Appendix G

Geotechnical Appraisal
Report

MacKays to Peka Peka Expressway

Preliminary Geotechnical Appraisal Report

The New Zealand Transport Agency

By MacKays to Peka Peka Expressway Alliance

29 September 2010
This report has been prepared for the benefit of the NZ Transport Agency (NZTA). No liability is accepted by this company or any employee or sub-consultant of this company with respect to its use by any other person.

This disclaimer shall apply notwithstanding that the report may be made available to other persons for an application for permission or approval or to fulfil a legal requirement.

Revision History

<table>
<thead>
<tr>
<th>Revision Nº</th>
<th>Prepared By</th>
<th>Description</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Jennifer Bradshaw/ Lucy Coe</td>
<td>DRAFT</td>
<td>29/09/10</td>
</tr>
</tbody>
</table>

Document Acceptance

<table>
<thead>
<tr>
<th>Action</th>
<th>Name</th>
<th>Signed</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prepared by</td>
<td>Jennifer Bradshaw/ Lucy Coe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reviewed by</td>
<td>Gavin Alexander</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Approved by</td>
<td>Ian Billings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>on behalf of</td>
<td>MacKays to Peka Peka Alliance</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# Table of Contents

1. **Introduction** .................................................................................. 1

2. **Proposed Scheme** ........................................................................ 1

3. **Available Geotechnical Investigation Data** .............................. 3

4. **Topography** .................................................................................. 4

5. **Geology** ........................................................................................ 4
   5.1 **Material Descriptions** ............................................................ 5

6. **Seismicity** ..................................................................................... 6
   6.1 **Fault Hazard** ............................................................................ 8
   6.2 **Seismic Design Hazard** .......................................................... 8
   6.3 **Liquefaction Hazard** ............................................................... 9

7. **Groundwater** ............................................................................... 9

8. **Ground Conditions along Proposed Alignment** ...................... 10

9. **Geotechnical Considerations** .................................................... 12

10. **Peat Deposits** ............................................................................. 12
    10.1 **Peat Extent and Thickness** .................................................. 13
    10.2 **Peat Treatment and Ground Improvements** .......................... 14
    10.3 **Re-use and Disposal of Peat** .............................................. 15

11. **Seismic Design** .......................................................................... 15
    11.1 **Liquefaction** ......................................................................... 15

12. **Earthworks** ................................................................................. 16
    12.1 **Cut Slopes** ........................................................................... 16
    12.2 **Embankments** ..................................................................... 16

13. **Bridge Structures** ...................................................................... 17
    13.1 **Foundations** ......................................................................... 17
    13.2 **Ground Improvements** ....................................................... 17

14. **Groundwater** ............................................................................. 17

15. **Geotechnical Testing** ................................................................. 18
Appendices

Appendix A – Previous Investigation Data – Summary Table
Appendix B – KCDC Fault Hazard Map
Appendix C – Groundwater Maps
Appendix D – Geological Long Sections
Appendix E – Proposed Investigation & Testing Schedules
1 Introduction

The SH1 MacKays to Peka Peka (M2PP) Expressway project is a critical part of the SH1 Wellington Northern Corridor. This corridor is one of seven Roads of National Significance (RoNS) prioritised by the Government to contribute to New Zealand’s economic growth. The M2PP Expressway Alliance has been formed to deliver this project.

The M2PP Expressway project starts at MacKays Crossing and joins back into SH1 to the north of the existing Peka Peka Rd intersection. The MacKays Crossing project, located to the south of this project, has recently been completed. The delivery of the Peka Peka to Otaki project located immediately north of this project, is expected to overlap with the delivery of this project.

The Project Alliance is currently undertaking the investigation and scoping phase for the M2PP Expressway Project. As part of this phase, a long-list of alignment options and sub-options has been developed. These options and sub-options are currently being evaluated to allow the selection of a short-list of options to be taken forward into the scheme assessment phase.

This Preliminary Geotechnical Appraisal Report presents a review of the geotechnical information available, and the geotechnical/hydrogeological issues that may impact on the proposed scheme. Additional geotechnical testing is required to further evaluate the geotechnical conditions for preliminary design of this project. The recommended scope of geotechnical testing for the investigation and preliminary design phase (Stage 1A) is presented.

The geotechnical aspects across the study area are presented in terms of four project sectors. For the options and sub-options, the geotechnical considerations are highlighted where these vary significantly between options. This report is intended to be read in conjunction with the overall project evaluation presented in the MacKays to Peka Peka Expressway Scoping Report.

2 Proposed Scheme

The M2PP Expressway project consists of approximately 18km of four lane median divided expressway. The proposed expressway starts to the north of MacKays Crossing on SH1, runs through the areas of Paraparaumu and Waikanae, and joins SH1 just north of the existing Peka Peka Road intersection.

The project has been divided into four sectors, from the south to the north, as described and shown below. The geotechnical conditions are described in terms of these sectors within this report.

- Sector 1 MacKays Crossing to just north of Raumati Road
- Sector 2 North of Raumati Road to north of Mazengarb Road
- Sector 3 North of Mazengarb Road to north of Te Moana Road
- Sector 4 North of Te Moana Road to Peka Peka.

The project scope comprises a number of interchanges along the length to provide connections with local roads. The scope also includes bridge structures for local road crossings to maintain connectivity and for river/stream crossings, with a 200m long crossing over the Waikanae River. Earthworks comprise new embankments across low lying areas, cut slopes through sand dunes and new approach embankments for structures.

A number of base options and sub-options have been developed for the project as part of the investigation and scoping stage. These options are described in detail within the Scoping Report.

The base options provide different levels of connectivity, with a varying number of interchanges/partial interchanges and an additional Waikanae River Crossing.

- Option 1 - north and south connections but no intermediate interchanges.
- Option 2 - north and south connections plus one intermediate interchange (Otaihanga Road or Kapiti Road).
- Option 3 - north and south connections plus two intermediate interchanges (Combination of Iharaka Street Extension, Kapiti Road, Otaihanga Road or Te Moana Road).

