NSW Roads and Maritime Services

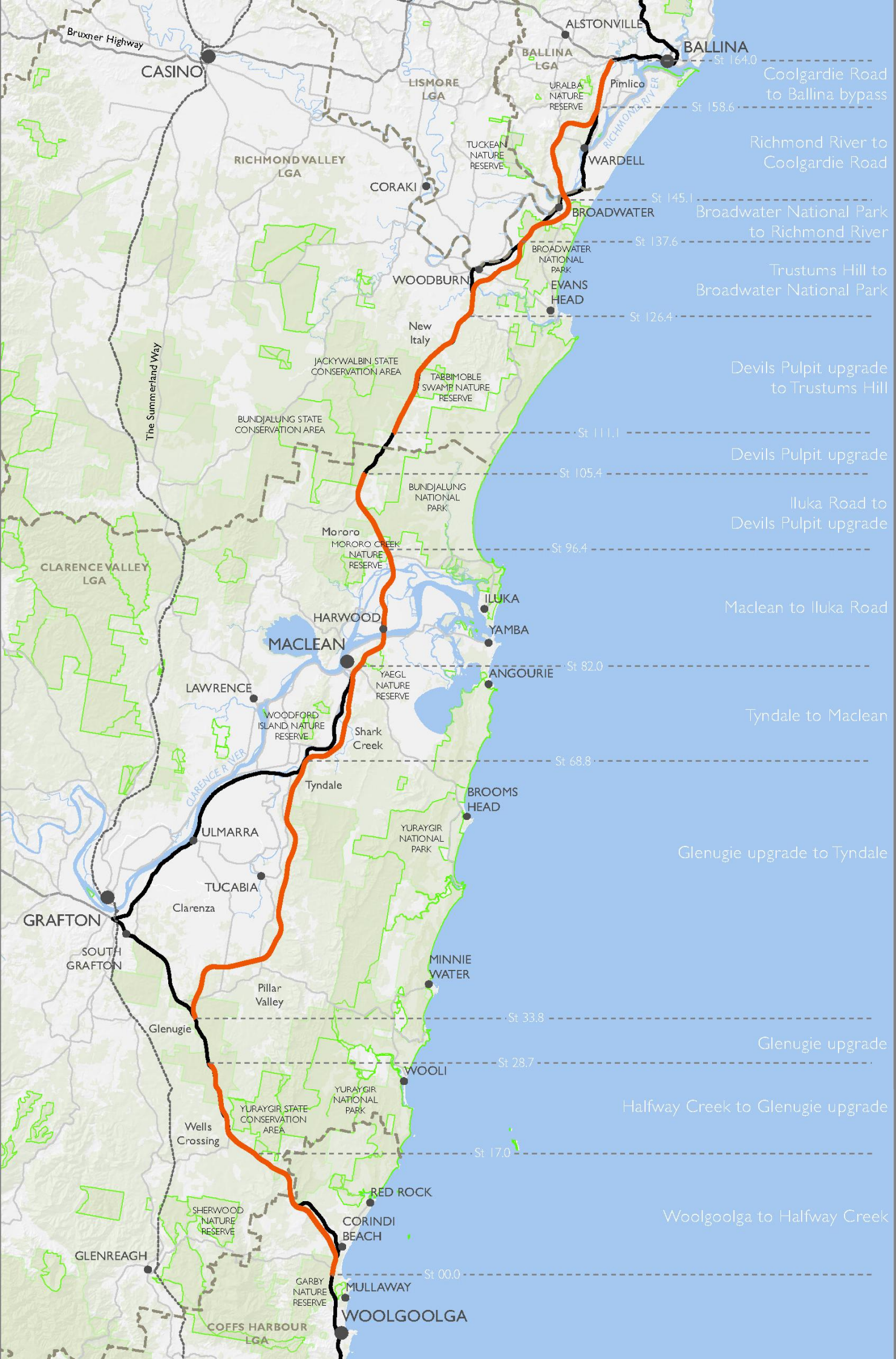
WOOLGOOLGA TO BALLINA | PACIFIC HIGHWAY UPGRADE

THREATENED FISH MANAGEMENT PLAN

Version 1.0

November 2013

Prepared by: NSW Roads and Maritime Services, Aurecon and Sinclair Knight Merz


Bruxner Highway
CASINO
ALSTONVILLE
BALLINA
BALLINA LGA
LISMORE LGA
URALBA NATURE RESERVE
Pimlico
RICHMOND RIVER
St 164.0
Coolgardie Road to Ballina bypass
11
St 158.6
Richmond River to Coolgardie Road
10
TUCKEAN NATURE RESERVE
WARDELL
RICHMOND VALLEY LGA
CORAKI
St 145.1
BROADWATER
Broadwater National Park to Richmond River
9
St 137.6
BROADWATER NATIONAL PARK
WOODBURN
EVANS HEAD
Trustums Hill to Broadwater National Park
8
St 126.4
New Italy
JACKYWALBIN STATE CONSERVATION AREA
TABBIMOBLE SWAMP NATURE RESERVE
Devils Pulpit upgrade to Trustums Hill
7
The Summerland Way
BUNDJALUNG STATE CONSERVATION AREA
St 111.1
Devils Pulpit upgrade
St 105.4
BUNDJALUNG NATIONAL PARK
Iluka Road to Devils Pulpit upgrade
6
Mororo
MORORO CREEK NATURE RESERVE
St 96.4
CLARENCE VALLEY LGA
ILUKA
HARWOOD
YAMBA
MACLEAN
Maclean to Iluka Road
5
ANGOURIE
St 82.0
YAEGL NATURE RESERVE
LAWRENCE
WOODFORD ISLAND NATURE RESERVE
Shark Creek
Tyndale to Maclean
4
St 68.8
CLARENCE RIVER
Tyndale
BROOMS HEAD
YURAYGIR NATIONAL PARK
ULMARRA
Glenugie upgrade to Tyndale
3
TUCABIA
Clarenza
GRAFTON
SOUTH GRAFTON
MINNIE WATER
Pillar Valley
St 33.8
Glenugie
Glenugie upgrade
St 28.7
WOOLI
YURAYGIR NATIONAL PARK
YURAYGIR STATE CONSERVATION AREA
Halfway Creek to Glenugie upgrade
2
Wells Crossing
St 17.0
RED ROCK
SHERWOOD NATURE RESERVE
CORINDI BEACH
Woolgoolga to Halfway Creek
1
GLENREAGH
St 00.0
GARBY NATURE RESERVE
MULLAWAY
WOOLGOOLGA
COFFS HARBOUR LGA

Contents

1. Introduction

1.1 Project overview

NSW Roads and Maritime Services (Roads and Maritime) is seeking approval for the Woolgoolga to Ballina Pacific Highway upgrade project (the project / the action), on the NSW North Coast. The approval is sought under Part 5.1 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) and the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The location of the project in the NSW North Coast region is shown in the figure above.

Since 1996, both the Australian and NSW governments have contributed funds to the upgrade of the 664-kilometre section of the Pacific Highway between Hexham and the Queensland border, as part of the Pacific Highway Upgrade Program.

Both governments have a shared commitment to finish upgrading the highway to a four-lane divided road as soon as possible. However, the actual timing of construction, opening to traffic and completion is dependent on funding negotiations between the Australian and NSW governments. Assessments would be adjusted accordingly based on actual opening dates, for example noise and traffic predictions.

The project would upgrade around 155 kilometres of highway and represents the last priority (known as 'Priority 3' in the upgrade program) in achieving a four-lane divided road between Hexham and the NSW/Queensland Border. The project therefore forms a major part of the overall upgrade program and when constructed, would complete the four-lane divided road program.

The project would be jointly funded by the NSW and Australian governments.

The project does not include the Pacific Highway upgrades at Glenugie and Devils Pulpit, which are located between Woolgoolga and Ballina. These are separate projects, with Glenugie now complete and Devils Pulpit under construction. Altogether, these three projects would upgrade 164 kilometres of the Pacific Highway. The project does include a partial upgrade of the existing dual carriageways at Halfway Creek.

A more detailed description of the Woolgoolga to Ballina Pacific Highway upgrade is found in the Pacific Highway upgrade: Woolgoolga to Ballina Environmental Impact Statement prepared by Roads and Maritime in December 2012.

1.2 Purpose and objectives

This plan addresses the potential and residual impacts of the project on Oxleyan Pygmy Perch (*Nannoperca oxleyana*) (listed as Endangered under the EPBC Act and NSW Fisheries Management Act 1994 (FM Act) and Purple Spotted Gudgeon (*Mogurnda adspersa*) (listed as Endangered under the FM Act) and potential habitat for these species. The Oxleyan Pygmy Perch has been confirmed within Sections 6, 7 and 8 of the project and there is potential for the Purple Spotted Gudgeon in Sections 1 to 3 and 6 to 10 of the project.

This plan identifies the proposed mitigation measures and monitoring program to be implemented for the Oxleyan Pygmy Perch and Purple Spotted Gudgeon. The plan has been developed in consultation with the NSW Office of Environment and Heritage (OEH), NSW Department of Primary Industries (Fisheries) and the Commonwealth Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC).

The objectives of the plan includes to:

- Provide a summary of the locations where these species would be impacted by the project.
- Describe the mitigation measures that would be implemented during construction and operation to eliminate or minimise risks to Oxleyan Pygmy Perch and the Purple Spotted Gudgeon populations and habitats.
- Describe the monitoring program that would be implemented during construction and operation of the project to assess the effectiveness of the specified management and mitigation measures.

- Outline an adaptive management framework based on specific goals for mitigation, appropriate monitoring of the performance of these measures against the goals and the identification and implementation of corrective actions to improve mitigation where required. Where shortfalls from the mitigation and adaptive management are identified appropriate provisional and offset measures would be implemented.

The plan identifies the general locations proposed for conducting monitoring events and the methods, variables and timing of the monitoring program. Details have been provided on the variables to be monitored in order to meet monitoring objectives. It was not possible to pre-select the monitoring sites at this point in the planning and design process, as this would require additional monitoring based on locations of suitable habitat. The final selection of monitoring sites would be subject to further interrogation following pre-construction surveys and would be presented in the first annual monitoring report with the intention of repeated sampling to be conducted at these locations.

1.3 Management structure and plan updates

Management structure

This species management plan provides a framework for any part of the proposed upgrade between Woolgoolga to Ballina. This plan would be updated during detailed design or pre-construction stage of any proposal that may affect threatened species relevant to this plan. The final management plan would be specific to the project section, stage, program of works or singular element of infrastructure which makes-up the overall Woolgoolga to Ballina upgrade. The plan would operate in conjunction with the Construction Environmental Management Plan (CEMP) and project specific flora and fauna management plan (FFMP), or may be incorporated into a wider framework that includes such plans.

Roads and Maritime would finalise this plan in consultation with the NSW Department of Planning and Infrastructure (DoPI) and other relevant agencies.

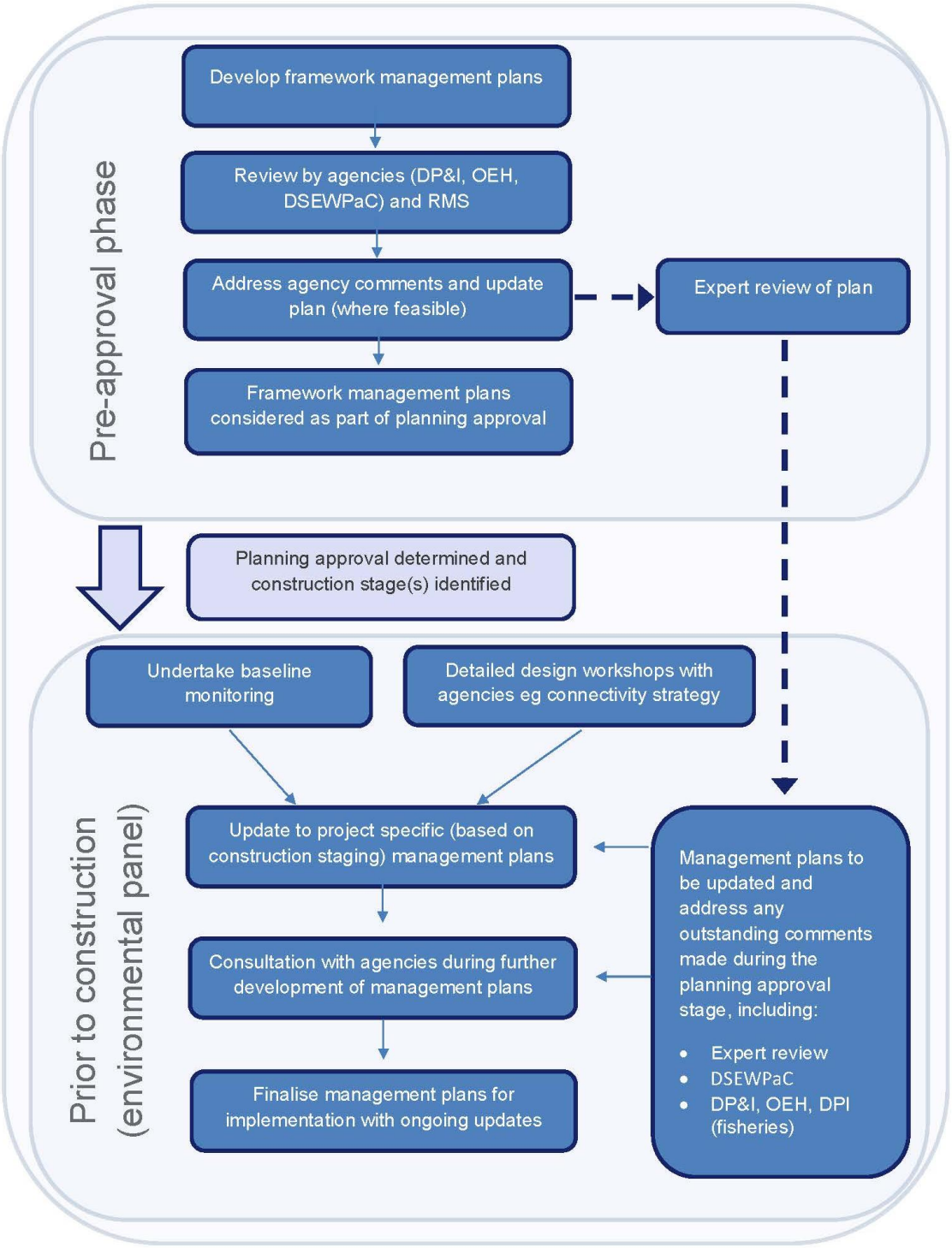
General responsibilities for environmental management would be outlined in the CEMP and FFMP. Responsibilities for implementation of this plan have been described throughout and summarised in Chapter 8. Following approval of the plan, the construction contractor and the contractors ecologist engaged for the relevant project sections would be responsible to oversee implementation of the plan.

Plan updates

The plan is intended to be a dynamic document subject to continual improvement. The management plan would be updated as required to meet the mitigation and management measures committed to in the EIS and PIR reports and any Condition of Approval (CoA) for the project. Prior to implementation, the plan would be updated following independent expert review to incorporate any necessary changes that arise from that review. The process for the update of the plan is illustrated in Figure 1-1 below.

This plan identifies the general locations proposed for conducting monitoring and the methods, variables and timing of the proposed monitoring program. Details have been provided on the parameters for the selection of the final monitoring sites, both impact and control sites. It is not possible to pre-select the monitoring sites at this point in the planning and design process, as this requires consultation with affected landowners. The final selection of monitoring sites would be subject to further interrogation through the implementation of targeted surveys (refer to section 5.3.1) and confirmation of landowner access and would be presented in the first annual monitoring report with the intention of repeated sampling to be conducted at these locations.

Figure 1-1 Process to develop management plan



1.4 Plan authors and expert review

Authors

This management plan has been prepared by personnel detailed in Table 1-1.

Table 1-1: Management plan authors

Personnel	Qualifications	Experience
Dr Andrew Sharpe, Senior Ecologist	PhD, BSc (Hons)	Andrew is an aquatic ecologist with a strong background in experimental design and in developing environmental monitoring programs. He has conducted fish surveys and water quality monitoring through SE Australian estuaries.
Sarah Douglass, Senior Aquatic Ecologist	MEnvMgt, BSc (EnvBio)	Sarah has extensive experience in assessing water quality and aquatic biota in streams throughout SE Australian and Northern Australia through. She is highly experienced at conducting fish surveys using a variety of methods including electrofishing, seine netting, gill netting, and bait trapping. Sarah is also experienced in the identification of fish and macroinvertebrates.
Kate Byrnes, Senior Environmental Scientist	BSc (Hons)	Kate has conducted and assisted in fish and macroinvertebrate surveys throughout eastern NSW using electrofishing, seine netting, gill netting and bait trapping methods. She has a strong background in water quality monitoring and analysis, particularly for large infrastructure projects.
Chris Thomson, Senior Ecologist	BAppSc, GradCertNatRes	Chris has seventeen years' experience in ecology and natural resource management. His strengths include ecological survey design and implementation, species identification, habitat evaluation and assessment, natural resource management and ecological impact assessment. He has comprehensive knowledge of environmental and threatened species legislation in Australia and has extensive experience combining land-use planning and conservation area management, including management of threatened flora and fauna species.

Expert review

An expert review of the plan was undertaken in August 2013 by Matthew Birch. Curriculum vitae for Matthew Birch is provided in Appendix A. Matt has a Bachelor of Science (Hons) and is currently undertaking a Doctor of Philosophy in Applied Aquatic Ecology at the University of New England. He has been working as a professional aquatic scientist for 10 years which includes 5 years in the northern rivers area

A copy of the review by Matthew Birch is provided as Appendix B, and the recommendations provided in this review have been summarised in **Table 1-1.** The table also identifies how each of the recommendations have been addressed. Recommendations have been addressed in one of three ways:

- Adopted - plan updated.
- Adopted - plan to be updated prior to implementation.
- To be reviewed - recommendation to be reviewed further by Roads and Maritime prior to implementation.

