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ARTC InlandRail

Inland Rail Programme

Narrabri to North Star Project

Environmental Impact Statement

Technical Report 3: **Aquatic Ecology Assessment**

Technical Report 4: **Commonwealth Matters Assessment**

Image: Newell Highway north of Narrabri, NSW

Technical Report 3:
Aquatic Ecology Assessment

Image: Railway and Newell Highway north of Narrabri, NSW

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AUSTRALIAN RAIL TRACK CORPORATION
INLAND RAIL - NARRABRI TO NORTH STAR EIS

Aquatic Ecology Assessment
IR Document Number: 02-2600-PE-P11-DE-0099

FINAL

October 2017

AUSTRALIAN RAIL TRACK CORPORATION INLAND RAIL - NARRABRI TO NORTH STAR EIS

Aquatic Ecology Assessment
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FINAL

Prepared by
Umwelt (Australia) Pty Limited
on behalf of
Australian Rail Track Corporation

Project Director: John Merrell
Project Manager: Lachlan Sweeney
Technical Director: Allison Riley
Technical Manager: Naomi Buchhorn
Report No. 3607/R08/Final
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Newcastle

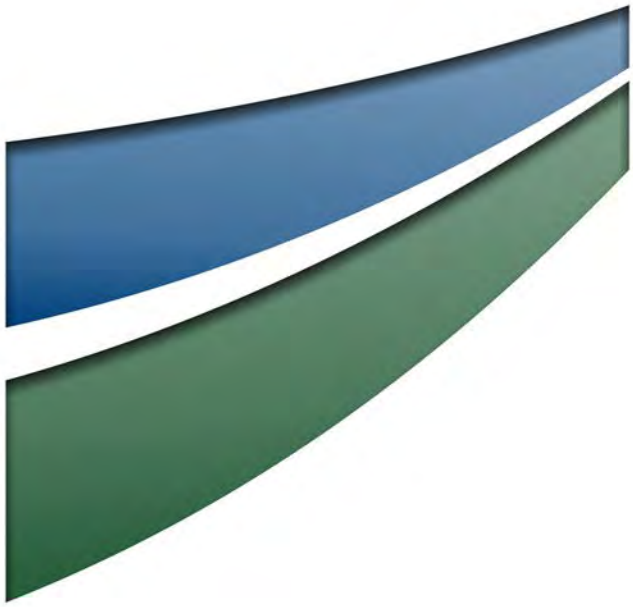
75 York Street
Teralba NSW 2284

Ph. 02 4950 5322

www.umwelt.com.au

This report was prepared using Umwelt's ISO 9001 certified Quality Management System.

Executive Summary



The Australian Government has committed to building a significant new piece of national transport infrastructure by constructing an inland railway between Melbourne and Brisbane, via central-west New South Wales (NSW) and Toowoomba in Queensland. The Inland Rail Project ('Inland Rail') is a major national Project that will enhance Australia's existing national rail network and serve the interstate freight market. This report relates to the Narrabri to North Star section of Inland Rail.

The proposal will involve upgrading the existing rail line between Narrabri and North Star including upgrading the existing track and track formation, replacing culverts and bridges, constructing five new crossing loops, rationalising and upgrading level crossings, curve easing and other ancillary works.

This Aquatic Ecology Assessment has been prepared on behalf of the Australian Rail Track Corporation (ARTC) to assess the potential impacts of the proposal on aquatic ecosystems.

The proposal crosses 82 mapped watercourses within three catchment areas of the Murray-Darling basin, being the Namoi, Gwydir and Border Rivers. While the watercourses range from first order streams to fifth order streams, the catchments are characterised by variable and unpredictable patterns of flow and water levels exacerbated by heavily cleared catchments and prevalence of agricultural land use, particularly irrigation.

The majority of watercourses in the proposal site are first order or second order streams with intermittent flow following rain events, little or poorly defined channels with no aquatic flora species. The watercourses have been modified by crossing structures for rail, road and agricultural land practices with minimal native vegetation retained along the banks of the watercourses.

There are 24 third order or higher streams within the proposal site. Analysis of key fish habitat values and sensitivity typing of the watercourses in combination with a literature review of fish community analysis by NSW DPI identifies that a number of these named watercourses have moderate or higher fish community value. The Mehi River and Gwydir River have both been identified as class 1 key fish habitat in accordance with NSW Department of Primary Industries (Fisheries) guidelines.

A number of state and Commonwealth listed threatened fish species, endangered populations and threatened ecological communities (TECs) are recorded or predicted to occur in major watercourses in the proposal site particularly the *Fisheries Management Act 1994* (FM Act) listed eel-tailed catfish endangered population and the *Environment Protection and Biodiversity Conservation Act 1999* listed Murray cod. Both species have been recorded in watercourses where there are no known barriers to fish passage and they may occur in aquatic habitats immediately upstream or downstream of the existing rail corridor. The Inland Rail alignment intersects watercourses that are part of the FM Act Aquatic Ecological Community in the Natural Drainage System of the Darling River Catchment. An assessment of significance of impact of the proposal on this community, threatened species and endangered populations has identified that the

proposal is unlikely to have an adverse impact, with the adoption of appropriately designed fish friendly crossing structures and other mitigation measures to further reduce impacts.

The assessment has considered the impact of the proposal on matters of national environmental significance as listed under the EPBC Act. No nationally listed endangered populations, TECs or aquatic migratory species are expected to occur in the watercourses within the proposal site.

Groundwater Dependent Ecosystems (GDEs) in the proposal site are associated with the riparian vegetation along major watercourses particularly the weeping myall open woodland (Gehan Creek), river red gum riparian tall woodland/open forest wetland (Gurly Creek, Mehi River, Gwydir River, Gil Gil Creek and Croppa Creek) and the coolabah – river coobah – lignum woodland wetland of frequently flooded floodplains and alluvial plains (Tycannah Creek). However, works to watercourse crossings are not expected to adversely alter local surface or groundwater flow regimes and the proposal is not expected to impact these GDEs.

Glossary

Additional assessment area	Additional area assessed outside the proposal site. It includes an approximate 60 metre buffer around culverts/underbridges and overbridges, an approximate 120 metre buffer around level crossings and some other areas to provide design flexibility for future planning
ARTC	Australian Rail Track Corporation
AUSRIVAS	Australian River Assessment System
BAR	Biodiversity Assessment Report
CEMP	Construction Environmental Management Plan
CMA Subregion	Catchment Management Authority Subregion
DECC	NSW Department of Environment and Climate Change (now OEH)
Distributary	Distributary or flood channels carry water from a river onto the floodplain.
DoEE	Commonwealth Department of the Environment and Energy
DPE	Department of Planning and Environment
DPI	Department of Primary Industries
EEC	Endangered Ecological Community
EP	Endangered Population
EP&A Act	*Environmental Planning and Assessment Act 1979* (NSW)
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth)
Existing rail corridor	The corridor within which existing rail infrastructure, subject to works as part of Inland Rail, are located. The existing rail corridor is defined by ARTC to mean everywhere within 15 metres of the outermost rails; or within the boundary fence where boundary fences are provided and are closer than 15 metres; or if the property boundary is less than 15 metres, the property boundary; or a permanent structure such as a fence, wall or level crossing separating the operating rail corridor from eased or non-operational land
FBA	Framework for Biodiversity Assessment
FM Act	*Fisheries Management Act 1994*
GDE	Groundwater Dependent Ecosystem
IBRA	Interim Biogeographic Regionalisation for Australia (Version 7)
IR	Inland Rail
KP	Kilometre point (rail line kilometrage)
LGA	Local Government Area
LPI	Land and Property Information
MNES	Matters of national environmental significance
NSW	New South Wales
OEH	Office of Environment and Heritage (NSW)
PCT	Plant Community Type
PMST	Protected Matters Search Tool

Proposal	The construction and operation of the Narrabri to North Star project
Proposal site	The area that would be directly affected by construction works. The proposal site is considered to have a width of 30 metres, providing for a 15 metre buffer on each side of the alignment centreline. It includes the location of proposal infrastructure, the area that would be directly disturbed by the movement of construction plant and machinery, and the location of the storage areas/compounds sites etc, that would be used to construct that infrastructure
SPRAT	Species Profile and Threats Database (Commonwealth)
SSI	State Significant Infrastructure
Strahler Stream Order	Classification system that gives a waterway an 'order' according to the number of tributaries associated with it.
TEC	Threatened Ecological Community
TSC Act	*Threatened Species Conservation Act 1995* (NSW)

Table of Contents

Figures

Plates

Tables

Appendices

Appendix A Survey Effort, Vegetation Map and Watercourse
Appendix B Key Fish Habitat Mapping, Narrabri, Moree-Plains and Gwydir LGAs

1.0 Introduction

1.1 Overview

The Australian Government has committed to delivering a significant piece of national transport infrastructure by constructing a high performance and direct interstate freight rail corridor between Melbourne and Brisbane. The Inland Rail programme (Inland Rail) involves the design and construction of a new inland rail connection, about 1,700 kilometres long, between Melbourne and Brisbane. Inland Rail is a transformational rail infrastructure initiative that will enhance Australia's existing national rail network and serve the interstate freight market.

Australian Rail Track Corporation Ltd (ARTC) is seeking approval to construct and operate the Narrabri to North Star section of Inland Rail ('the proposal'), which consists of 188 kilometres of upgraded rail track and associated facilities.

The proposal requires approval from the NSW Minister for Planning under Part 5.1 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act). The proposal is also a controlled action under the Commonwealth *Environment Protection Biodiversity Conservation Act 1999* (EPBC Act), and requires approval from the Australian Minister for the Environment and Energy.

This report has been prepared by Umwelt Pty Limited (Umwelt) as part of the environmental impact statement (EIS) for the proposal. The EIS has been prepared to accompany the application for approval of the proposal, and addresses the environmental assessment requirements of the Secretary of the Department of Planning and Environment (the SEARs), issued on 8 November 2016.

1.2 The Proposal

1.2.1 Location

The proposal is generally located in the existing rail corridor between the town of Narrabri and the village of North Star, via Moree. The location of the proposal is shown in **Figure 1.1**.

1.2.2 Key features

The key features of the proposal involve:

- upgrading the track, track formation, and culverts within the existing rail corridor for a distance of 188 kilometres between Narrabri and North Star
- realigning the track where required within the existing rail corridor to conform with required platform clearances for Inland Rail trains
- providing five new crossing loops within the existing rail corridor, at Bobbiwaa, Waterloo Creek, Tycannah Creek, Coolleearllee, and Murgo
- providing a new section of rail line at Camurra, about 1.6 kilometres long, to bypass the existing hairpin curve (the Camurra bypass)
- removing the existing bridges and providing new rail bridges over the Mehi and Gwydir Rivers and Croppa Creek

- realigning about 1.5 kilometres of the Newell Highway near Bellata, and providing a new road bridge over the existing rail corridor (the Newell Highway overbridge)

- providing a new road bridge over the existing rail corridor at Jones Avenue in Moree (the Jones Avenue overbridge).

The key features of the proposal are shown in **Figure 1.2**.

Ancillary work would include works to level crossings, signalling and communications, signage and fencing, and services and utilities.

Further information on the proposal is provided in the EIS.

1.2.3 Timing

Subject to approval of the proposal, construction is planned to start in early to mid 2018, and is expected to take about 24 months. Existing train operations along the Narrabri to North Star line would continue prior to, during, and following construction. Inland Rail as a whole is expected to be operational in 2025.

1.2.4 Operation

Prior to the opening of Inland Rail as a whole, the proposal would be used by existing rail traffic, which includes trains carrying passengers and grain at an average rate of about four trains per day. It is estimated that the operation of Inland Rail would involve an annual average of about 10 trains per day travelling north of Moree (between North Star and Moree) and 12 trains per day travelling south of Moree (between Moree and Narrabri) in 2025. This would increase to about 19 trains per day north of Moree (between North Star and Moree) and 21 trains per day south of Moree (between Moree and Narrabri) in 2040. The trains would be a mix of grain, intermodal (freight), and other general transport trains.

Once operational in 2025, the proposal would enable increased train running speeds in many areas that are currently the subject of restrictions due to local track conditions. Daily average train volumes are not expected to significantly change until Inland Rail through connection in 2025.

1.3 Purpose and Scope of this Report

The purpose of this report is to assess potential aquatic ecology issues from the operation and construction of the proposal, and where required, identify feasible and reasonable mitigation measures.

This aquatic ecology assessment has been prepared to address the Secretary's Environmental Assessment Requirements (SEARs). **Table 1.1** outlines the requirements relevant to this assessment.

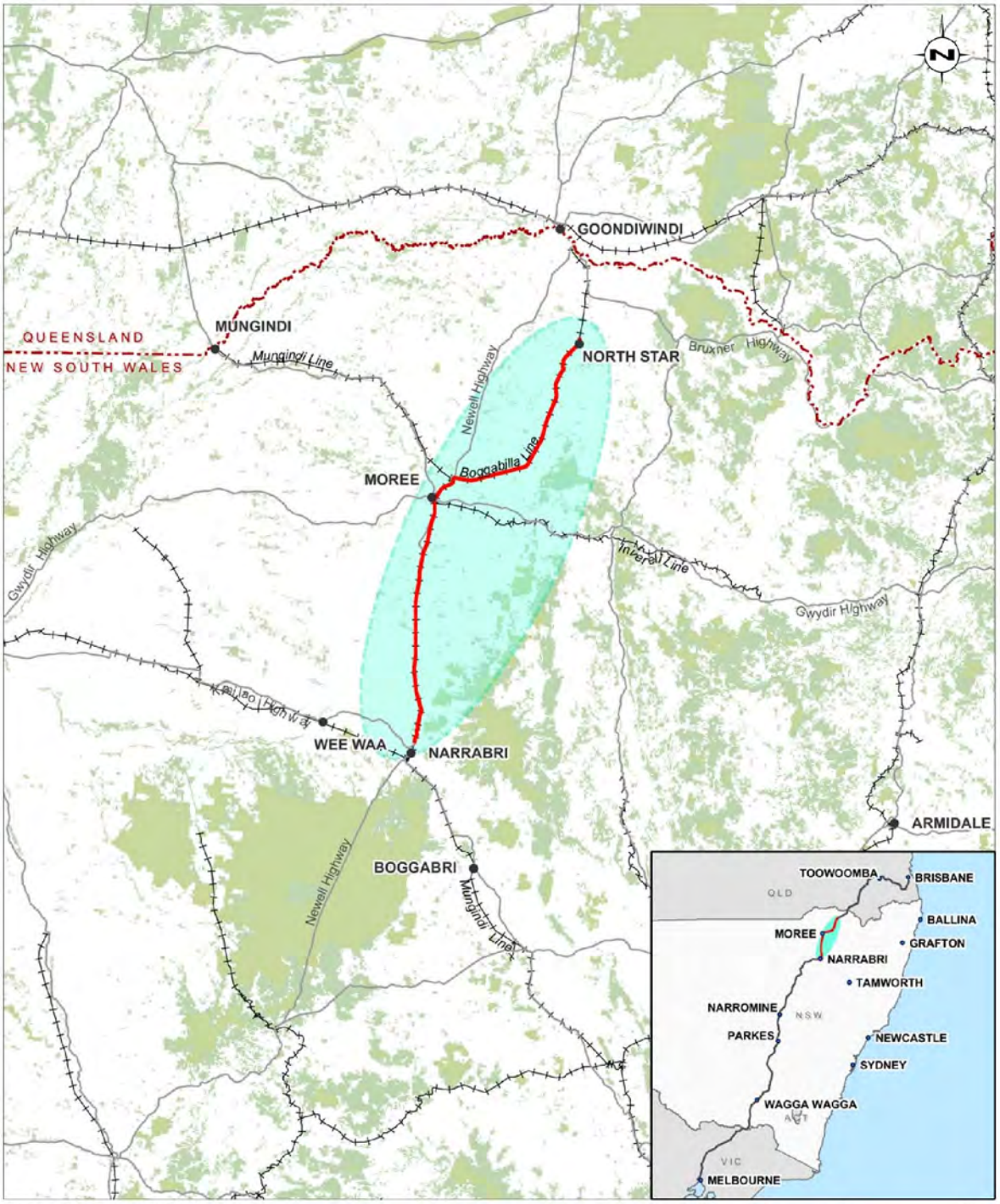
Specifically, this assessment:

- describes the existing general aquatic environment with a particular focus on waterway crossings, in terms of ecological values, including type and condition of aquatic habitats and groundwater dependent ecosystems

- determines the presence or likelihood of occurrence of threatened species, populations and Endangered Ecological Communities (EECs)as listed under the *Fisheries Management Act 1994* (FM Act)

- determines the presence or likelihood of occurrence of aquatic matters of national environmental significance (MNES) as listed under the *Environment Biodiversity and Conservation Act 1999* (EPBC Act)

- identifies threatened fish species, populations and ecological communities within the study area that have the potential to be impacted by the Project
- assesses the impact of the proposal on threatened fish species, populations and ecological communities.



LEGEND

- Proposal site
- Proposal location
- Main road
- Railway
- State border

FIGURE 1.1

Location of the Proposal

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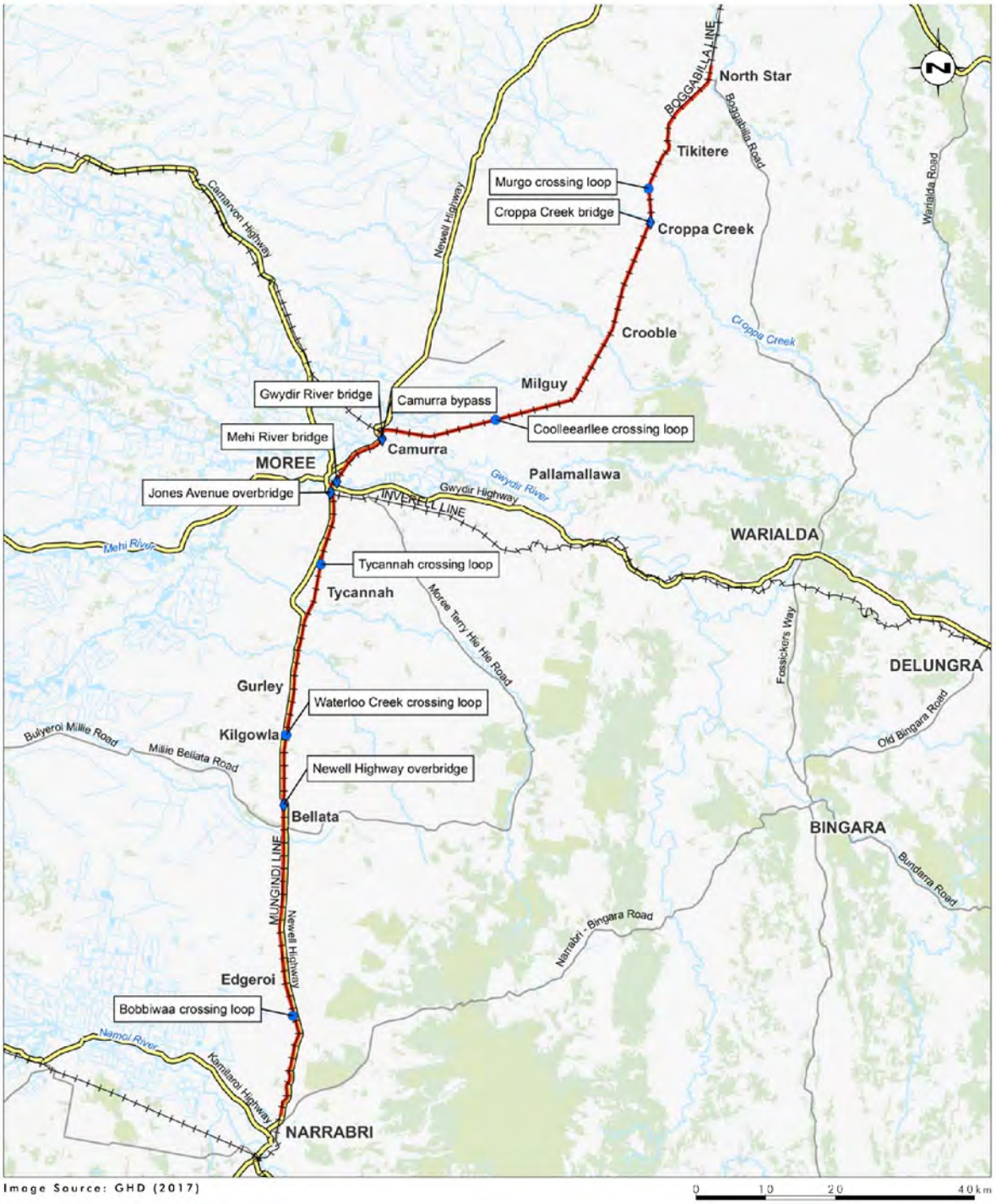

LEGEND

- New bridge
- Crossing loop
- The proposal
- Railway
- Highway
- Road

FIGURE 1.2

Key Features of the Proposal

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Table 1.1 Relevant SEARs

Agency/Key Issue/Requirements for Aquatic Ecology	Where addressed in this report
DPE SEARs – Biodiversity	
The Proponent must assess any impacts on biodiversity values not covered by the FBA as specified in s2.3	Section 4
The Proponent must identify whether the Project as a whole, or any component of the Project, would be classified as a Key Threatening Process in accordance with the listing in the *Threatened Species Conservation Action 1995* (TSC Act), *Fisheries Management Act 1994* (FM Act) and *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)	Section 4
Guidelines: • Framework for Biodiversity Assessment – Appendix 2 (OEH, 2014); • Policy and Guidelines for Fish Habitat Conservation and Management - Update (DPI, 2013); • Why do fish need to cross the road? Fish passage requirements for waterway crossings (NSW Fisheries 2003); and • Aquatic Ecology in Environmental Impact Assessment EIA Guideline (Marcus Lincoln Smith 2003).	This report
DPE SEARs – Protected and Sensitive Lands	
The Proponent must assess the impacts of the Project on environmentally sensitive land and processes (and the impact of processes on the Project) including, but not limited to: (a) protected areas (including land and water) managed by OEH and/or DPI Fisheries under the *National Parks and Wildlife Act 1974*; (b) Key Fish Habitat as mapped and defined in accordance with the *Fisheries Management Act 1994* (FM Act); (c) waterfront land as defined in the *Water Management Act 2000*; (d) land or waters identified as Critical Habitat under the TSC Act, FM Act or EPBC Act; and (e) biobank sites, private conservation lands and other lands identified as offsets.	Section 4 addresses aspects relevant to aquatic ecology

Agency/Key Issue/Requirements for Aquatic Ecology	Where addressed in this report
DPE SEARs – Water Hydrology	
The Proponent must describe (and map) the existing hydrological regime for any surface and groundwater resource (including reliance by users and for ecological purposes) likely to be impacted by the Project, including stream orders, as per the FBA.	Section 3 addresses aspects relevant to aquatic ecology
The Proponent must assess (and model if appropriate) the impact of the construction and operation of the Project and any ancillary facilities (both built elements and discharges) on surface and groundwater hydrology in accordance with the current guidelines, including: (a) natural processes within rivers, wetlands, estuaries, marine waters and floodplains that affect the health of the fluvial, riparian, estuarine or marine system and landscape health (such as modified discharge volumes, durations and velocities), aquatic connectivity and access to habitat for spawning and refuge; (b) direct or indirect increases in erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses;	Section 4 addresses aspects relevant to aquatic ecology
Guidelines: • Framework for Biodiversity Assessment – Appendix 2 (OEH, 2014) • Risk assessment Guidelines for Groundwater Dependent Ecosystems (Office of Water, 2012).	Section 3 and 4
Department of Primary Industries (Water)	
Assessment of impacts on surface and ground water sources (both quality and quantity), related infrastructure, adjacent licensed water users, basic landholder rights, watercourses, riparian land, and groundwater dependent ecosystems, and measures proposed to reduce and mitigate these impacts.	Section 4 addresses aspects relevant to aquatic ecology
Department of Primary Industries (Fisheries)	
The environmental assessment should specifically address the impacts on the aquatic ecology, waterway crossings and riparian buffer zones.	Section 4

Agency/Key Issue/Requirements for Aquatic Ecology	Where addressed in this report
General Aquatic Ecological Assessment The aquatic ecological environmental assessment should include the following information:	Section 3
• A recent aerial photograph (preferably colour) of the locality (or reproduction of such a photograph) should be provided.	Section 3
• Area which may be affected either directly or indirectly by the development or activity should be identified and shown on an appropriately scaled map (and aerial photographs).	Figure A.1 to A56
• Waterways within the area of development are to be identified.	Section 3
• Description and quantification of aquatic and riparian vegetation should be presented and mapped. This should include an assessment of the extent and condition of riparian vegetation and the extent and condition of freshwater aquatic vegetation and the presence of significant habitat features (e.g. gravel beds, snags, reed beds, etc).	Section 3 and Figure A.1 to A56
• Quantification of the extent of aquatic and riparian habitat removal or modification which will result from the proposed development	Section 4
• Details of the location of all waterways crossings and construction designs, such as bridges, culverts, or temporary access tracks.	Section 3
• Aspects of the management of the Project, both during construction and after completion, which relate to impact minimisation.	Section 4

Agency/Key Issue/Requirements for Aquatic Ecology	Where addressed in this report
Waterway Crossings DPI Fisheries need to be consulted with regards to the crossing methodology and site specific mitigation measures for replacement of culverts and bridges in watercourses that are considered to be Key Fish Habitat. The design and construction of bridges, culverts, and temporary access tracks across all waterways should be undertaken in accordance with the Department's *Policy and Guidelines for Fish Habitat Conservation and Management* (Update 2013). The replacement of waterway crossings needs to ensure that the works are undertaken with minimal impact on the aquatic environment within the immediate vicinity of the proposed works. The environmental assessment should provide details on methods of dredging, duration and timing of works, and the proposed mitigation measures to protect riparian and aquatic habitat. Another concern is the requirement to avoid temporary waterway crossings for heavy machinery wherever possible. DPI Fisheries should be consulted with regards to any temporary measures that will result in blocking fish passage. This includes coffer dams, temporary access tracks or redirecting flows whilst works are conducted.	Section 4
Riparian Buffer Zones DPI Fisheries policy advocates the use of terrestrial buffer zones as per the *Policy and Guidelines for Fish Habitat Conservation and Management (Update 2013)* available on the Department's website at http://www.dpi.nsw.gov.au/fisheries/habitat/publications/policies,-guidelines-andmanuals/fish-habitat-conservation which states that "*NSW DPI will generally require riparian buffer zones to be established and maintained for developments or activities in or adjacent to TYPE 1 or 2 habitats or CLASS 1-3 waterways*." The department anticipate that adequate riparian buffer zones will be maintained adjacent to the 90 watercourses that will be crossed as part of this Project.	Section 4
Department of Primary Industries (Attachment A)	
Relevant Policies and Guidelines The EIS should take into account the following policies (as applicable): • Risk Assessment Guidelines for Groundwater Dependent Ecosystems (NOW, 2012); • NSW State Rivers and Estuary Policy (1993); • NSW Wetlands Policy (2010); • NSW State Groundwater Policy Framework Document (1997); • NSW State Groundwater Quality Protection Policy (1998); and • NSW State Groundwater Dependent Ecosystems Policy (2002).	This report

Agency/Key Issue/Requirements for Aquatic Ecology	Where addressed in this report

Groundwater Dependent Ecosystems
The EIS must consider the potential impacts on any Groundwater Dependent Ecosystems (GDEs) at the site and in the vicinity of the site and:
• Identify any potential impacts on GDEs as a result of the Project including:
  • the effect of the Project on the recharge to groundwater systems;
  • the potential to adversely affect the water quality of the underlying groundwater system and adjoining groundwater systems in hydraulic connections; and
  • the effect on the function of GDEs (habitat, groundwater levels, connectivity).
• Provide safeguard measures for any GDEs.
	Section 3.5

Watercourses, Wetlands and Riparian Land
The EIS should address the potential impacts of the Project on all watercourses likely to be affected by the Project, existing riparian vegetation and the rehabilitation of riparian land. It is recommended the EIS provides details on all watercourses potentially affected by the Project, including:
• Scaled plans showing the location of:
  • wetlands/swamps, watercourses and top of bank;
  • riparian corridor widths to be established along the creeks;
  • existing riparian vegetation surrounding the watercourses (identify any areas to be protected and any riparian vegetation proposed to be removed);
  • the site boundary, the footprint of the Project in relation to the watercourses and riparian areas; and
  • proposed location of any asset protection zones.
• Photographs of the watercourses/wetlands and a map showing the point from which the photos were taken;
• A detailed description of all potential impacts on the watercourses/riparian land;
• A detailed description of all potential impacts on the wetlands, including potential impacts to the wetlands hydrologic
	Appendix A provides maps of each watercourse.
	Descriptions of the watercourse and riparian corridor are provided in Section 3.
	Impact assessment addresses aspects relevant to aquatic ecology as provided in Section 4.