The sub-options provide localised variation in alignment and interchange configurations. The significant variations in alignment being considered are outlined below:
In Sector 1, there are two alignment sub-options for the southern connection. Sub-options S1A to S1Ciii deviate from the existing SH1 to the south of Poplar Avenue and run across the corner of Queen Elizabeth Park, connecting into the designation north of Poplar Avenue. Sub-options S1Di and S1Dii continue along the existing SH1 alignment to Poplar Avenue and deviate to the north of Leinster Avenue, connecting into the designation immediately south of Raumati Road.

In Sector 2, sub-options focus on interchange locations, split interchanges and a slight alignment shift to the east of the designation.

In Sector 3, a number of cultural, environmental and property constraints have been identified. Six alignment sub-options (S3Ai to S3F) have been developed within this sector to reduce the impact of the Expressway.

In Sector 4, the alignment is constrained by ecological areas to the north of Te Moana Road. There are two alignment sub-options to the north of Smithfield Road, one along the designation and one to the east of the designation.

3 Available Geotechnical Investigation Data

A review of the available geotechnical data has been completed for the expressway corridor. Several geotechnical investigations have previously been undertaken across the project site, for both the development of a north-south link along the designation (proposed Sandhills Motorway and Western Link Road) and the new MacKays Crossing Project. In addition, there is geotechnical data available for the Waikanae area from the Kapiti Coast District Council borefield project. The previous geotechnical investigation data are tabulated in Appendix A.

The existing geotechnical information generally covers the designation corridor from Poplar Avenue to Te Moana Road. The majority of this data is shallow (test pits, or bores up to 10 m), with deep data only available at selected locations (Wharemaku Stream, Waikanae River, and Raumati Road). There is limited data available adjacent to SH1 to the south of Poplar Avenue, and in locations where the proposed alignment option is outside the current designation. No is data available from Te Moana Road to Peka Peka Road.

The sources of existing geotechnical information that have been used to develop the geotechnical model for this project are outlined below.

Western Link Road Geotechnical Reports (Opus):

- Stage 1, Raumati Rd to Te Moana Rd Design and Project Documentation Stage, Geotechnical Report May 2008
- Stage 1, Raumati Rd to Te Moana Rd Design and Project Documentation Stage, Site Investigation Report (addition to July 2007) April 2008
- Stage 1, Raumati Rd to Te Moana Rd Site Investigation Report July 2007
Stage 1, Raumati Rd to Te Moana Rd Design and Project Documentation Stage, Groundwater Monitoring Plan November 2008
Stage 1 Boreholes and Trial Pits, complete copy of bore logs and variable head tests May 2007
Stage 3 Geotechnical Investigations Site Investigations Report March 2009

Other Geotechnical Reports:
- Opus, 1999: SH1 Poplar Avenue to MacKays Crossing: Safety Improvements, Geotechnical Assessment of Trial Embankment

4 Topography

The expressway route traverses the Kapiti coastal lowlands to the west of the Tararua Ranges foothills. The route is undulating to rolling, with sand dunes forming areas of higher relief (up to around 20 m elevation) and intervening low-lying interdune areas, located within a relatively flat coastal plain a few metres above sea level. There are also low alluvial terraces associated with Waikanae River and streams in the area. The geology along the route is reflected in the landforms and topography observed.

5 Geology

The Expressway traverses across dune sands and swamp deposits, the dunes rising to around 20 m elevation, with intervening low lying areas and depressions typically containing peat. Recent river and fan alluvial deposits form low level terraces adjacent to the Waikanae River, including the present floodplain. The site is generally underlain by alluvial sand and gravel deposits, with greywacke bedrock expected to be encountered at depths between 70 and 120m.

Geological History

An understanding of the geological history of the Kapiti area provides a framework for interpreting the ground conditions which are likely to be encountered along the expressway route.

The near surface geology of the area developed during repeated glacial and interglacial cycles that have occurred over the past 2 million years. During the glacial cycles, sea levels were approximately 120 m lower than present as more water was locked up in ice-sheets and glaciers.
Conversely, when the climate warms during inter-glacial periods, sea levels rise because of melting of the ice-sheets and glaciers.

During the cold glacial periods, the Tararua Ranges held valley glaciers and the whole Wellington region was affected by intense periglacial activity. Physical weathering, combined with sea level fall, increased the amount of erosion from the ranges. This eroded material was redeposited as thick alluvial and glacio-fluvial outwash plains. Subsequent erosion of these deposits by the rising sea level occurred during the interglacial periods.

The oldest Quaternary deposits originate from the Last Interglacial (approximately 120,000 years ago). The rising sea level cut a cliff in the coastal hills, and deposited marine/beach gravel and sands, estuarine sands, and dune sands at the coast. These Pleistocene aged deposits can be expected at depth beneath the MacKays to Peka Peka route, forming a thick wedge over greywacke basement (depth to rock variable).

Towards the end of the Last Glaciation (15,000 years ago), sediment laden rivers laid down thick alluvial deposits of gravel, sand and silt as out-wash plains. These deposits form aggradation terraces known as the Parata Gravels which are exposed in the banks of the Waikanae River.

The rising Post-Glacial sea level eroded a flat sea bed along the Kapiti Coast, and the coast prograded as sediment was added from inland erosion. Beach and estuarine deposits accumulated, along with river alluvium. Several successively younger phases of sand dune formation took place. Collectively known as the Himatangi Group, the dune sands are interfingered with interdune swamp deposits named Paraparaumu Peat; the peat deposits may be overlain by sand dunes which in places have advanced over the swamps.

It is the dune sands and swamp deposits which dominate the geology along the expressway route, the dunes rising to around 20 m elevation, with intervening low lying areas typically containing peat. Some of the dune sands have a volcanic ash and pumice component from North Island volcanic activity around the time of their formation.

5.1 Material Descriptions

The geological units within the Kapiti Coast relevant to the Expressway route are described below. The unit names are taken from Heron and Van Dissen (1992).

Recent River and Fan Alluvium

Low level terraces adjacent to the Waikanae river, including the present floodplain. Generally moderately sorted, subrounded gravel to cobble sized greywacke with sandy/silty matrix, with local lenses of sand/sandy silt.

