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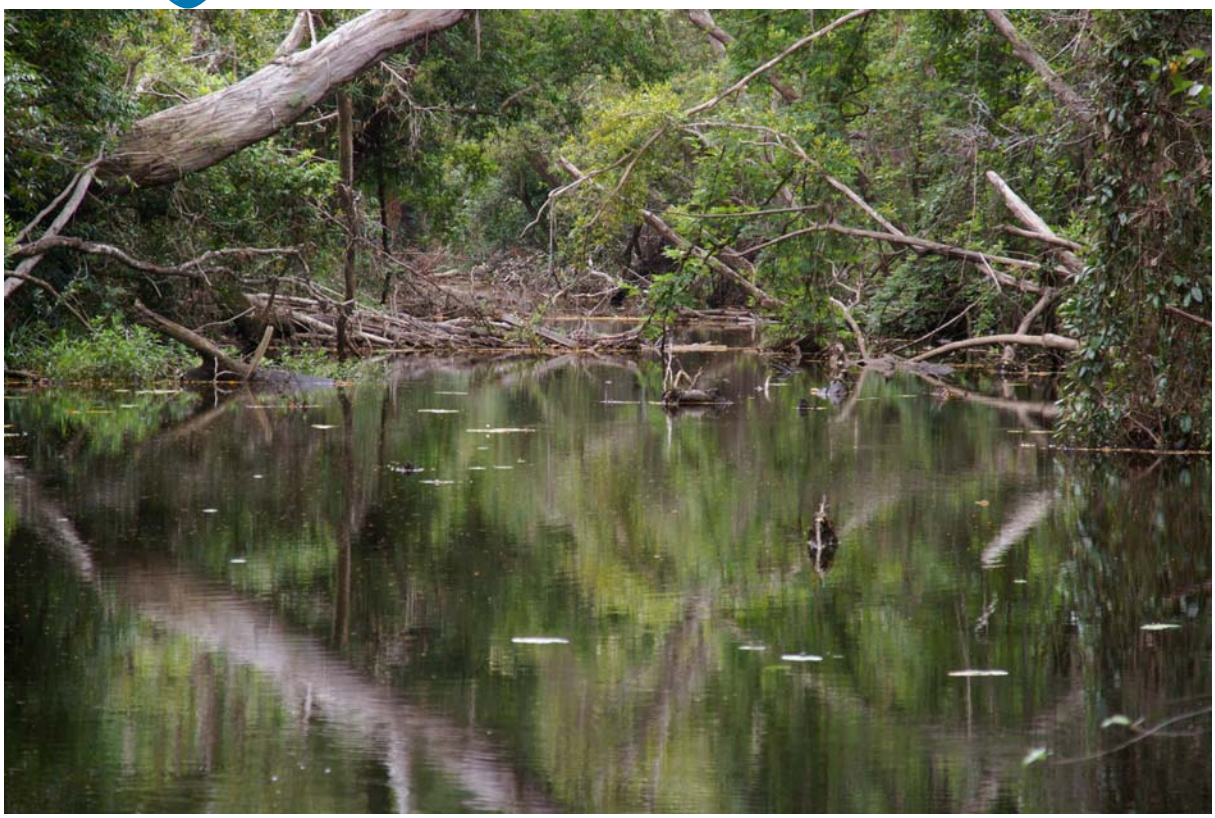

Northern Pipeline Infrastructure Stage 2 EIS

Six Mile Creek Study

January 2008

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EXECUTIVE SUMMARY

This study investigated the potential ecological impacts of the proposed Northern Pipeline Infrastructure Stage 2, specifically, with reference to proposed pipeline crossing construction intersecting with the Left Branch of Six Mile Creek and potential impacts on four EPBC-listed fish species. These were Mary River cod (*Maccullochella peeli mariensis*), lungfish (*Neoceratodus forsteri*), Oxleyan pygmy perch (*Nannoperca oxleyana*) and honey blue-eye (*Pseudomugil mellis*). The broad aim of this study was to provide information that will inform the EIS reporting for the Northern Pipeline Infrastructure Stage 2 Project. The assessment was based on a review of the relevant literature, feedback from key stakeholders and site visits carried out on 21 November and 20 December 2007. Habitat assessments were carried out in a study reach consisting of the main branch of Six Mile Creek immediately below Lake Macdonald and in the Left Branch of Six Mile Creek and a tributary of this sub-catchment. Habitat assessments covered stream reaches in the vicinity of three proposed pipeline crossing points.

Based on the available evidence, Mary River cod is the most likely of the four EPBC-listed species to occur in the study reach, but is unlikely to have established populations in the Left Branch of Six Mile Creek or its anabranch. Adults may move into this part of the study reach during autumn high flows, when Mary River cod traditionally move into tributary habitat to over-winter. Juveniles may also use the sub-optimal habitat in this part of the study reach to avoid predation by adults. Although not recorded in the study reach previously, limited historical data and reasonable matches between observed habitat in the Left Branch of Six Mile Creek and the preferred habitat of Oxleyan pygmy perch meant that the presence of a population of this species in the study reach could not be discounted. In contrast, available habitat is unlikely to support established populations of lungfish and honey blue-eye, so these species were excluded from further assessment of potential impacts associated with pipeline crossing construction.

Potential risks to Mary River cod and Oxleyan pygmy perch associated with pipeline crossing construction were assessed based on three alternative crossing methods: trenching; laying the pipeline over the creek above bank full level; and micro-tunnelling / thrust boring. Potential impacts related mainly to sediment mobilisation and potential restriction of fish passage. A range of mitigation measures were put forward to address these issues during the construction and operation phases. Specific crossing methods were not recommended, but based on the impact assessment findings, all three methods could be implemented without significant risk of impact to EPBC-listed fish species. While few potential impacts were identified for micro-tunnelling / thrust boring, the client has indicated that there are significant cost and logistical constraints associated with this method and further assessment would be needed to see if it was geologically feasible for the study reach. Opportunities may exist to attach new pipeline to an existing low level crossing structure spanning the Main Branch of Six Mile Creek. This would greatly reduce potential for sediment mobilisation impacts associated with bed and bank disturbance. However, the practicality of this option would need to be assessed by site engineers.

The study visit revealed that the nominated pipeline route would bisect a property on which there is a proposed expansion of an existing Mary River cod hatchery. This expansion would be not be possible if the Project went ahead based on the nominated route. While this cod hatchery does not currently supply broodstock for conservation purposes, it is regarded by Queensland Department of Primary Industry and Fisheries as being an important insurance policy for conservation-based stocking, particularly if the proposed Traveston Crossing Dam goes ahead. Given this, it is recommended that the pipeline be re-aligned to avoid any impacts on the proposed cod hatchery expansion.

In addition to impact assessment and the development of mitigation measures, suggested approaches to ongoing evaluation of mitigation measures under the EMP process are outlined in this report.

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1 INTRODUCTION

1.1 Background

The Northern Pipeline Interconnector (NPI) is a drought contingency 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.

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.

One balance tank and three pump stations are required to enable transfer of water from the Noosa and Image Flat WTPs to Brisbane. These are nominally located at Noosa WTP and the Image Flat connection, with one pump station and a balance tank at Nobels Road, Eudlo.

The NPI Stage 2 Project has recently been designated as a controlled action under Commonwealth Government legislation. This is because the proposed route intersects Six Mile Creek, a sub-catchment of the Mary River, in which a number of EPBC-listed fish species are known to occur. These fish species include Mary River cod (*Macculochela peeli mariensis*), lungfish (*Neoceratodus forsteri*), Oxleyan pygmy perch (*Nannoperca oxleyana*) and honey blue-eye (*Pseudomugil mellis*).

Hydrobiology was commissioned by the Southern Regional Water Pipeline Alliance to undertake an assessment of the potential impacts of the proposed pipeline on these four fish species. This report does not address potential impacts of the Project on other flora or fauna, except with reference to potential indirect impacts on any of the four target fish species.

1.2 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:

- Determining whether or not any of the EPBC-listed fish species (Mary River cod, lungfish, Oxleyan pygmy perch and honey blue-eye) are likely to occur in the study reach (the reach in which the proposed pipeline crossings occur);

- Characterising the existing environment with respect to habitat suitability for these species, the sensitivities of these species and their preferred habitats to change and existing impacts on these species and their habitats;

- Assessing the risks to the EPBC-listed fish species that were considered likely to occur in the study reach and outline mitigation measures to reduce risks to those species from activities associated with the Project;

- Providing information that informs the choice of crossing construction method used; and

- Outlining measures to ensure that nominated mitigation measures are effective.

2. METHODS

2.1 Study Area

The study area is situated in upper Six Mile Creek, a sub-catchment of the Mary River (see Figure 2-1). Six Mile Creek headwaters are situated near the township of Cooroy to the east of the Mary River and this creek discharges into the Mary River in the reach between Amamoor Creek and the township of Gympie. The main branch of Six Mile Creek is subject to flow regulation as a result of the presence of Lake Macdonald, the Noosa Shire water supply storage, in its upper reaches. This water storage is one of three major water storages on tributaries of the Mary River, the others being Borumba Dam on Yabba Creek and Baroon Pocket Dam on Obi Obi Creek. A dam (Traveston Crossing Dam) has been proposed for the main channel of the Mary River upstream of the confluence of Six Mile Creek and the Mary River and is currently subject to EIS approval. The Left Branch of Six Mile Creek –a tributary of the main branch - is not subject to regulated flows and receives inputs from a separate sub-catchment. The confluence of these two reaches is within a few kilometres downstream of Lake Macdonald.

This investigation focussed on the reach of Six Mile Creek immediately below the Lake Macdonald spillway, the Left Branch of Six Mile Creek and an anabranch of this sub-catchment, where, at present, the proposed pipeline alignment involves three creek crossings (see Figure 2-2).

2.2 Species Covered

The scope of this study was to address potential impacts of pipeline construction on four EPBC-listed species of fish: Mary River cod (*Maccullochella peeli mariensis)*, lungfish (*Neoceratodus forsteri*), honey blue-eye (*Pseudomugil mellis*) and Oxleyan pygmy perch (*Nannoperca oxleyana*). The following details the conservation status of each of these species:

2.3.1 Mary River Cod

- Closely related to the Murray cod (*Maccullochella peeli peeli*) and Eastern or Clarence River cod (*Maccullochella ikei*);
- First formally described as a new sub-species and as being unique to the Mary River system in 1993;
- Soon after being described as a separate sub species, Mary River cod were included as an endangered species in the Action Plan for Australian Freshwater Fishes (Wagner and Jackson 1993);
- Currently listed as endangered under *Environment Protection and Biodiversity Conservation Act* (1999) legislation (EPBC Act), the basis for which, was the declining abundance of the species and its very restricted distribution;
- Listed as Critically Endangered by the Australian Society for Fish Biology;

- Protected from recreational and commercial harvesting under the *Queensland Fisheries Act* (1999), except in designated areas upstream of ten dams stocked with cod to create recreational fishing opportunities. In these areas a "take and possession" limit of one cod (minimum length 50 cm) is allowed;

- Despite having a recovery program that is devoted to its preservation (Simpson & Jackson 1999), surprisingly little published information is available for the Mary River cod and a number of aspects of the Cod Recovery Program, which aimed to secure the future of this species by 2010, have not been funded for implementation.

2.2.2 Lungfish

- Variously known as Queensland or Australian lungfish;

- Protected since 1914 under the *Queensland Fish and Oyster Act* (1914) and, subsequently, under the *Fisheries Act* (1994);

- Listed as vulnerable under the EPBC Act based on their restricted natural distribution;

- Not currently considered at risk of extinction and are regarded as 'Common / Secure' by the Australian Society for Fish Biology.

2.2.3 Honey Blue-eye

- Listed as endangered under the EPBC Act and vulnerable under the Queensland Nature Conservation (NC) Act. Also listed as endangered under other legislation and listings such as The Action Plan for Australian Freshwater Fishes (Wagner and Jackson, 1993), the NSW Fisheries Management Act (1994), the IUCN Red list, the Australian Society for Fish Biology (ASFB) and the Australian New Zealand Environmental Council's (ANZECC) Threatened Fauna list.

2.2.4 Oxleyan Pygmy Perch

- Listed as endangered under the EPBC Act and vulnerable under the Queensland NC Act. Also listed as endangered under other legislation and listings such as the Action Plan for Australian Freshwater Fishes (Wagner and Jackson 1993), the *NSW Fisheries Management Act* (1994), the IUCN Red list, the Australian Society for Fish Biology (ASFB) and the Australian New Zealand Environmental Council's (ANZECC) Threatened Fauna list.