Agency/Key Issue/Requirements for Aquatic Ecology	Where addressed in this report
regime; groundwater recharge; habitat and any species that depend on the wetlands. • A description of the design features and measures to be incorporated to mitigate potential impacts. • Geomorphic and hydrological assessment of water courses including details of stream order (Strahler System), river style and energy regimes both in channel and on adjacent floodplains.	

1.4 Proposal Site Environmental Context

For the purpose of this assessment, the impacts of the proposal on aquatic ecology were assessed within the proposal site and within the additional assessment areas outside the proposal site that included, but were not limited to, the following:

- an approximate 60 metre buffer around culverts, underbridges and overbridges
- an approximate 120 metre buffer around the locations of level crossings.

This is a conservative approach intended to allow for design flexibility for future planning. The need for works in these additional assessment areas would be determined during detailed design. The variation between the proposal site and the additional assessment areas is shown in Figures A1 to A56 in **Appendix A**.

In addition, construction of the proposal would include ancillary activities such as the establishment of construction compounds, the upgrade of existing access tracks, the construction of new access tracks and works to alter existing powerlines. For the purposes of the current assessment, ground surface impacts associated with ancillary activities were considered to potentially occur within the specified areas that form part of the proposal site.

Two types of construction compound areas are proposed; minor compound/storage areas and larger compound sites. Minor compounds/storage areas are areas that would be used temporarily for the assembly of adjacent infrastructure such as culverts and turnouts. These compounds would be located within the rail corridor. Larger compound sites would be established for general construction activities associated with each stage of work, located within the proposal site.

1.4.1 Location

The proposal is located in the Brigalow Belt South and Darling Riverine Plains IBRA bioregions. A summary of the landscape features is provided in **Table 1.2**.

Table 1.2 Proposal Location in the Landscape

	Rail Line Location (KP)		
	573 – 673	**673 - 679.5**	**679.5 - 758.5**
IBRA Bioregion	Brigalow Belt South	Darling Riverine Plains	Brigalow Belt South
IBRA Subregion	Northern Outwash Northern Basalts	Castlereagh-Barwon	Northern Outwash Northern Basalts
Local Land Services	North West	North West	North West
Mitchell Landscapes	Belata Sands Gwydir Alluvial Plains Gwydir Channels and Floodplains Kaputar Slopes Namoi Channels and Floodplains	Gwydir Channels and Floodplains	Croppa Clay Plains Croppa Creek Channels and Floodplains Gwydir Alluvial Plains Yallaroi Basalts
LGA	Narrabri Moree Plains	Moree Plains	Moree Plains Gwydir
Major Surface Water Catchments	Namoi River Gwydir River (Mehi River)	Gwydir River	Gwydir River Border Rivers (Boomi River)

The southern section of the proposal is in the Narrabri local government area (LGA), the central section is located in the Moree Plains LGA and the northern section in the Gwydir LGA. The three LGAs are predominantly rural, with the main regional land uses based around agriculture (mainly grazing, grain and cotton production) with some urban land uses associated with the rural towns.

Narrabri, at the southern end of the proposal (**Figure 1.1** and **Figure 1.2**), is located approximately 447 kilometres south west of Brisbane, 521 kilometres north west of Sydney and 939 kilometres north east of Melbourne. It is located on the Namoi River at the junction of the Kamilaroi and Newell highways. The rail corridor passes through the town of Moree, approximately 96 kilometres north of Narrabri (**Figure 1.2**). Moree is located on the Mehi River at the junction of the Newell and Gwydir Highways. Both Moree and Narrabri are important regional towns providing a range of services to the surrounding areas. The proposal ends at the small town of North Star approximately 30 kilometres south of the NSW-Queensland border (**Figure 1.1**).

The width of the rail corridor varies between Narrabri and North Star. The rail corridor is defined by fences located approximately 20 metres either side of the rail line, however in some sections where fences are not present the rail corridor may be wider, extending out to about 30 to 40 metres from the rail line. The proposal site varies depending on the construction activities that are to take place in any given area. Further, the proposal may require works outside the rail corridor including those associated with curve easing and level crossing rationalisation. These works are anticipated to be generally in close proximity to the rail corridor subject to further design.

1.4.2 Proposal Site Topography and Natural Features

The proposal crosses 82 mapped watercourses including the Mehi River and Gwydir River; creeks such as Bobbiwaa Creek, Gehan Creek, Tycannah Creek and Gil Gil Creek; and other intermittent watercourses and canals constructed to convey irrigation waters (**Figure 1.3** and **Figure 1.4**). These watercourses occur within the Namoi, Gwydir or Border Rivers catchments in the north east of the Murray-Darling basin. Each of the watercourses occurring in the proposal site are shown in detail in Appendix A with a summary of the location of each relevant to the proposal site is shown on **Figure 1.5**.

The southern end of the proposal site is located immediately north of Narrabri on an embankment through the alluvial plains of the Namoi River (**Figure 1.3**). The Namoi River catchment represents approximately 4 per cent of the Murray-Darling Basin total catchment area and contributes approximately 3.2 per cent of the water to the basin. The Namoi River rises in the western slopes of the Moonbi Range and Great Dividing Range near Nundle, east of Tamworth flowing to the west, to Gunnedah then north west through Boggabri before it reaches Narrabri. Downstream of Narrabri the Namoi River flows across flat floodplain country to the Barwon River at Walgett (Green et al 2011a).

The Sustainable Rivers Audit 2 reported the overall ecosystem health of the Namoi River catchment at the end of a drought (2008-2010) as poor, the health of its fish community was rated as very poor with fewer than expected native species and a large number of introduced species (MDBA 2012). The condition of the macroinvertebrate community identified in the catchment was rated as moderate overall, though the lowland zone was rated poor (MDBA 2012). Riverine vegetation was also rated as poor condition overall, though the lowland zone rated higher and physical form rated moderate with notable effects of elevated sediment loads (MDBA 2012). Flow seasonality and variability was rated good (MDBA 2012).

The majority of the proposal site (between Edgeroi and Croppa Creek) occurs in the catchment of the Gwydir River. The Gwydir River catchment represents approximately 2.4 per cent of the Murray-Darling Basin total catchment area and contributes approximately 3.4 per cent of the water to the basin. The Gwydir River rises in the Great Dividing Range, west of Uralla and Guyra. Downstream of Moree, the Gwydir forms a delta-like structure with flows split into two major streams known as the Gingham Watercourse (northern arm) and the Lower Gwydir or Big Leather watercourse (southern arm), identified as the nationally significant Gwydir wetlands. The Gwydir River terminates in the Gwydir wetlands with river flows diverted into other distributaries include the Mehi River, Carole Creek and Gil Gil Creek.

A flood channel from the Gwydir River conveys the majority of flows from the Gwydir River into the Mehi River approximately 30 kilometres upstream of Moree (Green et al 2011b). Most of the surface water runoff into the Gwydir River is generated upstream of this point with minimal run off downstream due to terrain, absorbent soils and high evaporation (Green et al 2011b). The Mehi River flows to the south west through Moree eventually flowing into the Barwon River near Collarenebri. The proposal site crosses the Mehi River in Moree at approximately kilometre point (KP) 666 and the Gwydir River at KP 676 (**Figure 1.3** and **Figure 1.4**).

The Sustainable Rivers Audit 2 reported the overall ecosystem health of the Gwydir River catchment as poor (MDBA 2012). The health of fish community was rated poor with fewer than expected native species and an increasing number of introduced species (MDBA 2012). Macroinvertebrate community was rated moderate condition overall (MDBA 2012). Riverine vegetation was rated in moderate condition and overall hydrology was rated poor with lowland areas rated very poor (MDBA 2012).

North of the locality of Crooble, the proposal site crosses watercourses that flow via Whalan Creek to the Boomi River anabranch in the lower end of the Macintyre-Barwon river system in the Borders Rivers Catchment. The Boomi River flows into the Macintyre River and at that point the Macintyre River becomes the Barwon River (Welsh et al 2014).

Groundwater extraction in the Namoi River Catchment is one of the highest for any of the Murray-Darling basin catchments (MDBA). Groundwater is contained in the unconsolidated alluvial sediments along the Namoi River and its major tributaries (Green et al 2011a). West of Narrabri the catchment is underlain by the aquifers of the Great Artesian Basin (Green et al 2011a). The proposal site is located predominantly over the porous rock groundwater aquifer as mapped by Green et al (2011a).

The major groundwater aquifers in the Gwydir catchment are found in extensive unconsolidated alluvial sediments, associated with rivers and channels in the western half of the catchment west of Moree. Groundwater is found in fractured rock of several types in the eastern part of the catchment. There is a relatively small seam of porous rock aquifers in the middle of the catchment, which yields water from the Great Artesian Basin lying deep below the catchment (Green et al 2011b). The groundwater is heavily exploited for irrigation and domestic use. The proposal site is located predominantly over the inland alluvial groundwater aquifer as mapped by Green et al (2011b).

Within the Border Rivers catchment there is a high degree of connectivity between surface water features and the underlying groundwater systems (Green et al 2012). The western half of the catchment is underlain by the permeable sandstone aquifers of the Great Artesian Basin (Green et al 2012). North Star and Croppa Creek area is to the east of the Goondiwindi monocline and the top of the productive aquifer is less than 100 metres from the surface (Green et al 2012).

The landscape in the Gwydir subregion has been heavily modified with very little intact native vegetation cover and less than 0.4 per cent is managed for conservation (Welsh et al 2014). Across the subregion the floodplain woodlands of coolibah are the most extensive remnant community and the plains once supported extensive areas of native Mitchell and plains grass communities (Welsh et al 2014).

The majority of the proposal site has been heavily modified by past and ongoing disturbances associated with the rail corridor and surrounding agricultural activities. Clearance and maintenance of the rail corridor has resulted in the fragmentation and subsequent high level of disturbance and degradation of vegetation communities within the rail corridor. The proposal site passes through large areas of cotton production, an industry that is heavily reliant on irrigation that has required construction of diversion channels, dams and weirs.

Patches of native vegetation exist sporadically within the proposal site and are typically associated with adjacent Travelling Stock Reserves (TSRs), road reserves or farm woodland remnants. These patches generally comprised a woodland community with the dominant canopy species including bimble box (*Eucalyptus populnea*), belah (*Casuarina cristata*), silver-leaved ironbark (*Eucalyptus melanophloia*) and white cypress pine (*Callitris glaucophylla*). Extensive areas of natural grasslands also exist in the proposal site (Umwelt 2017a). Full description of the vegetation within the proposal site is provided in the Biodiversity Assessment Report (BAR) (Umwelt 2017a).

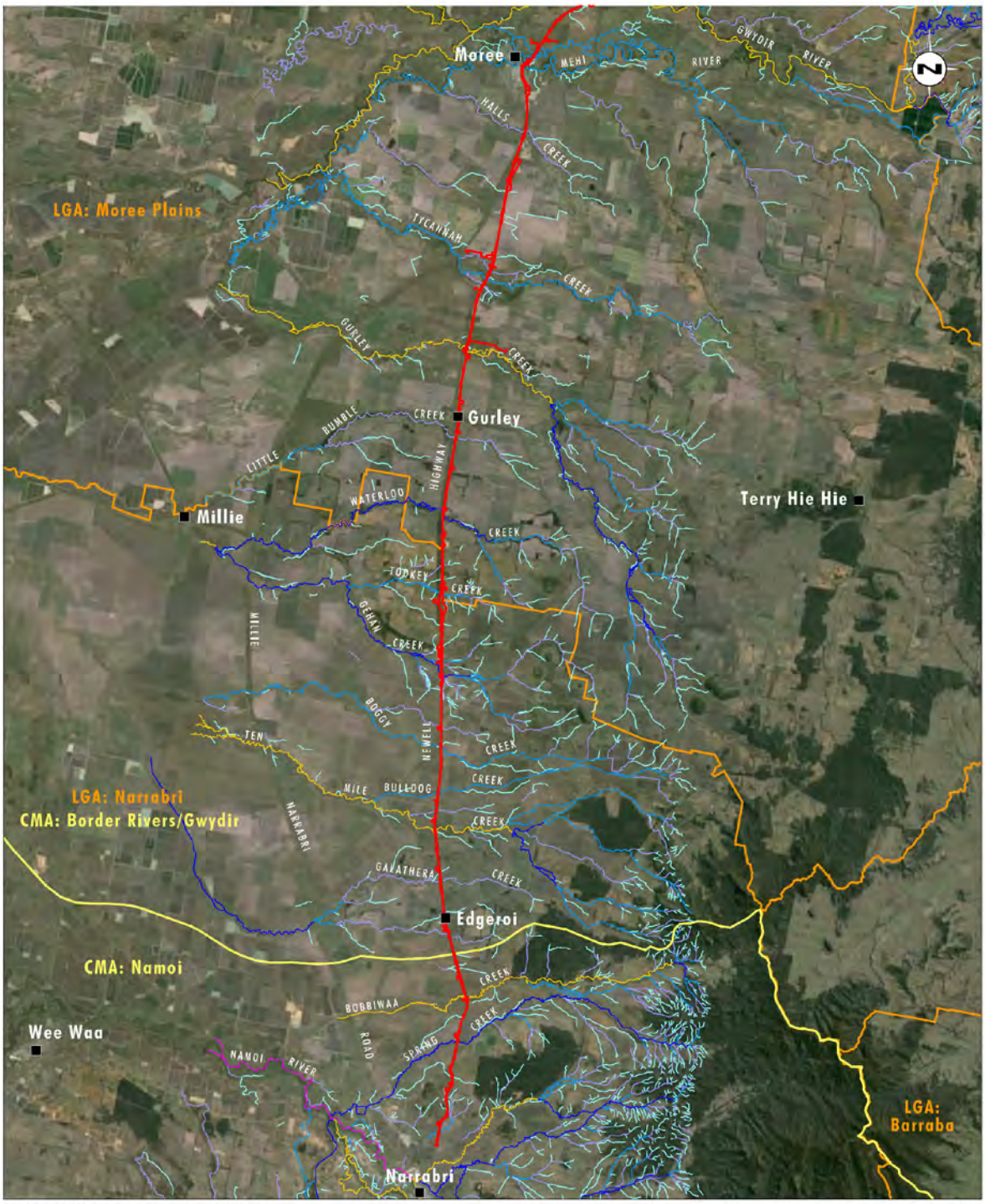


Image Source: Google Earth (2013)
Data Source: Geoscience Australia (2009), Parsons Brinckerhoff (2014), Umwelt (2016)

0 5 10 20km
1:450 000

Legend

- Proposal Site
- Local Government Area
- Catchment Management Authority
- Town Location

Stream Order:

- 1st Order
- 2nd Order
- 3rd Order
- 4th Order
- 5th Order
- 6th Order

FIGURE 1.3

Narrabri to Moree

File Name (A4): R08/3607_088.dgn
20170809 13.50

Image Source: Google Earth (2013)
Data Source: Geoscience Australia (2009), Parsons Brinckerhoff (2014), Umwelt (2016)

0 5 10 15km
1:350 000

Legend

- Proposal Site
- Local Government Area
- Town Location

Stream Order:
- 1st Order
- 2nd Order
- 3rd Order
- 4th Order
- 5th Order

FIGURE 1.4

Moree to North Star

File Name (A4): R08/3607_089.dgn
20170809 13.50

Legend

- Proposal Site
- Town Location

FIGURE 1.5

Narrabri to North Star Figures Map

1.5 Legislative Context

1.5.1 State

The proposal is declared State Significant Infrastructure and an EIS has been prepared under Part 5.1 of the EP&A Act. The environmental assessment requirements of the Secretary of the Department of Planning and Environment (the SEARs) have been issued and this report considers those requirements as relevant to aquatic species, communities and their habitat (**Table 1.1**) including impact on threatened fish, population and ecological communities as listed under the FM Act and EPBC Act and consideration of the protection and management of fish habitat and fish passage.

1.5.1.1 *Environmental Planning and Assessment Act 1979*

The *Environmental Planning and Assessment Act 1979* (EP&A Act) and the *Environmental Planning and Assessment Regulation 2000* (the Regulation) provide the framework for development assessment in NSW. The EP&A Act and the Regulation include provisions to ensure that the potential environmental impacts of a development are considered in the decision making process prior to proceeding to construction.

Part 5 of the EP&A Act defines the assessment process for proposals that do not require development consent. In accordance with the requirements of section 112, ARTC has formed the opinion that the proposal has the potential to significantly affect the environment. As a result, an EIS is being prepared.

Under section 115U(3), development may be declared to be State Significant Infrastructure if it is development *'that a State environmental planning policy permits to be carried out without development consent under Part 4: (a) infrastructure, (b) other development that (but for this Part and within the meaning of Part 5) would be an activity for which the proponent is also the determining authority and would, in the opinion of the proponent, require an environmental impact statement to be obtained under Part 5.*' As noted above, ARTC is of the opinion that an EIS is required and given that clause 14 and Schedule 3 of *State Environmental Planning Policy (State and Regional Development) 2011* permit the proposal to be carried out without development consent, the proposal is declared State Significant Infrastructure and under section 115W of the EP&A Act, the approval of the NSW Minister for Planning is required.

Under section 115ZG of the EP&A Act, a number of authorisations and the provisions of any act that may prohibit a State Significant Infrastructure Project, do not apply. Of relevance to this report is that a number of permits under the *Fisheries Management Act 1994* do not apply.

1.5.1.2 *Fisheries Management Act 1994*

The *Fisheries Management Act 1994* (FM Act) provides for the conservation, protection and management of fisheries, aquatic systems and habitats in NSW. The FM Act establishes mechanisms for:

- the listing of threatened species, populations and ecological communities or key threatening processes
- the declaration of critical habitat
- consideration and assessment of threatened species impacts in the development assessment process.

Section 3.4 of this report identifies threatened species, populations and communities likely to occur within the proposal site and **Section 4.1** of this report assesses likely impacts of the proposal in accordance with section 5A of the EP&A Act.

Division 3 of the FM Act provides for the conservation of the biodiversity of fish and aquatic vegetation and the protection of fish habitat though management of dredging and reclamation works. Upgrades of waterway structures such as bridges or culverts and the upgrade or construction of waterway crossings would require 'dredging' (excavation of water land or removal of material from water land) or 'reclamation' (using material to fill/reclaim or depositing material to construct anything other water land). Under section 199 a public authority must notify Fisheries and consider any matters raised by the department prior to carrying out dredging or reclamation work. **Section 3** of this report describes aquatic habitats and **Section 4** describes proposed works within the waterways.

Any upgrades of waterway structures and/or crossings will need to consider fish habitat class and the use of an appropriately designed structure that does not obstruct fish passage. **Section 3** of this report describes fish habitat class and **Section 4** identifies appropriately designed structures for waterways.

1.5.2 Commonwealth

1.5.2.1 *Environment Protection and Biodiversity Conservation Act 1999*

The EPBC Act is the primary piece of Federal legislation relating to the environment. Under the EPBC Act any 'action' that is has, or is likely to have, a significant impact on a matter of national environmental significance (MNES) requires approval from the Commonwealth Minister for the Environment. These matters are:

- listed threatened species and communities
- migratory species protected under international agreements
- Ramsar wetlands of international importance
- the Commonwealth marine environment
- World Heritage properties
- National Heritage places
- Great Barrier Reef Marine Park
- nuclear actions
- a water resource, in relation to coal seam gas development and large coal mining development.

The Action (that is, the proposal as described in **Section 1.1**) was deemed to comprise a 'Controlled Action' by DoEE on 20 September 2016, due to the potential for significant impacts on the following matters protected under the EPBC Act:

- listed threatened species and communities (18 and 18A).

DoEE considered the proposed action is likely to have a significant impact on MNES, including but not limited to:

- the removal of 268 ha of the critically endangered Natural Grassland on Basalt and Fine-textured Alluvial Plains of Northern New South Wales and Southern Queensland reducing an already greatly reduced ecological community and increasing the fragmentation of an important population

- the removal of 159 ha of foraging habitat for the vulnerable Koala (*Phascolarctos cinereus*) combined populations of Old, NSW and the ACT.

The DoEE also determined that the Action is to be assessed in accordance with the Bilateral agreement made under section 45 of the EPBC Act. Supplementary SEARs were issued on 8 November 2016 and a detailed response to each of the matters raised is provided in the Assessment of Commonwealth Matters report, (Umwelt 2017). This report identifies freshwater threatened species, populations and communities as listed under the EPBC Act and any migratory species that may occur or may occur within the proposal site (see **Section 3.4**). An assessment of the impact of the proposal on MNES is provided in **Section 4.2**.

2.0 Assessment Methodology

2.1 Literature and Database Review

A desktop review of previous documents and reports relevant to the proposal was undertaken. The following public ecological database searches were undertaken:

- a 10 kilometre buffer search from the centre of the rail line on the Commonwealth Department of the Environment Protected Matters Search Tool (DoE 2016 – accessed 6 April 2016 and updated 8 March 2017)
- a search of the Narrabri, Moree Plains and Gwydir LGAs was completed using the Primary Industries Fishing and Aquaculture Records Viewer (DPI 2016).

Relevant documents reviewed included:

- Melbourne Brisbane Inland Railway Parkes to Narromine and Narrabri to North Star – Ecological Investigations (Umwelt 2014a)
- Water Resources and Management Overview: Namoi Catchment (Green et al 2011a)
- Water Resources and Management Overview: Gwydir Catchment (Green et al 2011b)
- Water Resources and Management Overview: Border Rivers Catchment (Green et al 2012)
- Key Fish Habitat mapping for Narrabri, Moree Plains and Gwydir LGAs as prepared by DPI
- Reducing the Impact of Weirs on Aquatic Habitat NSW Detailed Weir Review for the Border Rivers/Gwydir CMA region (NSW DPI 2006)
- An oral history of fish and their habitats in the Gwydir River (Copeland et al 2003)
- Namoi: talking fish – making connections with the rivers of the Murray-Darling Basin (Frawley et al 2011)
- Native Fish Strategy for the Murray-Darling Basin 2003-2013
- Murray-Darling Basin sustainability rivers audit report 2
- Online publications and determinations for threatened fish, endangered populations and ecological communities as listed under the FM Act and the EPBC Act.

