over-winter, this assumption was based on the findings of Merrick and Schmida (1984), which were based on limited data. A more recent radio-tracking study by Simpson and Mapleston (2002) found evidence that contradicts this assumption, but this study was also based on limited data. Until the biology of this species is better understood, we have assumed that (a) cod need to move at this time of year for whatever reason and (b) that some individuals may migrate into tributary habitat during such times for whatever reason. The flow volume representing a 'typical fresh event' was determined from a review of hydrological data for the simulation period of January 1890 to December 31 1999. These were identified as flows that would occur at least twice a year on average.

.

Table 3-1 Flow-dependent habitat requirements of Mary River cod

Habitat Feature	Flows / Water Levels Required	Why Required	When Required
Deep Pool Habitat (>2m) with an area > 100 m^2	• Relatively stable baseflows (flows that at least provide for 10 cm above cease to flow level). • Flows equivalent to or greater than those associated with a typical 'fresh' event (i.e. equivalent to an increase of 2m above cease to flow level). • Habitat maintenance flows equivalent or greater than a 20 year ARI	• Reduce infilling of, or declining water levels in deep pool habitat used by adult Mary River cod. • Baseflows maintain pool depth by topping up water level • Depth maintenance required to inundate adult cod habitat and reduce potential for fish kills associated with elevated temperatures. • Flushing flows equivalent to or greater than typical 'fresh' event needed to scour pool beds to prevent infilling and to reduce problematic macrophyte growth linked to fish kills. • Flows ≥ 20 year ARI events facilitate the creation / maintenance of deep water pool habitat.	• Near constant baseflow. • 'Fresh' event–sized flows that normally occur at least twice per year. • Habitat maintenance flows required once every 20 years on average over time.
Within-channel	Elevated flows equivalent to or greater than those associated with a typical 'fresh' event in	• Stimulate cod movement out of tributaries back to their normal home range for spawning.	Autumn - Winter (May-June)

Habitat Feature	Flows / Water Levels Required	Why Required	When Required
	autumn - winter	• Maintain the evolutionary advantage of the strategy of within-channel movement by cod at such times, which may include increased access to prey or encounters with potential mates.	
Within-channel	Elevated flows equivalent to or greater than those associated with a typical 'fresh' event in spring -summer (or when water temperatures reach 20°C)	• Stimulate cod movement out of tributaries back to their normal home range for spawning. • Maintain the evolutionary advantage of the strategy of instream movement adopted by cod, which may include increased access to prey or encounters with potential mates.	Spring–Summer (September-February)
Riffle-run habitat	Water levels to be ≥ 30 cm above cease to flow level.	• Maintain habitats used by Mary River cod prey species. • Maintain 'run' habitat potentially used by juveniles. • Maintain pool-riffle-run connectivity to allow longitudinal movement of large adult cod at key times of the year.	Near constant, but particularly in May-June and September – February.
Bank undercut	Flushing flows roughly equivalent to or greater than a	Scour out and / or maintain depth in deep pools where adult cod normally	Flushing flows required once every

Habitat Feature	Flows / Water Levels Required	Why Required	When Required
habitat	5 year ARI flow	reside. Scour out rock undercuts, potentially used as spawning sites	5 years on average over time.

3.3.2 Lungfish

Table 3-2 outlines the flow-dependent habitat requirements for lungfish with an indication of what types of flows are required to maintain these features and the preferred timing of these critical flows.

With respect to the maintenance of riffle –run and glide habitat to allow longitudinal within-channel movement of lungfish in the breeding season, a previous study by Kind (2002), revealed that lungfish in the Mary River do not appear to undertake significant movement during breeding season or any other time of year, unlike those of other populations in the nearby Burnett River. Hence, provision of stream connectivity during lungfish in the Mary River may not be as critical. Nonetheless, we have assumed that it is, based on the precautionary principle.

Table 3-2 Flow-dependent habitat requirements of Lungfish

Habitat Feature	Flows / Water Levels Required	Why Required	When Required
Dense macrophyte beds in riffles, run, glide and pool margin habitat.	• Relatively stable baseflows. • Depth of water in riffles and glide habitat between 30 cm and 1m above cease to flow levels	• Used for breeding and as a nursery area for juveniles • Facilitate adult lungfish instream movement at breeding times.	Near constant baseflow, especially during August -December
Deep pool habitat	• Relatively stable baseflows (flows that at least provide for 10 cm above cease to flow level). • Flows equivalent to or greater than those associated with a typical 'fresh' event (i.e. equivalent to an increase of 2m above cease to flow level). • Habitat maintenance flows equivalent or greater than a 20 year ARI	• Reduce infilling of, or declining water levels in deep pool habitat used by adult lungfish. • Baseflows maintain pool depth by topping up water level • Depth maintenance required to inundate adult lungfish habitat and reduce potential for fish kills associated with elevated temperatures. • Flushing flows equivalent to or greater than typical 'fresh' event needed to scour pool beds to prevent infilling and to reduce problematic macrophyte growth	• Near constant baseflow. • 'Fresh' event-sized elevated flows that normally occur at least twice per year. • Habitat maintenance flows required once every 20 years on average over time. • Elevated discharges preferably outside of August-February period to avoid impacts on breeding and recruitment.

Habitat Feature	Flows / Water Levels Required	Why Required	When Required
		linked to fish kills. • Flows ≥ 20 year ARI events facilitate the creation / maintenance of deep water pool habitat.	

3.3.3 Mary River turtle

Table 3-3 outlines the flow-dependent habitat requirements for Mary River turtle with an indication of what types of flows are required to maintain these features and the preferred timing of these critical flows.

With respect to the requirement to maintain riffles to help facilitate oxygenation of water in the riffle zone and in pools immediately downstream, the basis for this is that oxygenation of the water column assists Mary River turtles with cloacal breathing. This mode of breathing, while not necessarily essential to their survival given that they also possess lungs, offers them an evolutionary advantage, because it allows them to stay underwater longer, thereby reducing risk of predation. This strategy is particularly useful for juveniles as they are most vulnerable to predation (EPA, 2007). It should be noted, however, that Mary River turtle have been observed living and breeding in **small** impoundments in the absence of riffle-run-glide habitat. For example:

- It has been captured and recorded breeding from within the Mary River Barrage impoundment in the lower catchment, although the ratio of juveniles to adults in that reach (35% juveniles to 65% adults) was considered sub-optimal for the long-term viability of that population (EPA, 2007). Note, however, that this ratio is not necessarily statistically different to ratios recorded in other parts of the catchment by Ecotone Environmental Services (2007);

- It has been recorded within the Tallegalla Weir impoundment, Tinnana Creek; and

- It has been captured and recorded breeding from within the Imbil Weir impoundment, Yabba Creek (although no data on nesting bank quantity or quality, Mary River turtle abundance or size structure data were presented in the EPA (2007) report for this reach).

These findings indicate that Mary River turtle may not have an obligate requirement for riffle-run-glide habitat. However, under the precautionary principle, we have assumed that maintenance of their preferred habitat provides the best chance for their long-term survival, so maintenance of flows that sustain these habitats was regarded as a habitat requirement for the purpose of this study.

With respect to maintaining riffle habitats for maintaining the availability of food sources for juvenile Mary River turtles such as macrophytes and macroinvertebrates, it should be noted that there has been no in-depth study of the diet of Mary River turtle and from the limited sampling undertaken by EPA (2007) and Flakus (2002), adults are considered primarily herbivorous, while juveniles are considered primarily carnivorous. Adults are known feed on a range of macrophytes as well as the fallen fruits of riparian trees including figs, lillypilly and black beans (EPA, 2007). Our supposition that juveniles feed on macroinvertebrates and macrophytes in riffle zones is based on:

- The regular observation of juvenile Mary River turtle living in or directly adjacent to riffle habitat during the Ecotone Environmental Services (2007) study;

- The Flakus (2002) dietary data, which suggests that diet of juveniles is distinct from adults in terms of the greater proportional consumption of macroinvertebrates over plant material by juveniles; and

- The relatively high proportions of hydropsychidae (caddisfly larvae), filamentous algae and *Vallisneria nana* (ribbon weed) consumed by Mary River turtle (adults and juveniles), as observed by Flakus (2002), together with the fact that these prey items tend to occur predominantly in riffle zones (QWI, 2007).