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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
Gympie
Murgon
Amamoor
Tiaro
Imbil
Kenilworth
Nambour
Pomona
Cooroy
Eumundi
Noosa Heads
Yandina
Maroochydore
Caloundra
Kilcoy
Bundaberg

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

138014A
138004B
138903A
138001A
138002C
138010A
138009A
138007A
138003A
138003B
138003C
138003D
138020A
138109A
138107A
138102A
138102C
138113A
138108A
138105A
138105D
138111A
138101A
138104A
138110A
138106A

Location Map

Location of Mary River Basin within Australia

Pomona
COOROY WEIR
Cooroy

= Study Reach

Northern Pipeline Interconnector (Stage 2)

Queensland Government
Department of Natural Resources

27/02/2001

A3-505189

Mary River Basin
Locality Map

1:500 000

KILOMETRES 0 10 20 30 40 50

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\Projects\BEG601- SRWP\T08 Gis Data\TOC 5 Northern Interconnector\Mapinfo\Workspaces\EIS\Hydrobiology Report\TOC5B\Figure 2.1 Mary River Basin & Study Reach Location.Wor*

Date: *7 January 2007 (Prior to Rev C)*

northern pipeline interconnector

NORTHERN PIPELINE INTERCONNECTOR

MARY RIVER BASIN & STUDY REACH LOCATION

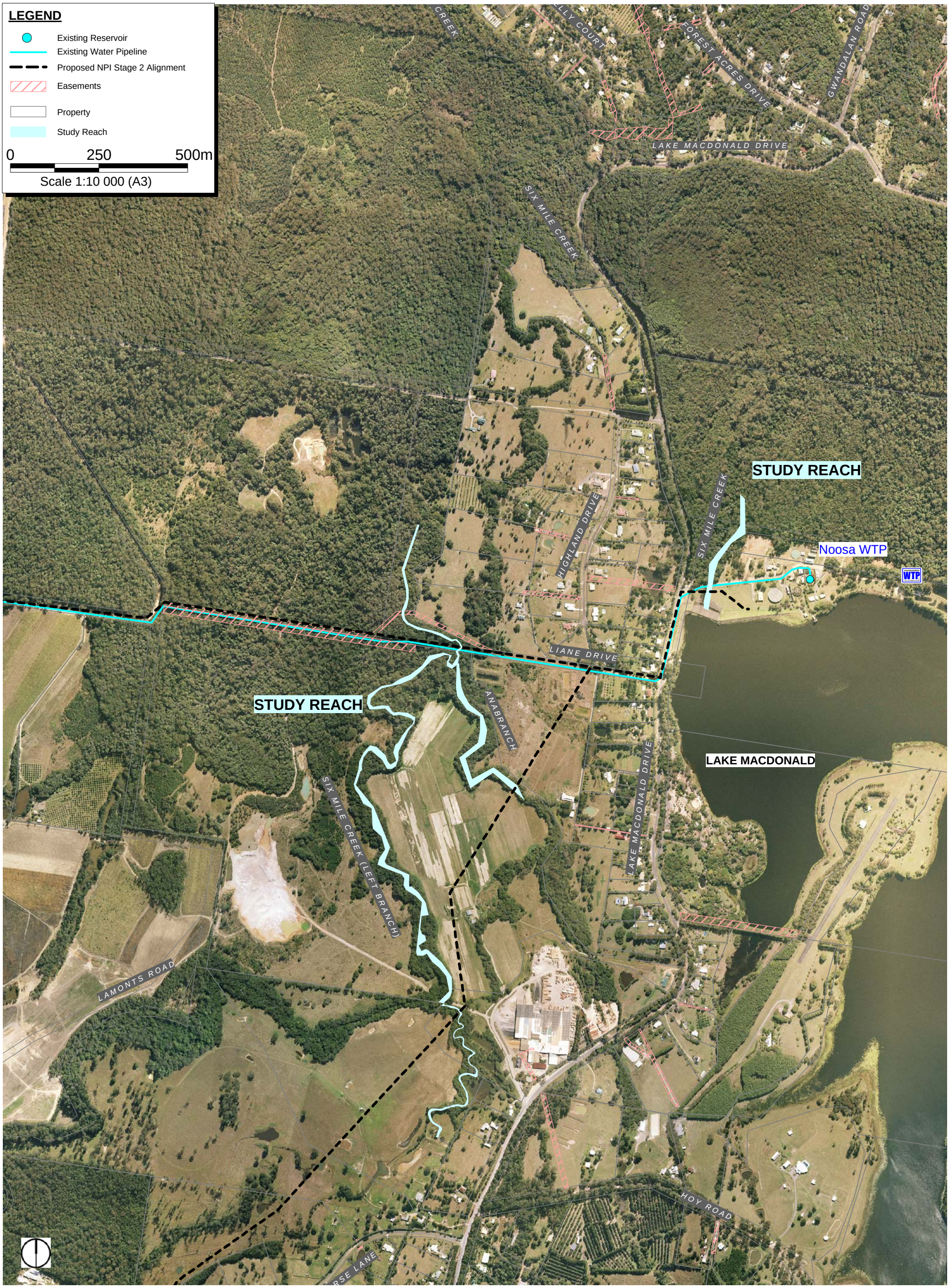
2.1

LEGEND

- Existing Reservoir
- Existing Water Pipeline
- Proposed NPI Stage 2 Alignment
- Easements
- Property
- Study Reach

0 250 500m

Scale 1:10 000 (A3)



Source: *Base data supplied by Natural Resources & Water*

Projection: *GDA94 (MGA56)*

File Path: *O:\BRS\Projects\BEG601- SRWP\T08 Gis Data\TOC5 Northern Interconnector\MapInfo\Workspaces\EIS\Hydrobiology Report\Figure 2.2 Six Mile Creek & Study Reach.wor*

Date: *7 January 2007 (Prior to Rev C)*

northern pipeline inter connector

NORTHERN PIPELINE INTERCONNECTOR

SIX MILE CREEK & STUDY REACH

2.2

2.3 Approach

2.3.1 Scope

Hydrobiology was commissioned to undertake this study in mid-November 2007, with a short turn-around for providing reporting outputs. Consequently, there was no opportunity to undertake meaningful primary data collection to assess the presence / absence, distribution and abundance of the four target species. Instead, this investigation relied upon two site visits to assess habitat conditions, a review of information in the literature regarding distribution, habitat preferences and sensitivities to various impacts, advice on distribution from local fish biology experts and professional judgement.

2.3.2 Site Visit

Two site visits were carried out, one on 21 November 2007 and one on 20 December 2007. The first site visit covered the Left Branch of Six Mile Creek, while the second site visit covered the Main Branch of Six Mile Creek immediately below Lake Macdonald and an anabranch in the lower reaches of the Left Branch of Six Mile Creek. The purpose of these site visits was to:

- Assess in-stream and riparian habitat conditions at proposed pipeline crossing points and upstream and downstream of the crossing points;
- Assess in-stream and riparian habitat quality and ascertain the likelihood for the fish species to occur in the reach; and
- Determine the surrounding land use and assess the extent to which existing impacts might influence the distribution and abundance of the EPBC-listed fish species.

Habitat assessments were carried out along all three reaches shown in Figure 2-2. Habitat assessment involved traversing these reaches upstream and downstream of the proposed crossing points and recording geomorphological features, such as:

- Points where the creek changed between pool and riffle habitat;
- Points where key features such as large woody debris and undercut banks occurred;
- Locations where choke points, nick points, bed and / or bank aggradation / erosion occurred; and
- Points where fish passage barriers occurred.

These features and others, such as the extent of riparian and macrophyte vegetation, the depth and width of streams and nature of stream bed habitats were recorded because they relate to key habitat features of the four EPBC-listed fish species. Standard stream habitat assessment methods such as State of the Rivers were not used for the habitat because these focus on condition assessment rather than identifying the presence or absence of particular habitat features of interest.

GPS coordinates; photos and field notes were recorded at each of these points and at the starting and finishing points for each survey. Extent of riparian cover was also noted at a broad level. A summary of the key habitat features observed during the habitat survey is provided in Section 3.1.1. Maps showing the location of key features are shown in Appendix I.

Spot water quality readings were also taken on both occasions to assess site conditions relative to the reported physiological tolerance ranges / preferences of the four EPBC-listed fish species. Given the 'snap-shot' nature of water quality sampling, these findings were indicative only. Furthermore, there were differences in flow conditions between sampling occasions which were likely to have influenced water quality readings. Hence comparisons between sites survey on different occasions were confounded to a degree by this. Maps showing the location of water quality sampling sites are shown in Appendix I. Spot water quality readings are shown in Appendix II.

2.3.3 Literature Review

The literature review covered:

- Primary literature (e.g. Simpson 1994; Simpson and Mapleston 2002; Simpson and Jackson 1996, Pickersgill 1998);
- Review summaries (e.g. Kennard 2003 -Mary Basin Water Resource Plan technical appendix; Traveston Crossing Dam EIS –SKM 2007);
- Information summaries provided by government agencies (e.g. Department of Environment, Water, Heritage and Arts and Queensland Environmental Protection Agency website information); and
- Books on freshwater fishes (e.g. Pusey et al. 2004; Allen et al. 2002).

Expert advice on records of each of the four target fish species occurring in the Six Mile Creek catchment was sought from the following persons outlined in Table 2-1. Advice on site-specific habitat conditions in the main branch of Six Mile directly below the dam was provided by Jeff Black (Noosa Shire Council) and David Hinton (Australian New Guinea Fish Association), while local land owners provided site-specific habitat condition information for the Left Branch of Six Mile Creek and its anabranch.

Table 2-1 List of persons contacted for professional advice on the distribution of the four targeted fish species

Name	Organisation	Comments
Bob Simpson	Queensland Department of Primary Industry and Fisheries (QDPIF)	Mary River Cod Expert –carried out key survey studies and was integrally involved in developing the Cod Recovery Program
Andrew McDougall / Tom Espinoza	Natural Resources and Water	Have carried out recent cod / cod habitat surveys in Six Mile Creek and other studies on lungfish in the Mary River catchment.
Mark Kennard	Griffith University	Author of fish fauna technical appendix of the Mary Basin Water Resource Plan (WRP).
Peter Kind	QDPIF	Head of freshwater fisheries research in Queensland. Carried out key lungfish studies in the Mary and Burnett rivers.
Michael Hutchison	QDPIF –Long Term Monitoring Program	Involved in the QDPI&F Long Term Monitoring Program in the main Mary River channel and other commercial consulting fish survey work in SEQ.
Bruce Hansen, Jeff Gunston, Adrian Tappin, Leo O'Reilly, Dave Hinton	Australian New Guinea Fish Association (ANGFA)	Key ANGFA contacts with knowledge on fish distribution data collected by ANGFA members in SEQ.
Jeff Johnson	Queensland Museum	Expertise in lungfish biology, involved in review of the Burnett River Dam technical study review with respect to lungfish. Also has access to Queensland Museum fauna distribution database.

3 RESULTS AND DISCUSSION

3.1 Site Visit

3.1.1 Habitat Characteristics

Due to the fact that the Left Branch of Six Mile Creek and the main branch are distinct in terms of geomorphology, flow conditions and water quality, the habitat characteristics of these two parts of the study reach are discussed separately below.

Left Branch of Six Mile Creek (including the anabranch)

Table 3-1 describes the key habitat features of this part of the study reach. Based on field observations recorded during the site visit and comparisons with observations made by Hydrobiology during the recent Traveston Crossing Dam EIS, the Left branch of Six Mile Creek and its anabranch can be described as typical of small creek systems that discharge into the Mary River main channel from the eastern side of the catchment, such as Belli Creek, Skyring Creek and Coles Creek. Similar features include the relatively dense riparian cover, narrow stream channels with limited hydraulic habitat diversity or macrophyte cover, clay-lined banks and beds dominated by sand, silt-clay and leaf litter. However, this part of the study reach lacked the deep pools (1.5 m deep or greater) that were observed during the SKM (2007) study in some of those other eastern tributaries. A notable feature of this part of the study reach was the slightly acidic and apparent tannin stained conditions of the water.

Table 3-1 Key habitat features of the Left Branch of Six Mile Creek and its anabranch

Feature	Description	Comments
Riparian vegetation	Relatively contiguous, mature riparian vegetation strip, generally less than 30 m wide adjacent land under development, but exceeding 30 m in parts, with some evidence of ecotonal changes with distance from the creek where this occurs. Some damage to riparian vegetation, particularly in the lower study reach of the main Left Branch of Six Mile Creek, due to a recent major storm (December 2006). Very limited understory, dominated by bare space / leaf litter. *Lomandra* is the dominant ground cover. Very limited weed species. No paragrass infestation	Provides extensive stream shading, leaf litter, snag and tree root habitat. Storm damage to riparian vegetation creates isolated patches of stream with more exposure to sunlight. Despite this, macrophyte growth was limited throughout this part of the study reach.

Feature	Description	Comments
	observed in study reach.	
Stream channel	Incised creek system with steep banks. Banks either vegetated or eroded down to the clay layer over time. Some off-channel flood-runners were observed. Lower layers of banks more sandy and prone to erosion. Left Branch of Six Mile Creek reaches were between 3-5 m wide on average, whereas the anabranch was only 1-2m wide on average.	Due to steep banks, the presence of off-channel wetlands is limited, suggesting fish fauna are largely confined to the channel in this reach. The channel may have moved over time, creating flood-runners. However, these do not appear to be recent features and banks appear to be stable in most parts. The stream bed featured sand as well as clay, with sand accumulating behind large individual logs lying across the stream channel.
Erosion and aggradation	Minimal, but some recent erosion occasionally observed, usually in association with riparian vegetation clearing. Historic erosion in the form of bank incision down to clay layer. Localised aggradation around large woody debris lying across the channel.	Riparian vegetation and underlying clay layer limit further bank erosion No evidence of major sand bars forming in the channel. Localised aggradation around large woody debris part of natural process.
Water level	The stream was generally shallow with average water depth between 0.3 m and 0.5 m. No pools exceeded 1 m depth in this part of the study reach at the time of the study. Water level observed was purportedly typical for the study reach (R. Manning, pers. comm.), but system has featured isolated pools during the recent drought. The Left Branch of Six Mile Creek and its anabranch do not receive direct flow input from Lake Macdonald, so are not subject to the effects of flow regulation. Isolated pools form in the drier months, especially during drought and particularly in	Deeper water refugia do not appear to exist in this part of the study reach. Low water levels in this section of the creek meant that a large proportion of the large woody debris, undercut and tree root habitat probably occur above the water line, and therefore, would not be available as fish habitat for a much of the time. Formation of isolated pools during droughts may pose a temporary barrier to fish movement and expose resident fish fauna to degraded water quality. No direct impact of water infrastructure on fish fauna of the Left Branch of Six Mile

Feature	Description	Comments
	the anabranch (R. Manning, pers. comm.).	Creek or the anabranch. These reaches receive flows from a different sub-catchment.
Instream Habitats	Dominated by shallow pools with occasional riffle zones at choke points or where large woody debris blocks stream flow. Average depths ranged between 0.3 m and 0.6 m. No deep water refugial pools in the study reach. No macrophyte habitat, except for limited macrophyte growth in more exposed canopy areas of the lower study reach near the quarry. Instream habitat dominated by large woody debris (branch piles and individual logs) and leaf litter. Undercut banks and tree root habitats observed, but often above the water line	Macrophytes growth limited by riparian shading. Lack of macrophytes and limited availability of undercuts suggests that the study reach represents non-preferred habitat for lungfish, Oxleyan pygmy perch and honey blue-eye. Abundance of large woody debris in these reaches, but less in the anabranch. However, the absence of deeper water pools co-occurring with submerged woody debris suggests that the study reach is not optimal habitat for Mary River cod.
Water Quality	Slightly acidic, low conductivity and water appears tannin-stained (see Appendix II)	The acidity of these reaches is significant because Oxleyan pygmy perch and honey blue-eye typically occur in acidic waters.
Existing Disturbances	Overall, limited disturbance to stream habitat, but some disturbance features could have a significant impact on the fish community. Adjacent land use is low density housing, agriculture, horticulture (turf farm) and quarrying. Reduction of riparian vegetation strip near developed land, potential input of nutrients / chemicals from adjacent turf farm Presence of causeways, including a fish barrier near the brick works limiting upstream access beyond the study reach. Presence of existing pipeline crossings. Inputs of treated wastewater	Quality of instream habitat is good, but the causeway near the brick works represents a fish passage barrier that would effectively restrict fish movement in and out of the Left Branch of Six Mile Creek and its anabranch for a large proportion of the time. This structure would limit the access of fish to good quality upstream habitat, except during higher flows that overtop the causeway. The nutrient status of the creek is not known, but filamentous algal growth was evident in the exposed reach near the quarry causeway, just downstream of the turf farm, suggesting the possible influence of nutrient input from the turf farm (associated

Feature	Description	Comments
	from the Cooroy wastewater treatment plant occur in reaches below the study reach.	with fertiliser use) on algal growth. Study reach not influenced by point source nutrient inputs. Existing pipeline crossing based on trenching methods, with pipes spanning the creek at mid-bank-full level and submerged on adjacent land. Insufficient data to assess any associated long-term impacts, but this pipeline crossing may have contributed to bank erosion downstream.

