Gateway Upgrade Project

9. Topography/ Geomorphology/Geology

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9. Topography/Geomorphology/Geology

9.1 Introduction

TOR Requirements:
This section should include descriptions and maps of the topographical, geomorphologic and geological features including:

- The topography of the site with contours shown at suitable increments, shown with respect to Australian Height Datum (AHD)
- Landforms of the site and surrounding areas, including an analysis of subsurface and slope stability where appropriate (landform patterns and elements should be described using the standardised classification of the Australian Soil and Land Survey Field Handbook, McDonald et al, 1990)
- Significant geological and landform features
- Potential economically significant mineral, energy and extractive material resources
- The geology of the wider Project area, with particular reference to the physical and chemical properties of surface and sub-surface materials and geological structures
- Hazards such as geological faults and unstable areas.

A review of the topographical, geomorphologic and geologic features relevant to the GUP has been undertaken and the potential impacts of the GUP assessed for the construction and operational phases. Mitigation measures to minimise the potential impacts have been recommended where appropriate.

9.2 Methodology

The methodology adopted for the existing environment assessment consisted of a desktop study of available geology plans, orthophotography and topography plans of the area. These were then ground truthed at a number of locations to generate the topography, landforms and the geology information presented below.

Landform patterns and elements have been described using the standardised classification of the Australian Soil and Land Survey Field Handbook, McDonald et al, 1990.

The impact assessment has been carried out for each of the three sections of the project. Issues addressed include stability and settlement requirements, general geotechnical considerations and construction risks.

9.3 Description of the Existing Environment

9.3.1 Mt Gravatt – Capalaba Road to Cleveland Branch Rail Line

Topography and Landforms

The southern section of the GUP contains a range of topographical landform patterns and elements. Elevations between Mt Gravatt–Capalaba Road and Old Cleveland Road range between 25m and 60m AHD with landform elements having relatively steep slopes associated with narrow hillcrests.

The general topography along the southern section of the GUP is shown in Figures 9.1a and 9.1b.

