CHAPTER 9
Groundwater

BRISBANE METRO
Draft Design Report

Contents

9. Groundwater

This chapter assesses the potential interaction between groundwater and Brisbane Metro. It includes a description of the existing hydrogeological setting and assessment of potential impacts and mitigation measures associated with Brisbane Metro's construction and operation.

9.1 Assessment methodology

Groundwater will be unaffected along the majority of the Brisbane Metro alignment as it largely comprises surface infrastructure or is operating within an existing alignment. As such, the study area for this assessment includes those locations where new below-ground infrastructure are proposed and where groundwater may be encountered. This includes the Cultural Centre precinct and Adelaide Street in the CBD.

This assessment is based on a desktop review of existing information and assessment of potential impacts. It involved:

- reviewing existing information relevant to groundwater values and conditions in the study area, including existing hydrogeological assessments, ground investigation reports, databases, and spatial information in the key areas of relevance for groundwater
- identifying hydrogeological issues and risks
- describing the existing groundwater conditions and values of areas near below-ground infrastructure
- assessing potential impacts of Brisbane Metro's construction and operation on groundwater values
- identifying measures to avoid, manage or mitigate potential groundwater impacts.

Information and data sources reviewed for this assessment included:

- assessments of hydrogeological conditions undertaken for other transport projects in the study area (e.g. the proposed CRR project EIS, BaT project EIS)
- Queensland Geological Survey 1:100,000 Brisbane geology map sheet
- Queensland Government Department of Natural Resources, Mines and Energy (DNRME) groundwater facility and licensing databases
- geotechnical and ground investigation reports commissioned by Council including for:
    - Woolloongabba Sewer Augmentation Stages 2 and 3 Geotechnical Investigation (2009)
    - Grey Street, South Brisbane Geotechnical Investigation (2008)
    - Grey Street, West End Boulevard Geotechnical Investigation (2008)
    - Brisbane City Hall Basement Damage Ground Water Investigation (2007)
    - Ann Street at City Hall Relief Drainage Geotechnical Investigation (2004)
    - Inner Northern Busway Queen Street to Roma Street Geotechnical Investigation (preliminary) (1998)
    - Victoria Bridge Abutment Settlement Geotechnical Investigation (1997).

This assessment considers potential environmental impacts on groundwater. Engineering aspects have been considered through the development of the concept design. No monitoring, testing or intrusive ground studies have been undertaken for this assessment. This will be undertaken as part of the ongoing design development process.

9.2 Legislative and policy context

Groundwater use and management in Queensland is regulated under the *Water Act 2000* (Qld) (Water Act) and the EP Act including the EPP (Water). The Water Act provides for the sustainable management of water and other resources. It seeks to advance the sustainable management of water, including protection of the biological

quality and health of natural ecosystems. One of the primary objectives of the Water Act is to maintain or improve the quality of naturally occurring waters and to protect them from degradation.

Under the EP Act, the EPP (Water) and the *Queensland Water Quality Guidelines 2009*[1] address the protection and enhancement of water quality. The EPP (Water) provides water quality guidelines and objectives for the protection of environmental values, and provides a framework for decision making related to Queensland waters.

9.3 Existing environment

9.3.1 Potential groundwater interaction

The majority of the alignment comprises the use of existing infrastructure or will require little or no excavation and is not expected to impact on the groundwater environment. Areas that have potential to interact with groundwater i.e. where below-ground sections of the alignment are required or where there are likely to be significant excavations, include:

- Cultural Centre precinct – excavation is proposed to occur to maximum depths of between approximately three metres to four metres AHD, and in relatively close proximity to the Brisbane River
- Adelaide Street in the CBD – given the depth of excavation, it is possible that groundwater may be encountered.

The following sections provide more detailed information on the hydrogeological conditions at these locations of potential groundwater impact.

Cultural Centre station

A boundary between the Neranleigh-Fernvale beds to the east and the Bunya Phyllite to the west runs roughly along Grey Street at South Bank. These strata are overlain by Quaternary Alluvium extending over South Bank at least as far back from the Brisbane River as Grey Street and, further north, as far back as Cordelia Street and along Melbourne Street to Boundary Street.

Two bores were drilled on the southern abutment to the Victoria Bridge to depths of eight metres and 8.5 metres below ground level[2]. Fill comprising predominantly silty gravel and clayey sand was encountered to a depth of four metres to 4.5 metres and 6.1 metres below ground level. Below the fill, alluvial clay was encountered with one of the bores encountering fine to medium sand at eight metres below ground level.