Unfortunately detailed dietary data reported by Flakus (2002) were pooled across size classes and, combined, juvenile and adult Mary River turtle appear to feed on a wide variety of prey. Hence, it is not possible to definitively tell whether juvenile Mary River turtles have a particular preference for predominantly riffle associated taxa. However, this seems unlikely given that many macroinvertebrate taxa in the Mary River occur in a variety of habitat types (QWI, 2007). Furthermore, if juveniles have the same sort of trophic plasticity as that reported by Flakus (2002) across adults and juveniles, their reliance on riffle associated prey may be limited. Based on the precautionary principle, however, we have assumed that juvenile Mary River turtle may have preferences for riffle associated prey species. It is on this basis that we have assessed potential indirect impacts of the Project on Mary River turtles associated with its potential impact on riffles and associated flora and fauna.

Table 3-3 Flow-dependent habitat requirements of Mary River turtle

Habitat Feature	Flows / Water Levels Required	Why Required	When Required
Riffle Habitat	• Relatively stable baseflows Water levels to be ≥ 30 cm above cease to flow level.	• Maintain preferred juvenile Mary River turtle habitat. • Maintain the availability of food sources for juvenile Mary River turtles such as macrophytes and macroinvertebrates. • Maintain connectivity between pools during within-channel movement associated with breeding activity. • Reduce exposure to desiccation and predation associated with traversing dry stream bed between pools. • Facilitate oxygenation of water in the riffle zone and in pools immediately downstream. • Maintain seasonal thermal profiles within fast water and immediate deepwater localities to ensure habitat conditions in favoured pools are not compromised.	Near constant baseflows, but particularly required in October - December, when Mary River turtles normally breed and December – January when eggs are incubating and hatchlings are emerging.

Habitat Feature	Flows / Water Levels Required	Why Required	When Required
Deep pool habitat	• Relatively stable baseflows (flows that at least provide for 10 cm above cease to flow level). • Flows equivalent to or greater than those associated with a typical 'fresh' event (i.e. equivalent to an increase of 2m above cease to flow level). • Habitat maintenance flows equivalent or greater than a 20 year ARI	• Reduce infilling of, or declining water levels in deep pool habitat used by adult Mary River turtle • Baseflows maintain pool depth by topping up water level • Depth maintenance required to inundate and moisten pool margins at localities suitable for nest banks, for inundating sub-surface basking habitat structure and ensuring a continued presence of macrophytes around pool fringing margins for turtle feeding. • Flushing flows needed to scour pool beds to prevent infilling. • Flows ≥ 20 year ARI facilitate the creation / maintenance of deep water pool habitat including the introduction of further instream snag habitat structure.	• Near constant baseflow. • 'Fresh' event-sized elevated flows that normally occur at least twice per year. • Habitat maintenance flows required once every 20 years on average over time. • Elevated flows preferably at times outside of October – December breeding season and subsequent incubation /hatching period from December - January
Sand banks with limited terrestrial plant growth	• Relatively stable baseflows (flows that at least provide for 10 cm above cease to flow	• Maintains deposition of sediment (i.e. nest bank formation). • Scours banks reducing area colonised by terrestrial plants,	• Near constant baseflows • 'Fresh' event elevated flows that normally occur at least

Habitat Feature	Flows / Water Levels Required	Why Required	When Required
	level). • Flows equivalent to or greater than those associated with a typical 'fresh' event (i.e. equivalent to an increase of 2m above cease to flow level).	increasing suitability as nest bank sites.	once per year. • Elevated flows preferably outside of breeding season (i.e. outside of September – November) and subsequent incubation /hatching period from December - January

3.4 Assessment of Modelled Flows against Relevant Guidelines

3.4.1 Water Resource Plan Environmental Flow Objectives

The range of EFOs put forward as part of the WRP process is aimed at protecting the broader aquatic community, which includes MNES species dealt with as part of this study. Comparisons of modelled EFO statistics for the proposed scenario against benchmark EFO values given in the final WRP indicate that the Project complies with all but the '30cm above cease to flow' EFO (Table 3-4). In the absence of any mitigation and, on its own, this result could be taken to indicate that the Project could affect the quality and availability of riffle-run habitat and connectivity between pools for large Mary River cod as far downstream from the abstraction point as Fishermans Pocket. It should be noted, however, that:

- The current full entitlement case also falls outside the target range, and the NPI is an improvement at the reporting node due to more water released in Six Mile Creek as spillover from Lake Macdonald;

- This analysis covers conditions over a full year, whereas riffle habitat assumes greater importance to the MNES species at certain times of the year (in other words this is a course assessment, so predictions of potential impacts on MNES species based on this assessment may be too conservative);

- The degree of non-compliance is relatively low and may not necessarily be either ecologically significant and / or outside the sensitivity margins of the IQQM model; and

- The WRP EFO in question states that any decision relating to flows must "minimise the extent to which…" the modelled flow value falls outside the desired range. As such, compliance with this EFO can be achieved by the licence holder / applicant clearly stipulating what mitigation measures have been taken to minimise the proportion of time the value falls outside the desired range.

In terms of comparisons with the Draft WRP EFOs, the proposed scenario does not comply with the '30cm above cease to flow' EFO, which is the same as that put forward in the final WRP. In addition, the proposed scenario does not comply with the 'days of flow < 1ML/day' EFO put forward in the Draft WRP. However, it should be noted that, in this case, the Draft WRP EFO statistic is considered to be erroneous as it does not take into account natural variation that could include zero days of flows less than 1 ML/ day. This was corrected for the final WRP. Hence, non-compliance with this Draft WRP EFO has no relevance in terms of assessing potential impacts of the proposed scenario on MNES species. Compliance with the EFOs relating to high to medium flows indicates that the Project is unlikely to impact on critical flows affecting pool and nest bank habitat maintenance or cues for movement and breeding of MNES species in the Mary River.

While not a reportable node, an assessment of how flow might change in Six Mile Creek was made based on EFO statistics for the Cooran node under the existing and proposed scenarios (Table 3-5). The WRP specifies ecological outcomes for Six Mile Creek that minimise changes to the low flow regime and changes to the hydraulic habitat requirements of Mary River cod

and lungfish. There is, however, no metric to assess compliance with this outcome stated in the WRP. The only compliance measure is a low flow release from the dam of up to 2.5 ML/d dependant on inflow. Results presented in Table 3-5indicate that the proposed scenario would result in less frequent extreme low flow periods and flows maintaining riffles (i.e. > 30 cm above cease to flow) would be greater in duration. This indicates that riffle zones would, at all times, receive at least the minimum flows required to be maintained, although it is also possible that some existing riffle habitat could be drowned out by increased flow in Six Mile Creek. Equally, however, new riffle habitat could be created by additional flow in this part of the study reach. Medium to high flows in Six Mile Creek would be closer to those under the pre-development scenario in terms of daily flow volume, suggesting the Project is unlikely to affect critical flows affecting pool habitat maintenance or cues for movement and breeding of MNES species in Six Mile Creek, other than in a beneficial way.