Recent Dune Sand (Himatangi Group)
Loose, medium sand, fresh/slightly weathered, with occasional thin clay/silt beds. Thin iron pans may be found near the water table in older (inland) dunes.

**Interdune Deposits (Paraparaumu Peat)**

Swamp deposits including soft peat and loose peaty sand through to spongy vegetable matter with high water content (some between 65 and 700% water by weight). This material is often described as woody peat with clay/silt and sand lenses. These deposits can extend beneath more recent dunes.

**Beach/Marine/Estuarine Deposits**

These deposits underlie the recent dune sands and interdune deposits, and tend to be gravelly sands nearer the mouths of rivers, elsewhere loose, fine to coarse sand.

**Terrace Alluvium (Parata Gravels and others)**

Poorly sorted greywacke gravel to boulder sized clasts in a matrix of coarse sand, with localised thin lenses of sand/sandy silt. Typically slightly weathered, older deposits may be moderately weathered. Loess may be found separating successive gravel deposits.

## 6 Seismicity

The Expressway is located within an area of high seismic activity. This section presents a summary of the known faults located in close proximity to the site. The design considerations associated with the seismicity, including the liquefaction hazard and design earthquake events are also presented.

There are SW-NE orientated active faults located north, south, and east of the Expressway route. Though no active faults are mapped passing directly through the site, there is a possibility that splinters of these major active faults may be present. Table 6.0 outlines the active faults in the area, their distances from the project site, and their characteristics (largely based on the published information contained in Begg and Johnston (2000), supplemented by more recent research).
### Table 1 – Active Faults

<table>
<thead>
<tr>
<th>Fault name</th>
<th>Distance from Expressway route</th>
<th>Estimated Characteristic Magnitude (Mw)</th>
<th>Recurrence Interval (1000 years)</th>
<th>Recurrence Interval Class</th>
<th>Elapsed time since last EQ (1000 years)</th>
<th>Est. single event displacement</th>
<th>Confidence of Recurrence Interval Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pukerua Fault*</td>
<td>7.5 km SW of southern end</td>
<td>7.6</td>
<td>2.5 - 5.0</td>
<td>Class II</td>
<td>&gt; Ohariu F. (&gt;1.06 - 1.14)</td>
<td>3.5 - 4.0 m (horz)</td>
<td>Low</td>
</tr>
<tr>
<td>Ohariu Fault</td>
<td>3 km E of route</td>
<td>7.6</td>
<td>1.3 - 3.8</td>
<td>Class II</td>
<td>1.06 - 1.14</td>
<td>3 - 5 m (horz)</td>
<td>Low</td>
</tr>
<tr>
<td>Gibbs Fault</td>
<td>4 – 5 km E of route</td>
<td>?</td>
<td>&gt; 3.0 to &lt;5.0</td>
<td>Class III</td>
<td>&lt;10</td>
<td>1.5 m (vert)</td>
<td>Low</td>
</tr>
<tr>
<td>Northern Ohariu Fault</td>
<td>2 km NE of northern end of route</td>
<td>7.3 - 7.7</td>
<td>3 - 3.5</td>
<td>Class II</td>
<td>&lt; 4</td>
<td>3 - 3.5 m</td>
<td>Low</td>
</tr>
<tr>
<td>Otaki Forks</td>
<td>15 km E of route</td>
<td>7.3 - 7.6</td>
<td>&gt; 3.0 to &lt;5.0</td>
<td>Class III</td>
<td>?</td>
<td>2.5 - 3.5 m (horz)</td>
<td>Low</td>
</tr>
<tr>
<td>Wellington Fault***</td>
<td>25 km E of route</td>
<td>7 - 7.6</td>
<td>0.9</td>
<td>Class I</td>
<td>0.3</td>
<td>3.5 - 5 m (horz)</td>
<td>High</td>
</tr>
</tbody>
</table>

* Pukerua Fault is considered part of the same geologic structure as the Shepherds Gully Fault, and rupture characteristics for the two are grouped in Begg and Mazengarb (1996). While this grouping is not given in the later map of Begg and Johnston (2000), it is assumed the rupture characteristics of the Shepherds Gully Fault also hold for the Pukerua Fault (in the absence of specific information for the Pukerua Fault).

** Currently the presence of the Hadfield Fault is disputed. It is likely to be a splinter fault as the Ohariu Fault steps to become the Northern Ohariu Fault. Earthquakes on the Ohariu and Northern Ohariu fault likely to govern seismic class.

*** The recurrence interval and elapsed time since last earthquake for the Wellington Fault quoted above are based on the media release on the GNS website, dated 18th September 2009.
6.1 Fault Hazard

A splinter fault of the Ohariu Fault known as the Hadfield Fault has been identified at the northern extent of the project, and this needs to be considered in relation to the proposed Peka Peka Road Connection. The fault is considered active, however this has been disputed. The fault complexity (i.e. possibly a fault zone as opposed to single fault trace), and level of uncertainty regarding its location, is indicated by the shaded triangle on the KCDC Fault Hazard Maps (Appendix B).

The fault is relatively well defined to the north-east of the scheme, though is less constrained, with greater uncertainty across the expressway area of interest.

This fault hazard needs to be considered in the selection of the Peka Peka Road interchange location, in particular the position of any interchange structures. Further work is required to better understand and define the fault complexity and hazard. This will reduce the uncertainty and zone of risk.

6.2 Seismic Design Hazard

The seismic design events for this project have been derived based on the Transit Bridge Manual and NZS1170.5. NZS1170.5 indicates that the Paraparaumu and Waikanae areas have a hazard factor (Z) of 0.4. Based on the ground profile information currently available and expected depths of soil, the site has been classified as subsoil class D.