Table 1-2 Expert review recommendations

ID No	Section	Recommendation	How recommendation is to be addressed
TFiMP1	8.3	Analyses of nutrients (total nitrogen, oxides of nitrogen, ammonia, total phosphorus, orthophosphates) and a series of dissolved and total trace metals (particularly those that become more toxic at low pH, e.g. aluminium) should be included in water quality monitoring. All of these parameters, with the exception of oxides of nitrogen,	Adopted- plan updated

ID No	Section	Recommendation	How recommendation is to be addressed
		are included in the draft Devils Pulpit to Ballina monitoring protocol for locations that are considered potential habitats for threatened fish. The TSMP should be updated to reflect this.	
TFiMP2	8.3	Where captured water is to be released directly into known or potential OPP habitat, dissolved inorganic carbon and lime pollution should also be monitored. In addition, any pre-release water treatment measures with the potential to impact upon water quality with respect to OPP should also be included in the suite of water quality parameters monitored at these sites;	To be reviewed prior to implementation
TFiMP3	8.3.1	The definition of a heavy rainfall event is included in the TSMP with respect to water quality monitoring. The draft Devils Pulpit to Ballina monitoring protocol utilises a figure of 15mm over a 24hr period to define a wet weather sample. The TSMP should be updated to reflect this.	Adopted- plan updated
TFiMP4	8.2/8.3	Monitoring of stream flow and velocity should be undertaken under the same time frame as water quality monitoring at sites with known or potential habitat for OPP. The water quality monitoring plans for these sites should be amended to reflect this	Adopted- plan updated
TFiMP5	8.2.1	The protocol for selecting control sites should be reviewed and should include a hierarchy of principles. A suggested hierarchy would be: 1. Control site located >2km upstream of impact site; 2. Control site located >1km upstream of impact site; 3. Control site located >2km downstream of impact site; or 4. Control site located in a different drainage, >2km upstream of any other impact or control site.	To be reviewed prior to implementation
TFiMP6	5.2	The identification of presence or absence of suitable habitat and potential corridors between existing populations and/or areas of high quality habitat should be identified at this stage also and should be added to the list of goals under Section 5.2. Although it is clear in Section 5.3.1, the identification of baseline water quality and habitat conditions should also be added to the list of pre-construction goals listed in Section 5.2. It is understood that baseline water quality and habitat conditions are already being assessed.	To be reviewed prior to implementation
TFiMP7	6.2	Minimal change to riparian habitats should be included as a goal under Section 6.2 along with promoting awareness among the construction staff, all contactors and the general community.	Adopted- plan updated
TFiMP8	6.3.3	The reasons for listing the OPP spawning season as October to December (p24), when the peak periods are reported to be October-December and February-April (Knight *et al.* 2012, updated from Knight *et a*l. 2007a), should be clarified in the TSMP.	Adopted- plan updated
TFiMP9	6.2	Benthic material and riparian condition in the measures for no change in habitat, as they are important features of habitat for OPP.	Adopted- plan updated
TFiMP10	6 and 7	The TSMP should include reference to the thresholds identified during pre-construction monitoring in the goals set for construction and operational phases.	Adopted- plan updated
TFiMP11	6.3	It is a recommendation of this review that if no release of water into OPP habitat is planned then it should be made clear in the TSMP. If release of water into OPP habitat is to occur then it is important to ensure that: ▪ release of stored water into OPP habitat is undertaken only as a last resort; ▪ water released into OPP habitat is at a pH that matches the	Adopted- plan updated

ID No	Section	Recommendation	How recommendation is to be addressed
		mean pre-construction pH of the waterway (as established during baseline water quality monitoring) to within 1 pH point; ▪ any chemical treatments used prior to the release of water stored in sediment basins will not persist in the environment or negatively impact upon the environment after release. ▪ potential pre-release water treatments and/or their derivatives are included as parameters in baseline water quality monitoring.	
TFiMP12	6.2	The TSMP should acknowledge that populations of *Gambusia holbrooki* are likely to fluctuate in response to stochastic factors and that changes to the in-stream habitat at crossing sites are very likely, particularly with respect to submerged and emergent vegetation.	Adopted- plan updated
TFiMP13	Tables 5-1, 6-1 and 7-1	Tables 5-1, 6-1 and 7-1. Where possible the stated corrective actions should be given time frames for their implementation. Post construction objectives, measures and thresholds should also be given time frames for their implementation.	To be reviewed prior to implementation
TFiMP14	Table 7-1	Water quality and flow/velocity objectives for the post construction phase should also be measured over a set number of rainfall events;	To be reviewed prior to implementation
TFiMP15	6	Indirect impacts upon known OPP populations outside of the construction corridor should be considered in addition to the potential impacts of acid sulphate soil disturbance on OPP.	Adopted- plan updated

Targeted surveys for Oxleyan Pygmy Perch and Purple Spotted Gudgeon were undertaken in September 2012 and May/June 2013 in Sections 1 and 2 as part of the detailed design. During both of these surveys, neither species were found (GeoLink 2012, Aquatic Science and Management 2013).

2.2.2 Breeding and feeding

Oxleyan Pygmy Perch breed between October and May, although spawning generally takes place between October and December when water temperatures exceed 20 °C. They scatter their eggs over sandy substrates or aquatic vegetation and developing larvae feed on rotifers and protozoans.

Oxleyan Pygmy Perch do not require high flows to trigger spawning, but are thought to disperse widely during floods or high flows. The prevalence of Oxleyan Pygmy Perch on within the study area may be attributed to intermittent connection between waterbodies during high rainfall or flooding events (emanating from the Richmond and Clarence Rivers). These could facilitate dispersal, thereby allowing the species to colonise new systems and/or recolonise previously disturbed areas (Knight et al 2009).This dispersal behaviour means that local distribution patterns can change substantially after heavy rainfall or floods, with relatively large number of individuals potentially colonising wetlands, lakes or streams that may have previously been dry.

Adult Oxleyan Pygmy Perch feed on copepods, cladocerans, caridinians, aquatic insects (especially chironomid larvae) diatoms, filamentous algae and some terrestrial insects.

2.2.3 Habitat requirements

Oxleyan Pygmy Perch only occurs in small coastal streams, swamps, streams and dune lakes that lie in the coastal lowland 'wallum' ecosystems with little or no flow (Arthington 1996; Pusey et al. 2004; Knight & Arthington 2008). The species is restricted to aquatic habitats with suitable physicochemical water quality conditions, specifically acidic waters (pH 3.3 – 6.9) with low conductivity (90 to 830µS/cm). Waters can either be clear or tannin stained. Previous studies (Knight & Arthington 2008) have correlated the presence of Oxleyan Pygmy Perch with an abundance of structural microhabitat in the form of dense aquatic vegetation and/or steep undercut banks fringed with woody debris root overhang from riparian vegetation. It can tolerate water temperatures in the range 12-28 °C. They require relatively clean siliceous sand substrates with some plant debris and dense stands of emergent or submerged vegetation (McDowall, 1996). They are often found in dense stands of the sedge *Eleocharis ochrostachys* as well as *Baumea articulata, Sphagnum falcatulum, Philydrum lanuginosum, Lepironia articulata* and *Restio pallens.*

2.3 Key threats

The key threats to Oxleyan Pygmy Perch relate to habitat loss or degradation, water pollution, competition and predation pressure from introduced species such as Eastern Gambusia (*Plague Minnow*), changes to hydrological regimes and instream barriers that restrict movement. Potential impacts associated with the Pacific Highway Upgrade project are described in more detail in Section 4.1.

2.3.1 Disturbance to stream habitat

Oxleyan Pygmy Perch rely on dense stands of submerged or emergent vegetation, undercut banks and submerged logs to provide cover from predators and to protect them from higher velocity flows. They also require clean sand substrates for egg development. Any activities that disturb the stream bed or stream bank, that remove stands of emergent or submerged vegetation or that remove submerged wood and rocks have the potential to reduce the quality and quantity of available habitat. Individual fish within the disturbed area may die as a result of trauma, stress or a lack of suitable food. Any reduction in cover is also likely to make individual fish more vulnerable to predators. Fish that are not killed may disperse to unimpacted areas, where they may experience competition from established members of the same species or other fish. Fish that remain in substantially disturbed areas may have reduced breeding success because the substrate is less conducive to egg development or there is unsuitable habitat and food for developing larvae.

2. Oxleyan Pygmy Perch populations

2.1 Background

The Oxleyan Pygmy Perch (Nannoperca oxleyana) is listed as endangered *under NSW Fisheries Management Act* 1994 *(*FM Act) and EPBC Act. The Oxleyan Pygmy Perch are listed as threatened because of their limited distribution, rarity, dependence on specific habitat characteristics and their vulnerability to threatening processes.

The Oxleyan Pygmy Perch appear to be only found in swamps, streams and dune lakes that lie in the lowland, coast 'wallum' heaths that are located on the north eastern coast of NSW (as far north to south-eastern Queensland). Their specific habitat requirements include fresh, acidic waters with abundant aquatic vegetation. Whilst their distribution is patchy, numerous locations with the project present the characteristics for potential habitat. The construction and operation of the project presents a key threatening process that could result in habitat disturbance, erosion, siltation and water quality decline. As such this management plan identifies the management and monitoring actions to be undertaken to enable the long-term survival of these species.

Figure 2-1 and Figure 2-2 show the Oxleyan Pygmy Perch records, critical habitat and connectivity structures.

2.2 Existing knowledge

2.2.1 Distribution

Previous surveys have confirmed the presence of Oxleyan Pygmy Perch (Nannoperca oxleyana) within Sections 6, 7 and 8 of the project at the following locations:

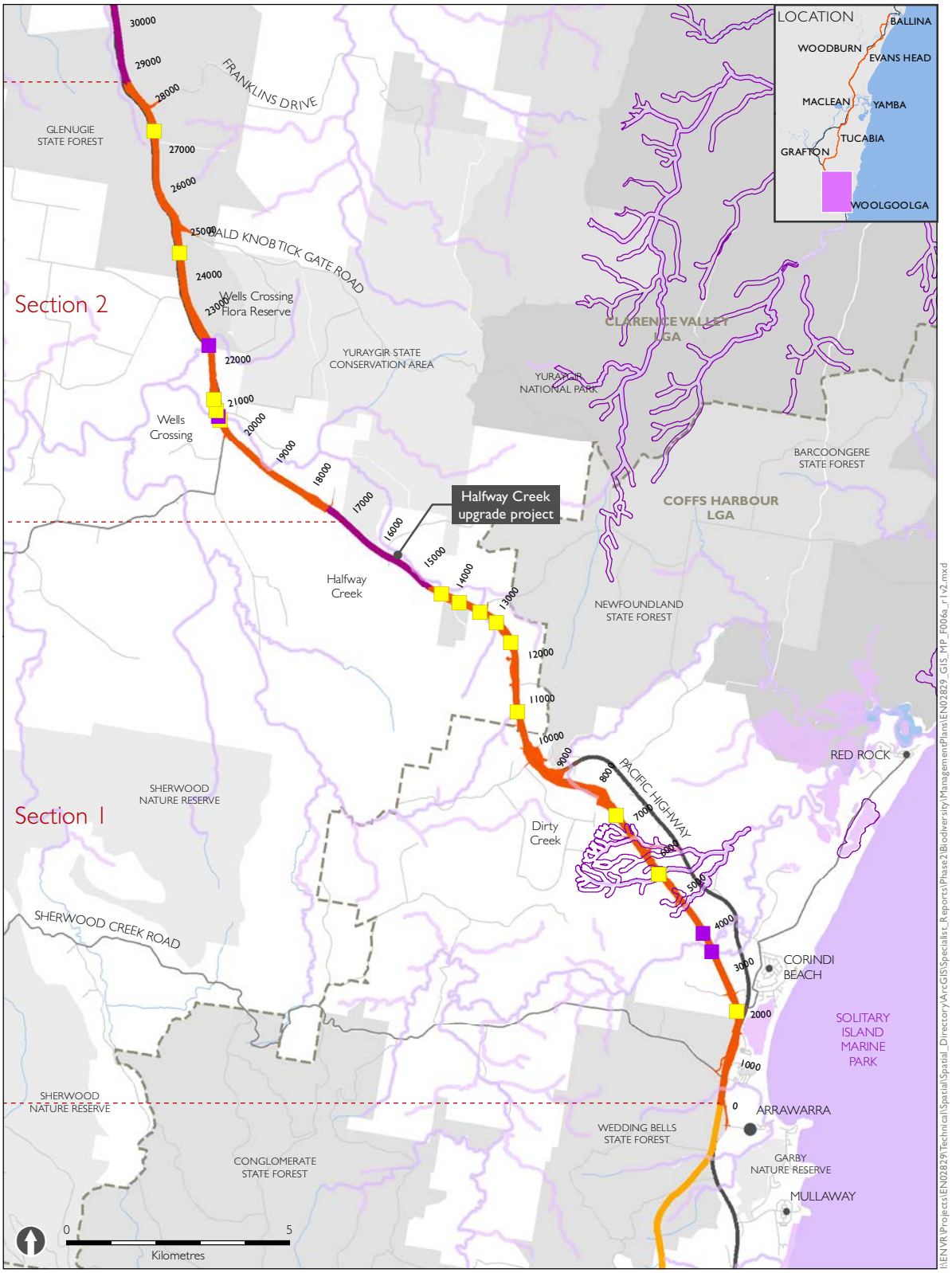
- Section 6: Small dam adjacent to Tabbimoble Floodway 2.
- Section 6: Tabbimoble Floodway (1.2km downstream of confluence of Floodway 2 and 3).
- Section 8: Broadwater National Park/McDonalds Creek.
- Section 8: Unnamed watercourse at station 134.700 near Lang Hill.
- Section 7:Unnamed watercourse at station 114.000 in Tabbimoble State Forest.

Other potential habitat for Oxleyan Pygmy Perch are restricted to aquatic habitats with suitable physicochemical water quality conditions and the presence of suitable microhabitat (aquatic vegetation and overhanging riparian root vegetation). As such, potential habitats which meet Oxleyan Pygmy Perch requirements would be restricted to the following locations within the project:

- Section 1: Dirty Creek, Arrawarra Gully and Cassons Creek.
- Section 3: Low lying swamps and wallum creek of the Coldstream River, south of Tucabia, Pillar Valley Creek and Black Snake Creek.
- Section 6: Tabbimoble Floodway 2 and 3, Bundjalung National Park (around seven kilometres downstream of project boundary), ephemeral streams in region.
- Section 6: Tabbimoble Creek, Mororo Creek.
- Section 7: Oakey Creek, Nortons Gully, Tuckombil Canal, Rocky Mouth Creek and many unnamed ephemeral streams.
- Section 8: Broadwater National Park, McDonalds Creek and vicinity of Rileys Hill and Lang Hill.
- Section 9: Tuckean Broadwater, Montis Gully and Eversons Creek.
- Section 10: North of Laws Road on east side of the existing highway.

Aquatic habitats outside these locations generally represent unfavourable conditions to support Oxleyan Pygmy Perch.

Figure 2-1 Oxleyan Pygmy Perch records, critical habitat and connectivity structures



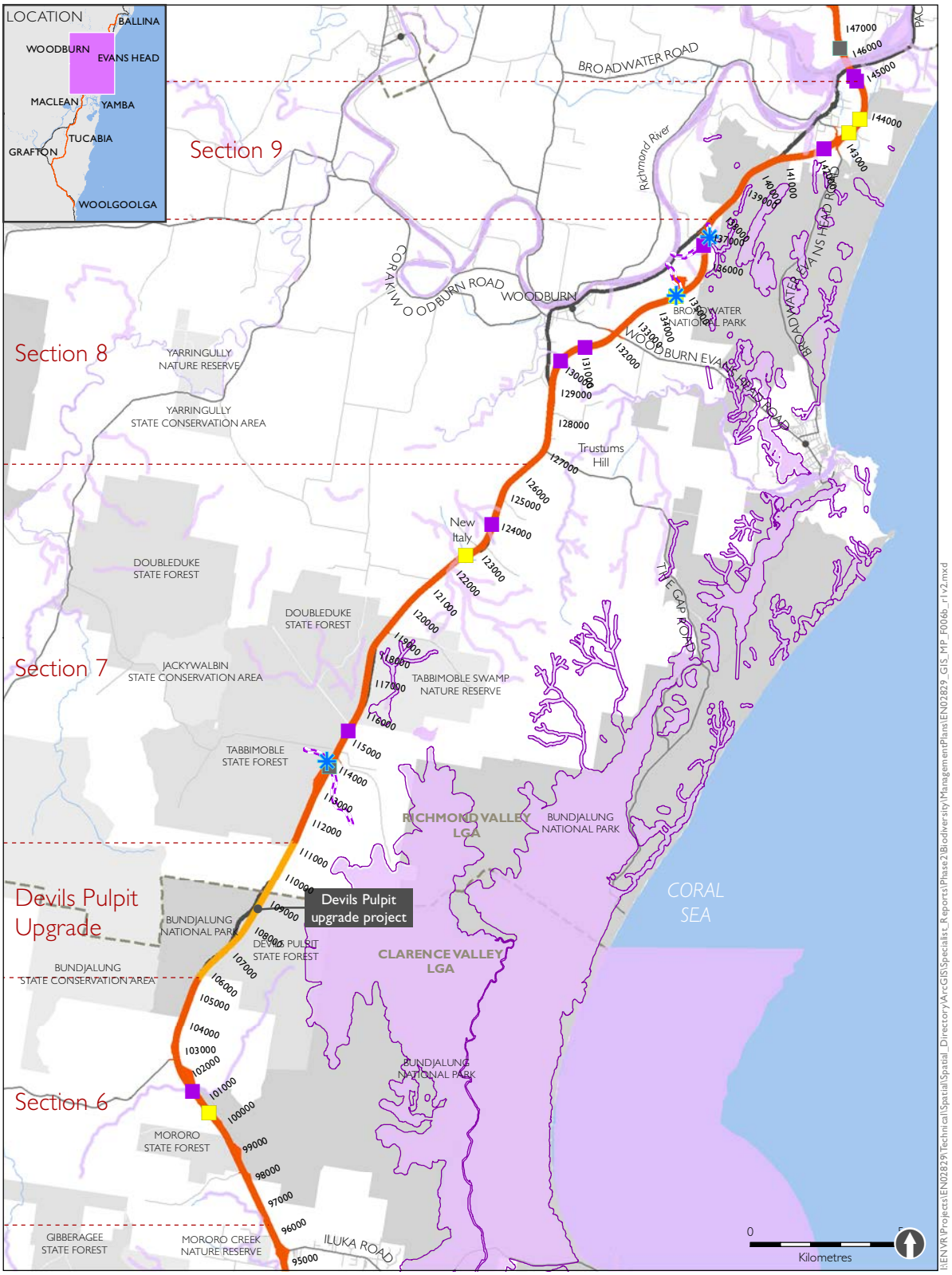
The project
Upgrade completed to dual carriageway
Upgrade under construction
Existing Pacific Highway

Oxleyan Pygmy Perch habitat (NSW DPI)
Key fish habitat (NSW DPI)

Fauna connectivity structures

Combined (bridge)
Combined (*Oxleyan Pygmy Perch*)
Combined (culvert)

Figure 2-2 Oxleyan Pygmy Perch records, critical habitat and connectivity structures



Fish in the immediate vicinity of any disturbance would be most affected. Unmitigated disturbances have the potential to fragment populations and disturbances that are widespread may substantially reduce local populations of Oxleyan Pygmy Perch.

2.3.2 Reduced water quality due to run-off from construction sites or new roads

Oxleyan Pygmy Perch require well oxygenated, mildly acidic water with low salinity and low levels of suspended sediment. Run-off from construction sites has the potential to severely affect water quality and acidity in receiving waterways. Specific impacts include lime pollution from concrete preparation areas that would make receiving waters more alkaline, and therefore potentially unsuitable for Oxleyan Pygmy Perch.

The introduction of sediment from construction sites is likely to adversely affect Oxleyan Pygmy Perch in several ways. First, fine sediment could smother the sand substrate, which would either suffocate any developing eggs that are already attached to the substrate or prevent eggs from successfully settling on the substrate. Second, suspended sediment can reduce light penetration, which in turn would reduce the growth of aquatic plants that Oxleyan Pygmy Perch rely on for cover. Third, fine sediment may coat hard surfaces that normally support biofilm production. Those biofilms are an important food source for macroinvertebrates, which are in turn an important food source for Oxleyan Pygmy Perch.

Chemical or fuel spills from construction activities and petrochemical run-off from the road when it is operational may have a toxic effect on Oxleyan Pygmy Perch in any receiving waters.

Organic material from mulch leaching into waterways can reduce visual clarity and contribute to the chemical imbalance of water so that it may impact on the Oxleyan Pygmy Perch. Leachate and tannins entering waterways can reduce visual clarity of the receiving waters and release other pollutants such as polyphenols volatile fatty acids, lignin and tannins into the waters that may reduce dissolved oxygen levels resulting in blackwater events that can have both lethal and sub-lethal effects on biota.

Discharges of turbid and highly alkaline wastewater are potential impacts associated with concrete batching plants. This can result in water quality unsuitable for the Oxleyan Pygmy Perch due to increased pH. The increased turbidity can also clog fish gills.

2.3.3 Increased pressure from exotic species such as Eastern Gambusia

Oxleyan Pygmy Perch are susceptible to predation and competition from introduced Eastern Gambusia (Plague Minnow). Gambusia are a similar size to Oxleyan Pygmy Perch. They also live in similar habitats and share similar diets. Gambusia form large schools and aggressively defend their territories by ‘fin-nipping’ other species such as Oxleyan Pygmy Perch. Such behaviour can exclude Oxleyan Pygmy Perch and other small-bodied native fish from their preferred habitat.

