Preliminary Geotechnical Appraisal Report

January 2010
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NZ Transport Agency

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</table>
Contents

Executive Summary 3

1 Introduction 5

2 The Site 7

3 Scope of this Appraisal 9

4 Regional Geology 11

4.1 Stratigraphy 11

4.2 Geomorphology 12

5 Seismic Hazards 15

5.1 Seismicity 15

5.2 Liquefaction Hazard 15

5.3 Earthquake Induced Slope Stability Hazard 15

5.4 Vulnerability of State Highways in the Wellington Region 16

6 Past Geotechnical Investigations 17

6.1 Previous Studies 17

6.2 Past Geotechnical Investigations 17

6.3 Observations 18

7 Proposed Development as part of Basin Reserve Improvements 19

7.1 Scenarios 19

7.2 Key Engineering Features of the Scenarios 20

7.3 Possible Road Form 21

8 Geotechnical Engineering Issues and Solutions 23

8.1 Key Geotechnical Engineering Issues 23

8.2 Fill Slopes, Retaining Walls and Foundations 26

9 Proposed Geotechnical Site Investigations and Testing 27

10 Recommendations 29

11 References 31

Appendix A - Options Plans 33

List of Figures

Figure 1: Location of site

Figure 2: Geological Features and Past Investigations
Executive Summary

The New Zealand Transport Agency (NZTA) has commissioned Opus International Consultants (Opus) to investigate and develop improvements to the road transportation in the Basin Reserve area, to scheme assessment report (SAR) stage.

We have completed a preliminary geotechnical appraisal for the project comprising a desktop study, site reconnaissance and a review of the key geotechnical issues for the currently proposed schemes. No geotechnical investigations have been undertaken for this project. However, past investigations for the Wellington Urban Motorway Extension and in particular for the Tunnel-Link project provide some information that gives us a basic understanding of the ground and groundwater conditions in the area.

The Basin Reserve area is located in a low lying valley between Mount Cook and Mount Victoria, with the state highway climbing down from opposite the Carrilion on Buckle Street to the low lying Basin Reserve, and rising to the Mount Victoria Tunnel west portal at the foot hills of Mount Victoria. The area is primarily underlain by late Holocene and Pliocene age Alluvium, underlain by late Triassic age Wellington Greywacke bedrock comprising interbedded sandstone, siltstone and mudstone.

Key geotechnical issues for the project are the soft and liquefiable ground in the vicinity of the Basin Reserve, with high groundwater levels and artesian groundwater at relatively shallow depths. Key geotechnical engineering issues for the potential road forms under consideration are presented, and potential risk management measures and solutions are indicated.

A staged programme of geotechnical investigations are proposed, with an initial Stage 1 to identify, ascertain their functionality and monitor available piezometers installed as part of some previous projects, in order to gain an understanding of present day seasonal groundwater fluctuations over a period of time.

Stage 2 geotechnical investigations will be recommended once the preferred option is chosen as part of the current scoping study.
1 Introduction

The New Zealand Transport Agency (NZTA) has commissioned Opus International Consultants (Opus) to investigate and develop improvements to the road transportation in the Basin Reserve area in Wellington City, to scheme assessment report (SAR) stage. The project is part of the Wellington Airport to Levin Road of National Significance, the Ngauranga to Airport Corridor Plan, which is directly connected to the Wellington Regional Land Transport Strategy (RLTS 2007-2016).

1. Increase the efficiency of through-traffic between the Mount Victoria Tunnel and the Inner City Bypass and SH1 Motorway.

2. Improve the efficiency, reliability and level of service of passenger transport services between Kent and Cambridge Terraces and Adelaide Road.

3. Improve safety for those who use the streets around the Basin Reserve.

4. Maintain or enhance the present level of service for local traffic between Kent and Cambridge Terraces and Adelaide Road and their connections to SH1.

