Chapter 4.0 - Groundwater

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Table of Contents

List of Tables

List of Figures

4.0 Groundwater

4.1 Overview

The objective of this chapter is to identify the existing groundwater conditions, potential impacts from the construction and operation of the KBP along the preferred alignment and to provide suitable mitigation measures, where necessary.

4.2 Approach and Methodology

This groundwater impact assessment has been undertaken as a desktop study of information available at the time of reporting. Information required for the assessment of groundwater hydrology within the corridor of interest was acquired from Department of Natural Resources and Water (DNRW) and included, where available:

- groundwater vulnerability data;
- existing borehole locations and associated historical groundwater data;
- stratigraphy and aquifer details; and
- local geological and topographical mapping.

Assessment of this information has revealed a current lack of groundwater quality data representative of the study area. Therefore, prior to construction it will be necessary to establish baseline data within the corridor if a greater appreciation of existing hydrogeological conditions, including groundwater quality, is required. This will then establish the pattern for monitoring through the environmental management phase during construction

4.3 Hydrogeological Setting

The hydrogeological description of the area of interest is based on groundwater vulnerability as shown in Figure 4.1, topography and geological mapping (refer to Figure 8.1 and Figure 8.3 in Chapter 8 Topography, Geology and Soils).

Groundwater vulnerability within the proposed road corridor area has been determined by DNRW using the DRASTIC mapping technique. This method gives consideration to all major geological and hydrogeological factors that affect and control groundwater movement. These factors include:

- depth to watertable;
- rate of (net) recharge;
- aquifer media;
- soil media;
- topography; and
- hydraulic conductivity of local aquifers.

Groundwater pollution potential is assessed following the weighting and ranking of each relevant DRASTIC feature.

Mapping of the study area suggests that groundwater along the preferred alignment is mostly of low-moderate vulnerability. This level of vulnerability is a reflection of the underlying geology in the area, this being dominated by the Neranleigh-Fernvale Beds (NFB), with some Bunya Phyllite in the east. As expected, groundwater vulnerability is mapped as being significantly greater over the Quaternary alluvial deposits associated with Cubberla and Moggill Creeks.

In reference to a combination of the groundwater vulnerability mapping, local groundwater level data and topographical mapping, it is possible to deduce that the general direction of groundwater flow in the area is likely to be towards the Brisbane River, with localised diversions towards Cubberla and Moggill Creeks.

Groundwater vulnerability data is provided by DNRW as a coarse-resolution raster data set. As such, delineated areas of differing groundwater vulnerability are indicative and are designed for strategic planning purposes rather than 'paddock scale' decision making.