Table 3-4 Comparison of modelled flows and EFOs at Fishermans Pocket

Objective Description		Objective Value		Pre-Development Scenario	Existing Allocation Scenario	Proposed Scenario	Must/Should Comply
				Final WRP Compliance			
Low Flow Objectives		Final WRP (06)	Draft WRP (05)				
Low Flow	days of flow<1ML	0-18%	2-18%	0.0	1.0	1.0	M
Low Flow Duration							
10 cm above cease to flow		80-98%	80-98%	98.6	97.4	96.2	S
30 cm above cease to flow		62-98%	62-98%	79.7	59.8	59.1	S
Periods of No Flow							
1-3 months	(30-90days)	0-18	0-16	0	3	0	S
3-6 months	(90-180 days)	0-3	0-3	0	0	0	S
6-9 months	(180-270 days)	0	0	0	0	0	S
> 9 months	(> 270 days)	0	0	0	0	0	S
Medium to High Flow Objectives							
Mean Annual Flow	At least	70%	70%	100	90.7	91.4	S
1.5 yr Daily Flow Vol	At least	42%	68%	100	83.4	86.1	
5 yr Daily Flow Vol	At least	69%	76%	100	94.4	94.4	S
20 yr Daily Flow Vol	At least	69%	85%	100	99.5	99.5	S
Seasonal Flow Patterns							
Annual Proportional Flow Deviation	No greater than	2.1	2.1	0	0.9	0.86	S
Flow regime	Class	Late Summer	-	Late Summer	Late Summer	Late Summer	S
		Does not comply with the Final WRP EFO					
		Does not comply with the Draft WRP EFO					

Table 3-5 Comparison of flow conditions at the Six Mile Creek node at Cooran under the existing entitlement and proposed NPI Stage 2 scenarios

Objective Description	Existing Entitlement	NPI Stage 2
Low Flow Objectives		
days of flow<1ML	7.0%	3.0%
Low Flow Duration		
10 cm above cease to flow	93.3%	97.3%
30 cm above cease to flow	63.4%	68.7%
Periods of No Flow		
1-3 months (30-90days)	11	3
3-6 months (90-180 days)	0	0
6-9 months (180-270 days)	0	0
> 9 months (> 270 days)	0	0
Medium to High Flow Objectives		
Mean Annual Flow	93.8%	98.8%
1.5 yr Daily Flow Vol	92.0%	96.0%
5 yr Daily Flow Vol	100.8%	102.4%
20 yr Daily Flow Vol	98.4%	98.8%
Seasonal Flow Patterns		
Annual Proportional Flow Deviation	0.62	0.34

3.4.2 MNES species-specific critical flows

Critical flow heights and time periods used for the high flow spells analysis were based on the flow-dependent habitat requirements of Mary River cod, lungfish and Mary River turtle outlined in .

Table 3-1, Table 3-2 and Table 3-3 respectively. Critical flows, up to those equivalent in size to a 5 yr ARI event, were considered as part of this study because:

- These flows create and maintain bank undercuts, which Mary River cod may use as spawning sites; and

- This was considered the upper limit in terms of flows that might be affected by the Project.

It is important to remember that the three MNES species share many of the same critical flow requirements, so results of high flow spell analysis for particular critical flows can often be used to assess the potential impacts of the Project on all three MNES species. In summary the critical flows used for this assessment were as follows:

- ***10 cm above cease to flow level*** – water levels that maintain shallow riffle habitat and, where sustained for long periods, are indicative of stable base flow that helps maintain water levels in deep pool habitat;

- ***30 cm above cease to flow level*** –water levels that maintain riffle-run habitats and connectivity between river reaches for large Mary River cod at key times;

- ***Flows equivalent to a 2m increase above cease to flow level*** – elevated flows equivalent to a typical 'fresh' event, which, when they occur at the appropriate times of year, stimulate Mary River cod movement. Mary River cod are expected to move in response to any noticeable elevation in flows (R. Simpson, QDPIF, pers. comm.), but for the purpose of this study, we have used a critical flow height of a 2m increase above cease to flow levels, which is roughly equivalent to a typical 'fresh' event (typical occurrence at least twice per year) as flows expected to trigger cod movement. Flows of this volume may also help maintain pool depth and Mary River turtle nesting bank habitat through scouring; and

- ***Flows equivalent to a 5 year ARI event***- elevated flows of a size that will certainly provide scouring maintenance to deep pool and turtle nest bank habitat, but may also scour banks providing bank undercuts that might be used as spawning sites for Mary River cod.

In terms of the specific periods of interest:

- Flow volumes providing for water levels equivalent to 10 cm above cease to flow level are nominally required all year around, but the critical period is during the naturally drier months (August to November) where flow input may be less than rates of evaporation and, where water harvesting would have its greatest potential impact;

- Flow volumes that provide for water levels of at least 30 cm above cease to flow level are required between August and February. This time period covers lungfish and Mary River turtle breeding and recruitment phase and the spring-summer within channel movement of Mary River cod. As is the case for the 10 cm above cease to flow level flows, the critical period is that between August and November, as low

flows are far less likely in the December to February period and, water harvesting would have its greatest potential impact at this time of year. Some adjustment to this period was made for Six Mile Creek as no established lungfish populations are likely to occur there (hence it was not necessary to factor in the beginning of the lungfish breeding period (August) in the analysis of flows in this reach).

- Flow volumes that provide for water levels of at least 30 cm above cease to flow level are also required between autumn –winter (May-June) to facilitate within-channel movement of larger Mary River cod;

- Elevated flows are required in autumn-winter (May-June) and during spring-summer (September – February) to help **stimulate** (as opposed to allow) Mary River cod movement. As described above for 10cm and 30 cm above cease to flow level flows, the Project has most potential to affect the frequency and duration of such flows during drier months of the year, so for the purpose of this study, the September – February critical period has been broken up into the 'dry period' (September – November) and the 'wet' period (December –February);

- Elevated flows are also important in maintaining the preferred habitat of all three MNES species (deep pools) and in maintaining nest banks for Mary River turtle through scouring. However, flows of this magnitude that occur in spring-summer can be detrimental to the recruitment of lungfish and Mary River turtle. Hence it was important to assess the frequency and duration of these types of flows during both breeding and recruitment times and at other times of year. This is particularly relevant to Six Mile Creek and reaches of the Mary River from the confluence of these two waterways to Fishermans Pocket given that increased flows are expected in Six Mile Creek if the Project goes ahead.

Table 3-6 shows the threshold flow volumes for each critical flow height at each node. These were calculated using the ratings table for each node. The ratings tables used were as follows:

- The NRW 2002 ratings curve was used for the Dagun Pocket node; and

- The NRW 2007 ratings curves were used for Fishermans Pocket and Cooran nodes.

Ratings curves were specific to each node, because each has a different cross-sectional profile. It should be noted that the August 2007 flood may have altered these cross-sectional profiles, but new ratings tables were not available at the time of this study. Values derived in this manner differ from those derived by the WRP TAP. Values for the 10cm ad 30 cm above cease to flow derived by the WRP TAP were based on pre-calculated flow depths for a selected range of riffle control widths and classification of various stream reaches in terms of riffle width as observed from field visits. Hence, the TAP-derived values are more representative of the reach below each node than those calculated based on cross-section bathymetry at specific nodes. For the purpose of this study, both sets of flow volumes were used for High Flow Spell analysis where available.

Results presented in

Table 3-7 are the outputs of High Flow Spell analysis. The two statistics of interest generated using the High Flow Spells analysis were:

- Mean occurrence of critical water levels being exceeded during the simulation period; and
- Mean duration that critical water levels were exceeded during the simulation period.

These statistics were generated for specified periods of the year based on the requirements of the MNES species.

A third statistic, mean % of time level exceeded, was calculated based on dividing the duration of exceedance for a given flow height by the number of days in a given specified period.