A number of shallow bores have been drilled along Grey Street[3], close to the Cultural Centre and near the junction with Peel Street[4]. All bores were drilled to a maximum depth of 3.45 metres below ground level and encountered fill comprising sandy clay to clayey gravel to depths of 0.9 metres to five metres below ground level. The underlying alluvium comprised silty sandy clay.

Bedrock was not proven in any of the bore logs reviewed, however geological mapping indicates the bedrock geology along South Bank should be quartzite and phyllite of the Neranleigh-Fernvale beds or Bunya Phyllite.

Excavations for the new underground Cultural Centre station beneath South Brisbane railway station and Grey Street are likely to extend to depths of four metres AHD. The available bore log data for this area is limited and shallow but it is possible that the alluvium extends to a significant depth with the possibility of sand and gravel horizons in the lower parts of the sequence. Groundwater levels here may be in the order of one metre to two metres AHD and are likely to show tidal variation, so groundwater control measures may be required during construction.

[1] DEHP (2009) Queensland Water Quality Guidelines 2009, Version 3, Queensland Government
[2] Brisbane City Council (1997) Victoria Bridge Abutment Settlement Geotechnical Investigation, Geotechnical Services section
[3] Brisbane City Council (2008a) Grey Street, South Brisbane Geotechnical Investigation, March 2008, prepared by Ground Engineering
[4] Brisbane City Council (2008a)

Brisbane CBD

The CBD is underlain by the Neranleigh-Fernvale beds with overlying Quaternary Alluvium in places including around City Hall, King George Square, and Albert Street.

A number of bore logs have been reviewed from locations around City Hall along Adelaide Street and Ann Street, and in the vicinity of Albert Street and Roma Street. Bores drilled along Adelaide Street and Ann Street adjacent to City Hall encountered fill of clay, sand and gravel to depths of between 0.8 metres and greater than 4.6 metres below ground level. A significant thickness of alluvium was also encountered in most bores with between 6.9 metres and 9.7 metres (8.1 metres to greater than 12 metres below ground level) in three bores on Adelaide Street next to City Hall. In three bores on Ann Street adjacent to City Hall, fill was thicker and present to between 0.8 metres and greater than 4.6 metres below ground level. Alluvium (6.5 metres thick) was only proven in one of the three bores. The alluvium encountered around City Hall typically comprised variably silty, sandy clay with occasional thinner beds of clayey sand and gravel in places. Extremely weathered phyllite (Neranleigh-Fernvale beds) was identified at depths between 5.5 metres below ground level and 12 metres below ground level around City Hall.

A number of bores in a line from Albert Street at Burnett Lane, across to the Roma Street and Turbot Street intersection are presented in a Council report[5], which interprets the deepest section of an east-west aligned alluvial channel as running beneath the centre of City Hall and the intersection of Adelaide and Albert streets. The depth of alluvium in the central part of the channel is in excess of 18 metres below ground level. Rockhead contours drawn from this investigation show rockhead at a maximum level of eight metres AHD on the intersection of Albert and Adelaide Streets. The alluvium is dominated by sandy clay with inter-beds of silty clay and coarser, more permeable material at depth. Underlying the alluvium are the Palaeozoic Neranleigh-Fernvale beds comprising weathered phyllite and quartzite.

Excavations along Adelaide Street for the below-ground section are likely to encounter a significant thickness of alluvium halfway along City Hall before connecting into the existing Albert Street bus tunnel and King George Square station, which, if saturated, may require groundwater control measures. The Neranleigh-Fernvale beds are considered unlikely to yield significant volumes of groundwater.

9.3.2 Hydrogeology of formations

Quaternary Alluvium

The Quaternary Alluvium comprises recent unconsolidated sediments associated with watercourses. Groundwater potential will generally be limited to coarser sandy and gravelly horizons within the sequence. Where such horizons are present within the alluvial sequence adjacent to watercourses there may be a strong hydraulic connection between the aquifer and the watercourse.

