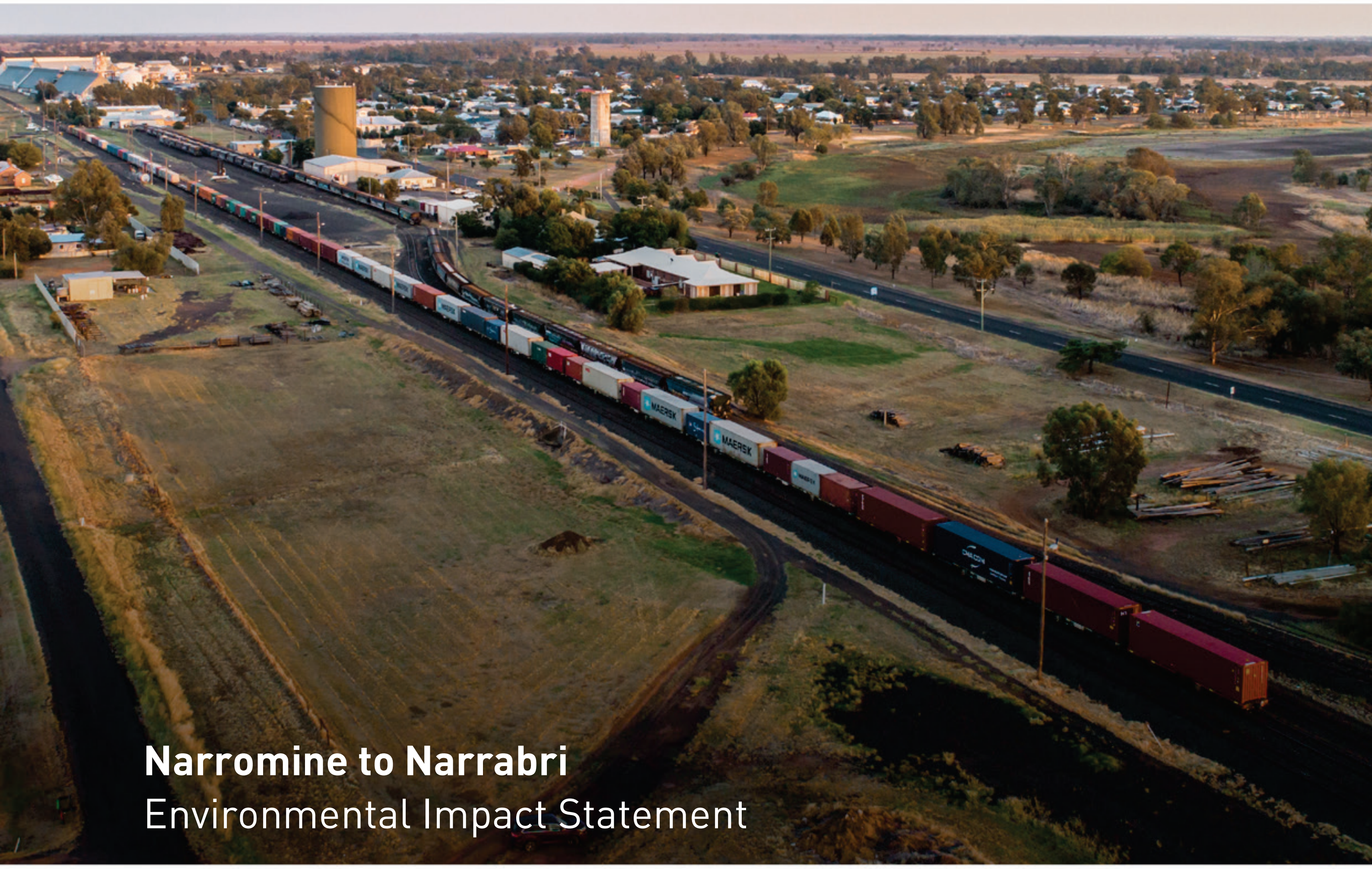
PART B
Impact assessment
Proposal infrastructure

CHAPTER B2
Water resources



Narromine to Narrabri
Environmental Impact Statement

The Australian Government is delivering Inland Rail through the Australian Rail Track Corporation (ARTC), in partnership with the private sector.

IR_1929

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B2. Water resources

This chapter provides a summary of the impacts of the Narromine to Narrabri project (the proposal) on water resources in the study area, including impacts on watercourses, hydrology and groundwater. A full copy of the assessment results is provided in Technical Report 4—Groundwater assessment and Technical Report 5—Surface water quality assessment.

B2.1 Approach

A summary of the approach to the assessment is provided in this section, including the legislation, guidelines and/or policies driving the approach and the methodology used to undertake the assessment. A more detailed description of the approach and methodology is provided in Technical Reports 4 and 5.

B2.1.1 Legislative and policy context to the assessment

Relevant legislation, policies and guidelines

The assessments were undertaken in accordance with the SEARs and with reference to the requirements of relevant legislation, policies and/or assessment guidelines, including:

- The EP&A Act, *Water Act 1912* (NSW), *Water Management Act 2000* (NSW) and the Water Management Regulation 2018
- *NSW Aquifer Interference Policy* (Department of Primary Industries, 2012a)
- *NSW State Groundwater Policy Framework Document* (Department of Land and Water Conservation, 1997)
- *NSW Groundwater Dependent Ecosystems Policy* (Department of Land and Water Conservation, 2002a).

The area in which the proposal site is located is subject to the following water sharing plans for surface water and groundwater:

- *Macquarie Bogan Unregulated and Alluvial Water Sources 2012*
- *Castlereagh (below Binnaway) Unregulated and Alluvial Water Sources 2011*
- *Namoi Unregulated and Alluvia Water Sources 2012*
- *NSW Murray Darling Basin Fractured Rock Groundwater Sources 2020*
- *NSW Great Artesian Basin Groundwater Sources 2020*
- *Namoi Alluvial Groundwater Sources 2020*
- *Macquarie Castlereagh Groundwater Source 2020.*

As described in section A8.10, deep aquifers have been identified for the extraction of groundwater for construction use. Twelve bore fields (PB1 to PB12) would be established along the proposal site, as shown in Figure B2.1. The area in which the bore fields are located is subject to the following water sharing plans for groundwater:

- *NSW Murray Darling Basin Fractured Rock Groundwater Sources 2020*
- *NSW Murray Darling Basin Porous Rock Groundwater Sources 2020.*

Secretary's Environmental Assessment Requirements

The SEARs relevant to water resources, together with a reference to where they are addressed in the EIS, are provided in Appendix A.