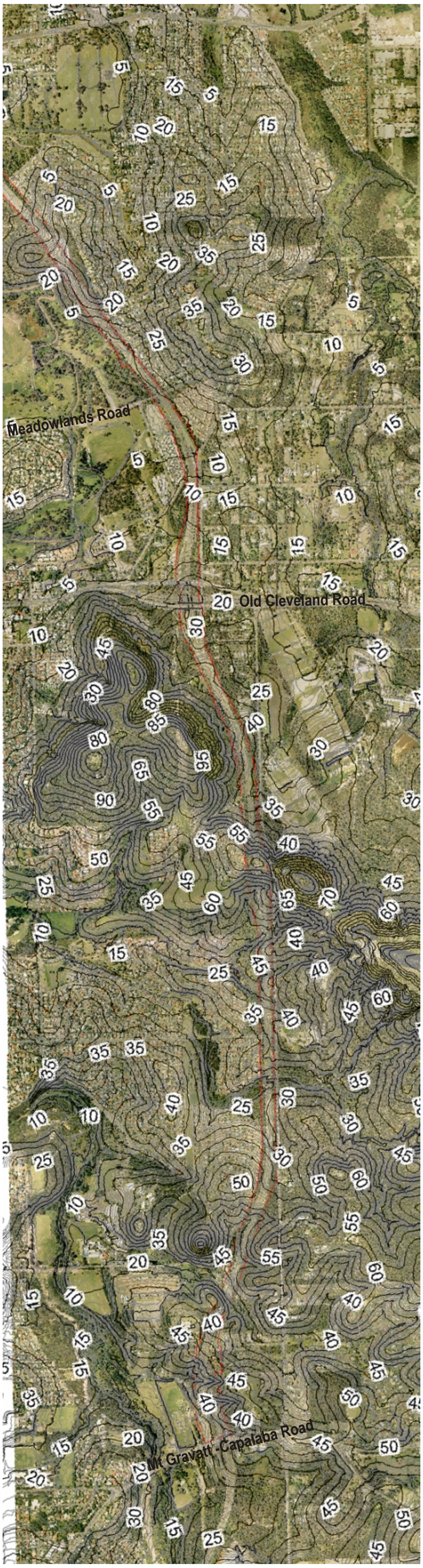


FIGURE 9.1a
Topography

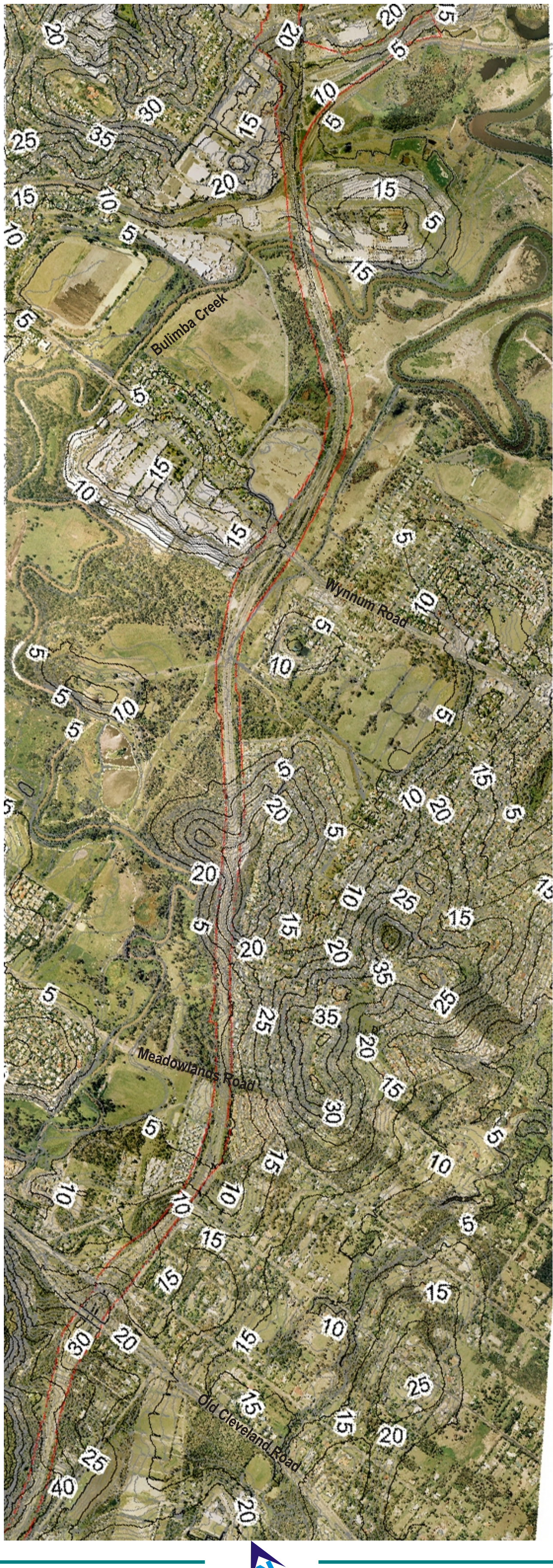


FIGURE 9.1b
Topography

Major landform patterns and elements within this section of the GUP and associated with the surrounding area include the following:

Chainage 5160 to 7000

The dominant landform pattern within this area consists of a series of undulating rises comprised of gently inclined slopes and narrow crests and gullies.

Chainage 7000 to 10000

The dominant landform pattern within this area is associated with the low hills, rises and ridge lines of the Mt Petrie and Belmont Hill features, which are comprised of very gently to gently inclined slopes and level footslopes with intermittent narrow crests and depressions.

Immediately south of Old Cleveland Road (CH8500 to 9700) the topography is relatively elevated as the alignment crosses the western footslopes of Mt Petrie and the associated low hills. Within this section of the GUP there are also a number of small open depression gullies intercepting the corridor, which have intermittent ephemeral flow after significant rainfall events.

Chainage 10000 to 15000

The dominant landform patterns within this area are the very gently inclined footslope of a low hill and level floodplain of Bulimba Creek.

The landform elements immediately north of Old Cleveland Road (CH10000 to 11000) continue to traverse the western footslope along the low hill towards the north until immediately south of Meadowlands Road, where the existing alignment intercepts the edge of the Bulimba Creek floodplain. The alignment then continues north and crosses the footslope to mid-slope of a series of rises and the elevated land intercepted by the existing alignment ranges between 5m and 20m AHD.

The GUP in the vicinity of the Wynnum Road underpass (CH13500) intercepts the Bulimba Creek floodplain. The alignment crosses the Bulimba Creek channel (CH14800) and continues north to intercept the lower slope of a rise, which ranges between 5m AHD at the footslope to 15m AHD at the crest (CH14900).

There is an isolated hillcrest located adjacent to the eastern side of the existing Motorway alignment where it crosses Bulimba Creek, immediately south of the Cleveland Branch Rail Line, which has a moderately steep slope southeast towards the Bulimba Creek channel. The northern slope of the hillcrest is gentler than the southern side and ranges between 5m AHD at the footslope and 20m AHD at the crest. Bulimba Creek and the associated floodplain area is low lying and relatively flat containing gentle slopes ranging between 1m and 5m AHD and perennial swampy areas, lagoons and areas subject to inundation.

A detailed description of landform patterns and elements as observed during the land survey is provided in Appendix G1.