Eastern Gambusia are able to tolerate a wider range of habitat conditions than many native fish and they are often abundant at sites that have been physically disturbed or that have degraded water quality. Eastern Gambusia are present in most waterways throughout the study area. However, they are not sufficiently abundant to exclude Oxleyan Pygmy Perch from high quality habitats. Substantail disturbance to any Class 1 or Class 2 waterways in the project would be likely to favour Eastern Gambusia and increase pressure on Oxleyan Pygmy Perch populations.

2.3.4 Hydrological changes and barriers to movement

Oxleyan Pygmy Perch can disperse large distances during high flow or flood events that connect habitats that would normally be isolated at low flows. This strategy is likely to be important for maintaining populations because it allows individuals to colonise wetlands, lakes or streams that have previously dried and other habitats where other pressures such as predation or physical disturbance have led to local population declines.

Oxleyan Pygmy Perch are not strong swimmers and have a preference for low flow conditions <0.3 m/s (Knight 2000). NSW Fisheries have indicated that flow conditions >0.4m/s would not be considered acceptable as Oxleyan Pygmy Perch have been shown to have an upper limit of velocity at 0.4m/s. During flood events in natural stream channels they seek refuge from high velocity flows in stands of submerged or emergent vegetation, or move to the shallow, slow-flowing margins of floodwaters that break out of the main stream channel. However, floods or other high flow events are also thought to play an important role for the species as temporary watercourses of overflows are thought to carry the species between otherwise isolated bodies of water, although the safe limits for Oxleyan Pygmy Perch during flood times is not known. Hydrological changes that alter the frequency, timing or duration of high flow or flood events may affect the ability of Oxleyan Pygmy Perch to disperse and could lead to substantial population declines. Similarly hydrological changes, such as increased velocity of run-off from impervious surfaces following high flow events may make existing habitats unsuitable for Oxleyan Pygmy Perch.

Culverts, bridges and other infrastructure that is used to cross natural waterways if not designed appropriately can impede fish movement in several ways by:

- Constricting the natural flow path and increase flow velocity in the main stream channel to a level that prevents the upstream movement of Oxleyan Pygmy Perch.
- Preventing floodwaters from breaking out onto the adjacent floodplain. Although this effect is likely to be restricted to the floodplain in the immediate vicinity of the structure, it may be sufficient to prevent Oxleyan Pygmy Perch from moving past the barrier in either direction and could therefore fragment populations that would have naturally been connected during floods.
- Erosion downstream of the structures can lower the natural streambed relative to the floor of the structure and may create a vertical drop that Oxleyan Pygmy Perch cannot negotiate.
- Reducing aquatic vegetation in the section of stream that runs through or underneath these structures. This is because the plants have been physically removed as part of the construction or installation and/or because shading by the structure prevents plants from growing. This lack of physical habitat and cover and the lack of natural daylight may deter Oxleyan Pygmy Perch from moving through these structures or may make them more susceptible to predators as they move through them.

Any barriers to movement or migration would be likely to limit the extent to which Oxleyan Pygmy Perch can disperse throughout their range. As a result the population could become fragmented and susceptible to local depletion or extinction.

3. Purple Spotted Gudgeon populations

3.1 Background

The Purple Spotted Gudgeon (*Mogurnda adspersa*) is listed as an endangered species in NSW under the *Fisheries Management Act 1994* (FM Act). Historically, two populations, the eastern and western population occurred in NSW. The Eastern Population was found in coastal catchment north of the Clarence River and the western population was patchily distributed in the Murray-Darling Basin. It is the Eastern Population that is considered in this management plan.

The construction and operation of the upgraded highway could result in habitat degradation (particularly the loss of aquatic plants), fluctuations in water levels and predation by exotic fish such as Eastern Gambusia, all of which are key threats to this species. As such this management plan identifies the management and monitoring actions to be undertaken to enable the long-term survival of the Purple Spotted Gudgeon.

3.2 Existing knowledge

3.2.1 Distribution

Populations of the Purple Spotted Gudgeon occur in inland drainages of the Murray-Darling Basin and coastal drainage systems of the east coast from Cape York Peninsula south to the Clarence River.

Purple Spotted Gudgeon have not been recorded within the project area, from targeted surveys; however, there are a number of waterways within the project area which have suitable habitats population. Potential habitats which meet may support Purple Spotted Gugeon requirements would be restricted to the following locations within the project:

- Section 1: Dundoo Creek and Boneys Creek.
- Section 2: Halfway Creek and Glenugie Creek.
- Section 3: Low lying swamps and wallum creek of the Coldstream River, south of Tucabia, Pillar Valley Creek and Black Snake Creek.
- Section 6: Tabbimoble Floodway 2 and 3, Bundjalung National Park (around seven kilometres downstream of project boundary), ephemeral streams in region.
- Section 6: Tabbimoble Creek, Mororo Creek.
- Section 7: Oakey Creek, Nortons Gully, Tuckombil Canal, Rocky Mouth Creek and many unnamed ephemeral streams.
- Section 8: Broadwater National Park, McDonalds Creek and vicinity of Rileys Hill and Lang Hill.
- Section 9: Tuckean Broadwater, Montis Gully and Eversons Creek.
- Section 10: North of Laws Road on east side of the existing highway.

Targeted surveys for Oxleyan Pygmy Perch and Purple Spotted Gudgeon were undertaken in September 2012 and May/June 2013 in Sections 1 and 2 as part of the detailed design. During both of these surveys, neither species were found (GeoLink 2012, Aquatic Science and Management 2013).

3.2.2 Breeding and feeding

Purple Spotted Gudgeon breed between December and February, when water temperatures is between 20°C and 34 °C and food is abundant (McDowall, 1996, NSW DPI, 2013). Spawning is not triggered by high flows or floods. Females produce adhesive eggs that they attach to hard substrates such as submerged rocks, wood or broad leafed aquatic plants (McDowall, 1996, NSW DPI, 2013). Males guard and fan the eggs until they hatch.

Adult Purple Spotted Gudgeon feed on worms, Eastern Gambusia, dragonfly larvae, chironomid and mosquito larvae.

3.2.3 Habitat requirements

Purple Spotted Gudgeon occur in isolated parts of the Murray, Murrumbidgee and Lachlan Rivers, as well as some tributaries of the Darling River in NSW and coastal streams in Northern NSW (i.e. north of the Clarence River) and Queensland (McDowall, 1996, NSW DPI, 2013). It prefers still or slow flowing water with abundant aquatic vegetation and submerged rocks and wood. It requires good water quality with pH between 5 and 8, conductivity of 72 to 4,295µS/cm, dissolved oxygen between 0.6 and 12.8mg/L and low turbidity.

3.3 Key threats

The key threats to Purple Spotted Gudgeon relate to habitat loss or degradation (especially the loss of aquatic plants), water pollution and fluctuating water levels due to river regulation (McDowall, 1996, NSW DPI, 2013). Introduced species also represent a substantial threat and it has been suggested that the introduction and expansion of Eastern Gambusia (Plague Minnow), which occupies similar habitat, has contributed to the decline of Purple Spotted Gudgeon. Eastern Gambusia compete with and prey on larval and juvenile Purple Spotted Gudgeon and Redfin prey on adults. Potential impacts associated with the Pacific Highway Upgrade project are described in more detail in Section 3.4.

3.3.1 Disturbance to stream habitat

Purple Spotted Gudgeon rely on dense stands of submerged or emergent vegetation, undercut banks and submerged logs to provide cover from predators and to protect them from higher velocity flows. They also require hard substrates such as submerged rocks, logs and broad-leafed aquatic plants to lay their eggs. Any activities that disturb the stream bed or stream bank, that remove stands of emergent or submerged vegetation or that remove submerged wood and rocks have the potential to reduce the quality and quantity of available habitat. Individual fish within the disturbed area may die as a result of trauma, stress or a lack of suitable food. Any reduction in cover is also likely to make individual fish more vulnerable to predators. Fish that are not killed may disperse to unimpacted areas, where they may experience competition from established members of the same species or other fish. Fish that remain in disturbed areas may have reduced breeding success because the substrate is less conducive to egg development or there is unsuitable habitat and food for developing larvae.

Fish in the immediate vicinity of any disturbance would be most affected. However, disturbances have the potential to fragment populations and disturbances that are widespread may reduce any local populations of Purple Spotted Gudgeon if they are present.

3.3.2 Reduced water quality due to run-off from construction sites or new roads

Purple Spotted Gudgeon require well oxygenated water with low salinity a low levels of suspended sediment. Run-off from construction sites has the potential to severely affect water quality in receiving waterways in several ways.

The introduction of sediment from construction sites is likely to have the greatest effect on Purple Spotted Gudgeon by smothering eggs or substrates where eggs could be laid. Suspended sediment in the water column can also reduce light penetration, which in turn would reduce the growth of aquatic plants that Purple Spotted Gudgeon rely on for cover, and would reduce the abundance of diatoms and other biofilms that are an important food source for macroinvertebrates, which are in turn an important food source for Purple Spotted Gudgeon.

Chemical or fuel spills from construction activities and petrochemical run-off from the road when it is operational may have a toxic effect on Purple Spotted Gudgeon in any receiving waters.

Organic material from mulch leaching into waterways alter/reduce the quality of water so that it may impact on the Purple Spotted Gudgeon. Leachate can affect the pH balance and visual clarity of the receiving waters and release other pollutants such as polyphenols volatile fatty acids, lignin and tannins into the waters that may reduce dissolved oxygen levels and have both lethal and sub-lethal effects on biota.

Discharges of turbid and highly alkaline wastewater are potential impacts associated with concrete batching plants. This can result in water quality unsuitable for the Purple Spotted Gudgeon due to increased pH. The increased turbidity can also clog fish gills.

3.3.3 Increased pressure from exotic species such as Eastern Gambusia

Purple Spotted Gudgeon are susceptible to predation and competition from introduced Eastern Gambusia (Plague Minnow). Eastern Gambusia occupy the same habitat as Purple Spotted Gudgeon and the expansion of Eastern Gambusia throughout NSW coincided with a decline in Purple Spotted Gudgeon (McDowall, 1996). Gambusia form large schools and aggressively defend their territories by 'fin-nipping' other species such as Purple Spotted Gudgeon, which can lead to death or a loss of condition. Eastern Gambusia also prey on Purple Spotted Gudgeon larvae and small juveniles.

Eastern Gambusia are able to tolerate a wider range of habitat conditions than many native fish and they are often abundant at sites that have been physically disturbed or that have degraded water quality. Eastern Gambusia are present in most waterways throughout the study area. However, they are not sufficiently abundant to exclude Purple Spotted Gudgeon from high quality habitats. Substantial disturbance to any Class 1 or Class 2 waterways in the project would be likely to favour Eastern Gambusia and therefore increase pressure on populations of Purple Spotted Gudgeon.

3.3.4 Barriers to movement

Purple Spotted Gudgeon do not migrate large distances, but they would be likely to move short distances (several hundred metres) to locate suitable habitat and avoid predators. They are not strong swimmers, and cannot tolerate flow speeds greater than 0.2-0.4 m/s. During flood events in natural stream channels they seek refuge from high velocity flows in stands of submerged or emergent vegetation, or move to the shallow, slow-flowing margins of floodwaters that break out of the main stream channel.

Culverts, bridges and other infrastructure that are used to cross natural waterways if not designed appropriately can impede fish movement or decrease habitat suitability in several ways by:

- Constricting the natural flow path and increase flow velocity in the main stream channel to a level that Purple Spotted Gudgeon cannot tolerate or that Purple Spotted Gudgeon from moving upstream through the structure to access other habitats.
- Preventing floodwaters from breaking out onto the adjacent floodplain, which may cut off a potential flow refuge for the Purple Spotted Gudgeon.
- Erosion downstream of the structures can lower the natural streambed relative to the floor of the structure and may create a vertical drop that Purple Spotted Gudgeon cannot negotiate.
- Reducing aquatic vegetation in the section of stream that runs through or underneath these structures. This is because the plants have been physically removed as part of the construction or installation and/or because shading by the structure prevents plants from growing. This lack of physical habitat and cover and the lack of natural daylight may deter Purple Spotted Gudgeon from moving through these structures or may make them more susceptible to predators as they move through them.

Any barriers to movement would be likely to limit the extent to which Purple Spotted Gudgeon can disperse throughout their range. As a result the population would be likely to become fragmented and susceptible to local depletion or extinction.

3.3.5 Hydrological changes

As described above, Purple Spotted Gudgeon favour still or slow flowing environments with stable water levels. They cannot tolerate flow velocities greater than 0.2-0.4 m/s. The construction of large impervious surfaces such as roads can create substantial run-off during heavy rainfall. If that run-off has been conveyed directly to natural waterways it would be likely to increase the frequency of events that have high velocities greater than 0.4 m/s and may therefore make habitats unsuitable for Purple Spotted Gudgeon.

4. Potentials impacts and management approach

The following chapter provides a brief overview of the potential impacts to Oxleyan Pygmy Perch and Purple Spotted Gudgeon with reference to the more detailed impact assessment presented in the EIS Biodiversity Working Paper and in the previous two chapters. It describes the potential impacts to the species at specific locations along the upgrade and during the pre-construction, construction and post-construction (operational) stages of the project. The mitigation approach presented in the EIS and documented in Chapters 5-7 of the management plan target the predicted impacts.

4.1 Potential impacts associated with the project

The construction and operation of the project has the potential to impact aquatic ecosystems due to changes in existing hydrological conditions, changes in water quality, habitat loss and in-stream barriers. A number of ecological assessments have been undertaken in order to inform planning decision around avoiding and minimising impacts on the project.

In general the types of impacts that would be likely to occur during the construction and operation of the project have been summarised below and in Chapters 5-7. These include:

- Loss of riparian and aquatic habitat, including food resources, shelter and refuge areas during non-breeding and breeding life-cycle events.
- Fragmentation of aquatic habitat.
- Changes to water quality as a result of works in or adjacent to aquatic habitats and alterations to natural hydrological flows.
- Invasion and spread of aquatic weeds and pest species.
- Potential spread of disease pathogens.

Loss of habitat, fragmentation and barrier to movements

Construction activity around watercourse can results in the loss of aquatic habitat associated with the removal of woody snags, changes to in-stream substrate and loss of aquatic plants. Construction of waterway crossings would also result in temporary localised disturbance and potential loss of riparian habitat at either the crossing location, or in locations where the road runs closely parallel to the riparian habitats. Construction works in close proximity to waterways can potentially impact on bank stability and water quality through excavation, clearing or placement of construction stockpiles, and scouring.

The removal of large woody debris or snags is listed under Schedule 6 of the FM Act as a key threatening process. Woody debris plays an important role in freshwater and marine ecosystems by providing essential habitat for aquatic organisms, providing a refuge from predation and a resting place away from the main flow of the waterway and providing important refuge and breeding habitat for fish including threatened species. Woody debris is a significant component of aquatic habitat throughout all waterways crossed by the project and while not quantified, was found in the majority of waterways. Construction of the project may reduce the presence and availability of woody debris and snags if not managed appropriately.

Construction and operation of both permanent and temporary waterway crossings such as bridges, causeways, fords and culverts are known to have substantial impacts upon passage of fish. Short term impacts include localised disturbance to riparian and in-stream habitats such as increased sedimentation and shading and long term impacts include the impediment of fish movements within their natural range, habitat changes and pollution. Inappropriate design of both temporary (during construction) and permanent (operation) in-stream structures and/or construction procedures may contribute to the creation or exacerbation of in-stream barriers to aquatic fauna passage. Such barriers could prevent the dispersal of Oxleyan Pygmy Perch and Purple Spotted Gudgeon if appropriate waterway crossings have not been implemented.

Changes to hydrological conditions

Construction activity around watercourses has the potential to result in changes to flow. Changes to hydrological conditions can be temporary or long term and may include temporary diversion of waterways, barriers that impede flow and changes to flow velocities. Changes in hydraulic flow as a result of culverts and bridges (such as flow velocities and levels) can result in barriers to aquatic fauna movements and changes to aquatic habitat including a gradual decrease in water depth and increased sediment and turbidity leading to change in the suitability of the habitat for fish. As Oxleyan Pygmy Perch are thought to use flood events to facilitate dispersal, waterway crossings have the potential to inhibit natural flow of floodwaters, thereby impacting the ability of the Oxleyan Pygmy Perch to recolonise areas. A strategy for balancing Oxleyan Pygmy Perch and flood requirements would be developed.

Changes to water quality

The construction and of the project has the potential to impact on water quality. The main impact to water quality during construction comes from stockpiling of earthworks and vegetation, and actual construction works in proximity to known and potential habitat such as cut and fill, removal of borrow material, haulage routes and general earthworks. For example a major borrow site occurs at Lang Hill adjacent to known habitat of the Oxleyan Pygmy Perch.

Potential impacts include increased turbidity and nutrients in waterway as a result of sediments from earthworks being washed into waterways. Stockpiles of vegetation from cutting of trees and shrubs may result in tannins leaching into the waterways and increased organics. This can increase stream Biological Oxygen Demand (BOD) and decrease dissolved oxygen which can affect aquatic life.

Increased pollutant load in road runoff is the main impact to water quality associated with the operation of the project. Pollutants in road runoff include nutrients, heavy metals, pesticides, herbicides and hydrocarbons which can impact negatively on the aquatic environment.

4.2 Detailed design considerations

Instream structures such as bridges and culverts have been presented in the concept design with the objective of minimising potential impact on flow regimes and fish passage, particularly the Oxleyan Pygmy Perch.

Waterway crossing structures have been designed to minimise the impacts of altering the natural flow regimes of these waterways as a priority. In achieving this the concept design considered the class of waterways with respect to known location and potential habitats for threatened fish in particular the Oxleyan Pygmy Perch. This was achieved through field surveys during the preferred route and the EIS stage and considered other records of threatened fish as reported in the Atlas of NSW Wildlife and DPI (2010).

Further targeted surveys would be conducted at the detailed design stage for each project section and are aimed at reconfirming the presence or absence of threatened fish in each waterway crossed by the project including unnamed and undefined watercourses and thereby inform the detailed design and the final selection of monitoring sites. Details of the survey methods and parameters are provided in this management plan and with the intent of these being replicated for all project sections. Upon completion the results of these surveys would be provided to DPI (Fisheries) and the final design updated in consultation with this agency to reflect the results and potential re-classification of waterways. The selection of ongoing monitoring sites for threatened fish would then reflect the results of the targeted surveys such that these focus on known habitat for threatened fish.

To minimise the impact of runoff during the construction and operation, runoff from the project would be directed to detention basins and monitored and treated before being discharged to drains and then local waterways. Basins would also be located adjacent to wetlands and watercourses to protect waterways from unexpected spills. Ensuring water quality is maintained during construction would help to prevent any increase in the numbers of the aquatic pest species Plague Minnow (Gambusia holbrooki) which thrive in disturbed aquatic habitats and ensure that suitable water quality conditions are maintained for threatened fish. The location and size of basins would be refined during detailed design.

In areas where Oxleyan Pygmy Perch has been confirmed, water stored or treated during construction would not be discharged into the waterway but used for irrigation. At these locations, suitable transportation and irrigation systems would be constructed. This would comprise of a containment system to hold the water and prevent incoming water coming in on the floodplain, then pumping away from the floodplain, storing and irrigation. Irrigation onto land would be subject to consultation and agreement with landowners. Timing and locations for irrigation and storage facilities would be detailed in the soil and water management plan (SWMP) for each project.

At the Lang Hill Borrow site,. potential impacts to nearby surface water (known habitat of the Oxleyan Pygmy Perch) have been minimised/mitigated initially at the concept design stage by reducing the area of borrow source and restricting these further away from the stream and locating the haul road away from known OPP habitat and ensure that it does not cross the waterway. Impacts to groundwater would be avoided by refining the cut profile so that excavation would be 3 metres above the groundwater table.