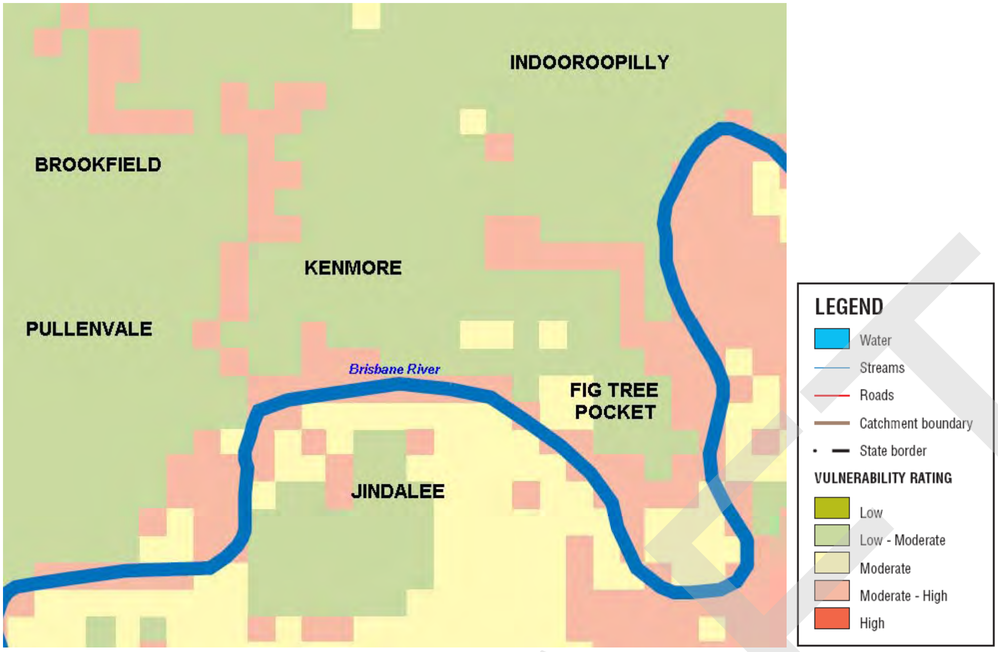

Figure 4.1: DRASTIC Groundwater Vulnerability Mapping of the Study Area (DNRW 2002)

4.3.1 Groundwater Bearing Geological Units

Neranleigh-Fernvale Beds

The majority of the proposed alignment sits over the NFB, which underlies an extensive area in Brisbane, the south of Redland Shire and the hinterland of the Gold Coast (EHA 2006). In Brisbane it outcrops to the west of the Bunya Phyllite in a broad band north of the Brisbane River from Mt Crosby through to Kenmore and extends north-west, forming the D'Aguilar Range. It also outcrops in another band from Enoggera to Chermside and extends through Brisbane City to Mt Gravatt, then south in Logan Shire.

This formation consists of metamorphosed sediments, sandstones and shales. The sediments have lost their intrinsic porosity but, as much of the rock is siliceous, fractures are not as in-filled with clay as in the Bunya Phyllite or Rocksberg Greenstone (refer to Chapter 8 Topography, Geology and Soils). The formation contains fractured rock aquifers, with fractures occurring at depths down to > 60 m, mostly close to drainage lines, but often unrelated to topographic features. As such, the fractured rock aquifers are unpredictable and many dry bores have been drilled into the hard rock of this formation. As a fractured rock aquifer, the rainfall infiltration/recharge is relatively rapid and the aquifers have a strong connection with surface water.

Bunya Phyllite

Near the eastern end of the alignment, in the vicinity of the Centenary Motorway, lies the Bunya Phyllite formation. It exists in a North West trending band from the Indooroopilly-Toowong-Paddington area through Mt Coot-tha to the Brisbane Forest Park, and forms much of the hill country in the western suburbs.

The Phyllite is a fine grained platy type of metamorphic rock that has very low porosity. It weathers to clay at the surface and joints. As a result, fractures in the rock are usually in-filled with clay. At depth there are occasionally clean fractures, but these are usually small. This formation contains fractured rock aquifers, but because of the nature of the rock, there is little potential for significant groundwater to be stored. Occasional small supplies have been encountered from fractures, but these are usually less than 0.2 l/s.

Any successful bores are located adjacent to gullies where fractured rock aquifers are more likely to occur and there is a source of recharge water. As such, these aquifers are strongly connected with surface water. From the perspective of town water supplies, no significant bores are known to exist within this formation in Brisbane. Most bore holes that have been drilled have been abandoned because of a lack of a suitable supply.

Quaternary

Groundwater within the quaternary alluvial deposits associated with Cubberla and Moggill Creeks is likely to be characterised by unconfined aquifers associated with the creeks.

4.3.2 Groundwater Levels and Extent of Aquifers

Historical groundwater monitoring data was acquired for all DNRW registered boreholes within a three kilometre buffer of the preferred alignment. A total of twenty one (21) bores were listed on the Groundwater Database, of which only two have been abandoned and destroyed.

A description of observed groundwater levels and aquifer thickness and type are detailed in Table 4.1 and shown in Figure 4.2.