Geology

The geology of the Mt Gravatt-Capalaba Road to Cleveland Branch Rail Line section comprises metamorphic rocks of the Devonian to Triassic periods approximately 380 to 260 million years ago, and conglomerate, sandstone, shale and tuff of the Triassic period approximately 220 million years ago.

Table 9.1 below contains summaries of these geological units and others expected along the alignment and their stratigraphic relationship. The regional geology is also shown on Figure 9.2. The relationship of the detailed geology on that map and the major stratigraphic units are also shown in Table 9.1.

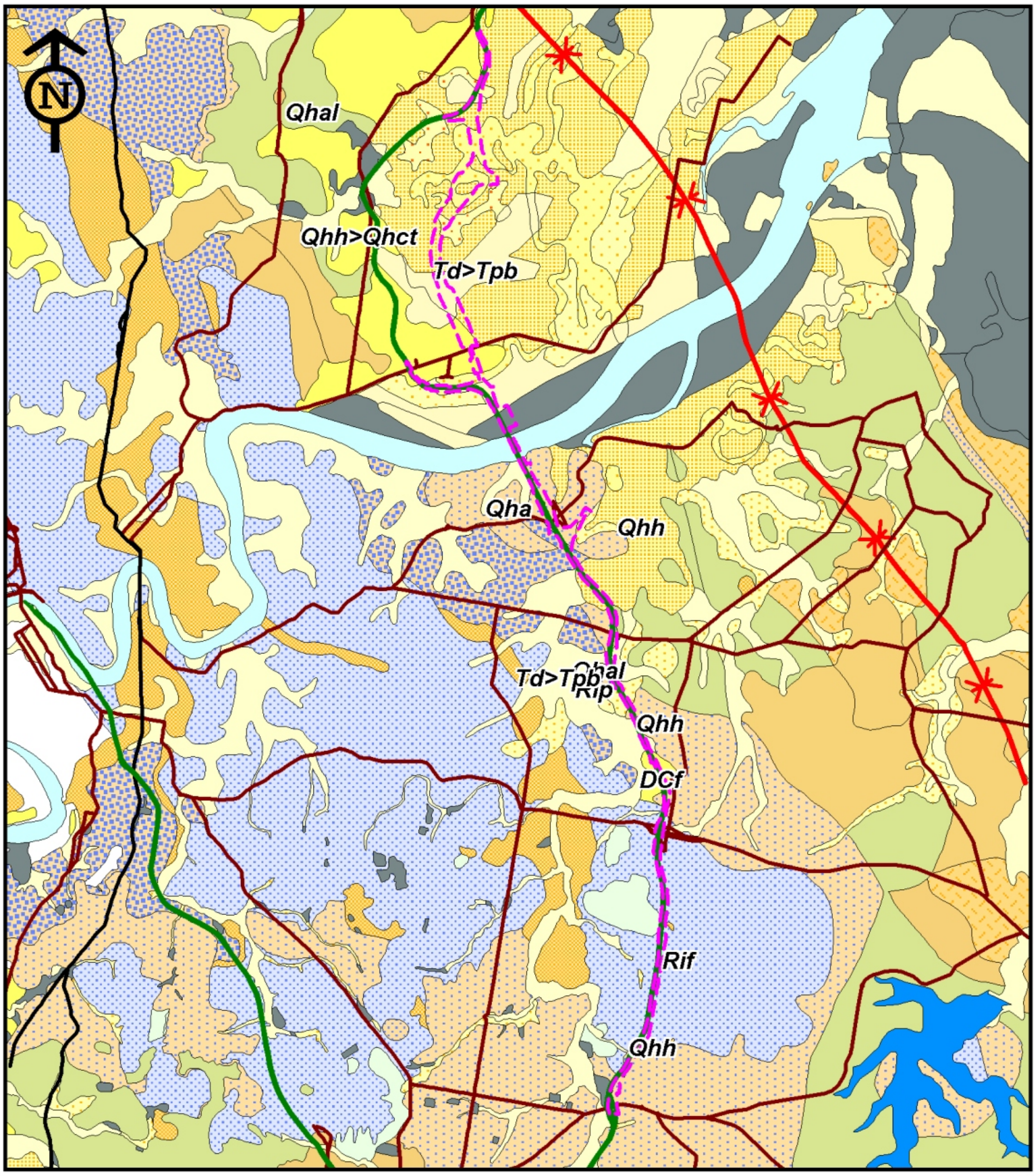
Table 9.1 Summary of Geological Units

Age	Name	Summary Description	Map Legend	Approximate Chainages
Quaternary	Holocene Alluvium	Sand, soft clay and gravel.	Qhc, Qhct, Qa	10700-11100 12500-13300 13900-15100 16850-24800
	Pleistocene Alluvium	Soft to firm silty clay, sand and gravel	Qpa	
Tertiary	Petrie Formation	Alluvial and colluvial-deposited silt, clay, sand and shale	Tp	No surface outcrop
Triassic	Woogaroo Subgroup	Sandstone, conglomerate, siltstone, shale and coal	RJbw	13450-13900
	Aspley Formation	Conglomerate, gravelly soils, basalt	Rip	15100-15200
	Tingalpa Formation	Shale, coal and sandstone.	Rin	5150-5700 5800-6150 10200-10700 11100-12500 13300-13450 15200-16850
Devonian	Neranleigh-Fernvale Formation	Phyllite, Greywacke, argillite, quartzite, chert, shale, sandstone and greenstone	DCf	5700-5800 6150-10200

Table Note:
Reference was made to the Australian 1:100,000 Geological Series Maps, Brisbane Sheet 9543, First Edition 1986 and Beenleigh Sheet 9542, First Edition 1974.

During the Devonian to Triassic periods, cyclic subduction and compression in the South Pacific slowed and basement Neranleigh-Fernvale beds were pushed up as a mountain belt against the continent. This unit consists highly metamorphosed rocks being phyllite, greywacke, argillite, quartzite, chert, shale, sandstone and greenstone. Constituents of this unit are generally hard, fine to medium grained and will be likely found in close vicinity to the Mt Gravatt-Capalaba Road intersection.

Concluding the late Triassic volcanic eruptions, rivers deposited sands and gravels along channels and floodplains to produce the Aspley (conglomerate) and Tingalpa (sandstones, shale, tuff and coal seams) Formations of the Ipswich Coal Measures. Rock of this nature is likely to be found north of Mt Gravatt-Capalaba Road to the Cleveland Branch Rail Line.



LEGEND