Additional mitigation during construction would include standard capture and storage of surface water run-off with off-site irrigation as described previously and standard sediment and erosion controls to prevent sediment load entering the waterway and protect water quality.

4.3 Mitigation and monitoring

A number of measures to mitigate and monitor the impact of the project on Oxleyan Pygmy Perch and Purple Spotted Gudgeon during construction and operation of the project were suggested in the EIS (biodiversity working paper). In general these measures would relate to:

- A targeted connectivity strategy.
- Suitable design of temporary and permanent waterway crossings.
- Construction measures, including timing and method of construction, water quality and sediment and erosion control,
- Aquatic habitat management measures including revegetation of disturbed areas of waterway.
-
- Develop a monitoring program to monitor impacts the effectiveness of mitigation measures and incorporate adaptive management actions where impacts are noted.

The proposed approach to management of potential impacts to Oxleyan Pygmy Perch and Purple Spotted Gudgeon throughout the pre-construction, construction and operational phases is illustrated below in Figure 4-1.

4.4 Effectiveness of mitigation measures

A range of mitigation measures have been identified to minimise the impact of habitat loss and fragmentation on threatened species potentially impacted by the project. The effectiveness and success of these measures would be assessed using a measureable and targeted monitoring program that would be implemented prior to the construction of each section of the project.

A summary of the proposed mitigation measures and evaluation of their effectiveness based on past experience with other highway upgrades is described in Table 4-1.

Figure 4-1 Proposed staging of management measures

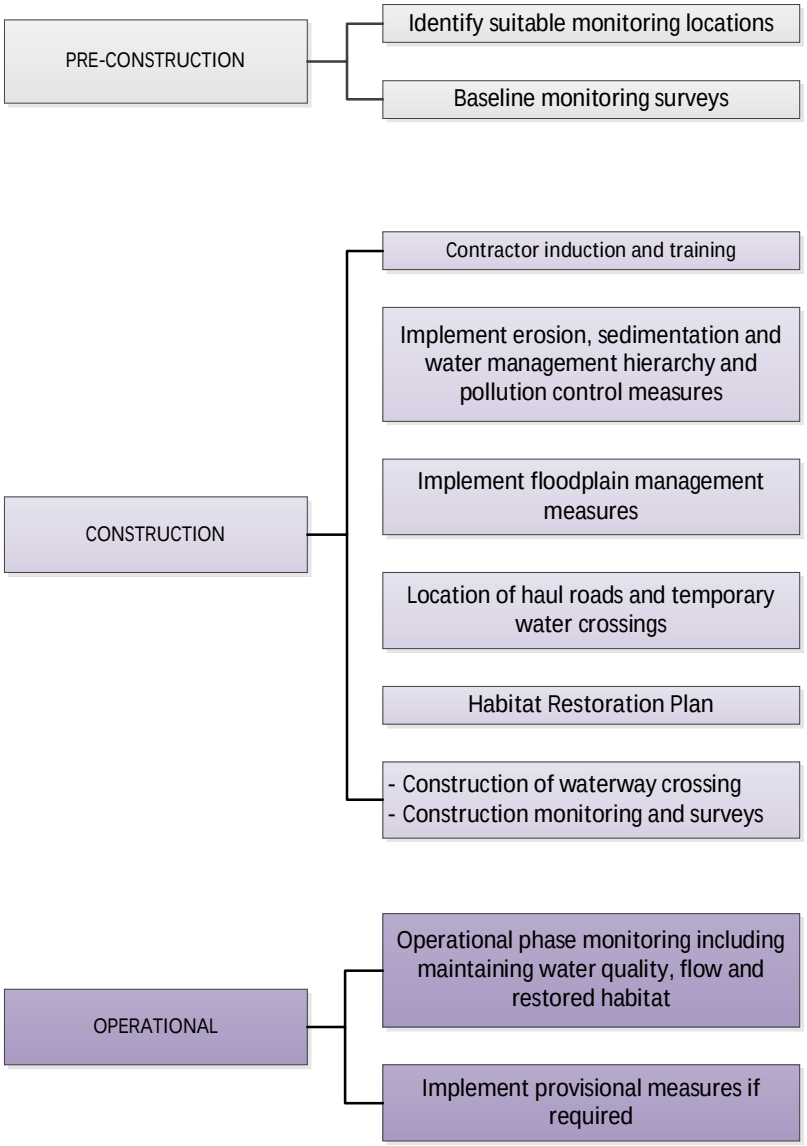


Table 4-1. Mitigation measures and evaluation of their effectiveness

Issue	Mitigation / control measure	History of success	Effectiveness rating
Impacts to threatened fish habitat adjacent to the project.	• Strict controls of temporary watercourse crossings. • Development of construction methodologies to reduce disturbance to instream habitats. • Management of instream woody debris. • Implementation of water quality control measures. • Management of sedimentation and erosion. • Management of aquatic weeds and pests. • Bed and bank reinstatement, habitat restoration	DPI Fisheries has been consulted on a number of occasions with regard to implementing mitigation measures to facilitate fish passage on Roads and Maritime highway projects. This involvement has extended over the last 14 years of the Pacific Highway upgrading program. Specific procedures have been drafted for the Oxleyan Pygmy Perch in consultation with NSW Fisheries. Experiences and findings from Devils Pulpit have been used to inform this plan for the Woolgoolga to Ballina project. Initial monitoring for Devils Pulpit has shown no change in water quality during construction.	High
Artificial structures creating a barrier to fish passage	• Design to prevent and/or minimise in-stream barriers, including appropriate design of bridges and culverts to ensure no physical, hydraulic and behavioural barriers to aquatic fauna movements. • Minimise culvert length where possible. Fisheries data has shown that fish passage is affected when culvert length reaches 60-70m, • Bridges on class 1 waterways with no piers in the channel • Natural substrate in the floor of culvert for potential habitat • Inspection, maintenance and cleaning of culvert structures to prevent blockages and restricted fauna movements.	Watercourse crossing (bridges and culverts) for the Devils Pulpit upgrade have been designed and constructed to be consistent with the Guidelines for Controlled Activities Watercourse Crossings (DWE 2008) and Why do Fish need to Cross the Road? Fish Passage requirements for waterway Crossings (NSW Fisheries 2003.This standard of bridge design meets with Roads and Maritime management goals of maintaining natural streamflow and velocity, and connectivity for threatened fish. Monitoring of fish passage would be undertaken during the operation of the Devils Pulpit upgrade and any findings would be used to inform fish passage within the Woolgoolga to Ballina Upgrade going forward.	Moderate, monitor success and implement corrective actions
Altered water quality conditions	• Sediment and erosion control during construction including protocols for discharge of basins and monitoring water quality • Strict controls on temporary watercourse crossings • Implementation of water quality control measures, including detention basins and operational spill basins at key locations. • Monitor water quality before discharge from basins,	Specific procedures have been drafted for the Oxleyan Pygmy Perch in consultation with NSW Fisheries. Experiences and findings from Devils Pulpit have been used to inform this plan for the Woolgoolga to Ballina project. Initial monitoring for Devils Pulpit has shown no change in water quality during construction.	High

	only discharge if appropriate conditions and no discharge to OPP habitat. • Apply methods to prevent change of pH during concrete construction in waterways (e.g. silt curtains on bridges).		
Artificial structures alter flow conditions	• Design to prevent and/or minimise in-stream barriers, including appropriate design of bridges and culverts to ensure no physical, hydraulic and behavioural barriers to aquatic fauna movements. • Natural substrate in the floor of culvert to maintain natural flow	DPI Fisheries have been directly involved with the design and implementation of hundreds of culverts to facilitate fish passage on Roads and Maritime highway projects. This involvement has extended over the last 14 years of the Pacific Highway upgrading program.	Moderate, monitor success and implement corrective actions
Fish trapped in pools adjacent to construction zone	• Development and implementation of a translocation strategy. • Translocation of fish outside the construction zone	Roads and Maritime has successfully translocated fish as part of the Banora Point Upgrade however this has not included translocation of Oxleyan Pygmy Perch or Purple Spotted Gudgeon. Oxleyan Pygmy Perch and Purple Spotted Gudgeon have been successfully maintained in aquaria (McDowall, 1996) and therefore it would be feasible that these species could be cleared from the immediate impact area and held in aquaria for the duration of the proposed construction activities.	Unknown, monitor success and implement corrective actions

4.5 Adaptive management approach

The management plan has been presented using an adaptive management approach based on firstly identifying specific goals for management and implementation of management actions followed by monitoring of the performance of these measures against the goals and identified thresholds. As a final step the monitoring would evaluate the effectiveness of the management measures using identified thresholds for performance and implementing corrective actions to improve mitigation where required.

To ensure the success of this approach the management goals presented in the plan were based on the following SMART principles:

- **S**pecific.
- **M**easurable.
- **A**chievable.
- **R**esults-based.
- **T**ime-based.

Details of the proposed monitoring program is described in Chapter 8 and includes measures to monitor the effectiveness of mitigation measures:

- Crossing structures.
- Water quality measures and pollution controls.
- Erosion and sedimentation controls.
- Habitat restoration measures.

5. Pre-construction measures

Oxleyan Pygmy Perch can disperse widely among isolated water bodies during or after high rainfall events when high flows connect a variety of river channel and floodplain habitats (Knight *et al.,* 2009). Therefore distribution patterns can vary substantially from one year to the next, especially if there has been a large flood. Extensive surveys for the presence of Oxleyan Pygmy Perch and Purple Spotted Gudgeon have recently been undertaken in areas of potential habitat in Sections 1 and 2 which have ruled out the presence of Oxleyan Pygmy Perch and Purple Spotted Gudgeon (Geolink 2012, Aquatic Science and Management 2013). However, due to the dispersal methods and habitat preferences of the Oxleyan Pygmy Perch such as unnamed ephemeral drainage lines, the potential for Oxleyan Pygmy Perch and Purple Spotted Gudgeon remains in other sections. Therefore updated surveys would be required to establish baseline conditions for Oxleyan Pygmy Perch and Purple Spotted Gudgeon closer to the construction start date and to inform the detailed design waterway crossing methodology. A list of potential sites for surveys was discussed in Chapter 2.

5.1 Potential impacts during pre-construction

- Location of ancillary facilities in close proximity to waterways.

5.2 Main goals for management

- Re-confirm the presence or absence of threatened fish species for input into the final design of waterway crossing structures and detention basins in consultation with DPI (Fisheries).
- Identify the presence or absence of suitable habitat, areas of high quality habitat and potential corridors between existing populations of threatened fish
- Identify baseline water quality and habitat conditions of the monitoring locations
- Identify the final set of monitoring locations for threatened fish.

5.3 Management measures

Details on the site specific mitigation measures for Oxleyan Pygmy Perch and Purple Spotted Gudgeon to be implemented during the pre-construction phase are detailed below and summarised in Table 5-1 along with performance thresholds and corrective actions. As a first stage in developing the management actions for threatened fish it is proposed to conduct baseline surveys to identify and re-confirm the distribution and abundance of threatened fish populations and establish baseline water quality and habitat conditions. The methods for the aquatic monitoring are summarised below and provided in detail in Chapter 8 which describes the overall monitoring program.

5.3.1 Aquatic monitoring

The *Woolgoolga to Ballina EA Biodiversity Technical Report (*Table 4-19) identified all sites with likely or known Oxleyan Pygmy Perch and/or Purple Spotted Gudgeon habitat as Class 1 in accordance with the standard NSW Fisheries Guidelines *Fish Passage Requirements for Waterway Crossings* (Fairfull & Witheridge 2003). However, due to the habitat preferences of the Oxleyan Pygmy Perch, ephemeral, unnamed and often undefined watercourse which were situated near sites with identified Oxleyan Pygmy Perch Habitat were classified conservatively as Class 2 rather than the Class 3 or Class 4 classifications these sites would normally receive.

Prior to and during detailed design targeted surveys would be conducted for each project section that occurs within the range of the Oxleyan Pygmy Perch and Purple Spotted Gudgeon (i.e. Sections 1-2 and 6-9). These surveys have already been competed for sections 1 and 2 (Woolgoolga to Glenugie) (refer GeoLink 2012 and Aquatic Science and Management 2013)

The objectives of the surveys include to:

- Re-confirm the presence or absence of threatened fish species for input into the final design of waterway crossing structures, and temporary and permanent detention basins in consultation with DPI (Fisheries).

- Identify a final list of monitoring sites that focuses on known or potential habitat for threatened fish species.
- Establish baseline conditions for the habitat and water quality parameters at known or potential threatened fish sites for ongoing monitoring during the construction and operational stages of the project.

A minimum of two pre-construction surveys would be conducted to confirm presence / absence and understand annual variation in the abundance of Oxleyan Pygmy Perch and Purple Spotted Gudgeon. Surveys would be conducted for all waterways crossed by the project and target OPP and PSG in addition to collecting baseline data on water quality and habitat condition as discussed. The ongoing aquatic monitoring program during construction and operation will focus on waterways with confirmed presence of threatened fish or high likelihood of presence based on the results of these surveys.

The targeted fish survey would follow the approach already undertaken for project Sections 1 and 2 (Woolgoolga to Glenugie) (GeoLink, 2012 and Aquatic Science and Management 2013). Details of the fish survey methodology used is described in Chapter 8, and the parameters surveyed include:

- Fish survey (survey of all fish species and reporting of the fish communities but targeted at OPP and PSG).
- Physico-chemical water quality parameters to be measured at all sites.
- A general description of the habitat characteristics of each monitoring site, in particular document riparian vegetation characteristics and condition, stream substrate composition and profile.

5.4 Performance thresholds and corrective actions

Table 5-1 summarises the pre-construction environmental planning measures for Oxleyan Pygmy Perch and Purple Spotted Gudgeon that are to be completed prior to the commencement of construction.

Table 5-1 Mitigation measures, performance measures and corrective actions

Main goals for mitigation	Proposed mitigation measure	Monitoring/timing frequency	Performance thresholds	Corrective actions if deviation from performance thresholds
Re-confirm the presence or absence of threatened fish species for input into the final design of crossing structures and basins in consultation with Fisheries	Conduct targeted surveys during detailed design focused on all potential waterways for the targeted species. Use outcomes of the survey to inform the detailed design and locations of mitigation measures.	Two surveys to be conducted pre-construction timed for June to September.	Two surveys are not completed prior to construction	Delay detailed design and construction in the relevant areas until two surveys are completed.
Identify the presence or absence of suitable habitat, high quality habitat, and potential corridors between existing populations	Identify any areas of high quality habitat or potential corridors between existing population during the habitat monitoring	Two surveys conducted prior to construction at the same time as fish surveys	Two surveys are not completed prior to construction	Delay detailed design and construction in the relevant areas until two surveys are completed.
Identify baseline water quality conditions	Conduct water quality surveys to establish thresholds for ongoing monitoring	Monthly, commencing at least 6 months prior to construction	Pre-construction monitoring completed prior to construction	Delay detailed design and construction in the relevant areas until sufficient baseline data has been collected.
Identify final set of monitoring locations.	Develop a pre-construction monitoring program to adequately	Initial site inspection prior to the pre-	Pre-construction site survey	If surveys identify presence of Oxleyan Pygmy Perch or Purple

Main goals for mitigation	Proposed mitigation measure	Monitoring/timing frequency	Performance thresholds	Corrective actions if deviation from performance thresholds
	monitor annual variation in abundance of Oxleyan Pygmy Perch and Purple Spotted Gudgeon. Sites selected as 'impact' or 'control' sites and would be up to 50 metres long. Impact sites approximately 100m upstream and downstream of proposed impact area.	construction environmental monitoring program. Monitoring to include water quality, fish survey and habitat assessment. Monitoring to be conducted outside breeding season and if possible mid to late afternoon. Annual pre-construction surveys at selected sites.	of Class 1 and 2 waterways with potential habitat completed prior to construction.	Spotted Gudgeon then additional control sites would be selected and sampled. These control sites would be added to ongoing monitoring program.

6. Construction management measures

6.1 Potential impacts during construction

- Disturbance and degradation to stream habitat.
- Contamination or other reduction in water quality.
- Changes in hydrological conditions.
- Loss of connectivity/barriers to movement.
- Creation of suitable habitat for noxious aquatic flora and fauna, especially Eastern Gambusia.

6.2 Main goals for management

- No change in stream habitat i.e. macrophyte,woody snag cover, benthic material and riparian habitatNo deterioration in water quality relative to the thresholds established during pre-construction monitoring in the vicinity or downstream of the construction works.
- No change in natural stream flow and velocity.
- No increase the abundance of Eastern Gambusia.
- Promote awareness among construction staff, contractors and the general community of threatened species and sound environmental practices.
- Successful translocation of threatened fish species.

6.3 Management measures

6.3.1 Construction work method statements

Construction work method statements would be prepared for specific activities to ensure sound environmental practices are implemented and to minimise the risk of environmental incidents or system failures, in accordance with the CEMP. This management plan would be included as an annexure to the project CEMP.

Construction work method statements would be prepared to address all construction Oxleyan Pygmy Perch and Purple Spotted Gudgeon management requirements for construction in consultation with relevant agencies, Roads and Maritime and the relevant project environmental manager prior to the commencement of identified activities.

6.3.2 Construction induction and training

Induction training would be conducted with all contractors and other staff that would be working in the areas of known and potential Oxleyan Pygmy Perch and Purple Spotted Gudgeon habitat and distribution in Sections 1-3 and 6-10 of the project. This training would identify Oxleyan Pygmy Perch and Purple Spotted Gudgeon habitat, potential and known locations and key threats. The importance of following the protocols in this plan would be made clear for any personnel that require access to the site.

6.3.3 Construction near waterways and waterway crossings

The greatest threats to Oxleyan Pygmy Perch and Purple Spotted Gudgeon during construction include:

- Disturbance and loss of habitat and creation of habitats conducive for noxious aquatic flora and fauna species

- Habitat and population fragmentation of existing population occurring either side of the current highway, within and outside of the construction zone
- Changes to hydraulic regime and creation of temporary and permanent instream barriers
- Reduction in water quality.

Bridges are planned for all class 1 waterways (Fairfull and Witheridge 2003), and would be constructed to cross all class 1 waterways with confirmed Oxleyan Pygmy Perch habitat unless otherwise agreed with DSEWPaC and NSW DII (Fisheries). Where feasible, bridge supports would not be constructed in the main channel and on stream banks, to minimise alteration to water flow and/or damage to stream bank vegetation. Due to the dispersal methods and habitat preferences of the Oxleyan Pygmy Perch unnamed ephemeral drainage lines with uncertain Oxleyan Pygmy Perch habitat were conservatively classified as Class 2 (rather than Class 3 or 4). The crossing methods of these watercourses would be further addressed based upon the results of the pre-construction surveys and in consultation with DII (Fisheries).

Design principles

In locations where Oxleyan Pygmy Perch and/or Purple Spotted Gudgeon are known to occur a number of design principles and management measures apply. These design principles meet the principles for Ecologically Sensitive Design (ESD) and have been adopted from the Biodiversity Connectivity Strategy. The design principles and management measures include:

- Bridges would be single span bridges with piers located outside the main channel.
- Bridge structures to be designed to prevent a backup of water during times of flood that would enable Eastern Gambusia to access water bodies where they are currently not found.
- Where there are existing or potential Oxleyan Pygmy Perch or Purple Spotted Gudgeon populations construction would not alter or reduce flow. Waterway crossings in areas of known Oxleyan Pygmy Perch or Purple Spotted Gudgeon habitat would be designed such that water velocities through structures do not inhibit Oxleyan Pygmy Perch or Purple Spotted Gudgeon under normal flow conditions. This would be achieved by maintaining the existing substrate and vegetative habitat as controls for velocity and maintaining the cross-sectional area of the waterway.
- Operational spill basins would be installed at key locations and other key drainage lines that lead directly into Oxleyan Pygmy Perch or Purple Spotted Gudgeon habitat. As such, all road surface runoff that have drainage lines leading directly into Oxleyan Pygmy Perch or Purple Spotted Gudgeon habitat would be directed into operational spill basins.
- Creek crossing structures designed to maximise light and habitat features within the passage. To achieve this, the design of culverts would encourage the deposition of sediment creating similar bed substrate to adjacent creek and the planning of specific plant species.
- Natural stream flow and velocity would be maintained as closely as possible.
- Surface level of causeway be the same or lower than the natural level of the stream bed to reduce interference with flow.
- Habitat within a culvert be as natural as possible (example allow rock and bed material to infill culvert base).
- There is maximum light penetration.