The information obtained was used to inform survey design, and was also used to assist in the description of ecological context, assessment of potentially occurring threatened species, endangered populations (EPs) and Threatened Ecological Communities (TECs).

2.2 Stream Order Mapping

In characterising the watercourses in the area, consideration has to be given to the Strahler ordering system, as described in *NSW Government Gazette no. 37* on 24 March 2006.

The Strahler ordering system is a hierarchical numbering system based on the degree of branching within a watercourse and provides an indication of the complexity of a creek system. The methodology used is as follows:

- at its origin, a watercourse is numbered as first order. The watercourse remains first order until it joins another watercourse
- if the watercourse joins another first order watercourse, downstream of the confluence is deemed second order. The confluence of two watercourses with a similar order results in the order increasing by one, so that two second order streams joining will result in a third order stream, and so on, moving downstream
- where a watercourse of a higher order joins with a lower order watercourse, downstream of the confluence remains at the higher order.

The Strahler stream orders have been assigned to Land and Property Information (LPI) natural drainage line layer, based on the Strahler number algorithm, using in-house Microstation tools. The first stream order has been manually assigned for irrigation channels and other artificial drainage lines. Stream orders have been mapped at 1:50000 scale.

2.3 Aquatic Habitat Description and Mapping

Preliminary mapping of the broad scale aquatic habitats within the proposal site was undertaken using recent aerial photography in conjunction with topographic maps prior to field surveys. Topographic maps were used to gain a broad understanding of catchment characteristics including adjacent land use, elevation, access routes, distance from source and location of barriers to fish passage, such as dams and weirs.

The proposal site occurs within the Namoi and Gwydir climatic subregions which are characterised as subtropical with a moderately dry winter and most rainfall occurring in summer (DoEE 2016a). In the north of the proposal site around North Star there is an average annual rainfall of 605 mm (DoEE 2016a), while in the southern extent at Narrabri there is a mean annual rainfall of 646 mm (DoEE 2016b). The majority of creeks and water courses in the proposal site are ephemeral and only flow after periods of high rainfall and the majority of field survey was undertaken in February 2016 which corresponds to the mean highest rainfall period for the Namoi and Gwydir regions.

Detailed aquatic habitat assessments were undertaken using recording sheets adapted from those developed for low gradient streams in the AUSRIVAS sampling protocol (available as a web resource (AUSRIVAS 2007)) at 10 locations along the alignment in September 2014 and were repeated at two locations (Mehi River and Gwydir River) in April 2016. Habitat assessments were undertaken at sites that were identified as containing permanent or semi-permanent aquatic habitat. An assessment of the aquatic habitat characteristics within each of the sampling sites was undertaken, and indicators of stream condition were also noted. The aquatic habitat characteristics were recorded using standard recording sheets (adapted from those developed for the AUSRIVAS sampling protocol for low gradient streams available as a web resource (AUSRIVAS 2007)). Some of the habitat features and stream condition indicators assessed included:

- characteristics of bed substrate
- presence of in-stream woody debris
- presence of gravel beds
- presence of drought and flood refuge areas
- depth of water
- width of channel
- presence of pool, riffle and edge habitats
- height of bank and evidence of erosion
- channel geomorphology
- evidence of sediment deposition
- degree of bank erosion
- the presence of natural or artificial barriers to fish passage upstream and downstream
- colour and clarity of water, and any visual evidence of water quality
- characteristics of in-stream, riparian and floodplain vegetation.

Notes were also compiled on the watercourse crossing structures and watercourse characteristics at 53 locations during inspections of bridges for roosting bats.

The aquatic survey was limited by the ephemeral nature of most of the creeks and watercourses in the proposal site which were dry at the time of the surveys.

2.4 Riparian and Aquatic Vegetation Survey and Mapping

Riparian and aquatic vegetation was surveyed to inform the ecological constraints analysis in 2014 (Umwelt 2014a) and the Biodiversity Assessment Report (BAR) (Umwelt 2017a). These surveys were undertaken over 20 days and three survey periods, being: 25 to 29 September 2014, 3 to 12 February 2016 and 20 to 24 April 2016.

At each plot/transect data was recorded according to Section 5 of the Framework for Biodiversity Assessment (FBA) (OEH 2014). This involved setting out 20 x 50 metre and 20 x 20 metre plots and a 50 metre transect. The location of each quadrat was recorded using a hand-held GPS with accuracy of ± 5 metres. The location of the 54 systematic plots/transects undertaken within the proposal site for the BAR is shown on Figure A1 to A56, **Appendix A**.

At each plot/transect, roughly 45 to 60 minutes was spent searching for all vascular flora species present within the 20 x 20 metre plot. Searches of each 20 x 20 metre plot were generally undertaken through parallel transects from one side of the plot to another. Most effort was spent on examining the groundcover, which usually supported well over half of the species present, however the composition of the shrub, mid-storey, canopy and emergent layers were also thoroughly examined. Effort was made to

search the tree canopy and tree trunks for mistletoes, vines and epiphytes. Full details of the survey effort and data collected are provided in Section 2.2.3 of the BAR (Umwelt 2017a).

Some minor areas of the corridor were inaccessible as private landholdings were not able to be surveyed by Umwelt ecologists during the survey period. The inaccessible areas were predominantly grasslands with a very small area of river red gum (*Eucalyptus camaldulensis*) and yellow box (*Eucalyptus melliodora*) woodlands (Umwelt 2017a). Vegetation communities were mapped in the inaccessible areas by reviewing existing vegetation mapping, undertaking vantage point or over the fence inspections, and completing additional plots/transects in proximity to the inaccessible areas.

2.4.1 Semi-quantitative Rapid Sampling

287 rapid vegetation assessments completed within the proposal site during the floristic surveys and as part of the ecological constraints analysis undertaken by Umwelt (2014a). This included assessment of riparian vegetation. Assessment areas were not fixed area-based, but were generally confined to an area similar to that of a 20 x 20 metre quadrat. These surveys were undertaken over five days between 25 and 29 September 2014.

Rapid sampling was used in combination with rapid reconnaissance and meandering transects primarily to assist in the delineation and refinement of vegetation mapping with respect to the distribution of native and non-native vegetation areas. Rapid vegetation assessment points were located within distinct vegetation community units (rather than within ecotones) to allow data collection for each community without confounding effects from adjacent communities. Dominant, common and some uncommon plant taxa were recorded within each rapid vegetation assessment points. The vegetation structure at each rapid vegetation assessment point was documented, including the dominant species in each stratum.

2.4.2 Vegetation Mapping

Vegetation mapping was undertaken using best-practice techniques to delineate vegetation communities across the proposal site for the BAR (Umwelt 2017a). Vegetation mapping involved the following key steps:

- preliminary review of digital airborne imagery to explore vegetation distribution patterns as dictated by change in canopy texture, tone and colour, as well as topography
- preliminary review of the modelled distribution of vegetation communities as part of the Border Rivers Gwydir/Namoi Regional Native Vegetation Mapping (OEH 2015)
- predicting the distribution of particular vegetation communities based on understanding the distribution of Biometric vegetation types (OEH 2014b)
- preparation of draft vegetation community map based on interpretation of digital airborne imagery and preliminary delineation of vegetation community floristics
- ground-truthing of vegetation map based on survey effort documented in the BAR (Umwelt 2017a)
- revision of vegetation community floristic delineations based on plot data
- revision of the vegetation map based on ground-truthing.

Vegetation communities were delineated through the identification of repeating patterns of plant species assemblages in each of the identified strata. Communities were named in accordance with their site character, with consideration of the naming conventions of those vegetation communities identified by the NSW Biometric vegetation types database (OEH 2014b).

3.0 Results

3.1 Catchment Description and Waterway Classification

As noted in **Section 1.4.2**, the proposal falls within three catchment areas of the Murray-Darling basin, being the Namoi, Gwydir and Border Rivers. The southern extent of the proposal (around Narrabri) is situated in the Namoi River catchment, around Edgeroi the rail line crosses into the Gwydir catchment with the majority of watercourses occurring in the proposal site draining into this catchment. Around Crooble the rail line crosses into the Border Rivers catchment.

The existing rail line crosses 82 mapped watercourses including: 37 first order streams; 20 second order streams; 11 third order streams; 5 fourth order streams; and 8 fifth order or higher streams. Figures A1 to A56 in **Appendix A** and **Table 3.1** provide details of the location of the watercourse crossings (based on the rail line kilometrage from south to north), Strahler stream order, the existing watercourse crossing structure, brief descriptions of the catchment, vegetation mapping in the rail corridor and a representative photo of the watercourse and/or structure in the rail corridor. Photographs were sourced from ecological investigations in the rail corridor and/or high level flood investigations undertaken by Umwelt in 2014 (Umwelt 2014b). Descriptions of the catchment were based upon an analysis of topographic maps and aerial photography.

In many locations downstream of the rail corridor the watercourse has been altered by external parties and land management processes. In some locations local farming practices have resulted in either the formation of broad drainage easements between fields (eg see photo for KP 721.645 in **Table 3.1**), complete removal of the watercourse to form a field with erosion evident (eg see photo for KP 588.815 in **Table 3.1**) and/or the construction of dams. The high level flooding investigations identified that downstream of 55 drainage structures the watercourse/flow path has been altered (Umwelt 2014b) (note not all of these are located on mapped watercourses assessed in this report).

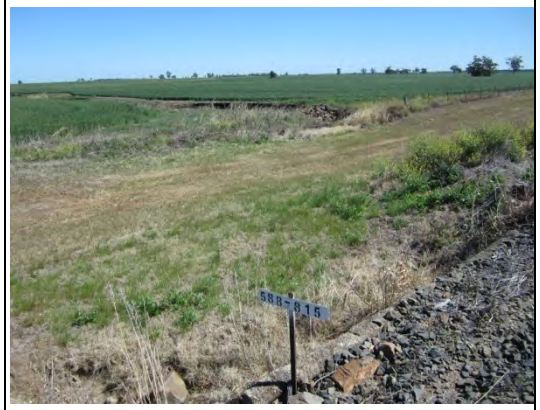
Table 3.1 Watercourses along alignment and description of existing structures and catchment

KP	Watercourse	Structure	Strahler Order	Catchment Description	Vegetation Mapping in Corridor[1]	Photos
Namoi River Catchment						
574.375 574.4	Unnamed	Two structures: concrete culverts at 574.375 and set of corrugated pipes at 574.40	Third order	Flat plain, cleared for agriculture. Downstream watercourse has been modified by irrigation channels and large dams. Watercourse modified upstream.	Cleared/Non-native Vegetation, **Figure A1**	 Pipes at KP 574.40
576.5	Unnamed	Not available	First order	First order tributary of watercourse at 574.40. Some remnant vegetation upstream.	Cleared/Non-native Vegetation, **Figure A2**	Not available
577.443	Unnamed	Box culverts	First order	First order tributary of watercourse. Remnant vegetation upstream.	Cleared/Non-native Vegetation, **Figure A2**	

KP	Watercourse	Structure	Strahler Order	Catchment Description	Vegetation Mapping in Corridor[1]	Photos
577.5 - 578	Unnamed	Not available	First order	First order tributary of watercourse. Some remnant vegetation upstream.	Cleared/Non-native Vegetation, **Figure A2**	Not available
579.475	Unnamed	Corrugated pipes	First order	Tributary of Spring Creek. Flat plain cleared for agriculture. Large remnant of native vegetation in upper catchment, approximately 2km upstream. Remnant vegetation downstream.	Cleared/Non-native Vegetation, **Figure A3**	 Downstream of rail line
582.605	Spring Creek	25m long concrete bridge	Fourth Order	Flat plain. Dry with exotic vegetation in rail corridor cleared downstream, evidence of erosion. No aquatic vegetation in stream. No permanent pools. River Red Gum upstream and remnant vegetation along watercourse upstream. Rises in foot slopes of Nandewar Range at northern end of Mount Kaputar National Park.	Cleared/non-native vegetation, **Figure A4**.	 View upstream of channel and Newell Highway bridge over Spring Creek

KP	Watercourse	Structure	Strahler Order	Catchment Description	Vegetation Mapping in Corridor[1]	Photos
584.805	unnamed	Pipes	First Order	Watercourse starts at rail line and Newell Highway. Cleared upstream and downstream.	Cleared/non-native Vegetation, **Figure A4**	

KP	Watercourse	Structure	Strahler Order	Catchment Description	Vegetation Mapping in Corridor[1]	Photos
586.200	Bobbiwaa Creek	Steel, timber and concrete bridge	Fifth Order	Dry watercourse dominated by weeds in the rail corridor. Remnant vegetation retained along watercourse upstream and downstream. Upper catchment in Bobbiwaa State Conservation Area. Remainder cleared for agriculture. Downstream watercourse modified for irrigation.	Cleared/Non-native Vegetation, Zone 8 River Red Gum Riparian Tall Woodland upstream and downstream. **Figure A5**	 View of watercourse upstream from rail line showing River Red Gums.  Channel downstream of rail line.

KP	Watercourse	Structure	Strahler Order	Catchment Description	Vegetation Mapping in Corridor[1]	Photos
588.815	Unnamed	Pipes	First Order	Flat plain. Cleared upstream and downstream. Not mapped 1.7km downstream.	Cleared/non-native Vegetation, **Figure A5**	 Watercourse downstream of rail line.
589	Unnamed	Not available	First Order	Flat plain. Cleared upstream and downstream. Not mapped 1.7km downstream.	Cleared/non-native Vegetation, **Figure A6**	Not available
Gwydir/Mehi River Catchment						
591.685	unnamed	Pipes	Second order	Tributary of Tarlee Creek. In-stream dams upstream and down; agricultural land; cleared land with some scattered trees and stands of remnant vegetation upstream.	Cleared/non-native Vegetation, Zone 1 Weeping Myall open woodland upstream and downstream of rail corridor **Figure A6**	 Downstream or rail line

KP	Watercourse	Structure	Strahler Order	Catchment Description	Vegetation Mapping in Corridor[1]	Photos
593.5-594	Tarlee Creek	Pipes. Rocks placed in stream upstream of crossing	First order	Upper reaches of Tarlee Creek. Some remnant vegetation upstream otherwise cleared. Locality of Edgeroi.	Cleared/non-native Vegetation, **Figure A7**	
596.430	Galathera Creek	Pipes	Second order	Flat plain; cleared land with some scattered trees upstream.	Cleared/non-native Vegetation, Zone 8 River Red Gum downstream **Figure A8**	 Downstream of rail line

KP	Watercourse	Structure	Strahler Order	Catchment Description	Vegetation Mapping in Corridor[1]	Photos
597-597.5	Unnamed	Pipes, concrete bed either side of line	First order	Tributary of Galathera Creek Flat plain; cleared land with some scattered trees upstream.	Cleared/non-native Vegetation, Zone 1 Weeping Myall open woodland either side of rail corridor **Figure A8**	 View along rail line to the north.
600.5	Ten Mile Creek	Concrete, steel and timber bridge	Fifth order	Upper reaches in footslopes of Castletop Mountain and Grattai Mountain in Mount Kaputar National Park. Remnant vegetation along watercourse. Road bridge upstream.	Cleared/non-native Vegetation with Zone 8 River Red Gum downstream upstream and downstream, **Figure A9**.	 View of rail and road bridge from downstream.
601.865	Unnamed	Pipes	First Order	Starts at Newell Highway. Flat plain; cleared.	Cleared/non-native Vegetation, **Figure A9/A10**	Not available

KP	Watercourse	Structure	Strahler Order	Catchment Description	Vegetation Mapping in Corridor[1]	Photos
602.45	Pan Creek	Pipes	Second order	Flat plain; cleared.	Cleared/non-native Vegetation, **Figure A10**	 View to north along rail line.
603.350	Bulldog Creek	Concrete bridge	Third order	Rises in Nandewar Range. Catchment largely cleared with remnant vegetation along watercourse. Pools between rail structure and road structure. Cleared downstream.	Cleared/non-native Vegetation, **Figure A10**	 View to north along rail line.

KP	Watercourse	Structure	Strahler Order	Catchment Description	Vegetation Mapping in Corridor[1]	Photos
607.830	Boggy Creek	pipes	Third order	Catchment cleared with little vegetation along watercourse.	Cleared/non-native Vegetation, **Figure A11**	 View south along line showing watercourse between rail line and Newell Highway (upstream).
609.55	unnamed	Concrete bridge	Second order	Tributary of Boggy Creek. Catchment cleared with little vegetation along watercourse.	Cleared/non-native Vegetation, **Figure A12**	 Watercourse downstream of rail line.

KP	Watercourse	Structure	Strahler Order	Catchment Description	Vegetation Mapping in Corridor[1]	Photos
613.99	Gehan Creek	Box culverts	Fourth order	Remnant vegetation in and near rail corridor otherwise catchment is cleared.	Zone 4 Queensland Bluegrass +/- Mitchell Grass grassland with Zone 1 Weeping Myall, **Figure A13**	 Downstream of rail corridor
614.650	unnamed	Bridge	Second order	Tributary of Gehan Creek. Flat plain south of Bellata township with a number of watercourses. All drain largely cleared catchment. Confluence with Gehan Creek approximately 1km downstream.	Cleared/non-native vegetation, **Figure A14**	 View to north along line showing large beds of *Phragmites* and standing water

KP	Watercourse	Structure	Strahler Order	Catchment Description	Vegetation Mapping in Corridor[1]	Photos
615	Unnamed	unknown	Third order	Tributary of Gehan Creek. Flat plain south of Bellata township with a number of watercourses. All drain largely cleared catchment. Confluence with Gehan Creek approximately 1km downstream.	Zone 4 Queensland Bluegrass +/- Mitchell Grass grassland, **Figure A14**	 View to north along rail line showing downstream.
616.179	Unnamed	Concrete bridge, box culverts	First order	Some remnant vegetation along watercourse otherwise cleared for cropping. Large dam immediately downstream of line	Zone 4 Queensland Bluegrass +/- Mitchell Grass grassland, **Figure A14**	 View to north along rail line showing downstream.

KP	Watercourse	Structure	Strahler Order	Catchment Description	Vegetation Mapping in Corridor[1]	Photos
618	Unnamed	Pipes	First order	Remnant vegetation in and near rail corridor otherwise catchment is cleared with cropping upstream.	Zone 6 Poplar Box-Belah – Derived Native Grassland, **Figure A15**	 View to north along rail line
620.610	Tookey Creek	Concrete bridge	Third order	Remnant vegetation along watercourse otherwise cleared for agriculture.	Zone 6 Poplar Box-Belah – Derived Native Grassland in rail corridor with Zone 5 Poplar Box – Belah woodland upstream and downstream **Figure A15**	 View of watercourse upstream of rail line.

KP	Watercourse	Structure	Strahler Order	Catchment Description	Vegetation Mapping in Corridor[1]	Photos
621.5	unnamed	-	First order	Flows through stand of remnant vegetation. Extractive industry in catchment. Tributary of Tookey Creek	Zone 6 Poplar Box-Belah – Derived Native Grassland in rail corridor with Zone 5 Poplar Box – Belah woodland upstream and downstream **Figure A16**	 View of watercourse downstream of rail line. Newell Highway in background.
623	Unnamed	-	Second order	Remnant vegetation along watercourse, rail and road corridor otherwise cleared for agriculture.	Zone 6 Poplar Box-Belah – Derived Native Grassland in rail corridor with Zone 5 Poplar Box – Belah woodland upstream and downstream **Figure A16**	 View of watercourse upstream of rail line.

KP	Watercourse	Structure	Strahler Order	Catchment Description	Vegetation Mapping in Corridor[1]	Photos
627.230	Waterloo Creek	Bridge	Fourth order	Remnant vegetation along watercourse, rail and road corridor otherwise cleared for agriculture.	Zone 4 Queensland Bluegrass +/- Mitchell Grass grassland in rail corridor with zone 8 River Red Gum upstream and downstream **Figure A17 and A18**	
627.490	Waterloo Creek	Bridge	Fourth order	Remnant vegetation along watercourse, rail and road corridor otherwise cleared for agriculture.	Zone 4 Queensland Bluegrass +/- Mitchell Grass grassland in rail corridor with Zone 8 River Red Gum upstream and downstream **Figure A17 and A18**	

KP	Watercourse	Structure	Strahler Order	Catchment Description	Vegetation Mapping in Corridor[1]	Photos
633.720	Little Bumble Creek	Bridge	Second order	Remnant vegetation along rail and road corridor. Minimal remnant vegetation along watercourse upstream otherwise cleared for agriculture. Large stand of remnant native vegetation immediately downstream of rail line. Ponding at structure.	Zone 4 Queensland Bluegrass +/- Mitchell Grass grassland in rail corridor **Figure A20**	 View along rail line to north showing upstream side of structure
641.540	Gurly Creek	Bridge, 70m long	Fifth order	Remnant vegetation along watercourse, rail and road corridor otherwise cleared for agriculture.	Cleared/non-native vegetation in rail corridor with zone 8 River Red Gum upstream and downstream **Figure A22**	

KP	Watercourse	Structure	Strahler Order	Catchment Description	Vegetation Mapping in Corridor[1]	Photos
647.095	Unnamed	Bridge	Second order	Remnant vegetation along watercourse, rail and road corridor otherwise cleared for agriculture. Tributary of Tycannah Creek	Zone 4 Queensland Bluegrass +/- Mitchell Grass grassland in rail corridor with Zone 3 Coolabah - River Coobah - Lignum woodland wetland upstream and downstream, **Figure A24**	 Watercourse upstream of rail line.
647.5	Tycannah Creek	Bridge	Third order	Remnant vegetation along watercourse, rail and road corridor otherwise cleared for agriculture.	Zone 4 Queensland Bluegrass +/- Mitchell Grass grassland in rail corridor with Zone 3 Coolabah - River Coobah - Lignum woodland wetland upstream and downstream, **Figure A24**	 View of bridge from upstream of rail line.

KP	Watercourse	Structure	Strahler Order	Catchment Description	Vegetation Mapping in Corridor[1]	Photos
648.170	Unnamed	Culverts at 648.170 and bridge at 648.320	Second order	Remnant vegetation along watercourse, rail and road corridor otherwise cleared for agriculture. Tributary of Tycannah Creek	Zone 4 Queensland Bluegrass +/- Mitchell Grass grassland, **Figure A24**	 View downstream of rail line at 648.170
649.520	Unnamed	Bridge	First order	Flat plain. Watercourse and catchment appear to be cleared of trees. Catchment cleared for agriculture.	Zone 4 Queensland Bluegrass +/- Mitchell Grass grassland, **Figure A24**	 View to west downstream of rail ine.
653	Unnamed	-	Second order	Watercourse modified upstream in channels through crop land.	Zone 4 Queensland Bluegrass +/- Mitchell Grass grassland, **Figure A25** and **A26**	Not available

KP	Watercourse	Structure	Strahler Order	Catchment Description	Vegetation Mapping in Corridor[1]	Photos
655.175	Unnamed	Corrugated pipes	First order	Catchment and watercourse cleared. In crop land	Zone 4 Queensland Bluegrass +/- Mitchell Grass grassland, **Figure A26**	 Watercourse upstream of rail ine.
660.610	Halls Creek	bridge	Second order	Some remnant vegetation along watercourse; catchment agricultural, rural-residential on outskirts of Moree. Tributary of the Mehi River. Watercourse condition and habitat value improves downstream of rail line.	Zone 4 Queensland Bluegrass +/- Mitchell Grass grassland in rail corridor with Zone 8 River Red Gum downstream **Figure A28**	 Halls Creek downstream of rail ine.

KP	Watercourse	Structure	Strahler Order	Catchment Description	Vegetation Mapping in Corridor[1]	Photos
						 Halls Creek upstream of rail ine.
666.341	Mehi River	Bridge	Fifth order	Distributary of Gwydir River approximately 30km upstream of Moree. Flat plain, remnant vegetation along river. Cleared catchment.	Zone 8 River Red Gum, **Figure A30**	 Mehi River bridge from north bank.

KP	Watercourse	Structure	Strahler Order	Catchment Description	Vegetation Mapping in Corridor[1]	Photos
666.645	Mehi River	Bridge	-	Floodplain on northern bank of Mehi River	Cleared/non-native vegetation **Figure A30**	 Bridge over northern floodplain of Mehi River
667.210	Duffys Creek	Bridge	Third order	Remnant vegetation along watercourse. Catchment largely cleared.	Cleared/non-native vegetation with Zone 8 River Red Gum upstream and downstream, **Figure A30**	 View north along bridge upstream.