RJbw	Quartzose sandstone, siltstone, shale conglomerate, coal
Qhal	Linear depressions (ox-bows); mud, clay
Qhaw	Swampy basins; mud, silt, peat
Qhmd	Fluvial delta, lithofeldspathic sublabile sand, muddy sand
Qhh>Qp	Anthropogenic deposits: land fill, mine tailings, rubble over Qpa
Td>Tpb	Duricrusted old land surface: ferricrete, silcrete and indurated palaeosols at the top of a deep weathering profile on Petrie Formation basalt
Rip	Sandstone, conglomerate, minor shale
Qhct	Tidal flats; sand, mud, grades offshore into Qhms
Td>Tpb	Duricrusted old land surface: ferricrete, silcrete and indurated palaeosols at the top of a deep weathering profile on Petrie Formation basalt
Qr	Residual soil, colluvium; sand, soil, clay, rock debris
Ri	Shale, conglomerate, sandstone, coal, siltstone, basalt, tuff
Qhcb	Beach ridges; sand, shelley sand
Qhmp	Prodelta; mud, sandy mud
Qhc	Undifferentiated coastal plains; mud, sand, commonly with a veneer of Qha
Qpa	High level alluvium; silt, clay, sand, gravel
Rif	Rhyolitic tuff, ignimbrite, agglomerate, conglomerate, sandstone, shale
Qhav	Levee banks; sand, gravel, silt
Qhe	Estuarine channels and banks; sandy mud, muddy sand, minor gravel
Qha	Clay, silt, sand; active stream channel and low terraces
Rin	Siltstone, shale, thin coal seams
Qhe	Estuarine channels and banks; sandy mud, muddy sand, minor gravel
Tp	Mudstone, siltstone, sandstone, oil shale, brown coal, limestone
DCf	Mudstone, shale, arenite, chert, jasper, basic metavolcanics, pillow lava, conglomerate
Toc(w)	Lacustrine and some fluviatile greenish claystone, mudstone, siltstone, shale, minor limestone, intraformational conglomerate, fine argillaceous sandstone;
Qa	Clay, silt, sand, gravel; flood plain alluvium

Syncline (Extracted from Brisbane Sheet 9543 (1986))
Regional Roads
Freeway/Motorway
Proposed Gateway Upgrade Corridor

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FIGURE 9.2
Regional Geology

FIGURE 9.1c
Topography

As the result of widespread erosion during the late Tertiary (Paleocene era), silt, clay, sand and shales were deposited as the Petrie Formation which may be encountered underlying the area of the Cleveland Branch Rail Line. Its formation is the result of a small basin opening up across southeastern Queensland during tension of the crust in the Tasman Sea. Sediments of this formation are undisturbed and can be expected to be weak.

Minor alluvial deposits can be expected due to recent infilling of drainage lines. No structural discontinuities have been identified within this region.