Table 4.1: Summary of Static Water Level and Aquifer Data

Reg. No.	Date Installed	Status[1]	SWL (mbgl[2])	Date Measured	Aquifer Lithology
124277	27/10/2004	EX	19.0	27/10/2004	Basic Volcanic e.g. Basalt
133320	10/10/2005	EX	6.0	10/10/2005	Shale
133878	29/06/2006	EX	11.0	29/06/2006	Shale
134119	24/07/2006	EX	14.0	24/07/2006	Shale
134161	19/09/2006	EX	5.0	19/09/2006	Clay
134465	6/09/2006	EX	9.0	6/09/2006	Basic Volcanic e.g. Basalt
134706	23/01/2007	EX	-	-	-
134710	8/02/2007	EX	12.6	8/02/2007	Shale
134729	18/01/2007	AD	DRY	18/01/2007	Shale
134730	13/02/2007	AD	DRY	13/02/2007	Shale
145392	18/10/2007	EX	5.0	18/10/2007	Shale
145613	4/12/2007	EX	-	-	-
145714	16/01/2008	EX	-	-	-
145715	16/01/2008	EX	3.5	16/01/2008	Clay
145716	21/01/2008	EX	-	-	Silt/Clay
145717	22/01/2008	EX	-	-	-
145718	24/01/2008	EX	-	-	-
145719	24/01/2008	EX	-	-	-
145720	24/01/2008	EX	-	-	-
145721	24/01/2008	EX	-	-	-

[1] EX – existing; AD – abandoned and destroyed
[2] mbgl – metres below ground level

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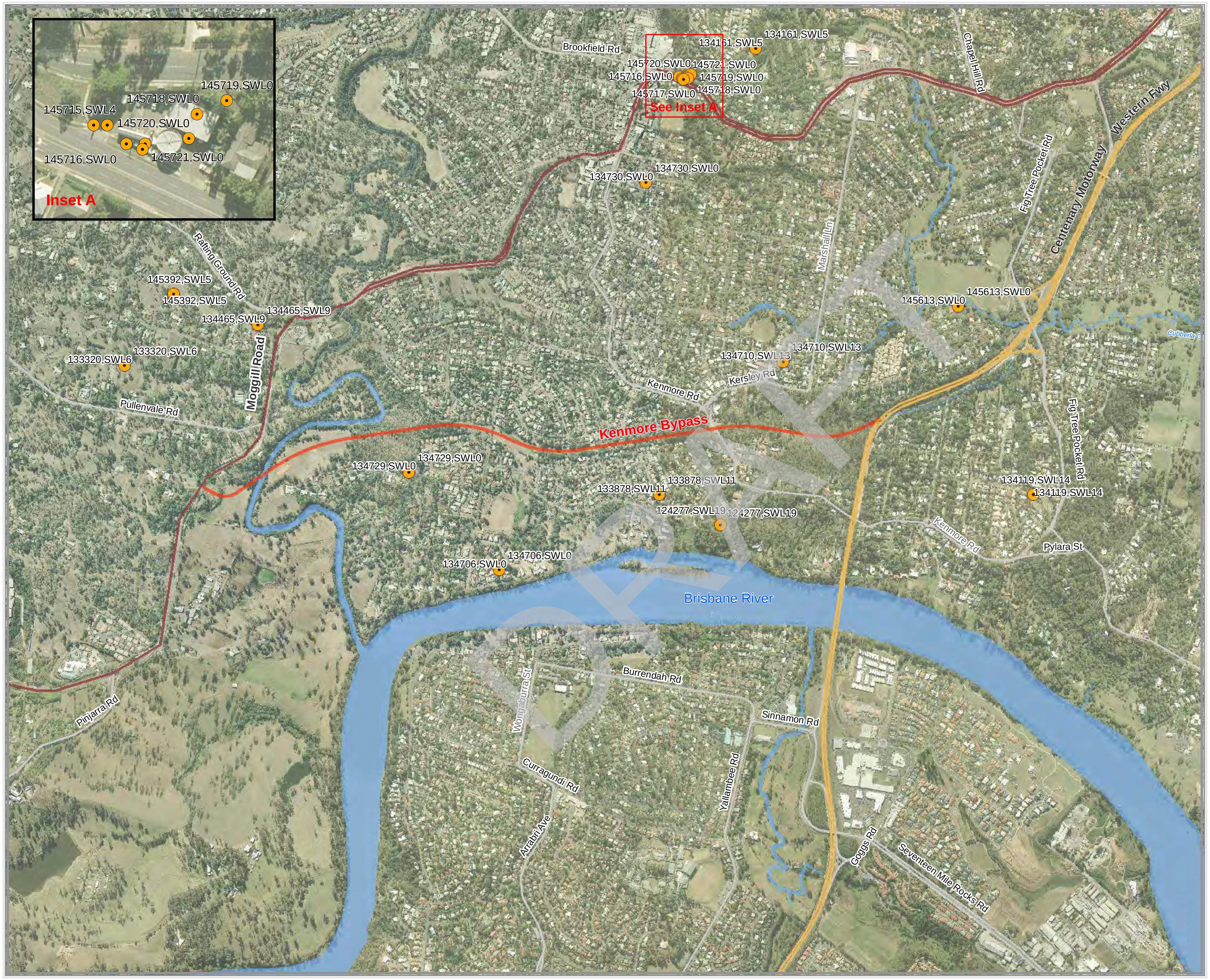