KP	Watercourse	Structure	Strahler Order	Catchment Description	Vegetation Mapping in Corridor[1]	Photos
667.945	Skinners Creek	Bridge	Third order	On floodplain of Mehi and Gwydir Rivers. Connects to Broadwater Creek. Both are channels between the Mehi and Gwydir Rivers. Connects with Duffy Creek upstream or rail line. Moree residential and rural-residential area.	Cleared/non-native vegetation with Zone 8 River Red Gum upstream and downstream, **Figure A30**	
672.348	Unnamed	Bridge	First order	Flat plain. Cleared catchment. Downstream diverted into a number of irrigation channels on floodplain of Gwydir River.	Cleared/non-native vegetation with Zone 8 River Red Gum upstream, **Figure A31**	 View north of rail line and Newell Highway crossings

KP	Watercourse	Structure	Strahler Order	Catchment Description	Vegetation Mapping in Corridor[1]	Photos
676-676.50	Gwydir River	Bridge	Fifth order	Flat plain. Cropping land. Remnant vegetation at rail line. **Refer to Section 3.3.2** for detailed description.	Zone 8 River Red Gum along both banks	
690.830	Unnamed	Bridge and pipes. Ballast in watercourse bed.	First order	Flat plain. Cropping land. Remnant vegetation at rail line.	Cleared/non-native vegetation in rail corridor with Zone 5 Poplar Box –Belah woodland upstream and downstream **Figure A36**	 View from downstream northern bank.

KP	Watercourse	Structure	Strahler Order	Catchment Description	Vegetation Mapping in Corridor[1]	Photos
696.990	Unnamed	Bridge	First order	Flat plain. Cropping land. Remnant vegetation at rail line.	Zone 6 Poplar Box-Belah – Derived Native Grassland, **Figure A38**	 Downstream of rail line.
700	Coolleearllee Watercourse	pipes	Second order	Flat plain. Cropping land. Remnant vegetation at rail line.	Cleared/Non-native vegetation, **Figure A38**	 View to east over structure

KP	Watercourse	Structure	Strahler Order	Catchment Description	Vegetation Mapping in Corridor[1]	Photos
703	unnamed	Corrugated pipes	First order	Flat plain. Cropping land.	Cleared/non-native vegetation, **Figure A39**	 View to east over structure
704.5-705	The Ponds	Corrugated pipes	Second order	Flat plain. Cropping land.	Cleared/non-native vegetation, **Figure A39, A40**	 View downstream to north of line

KP	Watercourse	Structure	Strahler Order	Catchment Description	Vegetation Mapping in Corridor[1]	Photos
706.250	Marshalls Ponds Creek	bridge	Second order	Flat plain. Cropping land. Remnant vegetation along the road reserve to east of watercourse.	Cleared/non-native vegetation, **Figure A40**	 View from downstream western bank.
708.445	Unnamed	Bridge and corrugated pipes	First order	Some remnant vegetation. Flat plain. Cropping.	Cleared/non-native vegetation, **Figure A41**	 View upstream from rail corridor.

KP	Watercourse	Structure	Strahler Order	Catchment Description	Vegetation Mapping in Corridor[1]	Photos
709.5-710	Unnamed	Corrugated pipes	First order	Flat plain. Cropping.	Cleared/non-native vegetation, **Figure A41**	
711.620	Bunna Bunna Creek	Bridge and corrugated pipes	Fifth order	Flat plain. Cropping. Remnant vegetation along watercourse and roads. Wide channel at rail line with a number of structures. Tributary of Gil Gil Creek.	Cleared/non-native vegetation with Zone 6 Poplar Box-Belah – Derived Native Grassland and Zone 5 Poplar Box – Belah woodland upstream and downstream in channel **Figure A42**	 Structure and downstream

KP	Watercourse	Structure	Strahler Order	Catchment Description	Vegetation Mapping in Corridor[1]	Photos
713.340	Unnamed	-	Second order	Flat plain. Cropping.	Cleared/non-native vegetation, **Figure A42**	 View to north over watercourse crossing
714.610	Unnamed	-	Second order	Flat plain. Cropping.	Cleared/non-native vegetation, **Figure A43**	 View to north over watercourse crossing

KP	Watercourse	Structure	Strahler Order	Catchment Description	Vegetation Mapping in Corridor[1]	Photos
716.620	Gil Gil Creek	bridge	Fifth order	Flat plain. Cropping. Remnant vegetation along watercourse. Rises in Bullala National Park to east of Crooble.	Cleared/non-native vegetation, Zone 8 River Red Gum **Figure A43**	 Watercourse downstream of rail line.
721.03	Unnamed	bridge	Second order	Flat plain. Cropping. Remnant vegetation along watercourse.	Cleared/non-native vegetation **Figure A44**	
721.0-721.5	Unnamed	-	First order	Flat plain. Cropping	Cleared/non-native vegetation, **Figure A45**	Not available

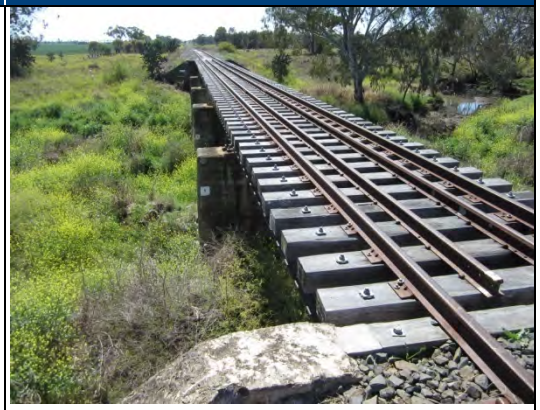
KP	Watercourse	Structure	Strahler Order	Catchment Description	Vegetation Mapping in Corridor[1]	Photos
721.645	Unnamed	culvert	First order	Flat plain, cropping land with remnant vegetation along watercourse and between rail and road.	Cleared/non-native vegetation, **Figure A45**	 Watercourse downstream through crops
723	Unnamed	culvert	Second order	Flat plain, cropping land with remnant vegetation along watercourse and between rail and road.	Cleared/non-native vegetation in corridor with Zone 5 Poplar Box-Belah woodland either side of rail line, **Figure A45**	
723.5	Unnamed	-	First order	Flat plain, cropping land with remnant vegetation between rail and road.	Cleared/non-native vegetation in rail corridor with Zone 5 Poplar Box-Belah woodland upstream **Figure A45**	Not available

KP	Watercourse	Structure	Strahler Order	Catchment Description	Vegetation Mapping in Corridor[1]	Photos
723.5-724	Unnamed	-	First order	Flat plain, cropping land with remnant vegetation between rail and road.	Cleared/non-native vegetation in rail corridor with Zone 5 Poplar Box-Belah woodland upstream **Figure A45**	Not available
724.5	Unnamed	Corrugated pipes	First order	Flat plain, cropping land. Watercourse only exists between 2 dams either side of line.	Cleared/non-native vegetation **Figure A46**	
725.275	Unnamed	Bridge	Second order	Flat plain, cropping land. Remnant vegetation along watercourse downstream.	Queensland Bluegrass +/- Mitchell Grass grassland, **Figure A46**	

KP	Watercourse	Structure	Strahler Order	Catchment Description	Vegetation Mapping in Corridor[1]	Photos
726	Unnamed	pipes	First order	Flat plain, cropping land. Remnant vegetation along watercourse downstream.	Cleared/non-native vegetation **Figure A46**	Not available
727	Unnamed	-	First order	Flat plain, cropping land. Remnant vegetation along watercourse downstream.	Cleared/non-native vegetation **Figure A46**	Not available
727	Unnamed	-	First order	Flat plain, cropping land. Remnant vegetation along watercourse downstream.	Cleared/non-native vegetation **Figure A46**	Not available
Border Rivers Catchment (Boomi River)						
728.5	Unnamed	-	First order	Flat plain, cropping land. Remnant vegetation along watercourse downstream. Tributary of Croppa Creek	Cleared/non-native vegetation **Figure A47**	

KP	Watercourse	Structure	Strahler Order	Catchment Description	Vegetation Mapping in Corridor[1]	Photos
730	Unnamed	Corrugated pipes	First order	Flat plain, cropping land. Remnant vegetation along watercourse downstream. Tributary of Croppa Creek	Cleared/non-native vegetation, Zone 2 Brigalow Belt-Belah open forest downstream **Figure A47**	
734	Unnamed	-	Third order	Flat plain, cropping land. Remnant vegetation downstream in golf course. Croppa Creek township in catchment Tributary of Croppa Creek	Cleared/non-native vegetation **Figure A48**	Not available
734.945	Unnamed	Bridge	First order	Flat plain, cropping land.	Cleared/non-native vegetation **Figure A49**	

KP	Watercourse	Structure	Strahler Order	Catchment Description	Vegetation Mapping in Corridor[1]	Photos
735.115	Croppa Creek	bridge	Fifth order	Flat plain, cropping land. Remnant vegetation along watercourse. Well defined channel	Cleared/Non-native vegetation in rail corridor, Zone 8 River Red Gum along watercourse with Zone 1 Weeping Myall on top of the banks, **Figure A49**	 View north along line from top of southern bank.
737.555	Unnamed	Bridge	First order	Flat plain, cropping land. Remnant vegetation downstream. Tributary of Yallaroi Creek.	Cleared/non-native vegetation, **Figure A50**	

KP	Watercourse	Structure	Strahler Order	Catchment Description	Vegetation Mapping in Corridor[1]	Photos
740.665	Unnamed	Bridge	First order	Flat plain catchment largely uncleared with remnant vegetation upstream. Confluence with Yallaroi Creek immediately downstream of rail line.	Queensland Bluegrass +/- Mitchell Grass grassland with Zone 8 River Red Gum upstream and downstream, **Figure A50, A51**.	 View to north along line
740.665	Yallaroi Creek		Fourth order	Flat plain catchment largely cleared with remnant vegetation along watercourse.		 Downstream of rail line.

KP	Watercourse	Structure	Strahler Order	Catchment Description	Vegetation Mapping in Corridor[1]	Photos
744.555	Tackinbri Creek	Bridge	Third order	Flat plain catchment largely cleared with remnant vegetation along watercourse.	Queensland Bluegrass +/- Mitchell Grass grassland with Zone 8 River Red Gum upstream and downstream, **Figure A52**.	 View of structure from downstream, south
750.965	Mungle Creek	Bridge	Third order	Flat plain catchment largely cleared with remnant vegetation along watercourse. Rises near Booraba Ridge, south of North Star. Flows into Whalan Creek.	Queensland Bluegrass +/- Mitchell Grass grassland with Zone 5 Poplar Box – Belah woodland upstream and downstream, **Figure A53** and **A54**	 View downstream from southern bank.

KP	Watercourse	Structure	Strahler Order	Catchment Description	Vegetation Mapping in Corridor[1]	Photos
751.120	Unnamed	culvert	First order	Tributary of Mungle Creek confluence just downstream of rail corridor. Flat plain catchment partly cleared for crops, remainder through remnant Poplar Box- Belah woodland.	Queensland Bluegrass +/- Mitchell Grass grassland with Cleared/Non-native vegetation, **Figure A53** and **A54**	 Downstream of rail line.
753	Unnamed	pipes	First order	Tributary of Mungle Creek. Flat plain catchment cleared for crops with remnant vegetation along watercourse.	Queensland Bluegrass +/- Mitchell Grass grassland, **Figure A54**	 Downstream of rail line.

KP	Watercourse	Structure	Strahler Order	Catchment Description	Vegetation Mapping in Corridor[1]	Photos
755	Unnamed	Pipes	Second order	Tributary of Dry Creek. Flat plain catchment cleared. Some remnant vegetation immediately upstream and downstream or rail corridor.	Zone 6 Poplar Box – Belah woodland Derived Native Grassland, **Figure A55**	 Downstream of rail line.
757	Dry Creek	Pipes and culvert	First order	Flat plain catchment cleared for crops/	Cleared/non-native vegetation, **Figure A55** and **A56**	 Downstream of rail line.

1. Vegetation mapping as described in BAR (Umwelt 2017a) and shown in Figures A1 to A56, Appendix A of that report.

3.2 Key Fish Habitat Classification and Sensitivity Analysis

Key fish habitat mapping has been prepared by Fisheries Ecosystems Branch of NSW DPI for LGAs across NSW. The intent of the mapping was to recognise key fish habitat that are important to the sustainability of recreational and commercial fishing industries, maintenance of fish populations and the survival and recovery of threatened aquatic species. The definition includes most permanent and semi-permanent freshwater habitats including rivers, creeks, lakes, lagoons, billabongs, weir pools and impoundments up to the top of the bank but excluding first and second order streams that only flow for a short period following rain and farm dams on these streams (NSW DPI).

The key fish habitat map outputs for the Narrabri, Moree Plains and Gwydir LGAs were reviewed and are provided in **Appendix B**. Whether watercourses along the rail corridor are mapped as key fish habitat is identified in **Table 3.2**. It is noted that some of the named watercourses crossed by the rail line are not identified as key fish habitat within the proposal site as the rail line crosses these watercourses high in their catchment. This includes Tarlee Creek, Little Bumble Creek, Tackinbri Creek and Dry Creek.

For the purposes of the application of the FM Act, NSW DPI has developed a classification scheme for the sensitivity of key fish habitat, to define the importance of habitat for the survival of fish and the ability of the habitat to withstand disturbance. Key fish habitat is defined in DPI (2013) as:

- Type 1 Highly sensitive key fish habitat including freshwater habitats that contain in-stream gravel beds, rocks greater than 500 mm in two dimensions, snags greater than 300 mm in diameter or 3 m in length, or native aquatic plants
- Type 2 Moderately sensitive key fish habitat including:
    - freshwater habitats and brackish wetlands, lake and lagoons other than those defined in Type 1, and
    - weir pools and dams up to full supply level where the weir or dam is across a natural waterway, or
- Type 3 Minimally sensitive key fish habitat including:
    - coastal and freshwater habitats not included in Type 1 or 2
    - ephemeral aquatic habitat not supporting native aquatic of wetland vegetation.

It is noted that for the purposes of the *Policy and Guidelines for Fish Habitat Conservation and Management* that first and second order streams on gaining streams are not considered key fish habitat (DPI 2013). Accordingly, the habitat sensitive type of watercourses in the proposal site, from south to north along the rail line, has been assessed and is identified in **Table 3.2**.

The functionality of the watercourse as fish habitat has been defined by NSW DPI (DPI 2013) to assess impacts of activities on fish habitat, in conjunction with habitat sensitivity, and to make management recommendations to minimise the impact of watercourse crossing structures on fish passage. Waterways are classified by NSW DPI (DPI 2013) for fish passage as:

- Class 1 major key fish habitat including marine or estuarine waterway or permanently flowing or flooded freshwater waterway (e.g. river or major creek), habitat of a threatened or protected fish species or 'critical habitat', or
- Class 2 moderate key fish habitat including non-permanently flowing (intermittent) stream, creek or waterway (generally named) with clearly defined bed and banks with semi-permanent to permanent

waters in pool or in connected wetland areas. Freshwater aquatic vegetation is present. Type 1 and 2 habitats present, or

- Class 3 minimal key fish habitat including named or unnamed waterway with intermittent flow and sporadic refuge, breeding or feeding areas for aquatic fauna (eg fish, yabbies). Semi-permanent pools form within the waterway or adjacent wetlands after a rain event. Otherwise any minor waterway that interconnects with wetlands or other Class 1-3 fish habitats, or

- Class 4 unlikely key fish habitat including waterway (generally unnamed) with intermittent flow following rain events only, little or no defined drainage channel, little or no flow or free standing water or pools post rain events (eg dry gullies or shallow floodplain depressions with no aquatic flora present).

The classification of watercourses for fish passage has been assessed and is identified in **Table 3.2** from south to north along the rail line. This classification and type is based on the watercourses in the vicinity of the existing rail line and proposal site.

The majority of watercourses along the rail line are first and second order streams with intermittent flow following rain events, little or poorly defined channels with no aquatic flora species. The watercourses have been modified by crossing structures for rail, road and agricultural land practices with minimal native vegetation retained along the banks of the watercourses. Accordingly these watercourses have been classified as Class 4 unlikely key fish habitats that are considered to be Type 3 minimally sensitive fish habitat.

Table 3.2 Habitat Sensitivity Analysis of Major Watercourses

KP	Watercourse	Strahler Order	Habitat Sensitivity Type	Classification of Watercourse for Fish Passage	Key Fish Habitat Mapping
Namoi River Catchment					
574.375	Unnamed	Third order	Type 3 minimally sensitive	Class 4 unlikely key fish habitat	Mapped as key fish habitat
582.605	Spring Creek	Fourth Order	Type 3 minimally sensitive	Class 3 minimal key fish habitat	Mapped as key fish habitat
586.2	Bobbiwaa Creek	Fifth Order	Type 2 moderately sensitive	Class 2 moderate key fish habitat	Mapped as key fish habitat
Gwydir/Mehi River Catchment					
600.5	Ten Mile Creek	Fifth order	Type 2 moderately sensitive	Class 2 moderate key fish habitat	Mapped as key fish habitat
603.35	Bulldog Creek	Third order	Type 3 minimally sensitive	Class 3 minimal key fish habitat	Mapped as key fish habitat

KP	Watercourse	Strahler Order	Habitat Sensitivity Type	Classification of Watercourse for Fish Passage	Key Fish Habitat Mapping
607.83	Boggy Creek	Third order	Type 3 minimally sensitive	Class 3 minimal key fish habitat	Mapped as key fish habitat
613.99	Gehan Creek	Fourth order	Type 3 minimally sensitive	Class 3 minimal key fish habitat	Mapped as key fish habitat
615	Unnamed	Third order	Type 3 minimally sensitive	Class 3 minimal key fish habitat	Mapped as key fish habitat
620.61	Tookey Creek	Third order	Type 3 minimally sensitive	Class 3 minimal key fish habitat	Mapped as key fish habitat
627.23	Waterloo Creek	Fourth order	Type 3 minimally sensitive	Class 3 minimal key fish habitat	Mapped as key fish habitat
627.49	Waterloo Creek	Fourth order	Type 3 minimally sensitive	Class 3 minimal key fish habitat	Mapped as key fish habitat
641.54	Gurly Creek	Fifth order	Type 2 moderately sensitive	Class 2 moderate key fish habitat	Mapped as key fish habitat
647.5	Tycannah Creek	Third order	Type 2 moderately sensitive	Class 2 moderate key fish habitat	Mapped as key fish habitat
666.341	Mehi River	Fifth order	Type 1 highly sensitive	Class 1 major key fish habitat	Mapped as key fish habitat
666.645	Mehi River	Fifth order	Type 2 moderately sensitive	Class 3 minimal key fish habitat	Mapped as key fish habitat
667.21	Duffys Creek	Third order	Type 2 moderately sensitive	Class 3 minimal key fish habitat	Mapped as key fish habitat
667.945	Skinners Creek	Third order	Type 3 minimally sensitive	Class 3 minimal key fish habitat	Mapped as key fish habitat
676-	Gwydir River	Fifth	Type 1 highly	Class 1 major	Mapped as key fish

KP	Watercourse	Strahler Order	Habitat Sensitivity Type	Classification of Watercourse for Fish Passage	Key Fish Habitat Mapping
676.50		order	sensitive	key fish habitat	habitat
711.62	Bunna Bunna Creek	Fifth order	Type 3 minimally sensitive	Class 4 unlikely key fish habitat in rail corridor. Grading to class 3 minimal downstream	Mapped as key fish habitat
716.62	Gil Gil Creek	Fifth order	Type 3 minimally sensitive	Class 4 unlikely key fish habitat in rail corridor. Grading to class 3 minimal downstream	Mapped as key fish habitat
Border Rivers Catchment (Boomi River)					
734	Unnamed	Third order	Type 3 minimally sensitive	Class 4 unlikely key fish habitat	Not mapped
735.115	Croppa Creek	Fifth order	Type 3 minimally sensitive	Class 3 minimal key fish habitat	Mapped as key fish habitat
740.665	Yallaroi Creek	Fourth order	Type 2 moderately sensitive	Class 2 moderate key fish habitat	Mapped as key fish habitat
744.555	Tackinbri Creek	Third order	Type 3 minimally sensitive	Class 3 minimal key fish habitat	Not mapped
750.965	Mungle Creek	Third order	Type 3 minimally sensitive	Class 3 minimal key fish habitat	Mapped as key fish habitat

A recent fish community status analysis by NSW DPI mapped and rated a number of watercourses that the rail line crosses (DPI 2015). In the Namoi River catchment this analysis identified both Bobbiwaa and Spring Creek as having moderate fish community value (DPI 2015). In the Gwydir River catchment this analysis identified:

- Mehi River as good fish community value
- Ten Mile Creek, Bulldog Creek, Gurly Creek, Tycannah Creek and Gwydir River as having moderate fish community value

- Gehan Creek, Waterloo Creek and Gil Gil Creek as having moderate fish community value but with a high alien presence

- Boggy Creek as very poor fish community value (DPI 2015).

The result of the fish community status analysis demonstrates the variability in fish habitat quality within the Gwydir and Namoi catchments. While the high level assessment of key fish habitat undertaken in accordance with the *and Guidelines for Fish Habitat Conservation and Management* indicates that the Gwydir River is Type 1 highly sensitive and Class 1 major key fish habitat, which reflects the importance and functionality of the waterway as fish habitat (DPI 2013), detailed fish community survey and analysis indicates that fish community value is considered only moderate, reflecting the *degradation of instream processes and habitat features across most major systems* (that) *has resulted in the majority of fish communities of the Northern Basin being in poor to moderate condition* (DPI 2015).

3.3 Aquatic Habitat Assessment Results

Detailed aquatic habitat assessments were undertaken using recording sheets adapted from those developed for low gradient streams in the AUSRIVAS sampling protocol (available as a web resource (AUSRIVAS 2007)) at 10 locations along the alignment in September 2014 and were repeated at two locations (Mehi River and Gwydir River) in April 2016. Habitat assessments were undertaken at sites that were identified as containing permanent or semi-permanent aquatic habitat.

The scores of the habitat assessments are summarised in **Table 3.3** with discussions provided below of the Mehi River and Gwydir River, both of which were classified as Class 1 Fish Habitat (refer to **Table 3.2** above). The un-named creek at KP 614.65 was identified as containing highly turbid pooled water within the proposal site and a stand of common reed (*Phragmites australis*) was also identified. The other creeks identified in **Table 3.2** were dry at the time of survey and did not exhibit defined aquatic ecological communities and were not re-surveyed as part of this assessment.

Table 3.3 Aquatic Habitat Scores

Habitat variable	Aquatic Habitat Assessment Site – Habitat Variable Score									
	KP 609.55	KP 614.650	KP 641.540	KP 666.341	KP 667.21	KP 667.3	KP 668	KP 672.348	KP 676	KP 735.115
Waterbody	Second order stream	Second order stream south of Bellata	Gurly Creek upstream	Mehi River	Duffys Creek	Billabong off Duffys Creek	Skinners Creek	Second order stream	Gwydir River	Croppa Creek upstream
Bottom substrate/ available cover	Poor 5	Poor 0	Fair 10	Poor 5	Poor 0	Poor 0	Poor 0	Poor 0	Poor 5	Poor 0
Embeddedness	Poor 2	Poor 0	Fair 10	Poor 5	Poor 0	Poor 0	Poor 0	Poor 0	Poor 5	Poor 0
Velocity/depth category	Poor 1	Poor 1	Poor 0	Good 15	Poor 0	Poor 0	Poor 0	Poor 0	Good 15	Poor 0
Channel alteration	Poor 3	Poor 1	Fair 7	Excellent 12	Fair 7	Poor 0	Poor 3	Poor 3	Excellent 12	Poor 3
Bottom scouring and deposition	Fair 3	Poor 1	Fair 7	Fair 7	Poor 3	Poor 0	Poor 0	Poor 0	Good 11	Poor 0
Pool/riffle, run/bend ratio	Fair 7	Poor 2	Good 11	Good 11	Poor 3	Poor 0	Poor 0	Poor 0	Fair 7	Poor 0
Bank stability	Poor 2	Good 8	Fair 5	Good 8	Good 8	Fair 5	Fair 5	Poor 2	Fair 5	Fair 5
Bank vegetative stability	Fair 5	Good 10	Good 8	Good 8	Good 8	Good 8	Fair 5	Poor 2	Fair 5	Fair 5

Habitat variable	Aquatic Habitat Assessment Site – Habitat Variable Score									
	KP 609.55	KP 614.650	KP 641.540	KP 666.341	KP 667.21	KP 667.3	KP 668	KP 672.348	KP 676	KP 735.115
Streamside vegetation cover	Excellent 9	Fair 5	Excellent 10	Excellent 10	Excellent 10	Excellent 10	Excellent 9	Poor 2	Excellent 10	Excellent 10
Total score	37	28	68	81	39	23	22	9	75	23

3.3.1 Mehi River

The Mehi River is a major distributary of the Gwydir River leaving the Gwydir River at Pallamallawa approximately 30 kilometres upstream of Moree. An assessment of physical aquatic habitat variables were undertaken in September 2014 (see scores in **Table 3.3**) and again in April 2016. The scores in April 2016 were similar to those displayed in **Table 3.3**. On both occasions visual assessment of the river noted that the river was very turbid which hindered scoring of some of the habitat attributes.

The banks of the Mehi River have been mapped as supporting river red gum riparian tall woodland/open forest wetland (**Figure A30**) with some aquatic vegetation noted on the banks and instream (**Plate 3.1**). Snags were also recorded in proximity to the rail corridor.

Plate 3.1

Mehi River rail line crossing showing river red gums along the bank and some instream aquatic vegetation along the banks.