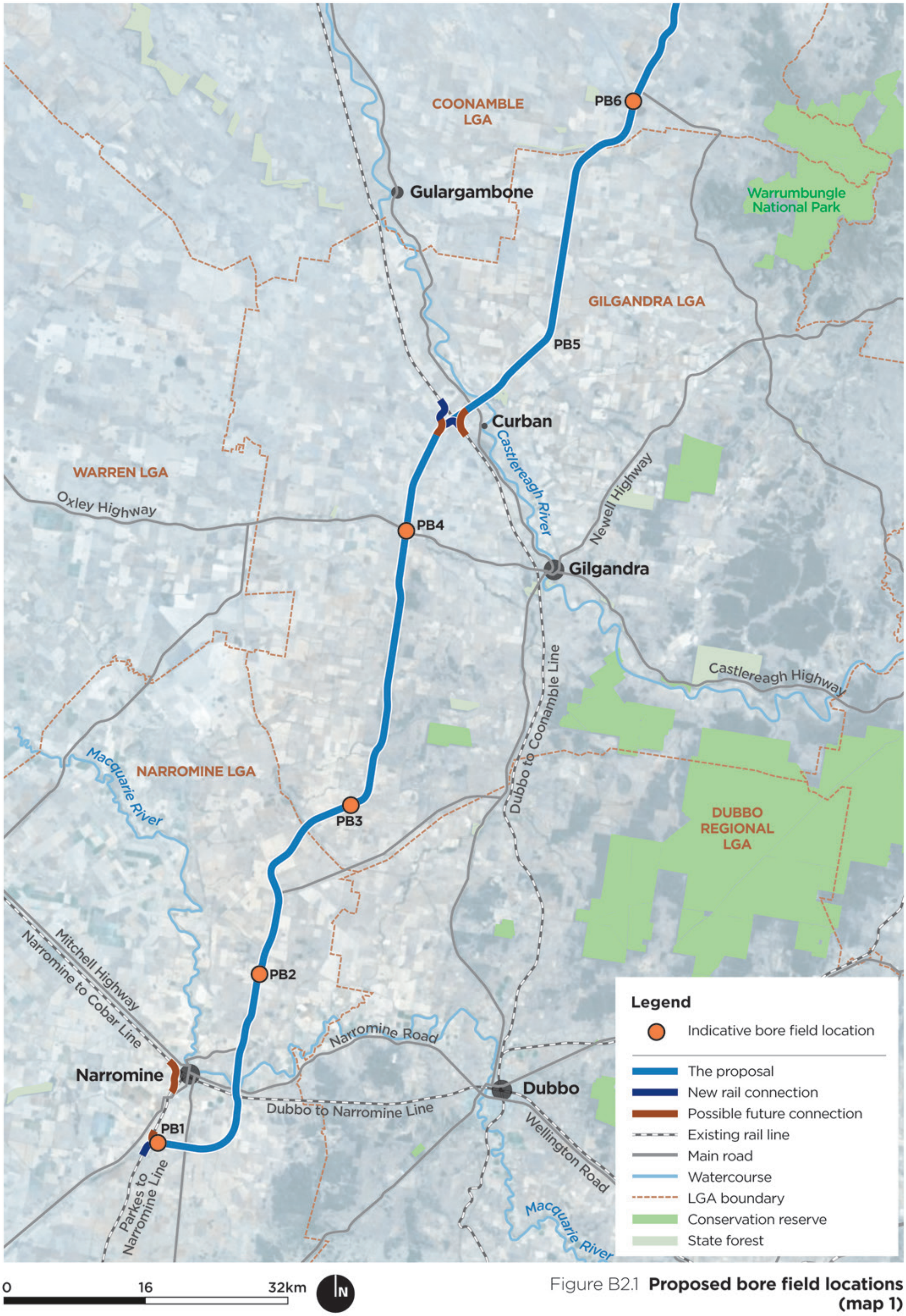

Figure B2.1 **Proposed bore field locations (map 1)**

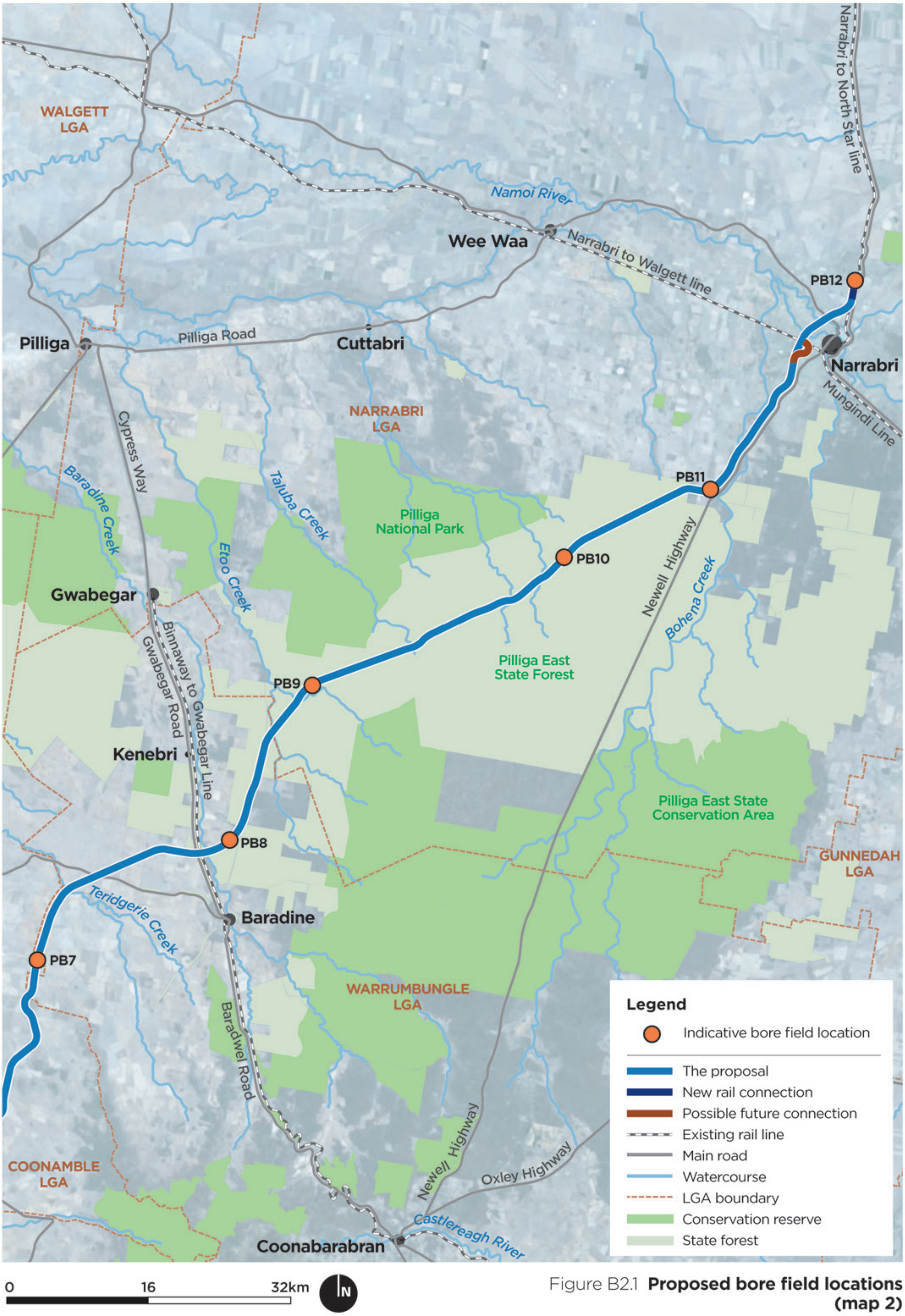

Figure B2.1 **Proposed bore field locations (map 2)**

B2.1.2 Methodology

Study area

The study area for the surface water assessment includes the catchment areas within which the proposal site is located and receiving watercourses, described in section B2.2.

The study area for the groundwater assessment incorporates a 20 kilometre (km) radius of the proposal site. This area was selected to capture sensitive receivers within the potential area of drawdown around the proposed bore field bores and increase the amount of bore data from existing groundwater bores available for analysis.

Key tasks

The assessment involved:

- Reviewing relevant proprietary databases detailing the existing groundwater, surface water, geological and hydrogeological environments, including:
  - The *Hydrogeological Atlas of the Great Artesian Basin* (Ransley et al., 2015)
  - Bureau of Meteorology (BoM) online databases
  - WaterNSW online database for registered groundwater bores.
- Reviewing similar assessments for other projects within, or close to, the study area
- Characterising the current hydrological and groundwater conditions in the study area
- Undertaking groundwater field investigations, including drilling, monitoring well installation, and water level monitoring at 40 locations within the proposal site, including one location within each proposed borrow pit
- Reviewing relevant outputs from the geotechnical field investigations that were undertaken to inform the design
- Undertaking visual site inspections at 25 watercourses within the proposal site
- Developing an analytical computer groundwater model and undertaking calculations to predict groundwater inflows and drawdown as a result of the proposal, including due to groundwater extraction from the bore field bores for construction water
- Assessing potential impacts on surface water and groundwater hydrology during construction and operation
- Recommending mitigation and management measures, including baseline monitoring of hydrological attributes.

B2.1.3 Risks identified

The environmental risk assessment for the proposal (see Appendix E) included consideration of potential water resources risks. Water resources risks with an assessed level of medium or above, identified by the environmental risk assessment, included:

- Temporary impact to the behaviour of local surface water systems during construction due to the presence of construction features, including erosion and sedimentation control structures
- Changes to flow patterns and altered hydrology due to construction in watercourses
- Extraction of groundwater from the proposed bore field bores may cause drawdown of the groundwater table, impacting sub-surface flows, water characteristics and availability
- Potential for bulk excavations to intersect the water table and lead to groundwater level drawdown, impacting nearby groundwater bores, groundwater dependent ecosystems, and watercourse baseflow
- Potential to create groundwater flow pathways between groundwater systems, as a result of groundwater extraction from the bore field bores.

The groundwater and surface water quality assessments considered the potential risks identified by the environmental risk assessment in addition to potential risks and impacts identified by the scoping report (see section A9.1), the SEARs and relevant guidelines and policies (as appropriate).

B2.1.4 How potential impacts have been avoided/minimised

The proposal has been designed to avoid and minimise potential modifications to surface and groundwater flows. The strategies that have been, and would continue to be, implemented include the following:

- Flow discharge points (culverts and longitudinal drainage) have been designed to include erosion controls, such as rock protection, to slow flow velocities and minimise the risk of erosion as surface water enters and exits the structure
- Bridges and culverts have been designed to have a minimal impact on existing surface flow paths across the proposal site
- Bridge piers have been located outside of watercourse channels, where practicable, to preserve stream flows and fauna passage
- Pre-cast structures would be used to minimise the potential for disturbance within watercourses during construction
- Works in the majority of watercourses would only be undertaken in dry weather conditions when watercourses are dry
- Deep aquifer bores have been proposed for groundwater extraction as a solution to the limited upper aquifer availability and lack of surface water within the region.

B2.2 Existing environment

B2.2.1 Rainfall and evaporation

Mean monthly and annual rainfall data was sourced from the BoM Narromine (site number 51005) and Narrabri (site number 53030) sites.

A review of the mean monthly and annual rainfall data indicates there are seasonal variations corresponding with a relatively 'wet' summer period (November–March) and relatively 'dry' winter period (April–October). Average annual rainfall varies between about 540 millimetres (mm) in Narromine and 660 mm in Narrabri.

Mean monthly and annual evaporation data was sourced from the BoM Wellington (site number 065035) and Gunnedah (site number 055024) sites, in the absence of evaporation data from the Narromine and Narrabri sites.

The rainfall and evaporation statistics indicate the study area is generally characterised by low monthly and annual rainfall, and high evaporation. On average there is no rainfall surplus for any month. The lowest rainfall deficit occurs in June, where the rainfall rate is surpassed by evaporation by about 4 mm in Narromine and 8 mm in Narrabri. The annual rainfall deficit is about -1,265 mm for Narromine and -1,099 mm for Narrabri. This indicates that the study area is typically subject to dry conditions.

B2.2.2 Catchments and watercourses

The proposal site is located within the major water catchments of the Macquarie-Bogan River, the Castlereagh River and the Namoi River.

The catchment boundaries and key watercourses within and near the proposal site are shown in Figure B2.2 and described on the following pages.