AECOM

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Metres

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Date - 13 May 2009

GDA
MGA94 Zone 56

Legend

- Borehole Location
- Centenary Motorway
- Kenmore Bypass
- Moggill Road
- River/creek

Data sources:
Roads, railway, rivers etc - Copyright 2006, MapData Sciences PTY LTD, PSMA

Aerial Imagery:
Copyright Qasco Surveys Pty Limited (2005).

Air Quality Information provided by ENSR Australia, Brisbane for the Kenmore Bypass Environmental Study.

KENMORE BYPASS GROUND WAATER

Borehole Locations

Figure 4.2

4.3.3 Groundwater Quality

No historical groundwater quality data was attached to any of the 21 bore hole report cards. Reference to Groundwater Resources of Queensland mapping (DNRW 2006) indicates that metamorphic aquifers within the study area have, on average, a bore yield of <5 l/s and a salinity of 1,500-5,000 mg/L total dissolved ions. These values have been determined by DNRW through the interpretation of data from licensed bores, investigative drilling and various hydrogeological reports, with some extrapolation across areas of limited data. As such, local groundwater sampling is required to confirm the accuracy of these high-level data sources.

DNRW mapping indicates that groundwater resources within the study area would likely be suitable for most stock purposes, as well as for some domestic and irrigation uses. However, land use within the area is predominantly residential and, consequently, a dense network of essential utilities supplies properties within the study area. It is unlikely that significant extraction of groundwater within the vicinity of the proposed road alignment is currently undertaken for drinking water and/or irrigation purposes.

The potential remains for the localised use of groundwater generated from private, unregistered boreholes for domestic or minor irrigation purposes.

4.3.4 Declared Groundwater Zones and Water Resource Planning

Mapping of Declared Sub-artesian Areas within Queensland, provided by DNRW, indicates that the study area does not extend into any Declared Sub-Artesian Area.

The proposed alignment is wholly within the Lower Brisbane River sub-catchment area of the Moreton plan area. As such, the local groundwater environment within the study area is managed under the *Water Resource (Moreton) Plan 2007* (Moreton WRP), under the *Water Act 2000*.

4.3.5 Environmental Receptors

Given that DRASTIC mapping has designated much of the corridor as low-moderate vulnerability to groundwater contamination, a monitoring program would be necessary to ensure minimal impact on sensitive receptors, being wells currently drawing on the aquifer. Further assessment could be undertaken during subsequent design stages to determine significant human and environmental receptors that may be impacted by the construction and operation of the project. This assessment may involve:

- conducting a census for potential unregistered groundwater wells located within 250m radius of locations where dewatering is to be undertaken;
- identifying any surface water bodies sensitive to groundwater movement (i.e. dams); and
- identifying all local users of groundwater resources within a one kilometre radius of the preferred alignment. This would include any potentially significant ecological areas.

