Appendix F Geotechnical Risks for Valley Floor

1. Introduction

This desk study summarises the high level geotechnical risks that are impact the short list options that have been identified to go forward as the proposed package of options for the Ngauranga Transportation Study addressing a cross valley link. The geotech assessment for these options have been assessed in this desk study with regards to geotechnical hazards.

The published geological map and accompanying report for the Wellington area[21] has been referenced to complete this desktop assessment. This report relies on published geological information which has not been done to a level of confidence that can be relied upon to provide accurate results for the projects investigated. This information should be supplemented by a full ground investigation and geotechnical interpretation to fully assess the risks.

2. Topography

Petone is located in the Lower Hutt Valley area of the Lower Hutt/Port Nicholson basin which has developed along the active Wellington Fault. The basin is deepest on its north western side, closest to the Wellington Fault scarp. The Hutt River deposits sediment in the Lower Hutt Valley and a delta is prograding into the harbour. The Lower Hutt Valley is subsiding so therefore the valley fill contains alluvium and marine sediments deposited during sea levels that were higher than what is currently occurring. Elevation in the Petone area is typically less than 5m above sea level.

3. Geomorphology

The steep Greywacke hills to the north west of the valley follow the trace of the Wellington Fault. The low lying flat Hutt valley represents the alluvial deposits of the Hutt River. It is believed that the linear form of the eastern harbour coastline suggests that the harbour is bounded by faults to the east and west.

4. Reclaimed Land

There are two areas of reclamation landfill in the study area. An area immediately to the south of the Petone Interchange, has been reclaimed. It is possible that reclaimed material extends beneath the proposed interchange, especially the eastern section. It is therefore likely that excavations in this area may encounter this material.

An extensive area to the south west of Seaview Road in Seaview has also been reclaimed. The reclaimed land in the Wellington Area generally consists of very loose or very soft to soft mixed clay, silt, sand, gravel (weathered rock fill) or sandy silt and mud pumped from the harbour floor (hydraulic fill)

[21] J.G. Begg & C. Mazengarb, (1996), Geology of the Wellington Area

It is expected that some superficial made ground may overlie the Hutt Formation sediments resulting from the construction of existing developments across the study area.

5. Geology of Hutt Valley Study Area

Implications of the geology on particular projects is outlined in the following sections. Below provides a summary of the known geology in the Lower Hutt Basin. The geology of the Lower Hutt basin comprises of Hutt Formation sediments. These sediments consist of the following units:

- Petone Marine Beds – Holocene shelly, sometimes gravelly, marine sands and silt;
- Waiwhetu Artesian Gravel – Last Glacial gravel, sand, silt and peat;
- Wilford Shell Bed – marine sediments of Last Interglacial age;
- Terrestrial Sediments beyond the influence of the development – these are sediments deposited in glacial and interglacial periods.

The lateral and vertical extents of the units are shown in the following diagram[1].