5. Improve pedestrian and cyclist access.

The Ngauranga to Airport Strategy study recommended possible improvements (Option B3) to the Basin Reserve area (Opus, 2006-2008), and Inquiry by Design Workshops were facilitated by Urbanismplus (2009), which further developed options from Option B3, renamed Option 1A. The workshop resulted in a total of five scenarios (Scenarios 1C, 2A, 8, 9A and 9B) for further investigation in the scoping stage of the Scheme Assessment.

The scoping and scheme development stages include geotechnical investigations and assessment, to provide information to develop robust options, designs and cost estimates that take into consideration the geotechnical issues and constraints at the project site. The first step in the geotechnical investigation is this Preliminary Geotechnical Appraisal Report.

The scheme assessment will include geotechnical investigations and assessment, to provide information to develop robust options and cost estimates that take into consideration the geotechnical conditions, issues and constraints at the project site.

We have prepared this preliminary geotechnical appraisal report to provide an overview of the key geotechnical issues of influence to the proposed improvements in the Basin Reserve area. Because Opus already holds some information in this area, and there are a variety of options under consideration at this scoping stage, it has been agreed with NZTA that recommendations on the scope of the geotechnical investigations will be prepared and investigations implemented after a preferred option is selected at the end of the scoping stage.
2 The Site

The proposed Basin Reserve Improvements are located between Taranaki Street and the Mount Victoria Tunnel west portal along State Highway 1 (SH 1), the Basin Reserve area and the adjacent sections of roads, especially Cambridge Terrace, Kent Terrace and Adelaide Road. The Basin Reserve is located in Wellington City, some 1.5 km south of the Wellington City centre, see Figure 1.

The NZMS 260 Map Grid Reference for the Basin Reserve is R27-R28 591 881.

The Basin Reserve Grounds is of historic importance and continues to be used for playing cricket. Government House is located to the southeast of the Basin Reserve, and the New Zealand War Memorial is located to the west along Buckle Street. Wellington College, St Marks and Wellington East Girls College are also located south east of the Basin Reserve grounds.

The Basin Reserve is surrounded by a square of four roads – Buckle Street (north), Dufferin Street (east), Rugby Street (south) and Sussex Street (west).
3 Scope of this Appraisal

We have completed:

- A desktop study of geology and hazard maps;
- A review of past relevant geotechnical reports and the results from past investigations;
- A site reconnaissance visit by our geotechnical engineer, P Brabhaharan;
- Perusal of the proposed scenarios from the Inquiry by Design workshop facilitated by Urbanismplus (2009);
- Consideration of the earthworks and structures that are under consideration, and geotechnical issues that may influence their development; and
- Consideration of a strategy for carrying out the geotechnical investigations in a staged manner given the programme for option selection and scheme development.

It is envisaged that once the option(s) for scheme assessment is chosen, this preliminary geotechnical appraisal report will need to be reviewed and updated, and will include recommendations for geotechnical investigations, testing and assessment.
4 Regional Geology

4.1 Stratigraphy

The regional geology of the area is shown on the 1:50,000 scale Geological Map 22 *Geology of the Wellington Area* (Institute of Geological & Nuclear Sciences, 1996), as reclamation fill, marine sediments and alluvium underlain by Wellington Greywacke, see *Illustration 1*.

*Illustration 1 - Regional Geology*

(After Institute of Geological and Nuclear Sciences, 1996)

The main geological units in the area based on the geology map comprise:

- Reclamation landfill (fr)
- Late Quaternary Holocene age, alluvium (fa) marginal marine sediments (fm).
- Pleistocene age alluvium (In).
- Late Triassic age Wellington Belt Greywacke, which generally comprises interbedded sandstone, siltstone and mudstone.

The local geology from the Department of Scientific and Industrial Research (1974) map (1:25,000 scale) is shown on *Illustration 2*. 
This map shows a similar geology, with the Basin Reserve area underlain by:

- sl – debris, fill
- sp – marine sand, silt, shell
- sh – post-glacial gravel
- ge, gk, gw – gravel
- r – undifferentiated greywacke rock.