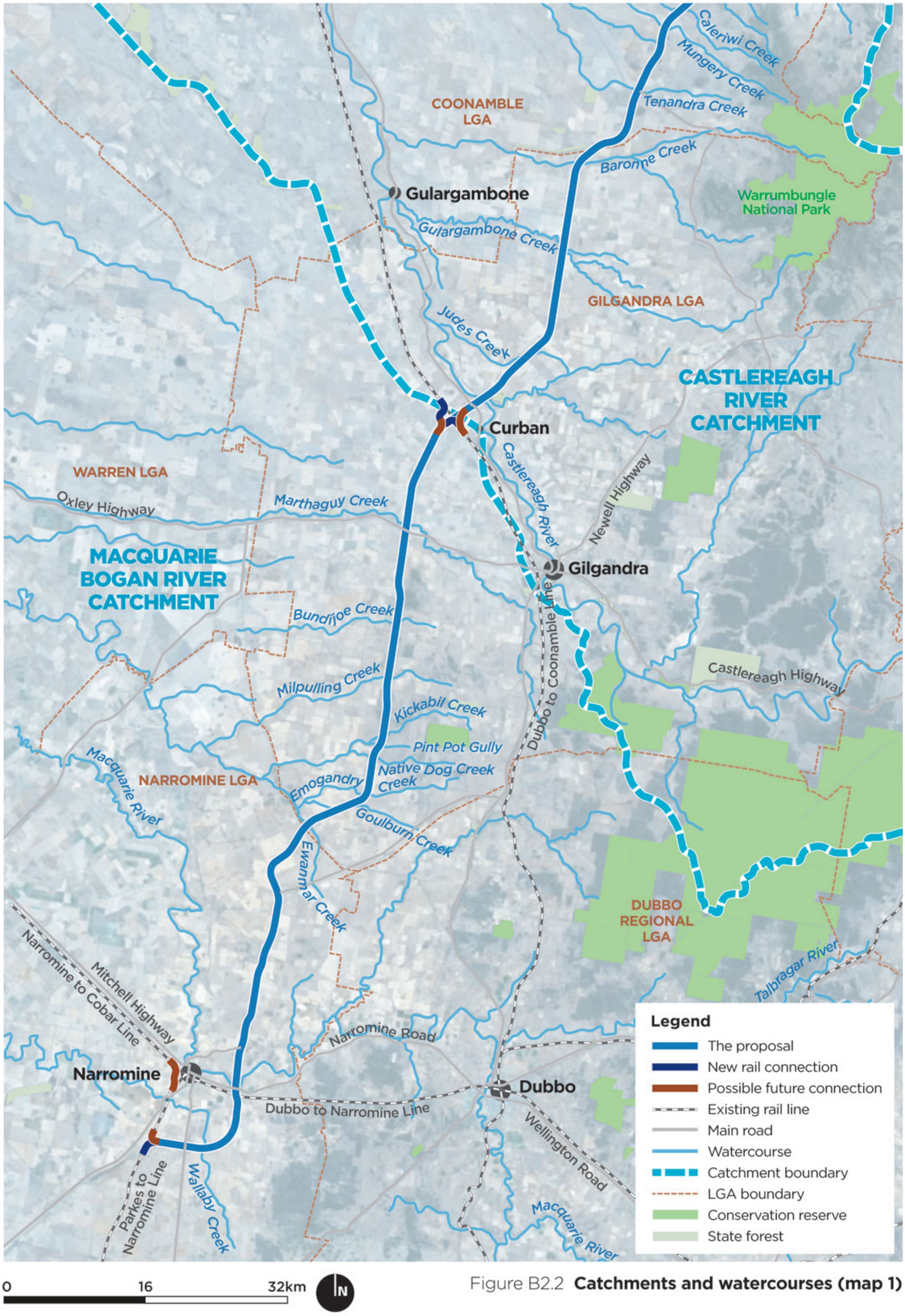

Figure B2.2 **Catchments and watercourses (map 1)**

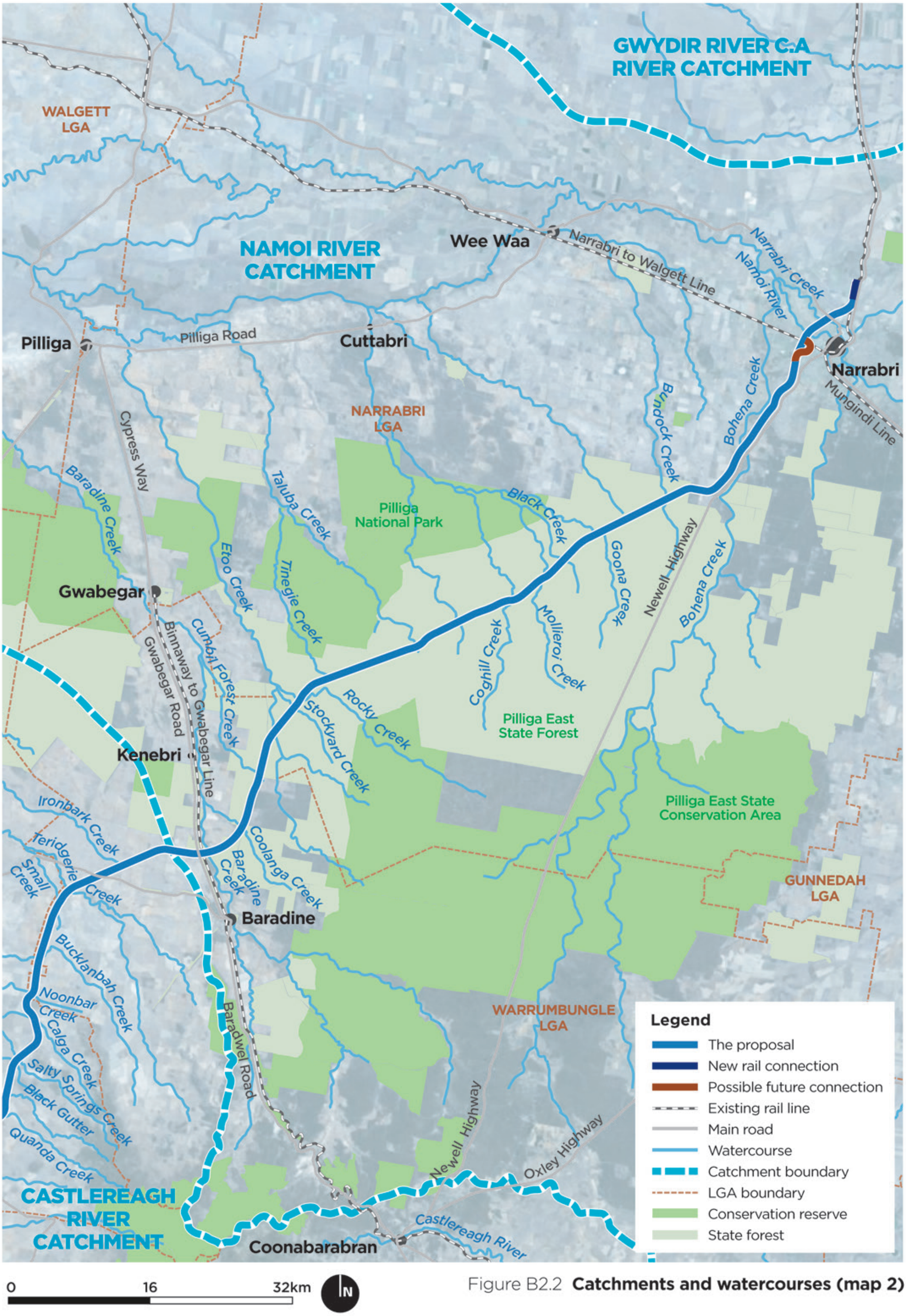

Figure B2.2 **Catchments and watercourses (map 2)**

Macquarie-Bogan River catchment

The Macquarie-Bogan catchment has an area of about 74,800 square km and encompasses the regional centres of Dubbo, Bathurst and Orange, and the Macquarie and Bogan rivers. The Macquarie River originates in the Great Dividing Range, flowing through Bathurst and Dubbo before draining into the Darling River via the lower Barwon River. The Bogan River originates in the Harvey Ranges and flows north-west through Nyngan before joining the Darling River near Bourke.

The Macquarie-Bogan catchment has a dry semi-arid climate.

Agriculture is the main land use within the catchment. Both rivers are major sources of town and agricultural water, and support the Ramsar-listed Macquarie Marshes located in the western reaches of the catchment, between Dubbo and Brewarrina. The catchment is regulated by two major storages—Burrendong Dam and Windamere Dam.

In addition to the Macquarie River, the following key watercourses are located within the Macquarie-Bogan catchment and are crossed by the proposal site:

- Wallaby Creek
- Ewenmar Creek
- Goulburn Creek
- Emogandry Creek
- Native Dog Creek
- Pint Pot Gully
- Kickabil Creek
- Milpulling Creek
- Bundijoe Creek
- Marthaguy Creek.

Castlereagh River catchment

The Castlereagh River catchment forms part of the Murray-Darling Basin and has an area of about 17,400 square km. The catchment encompasses the towns of Coonabarabran, Gilgandra and Coonamble and the Castlereagh River. The catchment contains predominantly agricultural grazing land as well as the Warrumbungle National Park and Goonoo State Conservation Area, located south-east of Gilgandra.

The Castlereagh catchment also has a dry semi-arid climate. Average annual rainfall in the Castlereagh and Macquarie-Bogan catchments ranges from about 1,200 mm in the south-east to 300 mm in the north-west.

The Castlereagh River originates in the Warrumbungle Ranges and flows east to Coonabarabran. It then flows in a southerly direction until it meets the confluence of the lower Macquarie River north of Carinda. The Castlereagh River is an unregulated river and has no major public water storages but does have a number of small dams and weirs in the catchment.