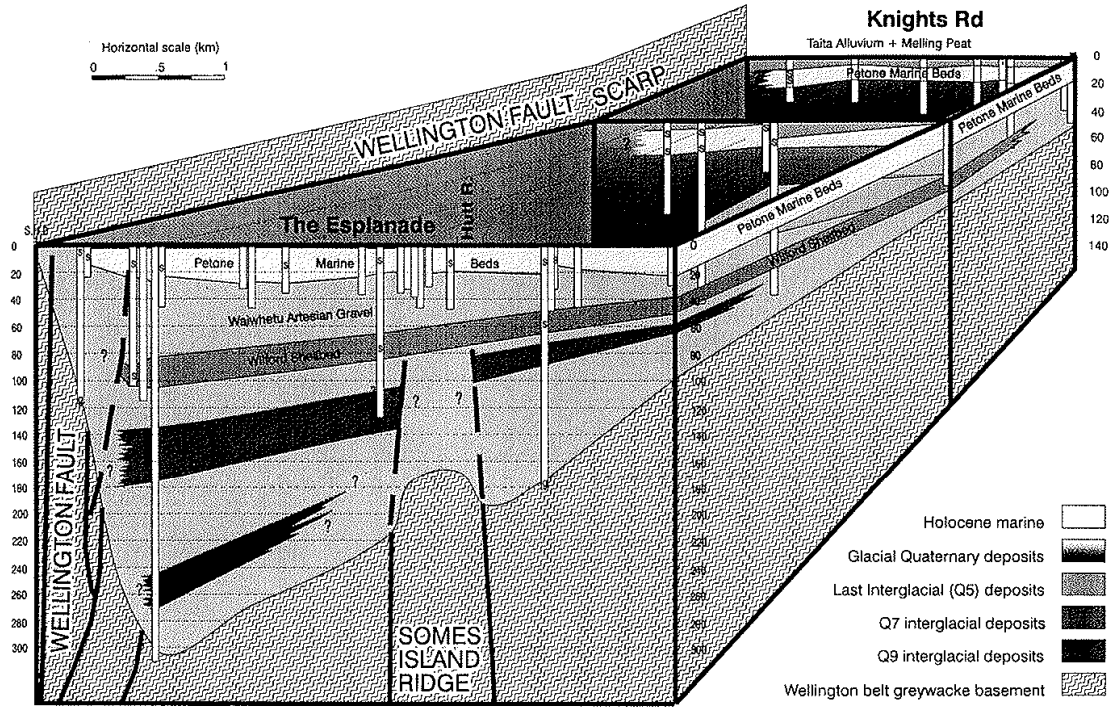

Figure 3.9 This three-dimensional representation of the sediments of the Lower Hutt basin from the Petone foreshore to Knights Road is based on drillhole information. The middle "fence" is about Wakefield Street. For simplicity, the Hutt Valley floor is shown as flat and horizontal; the vertical scale is depth in metres. The Petone Marine Beds consist of Holocene shelly marine sands and silt. Further inland the marine sediments are overlain by river gravel, sand, silt and peat (Melling Peat and Taita Alluvium). Beneath the Holocene marine sediments lie Last Glacial gravel, sand, silt and peat (Waiwhetu Artesian Gravel). The Wilford Shell Bed consists of marine sediments of Last Interglacial age. Beneath are terrestrial sediments of Waimea Glacial (Q6) age, terrestrial sediments of Karoro Interglacial (Q7) age (with minor marine incursions) and terrestrial beds of Waimaunga Glacial (Q8), "Brunswick" Interglacial (Q9) and Nemona Glacial (Q10) age. The position of the "Somes Island Ridge" is based on onshore gravity and seismic data from Port Nicholson.

The Hutt Formation sediments are overlying Greywacke rock. The Greywacke lies at depths of approximately 300m close to the Wellington Fault scarp in the west and approximately 180m depth to the east of the Hutt River, in the approximate area of the Wakefield to Rail Alignment.

The Petone Marine Beds extend to a depth of approximately 20m and the Waiwhetu Artesian Gravel to depths of 50-300m. These two units are expected to be encountered during foundation excavations for the proposed options.

Close to the Hutt River, Alluvium comprising river gravel, sand and silt overlies the Petone Marine Beds. Alluvial fan deposits and reclamation landfill are located in the area of the Petone interchange with SH2 and reclamation landfill is also situated in the Seaview area.

6. Petone Interchange

The proposed interchange consists of two roundabouts (one elevated and one at grade) with associated on and off ramps adjacent to and up to approximately 300m from the Wellington fault scarp.

Reference to the published geological map of the Wellington area indicates that the majority of the proposed interchange is underlain by Holocene alluvial fan deposits which consist of sediments originating from the Korokoro stream to the north. These fan deposits are likely to be a loose to dense sandy gravel which may be prone to scouring during storms and may erode if undercut.

An elongate area of reclamation landfill underlies The Esplanade in the interchange area and to the south of the existing Petone ramps. It is possible that the ground beneath the eastern extent of the proposed interchange consists of this material. The landfill is likely to consist of very loose to medium dense or very soft to soft mixed clay, silt, sand, gravel (weathered rock fill) or sandy silt (hydraulic fill). The fill generally has a low bearing strength and is susceptible to liquefaction and differential settlement.

The on and off ramps to the north and east are likely to be founded in the Petone Marine Beds consisting of loose to medium dense silt, sand, gravel and shells. These deposits are susceptible to liquefaction and lateral spreading, storm erosion and poor stability in cuts.

Reference to the GWRC geological hazard maps have indicated the following within or close to the proposed interchange area:

- Possible contaminated land sites;
- Combined earthquake hazard of 3 (moderate) to 5 (high);
- Moderate to variable liquefaction hazard;
- Groundshaking earthquake hazard of 1 (low) to 4 (moderate to high).

The table below indicates the potential impacts of these geohazards on the design and construction of the Petone Interchange.