The Class II active Lambton Fault is located through the Massey University Music School (Mount Cook) area.

4.2 Geomorphology

The Basin Reserve is bound by Mount Cook to the west, and the much higher Mount Victoria to the east. Newtown valley is located along Adelaide Road to the south and the Te Aro flats to the north. SH 1 climbs down from Buckle Street in the Mount Cook area to the Basin Reserve grounds, and then climbs up to the western portal of Mount Victoria Tunnel at the foothills of Mount Victoria hills.

Given that the basin reserve area was a low lying swamp prior to the 1850’s, the then colonial government planned an inland dock at the present Basin Reserve (hence the name basin), with a canal leading from the Wellington Harbour between Kent Terrace and Cambridge Terrace, see Illustration 3. However, this plan did not reach fruition as the area was uplifted in the 1855 Wairarapa Earthquake, draining the area, and presumably making the inland dock proposal more difficult.

Nevertheless, the Basin Reserve remains the lowest point in that locality, with groundwater and surface water draining to the north along the Cambridge / Kent Terrace corridor.
A number of streams were located in the area in the past. The historical 1840 plan of the City of Britannia (as Wellington was then called) showed two streams along either side of the Basin Reserve area, and a further stream between Sussex Street and Tasman Street, see Illustration 3. These are likely to have been culverted as the city developed.

Wellington Greywacke bedrock is exposed along Tasman Street to the west in the Mount Cook area and at the foothills of Mount Victoria adjacent to the tunnel entrance.
5 Seismic Hazards

5.1 Seismicity

The project is located in the Wellington Region, an area of high seismicity in New Zealand. The Region has a number of major active faults and a subduction zone capable of producing large earthquakes of Richter Magnitude 7.5 to 8. A number of active faults are located in the vicinity of the area, and are summarised in Table 1.

**Table 1: Active Faults in the Region**

<table>
<thead>
<tr>
<th>Active Fault</th>
<th>Recurrence Interval of Rupture</th>
<th>Characteristic Magnitude</th>
<th>Distance from Project Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wellington Fault</td>
<td>600 yrs</td>
<td>7.5</td>
<td>2.5 km</td>
</tr>
<tr>
<td>Ohariu Fault</td>
<td>2,200 yrs</td>
<td>7.5</td>
<td>7 km</td>
</tr>
<tr>
<td>Wairarapa Fault</td>
<td>1,500 yrs</td>
<td>8.1</td>
<td>17 km</td>
</tr>
<tr>
<td>Pukerua – Sheperds Gully Fault</td>
<td>3,500 yrs</td>
<td>7.4</td>
<td>10 km</td>
</tr>
</tbody>
</table>


The Wellington Fault is located at a distance of about 2.5 km from the Basin Reserve. Characteristic rupture of the Wellington Fault could give Richter magnitude 7.5 earthquakes, with fault displacements of the order of 4 m horizontal and 1 m vertical.

5.2 Liquefaction Hazard

A liquefaction hazard study (Brabhaharan, 1994) of the Wellington Region carried out for the Wellington Regional Council (1993) indicated that the eastern part of the Basin Reserve has a high potential for liquefaction, with liquefaction possible in a regional earthquake as well as a characteristic magnitude 7.5 Wellington Fault earthquake event.

The geotechnical investigations and assessment carried out for the Tunnel-Link project (Works Consultancy Services, 1991a) confirm the presence of liquefiable soil layers up to 3.5 m thickness in the Basin Reserve area.