In addition to the Castlereagh River the following key watercourses are located within the Castlereagh River catchment and are crossed by the proposal site:

- Judes Creek
- Gulargambone Creek
- Baronne Creek
- Tenandra Creek
- Mungery Creek
- Caleriwi Creek
- Quanda Creek
- Black Gutter
- Salty Springs Creek
- Calga Creek
- Noonbar Creek
- Bucklanbah Creek
- Small Creek
- Teridgerie Creek
- Ironbark Creek.

Namoi River catchment

The Namoi River catchment, which extends from the Great Dividing Range near Tamworth to the Barwon River near Walgett, has an area of about 42,000 square km. The catchment encompasses the towns of Tamworth, Gunnedah and Narrabri, which are on the Namoi River, and a number of smaller towns including Boggabri, Walgett, Wee Waa and Werris Creek. The catchment is heavily regulated, mostly via dams and instream regulatory structures. Cattle and sheep grazing is the main land use, followed by grain crops. The river system also supports the Billabong Wetlands located downstream of Narrabri and the Pilliga forests.

The Namoi catchment receives about 500 to 700 mm of rainfall each year. Peak precipitation occurs between November and February; however, there is high variability in rainfall from one year to the next (CSIRO, 2006).

The Namoi River rises in ranges near Tamworth, forming a number of streams and creeks before joining the Barwon River at Walgett. The river has developed an extensive floodplain, with around a quarter of the basin prone to flooding.

In addition to the Namoi River the following key watercourses are located within the catchment and are crossed by the proposal site:

- Baradine Creek
- Coolangla Creek
- Cumbil Forest Creek
- Etoo Creek
- Stockyard Creek
- Rocky Creek
- Tinegie Creek
- Coghill Creek
- Mollieroi Creek
- Black Creek
- Goona Creek
- Bundock Creek
- Bohena Creek
- Narrabri Creek.

Watercourses crossed by the proposal site

In total, the proposal site crosses 47 watercourses, which include three rivers. The majority of the watercourses are non-perennial (i.e. either intermittent or ephemeral). Intermittent watercourses cease flowing for weeks or months at a time, while ephemeral watercourses flow for short durations following rainfall. The stream flow characteristics in the study area are a result of the size of the contributing watercourse catchment areas, rainfall, limited groundwater baseflow and evaporation patterns in the region.

The watercourses crossed by the proposal site are listed in Table B2.1, together with their flow type. The stream order classification is also provided for watercourses that were visually inspected as part of the assessment.

The proposal site also crosses several unnamed tributaries within each catchment.

TABLE B2.1 WATERCOURSES INTERSECTING PROPOSAL SITE

Catchment	Watercourse	Stream order[1]	Flow Type
Macquarie River	Yellow Creek	-	Non-perennial
	Wallaby Creek	-	Non-perennial
	Unnamed tributary of Backwater Cowal (South)	-	Non-perennial
	Unnamed tributary of Backwater Cowal (North)	-	Non-perennial
	Macquarie River	9	Perennial
	Ewenmar Creek	4	Non-perennial
	Goulburn Creek	-	Non-perennial
	Emogandry Creek	4	Non-perennial
	Native Dog Creek	-	Non-perennial
	Pint Pot Gully	-	Non-perennial
	Kickabil Creek	4	Non-perennial
	Milpulling Creek	-	Non-perennial
	Marthaguy Creek	-	Non-perennial
Castlereagh River	Castlereagh River	7	Non-perennial
	Judes Creek	-	Non-perennial
	Gulargambone Creek	5	Non-perennial
	Baronne Creek	-	Non-perennial
	Tenandra Creek	4	Non-perennial
	Mungery Creek	-	Non-perennial
	Caleriwi Creek	-	Non-perennial
	Quanda Creek	-	Non-perennial
	Black Gutter	-	Non-perennial
	Salty Springs Creek	-	Non-perennial
	Calga Creek	-	Non-perennial
	Noonbar Creek	-	Non-perennial
	Bucklanbah Creek	-	Non-perennial
	Small Creek	-	Non-perennial
	Teridgerie Creek	-	Non-perennial
	Ironbark Creek	-	Non-perennial

Catchment	Watercourse	Stream order[1]	Flow Type
Namoi River	Baradine Creek	6	Non-perennial
	Coolangla Creek	3	Non-perennial
	Cumbil Forest Creek	1	Non-perennial
	Etoo Creek	5	Non-perennial
	Stockyard Creek	3	Non-perennial
	Rocky Creek	4	Non-perennial
	Tinegie Creek	1	Non-perennial
	Talluba Creek	3	Non-perennial
	Cubbo Creek	-	Non-perennial
	Coghill Creek	4	Non-perennial
	Mollieroi Creek	4	Non-perennial
	Black Creek	3	Non-perennial
	Goona Creek	3	Non-perennial
	Bundock Creek	2	Non-perennial
	Bohena Creek	6	Non-perennial - major
	Namoi River	9	Perennial
	Narrabri Creek	9	Perennial
	Breakout of Mulgate Creek	-	Non-perennial

Note:
1. Based on the Strahler stream order classification system.

Waterfront land

The definition of waterfront land, provided by the *Water Management Act 2000* (NSW), includes the following of relevance to the proposal: *'(a) the bed of any river, together with any land lying between the bed of the river and a line drawn parallel to, and the prescribed distance (usually 40 m) inland of, the highest bank of the river'*. A river is defined by the Act to include '*(a) any watercourse, whether perennial or intermittent and whether comprising a natural channel or a natural channel artificially improved*.'

The proposal would interact with waterfront land at those locations where the proposal intersects with watercourses (see Table B2.1).

Water sharing plans

As noted in section B2.1.1 the proposal site is located within an area covered by three water sharing plans for surface waters. The water sharing plans, and their respective water sources, are as follows:

- *Macquarie Bogan Unregulated and Alluvial Water Sources 2012:*
  - Wambangalong Whylandra Creek water source
  - Backwater Boggy Cowal water source
  - Coolbaggie Creek water source
  - Ewenmar Creek water source
  - Marthaguy Creek water source
- *Castlereagh (below Binnaway) Unregulated and Alluvial Water Sources 2011*:
  - Tooraweenah to Coonamble Tributaries water source
  - Teridgerie Creek water source
  - Gilgandra to Coonamble water source
- *Namoi Unregulated and Alluvia Water Sources 2012:*
  - Baradine Creek water source
  - Etoo and Talluba Creeks water source
  - Coghill Creek water source
  - Brigalow Creek water source
  - Bundock Creek water source
  - Bohena Creek water source
  - Spring and Bobbiwaa Creeks water source
  - Eulah Creek water source
  - Baradine Creek water source.

B2.2.3 Groundwater

Groundwater systems

The majority of the proposal site is in the Coonamble Embayment region in the east of the Surat Basin, which forms the south-eastern portion of the Great Artisan Basin. The Great Artesian Basin generally comprises Jurassic-Cretaceous sedimentary rocks; however, much of the Great Artesian Basin within the proposal site includes a cover of Cenozoic alluvial, residual or colluvial material. The alluvial deposits are relatively thick (30 to 70 m) and subject to wide-scale groundwater extraction by landowners.

The depth of the Great Artesian Basin ranges from about 160 to 420 m below ground level, with a typical depth of about 365 m below ground level beneath the proposal site. A regionally significant aquitard is likely to exist at the base of the Great Artesian Basin.

Shallow and deeper groundwater systems in and beneath the Great Artisan Basin have the potential to be intercepted by the proposal, either due to construction works or the drilling of groundwater bores and extraction of groundwater for construction water (at the proposed bore field bores). Key characteristics of these systems are described below.

Shallow alluvial groundwater system

This system consists of a semi-confined to unconfined aquifer with groundwater depths typically between 10 and 30 m below ground level, but shallower near major rivers and in low-lying areas. Groundwater levels from bores drilled as part of the field assessment ranged between 4.63 and 24.10 m below ground level. Recharge is low and via rainfall occurring in areas of high elevation. Discharge occurs through bore pumping, baseflow to rivers, and vertical leakage to underlying aquifers. The groundwater flow direction is similar to the local topography. Groundwater within this system is fresh to saline.

Deeper Great Artisan Basin groundwater systems

The study area lies within a Great Artisan Basin groundwater recharge area where recharge predominantly enters via aquifer strata at exposed outcrops. A recharge rate of less than 10 mm per year is expected. Discharge of the deeper Great Artisan Basin groundwater systems in the study area occurs through bore pumping, vertical leakage to overlying aquifers, and springs. Data from groundwater bores in the study area indicates an average groundwater depth of 66 m below ground surface. The regional groundwater flow direction in the vicinity of the proposal site is west to north-west. The main rock aquifer of the Great Artesian Basin in the study area is the Pilliga Sandstone, which forms part of the Hooray Sandstone and Equivalents stratigraphic unit.

Hydraulic conductivity

Hydraulic conductivity is a fundamental aquifer hydrogeological property that assists in understanding the potential for drawdown and its associated effects. Hydraulic conductivity is measured in metres per day and is a calculation of how quickly groundwater flows through a porous medium (soil matrix or rock mass) under natural conditions. The higher the value of hydraulic conductivity, the greater the movement of groundwater expected.

Based on the results of the field assessment, hydraulic conductivity was found to be variable in the alluvium unit and low in the rock unit. The highest conductivity was noted at a borehole screened in alluvial material between Narrabri Creek and the Namoi River. The conductivity was measured at 5.55 or 7.41 metres per day, depending on the method of analysis used.