Main branch of Six Mile Creek

Table 3-2 outlines the key habitat features of the main branch of Six Mile Creek surveyed during the site visit. The main branch of Six Mile Creek featured quite distinct habitat conditions compared to those of the Left Branch of Six Mile Creek and its anabranch. Such differences are probably because these two parts of the study reach receive flow input from different sub-catchments, combined with the presence of the dam on the main branch of Six Mile Creek. The main branch of Six Mile Creek immediately below the dam was a much wider channel (10-12 m wide on average) than the Left Branch of Six Mile Creek (3-5 m) or its anabranch (1-2 m). Consequently, riparian vegetation overhang was reduced and shading of the main channel was more limited. The main channel reach features pool / glide habitat with depths commonly exceeding 1 m. Anecdotal reports indicated deeper pools exist around a kilometre downstream of Lake Macdonald (David Hinton, ANGFA, pers. comm.). Furthermore, Simpson and Jackson (1996) reported that there are long stretches of riffle and run habitat between pools in Six Mile Creek and around 20 km of this creek consists of pools suitable as permanent habitat for Mary River Cod (which equates to around 50% of their range within this creek). This observation is corroborated by those of Pickersgill (1998), who also reported a substantial proportion of Six Mile Creek (mainly the mid-lower reaches well downstream of Lake Macdonald) as 'cod population in good cod habitat.'

Like other parts of the Six Mile Creek catchment, large woody debris was abundant, particularly after the recent storm damage to the canopy. However, this part of the study reach features slightly more macrophyte habitat (albeit that macrophyte growth is mainly restricted to the first 100 m downstream of the dam and the macrophyte community in this reach is probably derived from the dam –particularly the noxious *Cabomba caroliniana*).

The clarity of water in this reach was greater than that of the Left Branch of Six Mile Creek and its anabranch and the water appeared less tannin stained. Differences between flow conditions aside, there appears to be clear differences between the water quality characteristics of the main branch of Six Mile Creek and those of the Left Branch of Six Mile

Creek and its anabranch (See Appendix II). Unlike other parts of the study reach, water in the main branch of Six Mile Creek was not acidic. It was also lower in conductivity. At the time water quality readings were taken in this part of the study reach, surface water was spilling over the dam and water was visibly flowing downstream. The higher water temperatures recorded in this reach compared to other parts of the study reach may have been due to the release of warmer surface waters from the dam.

Table 3-2 Key habitat features of the main branch of Six Mile Creek

Feature	Description	Comments
Riparian vegetation	Relatively contiguous, mature riparian vegetation strip, generally less than 30 m wide in the first few hundred metres of the dam, but exceeding 30 m further downstream. Some damage to riparian vegetation, particularly near the dam, due to a recent major storm. Due to the combination of greater stream width and recent storm damage, riparian shading in this part of the study reach was somewhat less than that for the Left Branch of Six Mile Creek. Understory, generally more vegetated with species such as *Lomandra* compared to the Left Branch of Six Mile Creek. Very limited occurrence of terrestrial or semi-aquatic weed species. No paragrass infestation observed in study reach.	Riparian cover provided extensive stream shading, leaf litter, snag and tree root habitat, but more light reaches the stream bed in this part of the study reach compared with other parts, as the canopy was not as closed. Despite this, macrophytes cover was generally fairly limited, except near the dam.
Stream channel	Incised creek system with steep, mostly vegetated, banks. Some off-channel flood-runners were observed. The main branch of Six Mile Creek was between 10 and 12 m wide on average.	Due to steep banks, the presence of off-channel wetlands was limited, suggesting fish fauna would have been largely confined to the channel in this reach. The channel may have moved over time, creating flood-runners. However, these do not appear to be recent features and banks appeared to be stable in most parts. The stream bed featured sand as well as clay.
Erosion and aggradation	Minimal, but some recent bank erosion associated with scouring around an old causeway and other isolated incidences of bank slumping. Historic erosion in the form of	Riparian vegetation and underlying clay layer limit further bank erosion No evidence of major sand bars forming in the channel.

Feature	Description	Comments
	bank incision down to clay layer.	
Water level	The stream was generally between 1 m and 1.5 m deep immediately downstream of the dam and at the road crossing further downstream. This constituted pool / glide habitat. Anecdotal evidence suggested that there was a deeper pool approximately 1 km downstream of the dam locally known as the 'cod hole' (David Hinton, ANGFA, pers. comm.). Water levels observed were probably typical for this part of the study reach despite water flowing over the spillway at the time. Flow into the main branch of Six Mile Creek is regulated by the presence of the dam wall. Flow releases are either overflows from the spillway or controlled releases via a multi-level offtake to comply with permit conditions under the Resource Operation Plan. Hence, this part of the study reach is likely to receive constant baseflow and feature relatively stable water levels. Isolated pools are less likely to form in this reach for that reason.	Deeper pool / glide habitat relative to the Left Branch of Six Mile Creek and deep pool refugia (≥ 2m deep)are reported in this part of the study reach (Dave Hinton, ANGFA, pers. comm.). Higher water levels in this section of the study reach meant that the available large woody debris, undercut and tree root habitat would be more likely to occur below the water line and would, therefore, be available as fish habitat for a much greater proportion of time than equivalent habitat in the Left Branch of Six Mile Creek. However, additional releases from Lake Macdonald may be required under the Mary Basin Water Resource Plan to provide greater surety to the submergence of these instream habitats in future (see comments attributed to Tom Espinoza, NRW, in SKM (2007)). Direct impact of water infrastructure on fish fauna of the main branch of Six Mile Creek. This could include modified frequency, timing and magnitude of downstream flows and the release of water of a different chemical nature from the dam to that downstream. The presence of a multi-level offtake and a destratifier should reduce the impact of the latter.
Instream Habitats	Dominated by pool / glide habitat with occasional run habitat. Average depths immediately downstream ranged between 1 m and 1.5 m. Deeper	Some macrophytes were present, probably due to a combination of moderate stream shading and colonisation of the stream habitat by plants growing in

Feature	Description	Comments
	pools are said to exist further downstream (David Hinton, ANGFA, pers. comm.). Limited macrophyte habitat, except for isolated patches of *C. caroliniana* (cabomba), *Nymphoides indica* (water snow flake) and *Eleocharis dulcis* (water chestnut) within the first few hundred metres downstream of the dam. These macrophytes were not observed persisting further downstream, but may possibly have been scoured out by recent high flows. Instream habitat dominated by large woody debris (branch piles and individual logs) and leaf litter. Undercut banks and tree root habitats observed and these were generally at or just below the water line.	the dam that have washed over the spillway. Overall availability of this habitat to fish fauna is likely limited. Presence of the noxious weed cabomba is of concern in terms of potential for spread, but impacts on fish fauna in the study reach is probably limited. Highly reduced abundance of macrophytes suggested that this part of the study reach represents non-preferred habitat for lungfish, Oxleyan pygmy perch and honey blue-eye. Abundance of submerged large woody debris in pool / glide habitat near the dam and deeper pools further downstream suggested that this part of the study reach would be reasonable habitat for Mary River cod and perhaps useable by adult lungfish. Sighting of Mary River cod in the reach immediately below the dam as part of the site visit and recent sightings of both Mary River cod and lungfish among fish removed from a section just below the spillway (Jeff Black, Noosa Shire Council, pers. comm.) supports the above assertion.
Water Quality	Non-acidic and lower conductivity compared to the Left Branch of Six Mile Creek. Water temperature elevated near the spillway compared to downstream and the water was well oxygenated at the time of the site visit (see Appendix II).	Water quality conditions less typical of habitats preferred by Oxleyan pygmy perch and honey blue-eye, but within the tolerance ranges of lungfish and Mary River cod.
Existing Disturbances	Overall, limited disturbance to stream habitat, but some disturbance features would have an impact on the fish community. Altered flow regimes due to	Quality of instream habitat was generally good, but modified flows could limit access to large woody debris structure by Mary River cod at times.

Feature	Description	Comments
	the presence of the dam will probably have affected the fish community through influencing the nature, quality and availability of suitable habitat. Fish kills have been observed below the dam due to depleted dissolved oxygen levels and / or mortality associated with fish being washed over the spillway onto the toe of the spillway. . Presence of a large fish passage barrier in the form of the dam wall at Lake Macdonald. The low lying causeway immediately downstream of the dam wall is also known to trap fish that have congregated below the dam during high flows (Jeff Black, Noosa Shire Council, pers. comm.). Isolated bank erosion, mainly near the old causeway where scouring around concrete footings has occurred. Cabomba has invaded the downstream reach and heavy infestations have been known to occur in areas where riparian canopy has been reduced by clearing or storm damage (David Hinton, ANGFA, pers. comm.)	The dam wall represents a major barrier to upstream movement for fish in the main branch of Six Mile Creek. The old causeway immediately downstream was also a significant barrier, but the extent of upstream habitat was limited due to the presence of the dam wall. Water quality in the pool / glide between these two structures could become degraded during low flows, resulting in fish kills. Cabomba infestation and bank erosion probably too isolated to pose significant issues for fishes in this reach.

Plate 3-1 illustrates some of the key features identified in Table 3-1 above.

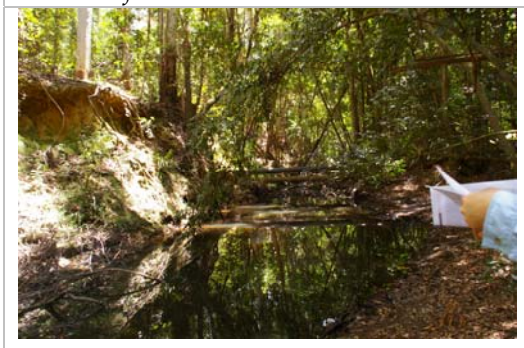
	
a) steep incised channel banks	*b) dense riparian cover and large woody debris*
	
c) the causeway at the brick works posing a barrier to fish movement	*d) water flowing through the same causeway during the December site visit*
	
e) eroded banks downstream of the existing pipeline crossing	*f) a flood runner adjacent the main creek*

Plate 3-1 Key features of the Left Branch of Six Mile Creek identified during the site visit

	
a) water flowing over the spillway at Lake Macdonald	*b) pool / run just downstream of the spillway featuring a bridge crossing with associated water pipeline spanning the creek*
	
c) turbulent flows at the remains of an old causeway that poses a barrier to fish passage	*d) bank scouring around the footings of the old causeway*
	
e) dead yellow belly associated with a recent fish kill immediately downstream of Lake Macdonald	*f) pool/ run habitat in the main channel of Six Mile Creek featuring dense riparian vegetation and large woody debris habitat*

Plate 3-2 Key features of the main branch of Six Mile Creek identified during the site visit

3.1.2 Other relevant observations

At the time of the site visit it was discovered that the owner of the property traversed to get to the anabranch of the Left Branch of Six Mile Creek, Russell Manning, runs a privately

owned Mary River cod hatchery on his property (see Plate 3-3). Mr Manning's hatchery is one of only two licensed commercial breeding facilities in the State, with the other facility located near Noosa. These hatcheries supply brood stock for recreational fishing and the aquarium trade. At the time of writing, Mr Manning's cod hatchery featured several grow out ponds and a series of egg harvesting, juvenile rearing and broodstock managing ponds maintained within a shed. Mr Manning had submitted an application for the expansion of his cod hatchery to include a large water storage and a number of new ponds. Advice from Dr Peter Kind (head of freshwater fisheries research), QDPI&F, suggested that, although Mr Manning's facility does not currently provide cod fingerlings for cod recovery, it may be required to do so at some point in the future, particularly if the proposed Traveston Crossing Dam proceeds and insufficient broodstock are available for restocking from the Gerry Cook Hatchery or the proposed new research facility outlined in SKM (2007). Consequently, Mr Manning's operation (present and proposed) is regarded as a key insurance policy for the Mary River cod conservation strategy by QDPI&F.

Plate 3-3 Mary River cod broodstock tanks at the privately owned hatchery

3.2 Literature Review

Findings presented below are based on a review of the published literature. Key sources included review information published in Pusey et al. (2004), Allen et al. (2002) and the Draft Traveston Crossing Dam EIS (SKM 2007) and the WRP technical appendix on fish by Kennard (2003). Physiological tolerance information was based on information presented in Pusey et al. (2004).