    - Maintain fauna and fish passage standards as detailed in the connectivity strategy, including maintaining minimum design widths, including for natural banks, while also providing for scour protection and cut and fill batters.
    - Bridges would be designed and sized to limit peak flood velocities to less than 1 metre per second in commonly occurring flood events, similarly to the bridge design over Macdonalds Creek where Oxleyan Pygmy Perch have been recorded.
    - Implementation of erosion and sediment control and pollution control measures to avoid impacts to aquatic ecosystems and water quality have been detailed in Section 6.3.6.
    - North of Broadwater National Park, south of Lang Hill (station 133.4): a bank of 20 culverts (RCBC), 3.3 metres wide and 1.2 metres high to provide a larger crossing.
-
- Bridge construction would consider the impact of high pH runoff on Oxleyan Pygmy Perch habitats as a result of concreting activities. There could be a high risk that runoff can increase pH of the receiving waterway if discharged from concreting sites. To reduce this risk to low, the following mitigation measures are proposed and further discussed in the Water Quality Paper:
    - Using pre-formed concrete piles and girder elements to minimise the need for concrete pouring in floodways'.
    - Reinforced form work incorporating water tight seals at all joints.
    - A shroud suspended under the bridge deck to intercept any spills that might occur in the event of any form work seepage.
    - Timely off-site disposal of any seepage caught in the shroud by the on-site supervision team.
    - Covering recently poured bridge decks with impermeable and durable plastic to prevent alkaline run-off entering waterways.

No water resulting from construction will be released directly into Oxleyan Pygmy Perch habitat. The release of water would only occur under the following conditions:

- Release of stored water into areas where Oxleyan Pygmy Perch are known or have potential to occur would only be undertaken as a last resort.
- Released water would be a pH level that matches the mean pre-construction pH determined during baseline monitoring of the waterway, to within 1 pH unit.
- Chemical treatments used prior to the release of water from sediment basins would not persist in the environment or negatively impact upon the environment after release.
- Potential pre-release water treatments and/or their derivatives would be included as parameters in baseline water quality monitoring.

After construction, river banks would be restored to protect them against erosion and would be no steeper than the natural river bank that they replaced.

Timing requirements

- The following provides construction timing requirement for the threatened fish species in this plan:
    - No instream works (works within a flowing waterway) to occur in waterways where Oxleyan Pygmy Perch and Purple Spotted Gudgeon are known to occur during the spawning season (October to December and February to March). Should preconstruction surveys identify Purple Spotted Gudgeon then the no instream works would of that particular waterway would occur during their spawning season of December to March.
    - Prior to any instream works consultation with NSW Fisheries regarding timing of instream works. In addition, a risk assessment would be undertaken to identify high and

low risk activities. Low risk activities require little or no ground disturbance within a 25 metre zone and have minimal to no pollution sources with the potential to reach the waterways. The following low risk activities may include:

- Cranage
- Underboring of waterways to relocate Telstra copper cable
- Decking work
- Formwork reinforcement
- Scaffolding
- Stripping of formwork
- Waterproofing
- Guard rail installation

- High risk activities would not be undertaken during the period October to December for Oxleyan Pygmy Perch or on a day when a rainfall event is predicted or the creek is in a flowing state. Instream work can only recommence once dry weather is forecast and the waterbody has returned to a non-flowing state. High Risk activities may include:
  - Piling in the waterway and within the bed and banks
  - Construction of temporary work platform within the waterways
  - Concreting of abutments, deck, and parapets
  - Clearing
  - Placing fill (bulk earthworks) on the floodplain adjacent to OPP waterways
  - Underboring of OPP waterways

6.3.4 Temporary watercourse crossings

Temporary watercourse crossings would be required during construction to facilitate equipment and personnel access to the construction works. All temporary water crossings and culverts would be constructed in accordance with Guidelines for Controlled Activities Watercourse Crossings (DWE, 2008) and Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings (NSW Fisheries, 2003) and with consultation of OEH, DPI (Fisheries), DSEWPaC and Roads and Maritime such that there are no barriers or impedances to instream fish movement.

Temporary crossings may include bridges, arches, multi-celled culverts, box culverts and pipe culverts. Where temporary access tracks occur over drainage lines with no flow, fords may be installed. The potential impacts of these temporary watercourse crossings on aquatic ecology values depends upon the type of waterway crossing, the duration that the crossing is in place and the traffic that would use the waterway crossing. The type of temporary crossing used would be dependent upon the results of the pre-construction Oxleyan Pygmy Perch and Purple Spotted Gudgeon surveys.

Wherever possible, existing crossings would be used, however where this is not feasible, the construction and operation of these temporary crossings would be designed to minimise impacts to the existing aquatic ecology and water quality values and to ensure that connectivity is maintained during construction. During detailed design locations for temporary crossings, the type of crossing, the duration each crossing would be established for the management and mitigation measures for each crossing location.

General temporary waterway access track mitigation measures have been provided below:

- Installation and subsequent decommissioning of temporary crossings would be undertaken outside of peak Oxleyan Pygmy Perch spawning seasons (October to December) at locations of that have known populations of Oxleyan Pygmy Perch or potential habitat within Section 1 to 3 and 6 to 10 of the project. Should preconstruction surveys identify Purple Spotted Gudgeon then the installation and subsequent decommissioning of temporary crossings of that particular waterway would be undertaken outside their spawning season of December to March.

- Temporary crossings would be constructed from clean fill using pipe or box culvert cells to carry flows. Where the waterway has known habitat for Oxleyan Pygmy Perch or Purple Spotted Gudgeon temporary crossing structures are unavoidable, they would be installed that so not directly impact the creek bed or impede water flow or fish passage. Eg. Bailey Bridge.
- All temporary works (example crossings, flow diversion barriers etc) would be removed as soon as practicable and in a way that does not promote future channel erosion.
- Where necessary creeks may need to be temporarily diverted to allow structures to be placed in order to minimise impacts to water quality.
- The preferred temporary structure for crossing waterways would be consistent with Witheridge (2002) where the use of bridges is the preferred structure for Class 1 (major fish habitat waterways).
- Scour protection on both sides of the waterway at temporary crossing structures within 50m of Class 1 waterways or within the range of the Oxleyan Pygmy Perch.
- At the completion of construction, the temporary crossings would be removed and rehabilitated.

6.3.5 Translocation

Every effort would be made to avoid any disturbance to the stream channel and in-stream habitat during construction. However, some level of disturbance may be unavoidable at certain sites. An experienced fish ecologist would assess any site where instream disturbance is likely to occur to determine whether translocations would be necessary. Oxleyan Pygmy Perch and Purple Spotted Gudgeon have been successfully maintained in aquaria (McDowall, 1996) and therefore it would be feasible that these species could be cleared from the immediate impact area and held in aquaria for the duration of the proposed construction activities. Alternatively individuals could be cleared from the proposed construction area and translocated to nearby habitat in the same stream that is unlikely to be affected by the construction activities.

The feasibility of translocation would need to be reviewed with the experienced fish ecologist, as translocation may only be possible where there are pools during low flow or where fish are trapped near the works area. A number of water quality and habitat parameters would need to be considered at potential translocation sites, including but not limited to pH and type of aquatic vegetation present to ensure recipient sites are suitable.

If translocations are required, fine mesh nets would be placed in the stream to span the full width of the channel upstream and downstream of the construction area. Backpack electrofishing, dip nets and unbaited bait traps (as per the population surveys described in Section 5.3.2) would be used to capture fish any fish within the construction area. Fishing would continue until no new individuals have been captured in 1200 seconds of electrofishing time and no new fish have been caught in bait traps left in suitable habitat for at least two hours (the traps would be checked every 30 minutes).

6.3.6 Earthworks and sediment control

Detailed site specific erosion and sediment control plans would be prepared as part of the CEMP and incorporate findings of the pre-construction Oxleyan Pygmy Perch and Purple Spotted Gudgeon surveys. Generally, runoff from identified sites would be treated by a sedimentation basin. The required water quality parameters for the basins discharging into this area would be identified in the CEMP based on pre-construction water quality and pre-construction Oxleyan Pygmy Perch and Purple Spotted Gudgeon monitoring programs and most likely subject to an EPL. Where possible discharges from the sediment basins during construction that do not meet the water quality parameters for Oxleyan Pygmy Perch habitat would not be discharged into the waterway but rather sprayed into adjacent open grass areas or used for construction purposes such as dust suppression to avoid changing water depth and physico-chemical conditions in the potential habitat. Discharge by diffuse method of land irrigation allowed if a minimum of 50 metres from the waterway and within project boundary. If diffuse discharge not be feasible then it would be pumped to a proposed storage facility.

Appropriate sediment fences would be erected around any threatened fish habitat where works are on or adjacent to waterways to prevent local run-off directly entering those waterways. Geofabric, would also be used where river banks are disturbed during the construction of bridges and other waterway crossings. These details would be further designed on a site specific basis as part of the CEMP following the outcomes of the pre-construction surveys.

All erosion and sediment control measures must be best practice based on industry guidelines and mush be certified in consultation with NSW DPI (Fisheries). These measures include:

- The timing requirements as discussed in Section 6.3.3 would be implemented for earthworks and sediment control.
- Instream works are defined in the NSW Office of Water State Guidelines for Controlled Activities and the *Water Management Act 2000*. They include works within a watercourse or waterfront land. The definition of waterfront land includes the bed and bank of any river, lake or estuary and all land within 40 metres of the highest bank of the river, lake or estuary. A rainfall event is defined as greater than 10 millimetres in a 24 hour period. It has been assumed that waterfront land refers to land on the floodplain and not land on the raised existing road level.
- There would be no stockpiling of material for bridgeworks within 50 metres of known areas of Oxleyan Pygmy Perch habitat.
- Chemicals and fuels to be stored and bunded so that the floor of the bund is above the 1 in 20 year flood event and the top of the bund above the 1 in 100 year flood event. No chemicals and fuels to be stored in the floodplain zone between Tabbimoble Floodway 2 and Tabbimoble Floodway 3.
- The area within 50 metres of Tabbimoble Floodway 2 and Tabbimoble Floodway 3 to be fully stabilised before the commencement of next spawning season.
- Batch plants would be located greater than 300 metres from Oxleyan Pygmy Perch habitat due to the risk of high alkaline runoff occurring (through spilling/overtopping Oxleyan Pygmy Perching events). Additionally, all batch plants would have measures to capture, re-use and treat alkaline runoff.
- Measures to be implemented for events such as rainfall events and fuel and chemical spills.
- Measures to be implemented to monitor, review and update the effectiveness of the sediment and erosion control measures implemented.

6.3.7 Habitat restoration

Temporary erosion control measures would be used to prevent damage to recently disturbed banks during high flow events. However, where possible, native riparian vegetation within the road reserve would be planted and managed over time to consolidate the banks and provide more natural erosion control. Where revegetation would not be possible (e.g. immediately under bridge due to permanent shading) rocks and other items may be used to protect disturbed banks and reduce flow. Any disturbed river banks would be restored to their natural gradient or have a lower gradient so as not to increase hydraulic sheer during high flows prior to the spawning season.

Any woody debris or rocks that are removed from the river channel during construction are to be returned to the river after construction has been completed.

6.4 Performance thresholds and corrective actions

Table 6-1 summarises the pre-construction environmental planning measures for Oxleyan Pygmy Perch and Purple Spotted Gudgeon that are to be completed prior to the commencement of construction.

Table 6-1 Mitigation measures, performance measures and corrective actions during construction

Main goals for mitigation	Proposed mitigation measure	Monitoring/timing frequency	Performance thresholds	Corrective actions if deviation from performance thresholds
No change in stream habitat i.e. macrophyte,woody snag cover, benthic material and riparian habitat during construction	Management of riparian and aquatic habitats. Development of construction methodologies to reduce disturbance to instream habitats. Management of instream woody debris. Rehabilitation of aquatic habitats near construction zones	Monthly inspection of disturbed areas for the occurrence of aquatic weeds.	No notable change in stream habitat 100 metres above and below construction works, ie Macrophyte and woody snag cover from baseline conditions NB: it is very likely that in-stream habitat will alter in the immediate vicinity of waterway crossings as some shading will occur	Implement appropriate rehabilitation and reconstruction strategies.
No deterioration in water quality in the vicinity or downstream of the construction works.	Implementation of water quality control measures. Management of sedimentation and erosion.	Event (following rainfall). Monthly.	Notable change in water quality from baseline conditions in the vicinity or downstream of the construction works. No evidence of sediment or erosion.	Undertake actions to control (and where necessary remediate) any impacts arising as a result of construction activities.
No change in natural stream flow and velocity.	Design to prevent and/or minimise in-stream barriers, including appropriate design of bridges and culverts to ensure no physical, hydraulic and behavioural barriers to aquatic fauna movements. Avoid the need for scour protection on the flow of creeks. For small creeks/waterways with known Oxleyan Pygmy Perch commit to keeping piers out of the main channel.	Event (following rainfall). Monthly. Fish survey biannually.	No notable change in natural stream flow and velocity 100 metres above and below construction activities.	Relocation of native fish if work result in isolation of pools for any period of time or they become susceptible to drying or poor water quality.
No increase the abundance of Eastern Gambusia and Plague Minnow	Management of riparian and aquatic habitats. Development of construction methodologies to reduce disturbance to instream habitats. Rehabilitation of aquatic habitats near construction zones.	Fish survey biannually.	Review mitigation measures update as required. NB: Eastern Gambusia are likely to fluctuate in response to stochastic factors outside the control of the construction teams which may not have been identified during pre-construction monitoring	Implement appropriate rehabilitation and reconstruction strategies.
Promote awareness among construction staff, contractors and the general community	Preparation of construction work method statements for specific activities. Induction training for all staff and contractors working in and known and potential habitat for Oxleyan Pygmy Perch and Purple Spotted Gudgeon	Each time a new staff member or contractor will be working in areas of known or potential habtitat	Induction of all staff working near known or potential habitat Adherence to protocols outlined in this plan	Revise awareness/induction training
Successful translocation of threatened fish species	Implementation of the translocation plan and monitoring of the plan to identify success of otherwise.	Monitoring of survival of translocated species. Fish survey biannually.	Translocated threatened fish species present in ponds where fish were translocated to. If absent move to corrective actions	If threatened fish species are not present in ponds where fish have been translocated to the translocation strategy would be with the DII (Fisheries).

7. Operational management measures

7.1 Potential impacts during operational phase

- Pollutant runoff leading to altered water quality conditions
- Altered flow conditions creating instream (hydraulic) barriers to threatened fish movements.
- Proliferation of instream and littoral weeds associated with loss of riparian vegetation and altered
- hydraulic and structural habitat conditions that may result in the creation of suitable habitats for noxious species (e.g. Eastern Gambusia).

7.2 Main goals for management

- To maintain water quality within the thresholds established during the pre-construction monitoring
- To maintain critical habitat condition during operation at known and potential habitat locations for the Oxleyan Pygmy Perch or Purple Spotted Gudgeon.
- To maintain natural stream flow and velocity and connectivity for threatened fish.

7.3 Management measures

7.3.1 Water Quality

Oxleyan Pygmy Perch and to a lesser extent the Purple Spotted Gudgeon have a narrow set of habitat requirements and would therefore be sensitive to changes in water quality conditions.

Increased pollutant load in road runoff is the main impact to water quality associated with the operation of the project. Petrochemical runoff from the road when operational may have a toxic effect on Oxleyan Pygmy Perch or Purple Spotted Gudgeon in any receiving waters.

To minimise the impact of runoff during the operation, runoff from the project would be directed to detention basins before being discharged to drains and then local waterways. Basins would also be located adjacent to wetlands and watercourses to protect waterways from unexpected spills. Operational spill basins would be installed at key locations and other key drainage lines that lead directly into Oxleyan Pygmy Perch or Purple Spotted Gudgeon habitat in Sections 1 to 3 and 6 to 10.

Poor water quality is known to occur throughout sections of the project. Therefore continued water quality monitoring would be important to identify baseline conditions and ensure that the project does not exacerbate existing poor water quality during the operation of the project.

The details of the monitoring program are provided in Chapter 8.

7.3.2 Maintaining flow

Water crossing structures from the concept design have been designed to minimise the impacts of altering the natural flow regimes of these waterways rivers as a priority. The design took into consideration the class of waterways, in particular Class 1 waterways as potential habitat for threatened fish. Detailed design of bridges and culverts would ensure that barriers to fish are not created, including the design of bridges to avoid where possible the placement of piers in the waterways.

Inspection and maintenance and cleaning of culvert structures would be done in accordance with Management Activities detailed in the Oxleyan Pygmy Perch Recovery Plan (DPI 2005). Maintenance and cleaning would be done would be undertaken by Roads and Maritime as part of regular highway maintenance in proximity and in response to an identified issue.to prevent blockages in potential habitat of threatened fish.

7.3.3 Maintenance of restored habitat

At the completion of construction, the bed and banks would be reinstated to a condition similar to or better than the original condition ensuring that there are no adverse impacts on the aquatic values (different measures may be required for each crossing). Banks would be graded to a slope that is no steeper than existing site conditions.

Chapter 8 details how aquatic and riparian habitats would be monitored.

7.3.4 Monitoring

Monitoring during the operation of the project would include fish surveys, water quality monitoring and habitat monitoring. Monitoring for Oxleyan Pygmy Perch and Purple Spotted Gudgeon would be established based on results of surveys during pre-construction and in consultation with NSW Fisheries. Where these species were absent during pre-construction surveys, no additional surveys would be undertaken, instead water quality and habitat monitoring, including monitoring of revegetated areas would be used to determine the effectiveness of mitigation measures.

Inspection, monitoring and maintenance of restored habitat areas are documented in Chapter 8.

7.4 Performance thresholds and corrective actions

Table 7-1 summarises the operational environmental planning measures for Oxleyan Pygmy Perch and Purple Spotted Gudgeon and corrective actions if the measure deviates from the performance criteria.

Table 7-1 Mitigation measures, performance measures and corrective actions during operation

Main goals for mitigation	Proposed mitigation measure	Monitoring/timing frequency	Performance thresholds	Corrective actions if deviation from performance thresholds
To maintain critical water quality condition during operation at known and potential habitat locations for the Oxleyan Pygmy Perch or Purple Spotted Gudgeon.	Implementation of water quality control measures, including detention basins and operational spill basins at key Oxleyan Pygmy Perch and Purple Spotted Gudgeon locations. Water quality monitoring.	Monitor water quality and effectiveness of basin following wet weather events (min 3 events over at least months) and/or monthly.	Analysis of monthly water quality data between paired upstream and downstream sites to determine any noticeable changes in water quality occurring during the operation of the project.	Immediate investigation into the specific cause so that appropriate remedial action can be taken.
To maintain natural stream flow and velocity and connectivity for threatened fish.	Inspection, maintenance and cleaning of culvert structures to prevent blockages and restricted fauna movements. Rehabilitation and restoration of disturbed areas to similar or better than original condition. Maintenance of connectivity for threatened fish.	Biannual surveys as part of the monitoring program outlined in Chapter 8. A regular schedule of maintenance would be implemented by Roads and Maritime as part of regular maintenance along the highway and in response to an identified issue. Surveys as part of the monitoring program outlined in Chapter 8.	Changes in habitat downstream of the construction area/upgraded highway that are not evident immediately upstream would be attributed to the operation of the upgraded highway. No increase the abundance of Eastern Gambusia. Fish found to be trapped or not using crossing structures.	Immediate investigation into the specific cause so that appropriate remedial action can be taken. Review and modify monitoring program. Make physical changes to the structure or floor as appropriate.