Along the Brisbane River including its floodplain and tributaries, the alluvium consists of both older (Pleistocene age) and younger (Holocene age) deposits. The Pleistocene Alluvium generally consists of stiff clays with variable silt/sand/gravel content, and horizons of sand and gravel. The review of bore log data in the key areas of groundwater interest along the Brisbane Metro alignment indicates the alluvial sequence appears to be dominated by clays with thinner inter-beds of sand and gravel in the lower parts of the sequence. This is typical of alluvium in the main Brisbane River channel, with gravel horizons often being encountered immediately above the bedrock.

Site investigations on the Quaternary Alluvium elsewhere in South Brisbane/West End close to the Brisbane River where more than 20 metres depth of alluvium was encountered, have shown a highly-permeable sand/gravel layer above bedrock.

Where present, alluvial sands and gravels may support moderate groundwater yields, however, the typical lateral discontinuity of these coarser horizons generally limits long-term sustainable yields. Alluvial sediments may form unconfined perched aquifers overlying less permeable bedrock.

[5] Brisbane City Council (1998) *Inner Northern Busway Queen Street to Roma Street Geotechnical Investigation (preliminary)*, June 1998

Collated hydraulic parameter data for the alluvium gathered from previous investigations is presented within the groundwater assessment for the proposed CRR project[6]. The somewhat limited dataset provides a hydraulic conductivity range for the alluvium ranges from 0.15 metres per day to 86 metres per day (moderately to very high). Average unconfined storage values in the dataset reviewed ranged from 0.003 metres per day to 0.017 metres per day.

Neranleigh-Fernvale beds

The Neranleigh-Fernvale beds are present across the CBD and South Bank. The nature of the strata (sandstone and mudstone metamorphosed to quartzite and phyllite) means that groundwater occurrence is typically limited to secondary porosity or within fractures and joints within the rock mass.

The bulk permeability of the Neranleigh-Fernvale beds will vary spatially with localised areas of higher permeability associated with zones of fracturing. In general, this formation is considered to be of very low to low permeability with isolated areas of higher permeability. Collated hydraulic data for the Neranleigh-Fernvale beds is presented in the groundwater assessment for the proposed CRR project[7]. Groundwater yields are generally very low and less than one litre per second.

A small proportion of packer tests (14%) undertaken as part of the investigations for the Clem Jones Tunnel and S1 Sewer were interpreted as indicating the potential for significant inflow. These higher-permeability results are likely to be associated with areas of localised dense fracturing rather than being indicative of broad areas of high permeability. The available data indicates hydraulic conductivity values are generally less than 0.01 metres per day. Pumping tests undertaken for the Eastern Busway project yielded transmissivity and storage values of 0.78 square metres per day and 0.009 respectively[8].

Bunya Phyllite

There is little available hydrogeological data specifically for the Bunya Phyllite. Its lithology is very similar to that of the Neranleigh-Fernvale Beds and so it is considered reasonable to assume that it is likely to exhibit the same range of hydraulic properties including little to no primary porosity and groundwater flow occurring principally via joints and fractures (secondary porosity).

9.3.3 Groundwater levels

Groundwater level data was collated for the groundwater assessment for the proposed CRR project[9]. Groundwater level monitoring was also undertaken in bores installed around City Hall for the Brisbane City Hall basement damage groundwater investigation[10]. It is considered that groundwater levels in the alluvium and bedrock close to the Brisbane River will very likely be no more than one metre to two metres AHD and fluctuate in response to tidal variations in the Brisbane River. Natural groundwater levels in the CBD are likely to also be in the order of a just a few metres AHD.

There is evidence that groundwater levels in the CBD have been reduced, likely through a combination of reduced recharge, below-ground construction and long-term dewatering of basements. Groundwater level monitoring around City Hall for the Brisbane City Hall basement damage groundwater investigation [11] involved the installation of six bores to depths of between 4.6 metres to 12 metres below ground level adjacent to City Hall along Adelaide and Ann Streets. Two of these were installed into the alluvial channel deposits that underlie City Hall, both to a depth of 12 metres below ground level (2.5 metres to three metres AHD). All bores were dry approximately two weeks after installation, indicating a local groundwater level of less than three metres AHD. This appears to be a clear indication that dewatering in the CBD has significantly lowered natural groundwater levels. This apparent groundwater lowering may be associated with basement dewatering and possibly the existing underground busway route below King George Square.