Geohazard	Potential Impact	Risk[22]	Recommendations
Construction of interchange on loose gravel prone to scouring.	Foundations, cuttings or embankments damaged during flood events.	Low	Drainage design should consider flood events and maintain flood level flows within controlled channels
Construction of interchange partially over reclaimed land.	Differential settlement of the road, and potentially of structures, resulting in increased maintenance costs and shorter serviceable life.	Medium	Ground investigation to accurately define the boundaries and material properties of the reclaimed land. Consider minor realignments to avoid reclaimed area (particularly with structures), or mitigate effects in design.
Cuttings for on and off ramps in Petone Marine Beds susceptible to liquefaction, lateral spreading and cutting instability.	Potential for inducing instability by creating cuttings and instability of structures during ground shaking events due to liquefaction.	High	Allow for retaining structures where cuttings are essential. Where possible maintain alignment at existing ground levels. Possible ground improvement required.
Piling in the vicinity of liquefiable fill and Petone Marine Beds.	Damage to adjacent structures during construction.	Medium	Ground investigation to identify extent of problem. Expert geological input will be required to assess the risk and recommend mitigation measures.

[22] Note: Risk refers to the potential severity of the consequences. Damage to infrastructure caused by ongoing erosion is considered low risk as it can be observed during maintenance and repaired or the road closed before a catastrophic failure. Damage that is likely to result in risk to life without significant warning would be considered as high risk.

Geohazard	Potential Impact	Risk[22]	Recommendations
Piling close to the Wellington Fault.	Loss of toe strength in hillside if pile driven through fault, changes to flow paths and stress regime by piling could initiate fault movement and cause damage to other infrastructure including drainage.	High	Ground investigation in location of possible piles to ensure fault surface cannot be punctured by piles
Construction in the vicinity of contaminated land	Risk that construction may mobilise contamination.	Low	Undertake a full desk study and physical testing programme on areas suspected to be contaminated early in the programme to allow time for monitoring. Consider ways to minimise pathways between contaminated and uncontaminated material during the design process (e.g. minimising use of piles)
Construction adjacent to Wellington Fault Scarp	Potential for unstable rock to fall and affect site.	Medium	Prior to construction, assessment of the Wellington Fault scarp should be undertaken to confirm stability of the rock slopes above the proposed construction area.

7. The Esplanade Traffic Calming

Possible modifications for this section of The Esplanade include traffic calming.

Underlying this section of The Esplanade are the Petone Marine Beds (see description in Section 5).

Reference to the GWRC geological hazard maps has indicated the following within or close to the proposed traffic calming:

- Possible contaminated land sites to the west of the section on the north side of The Esplanade;

- Council reserve (beach) to the south of The Esplanade;
- Combined earthquake hazard of 4 (moderate to high) to 5 (high);
- Moderate to high liquefaction hazard;
- Groundshaking earthquake hazard of 4 (moderate to high) to 5 (high).

As the traffic calming section is unlikely to include any new significant structures, it is assumed that this option will not increase the susceptibility of the scheme to geohazards. There is therefore no requirement for further study. Should this assumption change, this option should be investigated further.

8. The Esplanade Multilane Efficient Arterial

This option could require the widening of a section of The Esplanade and/or the construction of an additional bridge over the Hutt River to the north of the existing Waoine Bridge, which would become a two lane westbound only bridge.

The geology beneath the alignment from west to east consists of the following:

- Petone Marine Beds (see description in Section 5);
- Alluvium on Gear Island which consists of loose to dense silts, sands and gravels. Lense shaped fine sand inclusions within the Alluvium are susceptible to liquefaction, lateral spreading can occur along stream and river banks and soft silt lenses have low bearing strength;
- Reclamation Landfill on the eastern banks of the Hutt River (see description in Section 4);
- Alluvium from approximately 50m west of the roundabout (see description above).

Reference to the GWRC geological hazard maps has indicated the following within or close to the proposed option:

- Possible contaminated land to the south of The Esplanade and to the north of Waoine Street;
- Combined earthquake hazard of 5 (high);
- High liquefaction hazard;
- Groundshaking earthquake hazard of 4 (moderate to high) to 5 (high).

The table below indicates the potential impacts of these geohazards on the design and construction of mulit lane efficient arterial:

Geohazard	Potential Impact	Risk	Recommendations
Road widening and bridge construction in Petone Marine Beds susceptible to liquefaction, lateral spreading and cutting instability.	Potential for inducing instability by creating cuttings and instability of structures during ground shaking events due to liquefaction.	High	Allow for retaining structures where cuttings are essential. Where possible maintain alignment at existing ground levels. Possible ground improvement required.