Along the northern bank of the Mehi River the rail line crosses a number of watercourses and billabongs just to the east of Moree. Aquatic habitat assessments were undertaken at three locations being Duffys Creek (KP 667.21), Skinners Creek (KP 668) and a billabong (KP 667.3) (refer to **Plate 3.2**) between the two watercourses (see **Table 3.3**). These three areas are intermittent watercourses fringed with river red gum but with minimal fish habitat features.

Plate 3.2

Billabong on floodplain north of Mehi River at KP 667.3.

The Gwydir catchment fish community includes 15 native species recorded or expected to occur and up to five introduced species (DPI 2015). Native fish species of the lowland Gwydir River catchment include golden perch (*Macquaria ambigua*), spangled perch (*Leiopotherapon unicolor*), Murray cod (*Maccullochella peelii peelii*), freshwater catfish (*Tandanus tandanus*), purple spotted gudgeon (*Mogurnda adspersa*), olive perchlet (*Ambassis agassizii*) (expected), Australian smelt (*Retropinna semoni*), bony bream (*Nematalosa erebi*), carp gudgeon (*Hypseleotris klunzingeri*), unspecked hardyhead (*Craterocephalus stercusmuscarum*) and Murray-Darling rainbow fish (*Melanotaenia fluviatilis*) (DPI 2015). Alien species recorded or expected in the lowland sections of the Gwydir catchment include carp (*Cyprinus carpio*), *Gambusia holbrooki* and goldfish (*Carassius auratus*) (DPI 2015).

Fish passage upstream along the Mehi River is limited at the Moree Weir approximately two kilometres downstream of the rail line and at the Tareelaroi weir located at the confluence of the Mehi and Gwydir Rivers upstream of Moree (DPI 2006). Notwithstanding this, a recent fish community status review identified that the Mehi River near Moree is rated as good fish community value and was predicted to support threatened species. It was also noted that the threatened Murray cod is more common in the Mehi River compared to the Gwydir River (DPI 2015).

3.3.2 Gwydir River

The proposal site intersects with the Gwydir River approximately 10 kilometres north of Moree. An assessment of physical aquatic habitat variables were undertaken in September 2014 (see scores in **Table 3.3**) and again in April 2016. The scores in April 2016 were slightly lower than those displayed in **Table 3.3**. On both occasions it was noted that the river was very turbid which hindered scoring of some of the habitat attributes.

The banks of the Gwydir River have been mapped as supporting river red gum riparian tall woodland/open forest wetland (**Figure A33**) though coverage on the northern bank is more sparse than the southern bank (refer to **Plate 3.3** and **Figure A33**).

Plate 3.3

Gwydir River looking downstream from the rail line on the south bank.

Aquatic vegetation noted on the banks included *Juncus* sp. with *Azolla* sp and *Myriophyllum* sp. recorded instream (refer to **Plate 3.4**). Weeping willow roots and snags provide potential refuge for fish species (refer to **Plate 3.4**).

Plate 3.4

Vegetation along southern bank of Gwydir River

The Gwydir River is regulated approximately four kilometres downstream of the proposal site at the Boolooroo Weir and approximately 26 kilometres upstream at Tareelaroi Weir. Both of these structures act as barriers to fish passage for the majority of flow events (DPI 2006).

While no direct sampling of aquatic species was undertaken, a review of literature and database searches have identified that the Gwydir River supports a diverse range of habitat types and native fish species including threatened species (refer to **Section 3.4**) and species as listed in **Section 3.3.1**. A recent fish community status review identified that the Gwydir River near the proposal site is rated as good fish community value but is not predicted to support threatened species (DPI 2015).

3.4 Threatened Aquatic Species and Communities

Search of the NSW DPI records viewer for listed threatened species identified four threatened fish species and one endangered population listed under the FM Act as occurring within the Narrabri, Moree Plains and Gwydir LGAs prior to 1980 and post 1980 (refer to **Table 3.4**). Two of these species are listed as threatened under the EPBC Act.

Table 3.4 DPI records for threatened fish species in Narrabri, Moree Plains and Gwydir LGAs

Common Name	Scientific Name	Conservation Status		LGA		
		EPBC Act	FM Act	Narrabri	Moree Plains	Gwydir
western olive perchlet	*Ambassis agassizii*	-	EP	-	Yes	-
silver perch	*Bidyanus bidyanus*	CE	V	Yes	Yes	Yes
Murray cod	*Maccullochella peelii*	V	-	Yes	Yes	Yes
purple spotted gudgeon	*Mogurnda adspersa*	-	E	-	-	Yes
freshwater catfish	*Tandanus tandanus*	-	EP	Yes	Yes	Yes

Status: CE –Critically Endangered; E – Endangered; V – Vulnerable; EP – Endangered Population.

An assessment of the likelihood of occurrence of threatened fish species and endangered populations in watercourses within the rail corridor is provided in **Table 3.5**.

Table 3.5 Threatened and Migratory Species, Endangered Populations and TECs Recorded or with Potential to Occur in the Proposal Site

Scientific Name	Common Name	Legislative Status		Habitat Requirements and Likelihood to Occur in the Proposal Site
		FM Act	EPBC Act	
Threatened Ecological Communities				
Aquatic Ecological Community in the Natural Drainage System of the Lowland Catchment of the Darling River		EEC	-	*Aquatic Ecological Community in the Natural Drainage System of the Lowland Catchment of the Darling River* includes all natural creeks, rivers, streams and associated lagoons, billabongs, lakes, flow diversions to anabranches, the anabranches, and the floodplains of the Darling River within NSW, including the Menindee Lakes and the Barwon River. In its natural state, many of the water-bodies in this area are characterised by variable and unpredictable patterns of high and low flows. The natural morphology of the river systems includes deep channels, deep pool areas, suspended load depositional 'benches', higher floodplain 'benches', braided channels, terminal wetland complexes, gravel beds and riffle zones. The floodplain is also an integral part of this river system. Many fish species rely on the seasonal flow pattern and inundation of the floodplain for successful reproduction. The complex river morphology provides a multitude of habitats that play a critical role in the life cycles of the species making up this ecological community. The proposal site intersects with this community in the regulated tributaries of the Darling River being the Gwydir River downstream of Copeton Dam (located upstream of Bingara) and the Namoi River downstream of the Manilla River. Consideration of the impact of the proposal on this community is provided in **Section 4.1.**

Scientific Name	Common Name	Legislative Status		Habitat Requirements and Likelihood to Occur in the Proposal Site
		FM Act	EPBC Act	
Endangered Populations				
Tandanus tandanus – Eel tailed catfish in the Murray/Darling Basin		EP	-	*Tandanus tandanus* is non-migratory and lives in a wide range of habitats including rivers, creeks, lakes, billabongs and lagoons. Although it inhabits flowing streams, it prefers sluggish or still waters. It can be found in clear to turbid waters, and over substrates ranging from mud to gravel and rock. It is rare in natural riverine habitats but can be found in farm dams throughout inland NSW and southern Queensland. Moderate remnant populations occur in the Namoi catchment upstream of Wee Waa, the Gwydir catchment upstream of Moree and the Border Rivers catchment upstream of Goondiwindi (Fisheries Scientific Committee 2008). Eel tailed catfish have been recorded on the DPI Threatened and protected species – records viewer (accessed May 2016) in the: • Mehi River, upstream of Moree in 2009 and downstream of Moree in 2004 • Tycannah Creek upstream of the rail line in 2007 • Gwydir River wetlands downstream of Moree • Gwydir River and its tributaries upstream of Gravesend in 1975 and 2008 • Namoi River upstream and downstream of Narrabri in 2001 and 2009. Key sites include the Namoi River between Gunnedah and Wee Waa (DPI 2015). Consideration of the impact of the proposal on this population is provided in **Section 4.1.**

Scientific Name	Common Name	Legislative Status		Habitat Requirements and Likelihood to Occur in the Proposal Site
		FM Act	EPBC Act	
Ambassis adassizii – Western Olive Perchlet western population		E	-	A small native fish that was once widespread in the Murray-Darling in sheltered areas within rivers, creeks, ponds and swamps in slow-flowing or still waters (DPI 2013a). Now known from limited sites in the Darling River catchment and an isolated population in the central Lachlan catchment (DPI 2013a). Analysis of the DPI Threatened and protected species – records viewer (accessed May 2016) identified that the western olive perchlet has only been recorded in the MacIntyre River near Boggabilla in 1999 and upstream of Boggabilla. These records are remote from the proposal site. While recent surveys found the western olive perchlet in the Gingham waterholes (Gwydir wetlands) this was thought to be due to large overland flows from northern catchments (DPI 2015). None of the watercourses in the proposal site flow into the MacIntyre River and the species is not expected to occur in the proposal site. No further assessment is required.

Scientific Name	Common Name	Legislative Status		Habitat Requirements and Likelihood to Occur in the Proposal Site
		FM Act	EPBC Act	
Threatened Fish				
Bidyanus bidyanus	Silver Perch	V	CE	*Bidyanus bidyanus* prefers fast-flowing waters, especially where there are rapids. This species migrates to spawn. Historical records show that the species was widespread and abundant in most of the Murray-Darling drainage, excluding the cool, high, upper reaches of streams on the western side of the Great Diving Range. Only one natural population is known, which occurs downstream of Torrumbarry Weir in the Murray River (DPI 2006). Analysis of the DPI Threatened and protected species – records viewer (accessed May 2016) indicates that the silver perch has been recorded in the: • Mehi River downstream of Moree near Bullarah in 2004 • Gwydir River upstream of Bingara in 1995 and 1999 • Barwon River in 2002 • Namoi River upstream of Boggabri in 1999 and downstream of Wee Waa in 2001. Key sites include the Namoi River between Gunnedah and Wee Waa, the Horton River and Gwydir River upstream of Bingara (DPI 2015). All of these records are remote from the proposal site. Based on habitat preferences, the silver perch is not expected to occur in the proposal site no further assessment is required.

Scientific Name	Common Name	Legislative Status		Habitat Requirements and Likelihood to Occur in the Proposal Site
		FM Act	EPBC Act	
Maccullochella peelii	Murray cod	-	V	Murray cod occurs naturally in the waterways of the Murray-Darling basin in a wide range of warm water habitats ranging from clear, rocky streams to slow flowing turbid rivers and billabongs. It is a long lived, highly territorial species that is highly dependent on in-stream woody structures or large rocks for habitat (National Murray Cod Recovery Team 2010). Analysis of the DPI Threatened and protected species – records viewer (accessed May 2016) indicates that the Murray cod has been recorded in the • Mehi River, upstream of Moree in 2009 and downstream of Moree in 2007 • Gwydir River downstream of Moree in 2001 and 2001 • Gwydir River tributaries upstream of Gravesend in 2008 • MacIntyre and Barwon Rivers in 1999, 2005 and 2007 • Namoi River upstream and downstream of Narrabri in 2001, 2005 and 2009. NSW key sites include the Horton and Gwydir River and the Gwydir River population downstream of Copeton Dam is identified as an 'important population' (DPI 2015). Consideration of the impact of the proposal on this species is provided in **Section 4.2**.
Mogurnda adspersa	purple spotted gudgeon	E	-	Purple spotted gudgeon is a small robust fish that is a benthic species usually found in rivers, creeks and billabongs with slow-moving or still waters; often amongst weeds, rocks or snags. The western population historically occurred throughout the Murray-Darling basin drainages but is now largely confined to the Gwydir River (DPI 2013b). Analysis of the DPI Threatened and protected species – records viewer indicates that the purple spotted gudgeon has only been recorded in the Gwydir River tributary (Halls Creek and Horton River) upstream of Bingara in 2002, 2003 and 2005 and in tributaries of the MacIntyre River upstream of Bonshaw. These records are very remote from the proposal site. There are no records from the lower Gwydir River or other Border rivers in the immediate environs of the proposal site. No further assessment of the impact of the proposal on this species is required.

Scientific Name	Common Name	Legislative Status		Habitat Requirements and Likelihood to Occur in the Proposal Site
		FM Act	EPBC Act	
Notopala sublineata	Darling River Snail	CE	-	Once common and widely distributed throughout the Murray-Darling basin, the Darling River snail is found in flowing rivers, along banks attached to logs and rocks or crawling in the mud (DPI 2016). Recent surveys in the lower Darling River, upper Darling/Barwon River, Namoi River and Pilliga outwash failed to find any living individuals. Old shells were found near Bourke, Brewarrina and Walgett (Fisheries Scientific Committee 2016). The proposal site is upstream of the population near Walgett this species is unlikely to occur and therefore no further assessment is required.

3.4.1 Threatened Ecological Communities

The PMST report identified seven Commonwealth listed TECs within the proposal site and 10 kilometre buffer. All of these communities are terrestrial and have been assessed in the BAR (Umwelt 2017).

The rail corridor between Narrabri and North Star occurs within the mapped distribution of the *Aquatic Ecological Community in the Natural Drainage System of the Lowland Catchment of the Darling River* as listed under the FM Act.

An assessment of the likelihood of occurrence of the endangered ecologically community in watercourses along the rail corridor is provided in **Table 3.5**.

3.4.2 Ramsar Listed Wetlands

The PMST report identified that the proposal site and 10 kilometre buffer occur within the catchment of four Ramsar listed wetlands of international importance. The Ramsar listed wetlands include:

- Gwydir wetlands: Gingham and Lower Gwydir (Big Leather) watercourses
- The Coorong, and Lakes Alexandrina and Albert
- Banrock Station wetland complex
- Riverland.

Banrock Station wetland complex, Riverland, Coorong and Lakes Alexandrina and Albert wetlands are all located in South Australia between 900 and 1200 kilometres downstream of the proposal site.

The Gwydir wetlands Ramsar site is located approximately 45 km west of Moree over four discrete wetland areas located on floodplains as a series of natural and constructed channels and swamps. It is one of the few inland wetlands remaining in the Murray-Darling Basin, and is an example of an inland terminal delta (RIS 1999). The wetlands can span up to 1021 km^2 when fully flooded.

The wetlands are characterised by one of the largest stands of water couch (*Paspalum distichum*) and march club-rush (*Bolboschoenus fluviatilis*) remaining in NSW and large areas of Coolibah woodland. The wetland provides important breeding habitat for a vast array of waterbirds, while providing a resting site for migratory species. It also is an important fish breeding habitat (RIS 1999) and part of the FM Act listed natural drainage system of the lowland catchment of the Darling River endangered ecological community.

No Ramsar listed wetlands occur within 10 kilometres of the proposal site.

3.5 Groundwater Dependent Ecosystems

Groundwater Dependent Ecosystems (GDEs) are ecosystems in which species composition and ecological processes are determined by groundwater (Department of Land and Water Conservation 2002). Ephemeral waterways are likely to be fed by both surface and groundwater, and the associated riparian vegetation is therefore likely to be dependent, at least in some part, on groundwater.

Groundwater sources in the proposal site include alluvial sediments associated with the Gwydir River in the vicinity of Moree, where the alluvial sediments extend to over 40 metres below ground level. Alluvial groundwater associated with the Gwydir River would be recharged by rainfall infiltration and surface flows. Groundwater levels would be expected to rise following periods of above average rainfall and fall following periods of below average rainfall. In the vicinity of Narrabri, the proposal site may be underlined by alluvial

sediments associated with the Namoi River with the groundwater assessment identifying alluvial sediments at a depth of over 50 metres below ground level (GHD 2016).

The alluvial aquifer is underlined by fractured rock. This fractured rock overlies the Great Artesian Basin aquifer. The fractured rock outcrops outside of the extent of the alluvial aquifer. There is potential perched groundwater in the fractured rock above the Great Artesian Basin where, if present, groundwater would be expected to be low yielding (GHD 2016).

Outside the extent of the alluvial aquifers, the groundwater assessment (GHD 2016) identified that the majority of registered bores extend to depths of greater than 100 metres below ground level. These bores are likely to be extracting from the Great Artesian Basin aquifer.

Shallow alluvial sediments of depth of less than 10 to 20 metres below ground level may be intercepted along creek lines by the proposal. These perched shallow groundwater sources would be recharged by rainfall infiltration with groundwater levels expected to rise following rainfall events.

The Gwydir subregion contains a range of GDEs including wetlands, terrestrial vegetation and instream ecosystems fed by baseflow and springs focused on the Gwydir wetlands and floodplain systems (Welsh et al 2014). The main pressures on groundwater resources for these GDEs are river regulation and agriculture, particularly irrigation.

A review of the online Atlas of GDEs identified potential GDEs associated with:

- watercourses and riparian vegetation either side of the proposal site along Gurly Creek, Gehan Creek, Mehi River, Gwydir River and Croppa Creek
- riparian vegetation along Gil Gil Creek is identified of having a low potential for GDEs while upstream of the proposal site there is a higher potential for GDEs
- floodplain waterbodies upstream and downstream of the proposal site associated with Tycannah Creek are mapped as GDEs
- the Gwydir River wetlands, downstream of the proposal site.

Terrestrial vegetation in the proposal site associated with watercourses is identified in **Table 3.1** and includes weeping myall open woodland (Gehan Creek), river red gum riparian tall woodland/open forest wetland (Gurly Creek, Mehi River, Gwydir River, Gil Gil Creek and Croppa Creek) and coolabah – river coobah – lignum woodland wetland of frequently flooded floodplains and alluvial plains (Tycannah Creek).

As all of the current watercourse crossings have been previously disturbed and there is minimal native vegetation in the existing rail corridor itself. Limiting clearance of native vegetation through micrositing of the disturbance footprint at all watercourses will minimise clearance of the GDEs. Works to culverts and bridges is not expected to significantly change local flow regimes and will not disturb groundwater. No impacts are predicted and no further assessment of these GDEs is required.

One TEC listed under the *Threatened Species Conservation Act 1995* (TSC Act) that is predicted to occur in the proposal site is the *Artesian Springs Ecological Community in the Great Artesian Basin*. This ecosystem is listed as Critically Endangered under the TSC Act and Endangered under the EPBC Act and is a GDE. The listing under the EPBC Act is described as *the community of native species dependent on natural discharge of groundwater from the Great Artesian Basin*. This community is naturally restricted to artesian springs at the edges of the Great Artesian Basin that are the natural surface discharge points of aquifers in the Triassic, Jurassic and Cretaceous sedimentary sequence of the Great Artesian Basin but not including those springs arising from Tertiary sediments and basalts (TSSC 2001). These springs occur predominantly in

Queensland and South Australia with a few locations the Mulga Lands, Darling Riverine Plains and Cobar Peneplain Bioregions in north-western NSW. The DoEE Species Profile and Threats Database (SPRAT) identifies that the community is associated with spring supergroups in discharge areas including two in NSW:

- Bogan River supergroup – generally located north-west of Walgett, north-east of Coolabah and west of Carinda

- Bourke supergroup – generally located north east to north west of Bourke with some springs east of White Cliffs.

These springs are not within the proposal site or immediate environs and the proposal will not result in adverse impacts on the TEC. No further consideration of this GDE/TEC is required.

4.0 Impact Assessment

For the purposes of this assessment, the proposal site represents the area within the rail corridor, where the rail line overlays mapped watercourses. The proposal is shown on **Figure 1.2, Figure 1.3** and the set of figures in **Appendix A**.

The main impacts associated with construction of the proposal on aquatic ecological systems would be the removal and construction of new watercourse crossing structures along the existing rail corridor and upgrading of access tracks over watercourses within the proposal site for movement of construction equipment and personnel. Engineering features of the proposal that will impact the hydrology and hydraulics relate to the raising of the existing rail embankment along the majority of the length of the proposal. This work will form a raised embankment across the floodplain and upgraded structures will be required through that embankment to permit an appropriate flow to minimise adverse flooding impacts of the proposal (GHD 2017a). The proposal is shown on **Figure 2.1** and the location of proposed culverts is shown on Figures 2-2a and 2-2b of GHD (2017a).

GHD (2017) prepared a hydrology and flooding assessment for the proposal. The *Australian Rail Track Corporation Inland Rail Narrabri to North Star Water Quality Assessment* (GHD 2017a) and the *Australian Rail Track Corporation Inland Rail Narrabri to North Star Hydrology and Flooding Assessment* (GHD 2017b) assessment identified the potential impacts and associated management and mitigation measures with respect to anticipated hydrological and flooding impacts. The impacts identified in GHD (2017) considered relevant to this aquatic assessment are listed below:

- modified surface flow volume or rate downstream of the rail corridor
- changed surface flow paths across the rail corridor
- restricted water passage along irrigation drains or constructed channels
- modified groundwater flow volume or rate downstream of the rail corridor modified surface flow volume or rate downstream of the rail corridor
- restricted water passage along irrigation drains or constructed channels
- modified groundwater flow volume or rate downstream of the rail corridor during rail line operation.

This aquatic ecology assessment has considered the impacts identified above. For a detailed analysis of specific hydrology and flooding impacts related to the proposal refer to The Inland Rail Narrabri to North Star Water Quality report (GHD 2017a) and the Inland Rail Narrabri to North Star Hydrology and Flooding (GHD 2017b) assessment.

The majority of watercourses have been mapped as cleared/non-native vegetation in the rail corridor (refer to **Table 3.1**). The proposal would impact eight vegetation communities occurring within a 25 metre buffer of mapped watercourses. The vegetation communities impacted within the riparian zone are shown in **Table 4.1**.

Table 4.1 Area of clearance of riparian vegetation associated with watercourses in the proposal site

Vegetation Communities Occurring within 25m buffer of Watercourse	Area of Permanent Impact (ha)
Weeping Myall open woodland of the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion	0.5
Brigalow - Belah open forest / woodland on alluvial often gilgaied clay from Pilliga Scrub to Goondiwindi, Brigalow Belt South Bioregion	0.2
Coolabah - River Coobah - Lignum woodland wetland of frequently flooded floodplains mainly in the Darling Riverine Plains Bioregion	0.8
Queensland Bluegrass +/- Mitchell Grass grassland on cracking clay floodplains and alluvial plains mainly the northern-eastern Darling Riverine Plains Bioregion	9.6
Poplar Box - Belah woodland on clay-loam soils on alluvial plains of north-central NSW (moderate to good condition)	2.5
Poplar Box - Belah woodland on clay-loam soils on alluvial plains of north-central NSW (derived native grassland)	3.9
River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion	5.8
Coobah - Western Rosewood low open tall shrubland or woodland mainly on outwash areas in the Brigalow Belt South Bioregion	0.1
Total area	**23.4**

The impact of the proposal on riparian communities has been assessed in the BAR, in accordance with the Framework for Biodiversity Assessment. Further assessment of the loss of riparian communities is not provided in this assessment.

As identified in **Section 3**, some of the watercourses that intersect the proposal site comprise important aquatic ecosystems, in particular NSW DPI identified the Mehi River as good fish community value; while Bobbiwaa and Spring Creek in the Namoi catchment and Ten Mile Creek, Bulldog Creek, Gurly Creek, Tycannah Creek and Gwydir River in the Gwydir catchment are identified as having moderate fish community value. Gehan Creek, Waterloo Creek and Gil Gil Creek were identified as having moderate fish community value but with a high alien presence. These sensitive aquatic ecosystems will be subjected to temporary construction impacts that would be subject to appropriate controls to minimise and mitigate the potential for adverse water quality and fish habitat (including fish passage) impacts. The temporary construction impacts will occur in discrete areas where the rail corridor cross the watercourses and only a very small proportion of the aquatic habitat associated with the watercourses will be impacted. No long-term impacts are predicted.

There are minimal impacts on aquatic ecological systems associated with operation of the proposal including consideration of the potential for spills from trains and/or maintenance vehicles using the access track.

4.1 Threatened Species, Endangered Populations and TECs Assessed Under the FM Act 1994

Searches of available databases and literature review have identified a number of threatened species, endangered populations and TECs as listed under the FM Act 1994. As identified in **Table 3.5** the proposal site intersects with the following communities and populations listed under the FM Act:

- Aquatic Ecological Community in the Natural Drainage System of the Lowland Catchment of the Darling River

- *Tandanus tandanus* – Eel tailed catfish in the Murray/Darling Basin.

An assessment of significance is provided in **Table 4.2** which concludes that the proposal is unlikely to result in a significant impact on this community and endangered population, with the adoption of appropriately designed fish friendly crossing structures and other mitigation measures described in this report.

Table 4.2 Seven Part Test of Significance for matters listed under the FM Act

Aquatic Ecological Community in the Natural Drainage System of the Lowland Catchment of the Darling Catchment	Eel tailed catfish in the Murray/Darling Basin, Endangered Population
(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction	
Not applicable	Not applicable
(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction	
Not applicable	The eel tailed catfish is non-migratory, adults typically only move within a 5km range; preferring clear, sluggish or still waters of lagoons and back-waters; living, feeding and breeding near the bottom. They spawn in spring/summer when water temperatures are 20 to 24°C and eggs are laid in a nest of pebbles and gravel. The male guards the nest and eggs hatch after 7 days. The life cycle is threatened by loss of habitat and spawning sites through siltation, reduced spawning success through alterations to flow patterns and flooding regimes, and loss of spawning cues due to cold water pollution. The majority of watercourses in the rail corridor were dry at the time of inspection and have been silted with few permanent pools noted upstream or downstream of the proposal site that may provide preferred habitat for this endangered population. It is noted that the eel tailed catfish has been recorded upstream of the rail line in Tycannah Creek and in the Mehi River. Tycannah Creek has a well defined channel with no pools evident in or immediately upstream or downstream of the proposal site. The Mehi River is turbid, deep, wide and slow moving where the proposal site intersects (see **Section 3.3.1**). The works associated with removing and or replacing /upgrading bridges and culverts may impact on some small areas of breeding habitat through direct disturbance of the bottom, through alteration of natural flows, through clearance of vegetation or through blocking of fish passage. Replacement watercourse structures would be designed to maintain flows and avoid blockage of fish passage. Works would be undertaken in accordance with standard sediment and erosion controls to manage and minimise further siltation. These standard practices would minimise adverse effects on the life cycle of the population.