It should be noted that a number of DNRW registered wells are suitably close to the corridor, which along with the test wells established through this investigation would probably suffice as monitoring points.

4.4 Potential Impacts and Mitigation Measures

4.4.1 Potential Groundwater Impacts

4.4.1.1 Construction

The risk posed to groundwater flow, quality and quantity is generally greatest during the construction phase of such a project, as this is when the most concentrated impacts generally occur.

Potential construction phase impacts identified here are based upon construction activities commonly undertaken on road construction projects of a similar nature.

Disturbance and Ground Clearing

Clearing of access roads and the new road itself can alter groundwater recharge, introduce pollutants and increase sediment runoff.

Significant Compaction

Compaction can result in reduced groundwater recharge and can act as a barrier to shallow groundwater flow in shallow groundwater areas. It can also drive contaminated groundwater out of fill or acid sulfate soils (ASS).

Surface compaction is a necessary and common construction activity in the construction of a new section of road. As such, this is expected to occur along the entire alignment.

Significant Cut and Fill

Excavation of road cuttings can alter the groundwater recharge and alter the permeability of the subsurface. It can also reduce the depth to groundwater for surface contaminants.

Fill placement for road construction can reduce recharge and can impact on water quality if the fill is contaminated.

Land reformation in the form of cut and fills, is essential with respect to the development of any new road alignment. These activities are expected to occur at specific locations along the length of the alignment, with localised topographical variance a significant determinant in the extent of each. Lengths of the alignment where significant cutting will be required are identified on Figure 4.3 and include:

- Chainage 1500 to 1740;
- Chainage 1770 to 1790;
- Chainage 1800 to 1960;
- Chainage 2840 to 2850; and
- Chainage 2860 to 3220.

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Metres

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Date - 13 May 2009

GDA
MGA94 Zone 56

Legend

- Centenary Motorway
- Kenmore Bypass
- Moggill Road
- River/creek

Chainage Sections

- 1500 to 1740
- 1770 to 1790
- 1800 to 1960
- 2840 to 2850
- 2860 to 3220

KENMORE BYPASS

Chainage extent of significant cuttings along the proposed alignment

Figure 4.3

Dewatering

Cuttings that intersect groundwater may require dewatering. Groundwater levels in the immediate vicinity of the proposed alignment range from approximately 10 to 20 mbgl (metres below ground level) and as such, regular encounters with groundwater are not expected. However, cuttings into natural material are anticipated down to a maximum of 13 mbgl (Chainage 3180) and therefore dewatering may be required in specific locations.

The likelihood of encountering Potential Acid Sulphate Soils (PASS) has been identified in Chapter 8 (Topography, Geology and Soils) of this EAR. Dewatering activity within the alluvial deposits associated with Moggill Creek is at risk of exposing PASS to aerobic conditions and thereby initiating the oxidation process. This, in turn, may result in the acidification of localised groundwater and surface run-off, eventually migrating into nearby waterways. Although the impacts from dewatering are likely to be localised and temporary for the most part, conical groundwater depressions within deposits of ASS potential may result in wider reaching impacts.

Significant dewatering of shallow and/or deep aquifers may cause:

- temporary lowering of water levels in the nearby surface water features, including stationary and slow moving bodies of water; and
- temporary lowering of groundwater levels within any registered or domestic wells.

Any impacts due to short term dewatering activities away from the alluvial deposits of Moggill Creek are likely to temporarily influence groundwater within the immediate vicinity of the dewatering area. Groundwater levels would be expected to return to pre-construction levels following completion of work. However, drainage systems that intercept groundwater may have a more permanent impact.

Disturbance of Existing Contaminated Soils or ASS

The disturbance of contaminated soils in the construction of a road can release contaminants that may mobilise into groundwater. ASS can also become oxidised via construction disturbance, including filling, and can result in the generation of acidic groundwater. Refer to Chapter 8 (Topography, Geology and Soils) for further information.