The seismic design events have been derived from the importance levels outlined in the provisional amendment of the Transit Bridge Manual. For approach embankments and abutment walls associated with a bridge structure, the ultimate seismic design event is equivalent to that for the adjacent bridge structure. For embankments, cuts and retaining walls supporting the expressway and independent of bridge structures, the ultimate design event adopted is equivalent to a 1 in 1000 year return period event. The earthquake design parameters for the expressway route are then as follows:

Table 2 – Earthquake Design Parameters

<table>
<thead>
<tr>
<th>Application</th>
<th>Importance level</th>
<th>Annual probability of exceedance (APE)</th>
<th>Ru</th>
<th>PGA (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Embankments and retaining walls associated with an Expressway Over Bridge</td>
<td>3 or 4 (ULS)</td>
<td>1/2500</td>
<td>1.8</td>
<td>0.81</td>
</tr>
</tbody>
</table>
We recommend a site specific hazard assessment is undertaken to refine the seismic hazard, once the interchange and route alignment option has been selected.

### 6.3 Liquefaction Hazard

There is the potential for liquefaction to occur along the Expressway route, based on the high seismicity and ground conditions present.

Loose to medium dense sand deposits are present within the sand dunes and underlying marine and alluvial deposits. These deposits are susceptible to liquefaction where saturated, based on material characteristics and grain size. Above the ground water level, they will be susceptible to shaking induced settlement.

A preliminary liquefaction assessment has been carried out, considering the available borehole strength data and water levels from adjacent piezometers. This assessment indicates these saturated, loose to medium sand deposits are expected to liquefy under the 1000 year return period event. These deposits are expected to be encountered across the entire site.

Liquefaction of these deposits is expected to result in:

- Ground settlements.
- Seismic induced slope instability and horizontal movements of existing sand dunes and new embankments constructed over these deposits.
- Potentially lateral spreading or flow failure of existing sand dunes, new embankments, and new approach embankments for the Waikanae River Crossing.

The liquefaction hazard may be mitigated at specific locations by ground improvement techniques. Liquefaction potential and the likely effects are specifically addressed within Section 11.

### 7 Groundwater

Based on previous hydrogeological reports in the study area, it is understood that groundwater is drawn for public supply from a series of wells screened in the Waimea gravel aquifer at some 80 m
depth. The public water supply wells are primarily located along Ngarara Road, Park Avenue and Moana Road in Waikanae.

There are also shallow confined and semi-confined aquifers within the post glacial deposits, with groundwater levels near surface, located up to a few metres below ground in the interdunal areas, and at significant depths below ground in the dunes - though elevated a couple of metres relative to the interdunal areas (i.e. groundwater mounds beneath the dunes). A large number of wells for domestic supply are spread over the Kapiti Coast area and are mainly screened in these shallow aquifers.

It is understood that the groundwater flow in the region is east to west (i.e. toward the coast) on a 0.3 to 0.4% gradient, with the Waikanae River recharging groundwater in the east, and conversely groundwater feeding the river in the west of the region. The Mazengarb Drain and Wharemaku Stream are also said to be fed by groundwater.

Monitoring undertaken in Council observation wells suggests the shallow aquifers rapidly respond to rainfall recharge, and water levels may typically rise by 0.5 to 3.0 metres in winter. Plans indicating the range in groundwater levels across the scheme are attached in Appendix C.

8 Ground Conditions along Proposed Alignment

The topography and geology along the proposed base alignment is described in Table 8.0 below. Refer also to the long sections in Appendix D, which illustrate the geology and existing topography with the proposed design vertical alignment overlain for reference.
Table 3 – Topography and Soil Profile along the Proposed Route

<table>
<thead>
<tr>
<th>Sector</th>
<th>Location</th>
<th>Description</th>
<th>Topography</th>
<th>Soil Profile</th>
<th>Long Section Sheet</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>This sector begins north of MacKays Crossing and joins the designation south of Raumati Road. There are two alternative routes at the southern end: one passes through Queen Elizabeth Park (located south of Poplar Avenue), and one deviates from SH1 north of Poplar Road.</td>
<td>The topography is fairly low-lying through Queen Elizabeth Park (at elevations of around 6-7 m), the route initially situated east of the sand dunes in Raumati South, then from south of Poplar Avenue northwards it rises onto the eastern margin of the dunes (which are typically up to 20 m elevation).</td>
<td>Interdune Deposits (Paraparaumu Peat) can be found near surface between MacKays Crossing and Poplar Avenue, to thicknesses of around 4 to 6 metres. The peat is generally underlain by alluvial sand and gravel deposits. Toward the end of this sector there are dune sand deposits.</td>
<td>1, 2, 3 (ch 0-4680)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>This sector begins near Raumati Road, and runs through to a point approximately midway between Mazengarb and Otaihanga Roads, within the designation. The Otaihanga landfill is adjacent to the designation, off Otaihanga Road.</td>
<td>The topography is undulating, the route crossing over dunes which are typically up to 20 m elevation, with lesser amounts of lower-lying interdune areas in between. It appears that much of this sector of the road corridor preserves a remnant of what was a larger dune field which has undergone extensive earthworks for residential development in Paraparaumu. The Kapiti Rd interchange is constrained by the narrow designation in the urban area of Paraparaumu.</td>
<td>The ground conditions can be expected to comprise dune sand in the elevated areas, with as much as 4 metres of peat in the interdune areas. Underlying marine/beach sand and alluvium typically becomes very dense at depths of around 10 m below ground. The ground is understood to be contaminated by landfill leachate near Otaihanga Road.</td>
<td>3, 4, 5 (ch 4600-8355)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>This sector runs through the semi-rural area between Paraparaumu and Waikanae within the designation, ending north of Waikanae near Te Moana Road.</td>
<td>The topography is undulating, the route passing over dunes (which are typically up to 20 m elevation) and lower-lying interdune areas. Toward the centre of this sector the Waikanae River cuts through the route east-west, with associated low-lying alluvial terraces on either side.</td>
<td>The geology can be expected to comprise dune sand in elevated areas, with up to a few metres of peat in the interdune areas. Underlying alluvium typically becomes very dense at depths of around 10 m below ground. Within the Waikanae River area, very dense alluvial gravels underlie alluvial sand at around 15 m depth.</td>
<td>5, 6, 7, 8 (ch 8355-12250)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>This section runs from Te Moana Road through to Peka Peka Road over an area of farmland north of Waikanae.</td>
<td>The topography is undulating, dominated by dunes until Smithfield Road, east of which the route flattens out.</td>
<td>There are no previous geotechnical investigations in this area. Based on geomorphology and published maps, the geology is anticipated to comprise dune sand in the elevated areas, with some peat in low lying areas, underlain by marine/beach/estuarine deposits.</td>
<td>8, 9, 10, 11 (ch 12250-18339)</td>
<td></td>
</tr>
</tbody>
</table>
9 Geotechnical Considerations

