Appendix M
Groundwater Study

Hunter 8 ALLIANCE

Appendix M

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GHD

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Glossary of Term

Bund	An impervious embankment of earth or a brick wall, which may form part or all of the perimeter of a compound that is provided to retain liquid.
Chainage	The chainage at a location along a rail line is the distance of that point in relation to Sydney (NSW only) based on 0.000 kilometres being located at the end of Central No. 1 Platform.
Coal path	A train path that is dedicated to the movement of coal haulage.
Concept design	Initial functional layout of a concept, such as for the proposed duplication, to provide a level of understanding to later establish detailed design parameters.
Consent	Approval to undertake a development received from the consent authority.
Construction Environmental Management Plan	A document setting out the management, control and monitoring measures to be implemented during construction of a development, to avoid or minimise the potential environmental impacts identified during an environmental impact assessment process.
Crossover	Railway infrastructure which provides a train the ability to cross between two adjacent tracks.
Culvert	A totally enclosed drain under a road or railway.
Cumulative impact	The sum on the environment resulting from the successive effects of several different impacts.
Cut	An excavation for constructing below the natural ground level.
Cut and fill balance	Difference between earthwork cut and fill volumes.
Cut batters	The side slopes of cuttings.
Detailed design stage	The stage at which the project design is detailed on the basis of an approved concept design.
Director-General's Requirements	Requirements for an environmental assessment issued by the Director-General of the NSW Department of Planning in accordance with the Environment Planning and Assessment Act 1979.
Down Main	Primary (main) rail line that trains traverse when they are heading away from Sydney (usually positioned on the left when your back is to Sydney).
Duplication	Construction of an additional track adjacent to an existing single track.
Fauna	The animals of a given region or period, taken collectively.
Flora	Plants of a particular region that make up the vegetation of a site.
Fill	Earth used to construct an embankment.
Geotechnical	A discipline of engineering associated with studying the ground and its geology.
Gradient	The degree of ascent or descent with a uniform slope.

Groundwater	Subsurface water stored in pores of soil or rocks.
Hydrology	The study of rainfall and surface water run-off processes.
Hunter 8 Alliance	Hunter 8 Alliance, which has been formed to deliver a new third track and ancillary infrastructure between Maitland and Minimbah.
Intergenerational equity	That the present generation should ensure that the healthy diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.
Investigation corridor	A linear corridor which follows the route of the Main Northern Railway between chainages 194.500 kilometres and 224.200 kilometres and captures the footprint of disturbance for the third track and other associated works, including construction compounds, haul roads and spoil disposal areas
Key threatening process	A process specified in Schedule 3 of the Threatened Species Conservation Act 1995 that adversely affects threatened species, populations or ecological communities, or could cause those that are not threatened to become so.
Level crossing	A crossing provided at grade across the railway corridor.
Mitigation	Reduction in severity.
Option	A concept design alternative developed for consideration.
Overbridge	Where a road or pedestrian footway is situated over the railway line.
Plant	Construction machinery, vehicles or equipment needed to carry out mechanical or construction activities.
Precautionary principle	If there are threats of serious or irreversible damage, lack of full scientific uncertainty should not be used as a reason for postponing measures to prevent environmental damage.
Proponent	Australian Rail Track Corporation (ARTC).
Regenerated noise	Also referred to as “structure-borne” noise or “ground-borne” noise which results from ground-borne vibration, for example, from construction activities and may be transmitted into building structures, causing vibration of floor slabs and other heavy structures, and hence radiating noise into internal spaces.
Rail corridor	The area of land dedicated to the ARTC between Maitland and Minimbah.
Sediment	Material of varying sizes that has been or is being moved from its site of origin by the action of wind, water or gravity.
Spoil	Excess of rock and/or earth material resulting from construction activities.
Study area	The Study Area for this project is defined as a 5 km buffer around the investigation corridor.

Executive Summary

This Groundwater Study has been completed by the Hunter 8 Alliance to assess the potential impacts of the Maitland to Minimbah Third Track Project ('the Project') on groundwater resources.

A desktop review of the geology and hydrogeology was conducted to characterise existing groundwater conditions and to identify potential receptors of the Project. This included review of published geological maps, interrogation of the *New South Wales Natural Resource Atlas* website and interrogation of groundwater bore information for licensed bores provided by the Department of Water and Energy (DWE). Potential impacts of the Project were identified and mitigation and monitoring measures proposed based on the desktop review.

Permian-aged bedrock (including sandstone, siltstone, conglomerate and coal measures) indicated to be of typically low to moderate permeability with fresh to brackish/saline groundwater is mapped beneath the majority of the investigation corridor. The bedrock is indicated to be overlain by Quaternary-aged alluvial deposits along the main creeks and is mapped to the east, south east and north of the Project alignment at East Maitland where the groundwater is typically fresh. Groundwater levels are indicated to be relatively shallow in the vicinity of the creeks, within around 1 to 3 m of ground surface, and likely to provide base flow to surface water courses, provide inflow to Wentworth Swamp and potentially provide a source of water to some terrestrial vegetation. Regional groundwater flow is likely to be towards the Hunter River, to the north and north east whilst local shallow groundwater flow in both alluvial deposits and bedrock is likely to follow the fall in topography. No licensed groundwater bores have been identified within the investigation corridor and the two closest down gradient bores (identified as GW 200442 and GW 034601 by DWE) are approximately 700 m to the south of the investigation corridor.

Key Components of the Project

- Development of an understanding of the existing hydrogeological conditions for the Project investigation corridor and in the vicinity of the Project alignment, based on a desktop review.
- Identification of potential receptors and potential impacts of the proposed Project.
- Design and development of a groundwater monitoring network.
- Proposal of groundwater monitoring and mitigation measures.

The potential groundwater impacts identified for construction are:

- Potential for localised water logging where pre-construction groundwater levels are relatively close to the ground surface i.e. in the vicinity of the main creeks.
- Potential for localised, temporary reduction in shallow groundwater levels in the vicinity of Stony Creek at the intersection with Wollombi Road during temporary dewatering.
- Potential for localised degradation of groundwater quality beneath or down gradient of the Project alignment, if any accidental leaks or spills occur.

The potential groundwater impacts identified for the operational phase are:

- Potential for the localised degradation of groundwater quality from the application of additional herbicides within the rail corridor.

The measures proposed to monitor and mitigate the potential impacts are:

- Obtain baseline groundwater level and quality monitoring data for the installed shallow groundwater monitoring network (7 bores) prior to the start of construction.
- Conduct regular groundwater monitoring of the monitoring network during the construction phase and assess against established groundwater quality and level action criteria.
- Provision of appropriate containment facilities for storage areas for vehicles, machinery, equipment, chemicals etc.

Based on the current design of the Project and current hydrogeological understanding, the potential impacts are not considered to be significant. Licensed groundwater bores are unlikely to be impacted during construction of the Project or from operational use and no significant impact on the supply of groundwater to GDEs is anticipated.

1. Introduction

This Groundwater Study has been undertaken by the Hunter 8 Alliance on behalf of the Australian Rail Track Corporation (ARTC) for the Maitland to Minimbah Third Track Project (referred to as 'the Project'). This report has been prepared to assess baseline hydrogeological conditions of the rail corridor and near vicinity.

1.1 Background

ARTC was created by the Commonwealth and State Governments in 1998 to provide a single body responsible for the National Interstate Rail Network. ARTC is a Commonwealth Government corporation and currently has responsibility for the management of over 10,000 route kilometres of standard gauge interstate rail track in South Australia, Victoria, Western Australia and New South Wales (NSW), as well as the Hunter Valley Rail Network and other regional rail links in NSW.

The Hunter Valley Rail Network extends from the Port of Newcastle to Ulan and Narrabri in the west. It is used by passenger services, freight, wheat and coal services. The majority of trains carry coal from mines located across the Hunter Valley to either Carrington (Port Waratah) or Kooragang Island ports at Newcastle for loading onto ships for export.

Due to the forecast increase in coal throughput at the Port of Newcastle to 190 million tonnes per annum (mtpa) by 2012, a number of rail infrastructure improvements to the Hunter Valley Rail Network have been proposed by ARTC. One of the key improvement projects included in the ARTC ten-year strategic plan is a proposed third track adjacent to the existing Main Northern Railway between Maitland and Whittingham, known as the Maitland to Whittingham Third Track Project.

The Maitland to Whittingham Third Track Project is divided into two stages. Stage 1 consists of the construction of the third track between Minimbah and Whittingham. Project Approval for this project was granted by the Minister of Planning on 26 May 2009 and construction commenced in July 2009.

Stage 2 consists of the construction of the third track between Maitland and Minimbah, known as the Maitland to Minimbah Third Track Project. Stage 2 is the subject of this Groundwater Study and is referred to as 'the Project'.

The purpose of the Project is to increase rail reliability and future capacity between the Hunter Valley and the Port of Newcastle. In addition to providing increased track capacity, the Project aims to improve operational performance along the route. These improved efficiencies would be created through:

- Reduced impacts on coal traffic due to track maintenance activities.
- Reduced loss of freight train paths due to shadow effects from passenger services.
- Reduced loss of available train paths due to train breakdowns.

The Project would also bring benefits to the local and broader community by generating up to 650 full time jobs during construction, creating opportunities for local and regional goods and service providers, and providing greater security for existing coal industry jobs.

1.2 Description of the Project

The Hunter 8 Alliance, on behalf of the ARTC, is proposing to construct a third track adjacent to the existing Main Northern Railway between Maitland and Minimbah. The proposed third track would commence in Farley approximately 2 kilometres west of Maitland Station at approximate chainage 194.500 kilometres and would run adjacent to the Main Northern Railway for approximately 30 kilometres concluding at Minimbah at approximate chainage 224.200 kilometres.

The proposed third track would be predominantly located on the Up side of the Main Northern Railway. Approximately 3 kilometres of track, from chainages 210.170 kilometres to 211.180 kilometres and 214.060 kilometres to 216.000 kilometres, would be located on the Down side.

The Project would involve the construction of approximately 30 kilometres of new rail track as well as construction and/ or modification of major infrastructure along the Main Northern Railway. A summary of the major elements of the Project is provided in Table 1.1.