Fuel and Other Chemical Spills

Fuel, lubricant and other chemical spillages from normal construction activities, chemical storage areas, raw material stockpiles, refuelling areas, and as a result of accidents have the potential to contaminate groundwater.

Such contaminants may include total petroleum hydrocarbons (TPH), polycyclic aromatic hydrocarbons (PAH), benzene, toluene, ethylbenzene and xylene (BTEX) and heavy metals.

Groundwater impacts from spills are particularly likely in areas where surface soils are porous or where recent soil disturbance has created preferential pathways for the infiltration of contaminants down towards the water table. Consequences to groundwater of spillages will therefore be greater in the unconfined alluvial deposits associated with Cubberla and Moggill Creeks.

4.4.1.2 Operation

The risk posed to groundwater flow, quality and quantity is comparatively less during the operation of a road; however, risks remain.

Runoff

Surface water runoff from roads may include contaminants such as Polycyclic Aromatic Hydrocarbons PAH, hydrocarbons (fuel, oils and solvents), nitrogen compounds from exhausts, heavy metals and suspended solids.

This runoff would be directed through surface water control measures to achieve water quality objectives, so groundwater impacts of runoff will be controlled primarily though these means.

Contaminants in runoff are also likely to be attenuated via infiltration through soil horizons, although this will be lessened in high-permeability areas.

Groundwater Quality and Recharge

Groundwater water quality objectives are likely to be controlled via road drainage design for surface water quality objectives.

Further discussion of the potential surface water quality impacts, an intermediary phase in contamination of both shallow and deep groundwater systems, is included in Chapter 3 (Surface Water).

A hard-surface road has the effect of reducing groundwater recharge along its overall alignment, while re-directing and concentrating recharge in areas of surface water drainage discharge.

Recharge would be more important in areas of medium-high existing soil permeability, as shown in Figure 4.1.

Groundwater Flow

Significant cuttings or construction in areas of shallow groundwater require drainage systems to intercept groundwater and ensure groundwater remains below the road surface.

Affecting groundwater flows can impact spring and wetland feeds and potentially impact the local groundwater flow directions.

With the general direction of groundwater flow expected to be towards the Brisbane River, with localised diversions towards Cubberla and Moggill Creeks, the significant extent of cutting required between Chainages 2860 and 3220 in particular may disrupt or intercept regular groundwater flows.

4.4.2 Groundwater Mitigation Measures

A summary of the potential impacts and proposed groundwater mitigation measures can be found in Table 4.2.

4.4.2.1 Design

Using the appropriate receptors as described in Section 4.3.5, the hydrogeology should be reviewed and a monitoring program put in place.

A groundwater monitoring program, utilising existing and/or new monitoring bores, may be conducted in the design phase if a greater appreciation for the existing groundwater environment is deemed necessary. Such a program would aim to establish groundwater levels within the local area, general groundwater quality and background levels for contaminants of interest. Without pre-construction groundwater monitoring, it will not be possible to quantify the success of mitigation measures.

Potential impacts on groundwater could be mitigated through design by:

- limiting or eliminating the need for dewatering during construction;
- avoiding contaminated sites or ASS;
- limiting the depth of excavation in the alluvial areas near the creeks;
- considering the significance of environmental receptors and groundwater flow impacts in areas proposed of significant compaction, and consider alternatives, such as bridges; and
- protecting water quality that may infiltrate groundwater via WSUD (detailed in Chapter 3 -Surface Water).