It should be noted that the mean occurrence statistic can be misleading, because it is theoretically possible for the same result to be achieved where a given flow volume occurs at the same frequency during a given period but for different durations. For example, a mean occurrence of 1 might mean that the flow was either recorded on a single day, or it might also have occurred over the entire nominated period. Nonetheless, this statistic was used here because it was the only measure of flow frequency available on which to base comparisons between flow conditions under the existing entitlement scenario and those under the proposed scenario.

For critical flow heights equivalent to 10cm and 30 cm above cease to flow level, separate results are provided for flow volumes based on the cross-section at each node and flow volumes for the reach below each node calculated by the Mary River TAP.

Table 3-6 Discharge for the four critical habitat maintenance flows at Dagun Pocket, Fishermans Pocket and the Six Mile Creek node at Cooran.

Critical Flow Height	Dagun Pocket Discharge (ML / day)	Fishermans Pocket Discharge (ML / day)	Six Mile Creek node at Cooran (ML / day)
10 cm above cease to flow (ratings curve)	0.04	0.04	0.02
10 cm above cease to flow (TAP figure)	10	12	1
30 cm above cease to flow (ratings curve)	10.2	3.08	0.0648*
30 cm above cease to flow (TAP figure)	115	135	20
2 m above cease to flow (ratings curve)	4350	4861	676
5 year ARI**	105841	144236	12729

* = This value has been read off the latest rating table (2007) for Cooran. Previous rating tables have shown flows up to 0.9 ML/d for 30cm flow depth above cease to flow at the Cooran node. The low flow control for this station is described in NRW's old station summary report as "The control consists of a tangled mass of logs and sticks intermingled with sand fine gravel and small debris matter."

Results of High Flow Spell Analysis

Results of High Flow Spell analysis are presented in Table 3-7. These results indicate the following:

- Water harvesting associated with the NPI Stage 2 Project will have negligible, if any, impact on the critical flow levels required to cue Mary River cod movement or maintain deep pool and Mary River turtle habitat through scouring;

- Water harvesting associated with the NPI Stage 2 Project may affect flows providing for riffle–run habitat, stream connectivity and sustained baseflow at key times of the year. This is most evident at the Dagun Pocket node, which is closest to the Coles Crossing offtake, during the 'dry period' (August-November). Results vary according to the methods used to derive critical flow volumes, but the mean number of days the 10cm above cease to flow level flows are exceeded at Dagun Pocket during the dry period could be reduced by up to 14.2 days compared to that expected under the existing entitlement scenario. A similar reduction potentially applies to flows maintaining water levels at 30cm above cease to flow level at this same node. It is unclear whether such reductions would be ecologically significant in terms of the MNES species covered in this report, but it is assumed they may be so under the precautionary principle;

- The potential impacts identified above for Dagun Pocket during the 'dry period' were far less evident at the Fishermans Pocket node, although some reduction in the mean duration of flows providing for 10cm and 30 cm above cease to flow levels at this node are predicted by the model during the 'dry' period. However, given that the maximum reduction predicted was 3.64 days out of the 122 days covered by the August – November 'dry' period, such reductions in flow are probably not ecologically significant for any of the MNES species.

- Very little change in the frequency or duration of flows providing for 30 cm above cease to flow levels are predicted for the autumn-winter (May-June) period when Mary River cod are expected to undertake within-channel movement. This applies to the Mary River main channel and Six Mile Creek.

- Flows between a 2 m increase above cease to flow level and a 5 year ARI event do not increase noticeably in Six Mile Creek or at Fishermans Pocket during the spring-summer period or any other time of the year under the proposed scenario; and

- There is a general tendency for flows providing for 10cm and 30 cm above cease to flow levels to occur over a longer duration in Six Mile Creek under the proposed scenario compared to the existing entitlement scenario.

The implications of these findings are that:

- In low-flow conditions, the Project could affect MNES species due a decrease in water level over riffles in the Mary River and / or reduced baseflows leading to increased drawdown of deep pool habitat and / or a reduction in the ability of large Mary

River cod to move during spring-summer period. Any such effects would, however, likely be restricted spatially to between Coles Crossing and the confluence of the Mary River and Six Mile Creek;

- The Project will still allow flows that stimulate the movement of MNES species and maintain their habitats;

- Additional flows in Six Mile Creek associated with the Project are unlikely to significantly increase the prevalence or duration of higher flows in Six Mile Creek itself and downstream if the confluence with the Mary River at times when Mary River turtle and lungfish breed and recruit, so should not affect the recruitment success of these species; and

- Additional flows in Six Mile Creek will help sustain riffle-run habitat in this system and may even create new riffle-run habitat. However, these additional flows may also cause initial drowning of some riffles, which may cause short-term disturbance to habitat stability before the overall benefits of the increased flows are realised. Any negative effects are expected to be short-lived and not ecologically significant, particularly given that additional flows are also likely to improve deep pool water level maintenance, thereby providing cod and Mary River turtle with more sustained access to submerged structural habitat in this part of the catchment.

Table 3-7 Results of the high flow spell analysis for the Mary River and Six Mile Creek

High spell statistic	Dagun Pocket - Existing	Dagun Pocket -Proposed	Fishermans Pocket - Existing	Fishermans Pocket - Proposed	Cooran - Existing	Cooran - Proposed
10cm above cease to flow (brackets =results based on TAP figure)						
August-November period						
Mean occurrence of level exceeded	1 (1.23)	1.14 (4.47)	1.08 (1.22)	1.91 (2.92)	1.93 (1.94)	1.39 (1.67)
Mean number of days level exceeded	122 (119.74)	121 (105.54)	120.42 (118.88)	119.66 (114.18)	115.50 (115.50)	119.84 (117.25)
% of time level exceeded	100 (98.2)	99.2 (86.3)	98.7 (97.4)	98.1 (93.6)	94.3 (94.7)	98.2 (96.10)
30cm above cease to flow (brackets =results based on TAP figure)						
May-June period						
Mean occurrence of level exceeded	1 (1.32)	1.10 (1.31)	1 (1.30)	1.05 (1.34)	1.18 (1.33)	1.03 (1.28)
Mean number of days level exceeded	61 (46.21)	60.58 (45.32)	61 (51.55)	60.85 (51.30)	59.59 (54.31)	60.78 (54.40)
% of time level exceeded	100 (75.8)	99.3 (74.3)	100 (84.5)	99.8 (84.1)	97.7 (89.0)	99.6 (89.2)
August-November Period (Sept-November) period for Six Mile Creek)						
Mean occurrence of level exceeded	1.25 (2.62)	4.48 (1.84)	1.14 (2.35)	2.22 (2.02)	1.79 (2.13)	1.46 (2.19)
Mean number of days level exceeded	119.69 (48.23)	105.41 (41.78)	119.96 (56.37)	117.85 (52.73)	84.99 (54.42)	88.42 (57.06)
% of time level exceeded	98.1 (39.5)	86.2 (34.2)	98.3 (46.2)	96.6 (43.22)	61.77 (42.09)	64.51 (45.29)
2m above cease to flow						
May-June period						
Mean occurrence of level exceeded	0.57	0.57	0.72	0.72	1.02	1.06
Mean number of days level exceeded	10.3	10.35	10.68	10.72	8.05	8.16

% of time level exceeded	16.9	17.0	17.5	17.6	13.2	13.4

September-November Period						
Mean occurrence of level exceeded	0.11	0.11	0.17	0.17	0.20	0.28
Mean number of days level exceeded	5.0	5.1	5.5	5.5	4.38	4.18
% of time level exceeded	5.5	5.6	6.0	6.0	4.8	4.6
December-February Period						
Mean occurrence of level exceeded	1.13	1.12	1.35	1.36	1.43	1.52
Mean number of days level exceeded	13.85	13.94	15.15	14.80	12.15	12.10
% of time level exceeded	15.4	15.5	16.8	16.4	13.5	13.4
March-April Period						
Mean occurrence of level exceeded	1.16	1.15	1.33	1.34	1.51	1.55
Mean number of days level exceeded	14.74	14.76	16.38	16.48	12.58	12.44
% of time level exceeded	24.2	24.2	26.9	27.0	20.6	20.4
July-August Period						
Mean occurrence of level exceeded	0.21	0.21	0.24	0.24	0.29	0.29
Mean number of days level exceeded	7.06	7.22	7.75	7.9	5.12	5.24
% of time level exceeded	11.4	11.6	12.5	12.7	8.3	8.5