5.3 Earthquake Induced Slope Stability Hazard

An earthquake induced slope failure hazard study (Works Consultancy Services, 1994) carried out for and published by Greater Wellington Regional Council (1995) indicates a high slope failure susceptibility of the slopes at the Mount Victoria Tunnel portal areas. The high slope failure susceptibility could lead to very severe slope failure potential in a magnitude 7.5 earthquake associated with a characteristic rupture of the Wellington to Hutt Valley segment of the Wellington Fault, particularly at the east portal of the Mount Victoria Tunnel. This would give rise to small to very large slope failures.
5.4 Vulnerability of State Highways in the Wellington Region

A study of the vulnerability of the state highways in Region 9 (Wellington Region) was carried out for NZTA by Opus International Consultants (2008). That study indicated that the Mount Victoria Tunnel portal areas are vulnerable to failure, and are likely to lead to full closure of the highway in large earthquake events such as that associated with rupture of the Wellington Fault, and that it could take some time to reopen (possibly greater than 3 months).

It would be prudent for state highway upgrades to take into consideration this vulnerability, with a view to improving the resilience and route security of the state highway lifeline routes.
6 Past Geotechnical Investigations

6.1 Previous Studies

The Wellington Urban Motorway Extension (WUME) scheme was under consideration since the 1970’s to the mid 1990’s, to extend the motorway from the south portal of the Terrace Tunnel to the west portal of Mount Victoria Tunnel. During the early 1990’s this evolved into the Tunnel-Link scheme where this motorway extension was to be in a cut and cover tunnel over most of this length from about Ghuznee Street to Sussex Street, with an embankment / bridge around the north of the Basin Reserve grounds.

As part of these Wellington Urban Motorway Extension schemes, a series of geotechnical investigations, assessment and preliminary design was carried out. The stages of geotechnical investigations relevant to the Basin Reserve project are:

- Wellington Urban Motorway, Taranaki Street to Tory Street Section, Drilling Supervision & Laboratory Testing (Brickell Moss Rankine & Hill, 1972).

A variety of geotechnical investigations were carried out as part of these studies.

6.2 Past Geotechnical Investigations

**WUME, Taranaki Street to Tory Street Section (Brickell Moss Rankine & Hill, 1972)**

Site investigations, comprising five boreholes (identified as ‘B’ series in Tunnel-Link study) between Cuba Street and Tory Street, with Standard Penetration Tests (SPT) in the boreholes and laboratory tests on samples recovered. The locations of these investigations that fall within this project area are shown on Figure 2.

**WUME, Terrace Tunnel to Mount Victoria, Additional Site Investigations 1989 (Works Central Laboratories, 1990)**

Site investigations comprising 11 boreholes (identified as D series in Tunnel-Link study) with SPTs, 68 static cone penetration tests (identified as C series in the Tunnel-Link study), shear wave velocity tests and laboratory tests were carried out in 1989-1990. The locations of the site investigations that fall within this project area as shown on Figure 2.
Site investigations comprising 10 boreholes with SPTs, field and laboratory permeability tests and installation of piezometers were carried out in 1991. The locations of the site investigations that fall within this project area are shown on Figure 2.

Building Investigations

Other site investigations for buildings in the surrounding area may be available from Wellington City Council or building owners.

6.3 Observations

The following observations are made from a review of the past site investigations in the Basin Reserve area:

- There is some geotechnical information available in the immediate corridor of the previous Tunnel-Link scheme. In the Basin Reserve area, this is at the northern margin the Basin Reserve in the general location of Buckle Street and Dufferin Street.

- There are significant uncertainties as to the knowledge of the ground and ground water conditions in the Cambridge Terrace, Kent Terrace, Hania Street, Ellice Street and Brougham Street areas.

- The ground conditions vary quite significantly in this area, with the low lying area, and the Mount Victoria and Mount Cook foothills either side.
7 Proposed Development as part of Basin Reserve Improvements

7.1 Scenarios

The Ngauranga to Airport Strategy study recommended possible improvements (Option B3) to the Basin Reserve area (Opus, 2006-2008). This was followed by a Basin Reserve Workshop facilitated by Urbanismplus (2009), which further developed options from Option B3, which was renamed Scenario 1A. The workshop resulted in a total of five scenarios (Scenarios 1C, 2A, 8, 9A and 9B) for further investigation in the scoping stage of the Scheme Assessment, and these are shown on the sketches in Illustration 4.