Table 1-1 Major Project Elements

Project Elements	
Earthworks	Major cut and fill earthworks along the route. Other minor earthworks.
Track	Approximately 30 km of new track including turnouts and junctions. Relocation of turnouts from Minimbah and Branxton to Belford. Upgrade of maintenance siding turnouts at Branxton. Track reconditioning of existing Up Main at Greta and Branxton Stations and of the Branxton crossovers.
Drainage	Central and cess track drainage. Amendments to 53 culverts for cross drainage. Re-alignment of Sawyers Creek. Other drainage works around new structures.
Bridges	A new rail underbridge at Stony Creek and Wollombi Road, Farley. Closure of the stock crossing at Farley. Demolition of the existing rail overbridge at Old North Road, Allandale. A new rail underbridge at Allandale Road, Allandale. A new rail underbridge for an unnamed tributary of Anvil Creek (chainage 207.776 km).

Project Elements	
	Demolition and replacement of the existing rail underbridge at an unnamed tributary of Anvil Creek, Greta (chainage 209.989 km). A new rail underbridge at Sawyers Creek, Greta. Modification of the existing rail overbridge at Bridge Street, Branxton. A new rail underbridge at Black Creek, Belford. A new rail underbridge at Jump Up Creek, Belford.
Station Modifications	Modifications to Lochinvar Railway Station. Modifications to Greta Railway Station. Modifications to Branxton Railway Station.

1.3 Investigation Corridor

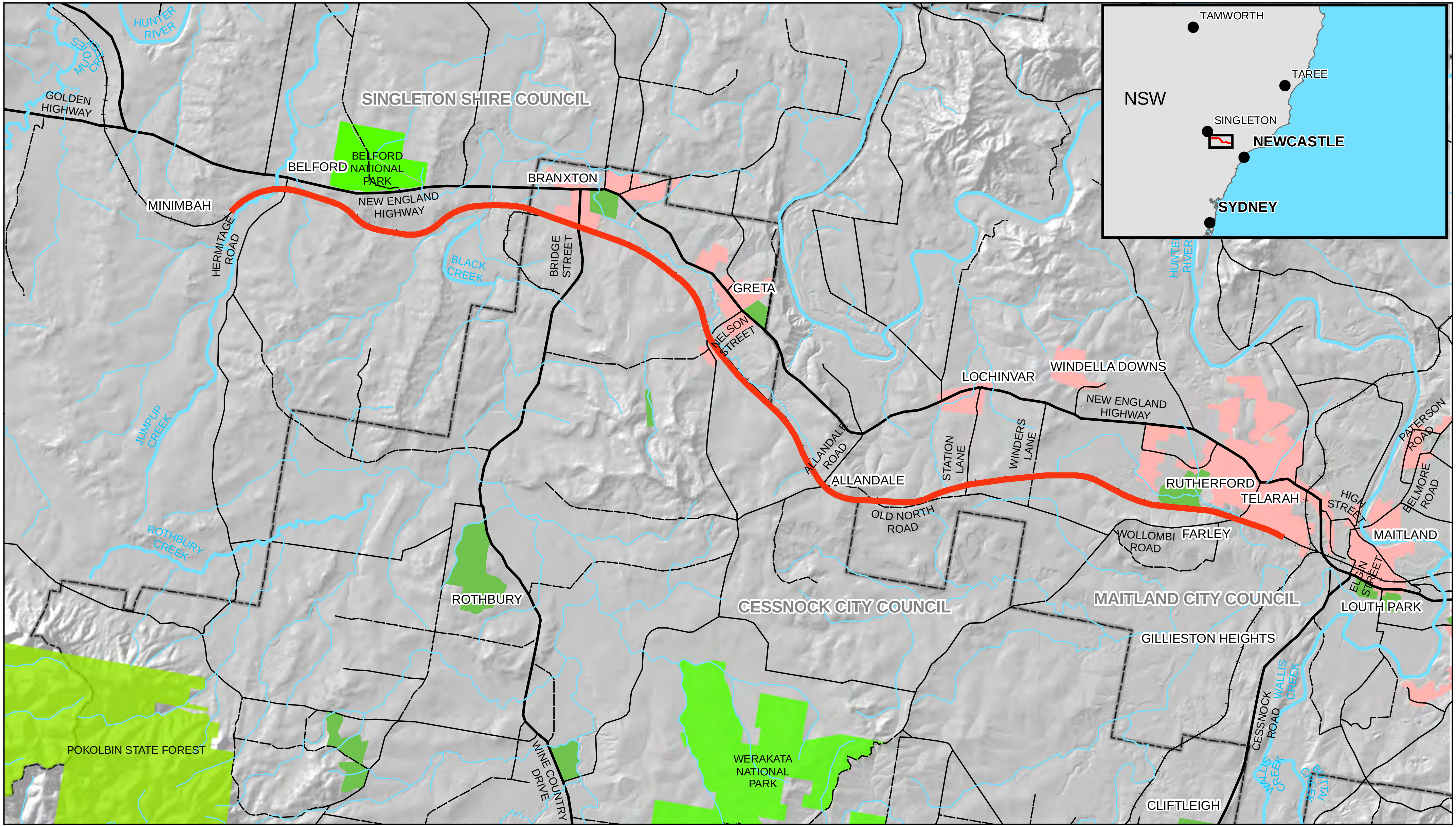
The investigation area for this Groundwater Study is a linear corridor which follows the route of the Main Northern Railway between chainages 194.500 kilometres and 224.200 kilometres and is shown in Figure 1.1.

The investigation corridor captures the footprint of disturbance for the third track and other associated works, including construction compounds, haul roads and spoil disposal areas.

1.4 Objectives and Purpose of this Report

The objectives of this Groundwater Study are to:

- Characterise existing groundwater conditions to establish a pre-development baseline.
- Assess the potential impact of construction and operation of the Project on Groundwater.
- Identify mitigation options and ongoing groundwater monitoring requirements.



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0 600 1,200 2,400 3,600 4,800

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Australian Geodetic Datum 1966
Grid: Integrated Survey Grid, Zone 56-1

N

LEGEND

- Project Location
- Railway
- Watercourse
- Highway
- Unsealed
- Main Road
- Minor Road
- Recreation Areas
- State Forest
- National Park
- Built Up Area
- LGA

Maitland To Minimbah Third Track
Environmental Assessment

Job Number	22-14471
Revision	A
Date	May 2010

Regional Location

Figure 1.1

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Data Source: GeoScience Australia: 250k Topo Data - Series 3. Created by: msmiljkovski, tmorton, fmackay

2. Existing Environment

2.1 Hydrology

The Project investigation corridor is within the Hunter-Central Rivers Catchment Management Authority (CMA) area where the Hunter River flows from west to east typically between around 2.5 and 6 km north of the alignment. Around East Maitland however the river is only around 1.5 km due east of the investigation corridor at its closest point. A number of tributaries and un-named drainage channels of the Hunter River intersect the investigation corridor and hence may be affected by the development. The main water courses that intersect or run close to the alignment of the corridor are shown in Figure 2.1 and include, from east to west:

- Telarah Lagoon and Wentworth Swamps.
- Swamp Creek.
- Stony Creek.
- Lochinvar Creek.
- Anvil Creek.
- Sawyers Creek.
- Black Creek.
- Jump Up Creek.

2.2 Hydrogeological Units

Digital mapped outcrop geology for the corridor alignment and surrounding area is shown in Figure 2.1. Two main geological hydrogeological units dominate the area:

- Quaternary-aged alluvial deposits (Qa).
- Permian-aged bedrock units including the Maitland Group, Greta Coal Measures and Dalwood Group.

Detailed descriptions of the geological units are presented in *Maitland to Minimbah Third Track: Geotechnical Desktop Study (Draft)* (Hunter 8 Alliance, 2009).

2.2.1 Alluvial Deposits

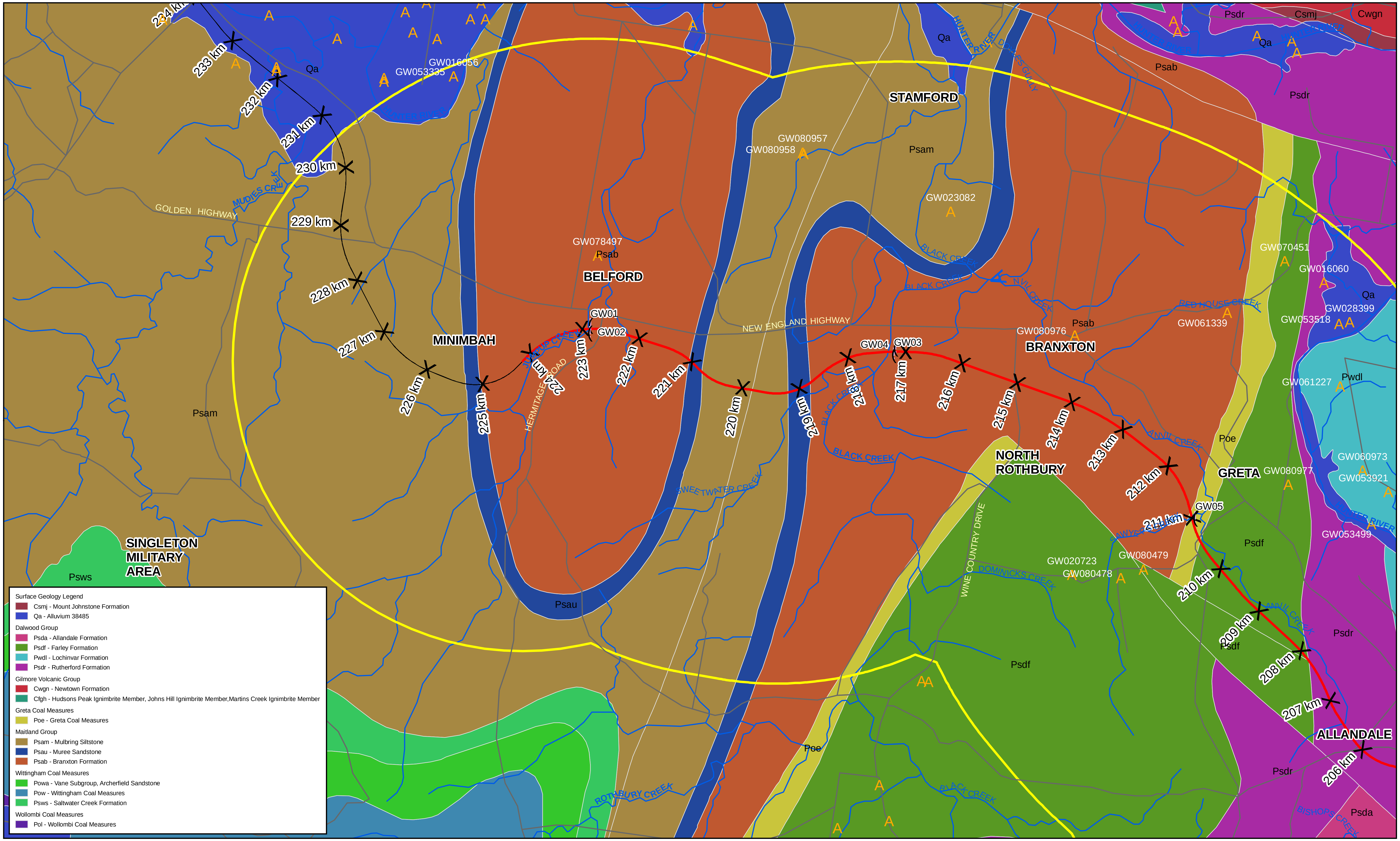
Water bearing alluvial deposits are likely to be located along many of the creeks and water courses however Quaternary-aged alluvial sediments (clay, silt, sand and gravel) are only mapped at outcrop locations over two short sections of the corridor alignment; one in the vicinity of Stony Creek and Swamp Creek at the east end (south side) of the Project site (see Figure 2.1) and the other in the vicinity of reaches of Black Creek to the west of Branxton (shown at 1-100 000 scale on the Newcastle Coalfield Regional Geology map). Geotechnical investigations for the Project have encountered alluvial deposits between 0.6 and 4 m thick at Jump Up Creek (clays, sands and gravels) (ARUP Geotechnics 13 August 2009) and up to 1 m thick in the vicinity of Stony Creek (at Wollombi Road) (gravel, clays and silts) (ARUP Geotechnics 16 August 2009). The permeability of the alluvial deposits is likely to vary spatially, depending on the presence or absence of significant sand and gravel horizons.