Mineral resources have been mined in the past in this region, with various clay mines being established to produce products such as bricks and some gravel mines have been operational. There is the potential that sand reserves may exist of suitable mining quality. It is understood that there are no worked deposits immediately adjacent to the current Motorway alignment. Such materials, where extracted as part of the GUP could be beneficially utilised, if not required as fill for the project.

9.3.2 Cleveland Branch Rail Line to Pinkenba Rail Line

Topography and Landforms

Chainage 15000 to 15750

The alignment between the Cleveland Branch Rail Line (CH15000) and Lytton Road (CH15750) continues upslope from the Bulimba Creek floodplain and surrounding area, which contains commercial/industrial development on the more elevated land ranging between 5m and 25m AHD. The landform pattern extending through this portion of the alignment is highly modified as a result of nearby commercial/industrial development and associated infrastructure.

Chainage 15750 to 16900

North of Lytton Road to the southern bank of the Brisbane River (CH15750 to 16900) along the existing alignment the landform pattern and topography is dominated by a ridgeline. The associated slopes are moderately inclined to steep with elevations ranging between <5m AHD on the bank of the Brisbane River to 25m to 30m at the crest.

Chainage 17350 to 19000

From the northern bank of the Brisbane River to the Pinkenba Rail Line the landform pattern and topography has been significantly modified as a result of land use development including the Royal Queensland Golf Course, industrial development and the Pinkenba Rail Line. The land surface within this portion of the alignment is dominated by relatively flat low-lying land with elevations generally being below 5m AHD.

The general topography along this section of the GUP is shown in Figure 9.1c.

A detailed description of landform patterns and elements as observed during the land survey are provided in Appendix G1.

Geology

Geologic units encountered through this section comprise the Woogaroo Subgroup within the southern end of this section at the Cleveland Branch Rail Line with the remaining extent being alluvium deposits derived by the meander of the Brisbane River.

The Woogaroo Subgroup was deposited during the late Triassic as the continent became more stable and mountain ranges began to erode. Large volumes of sand, gravel and silt were deposited in bars and channels as well as floodplains by large high velocity rivers. As the power of such rivers decreased, sediment began accumulating within floodplains resulting in the formation of the Woogaroo Subgroup.

The widespread Quaternary Period alluvium deposits are of two distinct layers being of the Pleistocene (2 million to 10,000 years old) and Holocene (10,000 years old to the present) periods.

Pleistocene Alluvium overlies Tingalpa, Aspley and Petrie Formations (as discussed in other sections) and comprises clay, sand and gravels. Pleistocene alluvium is separated from recent Holocene alluvium by an old land surface when sea level was 100m higher than the present level some 20,000 to 10,000 years ago.

Holocene alluvium can be divided into two sub-layers. An older, lower layer of clay with occasional sand lenses can be found accumulated in Pleistocene age paleo-gullies, and the most recent upper layer tends to contain more sand.

A simplified subsurface profile is presented as Figure 9.3. This profile covers the region north of the Brisbane River and provides a summary of the variable depths of alluvium in this region.

Mineral resources have been mined in the past in this region, with various clay mines being established to produce heavy products such as bricks and some gravel mines have been operational. There is the potential that sand reserves may exist of suitable mining quality. A discontinued coal mine was located immediately west of the current Gateway Bridge southern abutment.

A large northeast trending fault (Buranda Fault) cuts across the proposed alignment through possible Woogaroo Subgroup and Neranleigh-Fernvale basement. A further inferred fault may crosscut the Buranda Fault striking north/northwest. The stratigraphical relation between these two faults is unknown. The extent of this inferred fault is from Wynnum Road in the south to Lytton Road in the north through the Woogaroo Subgroup.

Table 9.1 provides a summary of these stratigraphic units. The corresponding detailed regional geology is also shown on Figure 9.2.

9.3.3 Pinkenba Rail Line to Nudgee Road

Topography and Landforms

Chainage 19000 to 21000

The landform pattern and topography from the Pinkenba Rail Line (CH19000) to Airport Drive (CH21000) has been significantly modified as a result of land use development including residential development, Doomben Racecourse, the old airport site and existing BAC land. The land surface within this section of the GUP is dominated by relatively flat low lying land with elevations generally being below 5m AHD, particularly along the eastern side of the alignment. The old airport site (CH19100 to 20750) and BAC land (south of Airport Drive) (CH20750 to 21000) are located to the eastern side of the existing Motorway between the Pinkenba Rail Line and Airport Drive. This area is dominated by flat low-lying alluvial plains containing intermittent swampy areas and crosses an engineered drainage channel located on the old airport site. On the western side of the Motorway residential land is located in areas above 5m AHD.