3.2.1 Habitat Preferences / Requirements

While the Left Arm of Six Mile Creek has some of the habitat features of the preferred habitats of all four fish species examined as part of this study, it does not appear to represent ideal habitat for any of these species (see Table 3-1, Appendix II and Table 3-3). Observed depth ranges which, based on anecdotal evidence, would be fairly typical for the study reach, are not those preferred by adult Mary River cod and lungfish. Lack of macrophytes in the study reach would make it non-preferred habitat for lungfish, Oxleyan pygmy perch and honey-blue eye, although large woody debris is sometimes used as habitat by lungfish for shelter (usually as submerged structure in deep pools) and leaf litter is sometimes used by Oxleyan pygmy perch. While the study reach would likely not be the preferred habitat of any of the EPBC-listed fish species, Mary River cod were occasionally observed in sub-optimal habitat during the SKM (2007) study and similar observations have been made for Oxleyan pygmy perch, which have been found in drains (Pusey *et al*. 2004).

The spot recordings for water quality taken during the site visit cannot be considered as definitively typical of the conditions in the study reach throughout any given year. However, the recoded pH in the Left Branch of Six Mile Creek was within the range recorded on many occasions previously by Mary River cod hatchery owner, Russell Manning, providing some comfort that the water quality recorded during the site visit was not atypical of conditions in this part of the study reach. With this in mind and in the absence of any other long-term water quality data for the Left Arm of Six Mile Creek, the physiological tolerance ranges of the four target species were necessarily benchmarked against the water quality readings recorded in this study. .

The recorded pH and conductivity ranges in the Left Arm of Six Mile Creek were below the tolerance ranges listed for lungfish, further suggesting that the study reach represented non-preferred habitat for this species. On the other hand, the recorded pH and conductivity ranges were well within the ranges tolerated by Mary River cod, Oxleyan pygmy perch and honey blue-eye. The pH range recorded during this study was unlikely to have been an aberration given that anecdotal observations for pH in the Left Branch of Six Mile Creek indicate that conditions are typically mildly acidic (R. Manning, pers. comm.).

Dissolved oxygen levels recorded in the Left Arm of Six Mile Creek during the lower flow conditions in November were generally below the literature-based tolerance limits of all four species, although values were occasionally within the tolerance range for Mary River cod, a species for which tolerance limits are based only on information for sites where it has been recorded and, for which, physiological tolerances are said to be 'not particularly specific' (Pusey *et al*. 2004). During the more elevated flow conditions in December, dissolved oxygen levels in this part of the study reach were more consistent with the preferences / physiological tolerance ranges of the four species (Appendix II). However, typical dissolved oxygen levels are probably closer to those recorded in November given that this part of the study reach is generally characterised by low flows (R. Manning, pers. comm.).

Water quality conditions in the main branch of Six Mile Creek were more consistent with the preferences / physiological tolerances of Mary River cod and lungfish than those of Oxleyan pygmy perch and honey blue-eye given that this part of the study reach was not acidic (see Table 3-3 and Appendix II). Dissolved oxygen levels in this part of the study reach were also conducive to the requirements of lungfish, although readings for dissolved oxygen in this reach were only taken during higher flow conditions and, therefore, may not be typical.

Water temperatures recorded in all parts of the study reach were consistently within the tolerance limits / preference ranges of all four fish species (see Appendix II and Table 3-3).

Table 3-3 Habitat preferences / physiological tolerance ranges for the four targeted fish species

Species	Preferred Physical Habitat	pH	Conductivity (µS/cm)	Temperature (°C)	Dissolved Oxygen (mg/L)
Mary River cod	High gradient upland streams to large, slow-flowing pools in lowland areas. Deep water pool habitat, abundant submerged large woody debris or other structure such as bedrock and undercut banks (where large woody debris is not available). Deep, shaded, slow flowing pools lined with mud-clay said to be 'ideal' habitat (probably based on the relatively good status of the Coondoo-Tinana population compared to other populations). Depth of water cod were caught during the seminal study by Simpson (1994) was 0.8 m -3.4 m. Physiological tolerances said to	6.0-7.3	100 - ≈ 800	15.7-29.0	3.9-9.7

Species	Preferred Physical Habitat	pH	Conductivity (µS/cm)	Temperature (°C)	Dissolved Oxygen (mg/L)
	be 'not particularly specific). Ranges reported here represent records for sites where cod have been observed				
lungfish	Adults prefer deep pools (3 m-10 m) with submerged structure for shelter Prefer to spawn in slow flowing reaches of shallow-moderate depth where macrophyte cover exceeds 70%. Juveniles thought to prefer similar habitat to that used for spawning. In the Mary River, lungfish are closely associated with overhanging vegetation, woody debris and macrophyte beds. Undercut banks can also be used as habitat. Open water habitat (lacking structure) is usually avoided.	7.0-9.1	421.0-1165.0	10-30	6.9-15.6
Oxleyan pygmy perch*	Coastal (between 7 and 123 km from coastline) lotic and lentic waterbodies, with darkly tannin-stained, dystrophic water, riparian cover and extensive macrophyte and/or leaf litter cover. Undercuts and large woody debris habitats may also be used. In Queensland, this species is most frequently observed in areas of low water velocity, mud and sand substrates in moderate depths (10 cm -50 cm)	4.2-6.7	68-300	16-32	5.0-13.0
Honey blue-eye	Coastal wallum ecosystems (both lentic and lotic), characterised by dystrophic, acidic, darkly stained waters with siliceous sand substrates and abundant submerged and emergent vegetation	4.4-6.8	17-896	14-29	6.8-8.7

* = information specific to specimens recorded for populations in southeastern Queensland

3.2.2 Species Distributions

Mary River cod

- Endemic to the Mary River, but recently stocked elsewhere to provide a recreational species for anglers;

- Historically thought to be distributed throughout most of the main channel and in large and small tributaries in the early 1900's and up to the 1960's, but the known distribution is currently only 170 km out of a presumed 700 km stream length;

- Major residual populations of this species occur in Obi Obi Creek, Six Mile Creek downstream of Lake Macdonald and Tinana-Coondoo creek, with reported potential breeding populations in Amamoor and Widgee creeks (see Figure 3-1);

- Six Mile Creek has been reported to host as many as 250 individual cod (personal communication attributed to John Koehn, Simpson & Jackson 1996);

- Populations in other parts of the catchment are thought to be patchy, although in excess of 30 individuals were observed in the upper reaches of the Mary River main channel during the recent Traveston Crossing Dam EIS (see Figure 3-1), suggesting populations in this reach may be larger than that reported previously (findings of previous studies have been based mainly on backpack electrofisher sampling, which is sub-optimal for catching cod in non-wadeable pool habitat and there has been more limited sampling in the main channel compared with tributary habitat prior to the SKM (2007) study);

- Cod have been stocked in Lake Macdonald and Borumba Dam and in select tributaries and parts of the Mary River main channel, but no assessment of stocking success or stock movement have been carried out to date;

- The stocking of cod in Lake Macdonald is expected to have benefited the downstream cod population (Simpson and Jackson, 1996), including adjoining tributaries such as the Left Branch of Six Mile Creek and Cooroy Creek; and

- A single adult individual approximately 60 cm in length was observed immediately downstream of Lake Macdonald during the study visit.

Lungfish

- Restricted to rivers of southeastern Queensland;

- Natural range is the Mary and Burnett Rivers, with some debate about the status of the Brisbane River population due to the translocation of this species to the Brisbane River and a number of other locations in the late 1800's;

- The status of translocations has not been well documented, but not all translocations were successful (e.g. it appears that they have not been successful in the Coomera River);

- Lungfish were commonly recorded along much of the Mary River main channel and in Yabba Creek during the recent Traveston Crossing Dam EIS survey (see Figure 3-2). They are also known to occur in other large western tributaries such as Amamoor Creek. They were not recorded in the eastern tributaries during the SKM (2007) study and have not been recorded previously in Six Mile Creek as part of any scientific studies (Kennard 2003; R. Simpson QDPIF, pers. comm.). However, lungfish were observed immediately below the spillway at Lake Macdonald after a recent high flow event and required removal from this zone by QDPIF staff (Jeff Black, Noosa Shire Council, pers. comm., Dave Hinton, ANGFA, pers. comm.). Given the habitat characteristics of Six Mile Creek, it is more likely that these individuals were among the occasional visitors to the upper reaches rather than part of a large established Six Mile Creek lungfish population.

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LEGEND

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Hervey Bay
Howard
Bundaberg
Location Map
Maryborough
MARY RIVER
MARY BARRAGE
TINANA CREEK
TEDDINGTON WEIR
TALLAGALLA WEIR
Tiaro
138014A
MIJINA CREEK
138004B
138903A
138001A
Gunalda
138002C
MARY RIVER
138010A
WIDE BAY CREEK
Kilkivan
138009A
Goomeri
GLASTONBURY CREEK
138007A
Gympie
138003A
138003D
138003B
138003C
138020A
Murgon
SIX MILE CREEK
Amamoor
138109A
138107A
AMAMOOR CREEK
138102A
138102C
138113A
138108A
KANDANGA CREEK
138105A
138105D
YABBA CREEK
Imbil
BORUMBA DAM
MARY RIVER
138111A
Kenilworth
138101A
138104A
138110A
OBI OBI CREEK
Nambour
138106A
BARROON POCKET DAM
Maleny
Kilcoy
Tin Can Bay
Pomona
COOROY WEIR
Cooroy
Noosa Heads
Eumundi
Yandina
Maroochydore
Caloundra
BRUCE HIGHWAY
BURNETT HIGHWAY

Location of Mary River Basin within Australia

Reaches where Mary River Cod are found are highlighted in purple on the Mary River Basin Map (left)
— = Highlighted reach

= Study Reach

Northern Pipeline Interconnector (Stage 2)

Queensland Government
Department of Natural Resources

27/02/2001

Mary River Basin
Locality Map

A3-505189

1:500 000

KILOMETRES 0 10 20 30 40 50

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\Projects\BEG601- SRWP\T08 Gis Data\TOC 5 Northern Interconnector\Mapinfo\Workspaces\EIS\Hydrobiology Report\TOC5B\Figure 3.2 Mary River Cod Distribution within the Mary River Basin.Wor*

Date: *9 January 2007 (Prior to Rev C)*

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NORTHERN PIPELINE INTERCONNECTOR

MARY RIVER COD DISTRIBUTION WITHIN THE MARY RIVER BASIN

3.1

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

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

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138102C
138113A
138108A
138109A
138107A
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138104A
138110A
138106A

Location Map

Location of Mary River Basin within Australia

Reaches where the Lungfish are found are highlighted in green on the Mary River Basin Map (left)

= highlighted reach

= Study Reach

Northern Pipeline Interconnector (Stage 2)

Queensland Government
Department of Natural Resources

27/02/2001

Mary River Basin
Locality Map

A3-505189

1:500 000

KILOMETRES 0 10 20 30 40 50

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\Projects\BEG601- SRWP\T08 Gis Data\TOC 5 Northern Interconnector\Mapinfo\Workspaces\EIS\Hydrobiology Report\TOC5B\Figure 3.2 Lungfish Distribution within the Mary River Basin.Wor*

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northern pipeline inter connector

NORTHERN PIPELINE INTERCONNECTOR

LUNGFISH DISTRIBUTION WITHIN THE MARY RIVER BASIN

3.2

Oxleyan pygmy perch

- Very restricted and patchy distribution on the mainland between Coondoo and Tinana creek (southeast Queensland) to the north and Tick Gate Swap in northern NSW to the south. Records of occurrence in Lake Hiawatha, further south, have not been backed up by recent surveys;

- Also occur on Fraser, North Stradbroke and Moreton islands in wallum wetlands;

- Other mainland populations in southeast Queensland include those in the Noosa, Maroochy and Pine rivers. Populations in the upper Noosa River said to be well established (Pusey *et al*., 2004) (see Figure 3-3);

- Genetic analysis suggests that discrete southeast Queensland populations have relatively high levels of allozyme and mitochondrial DNA variation, suggesting limited dispersal and interbreeding among populations;

- None of the waterways containing known populations of Oxleyan pygmy perch have any direct connectivity to Six Mile Creek;

- The limited sampling carried out in Six Mile Creek by Simpson (1994) and, more recently, by NRW, did not record this species. Both sets of sampling included sites in upper Six Mile Creek (However, number of sites sampled by Simpson (1994) = 4 with 1 upstream site f and number of sites recently sampled by NRW = 3 with one upstream site). Non-scientific trapping in Cooroy Creek and the reach of Six Mile Creek immediately below the dam over many years by Dave Hinton (ANGFA) has not yielded any individuals of this species (Dave Hinton, ANGFA, pers. comm.). ;

- Genetic analysis suggests that discrete southeast Queensland populations have relatively high levels of allozyme and mitochondrial DNA variation, suggesting limited dispersal and interbreeding among populations. Hence, if this species were present in Six Mile Creek, it may represent a relatively genetically distinct population.

Honey blue-eye

- Very restricted and patchy distribution in coastal-lowland swamps of southeastern Queensland (see Figure 3-4);

- Occurs in two highly disjunct populations – one in Dismal Swamp in the Water Park Creek system north of Rockhampton and one in streams, lakes and coastal dune wetlands from Tin Can Bay to Tibrogargan Creek, 45 km north of Brisbane;

- Recorded in most of the major creeks draining into Tin Can Bay;

- Relatively common in the Noosa River, particular the upper reaches; and

- Present on Fraser Island, but not on Moreton or Stradbroke islands.

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LEGEND

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Hervey Bay
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Imbil
Kenilwork
Nambour
Maleny
Kilcoy
Tin Can Bay
Searys Creek
Carland Creek
Noosa River
Pomona
Cooroy
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Yandina
Caloundra
Maroochydore
Bundaberg

MARY RIVER
MARY BARRAGE
TINANA CREEK
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WIDE BAY CREEK
WIDE BAY HIGHWAY
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YABBA CREEK
BORUMBA DAM
OBI OBI CREEK
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BURNETT HIGHWAY

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138106A

Location Map

Location of Mary River Basin within Australia

Creeks on Fraser Island

Reaches or locations where Oxleyan Pygmy Perch are found are highlighted or marked with a star in orange.