Beyond the east end of the investigation corridor the alluvial deposits are indicated to be at least 17 m thick and predominantly comprise sand and gravel, based on records for the licensed groundwater bores (DWE) in the area.

2.2.2 Bedrock

The published geology map (see Figure 2.1) shows that the bedrock along the length of the investigation corridor predominantly consist of sandstones, siltstones and conglomerates of the Permian-aged Maitland Group (Mulbring Siltstone, Muree Sandstone and Branxton Formation), Greta Coal Measures and Dalwood Group (Farley Formation, Rutherford Formation, Allandale Formation and Lochinvar Formation) and underlie the alluvial deposits (where present). The presence of licensed groundwater bores screened through bedrock and yield information from the DWE bore database (albeit limited), see Appendix A, indicate water bearing bedrock of typically low to moderate permeability. The mapped geology shows that the bedrock is regionally folded and faulted in the area surrounding the corridor therefore indicating the potential for fractured water bearing horizons as well as having a primary porosity (predominantly within the sandstone and conglomerate layers).

Abandoned coal mine workings in the Greta Coal Measures exist close to or beneath the alignment in two areas; one at Farley (approximate chainages 194.000 to 195.000 km) and the other at Greta (approximate chainages 211.000 to 213.000 km). The depth of the coal seam workings at Farley is not known and at Greta the mined depth has been reported to range between approximately 22 m and 128 m (Hunter 8 Alliance, 2009).



1:60,000 (at A3)

0 375 750 1,500 2,250 3,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Australian Geodetic Datum 1966
Grid: Integrated Survey Grid, Zone 56-1

LEGEND

- Project Location
- (Approximate Groundwater Monitoring Location
- A Licensed Groundwater Bore Locations
- 5km Buffer
- Watercourse

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Maitland to Minimbah Third Track
Groundwater Specialist Report

Job Number	22-14471
Revision	A
Date	May 2010

Groundwater Monitoring Network and Mapped Geology

Figure 2.1a

G:\22\14471\GIS\Maps\Deliverables\EA\Groundwater Specialist Report\Approx_Groundwater_Bores_20091006_2.1a.mxd

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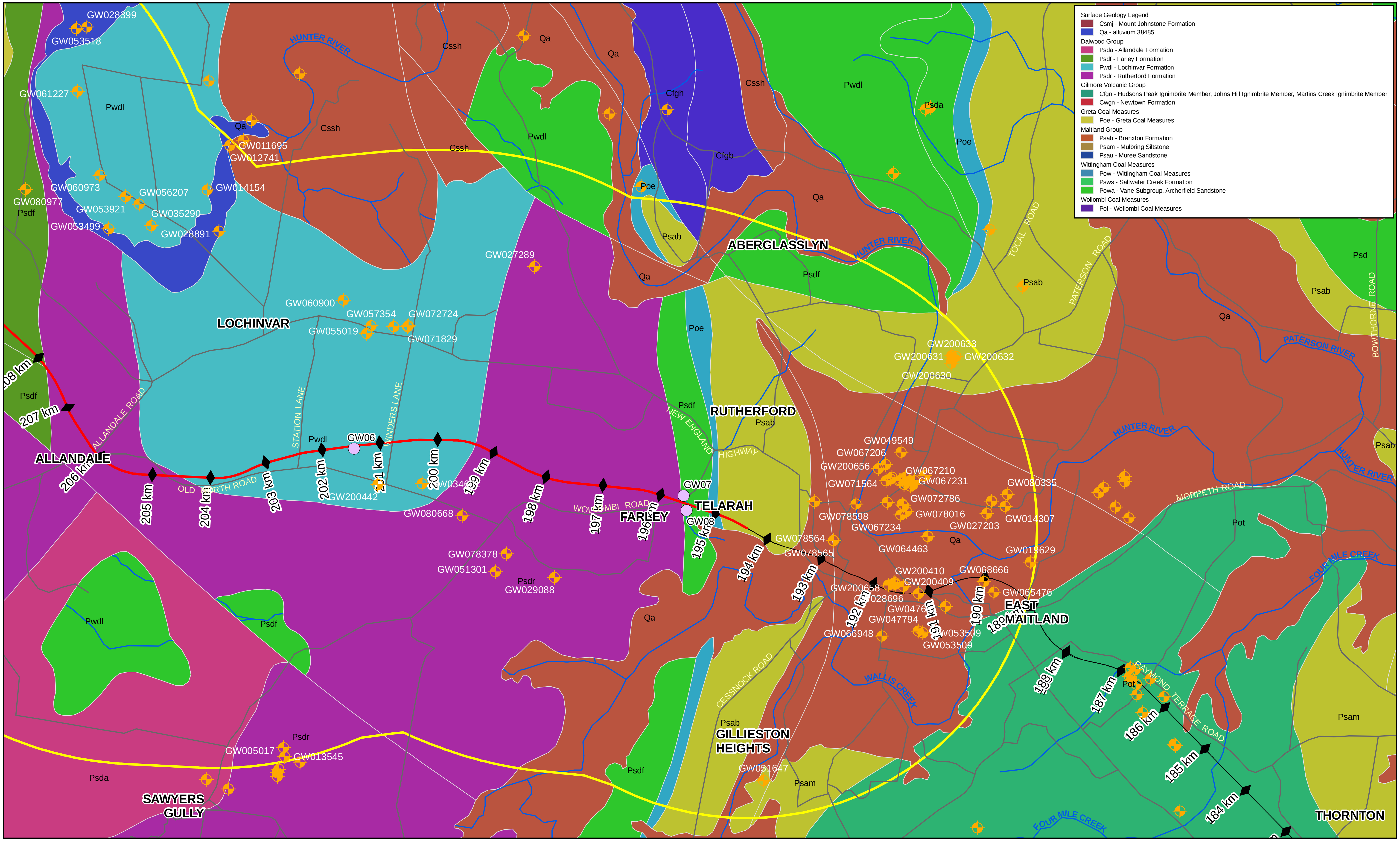
Data Source: Department of Water and Energy, NSW Government: Licensed Groundwater Bore - 2008. Created by: msmiljkovski



1:60,000 (at A3)

0 375 750 1,500 2,250 3,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Australian Geodetic Datum 1966
Grid: Integrated Survey Grid, Zone 56-1

N

LEGEND

- Project Location
- Approximate Groundwater Monitoring Location
- Licensed Groundwater Bore Locations
- 5km Buffer
- Watercourse

Maitland to Minimbah Third Track
Groundwater Specialist Report

Job Number	22-14471
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Groundwater Monitoring Network and Mapped Geology

Figure 2.1b

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Data Source: Department of Water and Energy, NSW Government: Licensed Groundwater Bore - 2008. Created by: msmiljkovski

2.3 Groundwater Recharge, Levels and Flows

The alluvial deposits will be recharged at outcrop via direct infiltration of precipitation or from infiltration of surface water following rainfall when surface water levels are higher than groundwater. Bedrock will be recharged via direct infiltration at outcrop and potentially also via infiltration from overlying alluvial deposits, where present.

Groundwater is expected to be relatively close to ground surface in the vicinity of the floodplains of the main drainage paths of Swamp Creek/Wentworth Swamp, Stony Creek, Anvil Creek, Jump Up Creek and Black Creek. At Jump Up Creek, geotechnical investigations for the Project encountered groundwater at 3.2 metres depth at 222.838BH1 and at 1.3 metres depth at 220.880BH1 (Arup Geotechnics 13 August 2009) and historic records for licensed bore GW 080976 within 200 m east of Anvil Creek reported a static water level of 3.6 metres below ground level. In addition, recent geotechnical investigations have identified soils between chainages 193 kilometres and 197.5 kilometres as having localised seasonal water-logging which is likely to be an indication of near surface groundwater in this area (Hunter 8 Alliance, 2009).

Spot groundwater level data within a 5 kilometres radius of the investigation corridor, obtained from the DWE database, is limited to 8 locations. The reported depths to groundwater (static water level, or SWL) for these locations range from 2 to 14 metres below ground level, with the exception of one location where groundwater was recorded at 54 metres depth. There are currently insufficient groundwater level data to confirm seasonal variations in groundwater levels or to interpret groundwater flow directions, however given the proximity of the site to the Hunter River regional groundwater flow is likely to be to the north and north east towards the Hunter River.

At a more localised scale groundwater flow within the shallow alluvial deposits and bedrock is likely to follow the fall in topography and therefore local flow directions are likely to vary along the length of the alignment. For example, in the vicinity of Jump Up Creek and Black Creek shallow groundwater flow is expected to be to the north towards the Hunter River and in the vicinity of Anvil Creek is expected to be towards the west and north west. At the eastern extent of the Project site, shallow groundwater flow is expected to be similar to the expected regional flow direction i.e. towards the north east and the Hunter River.