Chainage 21000 to 24800

North of Airport Drive (CH21000) through to Nudgee Golf Course (CH 24250 to 24800) the landform pattern and topography to the east of the existing Motorway is predominantly comprised of flat low lying floodplain areas containing intermittent swampy areas, Schulz Canal, isolated lagoons and the Kedron Brook Floodway channel. Elevations in this section of the GUP are generally below 5m AHD. At the northern extent of the project the Nudgee Golf Course is located on the eastern side of the existing alignment and the Nudgee Waterhole Reserve is located to the north west of the GUP, which is subject to inundation.

The general topography along the northern section of the GUP is shown in Figure 9.1d.

A detailed description of landform patterns and elements as observed during the land survey is provided in Appendix G1.

Geology

The area is part of a deltaic plain formed by the Brisbane River. The growth of the Brisbane delta progressed slowly to its present form as sediments supplied by the Brisbane River built up. The quaternary age alluvium/coastal sediments of the plain comprise interbedded clay, silt and sand and sometimes gravels near the base. The sediments can be divided into the Holocene and Pleistocene units as shown in Table 9.1.

The younger Holocene alluvium layer comprises either:

- Very soft to stiff dark grey and normally consolidated clay with minor interbedded sandy or silty strata and sometimes a thin gravelly base layer. The clay layer is highly compressible and exhibits significant settlement when loaded; or
- Sandy layer with soft clay confined to relatively thin layers.

The older Pleistocene (lower) alluvium consists mainly of firm to hard grey and brown clay, and sandy clay with interbedded sand and minor gravels. Dense gravels of varying thickness are commonly found at the base of this unit.

The underlying rock belongs principally to the Petrie Formation of Tertiary age. It consists of poorly lithified mudstone and sandstone with a thick layer of altered basalt. The rocks are mostly flat lying to gently dipping.

A simplified subsurface profile is presented as Figure 9.3. This profile covers the region north of the Brisbane River and provides a summary of the variable depths of alluvium in this region.

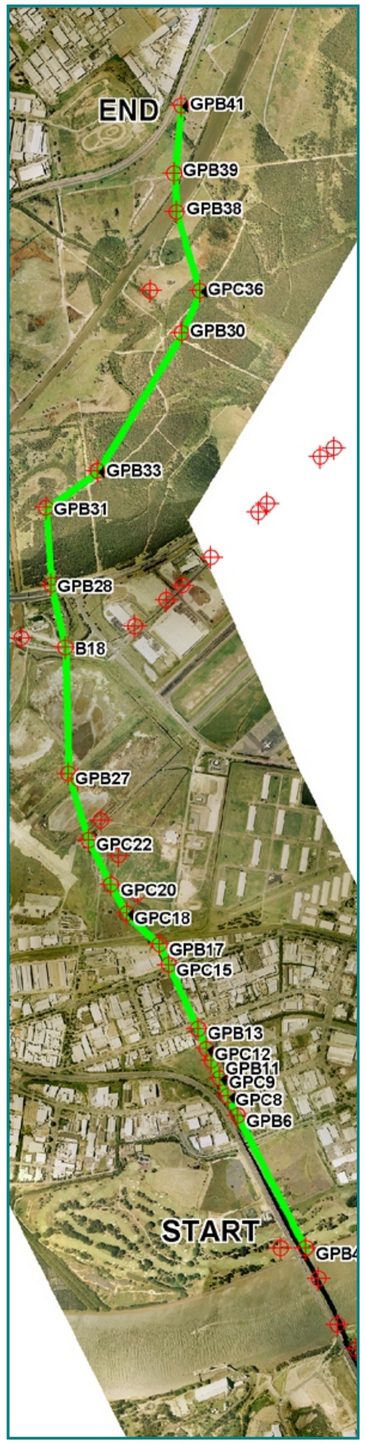
There is evidence of a syncline through this area, however no major structural discontinuities have been identified as associated with it.

There are potential economic sand deposits within this region and clay heavy products mines have been established and abandoned recently.

Queensland Government
Department of Main Roads
Australian Government
Department of Transport and Regional Services
Connell Wagner