4.4.2.2 Construction

Some of the construction phase impacts can be mitigated through design, as per Section 4.4.2.1. All other construction phase impacts can be mitigated by ensuring that site practices follow an EMP (C). With relevance to groundwater, the EMP (C) should address the following issues relevant to general road construction:

- minimising disturbance and controlling run-off from construction areas;

- ensuring good vehicle maintenance;
- addressing ASS management, where necessary;
- appropriately designing storage, stockpiling and refuelling areas and temporary drainage systems;
- requiring drainage design features to meet stated water quality objectives;
- emergency response plan to deal with spillages;
- special measures to prevent groundwater contamination if constructing through contaminated sites (if any); and
- groundwater quality and level monitoring as appropriate to assess the performance of the mitigation measures.

Significant Cuttings

As groundwater levels measured within 500m of the alignment are approximately 10-15m below ground level, significant cutting would be required before potential consequences to groundwater would be significant. This can be established by the baseline and construction phase monitoring program.

Dewatering

Significant dewatering, or as considered necessary, should be conducted under specific management strategies that could include, but may not be limited to:

- estimate surrounding area impacted by dewatering, dependent on anticipated pumping rates, rate of recharge and dewatering requirements;
- identify all susceptible receptors to groundwater level changes, including both registered and private monitoring wells;
- subject as few sites as possible to dewatering, with only the minimum required groundwater extracted during each event;
- contain poor quality discharge water and treat prior to disposal, subject to water quality guidelines being achieved;
- gauge daily groundwater levels in nearby privately owned (with permission) and registered bore holes; and
- should groundwater quality in the immediate vicinity degrade, monitor downstream waterways for impacts. Corrective action may be required and a long term management plan should be implemented until groundwater quality returns to background levels.

4.4.2.3 Operation

Groundwater mitigation measures for the road operational phase include:

- response plans to deal with any spillages;
- maintenance of WSUD elements; and
- groundwater quality and level monitoring for a short period after the opening of the road, as deemed appropriate.

Table 4.2: Potential Impacts and Mitigation Measures

Reference Code	Project Phase	Potential Impact	Potential Mitigation Measures
GW 01	Design	Wells currently drawing on the aquifer or other significant human and environmental receptors impacted by groundwater contamination.	Further assessment could be undertaken to determine existing wells or other significant human and environmental receptors that may be impacted by the construction and operation of the KBP. Assessment may include: • conducting a census for potential unregistered groundwater wells located within 250m radius of locations where dewatering is to be undertaken; • identifying any surface water bodies sensitive to groundwater movement (i.e. dams); and • identifying all local users of groundwater resources within a one kilometre radius of the preferred alignment. This would include any potentially significant ecological areas.
GW 02	Design	Impacts to the groundwater flow, quality and quantity.	• limiting or eliminating the need for dewatering during construction; • avoiding contaminated sites or PASS; • limiting the depth of excavation in the alluvial areas near the creeks; • considering the significance of environmental receptors and groundwater flow impacts in areas proposed of significant compaction, and consider alternatives, such as bridges; and • protecting water quality that may infiltrate groundwater via WSUD (detailed in Chapter 3 -Surface Water). Establishing a pre-construction groundwater monitoring program would enable monitoring of the success of these mitigation measures.

Reference Code	Project Phase	Potential Impact	Potential Mitigation Measures
GW 03	Construction	Clearing of access roads and the new road itself can alter groundwater recharge, introduce pollutants and increase sediment runoff.	Minimise disturbance and control run off from construction areas. Store all potentially hazardous chemical materials in accordance with AS/NZS 4452:1997 and 1596:2008 and AS 1940-2008. Implement an effective erosion and sediment control plan.
GW 04	Construction	Compaction can result in reduced groundwater recharge and can act as a barrier to shallow groundwater flow in shallow groundwater areas. It can also drive contaminated groundwater out of fill or ASS. Surface compaction is a necessary and common construction activity in the construction of a new section of road. As such, this is expected to occur along the entire alignment.	Identify all contaminated or potentially contaminated sites within the study area, avoiding disturbance of such sites and those identified as having PASS. Consider alternatives to significant compaction, such as bridges. Minimise, where possible, the extent and degree of all compaction activities.
GW 05	Construction	Excavation of road cuttings can alter the groundwater recharge and alter the permeability of the subsurface. It can also decrease the depth that surface contaminants need to traverse to affect groundwater. Fill placement for road construction can reduce recharge and can impact on water quality if the fill is contaminated.	As groundwater levels measured within 500m of the alignment are approximately 10-15m below ground level, significant cuttings would be required before potential consequences to groundwater would be significant. Further investigation of the local hydrogeology would be required to understand and mitigate impacts in this case. Groundwater quality and level monitoring as appropriate to assess the performance of the mitigation measures.