The key geotechnical considerations that have been identified for this project are:

- The presence of peat deposits across the site, and associated embankment settlements and stability.
- The high seismic hazard and known active faults (refer Section 6).
- The presence of relatively loose saturated sand deposits with the potential to liquefy during the design seismic events. Liquefaction induced slope instability and settlements.
- Founding conditions for bridge structures comprising alluvial deposits to depth, predominately interbedded dense sands and gravels.
- Potential effects on the shallow unconfined aquifer system, which is used for irrigation and feeds ecologically valuable wetlands. Potential groundwater effects may result from changes in permeability of the near surface material.

These aspects are described in detail in Sections 10 to 14. The geotechnical aspects are of particular relevance to the following proposed scheme features:

- Proposed earthworks including cuts up to 20m high and embankments up to 8.5m high.
- Proposed bridge structures, including foundations and ground improvements.

The geotechnical considerations identified above are generally widespread across the area of interest, and therefore are applicable to all options and sub-options under consideration to varying degrees. Any interchange locations or alignment variations where these issues are expected to be of higher significance are highlighted below.

10 Peat Deposits

Peat deposits have been encountered along the route in the low lying inter-dunal depressions. The peat is very soft, with a high water content. It varies in nature from fibrous to amorphous. These deposits are typically 0.5m to 4.0m thick, and up to 6m thick in some locations.

The presence of peat deposits across the site is a key geotechnical aspect for this project. Key considerations associated with construction of a road embankment over weak peat deposits include:

- Settlement of these underlying deposits. Post construction settlements and potential differential settlements will impact on the performance of the Expressway, resulting in poor rideability, altered surface drainage patterns and increased maintenance.
Stability of embankments constructed on weak foundations, in particular the temporary (construction stage) and seismic stability case.

Potential settlement of services beneath the embankment and adjacent structures and property.

10.1 Peat Extent and Thickness

The peat deposits vary in thickness and depth along the alignment. This variation is described along the Expressway route below. The differences in peat distribution for the scheme options and sub-options are presented in Table 10.1.

At the southern end of the Expressway, a large area of relatively thick peat is present from the edge of the foothills and across Queen Elizabeth Park. Peat depths of 4m to 6m are expected in this area. Peat is also present north of Poplar Avenue between the foothills and the sand dunes within the designation.

From Raumati Rd to Te Moana Rd, peat is present in isolated depressions between the sand dunes. Near Wharemaku Stream, the peat deposits are interbedded with alluvial deposits to a depth of 6m. Significant peat deposits are also expected in the low lying area near Ihakara Street Extension.

There is limited information available on the peat depth and extent to the north of Te Moana Road. Based on a site walk over and discussions with local contractors, there is expected to be a large area of peat to the north of Smithfield Road. This is expected to be in the order of 2 to 3m thick.

Table 10.1 – Peat Deposits along Expressway

<table>
<thead>
<tr>
<th>Location Description</th>
<th>Relevant Options</th>
<th>Peat Extent and Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southern end, from foothills west across Queen Elizabeth Park</td>
<td>All options run adjacent to SH1 Sub-options S1A - S1Cii run across Queen Elizabeth Park</td>
<td>The limited data and experience from recent projects in close proximity, suggest the peat is typically 4.0 to 6.0m thick.</td>
</tr>
<tr>
<td>Queen Elizabeth Park towards Poplar Avenue</td>
<td>Sub-options S1A - S1Cii</td>
<td>Typically 3.0m</td>
</tr>
<tr>
<td>West of the existing designation, between Poplar Avenue and Raumati Road</td>
<td>Sub-options S1Di - S1Dii</td>
<td>Typically 2.0 to 3.0m</td>
</tr>
<tr>
<td>Along designation between Poplar Avenue and Te Moana</td>
<td>All options</td>
<td>Peat and Sand Dunes. Peat generally in isolated areas along the</td>
</tr>
<tr>
<td>Location Description</td>
<td>Relevant Options</td>
<td>Peat Extent and Depth</td>
</tr>
<tr>
<td>------------------------------------------</td>
<td>------------------</td>
<td>--------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Road</td>
<td></td>
<td>alignment. Typically 1.0 to 3.0m, up to 4.0m.</td>
</tr>
<tr>
<td>Wharemaku Stream Bridge</td>
<td>All options</td>
<td>Peat interbedded with alluvial deposits to a depth of 6.0m.</td>
</tr>
<tr>
<td>East of designation, Wharemaku Stream to Kapiti Road</td>
<td>All options, particularly relevant to options 3B and 3C and sub-options S2Aii, S2Aii and S2Bi</td>
<td>Significant depression with up to 4.0m of peat.</td>
</tr>
<tr>
<td>Te Moana Road to Smithfield Road</td>
<td>All options</td>
<td>Limited data available. Peat and Sand Dunes. Peat generally in isolated areas along the alignment. Typically 1.0 to 2.0m.</td>
</tr>
<tr>
<td>North of Smithfield Road to Peka Peka Road</td>
<td>All options</td>
<td>The limited data and experience from recent projects in close proximity, suggest the peat is typically 3m</td>
</tr>
</tbody>
</table>

### 10.2 Peat Treatment and Ground Improvements

Ground improvements will be required where peat deposits are encountered below the Expressway footprint, to mitigate the risk of post-construction differential settlements, and increased maintenance requirements.

The level of ground improvements undertaken will directly affect the scheme cost and the residual risk of poor Expressway performance. The balance between upfront capital costs and on-going risk profile needs to be discussed and agreed with NZTA as this project progresses.

The treatment adopted will vary across the route depending on the depth and extent of the peat expected to be encountered, sensitivity of adjacent infrastructure, and cultural sensitivity of the area.