[6] SKM-Aurecon CRR JV (2011) Cross River Rail EIS Technical Report No. 4: Groundwater Assessment, prepared for TMR
[7] SKM-Aurecon CRR JV (2011)
[8] SKM-Aurecon CRR JV (2011)
[9] SKM-Aurecon CRR JV (2011)
[10] Brisbane City Council (2007) Brisbane City Hall Basement Damage Ground Water Investigation, August 207, prepared by Ground Engineering
[11] Brisbane City Council (2007)

Gathering accurate groundwater level data for the locations along the alignment where below-ground excavation is required will be an important step in informing the design and construction process. Consideration should also be given to the likely natural groundwater level in areas where levels have been lowered (e.g. in the CBD possibly by basement dewatering), as groundwater rebound may occur if local groundwater extraction and control measures change in the future.

9.3.4 Groundwater use

Registered bores near the Cultural Centre precinct and Adelaide Street are shown on Figure 9.1. A review of the bore records suggests that these bores were installed for groundwater monitoring rather than extraction (i.e. the bore records provide construction details typical of monitoring bores). There are no known or registered groundwater extraction bores in the vicinity of the Brisbane Metro corridor where construction dewatering may be required.

9.3.5 Groundwater-dependent ecosystems

A review of the Queensland Government mapping of groundwater-dependent ecosystems[12] indicates there are no groundwater-dependent ecosystems in the vicinity of Brisbane Metro that are expected to be impacted by groundwater control or dewatering operations during construction (Cultural Centre precinct and CBD).

9.4 Construction impacts

The key groundwater issue during construction is the potential need for groundwater lowering or control during excavation of below-ground sections of the alignment (i.e. Cultural Centre precinct and Adelaide Street) and the associated issues of groundwater management and disposal. The likely requirement for construction dewatering will be informed by groundwater investigations to be undertaken during the planning and design phases. No groundwater extraction bores or groundwater-dependent ecosystems are identified near locations where construction dewatering may be required. Therefore, no construction-related impacts are anticipated on these receptor types.

9.4.1 South Brisbane

The new underground Cultural Centre station located beneath Grey Street and the associated underpass of the existing railway corridor are likely to require groundwater control measures during construction due to the geology and the depth of excavation. Existing site investigation data for this area is limited and the logs reviewed to date are for relatively shallow bores. However, there is a potentially significant thickness of alluvium present in this area in relatively close proximity to the Brisbane River. It is possible that at greater depths the alluvium may contain significant sandy horizons which could be in hydraulic continuity with the river and may yield significant quantities of groundwater if penetrated during excavation for construction.