Baseline groundwater monitoring is to be undertaken prior to the commencement of construction that would include measurement of groundwater levels.

2.4 Groundwater Quality

Groundwater quality data for the licensed groundwater bores identified with 5 kilometres of the investigation corridor are summarised in Appendix A. These data indicate typically fresh groundwater beyond the eastern end of the corridor within the Quaternary-age alluvial deposits (which include sands and gravels), with recorded salinity ranging from 0 to 500 ppm (DWE 2009). Elsewhere recorded groundwater salinity indicates typically brackish to saline groundwater, with measured salinity typically ranging from 501 to 7,000 ppm in both unconsolidated material (sand, gravel, silt and clay) and in bedrock (sandstone, shale and andesite), with groundwater at one location approximately 2.7 kilometres north of the corridor, recorded in the range 7,001 to 10,000 ppm (GW 061339).

As discussed in Section 2.3, baseline groundwater monitoring is to be undertaken prior to the commencement of construction that would include sampling and analysis of groundwater for a range of key parameters.

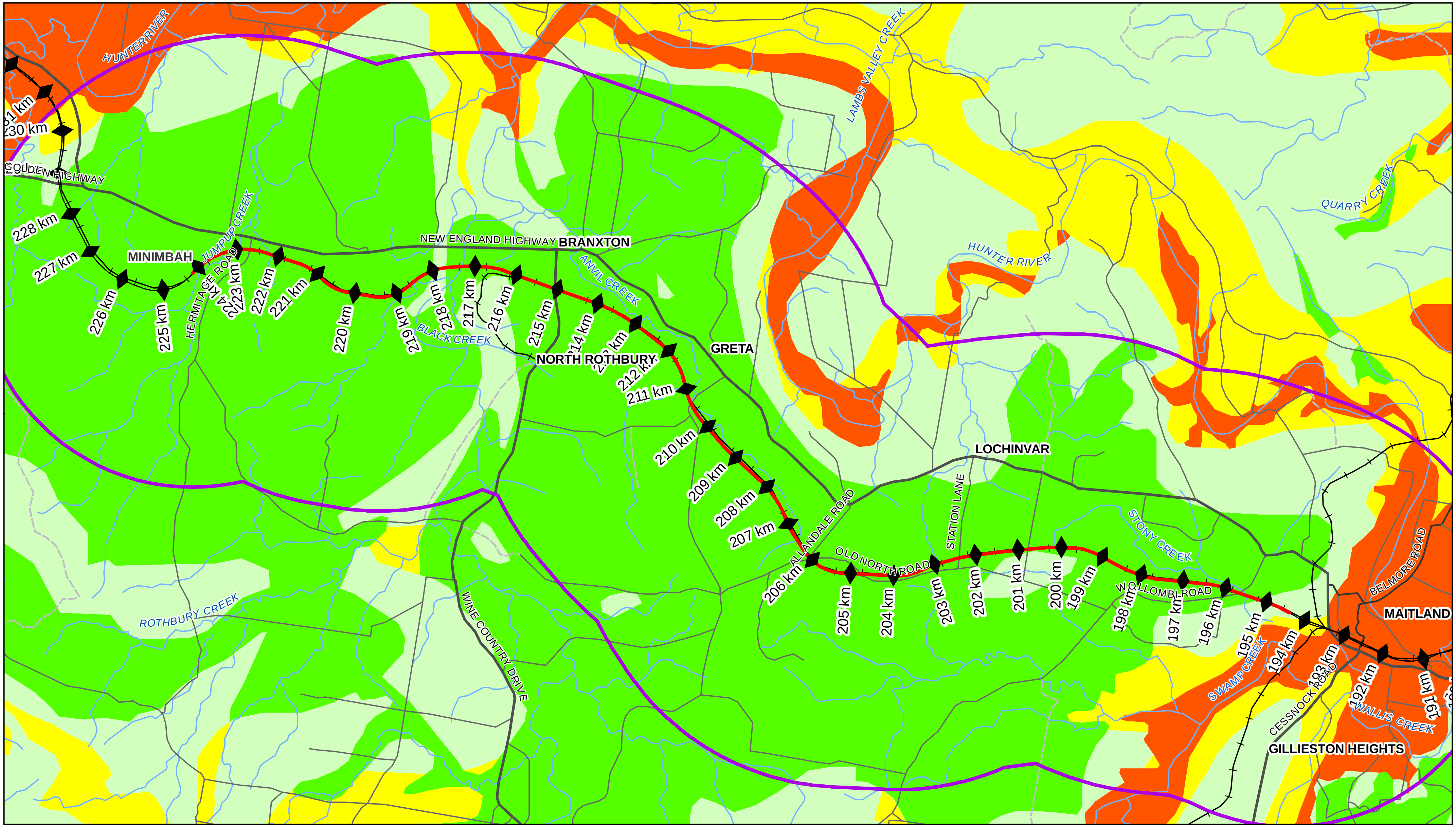
2.5 Aquifer Properties

Published yield information for the licensed bores identified within the 5 kilometres search area is limited to 8 locations, where records indicate permeability in bedrock is typically low to medium with reported yields ranging from 0.1 L/s (GW 200442 in conglomerate) to 3 L/s (GW 200658 in sandstone).

The baseline groundwater monitoring would include permeability testing.

2.6 Groundwater Vulnerability Mapping

Groundwater vulnerability mapping for the region (NSW Government 2009), shown in Figure 2.2, indicates low groundwater vulnerability for the majority of the Project alignment and surrounding area. Mapped low-moderate vulnerability intersects the Project alignment at Black Creek, is identified to the north and south of the alignment in the vicinity of Branxton and to the south of the alignment between Farley and Lochinvar. Mapped moderate and high groundwater vulnerability areas abut the east end of the alignment, including the vicinity of Stony Creek and Swamp Creek to the south and the Hunter River to the east and north.



1:120,000(at A4)

0 475 950 1,900 2,850 3,800

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Australian Geodetic Datum 1966
Grid: Integrated Survey Grid, Zone 56-1

N

LEGEND

- Principal Road
- Secondary Road
- Minor Road
- Track
- Existing Rail
- Water Course
- 5km Buffer
- Project Location

Groundwater Vulnerability

- High
- Moderate
- Low Moderate
- Low

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Maitland To Minimbah Third Track
Groundwater Specialist Report

Job Number	22-14471
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Date	MAY 2010

Mapped
Groundwater Vulnerability

Figure 2.2

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Data Source: Geoscience Australia: Topography - 2003; NR ATLAS: Groundwater Vulnerability Mapping - 2009. Created by: fmackay, msmiljkovski

2.7 Potential Receptors

Potential receptors are aspects of the existing hydrogeological environment that have the potential to be impacted by the Project and are discussed in the following sections.

2.7.1 Groundwater Dependent Ecosystems

Groundwater Dependent Ecosystem (GDE) mapping is not included in the on-line Natural Resources Atlas (New South Wales Government). The 4 GDE categories defined in the *NSW State Groundwater Dependent Ecosystem Policy* (Department of Land and Water Conservation 2002) are 'terrestrial vegetation', 'base flows in streams', 'wetlands' and 'aquifer and cave ecosystems'. The desktop review indicates the presence of the GDE categories of 'terrestrial vegetation', 'base flows in streams' and 'wetlands' within or in the near vicinity of the investigation corridor.

No Ramsar Wetlands or Directory of Important Wetlands have been identified within the investigation corridor or in the near vicinity of the Project alignment however Wentworth Swamp is located on the lower reaches of Stony Creek on the south side of the alignment and is likely to have some dependency on shallow groundwater. Although there are no data to quantify the degree of dependency of 'base flows in streams' and 'terrestrial vegetation' on groundwater it is likely there is some degree of interaction between groundwater and surface water, based on the desktop review. It is likely that groundwater provides some base flow to reaches of creeks in the vicinity of the Project alignment and creeks that intersect the alignment (and in particular the main creeks of Jump Up Creek, Black Creek and Stony Creek). Shallow groundwater is also potentially be used by some types of vegetation where groundwater is relatively close to ground surface such as in the vicinity of the creeks.

2.7.2 Licensed Groundwater Bores

The 98 licensed groundwater bores identified from the DWE database as part of the desktop study within a 5 kilometres radius of the Project alignment are shown in Figure 2.3, prefixed with GW. Selected information (including drilled depth, historic water quality data, interpreted screened lithology and historic static water level) for these bores is summarised in Appendix A. Fourteen out of the 98 licensed bores have not been considered as potential receptors as the recorded work status identifies the bores either as:

- Abandoned (four licenses; GW080957, GW080977, GW080478, and GW055019).
- Collapsed (three licenses; GW053499, GW053921 and GW061339).
- Water level observation bores (six licenses; (GW080958, GW080976, GW022693, GW022693, GW057354 and GW060900).
- A test hole (GW068666).