Geohazard	Potential Impact	Risk	Recommendations
Road widening and bridge construction in Alluvium liable to liquefaction, lateral spreading and low bearing strength.	Instability of structures during ground shaking events due to liquefaction, lateral spreading of foundations on the Hutt River banks and settlement of foundations due to low bearing strength.	High	Ground investigation and appropriate foundation design. Ground improvement may be required.
Road widening over reclaimed land.	Differential settlement of highway resulting in increased maintenance costs and shorter serviceable life.	Medium	Ground investigation to accurately define the boundaries and material properties of the reclaimed land. Mitigate negative effects in design.
Construction in the vicinity of contaminated land.	Risk that construction may mobilise contamination.	Low	Undertake a full desk study and physical testing programme on areas suspected to be contaminated early in the programme to allow time for monitoring. Consider ways to minimise pathways between contaminated and uncontaminated material during the design process (e.g. minimising use of piles)
Piling in the vicinity of liquefiable Petone Marine Beds.	Damage to adjacent structures during construction.	Medium	Ground investigation to identify extent of problem. Expert geological input will be required to assess the risk and recommend mitigation measures.

9. Wakefield to Rail Alignment

This proposed option is to construct a road adjacent to the existing railway line and construct a road bridge to the north of the existing rail bridge over the Hutt River.

From west to east, the ground beneath this section of the alignment consists of the Petone Marine Beds in the western section of the route, and Alluvium on top of Petone Marine Beds eastwards

from Ava Station. Refer to previous sections for descriptions of these deposits and identified geological hazards.

Reference to the GWRC geological hazard maps has indicated the following within or close to the proposed option E3:

- Two areas of possible contaminated land adjacent to the alignment;
- Council reserve to the south of the western approach of the existing rail bridge;
- Combined earthquake hazard of 5 (high) close to the Wellington Fault, 4 (moderate to high) along the alignment and 3 (moderate) 150m from the end of the alignment;
- Variable liquefaction hazard;
- Groundshaking earthquake hazard of 3 (moderate) and 4 (moderate to high) for the first 200m then 5 (high)changing to 4 (moderate to high) 150m from the end of the option alignment.

The table below indicates the potential impacts of these geohazards on the design and construction of the Wakefield to Rail Alignment

Geohazard	Potential Impact	Risk	Recommendations
Road construction in Petone Marine Beds susceptible to liquefaction, lateral spreading and cutting instability.	Potential for inducing instability by creating cuttings and instability of structures during ground shaking events due to liquefaction.	High	Allow for retaining structures where cuttings are essential. Where possible maintain alignment at existing ground levels. Possible ground improvement required.
Road and bridge construction in Alluvium with low bearing strength.	Potential for settlement of foundations due to low bearing strength.	Low	Ground investigation and appropriate foundation design. Ground improvement may be required.
Construction in the vicinity of contaminated land.	Risk that construction may mobilise contamination.	Low	Undertake a full desk study and physical testing programme on areas suspected to be contaminated early in the programme to allow time for monitoring. Consider ways to minimise pathways between contaminated and uncontaminated material during the design process (e.g. minimising use of piles).
Piling in the vicinity of liquefiable Alluvium and Petone Marine Beds.	Damage to adjacent structures during construction.	Medium	Ground investigation to identify extent of problem. Expert geological input will be required to assess the risk and recommend mitigation measures.

10. Wakefield to Rail Alignment to Elizabeth Street

This option connects the proposed option E3 road from Randwick Road to the north, running adjacent to the railway access tracks alongside an existing railway yard to Elizabeth Street.

The ground beneath the alignment generally consists of Alluvium on top of Petone Marine Beds, except for a 150m section of Petone Marine Beds 400m south of the start (north) of the section.

Reference to the GWRC geological hazard maps has indicated the following within or close to the proposed option E4:

- Possible contaminated land to the northeast of York Street (existing rail yard);

- Combined earthquake hazard of 3 (moderate) then 4 (moderate to high) 100m north of Elizabeth Street;
- Liquefaction hazard variable then high 100m north of Elizabeth Street;
- Groundshaking earthquake hazard of 4 (moderate to high).

The table below indicates the potential impacts of these geohazards on the design and construction of Option E4

Geohazard	**Potential Impact**	**Risk**	**Recommendations**
Road construction in Alluvium and Petone Marine Beds susceptible to liquefaction, lateral spreading, cutting instability and low bearing strength.	Potential for inducing instability by creating cuttings and instability of structures during ground shaking events due to liquefaction, lateral spreading of foundations on the Hutt River banks and settlement of foundations due to low bearing strength	High	Ground investigation and appropriate foundation design. Ground improvement may be required.
Construction in the vicinity of contaminated land	Risk that construction may mobilise contamination.	Low	Undertake a full desk study and physical testing programme on areas suspected to be contaminated early in the programme to allow time for monitoring. Consider ways to minimise pathways between contaminated and uncontaminated material during the design process (e.g. minimising use of piles)