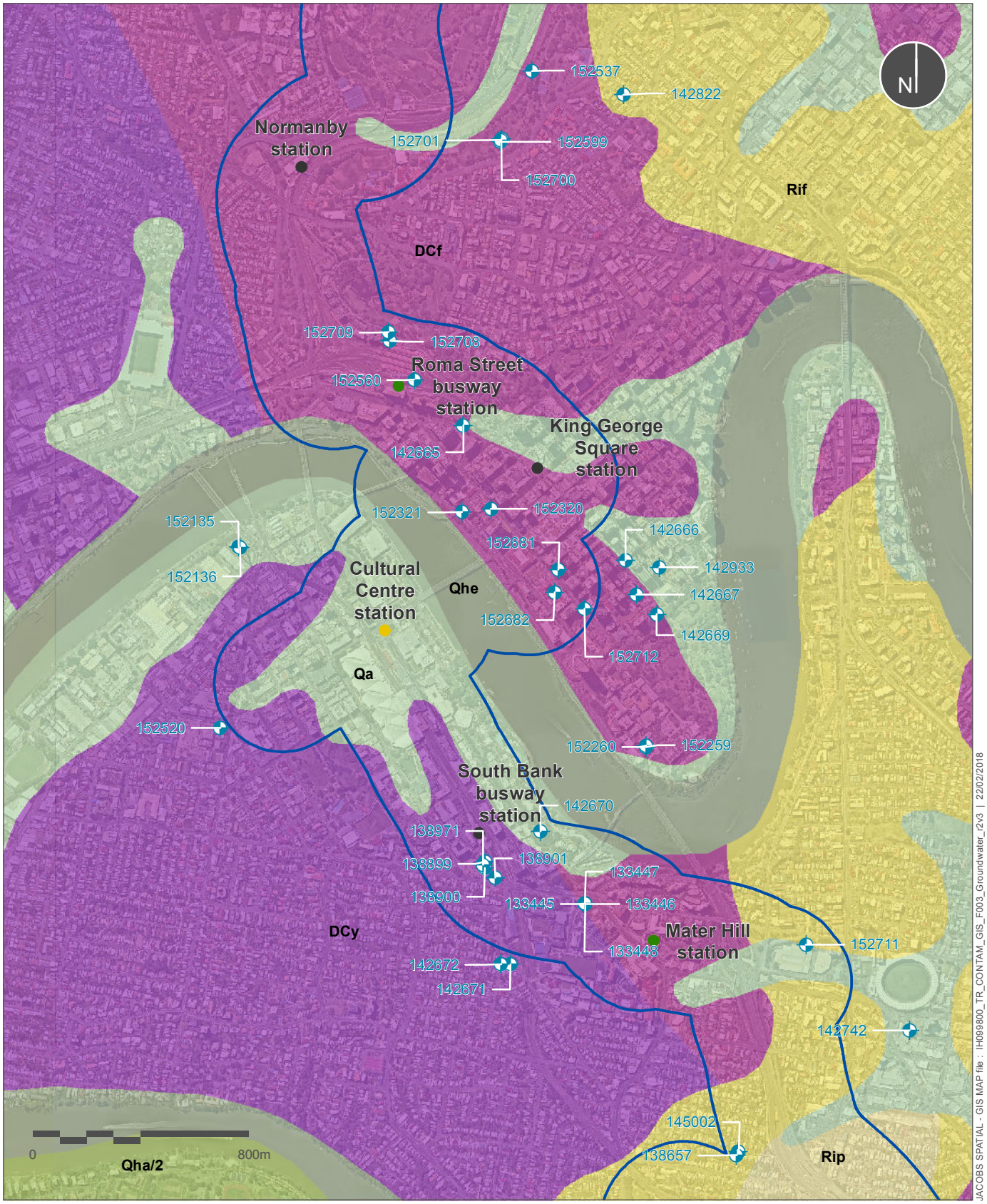
Depending on the final engineering solution adopted, groundwater levels may be locally lowered during construction, with potential for effects on local groundwater values. However, no significant groundwater values (groundwater users, groundwater-dependent ecosystems), have been identified in the vicinity of the Cultural Centre precinct.

There is a risk that groundwater in the vicinity of the Cultural Centre precinct is contaminated due to the local presence of contaminated land in the railway corridor (refer to Chapter 7). Consequently, the quality of groundwater needs to be established prior to any dewatering work, and if it is contaminated, any contaminated groundwater will require appropriate control and management prior to authorised disposal.

If contaminated groundwater is present in the vicinity of the new underground Cultural Centre station, it is possible that certain groundwater control measures (e.g. dewatering and the resulting drawdown) may mobilise this contamination to areas currently unaffected, towards receptors or into the construction works. Dewatering can potentially result in ground settlement around the excavation.

[12] Bureau of Meteorology (2017) Groundwater dependant ecosystem atlas

Figure 9.1: Registered bores in the vicinity of the Cultural Centre precinct and the CBD



Key

Study area

Stations

- New station
- Station modifications
- Station upgrades
- Registered borehole (DNRM 2016)

Detailed Surface Geology (DNRM 2016)

Quaternary

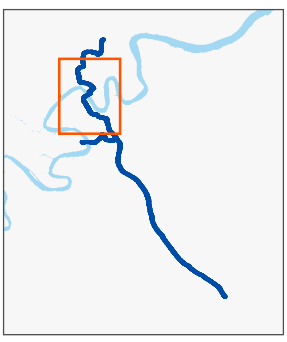
- Qha/2(Holocene
- Qhe (Holocene
- Qa (Quaternary

Triassic

- Rif (Brisbane Tuff)
- Rip (Aspley Formation)

Devonian-Carboniferous

- DCf (Neranleigh-Fernvale beds)
- DCy (Bunya Phyllite)



9.4.2 Brisbane CBD

As indicated in section 9.3.3, it is likely that groundwater levels in the CBD have been lowered over time by a combination of reduced infiltration, construction and long-term basement dewatering. As a result, excavations for the Adelaide Street tunnel are not expected to encounter significant volumes of groundwater or may be dry. In addition, no significant environmental groundwater values have been identified in the vicinity of these works.

9.5 Operational impacts

During operation, there is a risk of long-term groundwater ingress to new infrastructure constructed below the natural level of the water table. Groundwater rebound may occur if groundwater levels have been temporarily lowered during construction, and possibly due to cessation of local long-term groundwater extraction (e.g. basement dewatering in the CBD). The design will account for anticipated post-construction groundwater levels and possibly the need to avoid or manage long-term groundwater ingress to below-ground infrastructure.