8. Monitoring program

Monitoring would be undertaken to determine the effectiveness of mitigation measures.

Monitoring would be undertaken at the potential Oxleyan Pygmy Perch or Purple Spotted Gudgeon monitoring sites identified during the Pre-Construction Surveys. The monitoring program described below may need to be refined if new locations are found.

8.1 Objectives

Monitoring would be conducted during the construction and operational where known Oxleyan Pygmy Perch and Purple Spotted Gudgeon populations would be potentially impacted and for a period until such time as the mitigation measures has been proven to be effective with the potential to decrease the post construction monitoring period if monitoring results indicate the mitigation measures have been successful.

Monitoring would provide reliable information such that sound conclusions can be drawn in relation to management of these species. The overall monitoring objectives include:

- Evaluate the success of mitigation measures (including erosion and sediment control and pollution control measures).
- Determine the extent of secondary impacts of the proposal on Oxleyan Pygmy Perch and Purple Spotted Gudgeon populations and identify any additional mitigation measures that may minimise these impacts such as connectivity, stream mitigation, water quality and restoration of habitat.
- Determine the effectiveness of bridge design and bank rehabilitation in the management of Oxleyan Pygmy Perch and Purple Spotted Gudgeon.

The monitoring can be refined, subject to progress against the above matters. In order to fulfil these objectives a number of ecological variables would be monitoring, with each variable discussed below.

The final set of monitoring sites would be identified during detailed design as discussed in 5.3.1. It is expected that the initial surveys would be conducted in Section 1-2 and 6-10. The need for ongoing monitoring in these project sections would be confirmed at the end of the targeted surveys and depend on the presence of known and potential habitat for threatened species.

8.2 Fish survey

8.2.1 Methods, timing, intensity and duration

The *Woolgoolga to Ballina EA Biodiversity Technical Report (*Table 4-19) identified all sites with likely or known Oxleyan Pygmy Perch and/or Purple Spotted Gudgeon habitat as Class 1 in accordance with the standard NSW Fisheries Guidelines *Fish Passage Requirements for Waterway Crossings* (Fairfull & Witheridge 2003). However, due to the habitat preferences of the Oxleyan Pygmy Perch, ephemeral, unnamed and often undefined watercourse which were situated near sites with identified Oxleyan Pygmy Perch Habitat were classified conservatively as Class 2 rather than the Class 3 or Class 4 classifications these sites would normally receive.

The planned targeted fish surveys are described previous in the pre-construction chapter 5. A minimum of two pre-construction surveys would be conducted to confirm presence / absence and understand annual variation in the abundance of Oxleyan Pygmy Perch and Purple Spotted Gudgeon.

Surveys would be conducted for all waterways crossed by the project and target OPP and PSG in addition to collecting baseline data on water quality, habitat condition and flow and velocity as described in the following sections. The ongoing threatened fish monitoring program during construction and operation will focus on waterways with confirmed presence of threatened fish or high likelihood of presence based on the results of the surveys.

Impact and control site selection

The targeted fish survey would follow the approach already undertaken for project Sections 1 and 2 (Woolgoolga to Glenugie) (GeoLink, 2012 and Aquatic Science and Management 2013). These surveys sampled fish communities at up to 3 monitoring sites (upstream, at and downstream of the construction area) per location. Sites were selected based on the presence of suitable habitat such as sandy substrate, shallow slow-flowing water and the presence of aquatic vegetation, rocks and submerged logs. All of the sites were located within the project, but the upstream and downstream sites were located up to 100 metres outside of that corridor.

An experienced fish ecologist would select suitable survey sites along project sections 6-9 based on a visual inspection of instream habitat and property access requirements. Each assessment site would be up to 50 metres long.

If surveys at any sites identify the presence of Oxleyan Pygmy Perch or Purple Spotted Gudgeon then an additional control site would be selected and sampled. Due to property access constraints, control sites may not be feasible in upstream areas and may need to sample over known sites in conservation reserves for example Broadwater National Park. In some instances sites may only be abailable downstream of impact sites, or within other drainages, It may be necessary to sample several potential sites in order to select the final control sites in each waterway. Due to the constraints, the protocol for selecting optimum control sites uses a hierarchy of principles, where, subject to suitable habitat, sites are located:

1) >2 km upstream of impact site
2) >1 km upstream of impact site
3) >2 km downstream of impact site
4) In a different drainage and > 2km upstream of any other impact site

The selection of sites would need to be done by an experienced ecologist and be based on the distribution of suitable habitat and potential movement barriers between it and the proposed construction site. It is not known how far Oxleyan Pygmy Perch or Purple Spotted Gudgeon would be likely to move during their lifetime, but ideally the control site would be at least two kilometres upstream of the highway upgrade corridor if suitable habitat occurs that far upstream. Active sampling would be an important aspect of selecting suitable control sites because they would have similar habitat and a similar abundance of Oxleyan Pygmy Perch and Purple Spotted Gudgeon as the impact sites, where possible although considering that these species occur in low abundance and the Purple Spotted Gudgeon has not been identified in the study area.

These control sites would be added to the ongoing monitoring program and surveyed on every future sampling occasion so that any changes in abundance at or near the construction sites can be compared against a relatively independent control. We note that these upstream sites would not be truly independent controls, because they would be still within the same stream as potential impact sites and therefore there would be a possibility that changes at the impact sites may have some effect on the population at the nominated control sites. However, due to the extent of the Woolgoolga to Ballina alignment, it would not be possible to select any truly independent upstream coastal control sites.

Following the targeted surveys, a final subset of monitoring sites would be identified and reported in the monitoring report. These sites would be refined to known or potential habitat for the Oxleyan Pygmy Perch and Purple Spotted Gudgeon.

Fish sampling methods

Oxleyan Pygmy Perch and Purple Spotted Gudgeon live in similar habitats and are generally caught using the same sampling techniques. The DSEWPaC has developed guidelines for surveying threatened fish species (DSEWPaC, 2011). The guidelines include specific recommendations for Oxleyan Pygmy Perch and those recommendations would be adopted for targeted surveys of both species.

All surveys would be undertaken by experienced ecologists, who are able to identify Oxleyan Pygmy Perch and Purple Spotted Gudgeon in the field and hold all relevant permits for general fish surveys and targeted species surveys in NSW. Because electrofishing would be required, the people undertaking the surveys would need to be senior electrofishing operators and would need to comply at all times with the Australian Code of Electrofishing Practice (SCFFA, 1997).

Fish surveys would be conducted using a combination of backpack electrofishing, dip nets and bait traps. Seine nets would not be used as they would be likely to damage the fish (DSEWPaC, 2011). Backpack electrofishing would be used for 600 seconds (power on time) at each site. Voltage, current and pulse frequency would be adjusted to ensure that fish are stunned, but not harmed. An electrical output of 500v, 60Hz pulsed DC when electrofishing would induce forced swimming in Oxleyan Pygmy Perch sufficient to allow capture without causing tetany (muscle rigidity) (Knight *et al.,* 2007). Electrofishing would target shallow (<1 metre deep), still or slow-flowing habitats with submerged or emergent aquatic vegetation and submerged rocks and logs in proportion to the occurrence of these habitats at each site. All stunned fish would be retrieved with a fine (5 mm) mesh, knotless dip net and held in a large bucket containing water from the site. A minimum of ten unbaited standard collapsible bait traps would be deployed at each site for 30-60 minutes. Unbaited traps would be used, as baiting does not increase the probability of attracting fish (Knight *et al*., 2007). The bait traps would be placed 1.5 – 2.0 metres apart amongst or near submerged or emergent vegetation. If no Oxleyan Pygmy Perch or Purple Spotted Gudgeon are caught in the first sample period, then the bait traps would be deployed for another 30-60 minutes. Dip-netting is to be used in areas unable to be sampled effectively with other sampling techniques (i.e. in waters to shallow to deploy bait traps).

All fish caught at a particular site would be counted, identified, measured to determine relative abundance and size class distributions. Fish would be handled with wet hands and all handling would be kept to a minimum to prevent injury and stress. Fish would be held in a bucket or tank at the site for the duration of the survey to prevent errors associated with repeat captures of the same individuals. The bucket would be filled with water collected from the site and would be placed in the shade to prevent the temperature from increasing. If fish are to be kept in a bucket for extended periods it may be necessary to aerate the water and introduce some weed to minimise stress.

Oxleyan Pygmy Perch and Purple Spotted Gudgeon populations are likely to be most abundant towards the end of their breeding season, but surveys would not be conducted during the breeding season (DSEWPaC, 2011). Oxleyan Pygmy Perch mainly breed in summer, but the breeding season can extend from September to May in areas with warmer water (DSEWPaC, 2011). Purple Spotted Gudgeon breed between December and February (McDowall, 1996). Surveys for these species would therefore occur in May or June. Surveys would also be conducted during stable, low flow conditions. In addition to the proposed timing of surveys in May/June, consideration would be given to undertaking additional surveys of ephemeral drainage lines following a period of rain (ie wet season).

Arthington (1996) noted that more Oxleyan Pygmy Perch were caught in surveys conducted after 4:00 pm compared to morning surveys conducted around 8:00 am. We therefore recommend that were possible, most surveys would be conducted in the mid to late afternoon. However, where that is not possible, it would be important to vary the sampling time for control and impact sites and for sites immediately upstream and downstream of the construction corridor to ensure that predictable differences in sampling efficiency at different times do not bias survey results. The time that each site was surveyed would also be noted so any effect of time can be considered in subsequent analyses.

8.2.2 Performance thresholds and corrective actions

The objectives of the mitigation measures include to minimise the impacts of habitat loss, fragmentation and barriers to movement that have been created by the project to maintain the long-term viability of the Oxleyan Pygmy Perch and Purple Spotted Gudgeon in the project area. The status of Oxleyan Pygmy Perch and Purple Spotted Gudgeon abundance would be measured by achieving the performance thresholds detailed in **Table** 8-1.

Table 8-1 Performance thresholds for fish survey

Performance thresholds	Timing and corrective actions
Abundance of Oxleyan Pygmy Perch and Purple Spotted Gudgeon similar between construction site and at each site downstream of the construction corridor would be compared against the abundance in any survey sites immediately upstream and any upstream control sites. Abundance similar or higher than the results of previous surveys at the same sites.	If significant discrepancies between the abundance of fish at construction sites and downstream of construction sites compared to historical trends with respect to the sites immediately upstream of the construction sites and control sites further upstream have been identified then further investigation may be needed to determine the potential cause. Such measures would be determined in consultation with DII (Fisheries). Investigate instream habitat and consider improving habitat condition and connectivity. If a temporary crossing has been used, ensure design is in accordance with NSW DPI (Fisheries) guidelines and requirements. Additional water quality monitoring to ensure that it would not result in adverse effects.
No increase in the abundance of Eastern Gambusia at habitat sites compared with control sites	Monthly inspection through construction to ensure no weed incursion. Fish survey biannually. Rehabilitate area and structure habitat, improve drainage so that conditions are not conducive to pest species. Manage aquatic weeds and pests

8.3 Water quality monitoring

8.3.1 Methods, timing, intensity and duration

Water quality impacts during construction represent a substantial threat to Oxleyan Pygmy Perch and Purple Spotted Gudgeon and therefore ongoing monitoring would be conducted at each monitoring location. Water quality can vary temporally, and therefore monthly monitoring is recommended immediately upstream, at and immediately downstream of the proposed crossing at each site during the construction phase of the project. Water quality monitoring would continue following completion of construction until the waterways rehabilitated to an equal or better condition than pre-construction.

The water quality monitoring program would focus sampling at known and potential OPP and PSG sites and include monitoring of basic physico-chemical parameters (pH, dissolved oxygen, electrical conductivity, water temperature, turbidity and total suspended solids), nutrients (total nitrogen, oxides of nitrogen, ammonia, total phosphorus and orthophosphates) and dissolved and trace metals (Al, As, Cd, Cr, Fe, Cu, Pb, Mg, Mn, Zn). In the event that water is to be released directly into known or potential OPP habitat, dissolved inorganic carbon, lime, and any other parameters associated with pre-release water treatment and which could impact water quality would be monitored. Flow and velocity would be monitored at the same time. The monitoring program would commence at least six months prior to any construction and would continue throughout the construction period on a monthly basis to assess any impacts associated with the construction. Monitoring would continue to be undertaken during operation on a quarterly basis and during high and low flow events consistent with the baseline surveys until such time as known impact can be identified.

Acute pollution events would be most likely to occur during rain events. Monitoring would also be measured during or immediately after heavy rainfall (15mm over 24 hours). This monitoring would occur upstream and downstream of construction sites on all of the waterways included in the monthly monitoring program. At least three events would be monitored during the construction period and at least three events monitored after the road is operational over a period of at least six months to determine whether run-off has had an adverse effect on the stream environment.

8.3.2 Performance indicators and corrective actions

In the interim, the monthly water quality monitoring data would be analysed as a time series that compare each downstream site with its paired upstream site to determine any substantial changes between sites that may be a results of the road construction. The data can also be compared against ANZECC/ARMCANZ (2000) default trigger values and the known tolerances of Oxleyan Pygmy Perch and Purple Spotted Gudgeon to identify if any observed changes are likely to be ecologically significant. Following the collection of sufficient data, ANZECC/ARMCANZ (2000) recommend the development of site specific trigger values that represent the 'current status' of ambient water quality at the sites. These 'current status' trigger values can be compared with future monitoring data to assess for stable, improving or deteriorating water quality status at each site.

Event based monitoring would be likely to give much more variable results than the monthly monitoring program therefore each event would be analysed separately. For each event, water quality downstream of the construction site would be compared against water quality immediately upstream of the construction site. Large differences between upstream and downstream sites would trigger further investigation to determine the source of particular pollutants and appropriate actions would be taken to address any identified problems.

The main performance thresholds and corrective actions have been outlined in **Table** 8-2.

Table 8-2 Performance thresholds for water quality

Performance thresholds	Timing and corrective actions
Pre-construction site survey of Class 1 and 2 waterways with potential habitat completed prior to construction.	Timing: Pre-construction Corrective actions: If surveys identify presence of Oxleyan Pygmy Perch or Purple Spotted Gudgeon then additional control sites would be selected and sampled. These control sites would be added to ongoing monitoring program.
Notable change in water quality from baseline conditions in the vicinity or downstream of the construction works. No evidence of sediment or erosion. No weed incursion.	Timing: Monthly and event monitoring and annual reporting. Corrective actions: Implement appropriate rehabilitation and reconstruction strategies. Rehabilitate area and structure habitat, improve drainage so that conditions are not conducive to pest species.
Analysis of monthly water quality data between paired upstream and downstream sites to determine any noticeable changes in water quality occurring during the operation of the project.	Immediate investigation into the specific cause so that appropriate remedial action can be taken. Review and modify monitoring program. Make physical changes to the structure or floor as appropriate.

8.4 Aquatic habitat monitoring

8.4.1 Methods, timing, intensity and duration

Quantitative habitat surveys would be undertaken at each of the threatened fish monitoring sites described in section 5.3.1. The recommended methods are the same as those used for the assessment of Sections 1 and 2 between Woolgoolga and Glenugie (GeoLink, 2012), which are based on the methods described in Pusey *et al.* (2004).

To complete the survey, three transects would be established perpendicular to the channel at each site. The location of these transects would be identified by dividing the site into three even segments and then randomly selecting a point in each segment. Wetted width and average water depth would be measured along each transect.

Four 0.5 m^2 quadrats would be randomly positioned along each transect. Fewer quadrats may be used in channels that have a wetted width of less than 2.5 metres. Substrate composition, woody debris cover and vegetation cover would be estimated within each transect to give a total of up to 12 quadrats for each site. Aquatic plants in each quadrat would also be identified and recorded.

Four transects would also be randomly positioned along each stream bank to estimate the amount of root masses, undercut bank, vegetation overhang and riparian vegetation cover at each site. The total length of the four transects would equal approximately 20 per cent of the wetted perimeter at each site.

Photo points would be established at each site with a GPS and repeat photographs would be taken from the same location on each survey. Quarterly surveys would be undertaken until such time as it can be established that the habitat has been restored effectively.

Habitat surveys would be conducted at the same time as the fish surveys.

8.4.2 Performance indicators and corrective actions

Any habitat changes that have been identified at construction sites or downstream of the construction area that was not also evident at sites immediately upstream of the project would be attributed to the construction or operation of the project. Such results would trigger immediate investigation into the specific cause so that appropriate remedial action can be taken such as replanting, replacing lost trees, weeding and physical modification.

The main performance thresholds and corrective actions have been outlined in **Table** 8-3.

Table 8-3 Performance thresholds for aquatic habitat monitoring

Performance thresholds	Timing and corrective actions
Pre-construction site survey of Class 1 and 2 waterways with potential habitat completed prior to construction. Pre-construction monitoring program to adequately identify baseline variation in abundance of Oxleyan Pygmy Perch and Purple Spotted Gudgeon. Oxleyan Pygmy Perch or Purple Spotted Gudgeon recorded.	Timing: Pre-construction Corrective action: If surveys identify presence of Oxleyan Pygmy Perch or Purple Spotted Gudgeon then additional control sites would be selected and sampled. These control sites would be added to ongoing monitoring program.
No notable change in stream habitat 100 metres above and below construction works, ie Macrophyte and woody snag cover. No notable change in natural stream flow and velocity 100 metres above and below construction activities. No increase in the abundance of Eastern Gambusia No weed incursion. Translocated threatened fish species present in ponds where fish were translocated too.	Timing: Construction (monthly, event biannual) and operation (biannual survey) Corrective actions: Implement appropriate rehabilitation and reconstruction strategies. Undertake actions to control (and where necessary remediate) any impacts arising as a result of construction activities. Relocation of native fish if work result in isolation of pools for any period of time or they become susceptible to drying or poor water quality. Rehabilitate area and structure habitat, improve drainage so that conditions are not conducive to pest species. If threatened fish species are not present in ponds where fish have been translocated to the translocation strategy would be reviewed with the DII (Fisheries).
Changes in habitat downstream of the construction area/upgraded highway that are not evident immediately upstream would be attributed to the operation of the upgraded highway. No increase the abundance of Eastern Gambusia. Fish found to be trapped or not using crossing structures.	Timing: Construction and operation Corrective actions: Immediate investigation into the specific cause so that appropriate remedial action can be taken. Review and modify monitoring program. Make physical changes to the structure or floor as appropriate.

8.5 Translocation

Should translocation of threatened fish be undertaken during construction monitoring of the effectiveness of the translocation would be required. Trapping in the pond where the fish have been translocated too to assess the presence of or absence of the threatened fish would be undertaken. Details of the capture and relocation are to be reported in the aquatic monitoring program and include fish species, number and health of species captured, location of recipient site. The recipient sites are to be added to the ongoing aquatic monitoring program.

8.6 Evaluation, project review and reporting

Short monthly reports would be prepared during construction, with a detailed report prepared outlining the results of any monitoring undertaken pertaining to the project annually. Annual reports would be prepared during the first three years on monitoring. The frequency and need for reporting would reviewed after this initial monitoring period.

8.6.1 Responsibility

The contractor employed to undertake the Oxleyan Pygmy Perch and Purple Spotted Gudgeon monitoring for each relevant project section would be responsible for the evaluation of the monitoring information collected.