= Highlighted reach or location

= Study Reach

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Department of Natural Resources

27/02/2001

Mary River Basin
Locality Map

A3-505189

1:500 000

KILOMETRES 0 10 20 30 40 50

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\Projects\BEG601- SRWP\T08 Gis Data\TOC 5 Northern Interconnector\Mapinfo\Workspaces\EIS\Hydrobiology Report\TOC5B\Figure 3.2 Oxleyan Pygmy Perch Distribution.Wor*

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NORTHERN PIPELINE INTERCONNECTOR

OXYLEYAN PYGMY PERCH DISTRIBUTION WITHIN OR NEAR THE MARY RIVER BASIN

3.3

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LEGEND

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Hervey Bay
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Pomona
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Noosa River
Noosa Heads
Marcus Beach
Eumundi
Yandina
Kenilworth
Little Yabba Ck
Nambour
Maleny
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Kilcoy
Imbil

MARY RIVER
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KANDANGA CREEK
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BURNETT HIGHWAY

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138903A
138009A
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138107A
138102A
138102C
138113A
138108A
138105A
138105D
138111A
138101A
138104A
138110A
138106A

Tin Can Bay
Honey Blue-Eye has been found in most major creeks draining into Tin Can Bay

Creeks on Fraser Island

Reaches or locations where Honey Blue-Eye are found are highlighted or marked with a star in orange.

= Highlighted reach or location

= Study Reach

Northern Pipeline Interconnector (Stage 2)

Location Map

Location of Mary River Basin within Australia

Queensland Government
Department of Natural Resources

27/02/2001

Mary River Basin
Locality Map

A3-505189

1:500 000

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\Projects\BEG601- SRWP\T08 Gis Data\TOC 5 Northern Interconnector\Mapinfo\Workspaces\EIS\Hydrobiology Report\TOC5B\Figure 3.4 Honey Blue-Eye Distribution.Wor*

Date: *9 January 2007 (Prior to Rev C)*

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NORTHERN PIPELINE INTERCONNECTOR

HONEY BLUE-EYE DISTRIBUTION WITHIN OR NEAR THE MARY RIVER BASIN

3.4

- None of the localities it is known to have any direct connectivity with Six Mile Creek;
- A record of this species in Little Yabba Creek (Pusey and Kennard, 1999 *In* Pusey *et al.* 2004; Allen *et al.* 2002) is almost certainly in error (Pusey *et al.* 2004);
- A study by Arthington and Marshall (1993) (cited in Pusey *et al*. 1994) found this species in only a limited number of sites that appeared to have conditions likely to support populations;
- Not recorded in Six Mile Creek according to Kennard (2003), R. Simpson (QDPIF, pers. comm.) and T. Espinoza (NRW, pers. comm.), although fish sampling in Six Mile creek, particularly in upper reaches near Lake Macdonald, has been limited to date. Non-scientific trapping in Cooroy Creek and the reach of Six Mile Creek immediately below the dam over many years by Dave Hinton (ANGFA) has not yielded any individuals of this species (Dave Hinton, ANGFA, pers. comm.); and
- Populations of this species exhibit substantial temporal fluctuations, with reduction in population sizes during winter and increases during summer attributed to flood flushing flows and recruitment through reproduction, respectively. Therefore, there is greater potential for this species to be missed by fish surveys;

3.3 Implications of Findings

With the caveat that there has only been limited fish sampling in Six Mile Creek and no additional data were collected as part of the present study, the following implications of the findings presented above have been identified (see Table 3-4).

Mary River cod are the most likely of the four species to be present in the study reach, but it is highly unlikely that the Left Branch of Six Mile Creek or its anabranch would support substantial populations of this species given that lack of deep pool habitat and the reduced access to large woody habitat as a result of it being typically exposed by low water levels. It is possible, however, that Mary River cod would move in and out of this part of the study reach during high flow events, particularly during those events associated with autumn when cod usually move upstream into tributaries to overwinter (Simpson and Jackson 1996). Another possibility is that juvenile cod may use non-preferred habitat of this part of the study reach to escape predation from adults, given Mary River cod are aggressive predators and are territorial. While this is not a confirmed observation, it is a theory supported by anecdotal observations of cod populations in Widgee Creek by Simpson (pers. comm.). Mary River cod are known to occur in the main branch of Six Mile Creek and an individual was observed in the study reach during the site visit. For the purpose of this study, it is assumed that this species occurs throughout the study reach.

While no records of Oxleyan pygmy perch exist for Six Mile Creek, the habitat conditions in the Left Branch of Six Mile Creek and its anabranch appear to be a reasonable match for the habitat preferences of this species, apart from lack of macrophytes. Unlike honey blue-eye, which can sometimes co-occur with this species, use of leaf litter as habitat has been confirmed for Oxleyan pygmy perch (Pusey *et al*. 2004). Leaf litter habitat is abundant in the Left Branch of Six Mile Creek due to the presence of good riparian cover. In addition, the limited fish community data collection in the catchment and the sole use of backpack electrofishing surveys for previous scientific surveys does not provide enough confidence to assume that Oxleyan pygmy perch do not occur in this part of the study reach. Hence, for this impact assessment, it is assumed that Oxleyan pygmy perch possibly occur in the study reach.

Lungfish and honey blue-eye have a greater reliance on macrophyte habitat, very little of which occurs in the study reach due to dense riparian shading. Combined with the above, the lack of any previous recordings of honey blue-eye in Six Mile Creek suggests that this species is unlikely to occur in the study reach. While a few individuals of lungfish have been observed immediately below the spillway at Lake Macdonald, the habitat features of this part of the study reach are unlikely to support large established populations of this species. It is more likely that the observed individuals were visitors to the reach in response to elevated flows. Hence, for this impact assessment, it is assumed that neither species would typically occur in the study reach.

With these assumptions in mind, it is assumed that the Project could potentially impact upon Mary River cod and Oxleyan pygmy perch, but is highly unlikely to impact upon lungfish and honey blue-eye. Consequently, only Mary River cod and Oxleyan pygmy perch are considered further as part of this report.

Table 3-4 Likely presence / absence of the four target species in the study reach

Species	Likely presence / absence	Reason
Mary River cod	Probably present	• Known to occur in Six Mile Creek catchment, where it is regarded as having one of three remaining 'stronghold' populations. • Most water quality conditions meet its requirements / preferences. • Stocked cod in Lake Macdonald washed over the spillway during high flows may benefit the downstream population. • Shallow water depths may restrict cod occurring in the Left Branch of Six Mile Creek or its anabranch much of the time. • Adult cod may move into the Left Branch of Six Mile Creek during high flows in autumn. • Juveniles may utilise sub-optimal, shallower habitats to avoid being eaten by adults.

Species	Likely presence / absence	Reason
Lungfish	Almost certainly not present	• Lack of substantial macrophyte cover throughout the study reach and absence of deep pool habitat in the Left Branch of Six Mile Creek or its anabranch would limit the ability of this species to form established populations in the study reach. • Lungfish only occasionally observed in the main branch of Six Mile Creek and observed individuals probably visitors to the study reach rather than permanent residents. • No records of this species in the Left Branch of Six Mile Creek.
Oxleyan pygmy perch	Possibly present in the Left Arm of Six Mile Creek	• Not previously recorded in the study reach, but many of the habitat features in the Left Arm of Six Mile Creek and its anabranch overlap with those preferred by this species. • Study reach lacks emergent macrophyte habitat, but leaf litter is known to be used as a substitute habitat by this species. • Unlikely to occur in the main branch of Six Mile Creek due to lack of preferred habitat.
Honey blue-eye	Probably not present	• Some habitat features in the Left Arm of Six Mile Creek consistent with those preferred by this species, but not previously recorded in the study reach or elsewhere in Six Mile Creek. • Study reach lacks emergent macrophyte habitat and no records of this species using leaf litter as substitute habitat. • Habitat features in the main branch of Six Mile Creek even less suited to this species.

3.4 Mary River cod Habitat Requirements & Sensitivity to Change

Table 3-5 and Table 3-6 outline the habitat requirements and sensitivity to change for Mary River cod and Oxleyan pygmy perch respectively.

Table 3-5 Mary River cod habitat requirements and sensitivity to change

Feature	Reason required	Sensitivity to change
Large woody debris – particularly large individual logs and large branch piles and / or rock bars	• Cod use these structures for shelter. • Hollow logs assumed to be used as spawning sites based on hatchery observations of cod breeding in concrete pipes. • Cod observed to regularly be within 2 m of structural habitat.	• Loss of structural habitat through snag removal (de-snagging) or riparian vegetation clearing. Structural habitat above water line due to low flows (natural or artificially created). The latter could be a feature of the study reach in the main channel directly downstream from Lake Macdonald.
Deep pool habitat	• Preferred by adult cod. • Deep pools offer cooler water temperatures, particularly when associated with riparian overhangs. • More chance that structural habitat is submerged in deep pools.	• Pool infilling due to sedimentation resulting in loss of quality deep pool habitat. • Lower water levels due to droughts or flow regulation resulting in loss of quality pool habitat (loss of depth and exposure of structural habitat) • Shallowing of pools resulting in higher water temperatures and / or aquatic macrophyte infestation, leading to stress on cod (as observed in the upper reaches of the Mary River main channel (SKM 2007). • New deep pool habitat can be created by water infrastructure, and Mary River cod survive and grow well in Lake Macdonald.
Riffle zones	• Cod observed feeding immediately downstream of riffle zones (prey washed down into pools). • Cod migrate in autumn and spring, so need to have depth over riffles maintained to allow	• Loss of riffles due to altered flow regimes (natural or artificial) resulting in reduced access to prey. • Loss of height of water over riffles due to altered flow regimes (natural or artificial)

Feature	Reason required	Sensitivity to change
	movement.	resulting in reduced access to other parts of the river at key times.
Flow /temperature stimuli	• Cod do not need flow stimuli to breed based on hatchery observations, but elevated flows in spring and winter stimulate movement of this species and movement offers evolutionary advantages to cod. • Elevated flows at temperatures above 20^{o}C stimulate movement out of tributaries back to home range to breed during spring -summer.	• Altered flow regimes due to droughts or regulated flow may mask movement cues, resulting in loss of condition and / or reduced recruitment. There are no confirmed observations of this occurring. • Release of hypolimnetic water from water storages in spring may also mask movement cues, but there are no confirmed observations of this.
Movement within channel and into tributaries during winter	• Unclear and not necessarily related to spawning, but probably advantageous to the species. Reasons may include foraging or increasing encounters with potential mates.	• Loss of foraging opportunities or opportunities for encountering mates due to barriers to movement. In extreme cases, barriers could lead to population isolation, but no such effects have yet been observed for Mary River cod. • Barriers may occur naturally through formation of isolated pools, or water levels being reduced over riffle habitat. Flow regulation can have similar effects, but no such effects confirmed as yet. • Dense macrophyte growth and degraded water quality can also act as barriers to movement.
Water quality conditions (as described in Table 3-3)	• Estimated physiological tolerance range for Mary River cod. • Certain temperatures required for spawning cues and cooler	• Dissolved oxygen levels can be reduced due to extensive macrophyte growth, particularly in combination with reduced depth and low

Feature	Reason required	Sensitivity to change
	temperatures are feature of their favoured habitat (deep pools).	flows, resulting in mortalities. • Dissolved oxygen expected in lower layers of water storages, but oxygenated habitat exists above the thermocline for cod • Release of hypoxic, cooler hypolimnetic water from water storages without multi-level offtakes (e.g. Borumba Dam), potentially resulting in mortalities or interrupted movement cues. No records of this occurring. Lake Macdonald has a four level multilevel offtake and a destratifier unit (Dave Heerey, Noosa Shire Council, pers. comm.), so such impacts are unlikely to occur in the study reach.

Table 3-6 Oxleyan pygmy perch habitat requirements and sensitivity to change

Feature	Reason required	Sensitivity to change
Wallum habitat	• Preferred habitat	• Loss or alteration of habitat due to coastal development leading to reduced distribution, population size and genetic diversity for this species. Fortunately, many populations occur in protected areas such as National Parks, State Forests or Military Reserves.
Flushing flows	• Flushing of individuals downstream could represent a key part of the life history of this species (Pusey *et al*. 2004), but this is unknown.	• Altered flow regimes (natural or otherwise) may reduce / remove flushing flows to the detriment of this species. • In the study reach, artificially altered flow regimes only occur downstream of Lake Macdonald in the main branch of Six Mile Creek, where Oxleyan pygmy perch are unlikely to occur due to lack of preferred habitat.
Movement within drainage	• Breeding opportunities.	• Loss of breeding opportunities due to barriers to movement, resulting in reduced recruitment. • Barriers may occur naturally through formation of isolated pools. Flow regulation can have similar effects but this could only occur in the reach directly below Lake Macdonald, where this species is not expected to occur. • Dense macrophyte growth and associated degraded water quality can also act as barriers to movement. This type of barrier is unlikely to be a feature of the predominantly densely

Feature	Reason required	Sensitivity to change
		shaded study reach.
Water quality (as per Table 3-3)	• Predicted physiological tolerance range for local populations (although these differ slightly from northern NSW populations and are based on limited occurrence data). • Low turbidity required where populations rely heavily on macrophyte habitat (see 'Instream cover' below). • Water temperatures greater than 20^{o}C required for spawning (spawning occurs over spring and summer).	• Dissolved oxygen levels can be reduced due to extensive macrophyte growth, particularly in combination with reduced depth and low flows, resulting in mortalities. Paragrass infestations have been linked to impacts on this species, but limited growth of this or other macrophyte species in the study reach. • Potential mortality due to being flushed down into estuarine reaches during elevated discharges (Pusey et al. 2004). Unclear whether or not this is the case. • This species is not exposed to releases of hypolimnetic water to our knowledge, either in the study reach or elsewhere, so impacts on spawning cues likely to be very limited or non-existent. • Reduced macrophyte habitat due to elevated turbidity resulting in reduced macrophyte abundance. Such impacts largely irrelevant for the study reach, as macrophyte growth is extremely limited apart from isolated patches of the noxious cabomba in the main channel adjacent cleared vegetation.
In stream cover	• Protection against predators, shelter from elevated flows, egg laying site, feeding site and / or habitat used by prey species.	• Severe flushing can temporarily remove habitat structure. Such flushes occur naturally and could also occur through artificial release from dams, although no such impacts in relation

Feature	Reason required	Sensitivity to change
		to Oxleyan pygmy perch have been documented. • Elevated turbidity can reduce macrophyte growth, reducing available shelter and food supply. Road and bridge construction, urban development and housing construction have been identified as potential mechanisms for erosion-based sediment mobilisation impacts. Such impacts largely irrelevant for the study reach, as macrophyte growth is extremely limited apart from isolated patches of the noxious cabomba in the main channel in adjacent cleared vegetation.