Reference Code	Project Phase	Potential Impact	Potential Mitigation Measures
GW 06	Construction	Cuttings that intersect groundwater may require dewatering. Groundwater levels in the immediate vicinity of the proposed alignment approximately range from 10-20 mbgl and as such, regular encounters with groundwater are not expected. However, cuttings into natural material are anticipated down to a maximum of 13 mbgl (Chainage 3180) and therefore dewatering may be required in specific locations. Significant dewatering of shallow and/or deep aquifers may cause the following impacts: • temporary lowering of water levels in the nearby surface water features, including stationary and slow moving bodies of water; and • temporary lowering of groundwater levels within any registered or domestic wells.	Limit or eliminate the need for dewatering during construction through design. Significant dewatering, or as considered necessary, should be conducted under specific management strategies, that could include, but may not be limited to: • estimate surrounding area impacted by dewatering, dependent on anticipated pumping rates, rate of recharge and dewatering requirements; • identify all susceptible receptors to groundwater level changes, including both registered and private monitoring wells; • subject as few sites as possible to dewatering, with only the minimum required groundwater extracted during each event; • contain poor quality discharge water and treat prior to disposal, subject to water quality guidelines being achieved; • gauge daily groundwater levels in nearby privately owned (with permission) and registered bore holes; and • should groundwater quality in the immediate vicinity degrade, monitor downstream waterways for impacts. Corrective action may be required and a long term management plan should be implemented until groundwater quality returns to background levels.
GW 07	Construction	The disturbance of contaminated soils in the construction of a road can release contaminants that may mobilise into groundwater. ASS can also become oxidised via construction disturbance, including filling, and can result in the generation of acidic groundwater.	Identify all contaminated or potentially contaminated sites within the study area, avoiding disturbance of such sites and those identified as having ASS potential. Address ASS management, where necessary. Implement appropriate measures if constructing through contaminated sites. Refer to Chapter 8 Topography, Geology and Soils for further details.

Reference Code	Project Phase	Potential Impact	Potential Mitigation Measures
GW 08	Construction	Fuel, lubricant and other chemical spillages from normal construction activities, chemical storage areas, raw material stockpiles, refuelling areas, and as a result of accidents have the potential to contaminate groundwater. Groundwater impacts from spills are particularly likely in areas where surface soils are porous or where recent soil disturbance has created preferential pathways for the infiltration of contaminants down towards the water table. Consequences to groundwater of spillages will therefore be greater in the unconfined alluvial deposits associated with Cubberla and Moggill Creeks.	Handle and store all potentially hazardous chemical materials in accordance with AS/NZS 4452:1997 and 1596:2008 and AS 1940-2008. Appropriately design storage, stockpiling and refuelling areas, and temporary drainage systems. Emergency response plan to deal with any spillages. Ensure good vehicle and machinery maintenance. Use WSUD to protect quality of water that may infiltrate ground water.
GW 09	Operation	Surface water runoff from roads may include contaminants such as PAH, hydrocarbons (fuel, oils and solvents), nitrogen compounds from exhausts, heavy metals and suspended solids. This runoff would be directed through surface water control measures to achieve water quality objectives, so groundwater impacts of runoff will be controlled primarily though these means. Contaminants in runoff are also likely to be attenuated via infiltration through soil horizons, although this will be lessened in high-permeability areas.	Maintenance of WSUD elements.
GW 10	Operation	Groundwater water quality objectives are likely to be controlled via road drainage design for surface water quality objectives.	Response plans to deal with any spillages.