Illustration 4 - Scenarios from Basin Reserve Workshop

(After Urbanismplus, 2009)
As part of the current scoping phase, tunnel options may be considered between Taranaki Street and Ellice Street.

Plans showing the improvement Scenarios under consideration in the scoping stage of this project are included in Appendix A.

### 7.2 Key Engineering Features of the Scenarios

Two types of scenarios are being considered – scenarios involving at-grade road solutions (Scenarios 8, 9A and 9B), and options involving grade separation (Scenarios 1C and 2A).

**At-grade Scenarios**

The at-grade scenarios all involve the construction of additional lanes and intersections, particularly around the northwestern, northern and northeastern sides of the Basin Reserve ground. The new roads are all at grade.

Key engineering features of the at-grade scenarios are:

- Potential small embankments, cuttings and retaining walls as the new roads grade down towards the Basin Reserve and Cambridge Terrace / Kent Terrace to the north, and as they rise up towards the Mount Victoria Tunnel west portal.

- Large areas of road pavement at present ground level, particularly at the intersections along Cambridge and Kent Terraces and around the Basin Reserve.

**Grade-separated Scenarios**

Key engineering features of the grade-separated scenarios are:

- Long elevated structures between Buckle Street and the Mount Victoria Tunnel approach to the west portal. Option 2A has an additional elevated structure from Kent Terrace to the Mount Victoria Tunnel approach.

- Potential small embankments and cuttings as the new roads grade down towards the Basin Reserve and as they rise up towards the Mount Victoria Tunnel west portal.

- Some areas of road pavement at present ground level, particularly at the intersections along Cambridge and Kent Terrace and around the Basin Reserve.

**Tunnel Scenario along Buckle Street and Dufferin Street**

Key engineering features of this tunnel option are:

- Tunnel just below the surface along the Buckle Street and Dufferin Street corridor.

- Approach ramps with retaining walls, down from Taranaki Street, and rising towards the Mount Victoria Tunnel west portal.
7.3 Possible Road Form

At-grade Scenarios

At-grade scenarios will have small cuttings and embankments, and extensive pavements near present ground level.

Grade-separated Scenarios

The grade-separated scenarios will require the following forms of road construction:

- Approach embankments and retaining walls at the ends of the elevated structures. For the elevated structures that connect Buckle Street to the Mount Victoria Tunnel approach, the approach embankments/walls will be small because of the higher natural ground elevations at the end of the structures. A higher approach embankment and possibly retaining walls will be required for any approaches from the lower Basin Reserve area or Cambridge/Kent Terraces (such as for Scenario 2A).

- Elevated structures may be viaduct/bridge structures throughout their lengths. Alternatively they may be supported by embankments with retaining walls, except where the structure crosses other roads or facilities. Urban design and visual appearance will have a significant influence on the final choice.

- The scenarios could also have small cuttings, embankments and extensive pavements, although less of the pavement will be at existing ground level.

The embankments and retaining walls proposed could be up to 8 m high.

Tunnel Scenarios

The tunnel scenario may involve the following forms of road construction:

- Retaining wall structures along the approach ramps, similar to the forms (propped reinforced concrete trough structure and soil nailed walls) used successfully for the Wellington Inner City Bypass project. The retaining walls may be up to 8 m high.

- Cut and cover form of tunnel construction, along the main tunnel section. This will require the road to be typically depressed 6 m to 8 m below present road level.
8 Geotechnical Engineering Issues and Solutions

8.1 Key Geotechnical Engineering Issues

We have considered the key geotechnical engineering issues based on:

- Expected ground conditions given the geology and available site investigation results; and
- Types of earthworks and structures likely to be required for the possible road forms.

We summarise the key geotechnical engineering issues for the project in Table 2.