The treatment options available can be generally classified under two design approaches, as described below:

**Excavate and Replace**

This treatment option involves removing the peat deposits from below the expressway footprint. It is considered a high cost - low risk approach, as the potential risk of settlement is eliminated. This
approach is generally considered feasible where peat depths are less than 3m. Excavation and replacement is not considered a feasible treatment for greater peat depths based on economics, constructability and potential effects from dewatering. Environmental considerations associated with this treatment include disposal of peat and effects on groundwater.

**Pre-load and Surcharge**

This treatment option involves constructing the road embankment over the peat deposits and allowing the majority of settlement to occur prior to pavement construction, however some on-going creep settlements are expected as the peat continues to decompose. Other considerations associated with this treatment include potential to cause settlement to services below the footprint (and adjacent property), disposal of peat, and effects on groundwater.

Measures will need to be incorporated into the design to limit post-construction settlements to an acceptable level for serviceability and on-going maintenance. The magnitude of post construction settlements can be reduced by: surcharging above the final construction level, increasing the pre-load period, partial removal of the peat or strengthening of the peat with ground improvements. Differential settlements can be reduced by construction of a stiff raft over the peat.

10.3 **Re-use and Disposal of Peat**

The peat deposits are expected to be suitable for re-use as landscape fill, where on-going settlements are acceptable. These deposits would need to be dried to lower their naturally high water content prior to placement as fill, and may need to be mixed with sand.

11 **Seismic Design**

The proposed scheme is located in an area of high seismicity. The seismicity, including faulting and liquefaction hazards, is detailed in Section 6.

The seismic performance of the expressway, during and post seismic design events is a key design aspect. The acceptable level of damage, emergency access and post-earthquake repair requirements under design events needs to be considered by NZTA, and balanced against the economics and risk profile.

11.1 **Liquefaction**

Liquefaction is predicted to be widespread across the site under a significant earthquake event. Liquefaction induced instability and lateral spreading of slopes is expected. Movements are likely to be in the order of hundreds of millimetres up to several metres.

For earthworks (cuts and embankments) it is unlikely to be economically feasible to prevent seismic induced instability and lateral displacements where foundation soils liquefy. Ground improvements
to prevent wide spread liquefaction across the route are not currently proposed. This approach is in line with current practise, and has been adopted for other RONs projects (such as Christchurch Southern Motorway and Tauranga Eastern Link). Under a significant seismic event, the expected performance of slopes and envisaged repairs need to be assessed, and discussed with NZTA.

For bridge approach embankments, liquefaction is likely to result in lateral spreading of abutments and significant additional loads on the structure. This can lead to severe damage or collapse of the structures. It is expected that bridge structures along this NZTA strategic route will need to provide emergency access following a significant earthquake event and be repairable. Ground improvements at the bridge approaches are required to achieve this level of performance, and are currently proposed for this scheme.

12 Earthworks

The project earthworks involve:

- Cuts through sand dunes, up to approximately 20m high.
- Fill embankments across low lying areas, up to approximately 8m high.

The Expressway alignment(s) and earthworks requirements are associated with the undulating topography of the region and provision for grade separated crossings of local roads.

General earthworks considerations are detailed below, and are applicable for all options.

12.1 Cut Slopes

Design considerations for cut slopes within the sand dunes include:

- The cut slope profile required is likely to be approximately 3H:1V. A benched profile and drainage measures may be required for stability of large cut slopes.
- There are a number of existing cuts in the area. These cuts need to be inspected and the performance taken into consideration when assessing the stability of the proposed cuts.
- The dune sands are prone to erosion, by both wind and water. Water will be required during construction to control dust. Erosion control measures, such as re-vegetation of slopes, will need to be implemented during and immediately after construction.

12.2 Embankments

Design considerations for embankments include:

- The presence of peat deposits, and associated stability and settlement issues. These are detailed in Section 10.
The material cut from the sand dunes is suitable for use as cut to fill, and is likely to be used for
embankment construction. Additional water may need to be added to achieve the required
compaction, and confinement by a coarser granular fill may be required in places.

- The embankment profile is expected to be approximately 3H:1V. This may be steepened
depending on fill material type selected or use of reinforcement.
- The erosion control measures discussed above are also applicable for embankments
constructed using dune sands.

13 Bridge Structures

There are a number bridge structures required for interchanges, and local road and
river/stream/watercourse crossing along the expressway. The Waikanae River crossing is a major
river crossing, and the structure is expected to be approximately 200m in length to bridge across
the flood plain. The structures required for each option are detail in the Scoping Report.

General structural considerations are detailed below, and are applicable for all options.

13.1 Foundations

The site is underlain by dense to very dense sand/sandy gravel at depth. These are uncemented
and vary with depth. At the Waikanae River crossing, the founding conditions are predominantly
dense to very dense gravels at depth, with some cobbles and boulders. There is limited deep
geotechnical data at structure locations, and further investigations are required to confirm
foundation conditions.

For each bridge structure, piled foundations and approach embankments are expected to be
required. The pile design needs to consider:

- Scour depths.
- Negative Skin Friction (NSF) resulting from both consolidation and liquefaction settlements.
- Seismic induced embankment displacements.

13.2 Ground Improvements

Ground improvements will be required below the approach embankments for seismic performance,
based on high seismicity and liquefaction potential, refer Section 11.

14 Groundwater

The site is underlain by a series of shallow unconfined aquifers, with high connectivity. The
groundwater level is close to the existing ground level in the low lying areas and wetlands. The
shallow aquifers feed the wetland areas, which are considered to have high ecological value. Shallow residential bores target this aquifer for irrigation purposes. Constraints associated with groundwater include:

- Changes in permeability and groundwater flow resulting from the Expressway construction need to be considered and assessed. Potential permeability changes include consolidation of peat or removal of peat and replacement with another more permeable material.
- The choice of construction techniques adopted for excavation (earthworks and piling) need to consider potential dewatering and impacts on water quality.
- Changes in groundwater level resulting from the Expressway construction need to be considered and assessed, including potential settlements below the embankment and on surrounding properties.

15 Geotechnical Testing

Geotechnical investigations are recommended to further evaluate the geotechnical and hydrogeological conditions for the primary design, scheme assessment, and assessment of effects phases of this project. A schedule of the proposed investigations, along with the purpose for testing is provided in Appendix E.