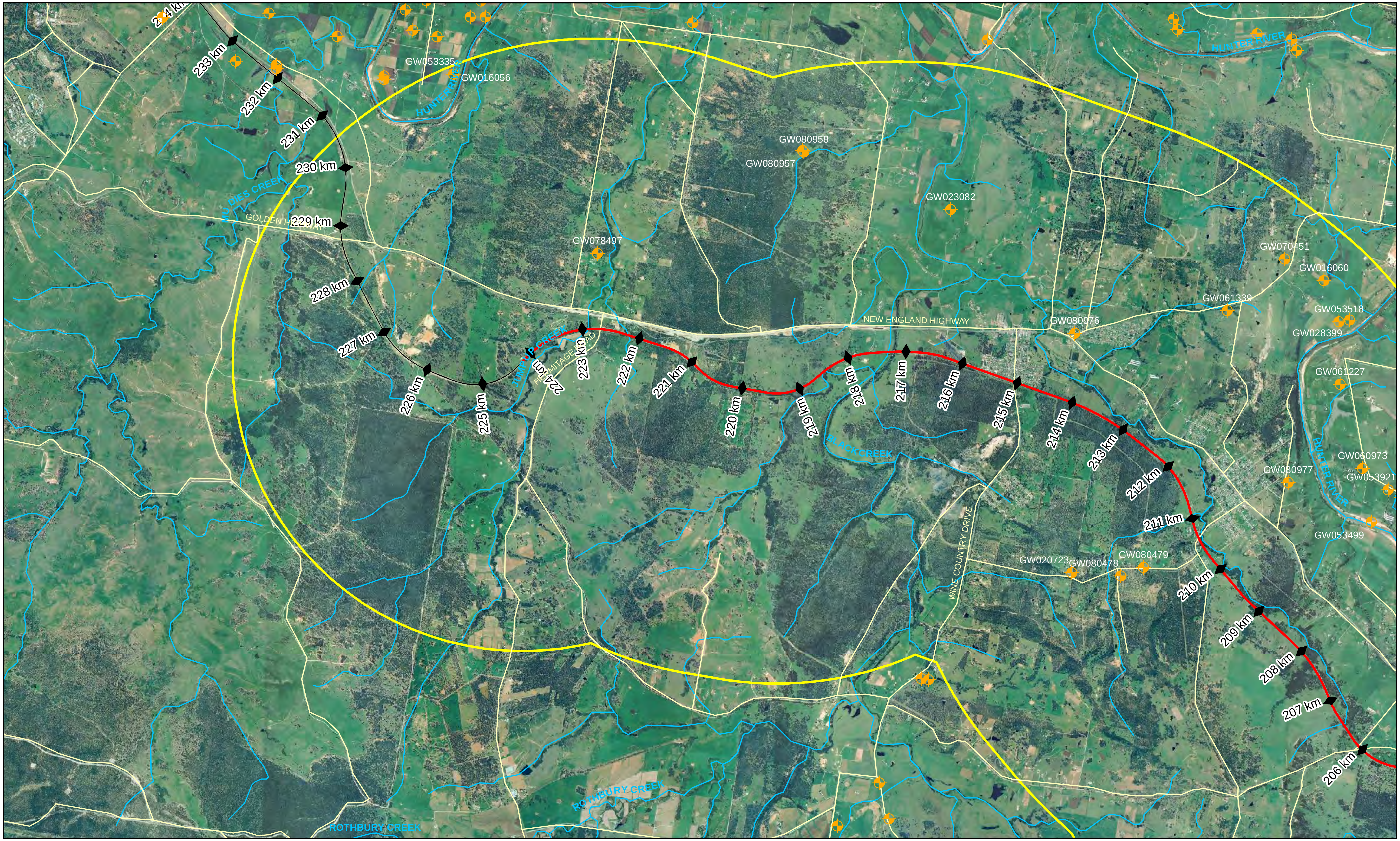
Interpretation of the bore database records for the identified licences in conjunction with the digital mapped geology (see Figure 2.1) indicates that existing licensed groundwater bores to the east and north east of the eastern end of the Project alignment, in the vicinity of the Hunter River, typically penetrate alluvial deposits (predominantly sand and gravel). The majority of the licensed groundwater bores distributed along the length of the Project alignment to the north and south are indicated to penetrate bedrock (including sandstone, tuff, andesite and conglomerate).

No licensed groundwater bores have been identified within the investigation corridor. The closest licensed groundwater bores to the Project alignment that are located within the potential flow path of groundwater that passes through the Project alignment (down gradient) and hence identified as potential receptors are:

- Licensed groundwater bores GW 200442, GW 034601, GW 080668, GW 078378, GW 051301 and GW 029088. These bores are located down topographic slope and hence down assumed gradient (south) of the Project alignment between chainages 201 and 197. Licensed bores GW 200442 (authorised for domestic and stock use, screened in conglomerate) and GW 034601 (authorised for domestic, farming and stock use, screened in gravel/shale) are located closest to the alignment, approximately 700 m to the south. These two groundwater bores are located within an area of low to moderate mapped groundwater vulnerability, which extends to within around 50 m of the Project alignment. Licensed groundwater bores GW 080668 (domestic, stock), GW 078378 (stock), GW 051301 (farming, stock) and GW 029088 (irrigation, stock) are located between 1.2 and 1.8 kilometres south of the alignment.
- Licensed groundwater bore GW 078497. This bore is located in the valley of Jump Up Creek approximately 1.3 kilometres down assumed gradient of the Project alignment and approximately 230 metres west of Jump Up Creek. DWE records indicate that the licensed purpose is for domestic and stock use and that the screened part of the bore penetrates shale to 18 metres below ground surface.

2.7.3 Shallow Groundwater

Shallow groundwater beneath the investigation corridor and down assumed gradient of the Project alignment within alluvial deposits (clay, sand and gravel) and bedrock, particularly in the vicinity of the main creeks including Jump Up Creek, Black Creek, Anvil Creek, Stony Creek and Sawyers Creek is also considered a potential receptor.



1:60,000 (at A3)

0 290 580 1,160 1,740 2,320

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Australian Geodetic Datum 1966
Grid: Integrated Survey Grid, Zone 56-1

N

LEGEND

- Licensed Groundwater Bore Locations
- Project Location
- 5km Buffer
- Watercourse

Hunt8r ALLIANCE

Maitland to Minimbah Third Track
Groundwater Specialist Report

Job Number 22-1447
Revision A
Date MAY 2010

Licensed Groundwater Bores

Figure 2.3a

G:\22\14471\GIS\Maps\Deliverables\EA\Groundwater Specialist Report\Licensed_Groundwater_Bores_20091006_2.4a.mxd

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 T 61 2 4979 9999 F 61 2 4979 9988 E ntlmail@ghd.com.au W www.ghd.com.au

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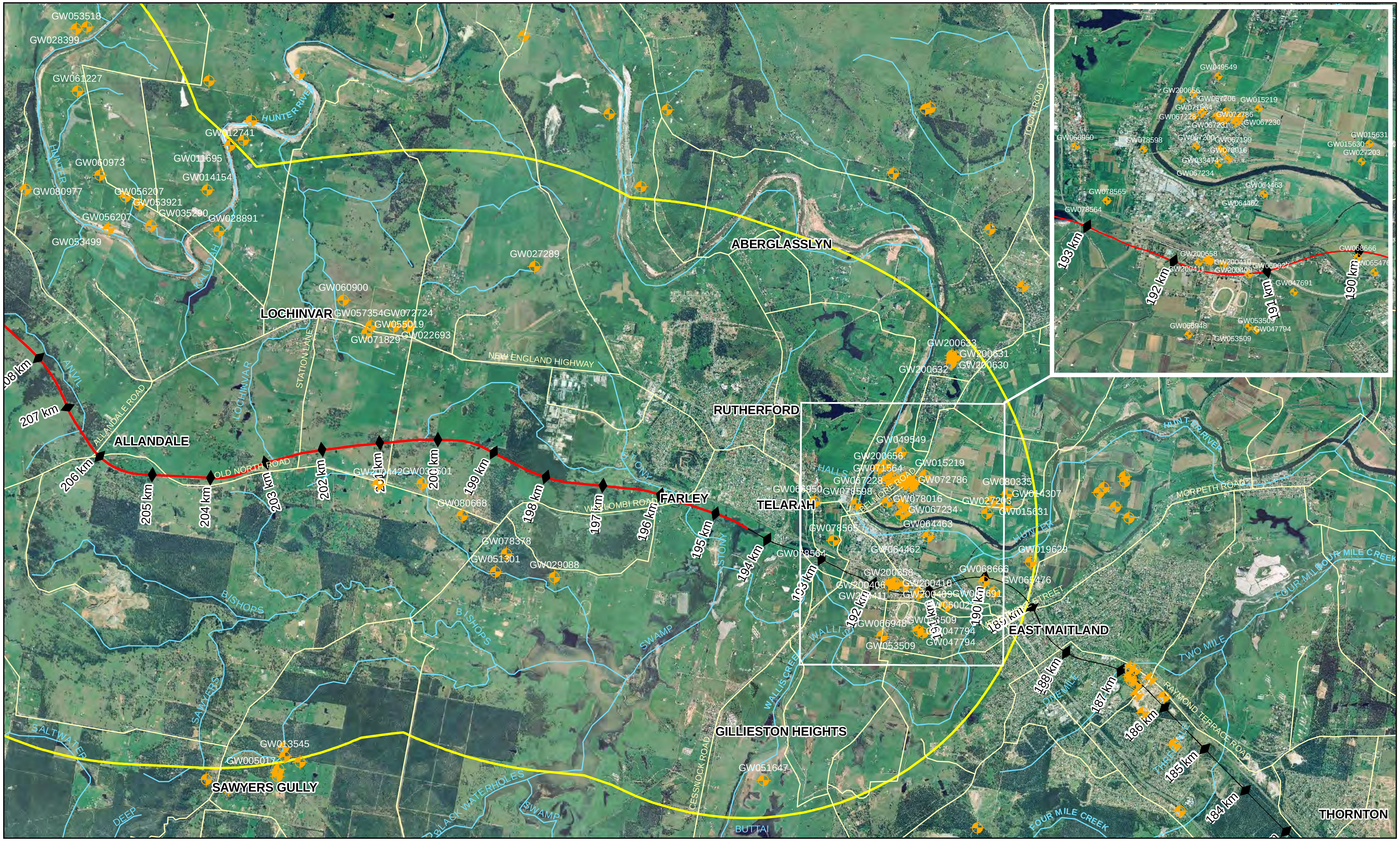
Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by: msmiljkovski



1:60,000 (at A3)

0 290 580 1,160 1,740 2,320

Metres

Geographic Coordinate System
Horizontal Datum: Geocentric Datum of Australia 1994

N

LEGEND

- Licensed Groundwater Bore Locations
- Project Location
- 5km Buffer
- Watercourse

Hunt8r ALLIANCE

Maitland to Minimbah Third Track
Groundwater Specialist Report

Job Number	22-14471
Revision	A
Date	MAY 2010

Licensed Groundwater Bores

Figure 2.3b

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Data Source: Department of Water and Energy, NSW Government: Licensed Groundwater Bore - 2008. Created by: msmiljkovski

3. Legislation

The following legislation and policy documents are applicable to the Groundwater Study of the Project:

- *Water Act* 1912. Approvals / licence requirements for the drilling and installation of groundwater monitoring bores fall under this act.
- *Water Management Act* 2000. This legislation provides the basis for the sustainable management of water (groundwater and surface water) through water sharing plans and includes the protection and restoration of water quality.
- *Protection of the Environment and Operations Act* 1997. This act identifies requirements for compliance with regards to the protection of water quality.
- *NSW Groundwater Policy Framework Document.* This framework focuses on the protection and management of groundwater and on ecosystems from which groundwaters are recharged or into which groundwaters discharge through the following policy documents:
  - NSW Groundwater Quality Protection Policy.
  - (Draft) NSW Groundwater Quantity Management Policy.
  - NSW Groundwater Dependant Ecosystem Policy.
- *National Water Quality Management Strategy, Guidelines for Groundwater Protection in Australia* (ARMCANZ & ANZECC 1995). These guidelines provide a framework for protecting groundwater from contamination in Australia.