FIGURE 9.1d
Topography

ALIGNMENT MAP



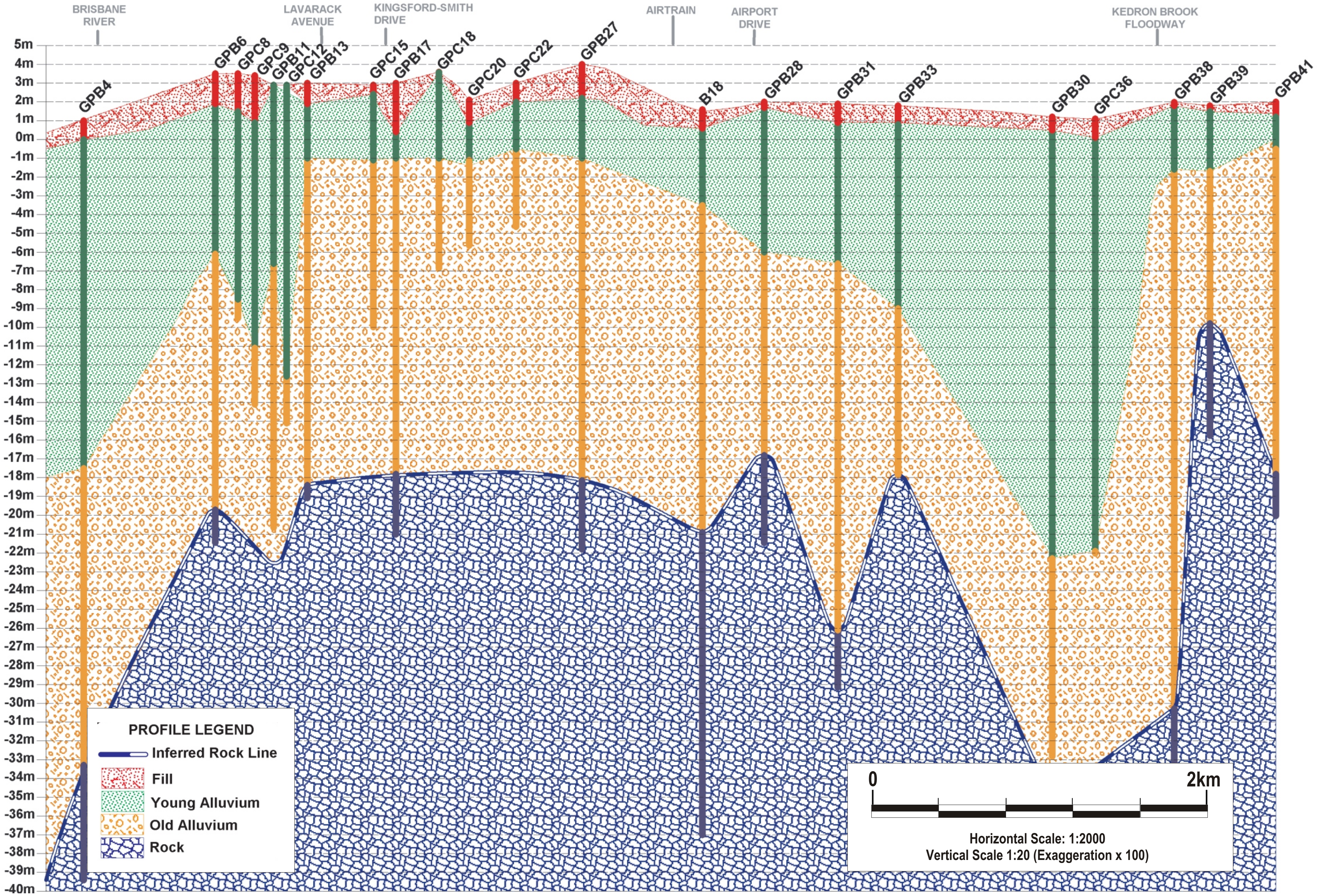


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FIGURE 9.3
Simplified Subsurface Profile for North of Brisbane River

9.4 Potential Impacts

TOR Requirements:

- Discuss the potential impacts on the topography, geomorphology and geology of the site in the local and regional context including the degree and nature of change to the existing landform features;
- Provide a contour map of the area pre- and post-construction; and
- Discuss the final drainage system and make comparisons between pre- and post-construction (see also Section 4.5 of these TOR).

9.4.1 Mt Gravatt – Capalaba Road to Cleveland Branch Rail Line

Whilst the majority of this section of the GUP comprises relatively minor cuts and fills on a competent geology, there are zones of weak soils. The weak soils are considered to be the major geotechnical issue for the GUP. The potential impacts of the topography, geomorphology and geology are considered to be earthworks, settlements and stability requirements of the cut and fill embankments. These works will also have implications for visual, drainage, noise and associated issues. For the most part, this section comprises relatively minor increases to the existing cut and fill embankments.

The geotechnical issues related to the project are illustrated in Figures 10.5a and 10.5b. The potential geotechnical issues are as follows:

- Stability of embankment and cut batters;
- Settlement of embankments constructed over weak alluvium;
- Time for settlement to occur;
- Construction and future (operational) settlement;
- Acid sulphate soils; and
- Horizontal/vertical stress induced by new embankments on nearby existing Gateway embankments/other structures.