It is proposed these investigations are carried out in two stages.

Initial Investigation Phase

The initial stage, programmed prior to preliminary design, will target areas along the route where there is limited geotechnical information available. The investigations during this phase have been scoped to provide general geotechnical information along the route corridor, and to assist in characterising the material types encountered in the area. These focus primarily on the southern and northern extents of the project.

The testing comprises:

- A series of cone penetration tests (CPTs) to provide efficient widespread coverage of the targeted areas.
- Boreholes to provide correlation of the between the CPT data and the ground conditions to the CPT data.
- A number of test pits to sample the peat deposits.
- Laboratory testing to characterise the materials encountered.
Second Investigation Phase

The second phase, programmed following more route certainty, is to determine the foundation conditions at specific interchange and bridge structure locations. This proposed investigation is to comprise of a series of deep boreholes to provide input into pile design. In addition, it will be used to fill in any gaps within the existing geotechnical data along the route where required.

The second phase will also include installation of piezometers, along the route and off-alignment, to provide information for groundwater modelling. These will be monitored to create a groundwater baseline for the project.

Additional Investigations

The following additional investigations are recommended:

- A trial embankment constructed on peat to provide information on settlement (magnitude and timing).
- Site specific seismic study, to further classify the Hadfield Fault complexity and refine the seismic hazard for the scheme.
16 References

Regional Natural Disaster Reduction Plan - Seismic Hazard, Geology of the Kapiti Coast (Pukerua Bay to Otaki), Wellington (part 4 of 1991/92 Study).


## APPENDIX A Previous Investigation Data - Summary Table
## Previous Geotechnical Investigation Data

<table>
<thead>
<tr>
<th>Report Title (author)</th>
<th>Year</th>
<th>Investigations Undertaken</th>
</tr>
</thead>
</table>
| Stage 1, Raumati Rd to Te Moana Rd Design and Project Documentation Stage, Geotechnical Report (Opus International Consultants) | May 2008    | - 2 CPTs  
- 2 SPs                                                                                                                                                                                                               |
| Stage 1, Raumati Rd to Te Moana Rd Design and Project Documentation Stage, Site Investigation Report (addition to July 2007) (Opus International Consultants) | April 2008  | - 5 BHs  
- 20 CPTs  
- 11 TPs (including 11 Scala tests, 6 in situ density tests, and 9 California bearing ratio tests)  
- 3 piezometers  
- 11 HAs  
- 151 SPs  
- 10 PTPs  
- 3.8 km Benkleman beam testing  
- 1 Pilcon shear vane test  
- Laboratory classification, compressibility and strength testing |
| Stage 1, Raumati Rd to Te Moana Rd Site Investigation Report (Opus International Consultants) | July 2007   | - 20 BHs (including 19 piezo installations, 18 permeability tests)  
- 20 TPs (including 7 scalas, 9 in situ CBR tests, 5 nuclear densometer tests, 6 push tube samples, 16 bulk samples)  
- 41 CPTs  
- 65 SPs  
- 15 HAs  
- 32 Pilcon shear vane tests  
- 3 push tubes  
- Lab testing (water content, Atterberg limits, particle size, one dimensional consolidation, triaxial, compression, organic content, CBR) |
<p>| Stage 1, Raumati Rd to Te Moana Rd Design and Project Documentation Stage, Groundwater Monitoring Plan (Opus International Consultants) | November 2008 | Groundwater monitoring results for 22 piezometers from existing bores (those listed in July 2007 and April 2008 reports)                                                                                                    |
| Stage 1 Boreholes and Trial Pits, complete copy of bore logs and variable head tests (Webster Drilling and Exploration Ltd) | May 2007    | Drillers records of 2007 investigation borehole, trial pit and variable head test data                                                                                                                                         |</p>
<table>
<thead>
<tr>
<th>Report Title (author)</th>
<th>Year</th>
<th>Investigations Undertaken</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 3 Geotechnical Investigations Site Investigations Report (Opus International Consultants)</td>
<td>March 2009</td>
<td>14 HAs</td>
</tr>
<tr>
<td>Paraparaumu Bypass, Land Disposal Study. Geotechnical Report (Works Consultancy Services)</td>
<td>1992</td>
<td>37 auger holes (truck mounted) 9 HAs Laboratory testing (standard compaction, particle size distribution)</td>
</tr>
<tr>
<td>Kapiti Coast SH1 Study. Paekakariki to Otaki Section. Geotechnical Desk Study Report (Works Consultancy Services)</td>
<td>1993</td>
<td>Desk study of geotechnical issues</td>
</tr>
<tr>
<td>SH1 Paraparaumu Bypass/ Arterial Land Disposal Study Geotechnical Report (Works Consultancy Services)</td>
<td>1992</td>
<td>37 Augers (truck mounted) 9 Hand Augers</td>
</tr>
<tr>
<td>Final Report - Waikanae Borefield Technical Report (Update of report issued 27 July 2004)</td>
<td>2005</td>
<td>19 pilot boreholes, 8 of which were completed as production wells; includes drillers logs, geological sections, and relevant water testing data.</td>
</tr>
</tbody>
</table>

HA = hand auger, BH = borehole, TP = test/trial pit, PTP = pavement trial pit, CPT = static cone penetrometer test, SP = Scala penetrometer test
APPENDIX B KCDC Fault Hazard Map
APPENDIX D Geological Long Sections
Mackays to Peka Peka Long Section
Sheet 2 (Ch 1700 - 3400m)

Legend:
- Gravel
- Sand
- Silt
- Clay
- Organics/peat
- Fill
- No recovery
- Water level
- Existing ground level
- Design vertical alignment

Distance (m)

Vertical Scale 1:250
Horizontal Scale 1:5000

Cu = Undrained Shear Strength (kPa) by Shear Vane
N = Standard Penetration Test Blows (/300mm)
Mackays to Peka Peka Long Section
Sheet 6 (Ch 8500 - 10200 m)

Legend:
- Gravel
- Sand
- Silt
- Clay
- Organics/peat
- Fill
- No recovery
- Water level