5 yr ARI						
May-June period						
Mean occurrence of level exceeded	0.009	0.009	0	0	0.009	0.009
Mean number of days level exceeded	2	2	0	0	2	2
% of time level exceeded	3.28	3.28	0	0	3.3	3.3

September-November Period						
Mean occurrence of level exceeded	0	0	0	0	0	0
Mean number of days level exceeded	0	0	0	0	0	0
% of time level exceeded	0	0	0	0	0	0
December- February Period						
Mean occurrence of level exceeded	0.101	0.101	0.055	0.055	0.11	0.11
Mean number of days level exceeded	3.3	3.3	3.46	3.46	2.82	2.82
% of time level exceeded	3.7	3.7	7.2	7.2	3.1	3.1
March – April period						
Mean occurrence of level exceeded	0.064	0.064	0.11	0.11	0.018	0.018
Mean number of days level exceeded	2.83	2.83	3.0	3.0	2.5	2.5
% of time level exceeded	4.6	4.6	4.9	4.9	4.1	4.1
July –August period						

Mean occurrence of level exceeded	0.009	0.009	0.009	0.009	0	0
Mean number of days level exceeded	3	3	2.0	2.0	0	0
% of time level exceeded	4.8	4.8	3.2	3.2	0	0

3.4.3 Seasonality of flow

Flow seasonality was assessed at the two reportable nodes of relevance in the Mary River (Dagun Pocket and Fishermans Pocket) and the Six Mile Creek node at Cooran. Dagun Pocket is nearest to Coles Crossing, where additional water will be abstracted as part of the Project and, therefore, represents a part of the study reach most likely to be exposed to potential impacts of reduced flow associated with water abstraction. Fishermans Pocket represents a part of the study reach that would be the least likely to exhibit any potential impacts of reduced flow. Not only is this site relatively distant from the Coles Crossing abstraction site (see Figure 2-1), it also receives additional flows from tributaries such as Amamoor Creek, Six Mike Creek and Deep Creek, which contribute significant flows to the main channel and are likely to compensate for any reduction of flows in the Mary River main channel associated with the Project. It should be noted that the Mary River receives flow input from Kandanga Creek ad Coles Creek, which lie in between the Coles Crossing offtake and Dagun Pocket. The proposed scenario does not restrict flow input from these creeks in any way. It should also be noted that Kandanga Creek was nominated as a reach for Mary River cod habitat by Pickersgill (1998) and, given the statement above, cod movement between the Mary River main channel and Kandanga Creek should not be affected by the proposed scenario.

Mary River

Figure 3-1 and Figure 3-2 show comparisons of median monthly flows under the various flow scenarios for Dagun Pocket and Fishermans Pocket respectively. For both nodes, median monthly flows resulting from existing entitlements are lower than the pre-development scenario. The NPI Stage 2 scenario results in negligible or minor further reduction from the existing entitlements. Importantly, the existing entitlement and NPI Stage 2 scenarios, follow the seasonal trend of the pre-development scenario, peaking during March and diminishing during the July to November period. This indicates that the Project is unlikely to significantly alter seasonal flow patterns in the Mary River main channel. It will result in slightly reduced median monthly flows in all months downstream of the abstraction point to Dagun Pocket, with this effect being negligible at Fishermans Pocket.

An interesting feature of the modelled scenario is that median monthly flows under the NPI Stage 2 scenario closely approximate or even exceed those for the existing entitlement scenario (see median monthly flows for February and March in Figure 3-2). This reflects two

things: firstly, impacts of abstraction diminish substantially with distance from the abstraction point and, secondly, additional spillovers from Lake Macdonald associated with the Project will, at times, slightly enhance flows in the Mary River main channel downstream of the confluence with Six Mile Creek.