Table 2: Key Geotechnical Engineering Issues

<table>
<thead>
<tr>
<th>Location</th>
<th>Road Form</th>
<th>Key Geotechnical Engineering Issues</th>
<th>Risk Management Measures and Possible Concepts</th>
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<tbody>
<tr>
<td>At-grade in the Basin Reserve and low lying Cambridge / Kent Terrace corridors</td>
<td>Road on existing ground</td>
<td>• Poor soft ground and wet ground conditions.</td>
<td>• Geotechnical investigations to confirm ground conditions.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• High groundwater levels, including artesian groundwater.</td>
<td>• Improvement of sub-grade by a combination of undercut and replacement, and use of geotextile / geogrid separation and reinforcement.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Poor subgrade for pavement.</td>
<td>• Drainage of pavement through the provision of sub-soil drainage.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Avoid small cuttings in already low lying areas.</td>
</tr>
<tr>
<td>At-grade in the Basin Reserve and low lying Cambridge / Kent Terrace corridors</td>
<td>Small Embankments</td>
<td>• Poor soft ground and wet ground conditions.</td>
<td>• Geotechnical investigations to confirm ground conditions.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Settlement of embankments.</td>
<td>• Preloading embankments to minimise post-construction settlements; Allow time for settlement during construction.</td>
</tr>
<tr>
<td>Low lying Basin Reserve and Cambridge / Kent Terrace areas.</td>
<td>Elevated Structures &amp; viaducts around the Basin Reserve area</td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------------------------------------------------</td>
<td>---------------------------------------------------------------</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| - High Embankments  
- Retaining Walls | - Bridge  
- Retaining Walls |
| - Poor soft ground and wet ground conditions.  
- Artesian groundwater conditions.  
- Stability of embankments on soft ground.  
- Settlement of embankments on compressible ground.  
- Instability of embankments due to liquefaction in earthquake events. | - Foundation conditions for bridges and retaining walls on alluvial deposits.  
- Artesian groundwater pressures. |
| - Geotechnical investigations to confirm ground/water conditions.  
- Undercut of soft ground and drainage measures.  
- Preloading; Allow time for consolidation settlement during construction, as vertical drains to accelerate consolidation may not be appropriate due to presence of artesian ground conditions.  
- Where possible avoid high embankments on the low lying soft ground susceptible to liquefaction and with artesian groundwater conditions. | - Geotechnical investigations to confirm ground and groundwater conditions.  
- Deep bored piles to support structures, founded in dense alluvium at some 25 m depth or in bedrock at some 30 m to 40 m depth in the Basin Reserve area. Shallower piles outside the low lying areas.  
- Pile construction under bentonite to resist uplift pressures and casing to ensure pile hole stability.  
- Reinforced soil walls outside the low lying soft ground areas. |
### Tunnel – Low Lying area around Basin Reserve grounds

- Cut and cover tunnel
- Poor soft ground and wet ground conditions.
- Artesian groundwater conditions.
- Uplift of tunnel structure.
- Difficult excavation in soft ground and support measures.
- Higher uplift pressures on tunnel structure due to liquefaction in earthquake events.
- Obstruction of natural groundwater flow by deep walls.
- Obstructions from old culverted streams in the area.
- Geotechnical investigations to confirm ground and groundwater conditions.
- Use of deep diaphragm wall or secant pile wall construction to facilitate excavation support and construction.
- Likely to need heavy structure or uplift resisting piles / anchors.
- Consider shallower tunnel, with higher above ground section buried and incorporated within embankment around Basin Reserve grounds?
- Diversion of old culverted streams along the Sussex Street end of the Basin Reserve or road where the tunnel invert is higher.

### Tunnel Approach Ramps – Cuba St to Taranaki St and approach to Mount Victoria west portal

- Cuttings
- Walls
- Variable ground conditions
- Moderate groundwater levels
- Geotechnical investigations to confirm ground and groundwater conditions.
- Soil nailed walls where depth of ramp is shallow and groundwater levels low.
- Propped RC trough structure in temporary supported excavation for deeper sections.
- These solutions successfully used for Wellington Inner City Bypass recently.