4. Impact Assessment

4.1 Environmental Risk Assessment

A detailed Environmental Risk and Impact Assessment (Risk Assessment) has been conducted as part of the Environmental Assessment process to evaluate the potential impacts that the Project could have on a wide range of environmental, social and economic assets and beneficial uses, which has contributed to help form the conclusions of this study.

In summary:

- The Risk Assessment was conducted to identify the potential environmental, social and economic impacts on the wider environment and community of implementing the Project.
- Heighten confidence and provide rigour for decision making and planning.
- The Risk Assessment was based on the Description of the Project included in the Environmental Assessment and the outputs of the risk assessment represent the risk and impacts of implementing the Project as described in the Description of the Project.
- The Risk Assessment was conducted in close consultation with all of the technical specialists and is based on input provided by those technical specialists. All of the Risk Assessment inputs including consequence and likelihood ratings were provided by the technical specialists.
- Incorporates the outputs of the Community Consultation which occurred as part of the Environmental Assessment, although separate to the risk assessment process. The values and outcomes of the community consultation were incorporated to inform the risk assessment process.
- The Risk Assessment approach used a multi-disciplinary group of technical specialists to assess the consequence and likelihood of the identified risks. To assess risks consistently, consequence tables were developed that clearly define levels of consequence, from insignificant to catastrophic, in terms of magnitude, space and time. Consequence, having regard to ‘reasonable worst- case scenarios’ (considering activity controls), and the likelihood of that consequence occurring are defined for all identified risks and impacts, allowing risks to be ranked.

  The consequence table relevant to this study and the likelihood descriptions are provided in Appendix B. The consequence tables used for estimating diverse consequence types on an even basis were developed specifically for the Project based on consultation and advice from the technical specialists. The likelihood table was developed to incorporate the scoping requirements concept of predicted and potential risks and impacts. The scale ranges from rare to almost certain.
- The risk ranking was calculated via the risk matrix, considering both consequence and likelihood allocations.

  The risk matrix and the risk outputs relevant to this report are both presented in Appendix B.

No potential impacts have been identified as posing an extreme, high or medium risk in the Risk Assessment for Groundwater, however a number of potential impacts have been identified and are discussed in Section 4.2.

4.2 Potential Impacts

A desktop review has been conducted to develop an understanding of the existing hydrogeological conditions in the vicinity of the project site, to identify potential receptors and potential impacts of the Project and to assist in the development of a groundwater monitoring network. The following have been used in the preparation of the desktop review:

- Published digital geological mapping at 1:250 000.
- Groundwater vulnerability mapping (NSW Natural Resources Atlas).
- Licensed groundwater bores database (DWE).
- Various geotechnical reports prepared for the Project.

A search of licensed groundwater bore database records, provided by DWE, identified 98 licensed groundwater bores (based on the Work Number) within a 5 kilometres radius of the development corridor, shown in Figure 2.3. Database records provided by DWE include bore construction, water bore zones, drillers log descriptions, water levels and bore work details. The authorised purpose of the licence (i.e. stockwatering, irrigation, domestic water supply etc.) is included on the work summary forms, also provided by DWE. Interrogation of the DWE database has been used to provide information on baseline hydrogeological conditions in the vicinity of the project site.

No significant impacts on groundwater resources and/or groundwater quality are anticipated based on the current design of the Project, which includes modifications to existing infrastructure and construction of new infrastructure (including culverts, cuttings, embankments and bridges) and only includes short term, localised dewatering for construction purposes at Wollombi Road. The use of groundwater as a resource for construction of the Project has not been considered as part of this study therefore any potential impacts in relation to this have not been considered here.

Justification for no significant impact is detailed in the following points:

- No significant / long term lowering of groundwater levels is anticipated given that no major dewatering is proposed. No significant impact on the supply of groundwater to GDEs is therefore anticipated.
- Provided that any additional culvert and other obstructions are adequately sized such that they do not constrict surface water or shallow groundwater flow no significant increases in groundwater levels are anticipated as a result.
- The majority of the investigation corridor and surrounding area is mapped as low groundwater vulnerability and therefore typically has a low potential for impact on groundwater resources as a result of the Project.

- No licensed groundwater bores are located within the Project investigation corridor. The seven licensed bores identified as potential receptors are located between 700 metres and 1.8 kilometres from the Project alignment, hence given that no dewatering is planned up-gradient of these boreholes and that the rate of abstraction from these bores is likely to be low given their authorised purpose the potential for any significant impact is considered to be limited.

Nevertheless, potential groundwater impacts during construction and/or post construction are outlined in Section 4.2.1 and Section 4.2.2 below. Proposed groundwater monitoring and mitigation measures to confirm no significant impact for the Project are summarised in Section 5.

4.2.1 Potential Impacts, Construction

The following potential impacts on groundwater have been identified for the construction phase:

Groundwater Levels

- Potential for localised water logging, as a result of groundwater level increases during the construction of any embankments, where pre-construction groundwater levels are relatively close to the ground surface i.e. in the vicinity of the main creeks.
- Potential for a localised, temporary reduction in shallow groundwater levels in the vicinity of Stony Creek at the intersection with Wollombi Road as a result of temporary dewatering as part of bridge pile construction works. The dewatering is unlikely to have any significant long term impact given the proposed short duration (a matter of a few weeks) and localised nature of the dewatering.

Groundwater Quality

- Potential for localised degradation of groundwater quality within alluvial deposits or bedrock that intersect, lie directly beneath or down gradient of the Project alignment if any accidental leaks or spills occur during construction. Licensed groundwater bores are unlikely to be impacted from construction given that the distance to the nearest licensed groundwater bores (GW 200442 and GW 034601) are more than 700 m from the rail corridor. The longevity of any impact would depend on the nature and extent of the leak or spill.

4.2.2 Potential Impacts, Operation

The following potential impacts on groundwater have been identified for the operational phase:

Groundwater Quality

- Potential for the localised degradation of groundwater quality within the alluvial deposits and bedrock that intersect the Project alignment and down gradient, from the application of additional herbicides within the rail corridor.

Groundwater Levels

No potential impacts on groundwater levels have been identified for the operational phase of the Project.

5. Mitigation Measures

Whilst no significant impacts on groundwater resources and/or groundwater quality are anticipated, this assessment is based on adoption of the mitigation strategies outlined below, which are also identified in the Environmental Risk Assessment (Appendix B). Pre and post construction monitoring of groundwater levels and groundwater quality is also required to provide a more extensive baseline data set than is currently available and to confirm the impacts of the proposed Project.

5.1 Pre-Construction

Baseline groundwater monitoring of shallow groundwater at approximately monthly intervals would be undertaken prior to the commencement of construction during the available pre-construction period. A monitoring program would continue during the construction phase (refer to Section 5.2). In anticipation of this, seven groundwater monitoring boreholes have been drilled and installed between chainages 223.00 kilometres (Jump Up Creek) and 195.00 kilometres for monitoring shallow groundwater. A Hydrapower Scout (a combination of auger and air-hammer methods of drilling) was used to advance the bores.

Each bore was installed with 50 millimetres diameter PVC casing and screen and fitted with a lockable monument cover. The bore annulus of the screened interval was filled with washed 1 to 3 millimetres filter pack, sealed with a bentonite plug and grouted to surface with a cement-bentonite grout. The annulus between the monument and PVC casing was backfilled with filter pack material to minimise the risk of fire damage to the casing. The bores were drilled, logged and developed under the supervision of a qualified GHD geologist and all fieldwork was carried out in accordance with the Australian Standards Site Investigation Code AS1726.

Following a stabilisation period of >48 hours after installation each bore was developed by airlifting for approximately 1 hour until the returning water contained no visible or very little fines.

Baseline monitoring would comprise measuring groundwater levels and collecting groundwater samples for quality analysis. Groundwater levels in each bore would be measured using a dip meter prior to the start of sampling. Bores would be purged dry or until three to five casing volumes had been removed and pH, EC, temperature, DO and redox potential had stabilised prior to obtaining groundwater samples. Field instruments would be calibrated prior to use, washed with clean water before use and cleaned between monitoring bores.

Samples would be collected using a bailer or waterra tubing fitted with a footvalve, filtered to <0.45 μm (dissolved metals sample only), placed in laboratory-supplied containers with preservatives appropriate for the required analyses and stored on ice for transport to the laboratory. Laboratory analysis would be submitted under chain of custody (CoC) documentation to NATA accredited Australian Laboratory Services (ALS), Brisbane.

The baseline groundwater monitoring would include analysis of the parameters listed in Table 5-1 and be conducted at approximately monthly intervals prior to the start of construction.

Table 5-1 Suggested Analytes for Groundwater Monitoring

	Parameters Analysed/Measured
***Field Parameters* (measured prior to sampling)**	Total dissolved solids (TDS), dissolved oxygen (DO), electrical conductivity (EC), pH, temperature, redox potential.
Laboratory Analysis	TDS, pH.
	Dissolved metals: Aluminium, arsenic, beryllium, barium, cadmium, chromium, cobalt, copper, lead, iron, manganese, mercury, molybdenum, nickel, selenium, vanadium, zinc.
	Nutrients: Ammonia as N, total phosphorous as P, nitrite as N, nitrate as N, total oxidised nitrogen.
	Major and minor ions: Calcium, magnesium, sodium, potassium, chloride, sulfate, alkalinity (carbonate and bi-carbonate), fluoride and silica.
	Phenols, PAHs (polycyclic aromatic hydrocarbons), BTEX (benzene, toluene, xylene, ethylbenzene), TPH (total petroleum hydrocarbons).
	Herbicides.