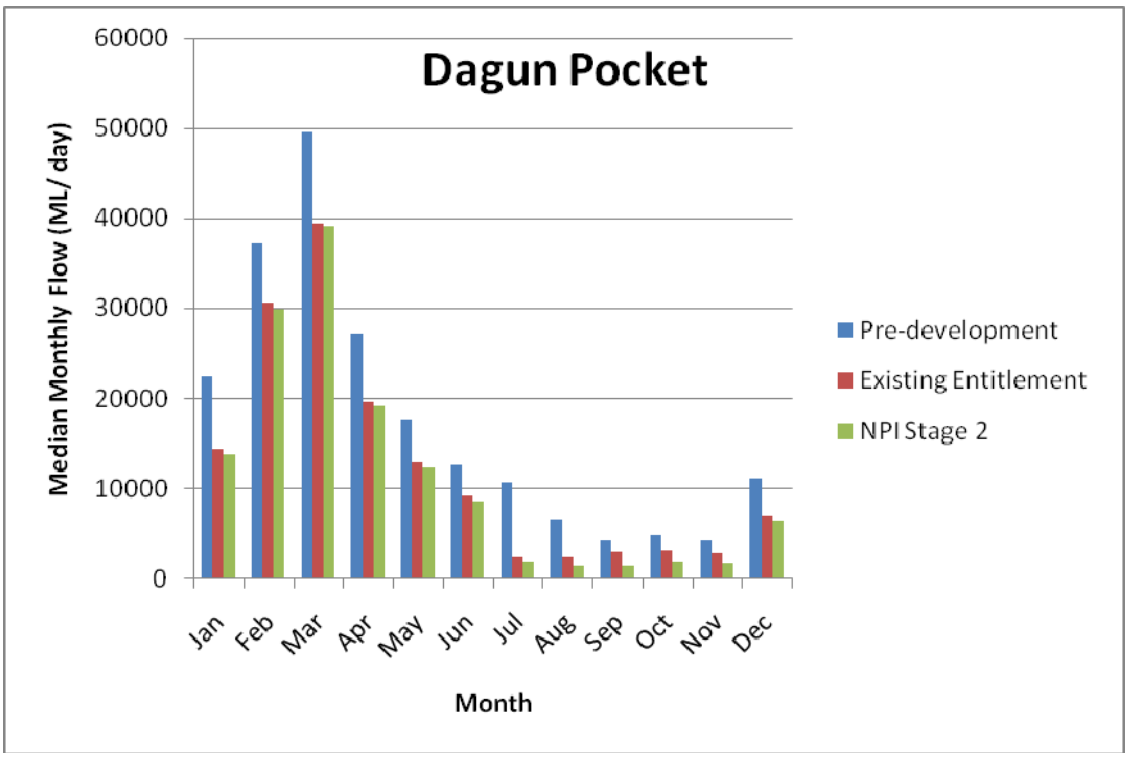

Figure 3-1 Median monthly flows at Dagun Pocket

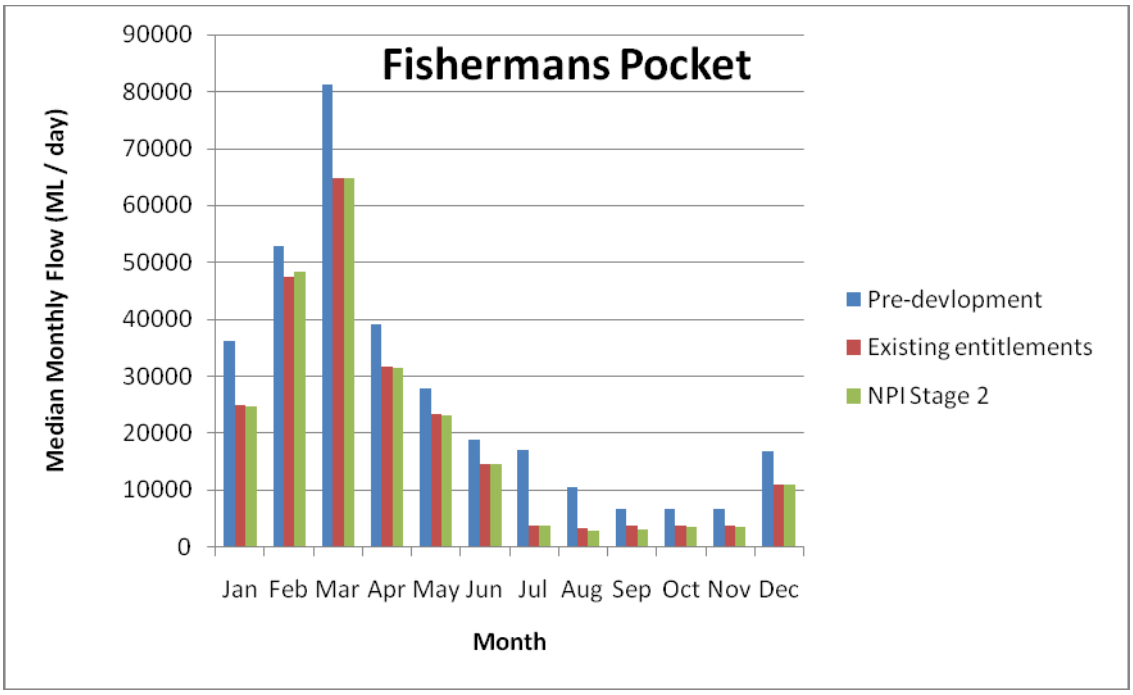

Figure 3-2 Median monthly flows at Fishermans Pocket

Six Mile Creek

Figure 3-3 shows the median monthly flows in Six Mile Creek at the Cooran node. These results indicate that median monthly flow under the proposed scenario is expected to be consistently greater than those under the existing entitlement and, at times, greater than those under the pre-development scenario. The additional flow in the catchment under the proposed scenario is caused by several factors, including:

- The water from Lake Macdonald will rarely be used under the proposed NPI Stage 2 scenario, so this storage is expected to remain full or nearly full most of the time; and

- Lake Macdonald is a large body of water (maximum area of about 250 ha). At times when the dam is full, rainfall that falls on this water body is practically completely converted to downstream flow. In other words, there are no interception losses from uptake by riparian vegetation as would have occurred under the pre-development scenario. This behaviour is amplified during higher rainfall periods.

During the low flow months, the proposed scenario has less streamflow than the pre-development scenario, because the effect of evaporation during those periods is greater than the benefit from rainfall on the storage area.

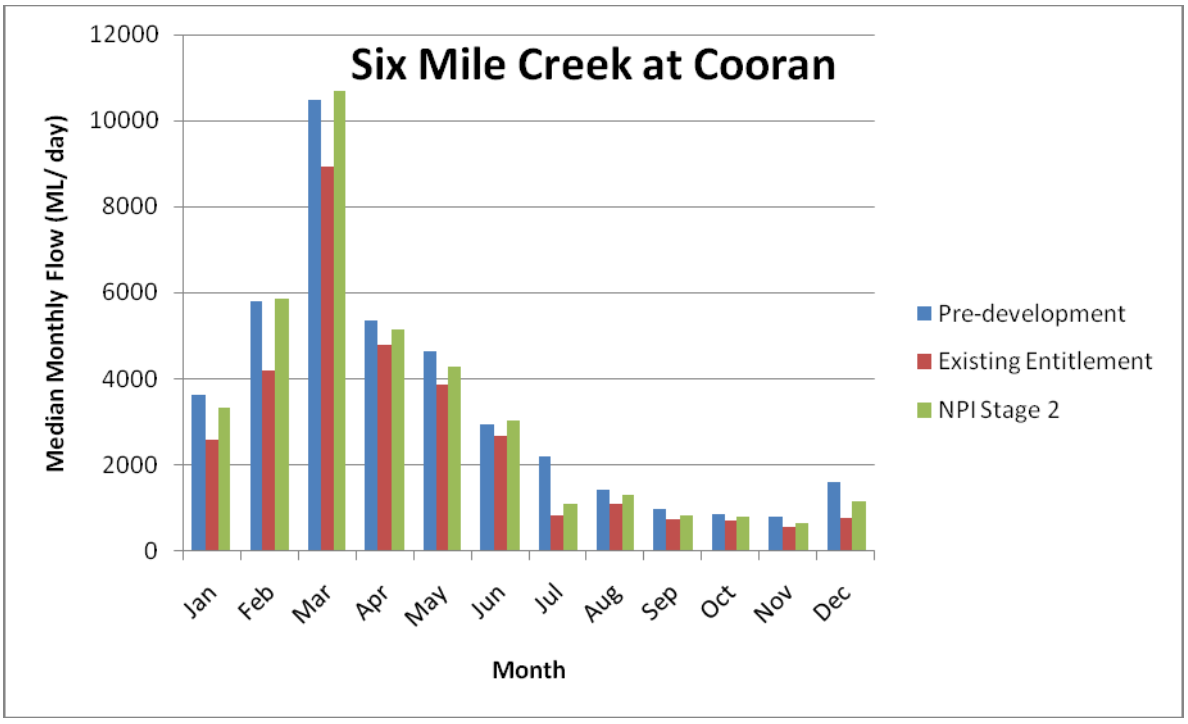

Figure 3-3 Median monthly flows at the Cooran node in Six Mile Creek

3.5 Summary of Potential Impacts on Aquatic MNES species

Table 3-8 summarises the extent of risks associated with potential impacts that could occur in association with the Project. In most cases, risks of potential impacts were considered to be low regardless of whether or not mitigation measures are put in place. This was based on the low likelihood that any of the potential impacts identified will occur, given the findings outlined above. While ratings for spatial and temporal extent and consequences were often 'moderate' and sometimes 'major' for many of the potential impacts listed in Table 3-8, the likelihood rating associated with most potential impacts was generally 'unlikely'. What this essentially means is that while impacts could result in moderate to major impacts on MNES species, should they occur, the low likelihood of those events occurring means that overall risk to MNES species from those impacts has to be regarded as being minor.

An exception to this is the potential for reduced availability of riffle habitat either through exposure associated with low flows. For such impacts, the likelihood rating increased to 'possible' and given the 'moderate' spatial and temporal scale on which such impacts are expected to occur and the 'moderate' nature of the potential consequences associated with this impact (see details in Table 3-8), risk to MNES species were rated as 'moderate' in the absence of any mitigation). Recommended mitigation measures (see details in Table 3-8), including the preferential take arrangements outlined for this Project, are likely to markedly reduce the potential for such impacts. Note, for instance, that the criteria for allowing abstraction from Coles Crossing would never allow for a situation where flows providing for water levels of 10cm above cease to flow level were not satisfied.

It should also be noted that additional flow expected in Six Mile Creek is likely to be beneficial to Mary River cod and Mary River turtle in terms of reducing draw down and infilling of deep pools and providing greater access to submerged large woody debris. Such benefits may extend for some distance downstream of the confluence of Six Mile Creek and the Mary River. Furthermore, these benefits would probably substantially outweigh any negative impacts of riffle drown out during the ecosystem resetting phase.

Over-riding the low risk ratings outlined in Table 3-8 are factors that should further reduce risk to MNES species associated with the NPI Stage 2 Project. As outlined in Section 2.2.2, these are:

- The fact that impacts associated with the Project are not expected to occur on a continuous basis (as was assessed above); and

- The fact that MNES species may have more flexibility in their habitat requirements than those under the assumptions made during this study.