Groundwater quality

The results of the field assessment indicated the following with regards to groundwater quality in the shallow alluvial groundwater system beneath the proposal site:

- Concentrations of copper, nickel, and zinc exceeded the ecological criteria for freshwater from the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (Australian and New Zealand Governments, 2018) in a number of groundwater samples
- Nutrient levels were variable, with two groundwater samples reporting ammonia concentrations slightly above the ecological criteria for freshwater
- Total dissolved solids concentrations ranged from 200 to 22,000 milligrams per litre, which is representative of fresh to saline groundwater. The average total dissolved solids concentration from the groundwater samples collected was representative of brackish groundwater.
- Pesticides were below the laboratory limit of reporting in all groundwater samples.

Groundwater users

A total of 192 registered groundwater bores are located within 1 km of the proposal site. The majority of these bores have beneficial uses, including stock/domestic, water supply and irrigation.

With regards to groundwater users close to the proposed bore fields, the following is noted:

- There is one existing bore licensed to extract water from the Lachlan Fold Belt Murray Darling Basin Groundwater Source (part of the *NSW Murray Darling Basin Fractured Rock Groundwater Source 2011* water sharing plan) located within a 5 km radius of the southern-most bore field (PB1)
- There are five existing bores licensed to extract water from the Lachlan Fold Belt Murray Darling Basin Groundwater Source (part of the *NSW Murray Darling Basin Fractured Rock Groundwater Source 2011* water sharing plan) located within a 5 km radius of bore field PB2 (directly north of PB1)
- There are no other existing bores licensed to extract water from either the Lachlan Fold Belt Murray Darling Basin Groundwater Source or the Gunnedah Oxley Basin Murray Darling Basin Groundwater Source (part of the *NSW Murray Darling Basin Porous Rock Groundwater Source 2011* water sharing plan) located within a 5-km radius of the other proposed bore fields (PB3 to PB12).

Groundwater dependent ecosystems

Groundwater dependent ecosystems rely on a supply of groundwater to support the species composition, structure and function of the ecosystem. As described in section B1.2.5, the proposal site crosses areas mapped as groundwater dependent ecosystems by water sharing plans and the *Groundwater Dependent Ecosystem Atlas* (BoM, 2020).

B2.3 Impact assessment—construction

B2.3.1 Water balance

Estimated water demand

As described in section A8.10.2, water would be required during construction to control dust, compact soil, undertake site concrete works, establish vegetation, and for amenities (toilets, sinks, showers, drinking), including at the temporary workforce accommodation. It is estimated that about 4,635 mega litres (ML) of water would be required over the course of construction, consisting of about:

- 4,165 ML to construct the proposal (about 1,041 ML per year)
- 470 ML of potable water (about 118 ML per year), the majority of which would be for the temporary workforce accommodation.

This would equate to an estimated average use of about 4.3 ML per day over the length of proposal site.

The actual amount of water required at the time of construction would depend on final design details, weather and the final construction methodology.

A conceptual water balance has been prepared for the proposal (see Figure B2.3) and is described in the following sections.

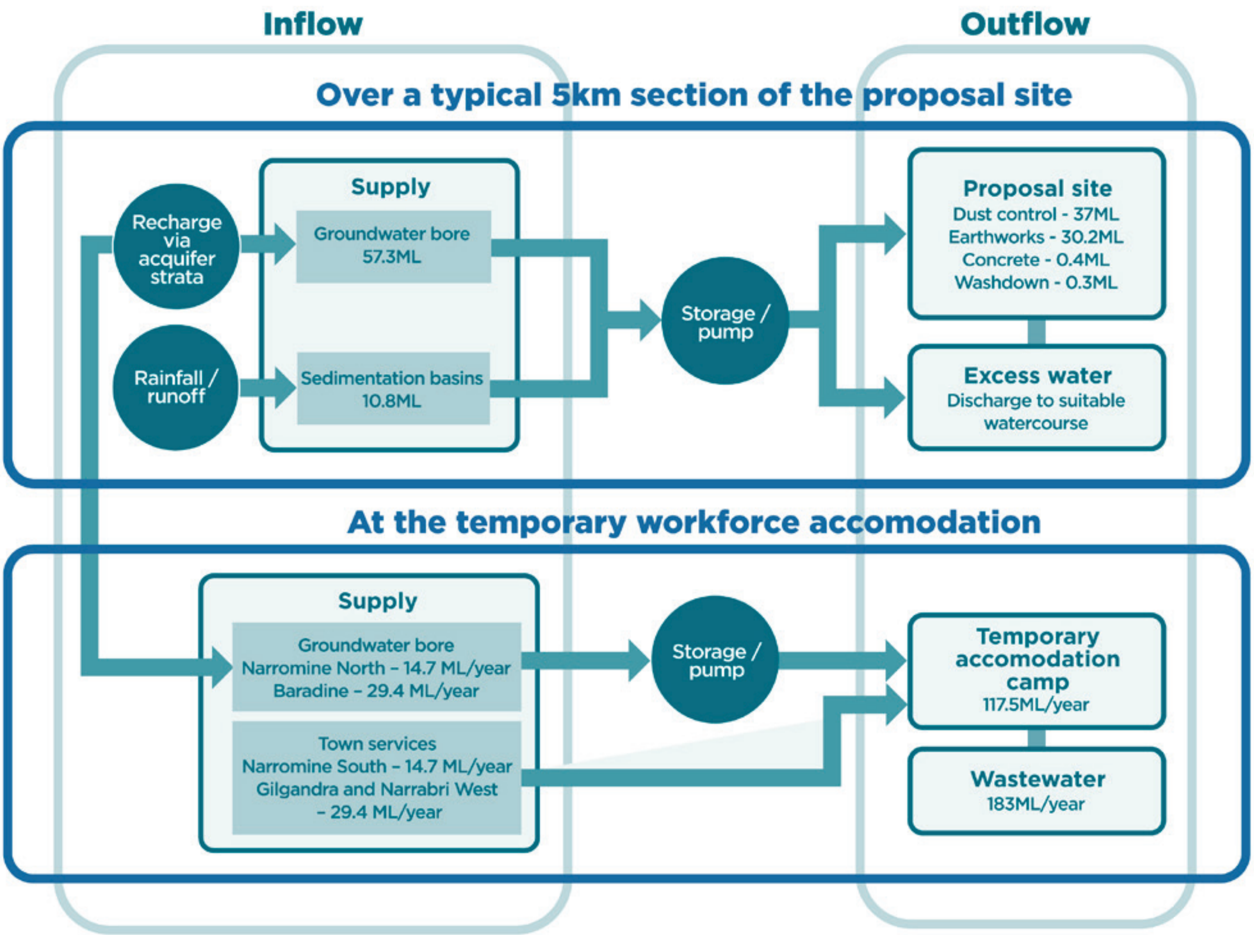

FIGURE B2.3 CONCEPTUAL WATER BALANCE

Inflows—sources of water

Groundwater

As described in section A6.3.5, it is proposed that the primary source of water for the proposal would be groundwater extraction from generally deep groundwater systems.

Based on available information, the deep groundwater systems that the proposal would extract from are likely to have low yields. This means that a network of bore fields would need to be established along the proposal site to meet the proposal's construction water demands. A total 12 bore fields are proposed along the proposal site, typically spaced about 25 km apart, as shown in the maps in Part E.

The number of bores within each bore field would range from 4 to 10, with an average of about 7 bores in each bore field.

At these bores, groundwater would be extracted from below the Great Artesian Basin from the following groundwater sources:

- Lachlan Fold Belt Murray Darling Basin Groundwater Source (part of the *NSW Murray Darling Basin Fractured Rock Groundwater Sources 2020 Water Sharing Plan*)
- Gunnedah-Oxley Basin Murray Darling Basin Groundwater Source (part of the *NSW Murray Darling Basin Porous Rock Groundwater Sources 2020 Water Sharing Plan*)

As noted in section B2.2.3, recharge to the deeper groundwater systems relevant to the proposed bore fields enters via aquifer strata at exposed outcrops. Average rainfall and evaporation values in the study area suggest that groundwater recharge is likely to be low (less than 10 mm per year).

Groundwater extraction from the bore fields would provide about 1,400 ML of construction water per year for the proposal site, or about 57.3 ML over the construction period for a 5 km section of the proposal site.

The depth of the bores would range from about 110 to greater than 300 m below ground level.

Groundwater extraction from groundwater bores is also proposed to supply potable water for the Narromine North and Baradine temporary workforce accommodation facilities. To meet potable water demand for people staying at these facilities, about 14.7 ML per year would need to be extracted for the Narromine North facility, and about 29.4 ML per year for the Baradine facility. Groundwater at these locations would be extracted from the Southern Recharge Groundwater Source (part of the *NSW Great Artesian Basin Groundwater Sources 2020 Water Sharing Plan*). Further information is provided in section C2.3.3.

The results of the groundwater and geotechnical investigations have indicated that groundwater levels are generally below the excavation depth for the construction of the proposed rail and road infrastructure. As a result, groundwater inflows into excavations are not expected for the majority of the proposal site. The exception to this is borrow pit A, where small groundwater inflows are anticipated. It is likely that the maximum groundwater inflow rate would be between 0.08 and 0.28 ML per year. Due to the anticipated low inflow rates, discharge of groundwater is not likely to be required and it is expected that any groundwater inflow would evaporate. The potential impacts associated with groundwater inflow in borrow pit A are considered in chapter C3.

There may also be potential to encounter shallow groundwater during piling of bridges if bored piles are used; however, any groundwater inflow during piling would be minimal.

Runoff and sedimentation basins

Sedimentation basins would be provided at regular intervals along the proposal site, including at all key construction infrastructure, such as compounds and temporary workforce accommodation sites. The sedimentation basins would capture any runoff within the proposal site.