3.5 Existing Impacts on Cod

The following have been documented as existing disturbances affecting Mary River Cod (see Table 3-7). The relevance of each type of disturbance to the Project is outlined in this table.

Table 3-7 Existing disturbances affecting Mary River cod

Activity / Feature	Impact	Relevant to study area / potential impacts of Project
Increased sedimentation	Infilling of pool habitat, reducing cod habitat availability and quality and potentially contributing to higher stream temperature impacts on cod	Yes - Without mitigation or appropriate construction methods, sediment mobilisation may be associated with crossing construction potentially leading to infilling of pools, some of which are already shallow.
Loss of riparian vegetation	Contributes to increased sedimentation, increased stream temperatures (through reduced shading) and reduced snag supply (i.e. reduced cod habitat)	Yes - Riparian corridor up to 30 m wide to be cleared for crossing construction if trenching or above bank full level pipeline crossing construction methods are used.
De-snagging	Removal of cod structural habitat	Yes – abundant snag habitat in study reach and isolated snag removal may be required for pipeline crossing construction if trenching is carried out. The practice of snag removal for improved navigability has largely been stopped in the Mary River catchment, so impacts largely historical. .
Flow regulation / Water resource development	Change in water level and flows. Changes could be positive in some respects (e.g. dams may provide additional deep water pool habitat with abundant food resources), or may be detrimental (e.g. potential inability to breed in dams, potential for dam walls to act as barriers, leading to population isolation). Several dams in the Mary River catchment, with new large one proposed for the Mary River main channel. Existing information suggests cod survive well in Lake Macdonald. No data available on breeding in dams or on impacts of modified downstream releases on cod,	Yes–Impacts of flow regulation on Mary River cod occur in the main branch of Six Mile Creek, which is exposed to artificial flow releases from Lake Macdonald, Downstream flows would be temporarily haltered or significantly reduced in association with trenching methods without some form of mitigation. . If trenching methods are used, flow diversion mechanisms will be employed.

Activity / Feature	Impact	Relevant to study area / potential impacts of Project
	but recent NRW monitoring suggests that additional volumes may need to be released from Lake Macdonald into Six Mile Creek to inundate snag habitat for cod (SKM 2007).	
Introduced fish species	Potential egg predation, predation / fin nipping of juveniles, competition with juveniles for food resources. Impacts suspected, but not documented. Stocked introduced species in the Mary River catchment such as yellow belly, bass and saratoga may prey on cod and possibly vice versa.	Yes - *Gambusia holbrooki* and yellow belly present in Six Mile Creek (Kennard 2003), but no other introduced species to our knowledge. *G. holbrooki* is more tolerant of disturbed conditions than native species, so may proliferate in areas disturbed by the Project.
Macrophyte infestation	Choking of waterway representing both a passage barrier and contributor to low dissolved oxygen levels, particularly during low flow conditions. The latter can lead to cod mortalities as observed in the upper Mary River main channel (SKM 2007).	Yes – No significant macrophyte stands present in the study reach due to dense riparian shading, but potential for spread of the noxious cabomba from the main channel to the Left Branch of Six Mile Creek and for this species to proliferate in cleared construction corridors. .
Fish Barriers	Restriction of movement, potentially leading to reduced condition and /or abundance and potential genetic isolation. Numerous barriers exist in the Mary River catchment, although some have been retrofitted by fish passage devices. It is uncertain whether or not cod will be able to use the fishways put forward for the proposed Traveston Crossing dam and overall strategy, which includes trap and transport, could, but is not guaranteed to work.	Yes –fish passage barrier present in the Left Branch of Six Mile Creek and the dam wall at Lake Macdonald represents a barrier to upstream cod movement from the main branch of Six Mile Creek. Potential barriers to cod movement if construction is carried out at critical times.
Overfishing	Thought to be a major factor in the low abundance of cod, but not a major current pressure due to protection status of cod (i.e. restricted to illegal takes and single takes in stocked water storages).	No – Not relevant to Project activities and project unlikely to open up greater opportunity for illegal takes.
Low genetic diversity	Low genetic diversity and low	Yes – Project potentially

Activity / Feature	Impact	Relevant to study area / potential impacts of Project
	numbers may expose Mary River cod to greater risk of population collapse due to disturbance.	affecting Mary River cod. Further reduction in abundance possible, although unlikely.

The following have been documented as existing disturbances affecting Oxleyan pygmy perch (see Table 3-8). The relevance of each type of disturbance to the Project is outlined in this table.

Table 3-8 Existing disturbances affecting Oxleyan pygmy perch

Activity / Feature	Impact	Relevant to study area / potential impacts of Project
Sediment mobilisation through road, bridge, urban development construction	Increased turbidity reducing macrophyte habitat abundance.	No – No significant macrophyte habitat in study reach.
Loss of habitat through development in coastal catchment	Reduced habitat availability leading to reduced abundance and potentially further population isolation (lower genetic diversity).	No – Only local scale habitat loss or modification potentially associated with the crossing construction.
Macrophyte infestation	Choking of waterway representing both a passage barrier and contributor to low dissolved oxygen levels, particularly during low flow conditions. The latter can lead to mortalities.	Yes – No significant macrophyte stands present in the study reach due to dense riparian shading, but potential for spread of the noxious cabomba from the main channel to the Left Branch of Six Mile Creek and for this species to proliferate in cleared construction corridors. growth
Introduced fish species	Potential egg predation, predation / fin nipping, competition for food resources by *Gambusia holbrooki*. Impacts suspected, but not documented. Stocked introduced species in the Mary river catchment such as yellow belly may prey on Oxleyan pygmy perch.	Yes - *Gambusia holbrooki* and yellow belly present in Six Mile Creek (Kennard, 2003), but no other introduced species to our knowledge. *G. holbrooki* is more tolerant of disturbed conditions than native species, so may proliferate in areas disturbed by the Project.
Taking for aquarium trade	Reduced abundance.	No – The Project will not enhance opportunities for collection for aquariums. Protection status and strong advice against collection from groups such as ANGFA to its members has reduced this impact, but illegal or inadvertent

Activity / Feature	Impact	Relevant to study area / potential impacts of Project
		takings still possible.
Limited dispersal and interbreeding between isolated populations	Small populations that are impacted more difficult to restore by natural dispersal, making conservation efforts difficult.	Yes – small population potentially existing in the study reach may be affected by the pipeline crossing construction activity without appropriate mitigation in place. Recovery from this could be potentially difficult.

3.6 Potential Impacts of Pipeline Crossings

3.6.1 Pipeline Construction Options

The nature and magnitude of impacts associated with pipeline crossing will depend greatly on the type of crossing method used. Several crossing methods are being considered as part of the Southern Regional Water Pipeline design and construction. The use of these will be on a case-by-case basis. It is therefore necessary to describe the various crossing methods before assessing potential impacts. Descriptions of the crossing options being considered are provided below in Table 3-9. These descriptions were provided by the client (Kate Rigg, SRWPA, pers. comm.).

Table 3-9 Description of crossing construction methods

Method	Activities involved	Relative cost / ease
Trenching	Clearing a riparian corridor up to 30 m wide (worst case scenario). Temporary flow diversion using dam and pump or dam and flume to divert around the worksite. The crossing will NOT involve pipes being laid across the channel at mid-bank full level, as is the case with the existing water pipelines. Excavation of bed and bank down to 2.5m below bed level. The trench will average 1.8 m wide and requires back filling. An area of creek bed approximately 15m wide will also need be excavated for machinery alongside the pipe trench. Storage of excavated materials in cleared area above bank full level. Controlled blasting may be required if rock beds are encountered, but trenching carried out mainly by hydraulic excavators and dozers or rippers – this is unlikely on alluvial plains and has only been identified as an issue at higher elevations Potential removal of instream snag habitat before trenching. Placement of rip rap to prevent erosion / damage to pipeline.	Cheapest (around $100 K per crossing) and simplest option

Method	Activities involved	Relative cost / ease
Constructing pipeline above bank full level	Clearing a riparian corridor up to 30 m wide (again, worst case). Pylons driven into bank and pipe dropped across waterway on a crane. No direct disturbance to bed of waterway Some excavation above bank full level on both sides of creek to raise and re-submerge pipeline. Placement of rip rap to prevent erosion / damage to pipeline.	Cost around $3-5 million roughly; significant design input required to determine flood levels etc.
Micro-tunnelling and thrust boring	Involves digging two pits to the required depth on either side of the area (up to 30m deep), drilling a tunnel between the two pits and inserting the pipe into one end and feeding it through to the other. Minimal riparian habitat disturbances compared to other methods	Most expensive option at around $8 M per crossing and more difficult – also a time constraint. Up to 3 months for shaft construction, and 3-9 months to drill tunnel. Availability of machinery is also an issue.

3.6.2 Potential Impacts

There are two broad classes of impact associated with the Project – possible impacts associated with the pipeline alignment and impacts associated with the construction and operation phases of the pipeline crossings themselves.

Pipeline alignment

The proposed pipeline involves two creek crossings and follows the route shown in Figure 2-2. It largely traverses cleared land and intersects at points in the study reach with relatively limited riparian vegetation cover. In this respect, the proposed pipeline route is favourable in terms of minimising impacts. However, the existing route bisects the property owned by Mr Russell Manning and could potentially affect the proposed Mary River cod hatchery expansion. While impacts to the proposed cod hatchery obviously do not directly affect wild cod populations, the hatchery is important for the long-term survival of the species. Therefore, impacts to the hatchery could be viewed as having an impact on Mary River cod. Given the importance placed on the existing and proposed expanded cod hatchery by QDPI&F as part of the overall Mary River cod conservation / recovery strategy, it is recommended that this situation should be avoided.

Crossing construction

Crossing construction has the potential to cause environmental impacts during both the construction and operation phase. Table 3-10 below outline potential impacts associated with each construction method during the construction and operation phase respectively, and potential mitigation options. Note that pipeline construction represents a linear impact, with impacts largely restricted to a narrow corridor at several fixed points. Physical impacts such as sediment mobilisation could extend along the stream line downstream from crossing points, but unless there was a severe erosion event arising from heavy rainfall coinciding with the construction phase, these impacts would largely be short-lived and restricted in terms of spatial extent. Construction could be strategically time to coincide with typically drier periods of the year to avoid major sediment mobilisation impacts.

Most impacts related to the construction phase are likely to be short-lived and confined for the duration of the construction period (expected to be between 1-3 weeks per crossing), particularly increases in turbidity or the creation of fish barriers (if trenching methods are used). There are a few potential impacts that may extend beyond this timeframe, which include:

- Reduced stream shading and snag supply in cleared corridors;
- Potential bed and bank erosion if the construction site is unstable or if large woody debris builds up against pipelines spanning the creek above bank full level; and
- Potential impacts associated with the introduction and / or enhancement of exotic species such as Cabomba or gambusia in modified crossing corridor habitat.

However, these impacts are likely to be highly localised and potentially controllable through mitigation action. In addition, the eventual re-establishment of riparian vegetation in crossing corridors through replanting is expected to reduce the potential for longer term impacts. Hence, these impacts represent minimal risk to Mary river cod or Oxleyan pygmy perch.

Overall there is no significant risk of impact to Mary River cod or Oxleyan pygmy perch posed by any of three modes of crossing construction method being put forward. While the micro-tunnelling / thrust boring method poses the least environmental risk. Costs and availability of equipment and / or engineering suitability of crossing sites for this method may prove prohibitive. Having said this, opportunities may exist for avoiding the use of trenching in the Main Branch of Six Mile Creek where the potential for crossing construction impacts on Mary River cod is greater. Existing water pipelines crossing this part of the study reach are attached to the low level crossing between Lake Macdonald Drive and the road to the Noosa Water Treatment Plant. The proponent should consider attaching the new pipeline to this low level crossing pending engineering advice as to whether this is possible in order to minimise the risk of impacts associated with disturbance to the stream bed and bank habitat.