Any embankments constructed over weak alluvium may undergo severe settlement problems. The extent and the duration of settlements will depend on the subsurface material. Granular material undergoes rapid elastic settlements while cohesive materials undergo settlement over a long period of time. The settlement in cohesive soils could be classified into consolidation settlement and creep settlement.

Embankment batters need to be designed to be stable in the short and long term depending on the type of the material underneath. In areas where the embankments are placed over cohesive alluvial soils then the undrained soil parameters of the underlying soils govern slope stability. For other geological conditions long term or effective stress parameters would control stability.

The embankment typically exerts stresses and deformations beyond its footprint. This can have a significant influence on nearby buildings and structures. Stress and deformation analysis will therefore need to be carried out during detailed design to assess the areal extent of movements.

Typical cross sections are included in Volume 3. These sections illustrate the changes to the existing topography and geomorphology along the GUP corridor. These sections present the extent of cut and fill operations, other earthworking details and location of retaining walls and other structures.

9.4.2 Cleveland Branch Rail Line to Pinkenba Rail Line

This section of the GUP generally mirrors the Mt Gravatt-Capalaba Road to Cleveland Branch Rail Line, in that there is both generally competent geology (south of the Brisbane River) and alluvium. However, north of the Brisbane River the depths of alluvium are considerably greater than that encountered in the southern section.

Therefore, the major issues within this section are fill embankments and associated settlement and stability issues. The extent of earthwork in this section is considered minimal. For additional detail of these issues refer to Section 9.2.1.

Figure 10.5c presents a summary of the geological and geotechnical issues along the GUP.

9.4.3 Pinkenba Rail Line to Nudgee Road

This section is dominated by deep alluvium and hence the major issues are fill embankments and associated settlement and stability issues. There is no excavation in this region, with the possible exception of excavating deep pile foundations. Therefore, the major impact will be from fill embankments and bridge structures. For additional detail of these issues refer to Section 9.2.1.

Figures 10.5c and 10.5d presents a summary of the geological and geotechnical issues along the GUP.

9.4.4 Summary of Impacts along Route

In summary the overall potential topographical and geotechnical impacts for the GUP are:

- Stability of embankment and cut batters;
- Settlement of embankments constructed over weak alluvium;
- Time for settlement to occur;
- Construction and future (operational) settlement;
- Acid sulphate soils; and
- Horizontal/vertical stress induced by new embankments on nearby existing Gateway embankments/other structures.

9.5 Mitigation Measures

9.5.1 Design

To minimise the potential impacts discussed above the following mitigation measures should be applied in design:

- Both short and long term batters will need to be assessed for global stability. The batter angles will need to be appraised during detail design based on material strengths and other properties. Detailed investigations will be required to determine these properties. Stability analysis will be required to assess the factor of safety of these slopes;
- Fill embankments during detailed design need to be assessed in terms of both settlements and stability;
- The detailed design of the GUP will need to be carried out in accordance with good engineering practice;

- In terms of geology, the design process will require the input of a comprehensive level of information on the subsurface profile, the strength and reactivity properties of the various materials and groundwater information; and
- A detailed geotechnical investigation will be required to obtain this information. Stability assessments will need to be undertaken and depending on any rock batter heights, this may need to include a rock mechanics study. Foundation design parameters will need to be derived, as will potential settlements of fill embankments and foundations.

9.5.2 Construction

To minimise the potential impacts during construction, the following mitigation measures should be applied:

- Bulk earthworks will need to be carried out in a controlled manner. Whilst anticipated earthworking will be dominated by filling (north of the River) and only relatively minor excavations will be required, both operations will need to be carried out under strict control;
- Drainage and overland water flows will need to be carefully controlled so as to not impact of the stability of fill embankments and natural soil slopes. Vegetation should be established as soon as practicable to ensure slope face degradation does not occur; and
- Careful construction practices will be required in the vicinity of any settlement monitoring devices to ensure damage does not occur.

9.5.3 Operation

To minimise the potential impacts during operation the following mitigation measures should be applied:

- An adequate level of maintenance on surface and subsurface drains will be required; and
- Vegetation on soil slopes should be maintained to prevent face degradation.

Other mitigation measures are included in the EMP (refer Section 23).

9.6 Conclusions

Whilst there are significant engineering issues associated with the GUP, in terms of geological and geotechnical aspects, it is considered that there is no direct impediment to the successful construction and operation of the project. The key geotechnical engineering issues are:

- Stability of the fill embankments and cut batters; and
- Settlements of the fill embankments.

As a result, careful engineering design is required to ensure that there are no instability issues and that magnitudes of settlement are within allowable tolerances. In order for this engineering design to proceed, extensive geotechnical investigations are required during detail design to characterise the subsurface materials along the GUP.

Appropriate mitigation measures have been provided to minimise impacts during the construction and operation phases.