Water contained within the sedimentation basins would either be discharged to the nearest watercourse or would supplement the construction water volumes if required; however, it is noted that the groundwater assessment undertaken to inform the EIS has assumed that all construction water would be sourced from groundwater. Discharge from sedimentation basins would occur prior to, or immediately following, forecast rainfall events that are likely to produce watercourse flows.

Taking into consideration the potential for evaporation, it is anticipated that up to 10.8 ML of water from the sedimentation basins would either be used as construction water or would need to be discharged over the construction period for a 5 km section of the proposal site.

Town services

It is anticipated that potable water for the Narromine South, Gilgandra and Narrabri West temporary workforce accommodation facilities would be provided by connections to the existing potable water supply network. About 14.7 ML per year would be required for the Narromine South facility, and 29.4 ML per year would be required for the Gilgandra and Narrabri West facilities.

Outflows/use

Construction water

Indicative construction water requirements for the proposal site as a whole, and for a typical 5-km section of the proposal site, are listed in Table B2.2.

TABLE B2.2 WATER REQUIREMENTS FOR THE PROPOSAL

Use	Volume for proposal site (ML)	Volume for typical five km section (ML)
Earthworks and formation preparation and materials conditioning	1,850	30.2
Dust suppression (stockpiles and haul roads)	2,270	37.1
Concrete production	25	0.4
Wash down	20	0.3
Totals	**4,165**	**68**

As shown in the table, water for earthworks and dust suppression comprises the bulk of the water requirements. The estimated volumes for dust suppression are based on assumed weather conditions and typical rates used to minimise the generation of nuisance dust outside the construction footprint and provide for safe operation of haul roads. Subject to consideration of potential offsite impacts and safety of haul road operations, a reduced dust suppression regime may be possible along parts of the proposal site.

As noted in section A6.3.5, opportunities to reduce the need for water would be further explored during detailed design and construction planning. Such options include:

- Use of additives
- Alternative compaction/construction techniques
- Improved reuse of excavated material
- Use of different materials for haul roads
- Reduced dust suppression regime where there is minimal potential for impacts.

It is anticipated that most of the water used for construction activities would either be absorbed by the activity or product (e.g. go into ground for compaction, be used for dust suppression or concrete) or evaporate. Potential surface water runoff from construction activities would be minor and managed by standard erosion and sediment controls. Any additional flow and infiltration would be negligible compared to regional rainfall levels.

Temporary workforce accommodation

Water would mainly be used at the temporary workforce accommodation to provide drinking water and water for site amenities and kitchens.

It is estimated that the facilities would produce a total of about 183 ML per year of wastewater, based on each worker generating an average of 250 litres of wastewater per day. Options to dispose of wastewater would include connections to the towns' existing wastewater network (where available), trucking or irrigation of treated wastewater. The preferred option/s would be confirmed by the construction contractor during detailed construction planning.

B2.3.2 Watercourses and hydrology

The proposal would involve works within and around perennial and non-perennial watercourses, including on waterfront land. Such works include:

- Installing erosion protection measures in accordance with the CEMP
- Construction of culverts and bridges as described in chapter A8
- Rehabilitating the disturbed area once works are complete.

If inadequately managed, work in watercourses and waterfront land has the potential to change the flow regime, impact riparian vegetation and aquatic ecology (considered in chapter B1), reduce the stability of beds and banks (considered in chapter B3) and contribute to erosion, sedimentation and water quality impacts (considered in chapter B5).

As described in section B2.1.4, the proposal includes a number of design features, particularly in relation to the use of pre-fabricated components, to minimise the extent of disturbance to watercourses. Additionally, only the Macquarie River and Narrabri Creek/Namoi River bridges would require piers to be constructed within flowing water. All other bridges and culverts would be constructed in watercourses that are ephemeral.

For the Macquarie River and Narrabri Creek/Namoi River bridges, piers would be constructed from barges using driven piles, minimising disturbance of beds and banks. Silt curtains would be used during construction to further minimise the potential for sediment transport. Where works are required within the beds and banks of other watercourses within the proposal site, the works would only be undertaken during dry periods, as far as practicable, and any impacts on landscape health would be managed by implementing standard erosion and sediment controls in accordance with the CEMP. Any works within waterways and/or on waterfront land would be undertaken in accordance with the *Guidelines for watercourse crossings on waterfront land* (DPI, 2012b).

The proposal would likely require the discharge of water from sedimentation basins, which, if inadequately managed, could alter surface water flows and cause localised scouring of sediments. If discharge is required, the exact volume of discharge water and discharge points would be identified prior to construction. Any discharge would be undertaken prior to, or immediately following, forecast rainfall events. Discharge points would take into consideration the hydrological attributes of the receiving watercourse, including whether there is sufficient flow volume and velocity to incorporate the discharge volumes.

Construction would result in a small increase in impervious areas (such as construction compounds), which would have the potential to increase the volume of water flowing to watercourses; however, the change in impervious area would be negligible compared to the overall catchment area.

Construction would involve temporary diversions to transfer runoff around work sites. This may involve excavations and embankments that could alter localised flow patterns and impact the stability of surrounding surface water receivers. These changes would be temporary and limited to the construction phase. Following construction, the landform would be restored as close as practicable to the pre-works condition.

With the implementation of the standard erosion and sediment control measures, any impacts on surface water hydrology and flow regimes as a result of construction would be limited in extent.

B2.3.3 Aquifer interference

As described in section B2.3.1, the proposal would involve the extraction of groundwater from deep groundwater systems beneath the proposal site. All other construction activities would be unlikely to intersect the groundwater table, with the exception of excavation activities in borrow pit A (discussed in chapter C3).

The passive or direct extraction of groundwater can lead to the lowering of the groundwater table or drawdown within the surrounding aquifer. This can reduce water availability within the aquifer, decreasing the amount of groundwater available for groundwater users, groundwater dependent ecosystems and surface water baseflows. It can also cause changes to the groundwater flow direction, causing water from other water sources (both ground and surface water) to flow towards the area of drawdown, altering the type and concentrations of nutrients (e.g. salinity) available.

The following sections consider the potential changes to the groundwater environment during construction and provide a summary of the results of the assessment of potential impacts on groundwater availability and quality due to groundwater extraction and drawdown. Impacts on groundwater quality from other construction activities are considered in chapter B5.

Area of groundwater influence

The groundwater modelling indicates that groundwater levels within the Great Artesian Basin and underlying rock aquifer would have the potential to change by less than 1 m due to the proposed extraction of groundwater from deep groundwater systems for construction water. Potential impacts on groundwater levels in the shallow groundwater system are considered unlikely due to the anticipated temporary duration of pumping (likely to be between 250 and 500 days at each bore field) and the large separation distance between the groundwater source that the bore fields would target and the shallow groundwater system.

Modelling undertaken for bore fields PB1 and PB2 indicated that groundwater levels outside of the Great Artesian Basin could reduce by between 37 m at the centre of bore field PB2 to 1 m, about 1.25 km away from bore field PB2.

There may be the potential for short-term increases in groundwater levels in areas of fill placement due to changes in hydraulic conductivity; however, the changes would be localised and negligible.

Impacts on groundwater dependent ecosystems

Extraction of groundwater from the proposed bore fields is considered unlikely to affect groundwater dependent ecosystems. The potential change in groundwater levels that would occur within the Great Artesian Basin, as a result of pumping from the majority of bore fields, would be less than 1 m. This change is within the bounds of natural variability due to climate and recharge processes. At the location of bore fields PB1 and PB2, the standing water levels are between 20 and 35 m below ground surface. It would be unlikely that any groundwater dependent ecosystems would be interacting with groundwater at this depth.

The distance from the proposal site to high priority groundwater dependent ecosystems (see section B2.2.3) also means that the potential for impacts on groundwater dependent ecosystems due to the proposed groundwater extraction is considered low.

Impacts on groundwater users

Construction would require decommissioning 10 existing groundwater bores located within the construction footprint, unless appropriate measures are implemented to prevent damage to the bores. As the majority of construction activities would be unlikely to intercept groundwater, groundwater level reductions at existing bores within the construction footprint are not anticipated. At bridge pier locations there may be a residual redirection of alluvial flows around the piers; however, this would be unlikely to extend more than 5 m from individual piers and would not impact groundwater flow at existing bores.

The *NSW Aquifer Interference Policy* (DPI, 2012a) requires that potential impacts on groundwater sources be assessed against the minimal impact considerations outlined in the policy. In the context of the *NSW Aquifer Interference Policy*, the proposal is considered to be underlain by highly productive groundwater sources. If the predicted impacts are less than the Level 1 minimal impact considerations for highly productive groundwater sources, then the potential groundwater impacts are acceptable. To meet the minimal impact considerations there should not be a reduction in groundwater level greater than 2 m at existing groundwater supply bores. Additionally, the beneficial use category of groundwater sources should not be lowered beyond 40 m from the proposed activity and the activity should not cause any existing bores to cease flowing.

With regard to the potential for impacts at existing bores due to extraction from the bore fields, the groundwater modelling indicated the following:

- One existing bore (bore ID 001568), located about 430 m from PB1, is predicted to experience drawdown of about 1.5 m. This does not exceed the *NSW Aquifer Interference Policy* (DPI, 2012a) minimal impact considerations; however, due to its proximity to the bore field, further information about this bore would be obtained as part of the groundwater monitoring program to ensure the potential for impacts is minimised (see section B2.5.1).
- One existing bore (bore ID 000986), located about 650 m from bore field PB2, is predicted to experience drawdown of about 4 m. This exceeds the *NSW Aquifer Interference Policy* minimal impact considerations. A mitigation measure has been provided (see section B2.5.2) to minimise the potential impacts on this bore.
- No bores are located within the 2-m drawdown contours from the other bore fields (PB3 to PB12). Drawdown impacts on bores located near these bore fields would be unlikely to exceed the *NSW Aquifer Interference Policy* minimal impact considerations.
- Groundwater flow reductions due to extraction of groundwater at the bore fields would be unlikely to cause any existing bores to cease flowing or result in the beneficial use category of groundwater sources being lowered beyond 40 m from the proposal site.