5.2 Construction

The following measures are proposed to monitor and mitigate the potential impacts identified in Section 4.2.1 for the construction phase:

- Monthly groundwater monitoring (levels and quality) of the seven monitoring bores prior to the start of construction (see Section 5.1), conducted to establish baseline groundwater conditions adjacent to the Project alignment, would be used to confirm groundwater quality and level action criteria against which to monitor conditions during construction. This program should be agreed with the relevant authorities prior to commencement.
- Develop and implement a groundwater monitoring program using the locations and parameters from the baseline groundwater monitoring to monitor groundwater levels and quality of shallow groundwater, to confirm any groundwater impacts during the construction phase. This program should be agreed with the relevant authorities prior to commencement.
- Groundwater monitoring should be conducted by a suitably qualified and experienced professional in accordance with the AS/NZS 5667.11:1998 *Australian/New Zealand Standard. Water quality – Sampling. Part 11: Guidance on sampling of groundwaters.*
- Regular assessment of groundwater monitoring results against baseline groundwater conditions during construction and review of monitoring program if necessary.

- If impacts on groundwater levels or quality are identified an assessment of further potential mitigation measures would be conducted.
- Storage areas for vehicles, machinery, equipment, chemicals and other potentially hazardous or polluting materials during construction should have appropriate facilities to contain spills, leaks and surface water runoff to reduce the potential for contamination of groundwater through infiltration.
- A response plan to deal with accidental spills and leaks would be included as part of the EMP.

5.3 Operation

The following measures are proposed to monitor and mitigate the potential impacts identified in Section 4.2.2 for the operation phase:

- Develop and implement a groundwater monitoring program to monitor groundwater levels and quality in shallow groundwater adjacent to the Project alignment to confirm any groundwater impacts twelve months after the completion of construction, subject to the identification and assessment of any impacts.

6. Conclusions

The hydrogeological units identified beneath and in the near vicinity of the Project alignment are:

- Variable permeability, relatively thin (probably <7 metres thick) water bearing alluvial deposits (clays, silts, sands and gravels) of Quaternary-age, indicated to be confined to the vicinity of the main creeks that intersect and pass alongside the alignment and mapped at outcrop beyond the east end of the Project alignment to the south, east and north.
- Overlying typically low to moderate permeability water bearing bedrock (predominantly sandstones, siltstones and conglomerates) of Permian-age.

The regional (deep) groundwater flow direction is likely to be to the north and north east, towards the Hunter River, however shallow groundwater flow in alluvial deposits and bedrock is likely to follow the fall in topography and hence flow towards the main creeks. A proportion of shallow groundwater (from alluvial deposits and/or bedrock) is likely to discharge to surface water.

Groundwater to the west, north and south of the Project alignment is indicated to be brackish to saline with recorded salinity typically in the range of 501 to 7,000 ppm. Fresh groundwater is indicated beyond the east of the Project alignment within the Quaternary-age alluvial deposits (which include sands and gravels) with recorded salinity typically in the range 0 to 500 ppm.

DWE database records indicate that no licensed groundwater bores are located within the assessment corridor and that the two nearest bores are located 700 m to the south (GW 200442 authorised for domestic and stock and GW 034601 authorised for domestic, farming and stock). No licensed bores are likely to be significantly impacted by the Project.

Potential impacts on groundwater resources/quality have been identified for the Project however they are not anticipated to be significant. In summary, the potential impacts identified are:

- Construction - Potential for a localised, temporary reduction in shallow groundwater levels in the vicinity of Stony Creek at the intersection with Wollombi Road as a result of dewatering.
- Construction - Potential for localised and temporary soil water logging as a result of embankment construction where existing groundwater levels are within 1 metre of ground surface.
- Construction - Potential for localised degradation of groundwater quality in alluvial deposits and/ or bedrock as a result of accidental leaks and spills.
- Operation - Potential for localised degradation of groundwater quality in alluvial deposits and/ or bedrock that intersect the Project alignment and down gradient, from the application of additional herbicides within the rail corridor.

Proposed activities to monitor and mitigate the potential impacts for groundwater identified for the Project have been outlined for pre-construction, construction and operational stages.

7. References

ARUP Geotechnics 2009. Technical Note, *Wollombi Road Up and Down Option (195.600km) – Preliminary Geotechnical Advice*. 16 August 2009.

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New South Wales Government, Department of Water and Energy (DWE) 2009. Groundwater Database Extract. Accessed July 2009.

Appendix A

Summary of Selected Data for Licensed Groundwater Bores within 5 kilometres of the Project Alignment

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Appendix A: Summary of Selected Data for Licensed Groundwater Bores within 5km of the Project Site

Work No.	Licence	Work Status	Easting	Northing	Drilled Depth (m)	Interpreted Screened Lithology	Comment on Interpretation	Salinity Summary	Yield (L/s)	Yield Description	SWL (m below reference point)
GW005017	20BL008819	Supply Obtained	354614	6373412	7	No data		No Data			
GW011695	20BL004555	(Unknown)	353498	6383777	0	No data		No Data			
GW012741	20BL005716	(Unknown)	353498	6383777	14	Alluvium		No Data			
GW012935	20BL005829	(Unknown)	366734	6377895	10	Gravel		Fresh			
GW012936	20BL005830	(Unknown)	366734	6377895	10	Gravel		Fresh			
GW012937	20BL005831	(Unknown)	366734	6377895	10	Gravel		Fresh			
GW012938	20BL005828	(Unknown)	366734	6377895	9	Gravel		Fresh			
GW013545	20BL008830	(Unknown)	354642	6373258	8	No data		Brackish			
GW014154	20BL007650	(Unknown)	353119	6383001	12	Silt		Fresh			
GW014307	20BL007107	(Unknown)	366969	6377806	9	Sand		No Data			
GW014308	20BL006245	(Unknown)	365401	6378216	10	Sand		No Data			
GW015219	20BL006117	(Unknown)	365582	6378311	9	Gravel		Fresh			
GW015630	20BL006395	(Unknown)	366734	6377895	10	Gravel		No Data			
GW015631	20BL006394	(Unknown)	366734	6377895	9	Gravel		No Data			
GW016056	20BL010857	(Unknown)	335475	6389718	13	Gravel	Geology at base of hole	No Data			
GW016060	20BL007939	(Unknown)	350540	6386444	0	No data		1001-3000 ppm			
GW019629	20BL013130	Supply Obtained	367424	6376857	0	No data		No Data			
GW020723	20BL013404	(Unknown)	346293	6381327	55	Sandstone	Geology at base of hole	Fresh			
GW022693	20BL015545	SWL Man obs - 6 to 12 mths	356377	6380704	0	No data		Fresh			8.21
GW023082	20BL015794	(Unknown)	344086	6387546	6	Gravel	Geology at base of hole	3001-7000 ppm			
GW027203	20BL019987	Supply Obtained	366658	6377678	9	Sand		No Data			
GW027289	20BL015464	(Unknown)	358789	6381789	6	Loam		No Data			
GW028246	20BL020385	(Unknown)	365244	6378275	10	Sand	Geology at base of hole	0-500 ppm			
GW028399	20BL020369	(Unknown)	350993	6385773	17	Gravel	Geology at base of hole	Fresh			
GW028696	20BL023291	(Unknown)	365244	6376396	9	Sand		501-1000 ppm			
GW028891	20BL023123	Supply Obtained	353338	6382296	0	No data		No Data			
GW029088	20BL021619	(Unknown)	359230	6376436	39	Shale and Sandstone	Geology at base of hole	No Data			
GW033474	20BL025913	(Unknown)	365225	6377782	10	Gravel	Geology at base of hole	No Data			
GW034601	20BL027721	(Unknown)	356916	6378005	10	Gravel	Geology at base of hole	No Data			
GW035290	20BL028602	(Unknown)	352164	6382371	10	Gravel		No Data			
GW047691	20BL112864	(Unknown)	365977	6376067	11	Gravel		No Data			
GW047794	20BL112496	(Unknown)	365515	6375630	0	No data		No Data			
GW049549	20BL110378	(Unknown)	365160	6378705	12	Gravel		No Data			
GW051087	20BL111989	Supply Obtained	365141	6378212	13	Gravel		0-500 ppm			
GW051301	20BL117025	(Unknown)	358213	6376514	53	No data		No Data			
GW051647	20BL112319	(Unknown)	362896	6373006	12	No data		No Data			
GW053335	20BL120622	Supply Obtained	335475	6389718	12	Gravel		501-1000 ppm			
GW053413	20BL117253	Supply Obtained	368580	6378073	10	Gravel		501-1000 ppm			
GW053499	20BL120321	Collapsed Bore	351436	6382298	10	No data		No Data			
GW053509	20BL120624	(Unknown)	365593	6375600	0	No data		0-500 ppm			4.19
GW053518	20BL120324	Supply Obtained	350811	6385739	16	Sand and Gravel	Geology at base of hole	1001-3000 ppm			
GW053921	20BL118123	Collapsed Bore	351714	6382857	0	No data		No Data			
GW055019	20BL112296	Abandoned Bore	355916	6380578	24	No data		Fair			14.2
GW056207	20BL111234	(Unknown)	351951	6382737	8	Gravel		1001-3000 ppm			
GW056987	20BL124440	Supply Obtained	365167	6378213	13	Sand and Gravel		501-1000 ppm			
GW057354	20BL125092	SWL Man obs - 6 to 12 mths	355988	6380712	23	Sandstone		1001-3000 ppm			14.23
GW060027	20BL166021	(Unknown)	365506	6376277	0	No data		No Data			
GW060900	20BL132352	SWL Man obs - 6 to 12 mths	355502	6381144	18	Andesite and sandstone		501-1000 ppm			2.23
GW060973	20BL132585	(Unknown)	351266	6383220	31	Gravel		No Data			
GW061227	20BL133326	(Unknown)	350854	6384662	28	Gravel		1001-3000 ppm			
GW061339	20BL133423	Collapsed Bore	348881	6385895	46	Sandstone		7001-10000 ppm	0.5	Total	
GW064462	20BL141710	(Unknown)	365649	6377264	11	Gravel		No Data			
GW064463	20BL141711	(Unknown)	365649	6377264	11	Gravel		No Data			
GW065476		(Unknown)	366807	6376325	0	No data		No Data			
GW066948	20BL144247	(Unknown)	364891	6375529	0	No data		No Data			
GW066950	20BL144667	(Unknown)	363688	6377823	0	No data		No Data			
GW067196	20BL144364	(Unknown)	365220	6378152	0	No data		No Data			
GW067199	20BL144263	(Unknown)	365199	6377813	0	No data		No Data			
GW067200	20BL144248	(Unknown)	364938	6377840	0	No data		No Data			
GW067203		(Unknown)	365010	6378272	0	No data		No Data			
GW067206	20BL144249	(Unknown)	364903	6378486	0	No data		No Data			
GW067210	20BL143565	(Unknown)	365246	6378183	0	No data		No Data			
GW067228	20BL145086	(Unknown)	364984	6378241	0	No data		No Data			
GW067230	20BL145082	(Unknown)	365376	6378154	0	No data		No Data			
GW067231		(Unknown)	365323	6378215	0	No data		No Data			
GW067234	20BL145638	(Unknown)	365175	6377627	0	No data		No Data			
GW068666	20BL144271	Test Hole	366632	6376502	13	Sand and Gravel		No Data			
GW070451		(Unknown)	349857	6386803	0	No data		No Data			
GW071564	20BL151706	(Unknown)	364910	6378208	14	Sand		No Data			
GW071829		(Unknown)	356617	6380711	0	No data		No Data			
GW072724		(Unknown)	356630	6380726	0	No data		No Data			
GW072786		(Unknown)	365334	6378128	15	No data		0-500 ppm			
GW078016	20BL145638	(Unknown)	365278	6377690	14	Sand		0-500 ppm			
GW078378	20BL166755	(Unknown)	358391	6376824	29	Ironstone		No Data			
GW078497	20BL166833	(Unknown)	338015	6386675	18	Shale		3001-7000 ppm	0.25		
GW078564	20BL167133	(Unknown)	364021	6377160	0	No data		No Data			
GW078565	20BL167134	(Unknown)	364028	6377161	0	No data		No Data			
GW078598	20BL166999	(Unknown)	364399	6377799	0	No data		No Data			
GW080335	20BL168489		367003	6378016	0	No data		No Data			
GW080431	20BL168762		368667	6378165	0	No data		No Data			
GW080478	20BL168855	Abandoned Bore	347134	6381287	0	No data		No Data			
GW080479	20BL168855		347523	6381446	0	Sandstone and shale		3001-7000 ppm	1		54.1
GW080668	20BL169135		357617	6377469	0	No data		No Data			
GW080957	20BL170098	Abandoned Bore	341515	6388518	102	Shale		No Data	0	dry	