Aquatic Ecological Community in the Natural Drainage System of the Lowland Catchment of the Darling Catchment	Eel tailed catfish in the Murray/Darling Basin, Endangered Population
(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: i. is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; and ii. is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction;	
The proposal site intersects watercourses that are part of the natural drainage system of the lowland catchment of the Darling River. The majority of the watercourses have been modified by in-stream structures, clearance of remnant vegetation and potentially altered by deposition of sediment from land practices in their catchments. The proposal would require localised disturbance of watercourses to replace existing watercourse crossing structures and may include clearance of adjoining riparian vegetation. The watercourse structures would be designed to avoid blockage of fish passage, minimise disturbance of remnant vegetation upstream and downstream of the work area, and minimise changes to the morphology of the watercourse. The proposal is unlikely to: • have an adverse effect on extent of this ecological communities such that its local occurrence is likely to be place ad risk of extinction, or • substantially and adversely modify the composition of the community.	Not applicable

Aquatic Ecological Community in the Natural Drainage System of the Lowland Catchment of the Darling Catchment	Eel tailed catfish in the Murray/Darling Basin, Endangered Population
(d) in relation to the habitat of a threatened species, population or ecological community: i. the extent to which habitat is likely to be removed or modified as a result of the action proposed; ii. whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and iii. the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality;	
The proposal would require localised disturbance of watercourses to replace existing watercourse crossing structures and may include clearance of adjoining riparian vegetation. Disturbance is limited to 50m upstream and downstream of the watercourse. These impacts represent a minimal to negligible area of the endangered ecological community. Assessment of habitat type and sensitivity of all of the watercourses is provided in **Table 3.2**. The Gwydir River and Mehi River and other major streams supporting higher quality fish habitat and/or with remnant vegetation along the banks and instream are likely to be important to the long-term survival of the ecological community in the locality. The Gwydir catchment upstream of Moree is considered to support a moderate remnant population of the eel tailed catfish (Fisheries Scientific Committee 2008) and the Mehi River between Wee Waa and Gunnedah is identified as a key asset site for this species (DPI 2015) and accordingly habitat in the Mehi River is likely to be considered important for the survival of the species. The watercourse structures would be designed to avoid blockage of fish passage and minimise disturbance of remnant vegetation upstream and downstream of the work area. Works would be undertaken in accordance with standard sediment and erosion controls to manage and minimise further siltation. These standard practices would minimise adverse effects relating to the fragmentation or isolation of habitats.	
(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly);	
No critical habitat has been identified in the proposal site.	No critical habitat has been identified in the proposal site.

Aquatic Ecological Community in the Natural Drainage System of the Lowland Catchment of the Darling Catchment	Eel tailed catfish in the Murray/Darling Basin, Endangered Population
(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan; and	
Priority action statements for Lowland Darling River and eel tailed catfish include the following recovery actions: • provide advice to consent and determining authorities and management authorities regarding habitat protection • community and stakeholder liaison, awareness and education • implement and enforce relevant fishing regulations • review regulatory and voluntary incentive based mechanisms to enhance habitat protection • pest eradication and control • stocking/translocation • habitat rehabilitation including: management of environmental flows; improved fish passage at major regulating structures; protection and rehabilitation of aquatic habitat and riparian vegetation; and mitigate impacts of cold water pollution. The proposal would replace some of the existing watercourse structures designed and constructed in accordance with the national guidelines *Why do fish need to cross the road? Fish passage requirements for waterway crossings* (Fairfull and Witheridge 2003). This is in keeping with recovery actions.	
(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.	
The proposal may contribute to the following key threatening processes: • installation and operation of instream structures and other mechanisms that alter natural flow regimes of rivers and streams • degradation of native riparian vegetation • removal of large woody debris. The proposal may require removal of large woody debris in the proposal site. Any large woody debris in the proposal site would be relocated upstream or downstream in consultation with an appropriate qualified ecologist. Through appropriate design of the watercourse crossing structure and avoiding/minimising disturbance of riparian vegetation the proposal would minimise the above threatening processes.	

4.2 Matters of National Significance Assessed Under the Commonwealth EPBC Act

Under the Commonwealth EPBC Act, the approval of the Commonwealth Minister for the Environment is required for any action that may have a significant impact on MNES. The proposal was referred to the Commonwealth DoE in June 2016, with the outcome of the supporting assessment concluding that the proposal is not likely to have a significant impact on any aquatic MNES.

Table 3.5 identifies whether the threatened fish species have been previously recorded in the rail corridor and buffer area, as well as its potential to occur and the potential for the proposal to impact the species. No nationally listed threatened endangered populations, TECs or aquatic migratory species are expected to occur in the watercourses within the development footprint. The threatened Murray cod has been recorded in the Mehi River upstream and downstream of Moree and in the Gwydir River downstream of Moree or in tributaries of the Gwydir River upstream of Gravesend. The closest records of the Murray cod to the proposal site are in the Mehi River. Accordingly an assessment of the impact of the proposal on the Murray cod is provided below and concludes that the proposal will not result in a significant impact on the Murray cod.

As noted in **Section 3.4.2** there are four Ramsar listed wetlands of international importance downstream of the proposal site. Three of these are located in South Australia and are highly unlikely to be impacted directly or indirectly by works on watercourses in the Gwydir catchment.

The proposal site is located approximately 40 kilometres upstream of the Ramsar listed Gwydir wetlands. It is noted that the Boolooroo Weir is located on the Gwydir River approximately 4 kilometres downstream of the rail line crossing structure and that the Tyreel Weir is also located downstream at the start of the Gwydir wetlands. Any potential hydrological changes including variations to flow direction, volume of water flow and sedimentation, which could in turn change water chemistry parameters, such as dissolved oxygen and turbidity, are unlikely to affect the Gwydir wetland systems located 40 kilometres downstream with two weir structures regulating flows.

Table 4.3 Significant Impact Assessment for the EPBC listed vulnerable Murray cod

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:	
lead to a long-term decrease in the size of an important population of a species	Within NSW, the Horton and Gwydir Rivers are identified as key asset sites for the Murray cod and the Gwydir River population downstream of Copeton Dam (including the proposal site) is identified as an 'important population' (DPI 2015) that appear to be widespread, abundant and recruiting (National Murray Cod Recovery Team 2010). The majority of existing records (DPI record viewer) are located upstream of the Tareelaroi Weir. The Murray cod is reportedly more commonly recorded in the Mehi River and may occur in the class 1 key fish habitats in the Mehi River and Gwydir River. Disruption of habitat would be limited to a small area associated with the points at which the rail lines cross these rivers and also limited to the construction period and is unlikely to lead to a long term decrease in the size of the population in the Gwydir River.
reduce the area of occupancy of an important population	Disruption of preferred habitat instream in the main channels of the Mehi River and Gwydir River would be limited to a small area associated with the points at which the rail lines cross these rivers and also limited to the construction period and appropriate design of structures would not obstruct movement of fish or reduce the area of occupancy of the important population. The works would not reduce the area of highest records in the Gwydir and Horton Rivers upstream of Tareelaroi Weir.
fragment an existing important population into two or more populations	The majority of existing records (DPI record viewer) in the vicinity of the proposal site in the Mehi River are located upstream and downstream of existing weir structures that may limit movement. There is a record (2009) downstream of the Tareelaroi Weir indicating that part of the population may exist in this section of the Mehi River. Dispersal of individuals upstream prior to spawning may be limited by existing weir structures. Appropriate design of structures as planned as part of the proposal would ensure that they do not obstruct fish passage and would not fragment the population that may occur upstream or downstream of the rail line.
adversely affect habitat critical to the survival of a species	The main channel of rivers and large tributaries and complex structural cover are important habitat features for the Murray cod. Works instream during construction may disturb submerged large snags in the relatively small areas affected by construction but would not alter the width of the main channel greater than that currently occupied by the existing structure.

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:	
disrupt the breeding cycle of an important population	Murray cod have an annual reproductive cycle with egg development through winter, spawning over 4 to 5 weeks when water temperatures exceed 15°C possibly in early September to mid October. Eggs are most likely laid in a sunken log. Recruitment success appears to be linked to higher river flows. Construction, particularly any removal of material, may disrupt the breeding cycle of individuals in this section of the river. However it is noted that the majority of records are upstream of the Tareelaroi Weir and that the proposal would is not likely to disrupt the breeding cycle of the important population.
modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	During construction of the bridge, habitats within the disturbance footprint and immediately upstream and downstream may be temporarily modified and isolated. However, with appropriate design of the bridge and relocation of any recovered snags in the long term, habitat would recover and would not be removed or isolated.
result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	The literature reports that introduced species such as carp and redfin may compete with the Murray cod for habitat resources and in case of redfin predation (National Murray Cod Recovery Team 2010). The proposed construction works are not expected to alter the number or distribution of introduced fish species in the Mehi or Gwydir Rivers.
introduce disease that may cause the species to decline, or	Little is known of the impact of diseases on Murray cod (National Murray Cod Recovery Team 2010). Naturally occurring pathogens may be a problem for injured fish. The proposal would not introduce any alien species that may act as a source of disease.
interfere substantially with the recovery of the species.	The proposed construction of new watercourse crossing structures would be designed to maintain the main channel flows and allow for passage of fish and would not alter flow regimes. Any recovered snags in the disturbance footprint would be relocated and bank vegetation rehabilitated such that habitat features recover in the long run. The proposal is not expected to substantially interfere with recovery actions for the species as set out in the national recovery plan (National Murray Cod Recovery Team 2010).

5.0 Impact Avoidance and Mitigation Measures

5.1.1 Construction Phase Impact Mitigation

A range of general mitigation measures are recommended to be employed across the proposal site during the construction phase to minimise impacts to aquatic ecological values, including:

- employee education and training including inductions for relevant staff, contractors and visitors to the site to inform personnel of the aquatic ecological issues present at the site and so they know their role and responsibilities in relation to the protection and/or minimisation of impacts
- areas of ecological value outside the development footprint would be fenced or signposted, where appropriate, to prevent the unnecessary disturbance during the construction phase.

To minimise impacts on water quality, erosion and sedimentation associated with spills and/or construction activities would be undertaken in accordance with the soil and water management sub-plan prepared as part of the Construction Environmental Management Plan (CEMP). The soil and water management sub-plan would be prepared in accordance with guidelines from *Managing Urban Stormwater: Soils and Construction Volume 1* (Landcom 2004) and *Volumes 2A, 2C, 2D and 2E* (DECC 2008) (the Blue Book), including:

- works within the riparian zone would maximise, where possible, the preservation of any existing vegetation and minimise disturbance
- planned works would, where possible, be scheduled for forecasted dry weather periods
- designs for works within or near watercourses would provide for the retention of natural functions and maintenance of fish passage in accordance with *Why do fish need to cross the road? Fish passage requirements for waterway crossings* (Fairfull and Witheridge 2003)
- management of sediment that has accumulated upstream to avoid sediment mobilisation
- spoil material removed should be disposed appropriately.

Watercourse crossings can act as a barrier to fish passage. To avoid the creation of barriers to fish passage it has been assumed that all in-stream watercourse structures would be designed to the minimum required (see **Table 5.1**) for the watercourse classification as provided in **Table 3.2**. Guidelines for the design and construction of watercourse structures to minimise impact on fish passage and aquatic habitats are provided in *Why do fish need to cross the road? Fish passage requirements for waterway crossings* (Fairfull and Witheridge 2003).

Table 5.1 Preferred Watercourse Crossing Type in Relation to Watercourse Classification (DPI 2013)

Watercourse Classification	Minimum Recommended Crossing Type	Additional Design Information
Class 1 Major Key Fish Habitat	Bridge, arch structure or tunnel.	Bridges are preferred to arch structures
Class 2 Moderate Key Fish Habitat	Bridge, arch structure, high flow design culvert or tunnel.	Bridges are preferred to arch structures, box culverts and fords
Class 3 Minimal Key Fish Habitat	Culvert or ford	Box culverts are preferred to fords and pipe culverts.
Class 4 Unlikely Key Fish Habitat	Culvert, causeway or ford	Culverts and fords are preferred to causeways

It is noted that DPI Fisheries policy and guidelines for riparian and freshwater vegetation include the implementation of riparian buffer zones for activities in or adjacent to type 1 or 2 habitats or class 1 to 3 watercourses. This policy does not apply to developments involving the maintenance to existing, or construction of new roads or bridges crossing a watercourse. However work compounds and stockpile sites should be located an appropriate distance from riparian vegetation to avoid indirect impacts on aquatic habitat values. As a guide, riparian buffer zones as recommended by DPI are: 100m for type 1 class 1 watercourses (Mehi River and Gwydir River), 50m for type 2 class 2 -3 watercourses and 10 to 50m for type 3 class 2 -4 watercourses.

To avoid any unnecessary clearance of established trees and native vegetation on the banks of watercourses and in-stream vegetation upstream and downstream of the rail corridor it is recommended that the native vegetation within a 25 metre buffer of watercourses be demarcated prior to clearing. This would assist in avoidance of impacts on any established trees and native vegetation outside of the area cleared for construction works. The proposal may require removal of large woody debris in the proposal site, though none was noted in the rail corridor assessments. Any large woody debris in the proposal site would be relocated upstream or downstream where practicable.

To minimise loss of fish within any semi-permanent pools in the impact zone, it is recommended that a dewatering procedure be developed and included in the biodiversity management sub-plan in the CEMP. The dewatering procedure would outline methods for collection and relocation of protected fish and euthanasia of pest species.

5.1.2 Operational Phase Mitigation

A range of strategies are recommended to mitigate adverse impacts during the operational phase of the proposal. This includes specific measures to minimise the potential impacts on the biodiversity and aquatic ecological values of the proposal site and the locality, including:

- continuation of general mitigation measures for relevant maintenance staff to inform personnel of aquatic ecological values, roles and responsibilities in relation to the protection of watercourses and riparian vegetation
- ongoing weed management

- regular inspection and maintenance of structures to ensure functionality and minimise blockage of fish passage
- management of spills.

6.0 Summary and Conclusion

The aquatic ecological assessment for the proposed upgrading of the existing rail line between Narrabri and North Star has been prepared based on a combination of field investigations and a review of available aerial photographs, topographic maps, databases, literature, policies and guidelines. The proposal crosses 82 mapped watercourses in the catchment of the Namoi, Gwydir or Border Rivers. The watercourses range from first order streams to fifth order streams and the catchments are characterised by variable and unpredictable patterns of flow and water levels exacerbated by heavily cleared catchments and prevalence of agricultural land uses.

The majority of watercourses in the proposal site are first order or second order streams with intermittent flow following rain events, little or poorly defined channels with no aquatic flora species. The watercourses have been modified by crossing structures for rail, road and agricultural land practices with minimal native vegetation retained along the banks of the watercourses. Accordingly these watercourses have been classified as under DPI Fisheries guidelines as Class 4 unlikely key fish habitats that are considered to be Type 3 minimally sensitive fish habitat.

There is 24 third order or higher streams including:

- Spring Creek and Bobbiwaa Creek in the Namoi River catchment
- Ten Mile Creek, Bulldog Creek, Boggy Creek, Gehan Creek, Tookey Creek, Waterloo Creek, Gurly Creek, Tycannah Creek, Mehi River, Duffys Creek, Skinners Creek, Gwydir River and Marshalls Pond Creek, Bunna Bunna Creek and Gil Gil Creek in the Gwydir River catchment
- Croppa Creek, Yallaroi Creek, Tackinbri Creek and Mungle Creek in the Border Rivers catchment.

Analysis of key fish habitat values and sensitivity typing of the watercourses in combination with a literature review of fish community analysis by NSW DPI identifies that a number of theses named watercourses have moderate or higher fish community value. The Mehi River and Gwydir River have both been identified as class 1 key fish habitat.

A number of state and Commonwealth listed threatened fish species, endangered populations and TECs are recorded or predicted to occur in major watercourses in the proposal site particularly the FM Act listed eel-tailed catfish endangered population and the EPBC Act listed Murray cod. Both species have been recorded in watercourses where there are no known barriers to fish passage that may limit the likelihood that they occur in aquatic habitats immediately upstream or downstream of the rail line. The proposal site intersects watercourses that are part of the FM Act Aquatic Ecological Community in the Natural Drainage System of the Darling River Catchment. An assessment of significance of impact of the proposal on this community, species and endangered populations has identified that the proposal is unlikely to have an adverse impact, with the adoption of appropriately designed fish friendly crossing structures and other mitigation measures to further reduce impacts.

The assessment has considered the impact of the proposal on MNES as listed under the EPBC Act. One nationally listed fish species, the Murray cod is considered to potentially occur in the habitats of the Mehi River however, with the adoption of appropriately designed fish friendly crossing structures and other mitigation measures as proposed is unlikely that the proposal will significantly impact this species.

GDEs in the proposal site are associated with the riparian vegetation along major watercourses particularly the weeping myall open woodland (Gehan Creek), river red gum riparian tall woodland/open forest wetland (Gurly Creek, Mehi River, Gwydir River, Gil Gil Creek and Croppa Creek) and the coolabah – river coobah – lignum woodland wetland of frequently flooded floodplains and alluvial plains (Tycannah Creek).

Clearance of riparian vegetation for proposed upgrading of watercourse structures may occur where it is not possible to undertake works within the existing disturbance area. However, works to watercourse crossings are not expected to adversely alter local surface or groundwater flow regimes and the proposal is not expected to impact on GDEs.

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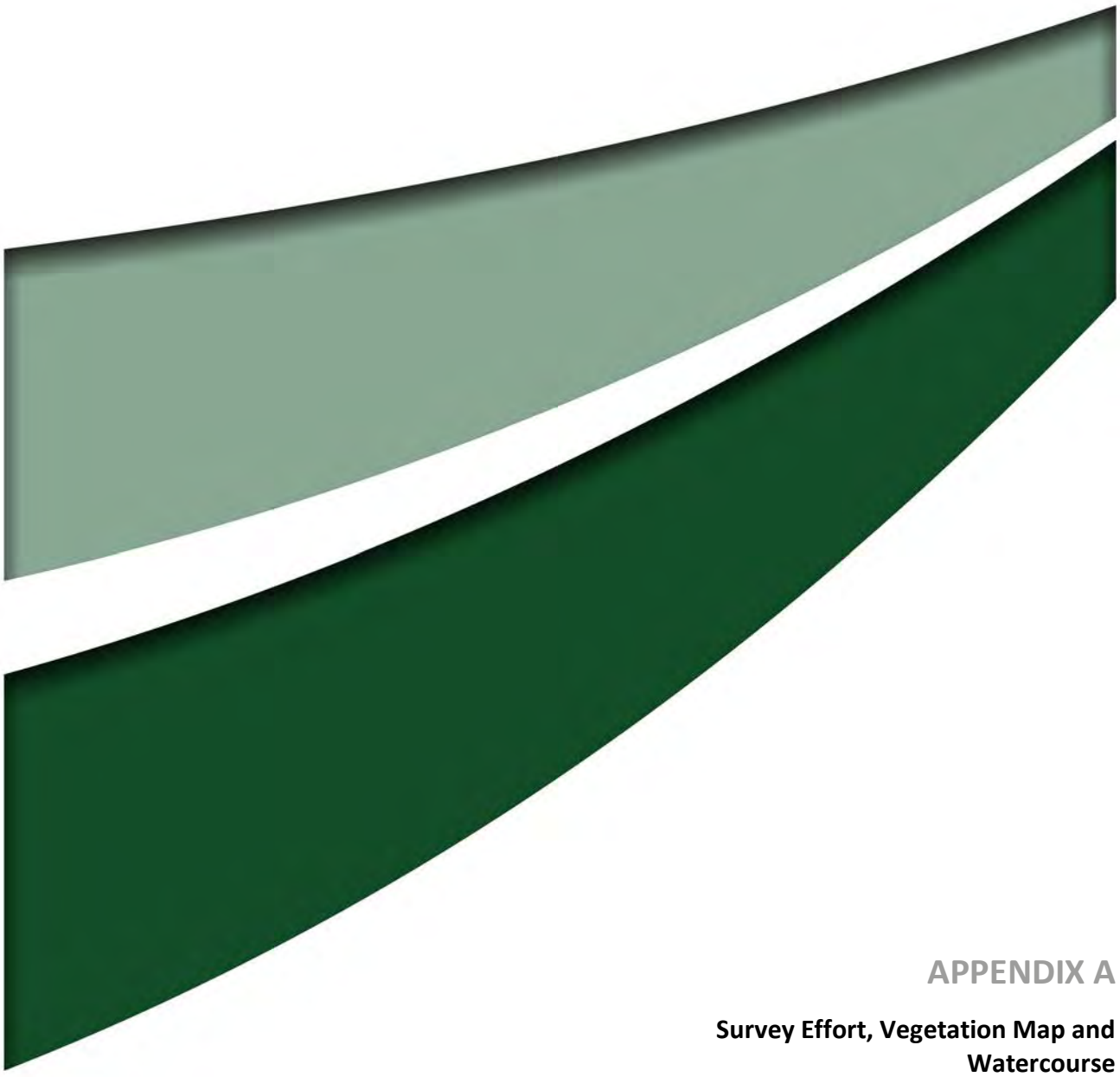

APPENDIX A

Survey Effort, Vegetation Map and Watercourse

Legend

- Proposal Site
- Local Government Area
- Catchment Management Authority
- Plot/Transect
- Rapid Assessment

Stream Order:

- 1st Order
- 2nd Order
- 3rd Order
- 4th Order
- 5th Order
- 6th Order

Vegetation:

- Cleared/Non-native Vegetation
- Zone 1 - PCT-27 BVT-BR233, NA219-Weeping Myall open woodland of the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion-Moderate - Good
- Zone 2 - PCT-35 BVT-BR120, NA117-Brigalow - Belah open forest / woodland on alluvial often gilgaied clay from Pilliga Scrub to Goondiwindi, Brigalow Belt South Bioregion-Moderate - Good
- Zone 3 - PCT-39 BVT-BR130, NA129-Coolabah - River Coobah - Lignum woodland wetland of frequently flooded floodplains mainly in the Darling Riverine Plains Bioregion-Moderate - Good
- Zone 4 - PCT-52 BVT-BR191, NA187-Queensland Bluegrass +/- Mitchell Grass grassland on cracking clay floodplains and alluvial plains mainly the northern-eastern Darling Riverine Plains Bioregion-Native Grassland
- Zone 5 - PCT-56 BVT-BR186, NA182-Poplar Box - Belah woodland on clay-loam soils on alluvial plains of north-central NSW-Moderate - Good
- Zone 6 - PCT-56 BVT-BR186, NA182-Poplar Box - Belah woodland on clay-loam soils on alluvial plains of north-central NSW-Derived Native Grasslands
- Zone 8 - PCT-78 BVT-BR196, NA193-River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion-Moderate - Good
- Zone 9 - PCT-135 BVT-BR284, NA271-Coobah - Western Rosewood low open tall shrubland or woodland mainly on outwash areas in the Brigalow Belt South Bioregion-Moderate - Good
- Zone 10 - PCT-413 BVT-BR346, NA348-Silver-leaved Ironbark - White Cypress Pine - box dry shrub grass woodland of the Pilliga Scrub - Warialda region, Brigalow Belt South Bioregion-Moderate - Good

umwelt

Image Source: ARTC (2016)
Data Source: ARTC (2016), Umwelt (2016)
Note: For full legend, refer to legend page