Table 3-10 Potential impacts and mitigation options associated with various construction methods

Construction Method	Activity	Consequence	Likelihood	Spatial Extent	Temporary Extent	Mitigation Option	Risk
CONSTRUCTION PHASE							
Trenching or Above bank full level pipeline crossing	Removal of riparian vegetation.	Loss of some snag habitat for cod and leaf litter supply for Oxleyan pygmy perch.	Almost certain.	Very narrow -15 m-30 m wide at only 2-3 crossing points	Long-term impact without mitigation. Medium to long term impacts with mitigation	Limit number of crossings required should an alternative route be used.. Revegetate cleared areas as soon as possible.	Very minor regardless of mitigation.
	Mobilisation of sediment during excavation and backfilling and riparian vegetation clearing.	Generation of turbid plumes and transient deposits of silt and sand.	Without mitigation: Turbid plumes –likely With mitigation: Turbid – Possible. Pool infilling associated with construction unlikely unless construction coincides with heavy rainfall.	Very narrow –within 10's (with mitigation) to 100's of metres (without mitigation).	Short-term increase in turbidity Medium term (< 1 year) longevity of sediment deposits	Trench or construct pylons during drier times of year Employ best practice erosion and sediment control. Minimise riparian vegetation clearing. Careful removal of vegetation.	Transient turbidity increase - Very Minor t regardless of mitigation Pool infilling Minor without mitigation, but if construction coincides with heavy rainfall where risk = Moderate., Minor with mitigation
	Potential spread of aquatic	Potential choking of waterway	Without mitigation - Possible	Probably narrow, with spread	Short-medium term	Identify areas affected by *C. caroliniana* before construction.	Moderate – without mitigation

Construction Method	Activity	Consequence	Likelihood	Spatial Extent	Temporary Extent	Mitigation Option	Risk
	weeds into the study reach and downstream areas.	creating barriers to movement and / or precursor to reduced dissolved oxygen levels if prolific growth occurs. This could result in fish kills or reduced recruitment of Mary River cod..	With mitigation - unlikely	largely limited to crossing points where vegetation has been cleared.		Advise construction crew of these areas and provide guidance on how to identify this weed species. Carry out crossing construction in these areas last or implement controlled wash down of construction equipment between crossing construction sites Inspect site post-construction and implement control/eradication program if necessary.	Minor –with mitigation.
Trenching only	Erosion of stockpiled sediment	Generation of turbid plumes. Transient deposits of silt and sand.	Without mitigation: Turbid plumes and localised sedimentation –Probably With mitigation: Turbid plumes and localised sedimentation–	Very narrow –within 10's (with mitigation) to 100's of metres (without mitigation).	Short-term increase in turbidity	Trench during drier times of the year. Avoid stockpiling in the creek bed and place stockpiled material well away from creek banks. Bund off stockpiled sediment. Implement best	Transient turbidity increase - Very Minor t regardless of mitigation Pool infilling Minor– without mitigation, but if construction

Construction Method	Activity	Consequence	Likelihood	Spatial Extent	Temporary Extent	Mitigation Option	Risk
			Possibly. Pool infilling associated with construction unlikely unless construction coincides with heavy rainfall.			practice stormwater management and erosion and sediment control in accordance with *Soil Erosion and Sediment Control, Engineering Guidelines for Queensland Construction Sites*.	coincides with heavy rainfall where risk = Moderate. Minor with mitigation
	Removal of snag habitat	Cod structural habitat is removed A range of physical impacts associated with direct disturbance of the watercourse.	Likely	Very restricted – only in trenched areas (i.e. maximum of a 30 m corridor)	Short-medium term without mitigation Very short term with mitigation	Avoid trenching where there are large individual logs or large branch piles. Replace removed large woody debris material on stream bed after backfilling. Refer to industry best practice guidelines on snag management (e.g. LWRRDC, www.environment.tas.gov.au)	Very minor regardless of mitigation
	Potential disruption to or restriction of fish movement while trenching is	Temporary restricting of fish movement, potentially resulting in reduced	Without mitigation – almost certain With mitigation -unlikely	Restricted based on limited stream length upstream of study reach.	Short-term – during construction period only.	Avoid trenching at times when cod and Oxleyan pygmy perch are likely to move within the stream channel– winter and spring-summer for	Moderate without mitigation, Minor with mitigation.

Construction Method	Activity	Consequence	Likelihood	Spatial Extent	Temporary Extent	Mitigation Option	Risk
	carried out	recruitment success for Oxleyan pygmy perch and / or the reduced condition or abundance of cod.				cod and spring-summer for Oxleyan pygmy perch.	
All construction methods, including micro-tunnelling / thrust boring	Accidental spills of chemicals such as hydrocarbons and drilling fluids	Degradation of water quality potentially affecting Mary River cod and or Oxleyan pygmy perch	Without mitigation – almost certain With mitigation -possible	Restricted to 10's or 100's of metres downstream	Medium term – up to several months in worst case scenario where slow flows and dense canopy reduce the rate of hydrocarbon breakdown	Employ industry best practice methods for managing accidental spills. Fuel, oil and chemicals to be stored in accordance with the Project Environmental Management Plan All spills to be reported and site crew issued with emergency response spill cleanup kits.	Moderate without mitigation, Minor with mitigation.
OPERATION PHASE							
Trenching or pipeline crossing above bank	Mobilisation of sediment through bed and bank	Pool infilling, generation of turbid plumes.	Without mitigation: Turbid plumes –Probably	Very restricted – within 10's (with	Medium term	Avoid trenching in areas where bank and bed stability is already low.	Increased turbidity – Minor regardless

Construction Method	Activity	Consequence	Likelihood	Spatial Extent	Temporary Extent	Mitigation Option	Risk
full level	erosion of exposed banks or stockpiled sediment		Pool infilling - possible With mitigation: Turbid – unlikely Pool infilling - unlikely	mitigation) to 100's of metres (without mitigation).		Avoid trenching in tortuous sections of high flow channel (e.g. large loop bends). Ensure backfilling is done with the same material as the stream bed (preferably the excavated sediment) Stabilise exposed banks and pylons and generally comply with best practice s erosion and sediment control in accordance with *Soil Erosion and Sediment Control, Engineering Guidelines for Queensland Construction Sites*.	of mitigation Pool infilling Moderate – without mitigation, Minor with mitigation
	Modified habitat conditions	Promote conditions for proliferation of exotic fish species Potentially	Unlikely	Very limited –largely restricted to construction corridor where habitats	Medium to Long term	As per options to reduce sediment mobilisation and riparian vegetation clearing.	Minor regardless of mitigation

Construction Method	Activity	Consequence	Likelihood	Spatial Extent	Temporary Extent	Mitigation Option	Risk
		reduced abundance of Mary River cod or Oxleyan pygmy perch due to increased predation pressure or competition.		have been modified..			
Pipeline crossing above bank full level only	Bed scouring due to build up of large woody debris against pipeline.	Pool infilling, generation of turbid plumes.	Without mitigation: Turbid plumes –Possible Pool infilling - unlikely With mitigation: Turbid – unlikely Pool infilling – unlikely	Very restricted – within o 100's of metres (without mitigation).	Medium term	Use hydrological modelling to set crossing height above level where high flows would push woody debris against pipe Regular maintenance of crossing to check for and remove built up woody debris against pipe.	Increased turbidity – minor regardless of mitigation. Pool infilling Moderate – without mitigation, Minor with mitigation

Construction Method	Activity	Consequence	Likelihood	Spatial Extent	Temporary Extent	Mitigation Option	Risk
	Restricted fish passage due to build up of large woody debris against pipeline.	Restriction of cod movement Potentially reduced breeding / recruitment success for leading to reduced cod abundance. Potential reduction of condition of resident cod.	Without mitigation – possible With mitigation –unlikely	Restricted based on limited stream length upstream of study reach.	Medium-long term without mitigation Short-medium term with mitigation	Use hydrological modelling to set crossing height above level where high flows would push woody debris across pipe Regular maintenance of crossing to remove built up woody debris against pipe.	Minor regardless of mitigation
Micro-tunnelling / thrust boring	No issues identified						

3.6.3 Risks to EPBC-listed Criteria

The following section is a summary of the risks of the Project impacting on Mary River cod and Oxleyan pygmy perch. Assessments have been made against the EPBC-listed criteria for impact assessment. Table 3-11 details the risk assessment for Mary Rover cod, while Table 3-12 details the risk assessment for Oxleyan pygmy perch. Broadly, the Project is unlikely to impact on any of the EPBC-listed impact assessment criteria. Therefore, the Project poses limited risk to either Mary River cod or Oxleyan pygmy perch on the basis that appropriate mitigation measures (as described in Table 3-10) and that the success of these strategies is monitored and any necessary adaptive management implemented (see Section 3-7).

Table 3-11 Assessment of potential impacts on Mary River cod based on EPBC- listed criteria

Will the proposed works	**Mary River Cod (Endangered)**
1) lead to a long-term decrease in the size of an important population of a species?	Unlikely given that most potential impacts occur on a restricted spatial scale over a narrow time frame and are therefore unlikely to result in severe long-term impacts on cod. . Recommended mitigation measures likely to further reduce the potential for any potential impact. Potential impacts on cod in the Left Branch of Six Mile Creek and its anabranch further reduced given that these parts of the study reach do not feature preferred Mary River cod habitat and, if utilised by cod at all, would probably be during high flow conditions in autumn when cod typically migrate into tributaries.
2) reduce the area of occupancy of an important population?	Unlikely given that the spatial extent of crossing construction would be limited and that any fish passage barrier formation associated with trenching methods would be short-lived and could be timed so as not to coincide with key periods of Mary River cod longitudinal movement. Even if crossing construction does create barriers to cod movement, the area of occupancy would not be greatly reduced given that two of the proposed crossing points are located close to existing fish passage barriers. Regular maintenance of above bank full level pipeline (if considered) during the operation phase would reduce the risk of the creek

	becoming blocked by the backing up of large woody debris against the pipe. Potential impacts on cod in the Left Branch of Six Mile Creek and its anabranch further reduced given that these parts of the study reach do not feature preferred Mary River cod habitat and, if utilised by cod at all, would probably be during high flow conditions in autumn when cod typically migrate into tributaries.
3) fragment an existing population into two or more populations?	See 2) above
4) adversely affect habitat critical to the survival of a species?	Unlikely given that the Left Branch of Six Mile Creek features sub-optimal habitat for cod and the closest deep refugial pool in the main branch of Six Mile Creek occurs around 1 km downstream of the proposed crossing point and is, therefore, unlikely to be impacted by crossing construction, Infilling of pools associated with sediment mobilisation considered to be unlikely and insignificant should it occur (even without mitigation), due to the limited spatial extent of the areas affected and the probability of any sediment build up being removed by high flow events in the short-medium term. The only caveat to this is if high flow events coincide with construction. However, this risk can be reduced by scheduling the timing of construction for the drier months of the year. Only small amounts of large woody debris would be removed from a small area if trenching was considered. This habitat structure could be replaced either by natural means or re-positioning of temporarily removed snag habitat from areas trenched.
5) disrupt the breeding cycle of an important population?	Unlikely if construction is carried out outside of autumn and spring when cod move Cod unlikely to use the Left Branch of Six Mile Creek as breeding habitat based on lack of large woody debris in association with deep pool habitat.
6) modify, destroy, remove, isolate or decrease the availability or quality of	Very unlikely. See points 2) and 4) above

habitat to the extent that the species is likely to decline?	
7) result in invasive species that are harmful to a species becoming established in the species' habitat?	Unlikely- Activities associated with construction will not involve translocation of exotic fish species and exotic fish already exist in Six Mile Creek. The limited spatial extent of any habitat disturbance will probably not foster increases in exotic fish to any significant extent. Spread of the noxious macrophyte *C. caroliniana* is possible given that it occurs in Lake Macdonald and in the first few hundred metres main branch of Six Mile Creek below this water storage (Jeff Black, Noosa Shire Council, pers. comm.). A pipe crossing is proposed in this reach. Also, this species can spread vegetatively by small fragments enhancing its ability to spread. However, mitigation measures outlined in Table 3-10 should greatly reduce the risk of spread to other sites. Furthermore, even should spread occur during the construction phase, this macrophyte is not expected to proliferate in the densely shaded study reach (shading is one of the control options cited for this species) and growth would probably be restricted to the construction corridor where riparian vegetation clearing occurs. In the longer term, the re-vegetation of the construction corridor would be expected to shade out these growth patches leading to their eventual die back.
8) introduce disease that may cause the species to decline?	Impossible given that most diseases potentially affecting cod would be associated with contact with exotic fish and the project will not involve the translocation of exotic fish.
9) interfere with the recovery of the species?	Unlikely given that the Project will not involve destruction or disturbance to revegetated areas, interference with re-stocking efforts or the placement of long term barriers to cod movement.
10) Mitigation measures	As outlined in Table 3-10

Table 3-12 Assessment of potential impacts on Oxleyan pygmy perch based on EPBC- listed criteria

Will the proposed works	Oxleyan pygmy perch (Endangered)
1) lead to a long-term decrease in the size of an important population of a species?	If this species were present in the study reach, it would represent an important population based on the limited numbers of this species and the likelihood that it would be genetically distinct from other populations. However, the activities relating to the project are unlikely to lead to significant large scale or long-term impacts on this population or habitats critical to its survival, particularly if mitigation measures are put in place.
2) reduce the area of occupancy of an important population?	Any barriers created by crossing construction would be temporary fixtures that only last as long as the construction phase. If mitigation measures are put in place, the extent of barriers to movement would be very limited and timed so as to avoid periods when Oxleyan pygmy perch move within the stream as part of breeding activities.
3) fragment an existing population into two or more populations?	See discussion for point 2) above.
4) adversely affect habitat critical to the survival of a species?	Unlikely, because habitat in the study reach is probably non-preferred habitat for this species. Also, crossing construction will probably have limited impact on the structural or physico-chemical habitat conditions required by this species.
5) disrupt the breeding cycle of an important population?	Unlikely if mitigation measures are put in place to reduce any barriers to movement and work is not carried out during the spring-summer breeding period.
6) modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?	Very unlikely. See discussions for point 4) above.
7) result in invasive species that are harmful to a species becoming established in the species' habitat?	Activities associated with construction will not involve translocation of exotic fish species and exotic fish already exist in Six Mile Creek. The limited spatial extent of any habitat disturbance will not foster increases in exotic

Will the proposed works	Oxleyan pygmy perch (Endangered)
	fish to any significant extent. Spread of the noxious macrophyte *C. caroliniana* is possible given that it occurs in Lake Macdonald and in the first few hundred metres main branch of Six Mile Creek below this water storage (Jeff Black, Noosa Shire Council, pers. comm.). A pipe crossing is proposed in this reach. Also, this species can spread vegetatively by small fragments enhancing its ability to spread. Moderate growth of cabomba spread to the Left Branch of Six Mile is more likely to benefit Oxleyan pygmy perch than harm this species. Any impacts associated with infestation would be restricted in spatial scale and would not persist in the long term (see discussions in Table 3-11).
8) introduce disease that may cause the species to decline?	Impossible given that most diseases potentially affecting Oxleyan pygmy perch would be associated with contact with exotic fish and the project will not involve the translocation of exotic fish.
9) interfere with the recovery of the species?	Unlikely given that the study reaches features apparent sub-optimal Oxleyan pygmy perch habitat and impacts will be spatially and temporarily restricted. The bulk of the initiatives in the recovery plan for this species are research, monitoring and education focussed, with limited specific advice on habitat rehabilitation. To our knowledge, there have been no specific habitat rehabilitation efforts in Six Mile Creek targeting Oxleyan pygmy perch (probably due to the fact that no records of this species exist or this sub-catchment). Therefore, the Project will not interfere with the recovery plan initiatives.
10) Mitigation measures	As outlined in Table 3-10

3.7 EMP Activities

3.7.1 Sediment Mobilisation Impacts

Of the potential sediment mobilisation-related impacts, changes in pool depth have a greater potential to affect Mary Cod than any transient increase in turbidity. Unlike changes in turbidity, the likely spatial and temporal extent of changes in pool depth makes them less likely to be detectable using standard monitoring techniques such as State of the River reporting. Therefore, observational assessments (e.g. photographic records, site visits by the site engineer) are recommended to determine whether or not sediment mobilisation-related issues are being adequately dealt with by the nominated mitigation measures. The following indicators should be noted and adaptive management measures implemented (see Table 3-13). These relate to both the construction and operational phases with timeframes for assessment provided where appropriate. The proponent should commit to undertaking this monitoring for at least the timeframe period outlined here.