8.6.2 Timing

A brief annual report would be prepared by the contractor for distribution to the Roads and Maritime and other relevant government agencies (DII (Fisheries), OEH and DSEWPaC) regarding the annual population counts.

A final report would be prepared at the conclusion of the monitoring period. This report would incorporate all the results of the monitoring and recommend any additional measures (if deemed necessary) to facilitate the long term survival of Oxleyan Pygmy Perch and Purple Spotted Gudgeon populations in the locality.

9. Summary table and implementation schedule

Table 9.1 provides an overall example summary of the actions proposed in the above plan. It also identifies the person responsible for the actions and the estimated timing of the project.

The program schedule would be updating following a review of the approval and project timelines.

Table 9-1: Summary table and implementation schedule of management plan

No.	Task	Responsibility	Pre-construction	Construction	Operational				
					Year 1	Year 2	Year 3	Year 4	Year 5
1. Pre-construction management									
1.1	Pre-construction monitoring and surveying to confirm monitoring sites.	Roads and Maritime/Contractors Ecologist	X						
1.2	Add/update as required (e.g. if OPP or PSG recorded)	Roads and Maritime/Contractors Ecologist	X						
2. Construction management									
2.1	Contractor induction and training	Roads and Maritime, Contractor		X					
2.2	Construction Method Statement (CMS)	Roads and Maritime, Contractor		X					
2.3	Implementation of erosion and sediment control and pollution control measures	Roads and Maritime, Contractor		X					
2.4	Location of temporary water crossings	Roads and Maritime, Contractor		X					
2.5	Translocation (if needed)	Roads and Maritime, Contractor		X					
2.6	Habitat restoration plan	Roads and Maritime, Contractor		X					
2.7	Construction monitoring and surveys	Roads and Maritime, Contractor		X					
3. Operational management									
3.1	Water quality monitoring	Roads and Maritime			X	X	X	X	X
3.2	Maintaining flow inspections and management	Roads and Maritime			X	X	X	X	X
3.3	Maintenance of restored habitat	Roads and Maritime			X	X	X	X	X
4. Monitoring program									
4.1	Fish survey								
4.2	Water quality monitoring	Roads and Maritime		X	X	X	X	X	X

No.	Task	Responsibility	Pre-construction	Construction	Operational				
					Year 1	Year 2	Year 3	Year 4	Year 5
4.3	Aquatic habitat monitoring								
4.4	Habitat restoration (until mitigation measures proven effective)	Roads and Maritime		X	X	X	X	X	X
4.5	Flow - inspection, maintenance and cleaning of culvert structures (until mitigation measures proven effective)	Roads and Maritime		X	X	X	X	X	X
4.6	Evaluation and reporting	Roads and Maritime		X	X	X	X	X	X

10. References

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Acronyms and abbreviations

Acronym / Abbreviation	Description
DP&I	Department of Planning and infrastructure
DSEWPaC	Department of Sustainability, Environment, Water, Population and Community
OEH	NSW Office of Environment
Project area	Are within the project boundary.
Study area	The study area encompasses the project boundary and any adjoining or adjacent habitat where potential indirect impacts may occur.
Roads and Maritime	Roads and Maritime Service

Appendix A – M.Birch CV

MATHEW BIRCH CURRICULUM VITAE

PERSONAL INFO

DOB: 25/11/1976
Languages: English, Spanish

QUALIFICATIONS

Bachelor of Science (Biological Sciences) (Hons Class 1), University of New South Wales

Bachelor of Arts (Spanish and Latin American Studies), University of New South Wales

PhD (Applied Aquatic Ecology) – University of New England - current undertaking

RECENT AQUATIC SCIENCE AND MANAGEMENT PROJECTS

November 2012 – March 2013

Project Title Groundwater Monitoring – Nambucca to Urunga Pacific Highway Upgrade, Environment Analysis Lab, GeoLINK, RMS.
Job Description Conduct field based data and sample collection of a groundwater monitoring project.

September 2012 – June 2013

Project Title Threatened Aquatic Species Monitoring – Woolgoolga to Glenugie Pacific Highway Upgrade, GeoLINK, RMS.
Job Description Extensive survey for threatened species of fish involving electrofishing and trapping. Monitor water quality and describe aquatic vegetation and habitats.

September 2012 – November 2012

Project Title Fish Salvage – Sapphire to Woolgoolga Pacific Highway Upgrade, GeoLINK, Leighton Fulton Hogan Joint Venture.
Job Description Capture and Translocation of fish from dewatered dams. Seine netting, fyke netting, trapping and hand netting under a wide variety of conditions.

July 2012

Project Title Fish Salvage – Bells Bridge Dewatering, RMS.
Job Description Capture and Translocation of fish from dewatered creek using traps and hand net. Provide advice on dewatering process.

April 2012 – Current

Project Title Coffs Creek Coastal Zone Management Plan, GeoLINK, Coffs Harbour City Council.
Job Description As part of a project team, prepare the Aquatic Ecological and Water Quality aspects of the Coffs Creek Coastal Zone Management Plan. Community and stakeholder consultation, literature review and strategy development.

Appendix B – M.Birch review

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Bellingen NSW 2454 | 0410 470 204 | ABN: 47576386408

Attention: Kim Collings

Senior Environmental Scientist

Sinclair Knight Merz.

9th September 2013

RE: W2B THREATENED SPECIES MANAGEMENT PLAN - REVIEW

Dear Kim,

Thank you for the invitation to contribute to a review of the Threatened Species Management Plan (TSMP) for Oxleyan Pygmy Perch (OPP) and Purple-Spotted Gudgeon (PSG) along the Pacific Highway upgrade between Woolgoolga and Ballina. Having reviewed the TSMP, background information relating to the project including the Biodiversity and Water Quality Working Papers and relevant sections of the Environmental Impact Study (EIS) in addition to a variety of articles relating to the species in question, I am submitting this letter by way of a response to the TSMP.

Background

The EIS for the Woolgoolga to Ballina section of the Pacific Highway upgrade has been on exhibition. Following review, various state government agencies have requested that TSMPs to be implemented during highway construction are prepared and accepted as a condition of approval of the EIS.

Among the threatened species identified as actually or potentially found along the upgrade corridor are the Oxleyan Pygmy Perch (*Nannoperca* oxleyana, OPP) and the Purple-spotted Gudgeon (*Mogurnda adspersa*, PSG). A draft TSMP has been prepared for OPP and PSG and comments from various state and federal government agencies have been incorporated. Roads and Maritime have requested that subject experts also review the draft plans prior to their acceptance.

Methods

In reviewing the TSMP for OPP and PSG, there were 5 specific tasks completed. They are as follows:

1. Review background information to the project, including the Environmental Impact Assessment and associated Biodiversity Working Paper.
2. Consider feedback provided from DSEWPaC, DP&I, EPA and DPI on the relevant draft Management Plan.
3. Provide a desktop review of the revised Management Plan from a scientific perspective of the relevant species addressed by the Management Plan.
4. Attend a teleconference debriefing to provide feedback on the Management Plan to Roads and Maritime and the authors.
5. Prepare a written review statement on the Management Plan on letter headed paper. This review should, as a minimum, provide feedback on the following key questions:

a. Is the design of the monitoring project appropriate for the species?
b. Is the frequency and timing of monitoring adequate?

c. Is the Management Plan clear on what basis the monitoring locations would be selected?
d. Are appropriate goals being set?
e. Are the mitigation and management actions sufficiently targeted for the species?
f. Are the objectives, performance measures, corrective actions and thresholds for corrective actions in accordance with SMART principles?
g. Do the management measure objectives, performance indicators, thresholds and corrective actions link sufficiently to allow effective implementation?
h. Has the Management Plan provided sufficient evidence where the proposed mitigation has previously been effective?
i. Does the Management Plan describe and discuss contingencies, should the proposed measures be ineffective?
j. If we can't demonstrate mitigation proposed will be effective, can we demonstrate that corrective actions will be effective?
k. Where there is no known research / evidence of the effectiveness of the specific measure proposed – have relevant alternative contingencies been committed to?
l. Have indirect impacts been addressed in the Management Plan, as relevant?

Review Statement

In general, the draft (version 0.4, August 2013) Threatened Species Management Plan prepared for OPP and PSG is comprehensive and well structured. It includes goals, mitigation measures performance thresholds and contingencies for each of the three phases of the project that comply with SMART principles, link together appropriately and are targeted to the species in question. The TSMP has been prepared in a way that demonstrates a clear understanding of the conservation and ecology of OPP and PSG. The recommendations of this review are mostly of a minor nature, as all of the key points are addressed in the TSMP. The draft TSMP does, however, contain sufficient spelling and grammatical errors to impede the clarity of some sections. A spelling and grammar review prior to finalisation of the document will improve its readability.

a. Is the design of the monitoring project appropriate for the species?

The monitoring program described in Section 8 of the TSMP includes a fish survey, water quality monitoring, aquatic habitat monitoring and translocation monitoring.

The methods described in the fish survey design of the monitoring program adhere to the accepted best practices for monitoring OPP as described by DSEWPaC (2011) and Knight *et al*. (2007b). The report includes recommended settings for backpack electrofishing with the important inclusion of adjusting voltage, current and pulse frequency to ensure animals are not harmed. The methods described adequately balance capture of both OPP and PSG and management of their wellbeing during the survey.

The methods described in the Water Quality Monitoring include monthly and event monitoring of basic physico-chemical parameters and total suspended solids. These are appropriate parameters to gain an understanding of water quality impacts upon OPP as the tolerance ranges to physico-chemical parameters are reasonably well described (Knight & Arthrington 2008, Pusey *et al*. 2004) and the potential impacts of suspended solids on reproductive and feeding success are well described in Section 2.3.2 of the TSMP. However, nutrient enrichment and contamination with toxic substances can also have impacts upon OPP (DPI 2007), and it is a recommendation of this report that analyses of nutrients (total nitrogen, oxides of nitrogen, ammonia, total phosphorus, orthophosphates) and a series of dissolved and total trace metals (particularly those that become more toxic at low pH, e.g. aluminium) be included in water quality monitoring. Furthermore, to account for potential impacts of tannin leachates and the treatment of stored water it is a recommendation of this review that dissolved inorganic carbon and lime pollution are also monitored. Any additional pre-release water treatment measures with the potential to impact upon water quality with respect to OPP should also be included in the suite of water quality parameters monitored.

The methods described in the Aquatic Habitat Monitoring are clearly outlined in Section 8.4.1 of the TSMP. The methods are appropriate for describing the habitats in the types of waterways frequented by PSG and OPP and also for capturing natural habitat variability in such waterways.

b. Is the frequency and timing of monitoring adequate?

The TSMP is not entirely clear on the frequency of monitoring of OPP and PSG. Monitoring is referred to as biannual in Table 6-1 but annual in Table 5-1 (preconstruction). In all cases it is scheduled to be undertaken in May/June. The TSMP proposes that no monitoring is to be undertaken during the breeding season which can begin in October and last through to May (Knight *et al*. 2012). Realistically, this leaves the opportunity for a maximum of two surveys per year, one in late May - early June and one in Late August early September. If only one survey is to be undertaken annually it should be scheduled for late May, early June, following the breeding season and prior to the (typically) dry winter season when the potential range for OPP contracts.

Water quality monitoring is proposed to be undertaken on a monthly basis prior to and during construction and quarterly basis during the operational phase. Additional event based samples are also proposed, although this section of the TSMP does not include a definition for heavy rainfall (i.e. how many mm/24hr period at which weather stations). Monthly monitoring backed up by event based monitoring should be adequate to form a useful baseline and to assess the impacts of construction on water quality. It is a recommendation of this review that the definition of a heavy rainfall event (with respect to triggering extra water quality monitoring) is included in the TSMP.

Aquatic habitat surveys are proposed to be undertaken at the same time as fish surveys. Timing the surveys in this way will minimise the impact of survey work on fish and their habitat.

Changes to natural stream flow and velocity have been identified as key threats to OPP (DPI 2005). The TSMP suggests that stream velocity would be measured during fish and habitat monitoring. However, fish and habitat monitoring are currently not proposed to be undertaken at sufficient frequencies adequately sample the range of flow and velocity conditions during the pre-construction, construction and operational phases. It is a recommendation of this review that monitoring of stream velocity should be undertaken at the same frequency as water quality monitoring (ie, monthly and following rainfall events). This may require amending the current water quality monitoring programs for the various Woolgoolga to Ballina highway upgrade sections. In order to assess the goal of no change in hydrological conditions an adequate baseline of water velocity conditions need to be collected.

c. Is the Management Plan clear on what basis the monitoring locations would be selected?

The TSMP describes the selection of impact and control sites for fish monitoring under Section 8.2.1.

The methods for selecting impact fish and habitat monitoring sites are clearly outlined in the TSMP. Impact fish and habitat monitoring sites are to be selected following the outcomes of the targeted surveys. The sites will be selected based upon the location of known or potential habitat for OPP and PSG. It is important that both known and potential habitat are monitored, as OPP are thought to have extensive dispersal abilities and habitat fragmentation is one of the key threats implicated in the decline of OPP (Knight *et al*. 2009, Knight *et al*. 2012). Continued monitoring at sites with *potential* habitat for PSG and OPP will also allow performance thresholds to be assessed. Although OPP are regarded as habitat specialists, applying the known range of water quality values and habitat types of OPP to a survey of *potential* habitats for OPP will result in a large number of potential sites. In order to contain the number of survey sites to a realistic figure it is a suggested that a ranking system be developed to utilise water quality and habitat information generated during the targeted surveys. For example, each site could be scored and ranked on its:

- Distance (along stream) from known OPP populations;
- pH at the time of the survey;
- ratio of sand/mud in benthic material;
- presence/absence of undercut banks and root mass along banks;
- proportion of emergent rushes and submerged vegetation;
- observed proportion and abundance of *Gambusia holbrooki*.

It is anticipated that this measure would result in a smaller number of total sites for monitoring and therefore more efficient use of resources.

The basis given in the TSMP for selecting control fishing and habitat monitoring sites is clear. According to the TSMP a control site is to be selected for every site with a confirmed population as determined by the targeted surveys (which are being undertaken in order to inform the detailed design phase). At present the TSMP suggests that control sites should be located upstream of the upgrade corridor but may need to be located downstream due to a lack of suitable habitat upstream. A figure of 2km is given as a minimum distance upstream for the suitable location of the control site. No equivalent downstream distance is provided. There is potential for some difficulty finding suitable control sites using this protocol. In some cases there may be difficulty finding appropriate control sites without access constraints within the same drainage area (upstream or downstream), subcatchment or catchment. Setting one monitoring control site for each population located within the construction corridor is suitable. However, it is a recommendation of this review that the protocol for selecting control sites be reviewed and that it include a hierarchy of principles. A suggested hierarchy would be:

1. Control site located >2km upstream of impact site;
2. Control site located >1km upstream of impact site;
3. Control site located >2km downstream of impact site;
4. Control site located in different drainage, >2km upstream of any other impact site;

Water quality monitoring sites are to be located immediately upstream and immediately downstream of the proposed crossings at known and potential OPP and PSG sites.

d. Are appropriate goals being set?

The goals for management have been presented for the pre-construction (Section 5.2 and Table 5-1), construction (Section 6.2 and Table 6-1) and operational phases of the project (Section 7.2 and Table 7-1).

The goals for the pre-construction phase are to re-confirm the presence or absence of threatened fish species and to identify the final set of monitoring locations. These are appropriate goals for the species and realisation of these goals will assist species management and monitoring in the construction and operational phases of the project. However, it is a recommendation of this review that presence absence of suitable habitat and potential corridors between existing populations and/or areas of high quality habitat should be identified at this stage also and should be added to the list of goals under Section 5.2. A further recommendation is that the identification of baseline water quality and habitat conditions is also added to the list of pre-construction goals listed in Section 5.2 (the text under Section 5.3.1 indicates that this is planned).

The listed goals for the construction phase of the project are:

- no negative changes in in stream habitat;
- no deterioration of water quality;
- no hydrological changes;
- no increased in abundance of *Gambusia holbrooki*; and
- successful translocation of fish species.

These goals are appropriate for the species and their realisation will ensure that impacts from the construction phase of the project are minimised. Habitat loss and fragmentation, sedimentation and pollution of water, changes to hydrology and increasing abundance of the *G. holbrooki* have been identified as key threats to OPP (Knight *et al*. 2012, DPI 2005) and PSG (DPI 2013). Direct impacts of construction work may need to be avoided by translocation. Other relevant threats that have been identified include lack of community awareness (DPI 2005) and changes to riparian habitats (Knight *et al*. 2012). It is a recommendation that minimal change to riparian habitats be included as a goal under Section 6.2 along with promoting awareness among the construction staff, all contactors and the general community (riparian habitat restoration is addressed under Section 6.3.7 and management measures addressing awareness are already in place under Section 6.3.2). A further recommendation of this review is that design parameters of crossings should be used to maintain existing water velocity/flow by utilising existing cross sectional areas, substrate and in-stream habitats in areas of known and potential OPP habitat. Where existing water velocities are not adequately described a maximum water velocity of 0.3m/s should be included as a design goal for water crossings over known and potential OPP habitat. Where translocations are required they should be over as small a distance as feasible and translocations between catchments should be avoided (Knight *et al*. 2009)

The listed goals for the operational phase of the project are to maintain water quality and hydrological conditions. These goals are appropriate for both OPP and PSG and along with the goals for the pre-construction and construction phases should ensure minimal impact upon both species.

The OPP Recovery Plan (DPI 2005) includes increasing habitat connectivity as a goal. It is a recommendation of this review that the TSMP adopt the goal of an increase in habitat connectivity via rehabilitation of vegetative habitat in degraded drains and waterways forming potential corridors on Roads and Maritime acquired land. For example, degraded agricultural drains through Roads and Maritime acquired land could be revegetated to increase available habitat for OPP and improve connectivity. The TSMP could include a list of aquatic plants that OPP are commonly associated with, to be updated following the targeted survey. The list (following DPI 2005) would include emergent rushes (eg. *Lepironia articulata*, *Schoenus brevifolius*, *Restio (Baloskion) pallens*, *Eleocharis* spp., *Gahnia* sp., *Juncus* sp.), water lilies (*Nymphaea* sp.), bladderworts (*Utricularia* sp.) and mosses (e.g. *Sphagnum falcatulum*). OPP are also found among leaf litter, root masses and occasionally woody debris (DPI 2005). A densely covered riparian zone, of typical *Banksia* and *Melaleuca spp*., is therefore also desirable. There is a well-documented history of rehabilitating and managing waterways in the Evans Head area to improve habitat for OPP (DECC 2009).

e. Are the mitigation and management actions sufficiently targeted for the species?

Mitigation and management measures are listed for the pre-construction (Section 5.3, Table 5-1) construction (Section 6.3, Table 6-1) and operational (Section 7.3, Table 7-1) phases of the project.

The pre-construction management and mitigation measures include a targeted fish and habitat survey, and baseline water quality survey. The methods and timing of the fish and habitat survey described in the TSMP conform to the accepted best practice for OPP and PSG (DSEWPaC 2011, although seine netting for PSG cannot be implemented due to restrictions for OPP). The water quality monitoring parameters described are targeted for the species as pH and suspended solids have been identified as having particular relevance to OPP and the tolerance ranges for both OPP and PSG are relatively well described (see Pusey *et al*. 2004). However, it is a recommendation of this review that some other parameters should be included (see question a, above).

The construction phase mitigation and management measures include:

- the preparation of construction work method statements (CWMS) for specific activities to address the management requirements for construction;
- induction and training activities for contractors and staff working in the areas of known and potential OPP and PSG habitat;
- design measures and timing restraints for construction around known and potential OPP and PSG habitat;
- design and construction measures for temporary watercourse crossings;
- fish translocation procedures;
- earthworks and sediment control; and
- habitat management and restoration.