Appendix A: Summary of Selected Data for Licensed Groundwater Bores within 5km of the Project Site

Work No.	Licence	Work Status	Easting	Northing	Drilled Depth (m)	Interpreted Screened Lithology	Comment on Interpretation	Salinity Summary	Yield (L/s)	Yield Description	SWL (m below reference point)
GW080958	20BL170099	Instrumented Bore - Water Levels	341535	6388489	0	Shale		No Data			5.18
GW080976	20BL170110	SWL Man obs - 6 to 12 mths	346265	6385453	36	Tuff		No Data	0.78	Airlift, total yield	3.65
GW080977	20BL170111	Abandoned Bore	349990	6382955	42	Tuff	Geology at base of hole	No Data			
GW200406	20BL169474		365064	6376438	9	Sand		No Data			
GW200409	20BL169474		365104	6376430	9	Sand		No Data			
GW200410	20BL169474		365094	6376455	2	Sand		No Data			
GW200411	20BL169474		365099	6376449	9	Sand and Clay		No Data			
GW200442	20BL169236		356154	6377977	41	Conglomerate		No Data	0.1	cumulative	
GW200630	20BL168823	Supply Obtained	365997	6380255	11	Sandstone	Geology at base of hole	No Data			
GW200631	20BL168823	Supply Obtained	366009	6380334	7	Sandstone		1001-3000 ppm			
GW200632	20BL168823	Supply Obtained	366072	6380376	4	Sand and Clay		No Data			
GW200633	20BL168823	Supply Obtained	366003	6380388	4	Silt and Clay		1001-3000 ppm			
GW200656	20BL170957	Supply Obtained	364777	6378416	16	Gravel		No Data	2		
GW200658	20WA204053	New Bore	364987	6376414	102	Sandstone		0-500 ppm	3		

Appendix B

Environmental Risk Assessment Tables

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Consequence Table

Aspect	Insignificant	Minor	Moderate	Major	Catastrophic
Groundwater	Negligible change to groundwater regime and availability	Changes to groundwater regime and availability but no significant implications	Changes to groundwater regime and availability with minor implications	Groundwater regime or availability significantly compromised	Widespread groundwater resource depletion and subsidence

Likelihood Table

Likelihood	Description
Almost Certain	The event is expected to occur in most circumstances
Likely	The event will probably occur in most circumstances
Possible	The event could occur
Unlikely	The event could occur but not expected
Rare	The event occurs only in exceptional circumstances

Risk Matrix

Likelihood Level	**Consequence Level**				
	Insignificant	Minor	Moderate	Major	Catastrophic
Almost Certain	Low	Medium	High	Extreme	Extreme
Likely	Low	Medium	High	High	Extreme
Possible	Negligible	Low	Medium	High	High
Unlikely	Negligible	Low	Medium	Medium	High
Rare	Negligible	Negligible	Low	Medium	Medium

Environmental Risk Register - Groundwater

Risk No	Risk Pathway Description (how the project interacts with assets, values and uses)	Description of Consequences	Planned Controls to Manage Risk (as per Project Description)	Risk Assessment (Control)			Additional Controls Recommended to Reduce Risk	Treated Risk Assessment		
				Consequence	Likelihood	Risk Rating		Consequence	Likelihood	Risk Rating
1	Dewatering at Wollombi Road during construction.	Localised and temporary lowering of groundwater levels in the vicinity of Stony Creek at Wollombi Road.	Minimise duration and extent of construction activities.	Insignificant	Almost certain	Low				
2	Construction of the project results in accidental spills over and in the vicinity of groundwater bearing alluvial deposits or bedrock. Most likely to impact through infiltration where groundwater is shallow, i.e. at the major creek crossings and where medium to high type permeability bedrock outcrop.	Localised degradation in Groundwater quality from leaks and spills occur during construction.	Spill and clean up kits to be on-hand and management procedures in place. Conduct groundwater quality monitoring of control bores (up gradient) and of down gradient monitoring bores once per month during the construction period.	Minor	Possible	Low	If a monitoring bore is rendered unusable by construction activities then the bore should be replaced and relocated in a suitable alternative location, in consultation with a Hydrogeologist. If control and trigger values are exceeded, conduct an assessment and take appropriate action to mitigate impact.	Minor	Unlikely	Low

Risk No	Risk Pathway Description (how the project interacts with assets, values and uses)	Description of Consequences	Planned Controls to Manage Risk (as per Project Description)	Risk Assessment (Control)			Additional Controls Recommended to Reduce Risk	Treated Risk Assessment		
				Consequence	Likelihood	Risk Rating		Consequence	Likelihood	Risk Rating
			Regular assessment of monitoring results against baseline conditions, established prior to construction. If a spill occurs, assess significance of spill and potential for impact on groundwater quality. Review the groundwater monitoring program, which may involve additional sampling/ construction of additional monitoring locations if considered necessary. Emergency response plan.							

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Risk No	Risk Pathway Description (how the project interacts with assets, values and uses)	Description of Consequences	Planned Controls to Manage Risk (as per Project Description)	Risk Assessment (Control)			Additional Controls Recommended to Reduce Risk	Treated Risk Assessment		
				Consequence	Likelihood	Risk Rating		Consequence	Likelihood	Risk Rating
			Groundwater Management Plan. Collection of groundwater quality data over a number of months prior to the start of construction to establish baseline conditions and to identify control and trigger values against which to review monitoring data collected during construction.							

Risk No	Risk Pathway Description (how the project interacts with assets, values and uses)	Description of Consequences	Planned Controls to Manage Risk (as per Project Description)	Risk Assessment (Control)			Additional Controls Recommended to Reduce Risk	Treated Risk Assessment		
				Consequence	Likelihood	Risk Rating		Consequence	Likelihood	Risk Rating
3	Construction of the project embankments adjacent to areas where groundwater levels are typically close to ground surface, such as creek crossings, resulting in a temporary increase of local groundwater levels. This includes intersections with Jump Up Creek, Black Creek, Stony Creek, and where Anvil Creek flows close to the Project site.	Potential for temporary localised water logging as a result of (temporary) increase in groundwater levels.	Groundwater level monitoring of control bores (up gradient) and of down gradient monitoring bores once per month during construction period. This includes collection of groundwater quality data over a number of months prior to the start of construction to establish baseline conditions and to identify control and trigger values against which to review monitoring data collected during construction.	Minor	Possible	Low	If a monitoring bore is rendered unusable by construction activities then the bore should be replaced and relocated, in a suitable alternative location, in consultation with a Hydrogeologist. If control and trigger values are exceeded, conduct an assessment and take appropriate action to mitigate impact.	Minor	Possible	Low

Risk No	Risk Pathway Description (how the project interacts with assets, values and uses)	Description of Consequences	Planned Controls to Manage Risk (as per Project Description)	Risk Assessment (Control)			Additional Controls Recommended to Reduce Risk	Treated Risk Assessment		
				Consequence	Likelihood	Risk Rating		Consequence	Likelihood	Risk Rating
			Regular assessment of monitoring results against baseline conditions. Soil and water management plan.							
4	Operational spraying of additional quantities of herbicides along the rail line to account for the third track as part of ongoing track maintenance.	Degradation in groundwater quality as a result of the use of additional quantities of herbicides. south in the vicinity of drainage channels/creeks that drain towards Swamp Creek.	Groundwater quality monitoring of control bores (up gradient) and of down gradient monitoring bores once every 6 months following completion of construction.	Insignificant	Possible	Negligible				

Risk No	Risk Pathway Description (how the project interacts with assets, values and uses)	Description of Consequences	Planned Controls to Manage Risk (as per Project Description)	Risk Assessment (Control)			Additional Controls Recommended to Reduce Risk	Treated Risk Assessment		
				Consequence	Likelihood	Risk Rating		Consequence	Likelihood	Risk Rating
	Most likely to impact through infiltration where shallow groundwater is close to ground surface, i.e. at the major creek crossings and where medium to high type permeability bedrock outcrop.	Potential to impact on the groundwater quality of existing licensed groundwater bores (and which are not indicated to be monitoring bores) located down assumed gradient of the Project alignment; GW 078497 ~1.3km down gradient of the alignment at Jump Up Creek; GW 200442, GW 034601, GW 080668, GW 078378, GW 051301 and GW 029088 down gradient of the alignment, of these GW 200442 and GW 034601 are the closest at approximately 700 m	Regular assessment of monitoring results against baseline conditions established prior to construction. Review of the post construction monitoring program after 12 months (once two post construction sampling rounds have been completed and data reviewed).							