As indicated in section 9.4, there is a risk that groundwater in the vicinity of the Cultural Centre station is contaminated. Consequently, there may be a risk to sub-water table structures from aggressive groundwater conditions although this will be addressed through the detailed design.

9.6 Mitigation and management measures

Investigations will be undertaken at the new underground Cultural Centre station and Adelaide Street tunnel to accurately establish the existing groundwater regime in terms of groundwater levels and groundwater quality (including seasonal and tidal variability in levels). If construction dewatering is required, the nature of the saturated strata (permeability and storage) should also be determined. This will inform a more detailed assessment of the potential groundwater risks and construction process (groundwater control and disposal) and the design (post-construction groundwater levels and prevention and management of groundwater ingress).

Groundwater investigations are considered particularly important in the vicinity of the Cultural Centre station, which is likely to require excavation to depths of up to four metres AHD. Site investigation data currently available for this location is limited and shallow and does not include groundwater level data, although it is considered that the natural groundwater level may be in the order of two metres AHD. There is a potentially significant thickness of alluvium present in this area in relatively close proximity to the river and investigations here should clearly establish the thickness and nature of the alluvium.

Investigations are also required to establish the quality of groundwater in this location which is considered likely to exhibit a degree of contamination from historic land uses. This data is required to determine the necessary treatment and disposal options during construction and/or the most appropriate construction and operational groundwater control techniques.

There is evidence that the natural groundwater level in the CBD has been reduced, possibly by basement dewatering. Groundwater monitoring in the vicinity of City Hall suggests levels are locally lower than three metres AHD. The design should consider the potential risks to the development from groundwater level rebound in the event that any current controls on groundwater levels change in the future.

9.6.1 Construction

If groundwater investigations indicate that significant groundwater inflows to excavations during construction are possible then appropriate construction techniques such as cut-off walls keyed into bedrock may be required to control or limit the inflow of groundwater. The construction technique could seek to minimise groundwater inflow to excavations and thereby reduce groundwater management and disposal issues, such as groundwater exclusion rather than active dewatering. This would also minimise off-site drawdown and the potential for contaminated groundwater migration in areas such as the Cultural Centre precinct, and the potential for dewatering associated with ground settlement around the excavation. Appropriate investigations at the planning and design phase will allow selection of the most suitable groundwater control, management and disposal methods during construction, for both environmental and engineering risk mitigation.

Where construction requires below-ground excavations, appropriate protocols for the control and containment of fuel and chemicals should be followed to minimise the potential for releases to ground and contamination of the local groundwater environment.

9.6.2 Operation

Groundwater investigations at the planning and design phase will ensure that appropriate design and construction minimises any significant risks from groundwater ingress or future rebound of groundwater levels above the level of below ground structures.

The need for long-term active groundwater controls such as pumping and management (treatment and disposal) can be avoided by appropriate design and construction such as effective groundwater exclusion rather than ongoing minor dewatering. Avoiding a solution which requires ongoing dewatering during operation would avoid the long-term mobilisation of potentially contaminated groundwater.

The design should consider the risk to sub-water table structures from aggressive groundwater conditions.

9.7 Summary

The majority of the alignment will require little or no excavation and no impacts on the groundwater environment are anticipated along these sections. Excavation works within the CBD and the new Cultural Centre station for Brisbane Metro may require groundwater control during construction. Investigations will be required at these locations to accurately establish the existing groundwater regimes to inform a more detailed assessment of the potential groundwater risks and construction process (groundwater control and disposal) and the design (post-construction groundwater levels and prevention and management of groundwater ingress).

If groundwater investigations indicate that significant groundwater inflows to excavations during below-ground construction are possible then appropriate construction techniques such as cut-off walls keyed into bedrock may be required to control or limit the inflow of groundwater. Where construction requires below-ground excavations, appropriate protocols for the control and containment of fuel and chemicals should be followed to minimise the potential for releases to ground and contamination of the local groundwater environment.

The need for long-term active groundwater controls such as pumping and management (treatment and disposal) can be avoided by appropriate design and construction such as effective groundwater exclusion rather than ongoing minor dewatering. The design should consider the risk to sub-water table structures from aggressive groundwater conditions.