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Legend

- Proposal Site
- Rail Line Chainage

FIGURE A1

Vegetation Map, Landscape Assessment and Watercourses

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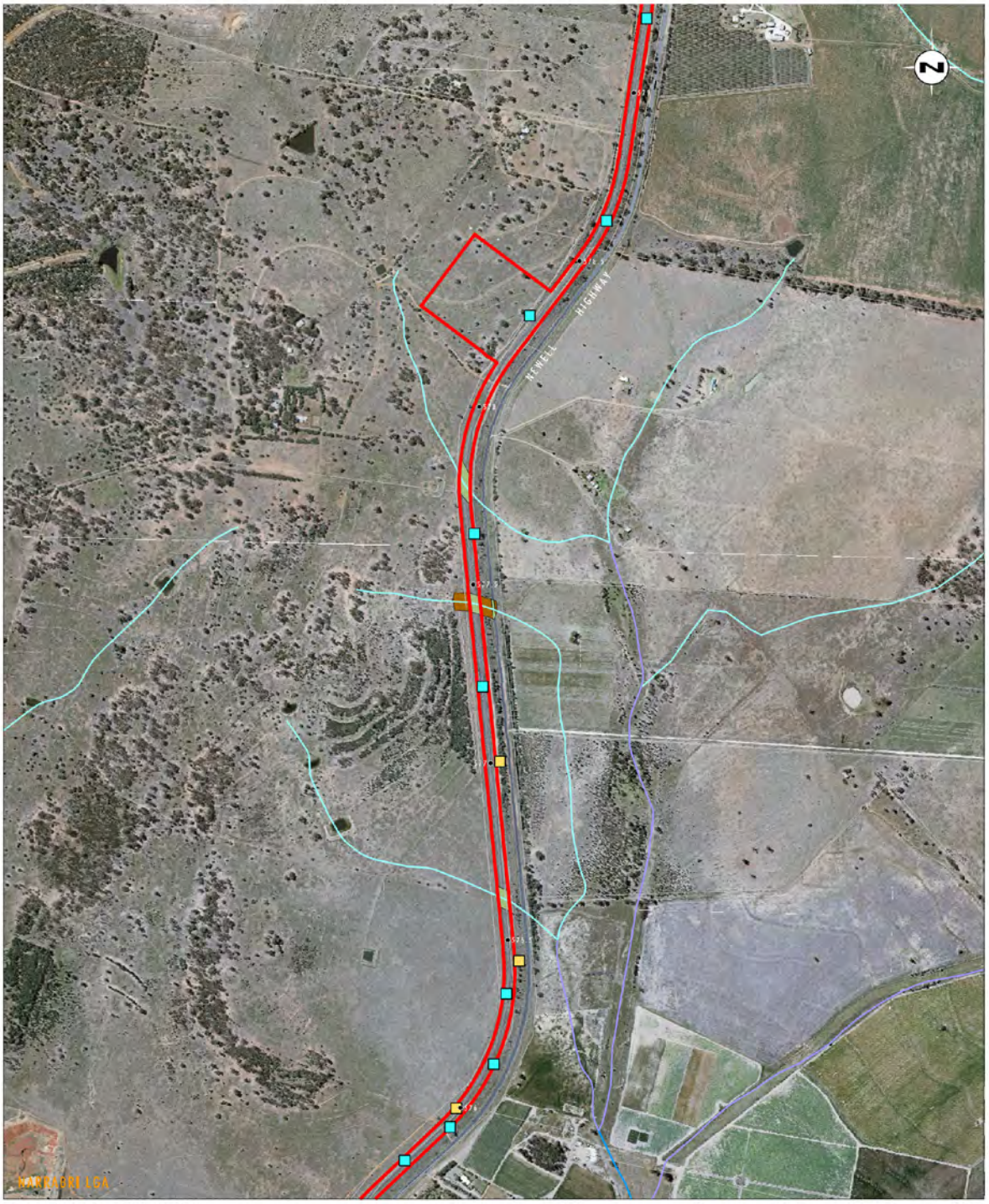

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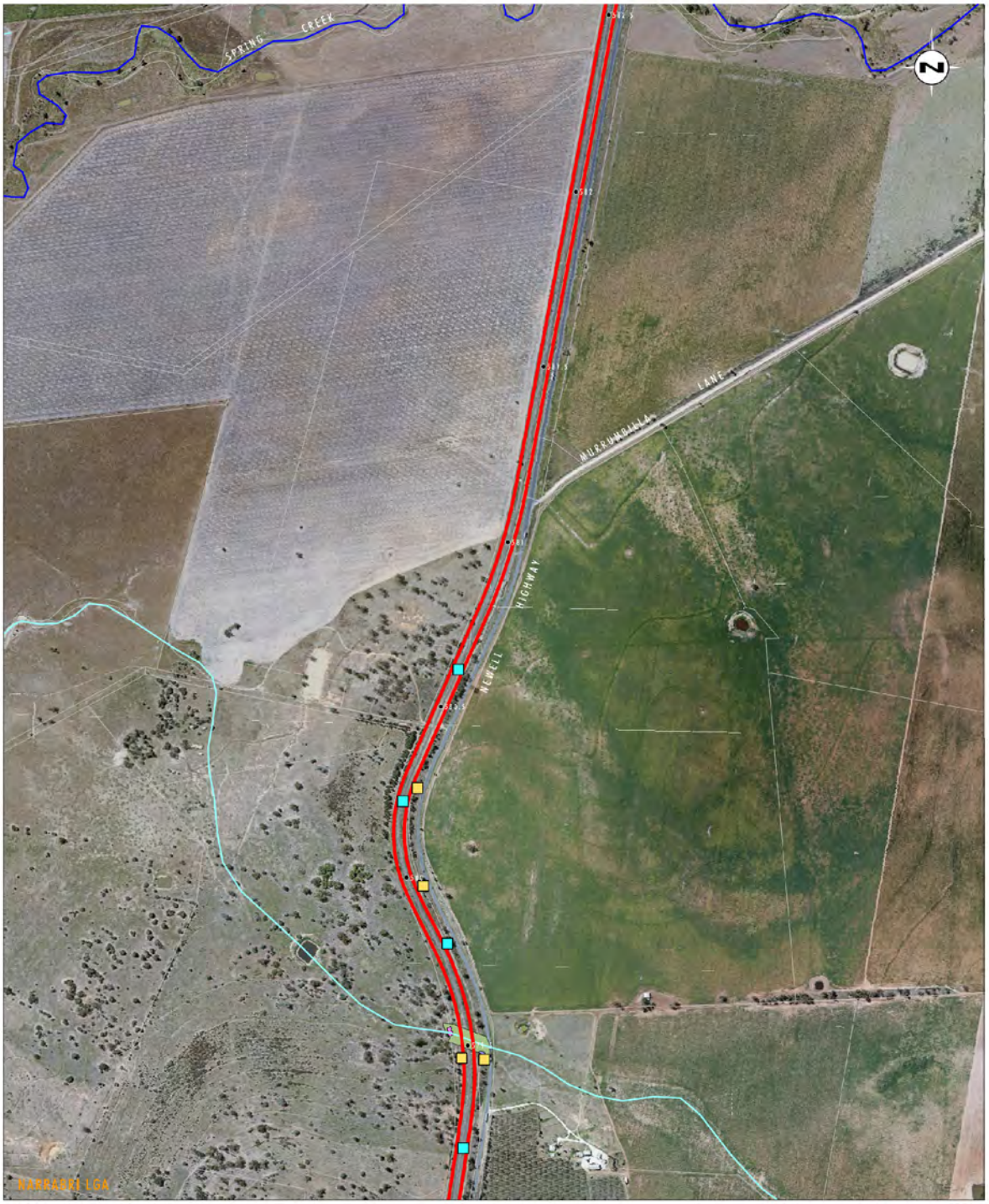
Legend

- Proposal Site
- Rail Line Chainage

FIGURE A2

Watercourses and Riparian Vegetation



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Legend

- Proposal Site
- Rail Line Chainage

FIGURE A3

Watercourses and Riparian Vegetation

Image Source: ARTC (2016)
Data Source: ARTC (2016), Umwelt (2016)
Note: For full legend, refer to legend page

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Legend

- Proposal Site
- Rail Line Chainage

FIGURE A4

Watercourses and Riparian Vegetation

Image Source: ARTC (2016)
Data Source: ARTC (2016), Umwelt (2016)
Note: For full legend, refer to legend page

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Legend

- Proposal Site
- Rail Line Chainage

FIGURE A5

Watercourses and Riparian Vegetation

Image Source: ARTC (2016)
Data Source: ARTC (2016), Umwelt (2016)
Note: For full legend, refer to legend page

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Legend

- Proposal Site
- Rail Line Chainage

FIGURE A6

Watercourses and Riparian Vegetation

Image Source: ARTC (2016)
Data Source: ARTC (2016), Umwelt (2016)
Note: For full legend, refer to legend page

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Legend

- Proposal Site
- Rail Line Chainage

FIGURE A7

Watercourses and Riparian Vegetation

Image Source: ARTC (2016)
Data Source: ARTC (2016), Umwelt (2016)
Note: For full legend, refer to legend page

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Legend

- Proposal Site
- Rail Line Chainage

FIGURE A8

Watercourses and Riparian Vegetation

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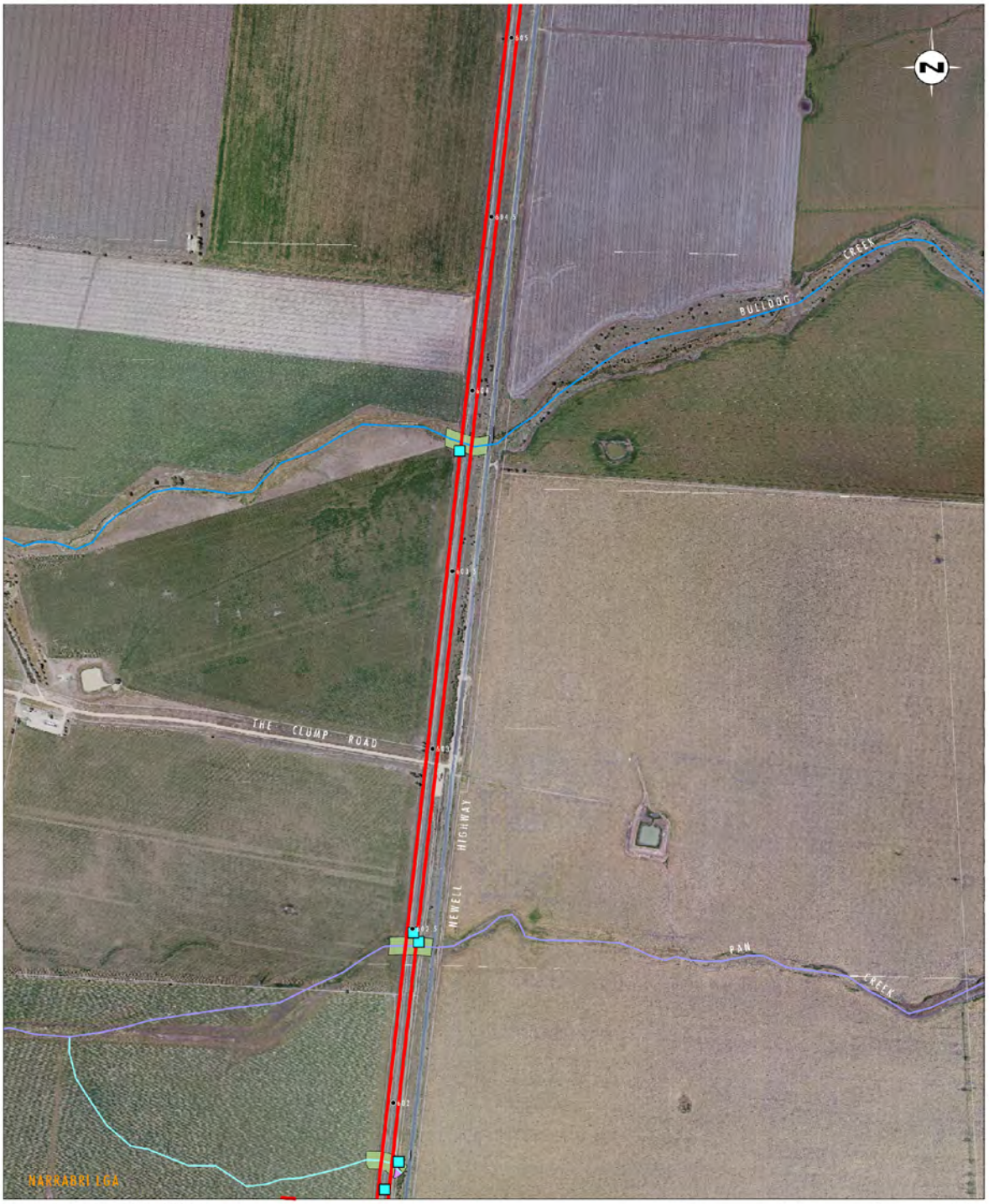
Legend

- Proposal Site
- Rail Line Chainage

FIGURE A9

Watercourses and Riparian Vegetation



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Data Source: ARTC (2016), Umwelt (2016)
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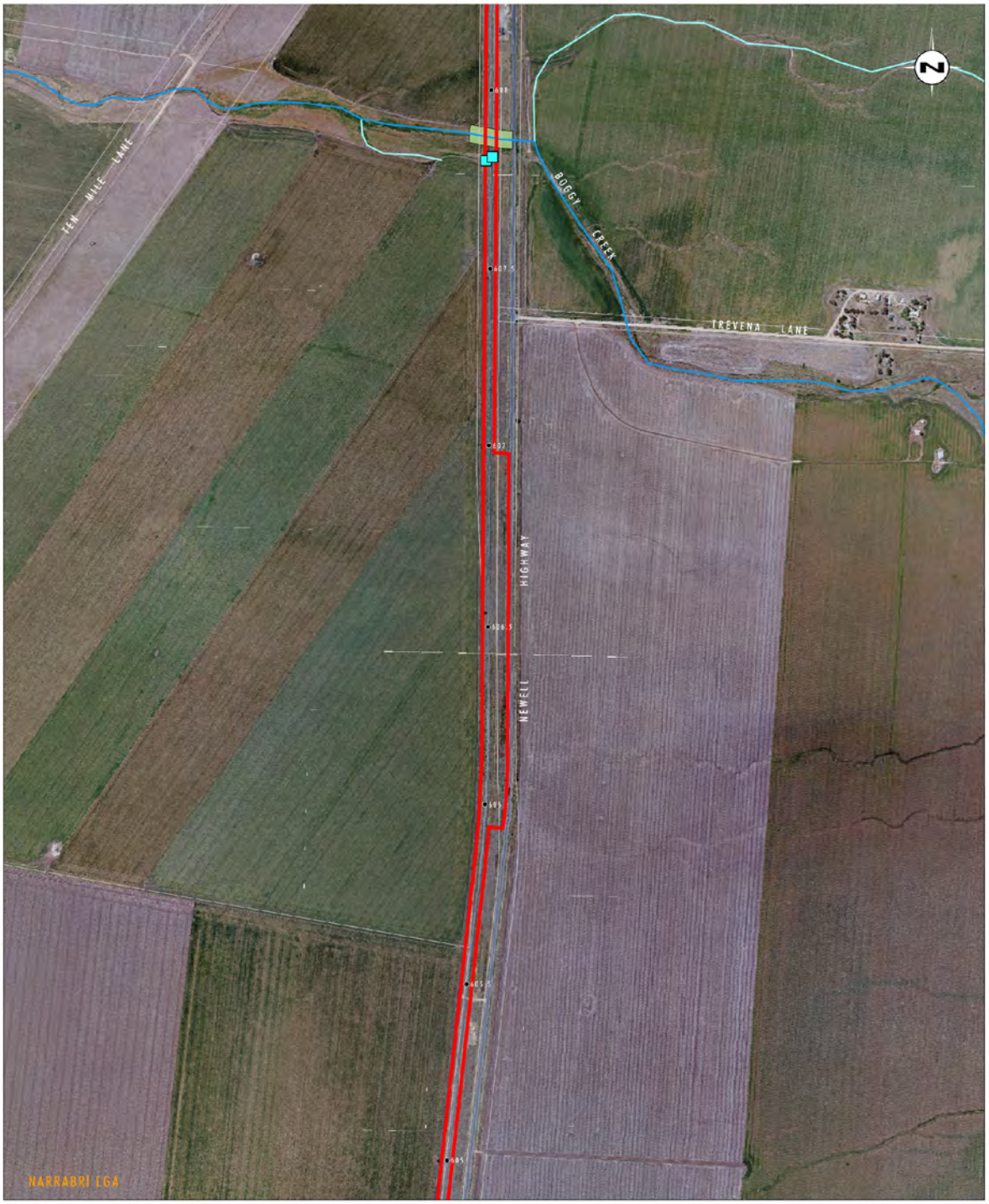
Legend

- Proposal Site
- Rail Line Chainage

FIGURE A10

Watercourses and Riparian Vegetation



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Legend

- Proposal Site
- Rail Line Chainage

FIGURE A11

Watercourses and Riparian Vegetation

Image Source: ARTC (2016)
Data Source: ARTC (2016), Umwelt (2016)
Note: For full legend, refer to legend page

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Legend

- Proposal Site
- Rail Line Chainage

FIGURE A12

Watercourses and Riparian Vegetation

Image Source: ARTC (2016)
Data Source: ARTC (2016), Umwelt (2016)
Note: For full legend, refer to legend page

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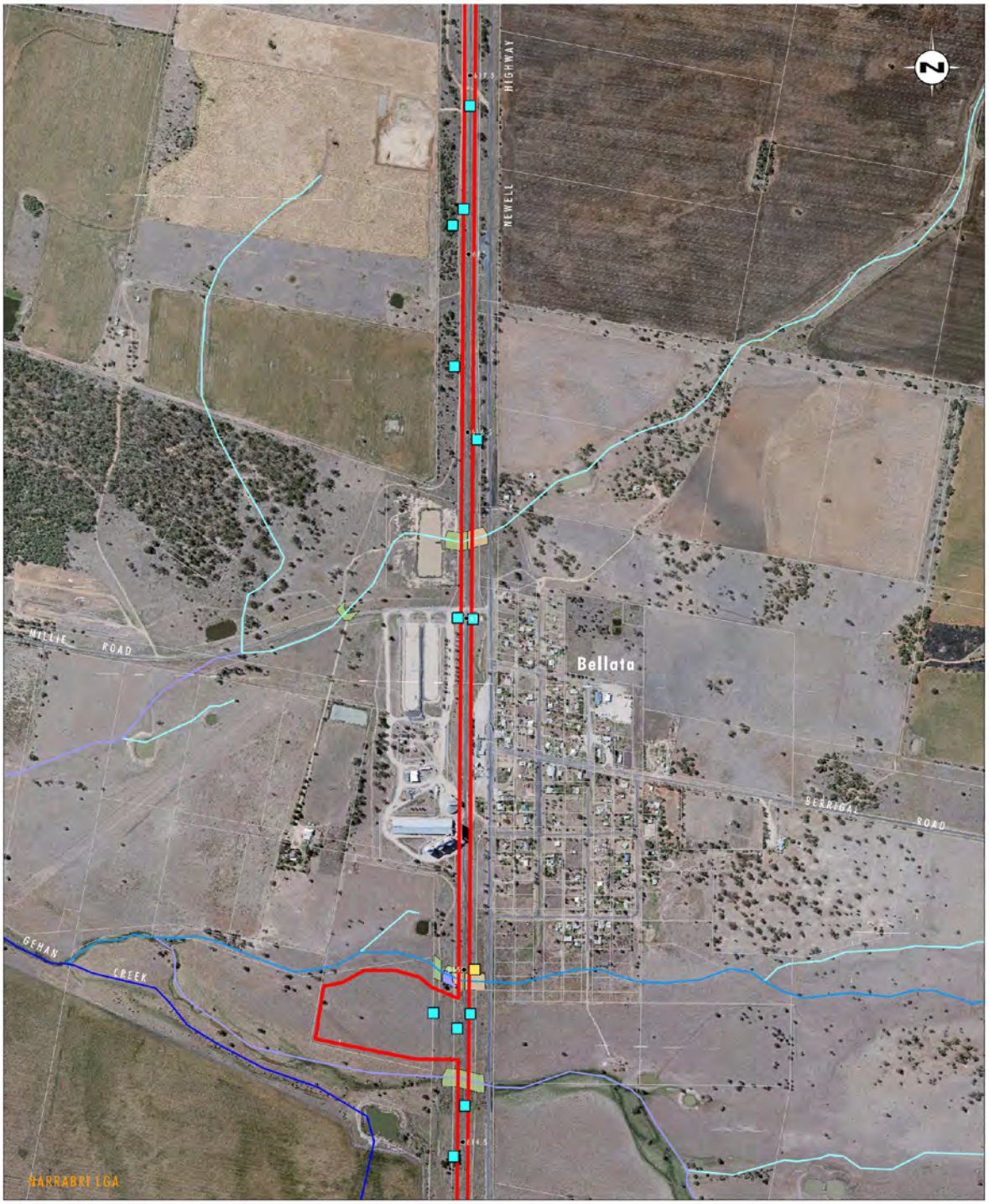
Legend

- Proposal Site
- Rail Line Chainage

FIGURE A13

Watercourses and Riparian Vegetation



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Legend

- Proposal Site
- Rail Line Chainage

FIGURE A14

Watercourses and Riparian Vegetation

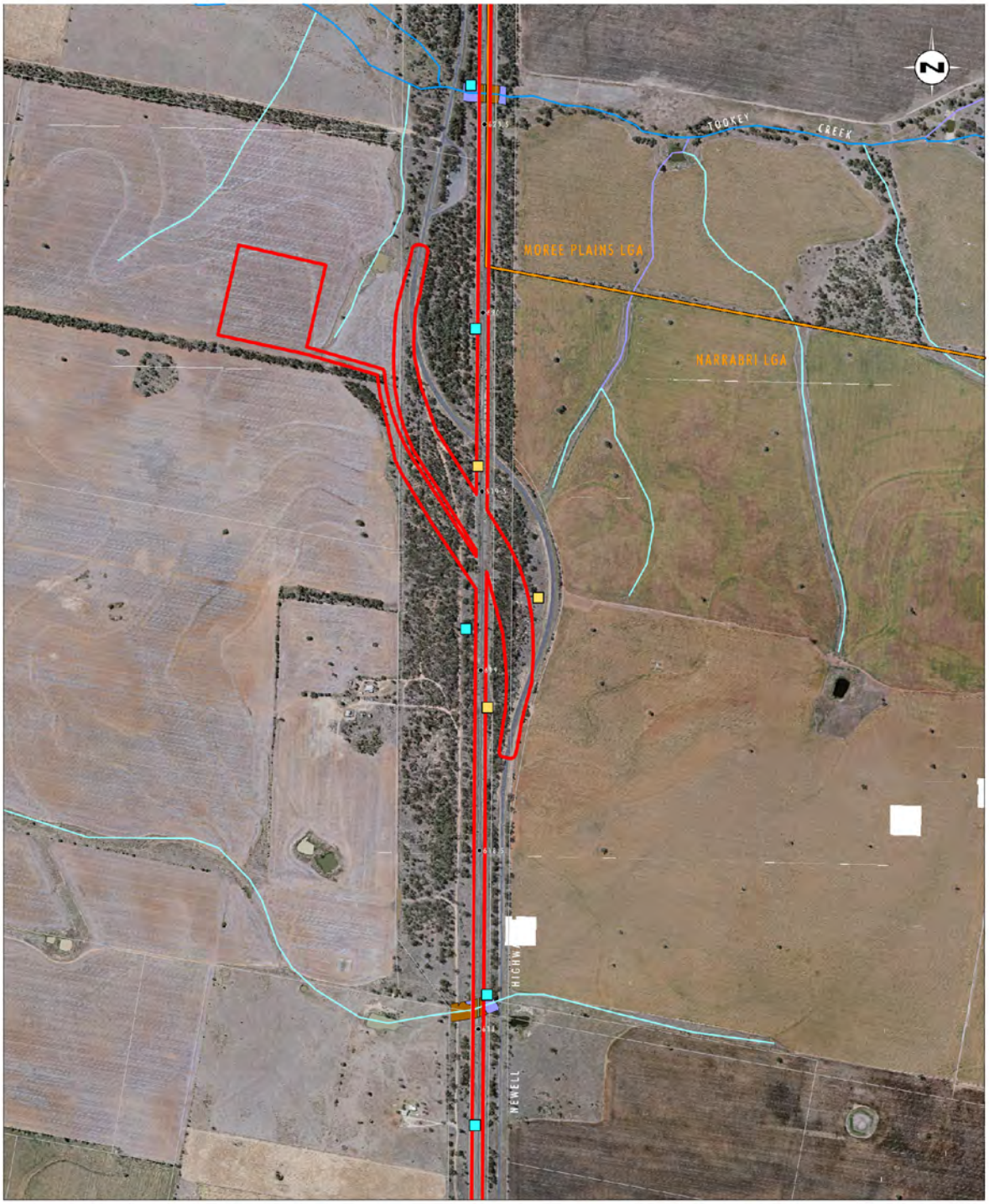

Image Source: ARTC (2016)
Data Source: ARTC (2016), Umwelt (2016)
Note: For full legend, refer to legend page