Table 3-13 Suggested measures for assessing and managing sediment mobilisation

Indicator	Action
Plume generated by the construction of the crossing exceed ANZECC (2000) guidelines beyond 100 m downstream of the crossing point.	Implement tighter control on sediment action management, including adding additional or improved sediment control barriers until turbid plume dispersion area is reduced to within 100 m
Visible runoff from the stockpiled excavated sediment into the waterway.	Move stockpiled sediment further away from the waterway and / or reconfigure bunds or drainage lines to better direct runoff into coffer dams.
Noticeable bank slumping at or immediately downstream of the crossing construction site	Improve bank stability based on engineering advice in accordance with best practice sediment management guidelines. Plant older seedlings to increase the rate of riparian vegetation re-establishment. Assess after large flow events for several years after construction.
Formation of sand bars downstream of the crossing and expansion of the area of these over time.	As above for bank slumping. Consideration of excavation of notable sediment build up downstream of crossings at the discretion of the site engineer and only if further environmental impacts are not likely to be incurred.
Build up of large woody debris against the	Monitor after large flow events for up to 5

Indicator	Action
pipeline (if the above bank full level crossing is used) and obvious bed or bank scouring on the downstream side.	years. Remove large woody debris lying against raised pipeline where required and assess the necessity and / or frequency of further maintenance based on observations.

3.7.2 Population assessment

A key limitation of this study is the paucity of primary data on whether or not Mary River cod, Oxleyan pygmy perch, honey blue-eye and lungfish occur in the study reach and their abundance and distribution should they occur in this reach. Therefore, further fish sampling is recommended prior to the construction phase to help confirm the assumptions made in this report and, if possible, provide some estimates of population size and condition for post-development comparison.

4 REFERENCES

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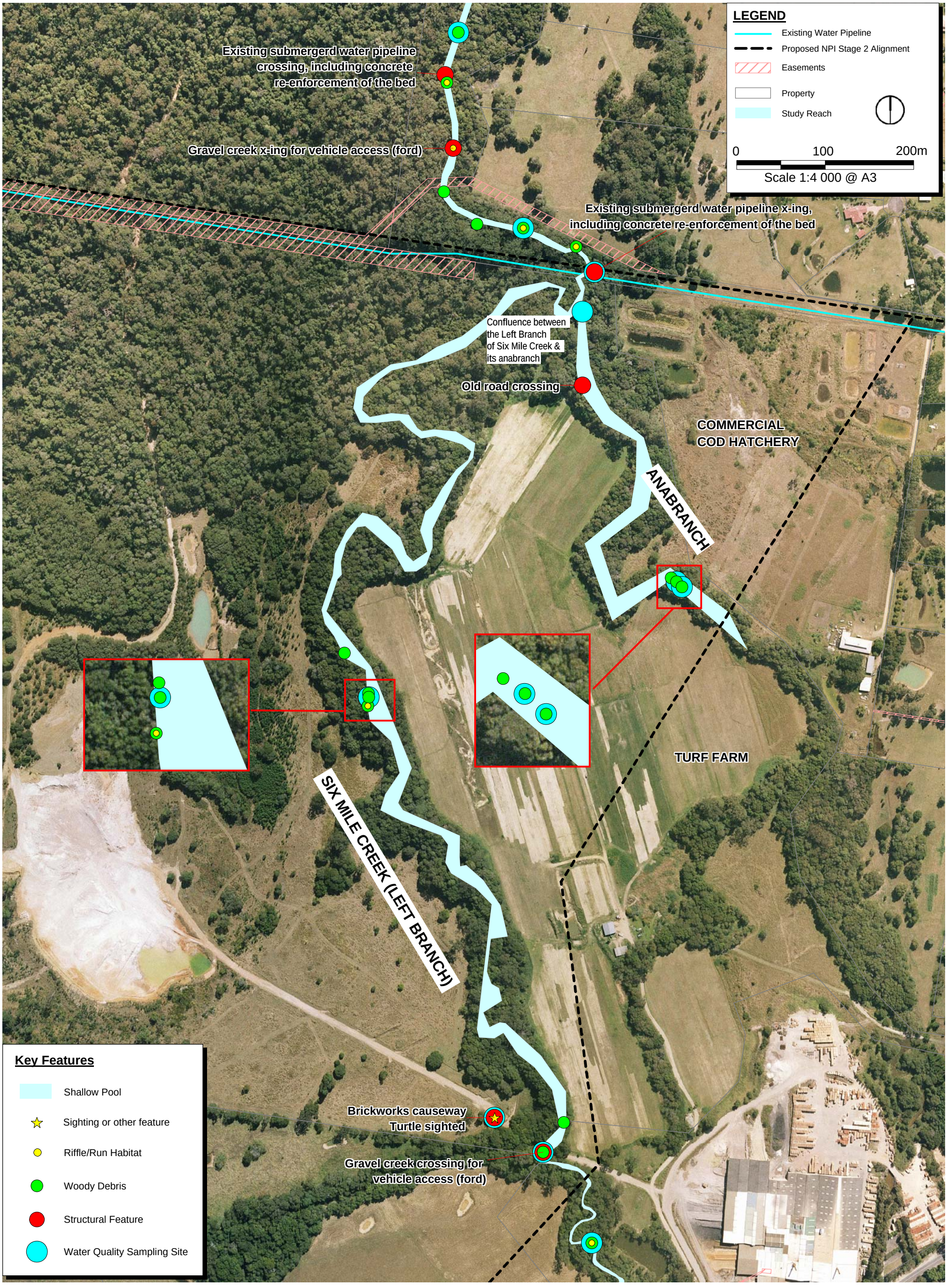
Appendix I – Habitat Survey Key Features



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Projection: *GDA94 (MGA56)*

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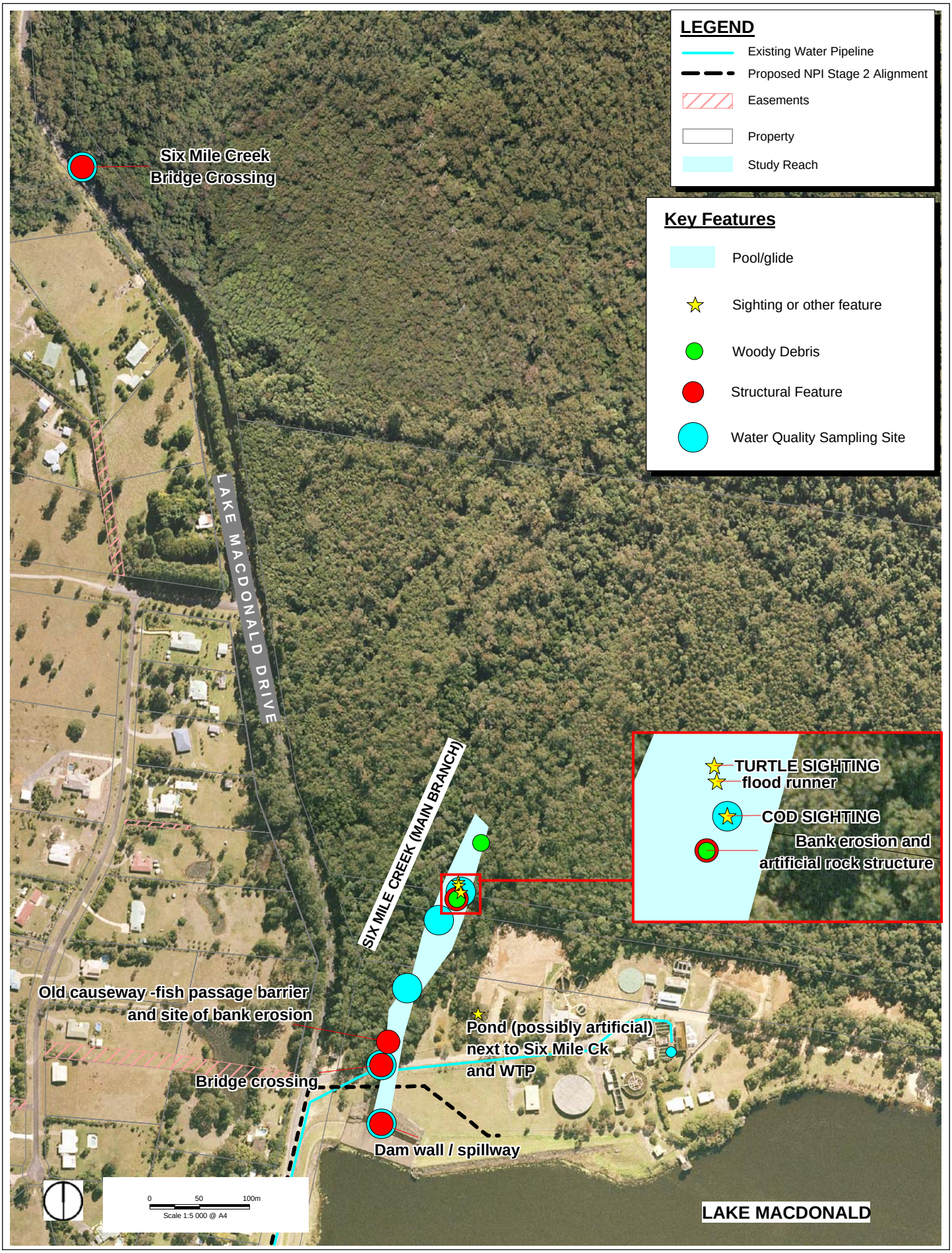
Date: *7 January 2007 (Prior to Rev C)*

northern pipeline inter connector

NORTHERN PIPELINE INTERCONNECTOR

Appendix I 1.1

SIX MILE CREEK LEFT BRANCH & ANABRANCH KEY FEATURES



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Projection: *GDA94 (MGA56)*

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Date: *8 January 2007 (Prior to Rev C)*

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NORTHERN PIPELINE INTERCONNECTOR

SIX MILE CREEK (MAIN BRANCH) KEY FEATURES

Appendix I 1.2

Appendix II –Spot Water Quality Readings

Water quality – Left Branch of Six Mile Creek

Spot readings of water quality taken during the site visits showed that the Left Branch of Six Mile Creek and its anabranch were slightly acidic and not influenced by saline groundwater seepage, as appears to occur in some of the other eastern tributaries (e.g. Coles and Skyring creeks - SKM, 2007). Water temperatures were relatively moderate for summer reflecting the influence of dense stream shading (except at site 4 where the storm damaged canopy and vegetation removal near the brick works causeway exposed the waterway to more direct sunlight).

Dissolved oxygen levels were generally low to moderate and below the Local Water Quality Objectives (EPA, 2006) for lowland, tannin-stained streams of the Mary River catchment (guideline values of 85%-110% saturation) during the low flow period in November. Low dissolved oxygen levels were also noted for other eastern tributaries of the Mary River during the Traveston Crossing Dam EIS survey (SKM, 2007). Dissolved oxygen levels were higher in the Left Arm of Six Mile Creek in December and were more consistent with the EPA (2006) guideline values at a time when flows were more elevated. .

Values for pH were within the ranges for ecosystem protection outlined in the Local Water Quality Objectives (EPA, 2006) for small, tannin-stained streams of the Mary River catchment (expected pH range = 6.0 and 8.0).

Turbidity was only measured during the site visit on the second site visit in December at a time when there was elevated flow and, consequently, sediment mobilisation. The limited available data indicate that even given these circumstances, turbidity levels were not uniformly above EPA (2006) guideline values for small tannin-stained streams (<25 ntu). This may be a reflection of the limited disturbance to the banks and riparian vegetation in this part of the study reach.

Spot water quality readings for the Left Branch of Six Mile Creek

		Anabranch							
Date	21/11/07	20/12/07	21/11/07	21/11/07	21/11/07	20/12/07	21/11/07	21/11/07	20/12/07
Site	1	1	2	3	4	4	5	6	1
Temp. (°C)	20.9	22.3	20.7	20.6	25.9	22.9	22.3	23.8	23.1
pH	6.35	6.75	6.39	6.26	6.38	6.55	6.42	6.41	6.86
Cond. (µS/ cm)	306	121	195.2	209	215	120	320	326	121
TDS (mg/L)	116.3	n/a	117	175	130	n/a	193	198	n/a
Turbidity (ntu)	n/a	17	n/a	n/a	n/a	30	n/a	n/a	17
Oxy. (mg/L)	2.32	10.14	1.73	2.64	4.63	9.72	1.75	3.24	10.19
Oxy. (%saturation)	26	118	19	30	58\	118	20	39	118

Water quality – main branch of Six Mile Creek

The main branch of Six Mile Creek was generally higher in temperature, pH and dissolved oxygen and lower in turbidity and conductivity than the Left Branch of Six Mile Creek and its anabranch. Turbidity and pH for this reach were within the EPA (2006) guidelines for lowland streams of the Mary River Basin, while dissolved oxygen levels were slightly above the EPA (2006) guideline values.

Spot water quality readings for the main branch of Six Mile Creek

Site	1	2	3	4	5	6
Temp. (°C)	27	26.6	26.4	26.5	26.4	25.5
pH	7.76	7.60	7.47	7.35	7.35	7.20
Cond. (µS/ cm)	194	56	77	79	79	77
Turbidity (ntu)	5	8	7	5	6	6
Oxy. (mg/L)	9.44	9.33	8.98	8.81	8.76	8.68
Oxy. (%saturation)	120	120	118	118	118	118