Surface and groundwater interaction

As noted in section B2.3.1 the majority of construction activities would be unlikely to intersect the groundwater table, with the exception of extraction of groundwater for construction water use.

Given the level and radius of groundwater drawdown anticipated, due to the extraction of groundwater at the bore fields, changes to the baseflow of watercourses within the study area are considered unlikely.

Groundwater quality

The groundwater that would be extracted from the deeper groundwater systems is currently of unknown quality. If this groundwater is not of suitable quality, and is not treated prior to application during construction, there is the potential that it could impact surface water, shallow groundwater systems and the quality of vegetation and surface soils. Monitoring information would be obtained during the detailed design phase in accordance with the measures provided in section B2.5.2.

The construction of deep groundwater bores could result in connectivity between aquifers. This has the potential to cause contamination and pressure loss across aquifers if the bores are not adequately constructed. Groundwater wells would be installed by an appropriately licensed driller (i.e. one licensed to construct the required bores within the Great Artesian Basin) in accordance with the *Minimum Construction Requirements for Water Bores in Australia* (National Uniform Drillers Licensing Committee, 2012).

Potential for settlement

Groundwater drawdown has the potential to cause ground settlement as a result of water being removed from pore spaces, which, in turn, can cause consolidation of soils. This risk is generally applicable to relatively soft soils and is not expected to occur in areas where the water table is hosted in a fractured rock groundwater system. Settlement can cause damage to existing buildings and infrastructure.

As noted above, water table drawdown would be most pronounced around the bore fields. With the exception of bore field PB2, water table drawdown at the bore fields is anticipated to be minor and within the range of typical groundwater level responses to long-term climate trends; therefore, it is not anticipated that settlement would occur, due to extraction of groundwater at these locations. At bore field PB2, some settlement could occur under certain conditions, such as large water table drawdown in areas of soft soils.

Alluvium soils are mapped to the east of bore field PB2. While this area may be subject to drawdown of up to 6 m, based on the groundwater modelling results, any associated settlement in this area is anticipated to be minor. Additionally, a review of aerial photography indicates that no existing infrastructure is located in this area; therefore, if settlement did occur in the vicinity of bore field PB2, it would not cause damage to buildings and infrastructure.

B2.3.4 Water availability

Water take

No direct water take is proposed from watercourses within or around the proposal site. Additionally, there would be no change to the baseflow of watercourses due to the extraction of groundwater. As a result, there would be no impact on water availability within those watercourses that are designated water sources under the water sharing plans listed in section B2.2.2.

Groundwater take is proposed from the following regulated/licensed sources:

- Lachlan Fold Belt Murray Darling Basin Groundwater Source which is part of the *NSW Murray Darling Basin Fractured Rock Groundwater Sources 2020*—for extraction from 26 bore field bores
- Gunnedah-Oxley Basin Murray Darling Basin Groundwater Source which is part of the *NSW Murray Darling Basin Porous Rock Groundwater Sources 2020*—for extraction from 62 bore field bores.

It is estimated that the following allocation volumes would be required for construction water:

- About 420 ML per year from the Lachlan Fold Belt Murray Darling Basin Groundwater Source
- About 980 ML per year from the Gunnedah-Oxley Basin Murray Darling Basin Groundwater Source.

The estimated yearly non-potable construction water volumes are less than 1 per cent of that considered potentially available under a controlled allocation within these water sources. The exact volumes required would be confirmed during detailed design and construction planning.

Water supply infrastructure

The proposal site crosses a number of farm dams, irrigation canals/drainage channels and water supply infrastructure. The proposal's land requirements (see section B12.3.1) would require the removal of some farm dams and the relocation/replacement of some of these features and infrastructure. The proposal would be designed, and construction would be managed, to ensure that potential impacts on these features and infrastructure would not affect their water supply functions or water availability either locally (for individual properties/dams) or, more broadly, for the catchment. This would involve providing replacement infrastructure (where required) prior to impacts occurring, in consultation with the infrastructure owner/landholder.

Further information about the proposed approach to managing potential impacts to utilities and farm dams, including water supply utilities, is provided in section A8.12 and Chapter B12. A dam dewatering protocol would be developed and implemented as part of the soil and water management plan to manage the process of dewatering for farm dams that may require relocation and/or decommissioning (see section B5.5.2).

B2.3.5 Stormwater and wastewater management

Surface water at construction sites would be managed by implementing standard erosion and sediment control measures in accordance with *Managing Urban Stormwater—Soils and Construction*: Volume 1 (Landcom, 2004), Volume 2C *Unsealed Roads* (DECC, 2008a) and Volume 2D *Main Road Construction* (DECC, 2008b) (collectively referred to as the 'Blue Book').

Wastewater could result from the following activities/sources:

- Use of site amenities at construction compounds and temporary workforce accommodation
- Dewatering of groundwater and surface water runoff from excavations
- Sedimentation basins
- Use of concrete batching plants
- Use of vehicle wash down areas.

Wastewater from site amenities would be removed via vacuum trucks on a regular basis and would be disposed of in accordance with relevant regulatory requirements.

Wastewater from other construction activities would be initially contained onsite to confirm it meets relevant water quality requirements (see chapter B5). Discharge of wastewater to surface water would consider the hydrological attributes of the receiving waterbody, including whether the receiving waterway has sufficient flow volume and velocity to incorporate and disperse the potential discharge.

B2.4 Impact assessment—operation

B2.4.1 Water balance

No water would be required from surface and groundwater sources during operation. Any water required during maintenance activities would be brought to site in accordance with ARTC's existing maintenance procedures; therefore, there would be no impact on water availability due to operation of the proposal.

Maintenance activities are not expected to require excavation to depths at which groundwater may be encountered.

B2.4.2 Watercourses and hydrology

The presence of the proposed rail corridor and raised rail formation could affect surface water flows across the floodplain. This could change the upstream flooding regime and result in more concentrated flows through culverts that discharge to downstream watercourses.

The proposal could also modify flow paths across floodplains as a result of the installation of culverts, longitudinal drainage and bridges. The installation of such structures could change the pattern of cross drainage from upslope to downslope areas, due to increased flood levels and velocities upstream and downstream of culverts, drainage and bridges. This may change the patterns of erosion and scouring within existing watercourses and drainage lines, and within the broader floodplain area.

These impacts are likely to be minimal because where there is potential for increased flow velocities at bridges and culvert outlets, scour protection would be provided to mitigate impacts. Additionally, as noted in section B2.1.4, bridges and culverts have been designed to have a minimal impact on existing surface flow paths across the proposal site.

Further information regarding flooding and flow velocities is provided in chapter B3.

Maintaining the culverts and bridge structures could disturb watercourses and/or waterfront land, which could impact riparian vegetation and contribute to erosion, sedimentation and water quality impacts. Given the small scale of maintenance activities that would likely be required, any impacts would be minor and managed by implementing ARTC's existing standard operating procedures.

B2.4.3 Aquifer interference

No extraction of groundwater is proposed during operation.

As pumping of the bore fields would not occur during operation, potential groundwater level drawdowns in the vicinity of the bore fields would also be negligible and within the *NSW Aquifer Interference Policy* (DPI, 2012a) minimal impact considerations.

Given the above, negligible impacts on groundwater dependent ecosystems, groundwater users and surface water baseflows are anticipated.

B2.4.4 Stormwater and wastewater management

Surface water during maintenance activities would be managed by implementing standard erosion and sediment control measures in accordance with the Blue Book.

There are not expected to be any activities undertaken during operation that would generate wastewater requiring discharge.

B2.5 Mitigation and management

B2.5.1 Approach

Approach to mitigation and management

The assessment identified that if construction is not adequately managed, including managing the extraction of groundwater and works within and near watercourses, it would have the potential to impact surrounding groundwater users and surface water hydrology.

There is limited potential for operation impacts, as groundwater would not be extracted during operation and all landforms would be rehabilitated in accordance with the rehabilitation strategy described in section A8.7.

The proposal would include appropriate erosion and scour protection to minimise the potential for impacts within watercourses.

Approach to managing the key potential impacts identified

All works within and near watercourses would be undertaken in accordance with the *Guidelines for watercourse crossings on waterfront land* (DPI, 2012b). Where discharge to watercourses is required, discharge would consider the hydrological attributes of the receiving waterbody. This would include considering whether the receiving waterway has sufficient flow volume and velocity to incorporate and disperse the potential discharge.

Scour protection measures would be provided at culvert and longitudinal drain outlets to minimise the potential for surface water hydrology impacts due to scouring and erosion. Appropriate scour protection measures would also be incorporated into the design of bridge piers and abutments.

Prior to construction, a bore census would be undertaken for existing groundwater bores within 1 km of the proposed bore field bores. The main purpose of the census would be to collect baseline groundwater data. This would provide a basis to determine if the extraction of groundwater during construction has caused water level reductions and whether 'make good' provisions are required in accordance with the *NSW Aquifer Interference Policy* (DPI, 2012a) minimal impact considerations. Although not defined in the *NSW Aquifer Interference Policy*, if 'make good' provisions apply, a bore impacted by drawdown would require replacement or some form of rectification. This could involve drilling a replacement bore, possibly in a different location, or to a deeper depth to reinstate the pre-impacted groundwater level and bore yield.