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Legend

- Proposal Site
- Rail Line Chainage

FIGURE A15

Watercourses and Riparian Vegetation

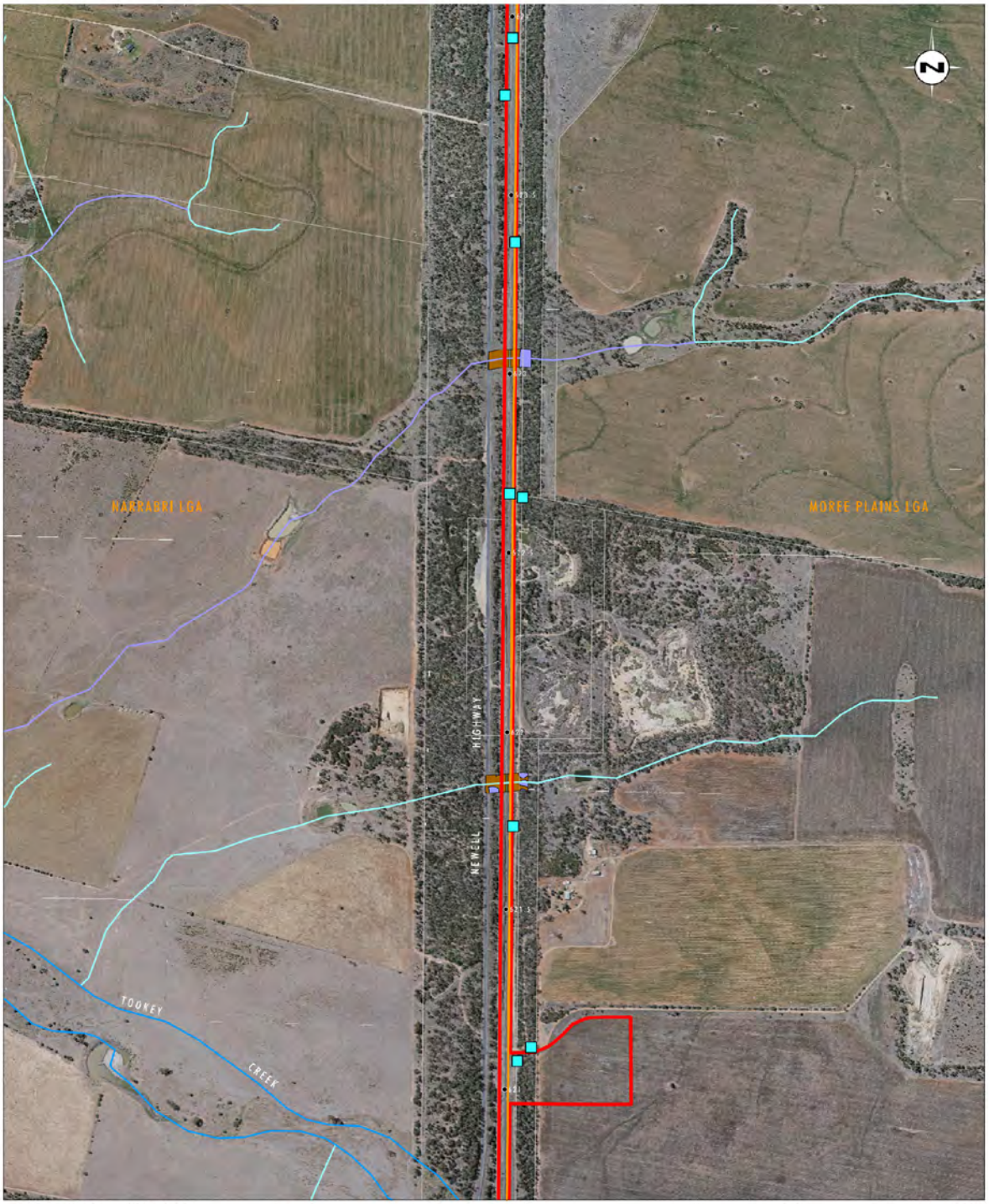

Image Source: ARTC (2016)
Data Source: ARTC (2016), Umwelt (2016)
Note: For full legend, refer to legend page

0 250 500 750m
1:15 000

Legend

- Proposal Site
- Rail Line Chainage

FIGURE A16

Watercourses and Riparian Vegetation

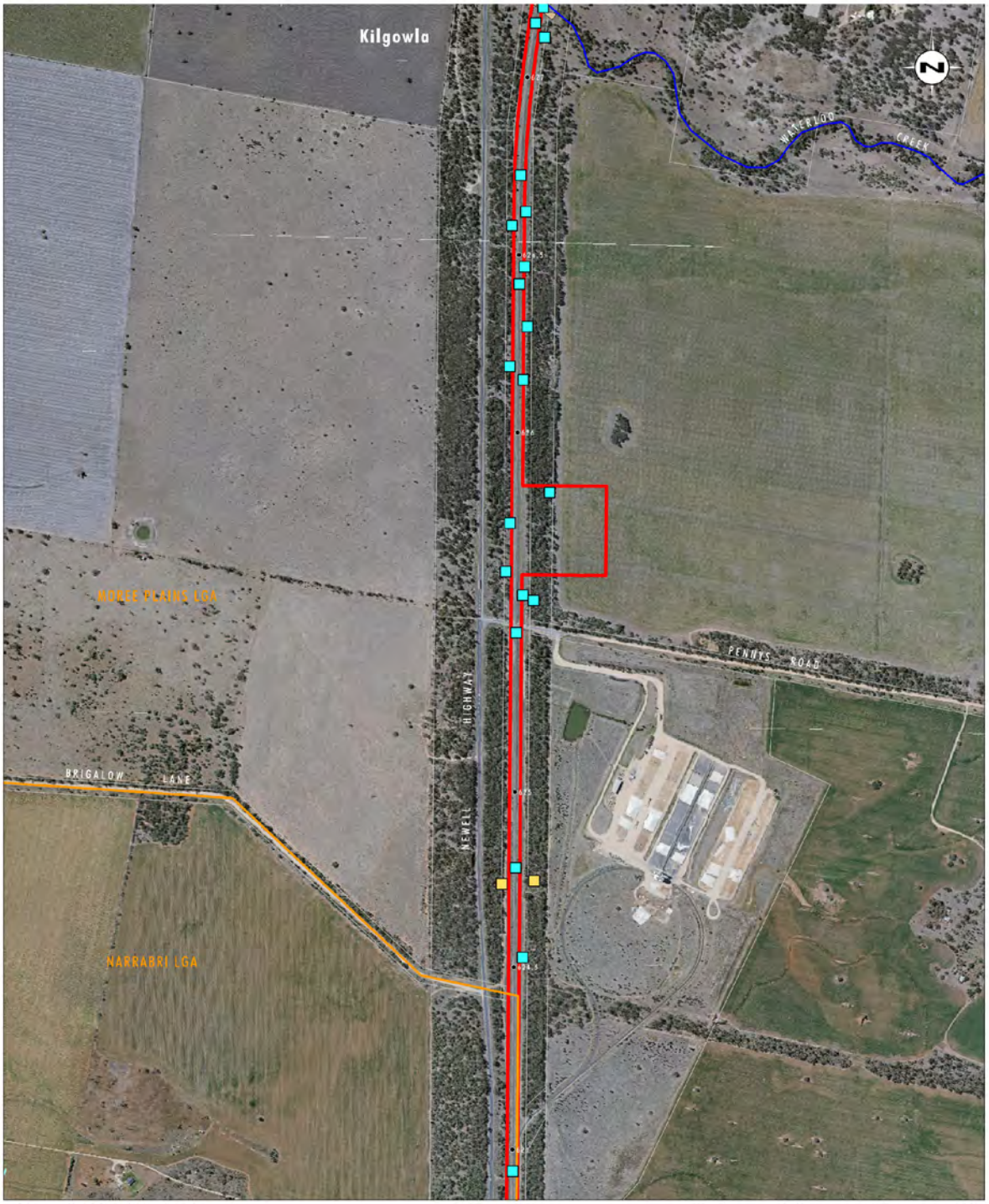

Image Source: ARTC (2016)
Data Source: ARTC (2016), Umwelt (2016)
Note: For full legend, refer to legend page

Legend

- Proposal Site
- Rail Line Chainage

FIGURE A17

Watercourses and Riparian Vegetation

File Name (A4): R08/3607_106.dgn
20170809 14:09

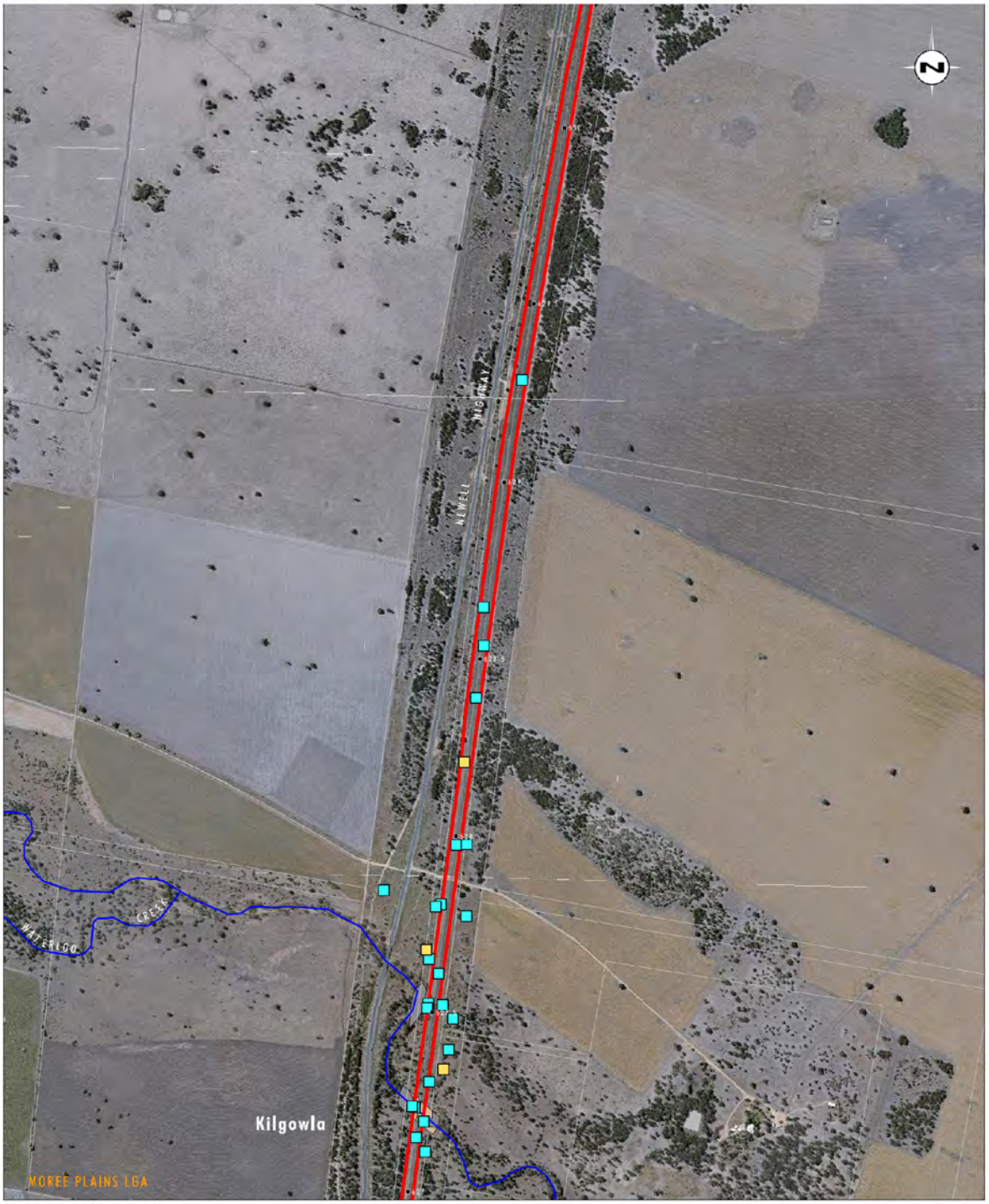

Image Source: ARTC (2016)
Data Source: ARTC (2016), Umwelt (2016)
Note: For full legend, refer to legend page

0 250 500 750m
1:15 000

Legend

- Proposal Site
- Rail Line Chainage

FIGURE A18

Watercourses and Riparian Vegetation

Image Source: ARTC (2016)
Data Source: ARTC (2016), Umwelt (2016)
Note: For full legend, refer to legend page

0 250 500 750m
1:15 000

Legend

- Proposal Site
- Rail Line Chainage

FIGURE A19

Watercourses and Riparian Vegetation

Image Source: ARTC (2016)
Data Source: ARTC (2016), Umwelt (2016)
Note: For full legend, refer to legend page

0 250 500 750m
1:15 000

Legend

- Proposal Site
- Rail Line Chainage

FIGURE A20

Watercourses and Riparian Vegetation

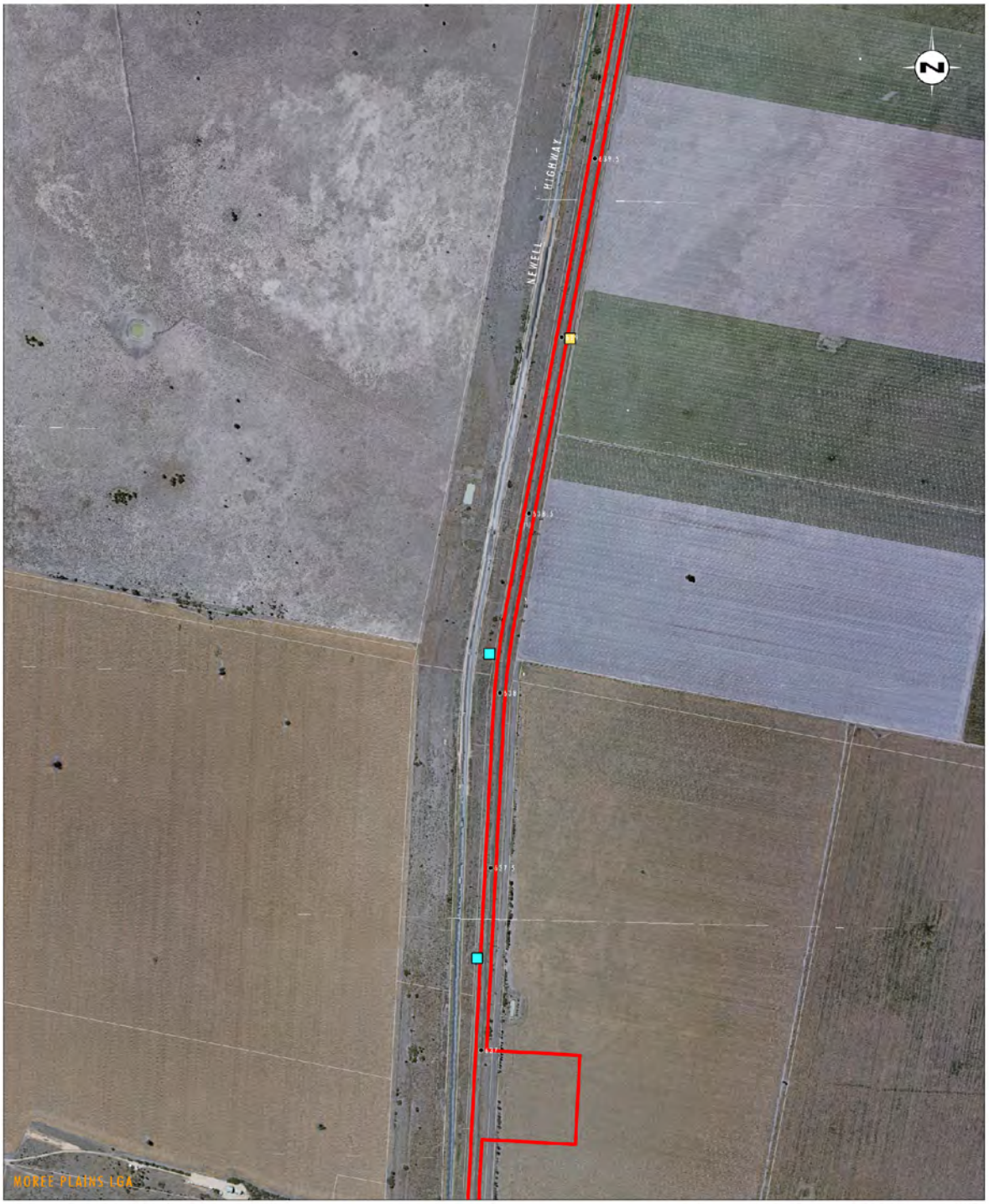

Image Source: ARTC (2016)
Data Source: ARTC (2016), Umwelt (2016)
Note: For full legend, refer to legend page

0 250 500 750m
1:15 000

Legend

- Proposal Site
- Rail Line Chainage

FIGURE A21

Watercourses and Riparian Vegetation

Image Source: ARTC (2016)
Data Source: ARTC (2016), Umwelt (2016)
Note: For full legend, refer to legend page

0 250 500 750m
1:15 000

Legend

- Proposal Site
- Rail Line Chainage

FIGURE A22

Watercourses and Riparian Vegetation

Image Source: ARTC (2016)
Data Source: ARTC (2016), Umwelt (2016)
Note: For full legend, refer to legend page

0 250 500 750m
1:15 000

Legend

- Proposal Site
- Rail Line Chainage

FIGURE A23

Watercourses and Riparian Vegetation

umwelt

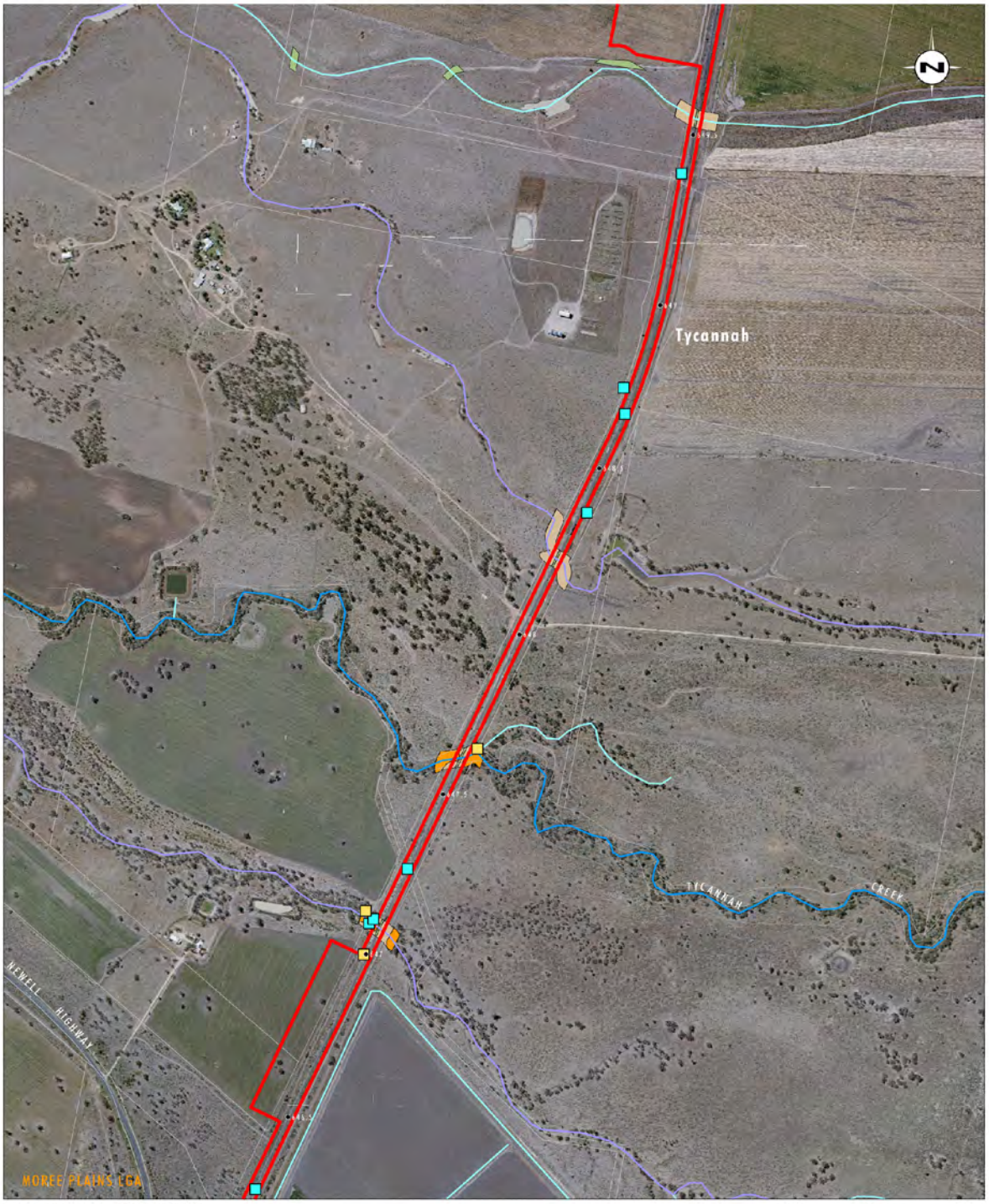

Image Source: ARTC (2016)
Data Source: ARTC (2016), Umwelt (2016)
Note: For full legend, refer to legend page

0 250 500 750m
1:15 000

Legend

- Proposal Site
- Rail Line Chainage

FIGURE A24

Watercourses and Riparian Vegetation

File Name (A4): R08/3607_113.dgn
20170809 14.04

Image Source: ARTC (2016)
Data Source: ARTC (2016), Umwelt (2016)
Note: For full legend, refer to legend page

0 250 500 750m
1:15 000

Legend

- Proposal Site
- Rail Line Chainage

FIGURE A25

Watercourses and Riparian Vegetation

Image Source: ARTC (2016)
Data Source: ARTC (2016), Umwelt (2016)
Note: For full legend, refer to legend page

0 250 500 750m
1:15 000

Legend

- Proposal Site
- Rail Line Chainage

FIGURE A26

Watercourses and Riparian Vegetation

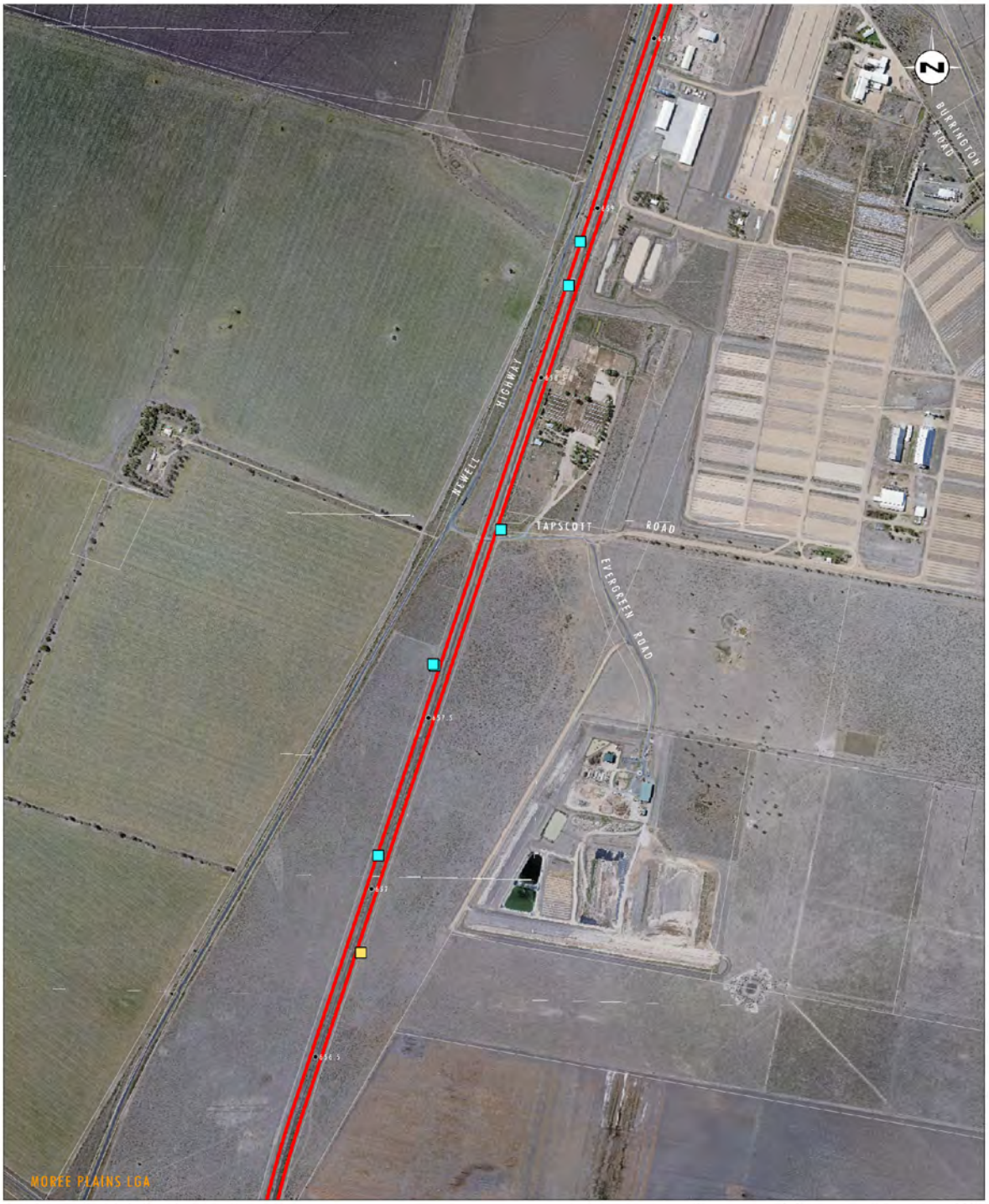

Image Source: ARTC (2016)
Data Source: ARTC (2016), Umwelt (2016)
Note: For full legend, refer to legend page

0 250 500 750m
1:15 000

Legend

- Proposal Site
- Rail Line Chainage

FIGURE A27

Watercourses and Riparian Vegetation

Image Source: ARTC (2016)
Data Source: ARTC (2016), Umwelt (2016)
Note: For full legend, refer to legend page

0 250 500 750m
1:15 000

Legend

- Proposal Site
- Rail Line Chainage

FIGURE A28

Watercourses and Riparian Vegetation

Image Source: ARTC (2016)
Data Source: ARTC (2016), Umwelt (2016)
Note: For full legend, refer to legend page

0 250 500 750m
1:15 000

Legend

- Proposal Site
- Rail Line Chainage

FIGURE A29

Watercourses and Riparian Vegetation