The details of the proposed mitigation and management measures are extensive. In general the proposed mitigation and management are well targeted to the species as they address the relevant key threats to OPP and PSG, which are habitat fragmentation and loss, water pollution, changes to the hydrological regime, sedimentation and an increased abundance of *G. holbrooki* (Knight *et al*. 2012, DPI 2007, DPI 2013). In addition, the proposed timing restrictions will further minimise disturbances during the spawning season. However, the timing requirements in the TSMP list the OPP spawning season as October to December (p24), when the peak periods are reported to be October-December and February-April (Knight *et al*. 2012, updated from Knight *et al*. 2007a). It is a recommendation of this report that the reasons for this anomaly are clarified in the TSMP. It is understood that the Devils Pulpit Pacific Highway upgrade is being undertaken with the greatest levels of controls at OPP sites between October and December. It is also understood that similar approvals will be sought for the other OPP sites along the greater Woolgoolga to Ballina Pacific Highway upgrade. The proposed mitigation and management measures for the construction phase do not include pre-release water treatments. It is understood that this is because at this stage there is no planned release of stored water into waterways in OPP habitat. Instead, stored water is to be released via irrigation at a set distance from OPP habitat. It is a recommendation of this review that if no release of water into OPP habitat is planned then it should be made clear in the TSMP. If release of water into OPP habitat is to occur then it is important to ensure that:

- release of stored water into OPP habitat is undertaken only as a last resort;
- water released into OPP habitat is at a pH that matches the mean pre-construction pH of the waterway (as established during baseline water quality monitoring) to within 1 pH point;
- any chemical treatments used prior to the release of water stored in sediment basins will not persist in the environment or negatively impact upon the environment after release.
- potential treatments and/or their derivatives are included as parameters in baseline water quality monitoring.

The known water quality tolerances of OPP in NSW are presented in Table 1.1.

Table 1.1 Summary of water quality information from NSW sites where OPP have been collected.

Measure	*Range*	*Mean ± SE*
Temperature (°C)	10.9 – 28.3	16.1 ± 0.34
Dissolved Oxygen (mg/L)	2.15 – 10.02	6.42 ± 0.189
pH	3.32 – 6.9	4.47 ± 0.087
Conductivity (µS/cm)	68 - 2148	186 ± 22.7
Turbidity (NTU)	0 – 80	14 ± 3.6

From Knight & Arthrington (2008)

In addition, the habitat preferences of the species are well described in the literature down to the aquatic plants that are most often found at known OPP locations (Knight *et al*. 2009). This provides an opportunity along with information collected during the targeted surveys, to include a list of preferred aquatic plant species to utilise in any habitat restoration works (see Question d, above).

The management and mitigation measures proposed for the operational phase of the project include measures to protect water quality, maintain natural flow regimes and maintain restored habitat. These measures are also suitably targeted for the species, as they address the relevant potential threats posed by the highway upgrade; being water pollution, hydrological changes and habitat loss and fragmentation.

f. Are the objectives, performance measures, corrective actions and thresholds for corrective actions in accordance with SMART principles?

The objectives, performance measures and corrective actions and thresholds are in accordance with SMART principles.

The objectives performance measures, corrective actions and thresholds are specific in that they relate specifically to the threatened species in question and the current understanding of their conservation biology. They are also specific in that some of the objectives and measures are proposed in a flexible fashion so that they can be adjusted for individual water crossings along the upgrade alignment. They are mostly specific in the sense that they set clear goals but there are some exceptions to this. The exceptions include:

- No change in stream habitat (p 28) should include benthic material and riparian condition as measures in addition to woody debris and macrophytes;
- All of the goals set for the construction and operational phases could include reference to the thresholds set during pre-construction monitoring.

Measurable thresholds have been proposed for each of the individual goals and associated mitigation/management measures. In addition, for each of the thresholds that will rely on comparative information for their measurement, suitable data gathering has been proposed as part of the pre-construction surveys or comparisons will be made between upstream and downstream pairs of samples. For example, pre-construction surveys of water quality and in stream habitat will inform performance measurements for habitat management, habitat restoration, water quality control and sediment and erosion measures.

The majority of the proposed objectives, performance measures, corrective actions and thresholds are achievable. Many of the construction phase measures are currently being successfully implemented on the Devils Pulpit Highway upgrade. Some of the measures, such as targeted pre-construction surveys have been already been arranged. The only two performance thresholds that may be difficult to achieve are 'No increase in the abundance of Eastern Gambusia' and 'No notable change in stream habitat 100m above and below construction works'. Populations of Eastern Gambusia are likely to fluctuate in response to forces no under the control of the highway construction team and the rapid increases that are possible may not be captured in pre-construction surveys. In addition, at the immediate site of waterway crossings changes to the in-stream habitat are very likely, particularly with respect to submerged and emergent vegetation, and this should be acknowledged in the TSMP.

The objectives, performance measures and corrective actions and thresholds are focussed on results that reflect an understanding of the conservation biology of the species in question. For example, OPP are a habitat specialist with extensive dispersal capabilities and an opportunistic life-cycle strategy. This means that habitat connectivity and availability is of utmost importance and that disturbances during years where conditions are favourable could have long lasting negative consequences. The objectives, mitigation measures and performance thresholds all address the importance of these principles.

The majority of the objectives, performance measures and corrective actions and thresholds are not time time-based. For the pre-construction and construction phases of the project this is not possible as the construction starting dates and the length of the construction period are not known at this point in time. However, it is a recommendation of this review that: (if adherence to SMART principles is a goal for the TSMP)

- where possible the corrective actions should be given time frames for their implementation;
- post-construction objectives, measures, thresholds and corrective actions should be given time frames;
- water quality and flow/velocity objectives for the post construction phase should also be measured over a set number of rainfall events.

g. Do the management measure objectives, performance indicators, thresholds and corrective actions link sufficiently to allow effective implementation?

The objectives, monitoring, performance thresholds and corrective actions all link very well in the document. The tabular presentation of these aspects of the report (Tables 5-1, 6-1 and 7-1) demonstrates this neatly. Each objective has been listed along with the measures to achieve it, performance thresholds for its effectiveness and any related corrective actions.

h. Has the Management Plan provided sufficient evidence where the proposed mitigation has previously been effective?

An evaluation of the proposed mitigation measures is presented in Table 4-1 of the TSMP. The TSMP outlines the successes of many of the proposed measures at the Devils Pulpit upgrade. The evidence provided is sufficient, and where measures relate specifically to OPP the evidence from Devils Pulpit may be the only evidence available. The approach of monitoring outcomes at Devils Pulpit for success and adapting the TSMP accordingly is adequate. Where measures relate to general environmental management, such as bed and bank restoration, habitat restoration, sediment and erosion control and implementation of detention basins and operational spill basins more specific evidence could be provided.

i. Does the Management Plan describe and discuss contingencies, should the proposed measures be ineffective?

The TSMP describes corrective actions for all of the proposed mitigation measures, should they not meet the performance thresholds defined in the document. It is important to note that any new measures added as a result of this, or other reviews, should be incorporated into the TSMP with the relevant contingencies.

j. If we can't demonstrate mitigation proposed will be effective, can we demonstrate that corrective actions will be effective?

The proposed mitigation methods can be demonstrated to have been effective in comparable applications. However, in the case that one of or some of the performance thresholds are not met during the implementation of the plan, many of the corrective actions are non-specific and their effectiveness will be difficult to measure.

k. Where there is no known research/evidence of the effectiveness of the specific measure proposed – have relevant alternative contingencies been committed to?

All of the specific measures proposed have been demonstrated to be effective in previous applications.

l. Have indirect impacts been addressed in the Management Plan, as relevant?

Many indirect impacts of construction and operation have been explored and addressed within the TSMP. For example, the potential proliferations of aquatic weeds and invasive fish species due to habitat disturbances and changes to hydrology and water quality have been addressed. However, there are some indirect impacts of the construction period upon OPP that have not been considered. Indirect impacts upon existing populations of OPP outside of the immediate construction corridor have not been addressed in the plan. Although, habitat for OPP mapped by DPI (Fisheries) has been identified the fact that populations of OPP have been observed in the majority of these waterways has not been adequately explored in the background documents. This is of particular relevance in the cases where populations exist on both sides of the existing highway (for example between the two intersections with Rileys Hill Rd) and construction has the potential to increase the pressures causing habitat fragmentation and hydrological changes – both of which have been identified as key threatening processes (Knight *et al* 2012, DPI 2005). Indirect impacts upon OPP and PSG due to potential disturbance of acid sulphate soils, particularly in sections 8 and 9, have not been considered. It is a recommendation of this review that indirect impacts upon OPP populations outside of the construction corridor be considered and that the potential impacts of acid sulphate soil disturbance on OPP be considered in the TSMP.

m. Are qualifications and experience of authors in subject field relevant?

The authors are well qualified to prepare the Threatened Species Management Plan for OPP and PSG. All four of the authors have relevant graduate and postgraduate qualifications. Collectively the authors have practical experience in the design and delivery of fish surveys, water quality monitoring, environmental management of infrastructure projects, threatened species legislation, threatened species management and natural resource management generally.

n. Any other matters.

Along with the above suggestions, the following general issues were identified in the report:

- Under Section 7.3.2, 'Maintaining Flow', maintenance and cleaning of culvert structures should be done in accordance with principles set out in MA10 of the OPP Recovery Plan (DPI 2005). These
- Under Section 6.3.3, 'Design Principles', the third dot point should include substrate and vegetative habitat as controls for velocity;
- Under Section 6.3.6, 'Earthworks and Sediment Control' the fourth dot point should be updated to include waterways that are relevant to the TSMP; and
- Under Section 6.2, Eastern Gambusia and Plague Minnow are referred to as separate species. These are two common names for the same fish (*Gambusia holbrooki*), not separate species.

Conclusions

The TSMP is thorough and well organised. It is based on sound information contained in the working papers for biodiversity and water quality and the Environmental Impact Study. It focusses on managing the potential threats that have been identified in the literature as being most significant to OPP and PSG, being habitat loss and fragmentation, water pollution, hydrological changes and an increase in the abundance of *Gambusia holbrooki*. The TSMP describes a variety of management objectives and links them to actions, measurable thresholds and corrective actions in a way that should facilitate the implementation of the plan in its entirety and across the pre-construction, construction and operational phases. However, there are a number of minor recommendations arising from this review. They are presented in Table 1.2.

Table 1.2 Summary of recommendations arising from this review

Section	*Recommendation*
8.3	Analyses of nutrients (total nitrogen, oxides of nitrogen, ammonia, total phosphorus, orthophosphates) and a series of dissolved and total trace metals (particularly those that become more toxic at low pH, e.g. aluminium) should be included in water quality monitoring. All of these parameters, with the exception of oxides of nitrogen, are included in the draft Devils Pulpit to Ballina monitoring protocol for locations that are considered potential habitats for threatened fish. The TSMP should be updated to reflect this.
8.3	Where captured water is to be released directly into known or potential OPP habitat, dissolved inorganic carbon and lime pollution should also be monitored. In addition, any pre-release water treatment measures with the potential to impact upon water quality with respect to OPP should also be included in the suite of water quality parameters monitored at these sites;
8.3.1	The definition of a heavy rainfall event is included in the TSMP with respect to water quality monitoring. The draft Devils Pulpit to Ballina monitoring protocol utilises a figure of 15mm over a 24hr period to define a wet weather sample. The TSMP should be updated to reflect this;
8.2/8.3	Monitoring of stream flow and velocity should be undertaken under the same time frame as water quality monitoring at sites with known or potential habitat for OPP. The water quality monitoring plans for these sites should be amended to reflect this

Section	*Recommendation*
8.2.1	The protocol for selecting control sites should be reviewed and should include a hierarchy of principles. A suggested hierarchy would be: 1. Control site located >2km upstream of impact site; 2. Control site located >1km upstream of impact site; 3. Control site located >2km downstream of impact site; or 4. Control site located in a different drainage, >2km upstream of any other impact or control site.
5.2	The identification of presence or absence of suitable habitat and potential corridors between existing populations and/or areas of high quality habitat should be identified at this stage also and should be added to the list of goals under Section 5.2. Although it is clear in Section 5.3.1, the identification of baseline water quality and habitat conditions should also be added to the list of pre-construction goals listed in Section 5.2. It is understood that baseline water quality and habitat conditions are already being assessed.
6.2	Minimal change to riparian habitats should be included as a goal under Section 6.2 along with promoting awareness among the construction staff, all contactors and the general community.
6.3.3	The reasons for listing the OPP spawning season as October to December (p24), when the peak periods are reported to be October-December and February-April (Knight *et al*. 2012, updated from Knight *et al*. 2007a), should be clarified in the TSMP.
6.2	Benthic material and riparian condition in the measures for no change in habitat, as they are important features of habitat for OPP.
6 and 7	The TSMP should include reference to the thresholds identified during pre-construction monitoring in the goals set for construction and operational phases.
6.3	It is a recommendation of this review that if no release of water into OPP habitat is planned then it should be made clear in the TSMP. If release of water into OPP habitat is to occur then it is important to ensure that: ▪ release of stored water into OPP habitat is undertaken only as a last resort; ▪ water released into OPP habitat is at a pH that matches the mean pre-construction pH of the waterway (as established during baseline water quality monitoring) to within 1 pH point; ▪ any chemical treatments used prior to the release of water stored in sediment basins will not persist in the environment or negatively impact upon the environment after release. ▪ potential pre-release water treatments and/or their derivatives are included as parameters in baseline water quality monitoring.
6.2	The TSMP should acknowledge that populations of *Gambusia holbrooki* are likely to fluctuate in response to stochastic factors and that changes to the in-stream habitat at crossing sites are very likely, particularly with respect to submerged and emergent vegetation.
Tables 5-1, 6-1 and 7-1	Where possible the stated corrective actions should be given time frames for their implementation. Post construction objectives, measures and thresholds should also be given time frames for their implementation.
Table 7-1	Water quality and flow/velocity objectives for the post construction phase should also be measured over a set number of rainfall events;

Section	*Recommendation*
7	Indirect impacts upon known OPP populations outside of the construction corridor should be considered in addition to the potential impacts of acid sulphate soil disturbance on OPP.

In addition to the above recommendations, there are a number of suggestions arising from this review. These are presented in Table 1.3.

Table 1.3 Summary of suggestions arising from this review

Section	*Recommendation*
8.2	A ranking system could be developed to utilise water quality and habitat information generated during the targeted surveys to prioritise sites with potential habitat for continued monitoring.
7.2	The TSMP could adopt the goal of an increase in habitat connectivity via rehabilitation of vegetative habitat in degraded drains and waterways forming potential corridors for threatened fish on Roads and Maritime acquired land.

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Sincerely,

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Appendix C – Tannin leachate management procedure

This management protocol details the measures to be adopted to reduce the mobilisation of tannins within the project catchments. Tannins have been identified as a potential impact to water quality associated with construction related activities. High loads of tannin can be toxic and create an imbalance in the natural system. Measures so be implemented to mitigate potential impacts are provided below. Whilst previous studies have indicated that existing water quality is influenced by organic matter, baseline surface water quality monitoring would be undertaken to determine natural stream pH levels.

The construction related phases with risk to tannin mobilisation and the potential impacts are provided in the table below.

Construction related phase	Potential Impact
Clearing operations	Tannins from fresh cleared vegetation mobilising and entering waterways affecting visual clarity and contributing to chemical imbalance in waterway.
Storage of Mulch Stockpiles	Tannin leachate from mulch stockpiles mobilising and entering waterways affecting visual clarity and contributing to chemical imbalance in waterway.
Usage of mulch bunds as sediment control	Tannin leachate from mulch bunds mobilising and entering waterways affecting visual clarity and contributing to chemical imbalance in waterway.
Use of mulch for restoration/rehabilitation works	Tannin leachate from mulch used in rehabilitation mobilising and entering waterways affecting visual clarity and contributing to chemical imbalance in waterway.

For prevention and minimisation against potential impacts, there are mitigation measures that should be implemented during various phases, including prior to and during construction, during the planning phase etc. These measures include:

- Provide ready access to appropriate spill kit equipment and develop contingency plans and ready access to appropriate equipment on site to deal with any spills (Prior to construction).
- Prior to clearing operations, ESCPs to be developed and all sediment and erosion controls are to be installed on the ground (Prior to construction).
- The drainage line downstream of culverts would remain vegetated. However, where this area is to be cleared for ancillary or permanent design, the trees may be broken or cut down leaving the stump and all groundcover to stabilize the drainage path (At all times).
- Final clearing of the drainage lines would only occur when the construction is required in the area (at all times).
- Mulch Stockpiles to be located on ground above 1 in 100 ARI flood level for the Tabbimoble waterways and at least 100m from a waterway (Planning phase).

- Expectations are that a large volume of mulch would be generated onsite. Conservative estimates suggest that less than ¼ of the mulch generated would be required for rehabilitation and temporary sediment controls. The excess would be exported offsite to local industry or community. Potential receivers include local horticultural societies and sugar mills. Disposal options should be secured prior to mulch generation. It would be attempted to arrange the exportation of this material as soon as possible after mulching to mitigate the need for large volume storage areas on site. If disposal cannot occur within a short timeframe, storage of cut vegetation prior to mulching may be considered. The S 143 validation process would be followed for exportation of material offsite (during construction)
- Inspections of Mulch Stockpiles would be included in the Weekly Environmental Checklist and during rainfall. This would include inspections for any signs of tannin leachate breaching controls (weekly and during rainfall events)
- Where it is discovered that tannin Leachate is being mobilised beyond the controls. Corrective actions are to consider; Removal of mulch offsite; replacement with aged mulch from offsite and covering the mulch stockpiles to prevent water infiltration (at all times)
- The mulch stockpiles are to be a maximum of 3m in height and on relatively flat ground at least 5m from adjacent vegetation (at all times).
- The heights of the stockpiles are to be kept less than 3m to reduce the potential of internal combustion and reduce the stored volume of tannins to manage (at all times)
- They are to be surrounded upslope by clean water diversions and downslope to have sediment fence or catch drains and retention basin to capture any tannin leachate. The decision to put a tannin leachate catch drain and retention basin would depend on the specific location. Where the land is flat and vegetated it would not be necessary as leachate from the stockpile would not be effectively drained into a retention basin (at all times).
- Where a catch drain and leachate retention basin is used, the captured water cannot be discharged directly from the basin unless authorised in the EPL. The water is only to be used for dust suppression or soil conditioning on site after testing to be within limits for discharge to land (at all times).
- Mulch bunds are able to be used on the project for temporary sediment controls. However, there use is not to occur on the Tabbimoble Floodplains and inside the 1/100 ARI Flood Levels. These controls would be inspected weekly and during rain events (>10mm) as all other erosion and sediment controls (at all times).
- Monitoring for surface water would include NTU, DO, temperature and pH monitoring. The visual clarity (NTU) can be affected by tannins and organics can change pH. The WQO have been calculated from the baseline monitoring for the area and appear in the Surface Water Monitoring Plan (monthly, during instream works and prior to discharge of basins).
- A 60:40 topsoil / mulch would be used for rehabilitation of batters and disturbed. The mixture would be trialled on a small scale first to ensure its application stays on the batter and seed strike occurs (during rehabilitation / restoration works).

The location of proposed stockpiles would be documented in the Soil and Water Management Plan. Whilst there are numerous locations for stockpile sites, those located near a waterway are most likely to impact on water quality. These locations are:

- Section 1 (station 3.3-3.4) – stockpile near the Corindi River.
- Section 2 (station 19.1-19.8) – stockpile near Halfway Creek.
- Section 3 (station 45.6-46.0) – stockpile near Pillar Valley Creek.
- Section 4 (station 79.5-80.0) – stockpile near South Arm.
- Section 5 (station 86.0) – stockpile near James Creek.