Test bores would also be installed during detailed design and further investigations would be undertaken to confirm the proposed bore field hydrogeological conditions, including the:

- Thickness and hydraulic conductivity of the layers at the base of Great Artesian Basin
- Depth and location of the proposed bore field bores.

Groundwater monitoring program

The potential for groundwater level reductions due to the extraction of groundwater would be monitored by developing and implementing a groundwater monitoring program for the proposed bore fields. The program would monitor groundwater levels and quality at selected locations, and would include:

- Measuring groundwater levels using data loggers within at least one bore in each bore field
- Sampling and laboratory analysis of groundwater samples from at least one bore in each bore field for:
  - Physical properties—pH, total dissolved solids, turbidity, hardness, major anions, cations and alkalinity
  - Dissolved heavy metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, zinc)
  - Other analytes relevant to the design, which would be confirmed at detailed design.

Groundwater levels would be measured using data loggers at a minimum of six hourly intervals prior to and during construction. Monitoring of groundwater levels would continue, following construction, until water levels recover to baseline conditions.

Groundwater quality monitoring would be undertaken prior to and during construction to ensure the groundwater is suitable for application during construction, or to confirm the treatment requirements prior to application. A minimum of three groundwater quality sampling rounds would be undertaken prior to construction. Groundwater sampling would continue on a monthly basis during construction while groundwater is being extracted from the bore fields.

Approach to managing other impacts

A soil and water management plan would be prepared and implemented as part of the CEMP. The plan would detail processes, relevant requirements and responsibilities to minimise potential soil and water impacts during construction. The plan would be prepared in accordance with relevant guidelines and standards, including the Blue Book. Further information on the CEMP is provided in chapter D5. The requirements for the soil and water management plan are discussed in the CEMP outline provided in Appendix I.

Expected effectiveness

Implementing a groundwater monitoring program prior to, during and following construction, would confirm the effectiveness of mitigation measures. The results would provide information to drive further development of additional or optimised measures to ensure that any subsequent impacts are appropriately managed. Construction of the proposed bore field bores by appropriately licensed drillers, in accordance with relevant regulatory requirements, would also ensure the effectiveness of the proposed mitigation measures.

The implementation of erosion and sediment control measures to manage water hydrology impacts would be in accordance with the requirements of the Blue Book. The measures contained in the Blue Book are based on field experience, tailored to particular project types, and have been extensively used and demonstrated to be effective. In general, the implementation of measures in accordance with the Blue Book would either result in a reduced potential for the impact to be realised or the impact would be avoided (e.g. not undertaking works during wet weather and minimising areas of disturbance); therefore, there is no reason the proposed mitigation measures should not be effective if implemented in accordance with the Blue Book requirements.

Interaction between measures

Mitigation measures to minimise impacts on water resources may overlap with mitigation measures proposed for the control of flooding, soil and water quality impacts (see chapters B3 to B5). All measures for the proposal would be consolidated and described in the CEMP. The plan would identify measures that are common between different aspects. Common impacts and common mitigation measures would be consolidated to ensure consistency and implementation.

B2.5.2 List of mitigation measures

Measures that would be implemented to address potential impacts on water resources are listed in Table B2.3.

TABLE B2.3 WATER RESOURCES MITIGATION MEASURES

Stage	Ref	Impact/issue	Mitigation measure
Detailed design/ pre-construction	WR1	*Construction and potable water supply*	Construction water supply options would continue to be explored during detailed design and could include reuse of excess water from the Narrabri Gas Project or other suitable facilities in the area, or lease and/or purchase of existing water access licences from surrounding landholders.
	WR2	*Impacts to existing bores*	Where existing licensed bores are located within the proposal site, they would be decommissioned in accordance with the *Minimum Construction Requirements for Water Bores in Australia* (National Uniform Drillers Licensing Committee, 2012).
	WR3		A bore census would be undertaken for existing licensed bores within 1 km of the proposal's bore fields, where landholders permit. The census would collect baseline groundwater level data and information on a given bore's typical usage and characteristics (including bore construction, pump depth, yield, water level during pumping and water level outside of pumping periods).
	WR4	*Impacts from extraction of groundwater*	Test bores would be installed during detailed design, and further investigation would be undertaken by a qualified hydrogeologist, to confirm the depth and location of the proposed bore field bores. The bore fields would consider the bore field design considerations detailed in section 11.1 of Technical Report 4—Groundwater assessment.
	WR5		Water volumes required to be extracted from groundwater for construction water would be confirmed and the appropriate approvals would be obtained prior to extraction. Monitoring would be undertaken during extraction to ensure volumes stipulated by licence requirements are not exceeded.
Construction	WR6	*Sedimentation and erosion management*	A soil and water management plan would be prepared and implemented as part of the CEMP. The plan would include measures, processes and responsibilities to minimise the potential for soil and water impacts during construction.
	WR7	*Monitoring groundwater drawdown and quality*	A groundwater monitoring program would be developed and implemented as part of the soil and water management plan to monitor potential groundwater impacts. The program would define the following in accordance with chapter 10 of Technical Report 4—Groundwater assessment: ▶ Monitoring parameters ▶ Monitoring locations ▶ Frequency and duration of monitoring. The monitoring program would include baseline monitoring to determine the water quality of groundwater from the proposed bore field bores. Monitoring of groundwater levels would continue following the completion of groundwater pumping and extraction until water levels recover to baseline conditions.
	WR8	*Bore field groundwater quality*	The quality of groundwater obtained from the proposed bore field bores would be assessed for the suitability of its intended use. Where required, treatment systems would be designed to ensure water quality does not exceed the relevant water quality criteria from the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (Australian and New Zealand Governments, 2018).
	WR9	*Impacts on existing bores*	Where groundwater monitoring identifies the potential for groundwater drawdown in existing bores to exceed the *NSW Aquifer Interference Policy* minimal impact considerations, make good provisions would be triggered for those bores in consultation with the relevant landholders.

Stage	Ref	Impact/issue	Mitigation measure
Construction (continued)	WR10	*Proposal bore construction*	All bores required for the proposal would be constructed by appropriately licensed drillers in accordance with the *Minimum Construction Requirements for Water Bores in Australia* (National Uniform Drillers Licensing Committee, 2012) and the relevant requirements of each Water Sharing Plan.
	WR11	*Works within watercourses*	Works within or near watercourses would be undertaken with consideration of the *Guidelines for watercourse crossings on waterfront land* (DPI, 2012b).
	WR12	*Unforeseen water table penetration by bulk earthworks*	If bulk excavations unexpectedly intersect the water table, potential impacts would be assessed by a hydrogeologist and adaptive mitigation measures implemented, as required.
	WR13	*Proposal bore fields*	Where there is benefit to the local community, the potential for retaining bores post-construction would be considered in consultation with relevant stakeholders (e.g. local councils). Any approvals, operating costs and maintenance associated with retaining and using these bores would be the responsibility of the party that takes ownership.

B2.5.3 Managing residual impacts

Residual impacts are impacts of the proposal that may remain after implementation of:

- Design and construction planning measures to avoid and minimise impacts (see sections A7.2 and A8.1)
- Specific measures to mitigate and manage identified potential impacts (see sections B2.5.1 and B2.5.2).

The key potential water resources issues and impacts originally identified by the environmental risk assessment (see section A9.1) are listed in Table B2.4. The (pre-mitigation) risks associated with these impacts, which were identified by the environmental risk assessment, are provided. Further information on the approach to the environmental risk assessment, including descriptions of criteria and risk ratings, is provided in section A9.1.

The potential issues and impacts identified by the environmental risk assessment were considered as part of the water resources impact assessment, summarised in sections B2.3 and B2.4. The mitigation and management measures (listed in Table B2.3) that would be applied to manage these impacts are also identified. The significance of potential residual impacts (after application of these mitigation measures) is rated using the same approach as the original environmental risk assessment. The approach to managing significant residual impacts (considered to be those rated medium or above) is also described.

TABLE B2.4 RESIDUAL IMPACT ASSESSMENT—WATER RESOURCES

Assessment of pre-mitigated risk (see section A9.1 and Appendix E)					Mitigation measures (see Table B2.3)	Residual impact assessment			
Phase	Potential impacts	Likelihood	Consequence	Risk rating		Likelihood	Consequence	Risk rating	How residual impacts will be managed[1]
Construction	Temporary impact to the behaviour of local surface water systems during construction due to the presence of construction features, including erosion and sedimentation control structures	Possible	Moderate	Medium	WR6	Unlikely	Minor	Low	n/a
	Changes to flow patterns and altered hydrology due to construction in watercourses.	Possible	Moderate	Medium	WR6 and WR11	Unlikely	Minor	Low	n/a
	Extraction of groundwater may cause drawdown of the groundwater table, impacting sub-surface flows, water characteristics and availability.	Possible	Major	High	WR2 to WR5, WR7 to WR10	Unlikely	Moderate	Low	n/a
	Potential for bulk excavations to intersect the water table and lead to groundwater level drawdown, impacting nearby groundwater bores, groundwater dependent ecosystems and watercourse baseflow.	Possible	Moderate	Medium	WR3, WR7 and WR12	Unlikely	Minor	Low	n/a
	Potential to create groundwater flow pathways between groundwater systems as a result of groundwater extraction from the bore field bores.	Unlikely	Major	Medium	WR4, WR7, WR9 and WR10	Rare	Moderate	Low	n/a

Note:

1. For residual impacts with a risk rating of medium or above.