### Tunnel - Taranaki St to Sussex Street

- Cut and cover tunnel
- Ground conditions variable
- Geotechnical investigations to confirm ground and groundwater conditions.
- Propped or covered RC trough structure in temporary supported excavation for deeper sections.
- Unsupported excavation possible where ground is favourable, if road is away from the Carillion.
We consider that the geotechnical issues can be resolved through:

- An appropriate level of geotechnical investigations;
- Early consideration of issues during concept development and preliminary design; and
- Integrated consideration of the issues with the development of the project, to achieve an appropriate urban form and resilience.

### 8.2 Fill Slopes, Retaining Walls and Foundations

We propose that the preliminary road forms, concepts, fill slopes and foundations provided in Table 3 be used in the development of options and design concepts, until the geotechnical investigations and assessment is completed.

**Table 3: Preliminary Fill Slopes, Retaining Systems and Foundations**

<table>
<thead>
<tr>
<th>Road Form</th>
<th>Preliminary Concepts</th>
<th>Preliminary Slope</th>
</tr>
</thead>
<tbody>
<tr>
<td>Embankments</td>
<td>• Unreinforced.</td>
<td>26º (2H : 1V)</td>
</tr>
<tr>
<td></td>
<td>• Use of weathered greywacke derived fill from quarries.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Given urban context, likely that there would lack of space for unsupported embankments.</td>
<td></td>
</tr>
<tr>
<td>Embankments where space is constrained</td>
<td>• Reinforced soil embankments.</td>
<td>45º (1H : 1V)</td>
</tr>
<tr>
<td></td>
<td>• Avoid reinforced soil fills steeper than 45º.</td>
<td></td>
</tr>
<tr>
<td>Retaining Walls</td>
<td>• Reinforced soil walls with concrete facing.</td>
<td>Vertical</td>
</tr>
<tr>
<td></td>
<td>• Facing panels can be architecturally designed to suit.</td>
<td></td>
</tr>
<tr>
<td>Bridge Abutments</td>
<td>• Reinforced soil walls; or</td>
<td>Vertical 26º (2H : 1V)</td>
</tr>
<tr>
<td></td>
<td>• Open spill through slopes.</td>
<td></td>
</tr>
<tr>
<td>Bridges</td>
<td>• Deep bored piles to support bridges, with bentonite used during construction to resist artesian pressures in Basin Reserve area.</td>
<td></td>
</tr>
</tbody>
</table>

The above concepts are preliminary only and should be reviewed based on the results of the geotechnical investigations.
9 Proposed Geotechnical Site Investigations and Testing

We propose a staged geotechnical investigation programme given the development of the concepts and design is in progress. We have some knowledge of the ground conditions from geotechnical investigations we have carried out in the past.

Stage 1 investigations will be carried out to ascertain the condition of existing piezometers installed some twenty years ago, and start to obtain some current information of the groundwater conditions. If these are still functional, they would provide valuable information at a modest cost. Commencement of monitoring now will provide us information on seasonal fluctuations.

Stage 2 investigations will be scoped and carried out later, when the preferred option has been chosen as part of the scoping study, and when we have ascertained the condition of the past piezometers installed in the area.

The Stage 1 geotechnical investigations will include:

- Identify location and ascertain condition of existing piezometers.
- Monitor the groundwater levels in the existing piezometers on a monthly basis until the commencement of the Stage 2 geotechnical investigations.

The results from the Stage 1 investigations will be reported with the results of the subsequent Stage 2 investigations.

An estimate of the costs of the geotechnical investigations are provided separately.
10 Recommendations

We recommend that:

1. Geotechnical issues and recommendations identified in Tables 2 and 3 are considered in the selection and preliminary development.

2. NZTA provide approval to proceed with the Stage 1 geotechnical investigations which comprises identifying the existence and functionality of the past piezometers installed for the Tunnel-Link project, and monitoring them monthly until the Stage 2 investigations.
11 References


Option A
Option B
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