Table 3-8 Potential impacts of water abstraction on the aquatic MNES species and mitigation measures to counter these

Potential Impact	Spatial Scale	Temporal Scale	Likelihood	Consequence	Mitigation Measure	Risk
Reduced baseflows (water depths of 10 cm above cease to flow levels not sustained during dry periods)	Moderate (Coles Crossing to the confluence of Six Mile Creek)	Moderate (August-November dry period)	Possible	Moderate -potentially leading to reduced abundance of MNES species in affected area, but not to local extinction)	Assess hydrological flow regime to ensure critical flow levels are met. Adapt water abstraction strategy as per preferential take arrangements Assess extent and quality of riffle habitat in affected reach (particularly focussing on whether or not they are inundated or exposed) and adapt harvesting strategy as required to maintain these habitats.	Moderate – without mitigation Minor – with mitigation
Restricted movement, reduced availability of preferred habitat (riffle) due to low	Moderate (Coles Crossing to the confluence of Six Mile Creek)	Moderate (August-November dry period)	Possible	Moderate -potentially leading to reduced abundance of MNES species in affected area, but not to local	Assess hydrological flow regime to ensure critical flow levels are met. Adapt water	Moderate – without mitigation Minor – with

water levels.				extinction)	abstraction strategy as per preferential take arrangements Assess extent and quality of riffle habitat in affected reach and adapt harvesting strategy as required to maintain these habitats.	mitigation
Reduced availability of critical habitat (riffles) due to drown out	Moderate –within Six Mile Creek	Major -Most of the year, but particularly between December and March	Possible	Minor-potentially leading to reduced abundance of MNES species in affected area, but not to local extinction. The most likely outcome would be a potential redistribution of Mary River cod and Mary River turtle within Six Mile Creek. Beneficial effects of increased flow on access to submerged deep pool habitat in Six Mile Creek	Assess extent and quality of riffle habitat in affected reach and adapt harvesting strategy as required to maintain these habitats.	Minor – without mitigation Negligible– with mitigation

				should counter such effects.		
Cues for movement and / or maintenance of habitats and prey species altered or reduced	Major –anywhere within the study reach	Moderate - Mainly restricted to key periods of the year	Unlikely	Moderate -Reduced abundance through effects on recruitment and altered habitat or prey availability possible, but local extinction not expected.	Assess hydrological regime to ensure that seasonality of flows and critical flow levels that occur in particular seasons are maintained. Adapt harvesting strategy if necessary.	Minor – regardless of mitigation
Reduced availability and quality of deep pool and suitable turtle nesting bank habitat due to reduced frequency and duration of habitat maintenance flows.	Major –anywhere within the study reach	Moderate – mainly restricted to low flow periods	Unlikely	Moderate -Reduced abundance possible, but local extinction not expected.	Assess hydrological regime to ensure that habitat maintenance flows continue to occur at frequencies and durations at least consistent with those under existing entitlements. Monitor the status of deep pool and turtle nesting bank habitat within the	Minor – regardless of mitigation

					study reach. Adapt harvesting strategy if necessary.	
Flushing of eggs and juveniles of lungfish and Mary River turtles downstream due to an increase in the frequency and / or duration of elevated flows during breeding and recruitment periods.	Moderate – impacts on Mary River turtles likely to be restricted mainly to Six Mile Creek if they occur, but it is possible that both species could be somewhat affected in the reach of the Mary River immediately downstream of the confluence with Six Mile Creek..	Moderate – generally restricted to the spring-summer period, when elevated flows occur more typically	Unlikely	Moderate -Reduced abundance possible, but local extinction not expected.	Assess hydrological regime to ensure that elevated flows do not occur at frequencies and durations greater than under existing entitlements during the spring-summer period. Adapt harvesting strategy if necessary.	Minor– regardless of mitigation

3.6 Recommended Monitoring

Table 3-9 outlines potential indicators and monitoring strategies that could be applied as part of EMP-associated activities. As with all EMP-related monitoring, results will need to be linked to adaptive management activities, which may include altering the size and timing of water abstraction or use of alternative sources. Most of the monitoring strategies put forward in this study are based on monitoring surrogates (indicators) of the status of MNES-species population status rather than direct measures of individuals or populations. Measuring impacts associated with the Project on MNES-species populations can be difficult due to the already low abundance and patchy distribution of species such as the Mary River cod and Mary River turtle. While some direct measures of the effects of the Project on MNES species have been put forward in Table 3-9 (e.g. monitoring egg laying of Mary River turtle and lungfish and monitoring size class structure in Mary River cod and lungfish populations in the study reach), this type of monitoring would require data collection over many years to provide meaningful interpretation of results (including gathering baseline data for comparison), so may be beyond the scope of the EIS.

One of the easiest surrogates to measure is the extent to which critical flows are maintained. This can be done simply by reviewing the hydrological data for the relevant nodes at key times. Other surrogates include measures of specific habitat features such as extent of riffle, run and pool habitat, extent of submerged large woody debris, extent of nesting banks and extent of bank undercuts. Monitoring these features will require some preliminary investigation to indentify representative habitat for performance monitoring. Broad details of assessment methods for each habitat feature are provided in Table 3-9. Given that most of the possible impacts on flows and water level associated with the Project are likely to be at their worst during low flow ('dry') periods, monitoring will need to be timed to coincide with such periods. For some habitat features, monitoring will need to be carried out at key times in relation to the typical movement and breeding times of the MNES species.

While the main emphasis of monitoring under the EMP is on the monitoring of surrogate indicators of MNES species health, the possibility of undertaking baseline studies to establish species-habitat interactions and the presence of Mary River turtle in Six Mile Creek should not be ruled out. Such monitoring could provide valuable data that would help improve predictions of how likely potential impacts identified in this study are and how to better manage those impacts. For instance, better data on the degree of reliance on particular habitat features by MNES species could provide increased focus to what should be monitored and managed for in relation to water abstraction. Surveys of Mary River turtle in Six Mile Creek could be used to determine whether this tributary represents a critical habitat or, in fact, like other tributaries, Six Mile Creek hosts very few, if any, Mary River turtles. Such ecological studies on MNES species, if applied, should have a wider scope than is relevant to the spatial scale of this Project and should also be collaborative with respect to the other water resource activities in the catchment.

The possibility of the proponent contributing to MNES habitat improvement elsewhere in the catchment to compensate for any impacts that might arise through water harvesting should also not be ruled out. Such measures could include targeted riparian re-vegetation, fencing off moderate to excellent quality MNES habitat from cattle access and 're-snagging' of suitable deep pool habitat. Such a mitigation strategy would present good opportunities

to link with local land care groups and provide a practical measure that could result in some real benefits to these MNES species.

Table 3-9 Potential indicators and monitoring methods

Ecological Goal	Water level required above cease to flow level	Potential Indicators	How to monitor
Riffle habitat quality maintained	> 0.3 m	Extent to which habitat maintenance flows occur. Riffles presence / persistence	Identify a set of indicator riffles for performance monitoring. Measure depth, surface area and persistence across seasons of nominated riffles. Monitoring to be carried out during times of the year relevant to movement and breeding as well as seasonally low flow periods.
Maintain macrophyte habitats in riffle and run habitats	0.3-1.0 m	Extent to which habitat maintenance flows occur. % substrate covered by macrophytes, macrophyte diversity. * Abundance of lungfish eggs and juveniles in the affected reaches. * Recruitment of lungfish and Mary River turtles into the local populations	Identify a set of indicator riffles and runs for performance monitoring. Measure macrophyte density along transects or in quadrats and record details of macrophyte community structure. Monitoring to take place during seasonally low flows and during key times for Mary River turtle and lungfish breeding and recruitment.

Ecological Goal	Water level required above cease to flow level	Potential Indicators	How to monitor
			* Undertake egg and juvenile lungfish surveys. * Undertake Mary River turtle surveys. * Undertake size-frequency data collection for lungfish and Mary River turtle in the affected reaches over extended period.
Maintain structural habitat submergence and water temperatures in pools that support Mary River cod.	≥ 2m in pool habitat	Extent of waterhole drawdown. % of large woody debris covered by water. Changes in thermal profile in pools currently favoured by Mary River turtle.	Identify suitable pools for performance monitoring. Monitor area and depth of representative pools pre and post development, particularly during seasonally low flow periods. Monitor the % of large woody debris inundated in representative pools pre and post development. Monitor water temperature in nominated pools pre and post development.
Stimulate the	≥ a 2m increase in	Extent to which these flows are	* Undertake tagging of key species and

Ecological Goal	Water level required above cease to flow level	Potential Indicators	How to monitor
movement of Mary River cod and provide maintenance of deep pool habitat.	water level	emulated at key times of the year Movement patterns of key fish species at key times of the year. * Recruitment level for Mary River cod into local population. Continued presence and expansion of confirmed nest banks.	carry out surveys at key times of the year to assess observed versus predicted movement patterns. Combine with studies of recruitment patterns based on abundance and length-frequency distribution. Establish confirmed nest banks for Mary River Turtles and monitor the frequency of subsequent egg deposition events. Monitor vegetative cover over nest banks, noting excessive terrestrial plant growth.
Scour deep pool habitat to reduce infilling impacts and create / promote undercut habitat for Mary River cod	5 year ARI (14 m)	Extent to which these flows occur. The presence / extent of bank undercuts in the affected stream reach	Monitor the distribution and abundance of bank undercut habitat in the affected reaches before and after these flow events.

* = Indicators relating to direct assessments of the Project on MNES species

4 CONCLUSIONS

Water harvesting under the proposed NPI Stage 2 Project is unlikely to lead to significant impacts on Mary River cod, lungfish or Mary River turtle. Decreases in flow in the Mary River main channel associated with the Project could result in a possible reduction in riffle habitat availability and / or quality and increased deep pool draw down due to reduced flow volumes during the 'dry' period of the year. Theses impacts, in turn, could potentially result in moderate impacts to MNES species in the absence of any mitigation. However, such impacts are not expected to extend beyond the reach between Coles Crossing and the confluence of Six Mile Creek and the Mary River and they could be reduced to minor levels through mitigation. Mitigation options could include adopting the preferential take strategy, reviewing hydrological models to determine whether or not critical flows for MNES are satisfied and undertaking performance monitoring of surrogate flow-dependent habitat features required by MNES species. Undertaking habitat improvement initiatives targeting MNES species could also be considered to compensate for any potential impacts associated with the Project.

One additional, short-term, impact could potentially arise in Six Mile Creek due to reduced riffle habitat availability in Six Mile Creek caused by increased flows associated with additional spills over the dam wall at Lake Macdonald. In the longer-term, additional flows in Six Mile Creek expected under the proposed scenario are likely to have benefits to Mary River cod and Mary River turtles in terms of reducing the rate of draw down and infilling of deep pools and increasing the access of these species to submerged woody debris. This would probably compensate for and probably outweigh any impacts associated with a reduction in riffle habitat associated with drown out, particularly given that new riffle habitat may be created by the additional flows in this part of the study reach.

The risk assessment carried out for this study was conservative in nature given that it assumed constant take of water rather than extremely periodic takes during drought conditions on a regional scale and the assumption that all habitat preferences of MNES species represent habitat requirements. This merely underscores the finding that the actual risk to MNES species posed by water harvesting under the NPI stage 2 Project is low.

5 REFERENCES

Werren and Arthington (2003) - Environmental conditions report: Mary Basin water Resource Plan, Volume 2, Appendix I –Turtles and other reptiles.

Cann, J. (1998) Australian Freshwater Turtles. J. Cann and Beaumont Publishing: Singapore.

Cann, J. and Legler, J. M. (1994). The Mary River Tortoise: a new genus and species of short-necked turtle from Queensland, Australia (Testudines; Pleurodira). Chelonian Conservation and Biology 1(2): 81-96.

Cogger, H.G., E.E. Cameron, R.A. Sadlier & P. Eggler (1993). The Action Plan for Australian Reptiles. Australian Nature Conservation Agency: Canberra.

Ecotone Environmental Services Pty Ltd (2007) Traveston Crossing Dam Project Ecological Study: Terrestrial Fauna and Freshwater Turtles. Final Report. Prepared for Queensland Water Infrastructure Pty Ltd. EES Document 2007/06.

Hydrobiology (2008). Northern Pipeline Infrastructure Stage 2 EIS: Six Mile Creek Study. Prepared for Southern Regional Water Pipeline Alliance, January 2008. 75 pp.

Flakus, S. (2002). The ecology of the Mary River Turtle, *Elusor macrurus*. MSc Thesis, University of Queensland.

Kennard, M.J. (2003) Environmental conditions report: Mary Basin water Resource Plan (WRP). Volume 2 - Appendix H Freshwater Fish.

Kind, P.K. (2002). Movement patterns and habitat use in the Queensland lungfish *Neoceratodus forsteri* (Krefft 1870). PhD Thesis, University of Queensland

Merrick, J.R. and Schmida G.E. (1984). Australian Freshwater Fishes: Biology and Management. Griffin Press Limited, South Australia

NRW (2003). Draft Ecological Asset - Critical Water Link table. Advice from QDPI&F received as part of input to the Mary Basin Water Resource Plan. Provided to Hydrobiology by Andrew McDougall (Bundaberg NRW office).

Pickersgill, G. (1998). Conserving and Rehabilitating Mary River Cod Habitat: Mapping and Extension. Final Report (July 97 – July 98). Report to the World Wildlife Fund for Nature. Brisbane.

Pusey, B.J., Kennard M. and Arthington A. (2004) Freshwater Fishes of North-Eastern Australia. CSIRO Publishing, Collingwood, Australia.

QWI (2007). Chapter 8 – Aquatic Environments, Traveston Crossing Dam EIS report, October 2007. Pp: 8-1 - 8-55.

Queensland Fauna Consultancy Pty Ltd (2007). Impact and Management advice for the

Giant Barred Frog *Mixophyes iterates* and the Mary River Turtle *Elusor macrurus* for the proposed Northern Pipeline Interconnector Stage 2. Advice prepared for Southern Regional Water Pipeline Alliance, Brisbane

Simpson, R. (1994). An investigation into the habitat preferences and population status of the endangered Mary River Cod (*Maccullochella peelii mariensis*) in the Mary River systems, south-eastern Queensland. Queensland Department of Primary Industries Report No. QI94011.

Simpson, R. and Jackson, P. (1996). The Mary River Cod Research and Recovery Plan. Department of Primary Industries Fisheries Group. Brisbane.

Simpson, R. and Mapleston, A.J. (2002) Movements and habitat use by the endangered Australian freshwater Mary River cod, *Maccullochella peelii mariensis*. Environmental Biology of Fishes, 65: 401-410.

Tucker, A.D., Priest, T., Guarino, E. & Couper, P. (2000). Turtle biodiversity in regard to regional conservation planning: additional recommendations for mitigation in Cumulative Effects of Dams and Weirs on Freshwater Turtles: Fitzroy, Kolan, Burnett and Mary Catchments. Pp 105-130. Report for Queensland Parks and Wildlife Service, Bundaberg.

Personal Communications

Craig Latta, pers. comm.; Ecotone Environmental Services, 2007.

R. Manning, pers. comm.; Queensland Fauna Consultancy, 2007.