Existing ground level
Design vertical alignment

Cu = Undrained Shear Strength (kPa) by Shear Vane
N = Standard Penetration Test Blows (/300mm)

Distance (m)
Elevation (mRL)

Vertical Scale 1:250
Horizontal Scale 1:5000

3230901/300 Printed 24/08/2010
Legend:
- Existing ground level
- Design vertical alignment

SECTOR 3
SECTOR 4

Vertical Scale 1:250
Horizontal Scale 1:5000

MacKays to Peka Peka Long Section
Sheet 8 (Ch 11900 - 13600 m)
APPENDIX E Proposed Investigation & Testing Schedules
<table>
<thead>
<tr>
<th>Sector</th>
<th>Location</th>
<th>Reason</th>
<th>Item</th>
<th>Quantity</th>
<th>Purpose</th>
<th>Depths</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Waterfall Road to Poplar Avenue</td>
<td>No existing geotechnical investigation data south of Poplar Avenue, also filling in gaps in the data between Poplar Avenue and Raumati Road</td>
<td>Borehole</td>
<td>4</td>
<td>At accessible locations, for general information</td>
<td>10 m</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Piezometer</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4 Monitoring groundwater levels</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CPT test</td>
<td>10 m</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>22 In grid layout to cover range of potential alignments and investigate lateral variability in ground conditions</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Test Pit</td>
<td>Up to 4 m</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5 Investigate and sample interdune deposits (peat)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Te Moana Road to Peka Peka Road</td>
<td>No existing geotechnical investigation data north of Te Moana Road</td>
<td>Borehole</td>
<td>11</td>
<td>At regular intervals, for general information</td>
<td>10 m</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Piezometer</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>11 Monitoring groundwater levels</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CPT test</td>
<td>10 m</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>41 In grid layout to cover range of potential alignments and investigate lateral variability in ground conditions</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Test Pit</td>
<td>Up to 4 m</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2 Investigate and sample interdune deposits (peat)</td>
<td></td>
</tr>
<tr>
<td>Sector</td>
<td>Location</td>
<td>Reason</td>
<td>Item</td>
<td>Quantity</td>
<td>Purpose</td>
<td>Depths</td>
</tr>
<tr>
<td>--------</td>
<td>---------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
<td>------------</td>
<td>----------</td>
<td>--------------------------------------------------------------------------</td>
<td>--------</td>
</tr>
<tr>
<td>1</td>
<td>Poplar Avenue interchange &amp; Raumati Road crossing</td>
<td>Half interchange &amp; local road crossing</td>
<td>Borehole</td>
<td>3</td>
<td>2 deep bores at interchange, 1 at local road crossing</td>
<td>20 m</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2 At interchange</td>
<td>10 m</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Piezometer</td>
<td>3</td>
<td>2 at interchange, 1 at local road crossing</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>CPT</td>
<td>3</td>
<td>2 at interchange, 1 at local road crossing</td>
<td>10 m</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Test Pit</td>
<td>4</td>
<td>Investigate and sample interdune deposits (peat)</td>
<td>Up to 4 m</td>
</tr>
<tr>
<td>2</td>
<td>Kapiti Road interchange &amp; Mazengarb Road, Ihakara Street and Wharemaku Stream crossing</td>
<td>Interchange &amp; local road crossings</td>
<td>Borehole</td>
<td>3</td>
<td>1 at each local road crossing</td>
<td>20 m</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3 At interchange</td>
<td>30 m</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Piezometer</td>
<td>5</td>
<td>2 at interchange, 1 at each local road crossing</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>CPT</td>
<td>5</td>
<td>2 at interchange, 1 at each local road crossing</td>
<td>10 m</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Scala</td>
<td>20</td>
<td>Peat thickness South of Kapiti Road</td>
<td>Up to 4 m</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Test Pit</td>
<td>4</td>
<td>Investigate and sample interdune deposits (peat)</td>
<td>Up to 4 m</td>
</tr>
<tr>
<td>3</td>
<td>Te Moana Road interchange, Otaihanga Road and Waikanae River</td>
<td>Interchange, local road crossing, and river crossing</td>
<td>Borehole</td>
<td>5</td>
<td>2 bores at interchange and river crossing, 1 at local road crossing</td>
<td>20 m</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2 2 deep bores at river crossing</td>
<td>30 m</td>
</tr>
<tr>
<td>Sector</td>
<td>Location</td>
<td>Reason</td>
<td>Item</td>
<td>Quantity</td>
<td>Purpose</td>
<td>Depths</td>
</tr>
<tr>
<td>--------</td>
<td>----------</td>
<td>--------</td>
<td>------------</td>
<td>----------</td>
<td>-----------------------------------------------------</td>
<td>--------</td>
</tr>
<tr>
<td></td>
<td>crossings</td>
<td></td>
<td>Piezometer</td>
<td>5</td>
<td>2 at interchange and river crossing, 1 at local road crossing</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>CPT</td>
<td>5</td>
<td>2 at interchange and river crossing</td>
<td>10 m</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Test Pit</td>
<td>4</td>
<td>Investigate and sample interdune deposits (peat)</td>
<td>Up to 4 m</td>
</tr>
<tr>
<td>4</td>
<td>Peka Peka Road interchange and Ngarara Road crossing</td>
<td>Half interchange and local road crossing</td>
<td>Borehole</td>
<td>1</td>
<td>At Ngarara Road crossing</td>
<td>20 m</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td>Deep bores at interchange</td>
<td>30 m</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Piezometer</td>
<td>2</td>
<td>1 at interchange, 1 at local road crossing</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>CPT</td>
<td>2</td>
<td>1 at interchange, 1 at local road crossing</td>
<td>10 m</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Test Pit</td>
<td>4</td>
<td>Investigate and sample interdune deposits (peat)</td>
<td>Up to 4 m</td>
</tr>
</tbody>
</table>
Appendix H

Principal Structures
**Principal Structures**

The principal structures that have been identified for the various options and sub-options are described below. The structures are firstly described in the table below for alignment option 3 and then variations for other options and sub-options are identified in a separate table.

### a. Structures for Base Option 3 Alignment

<table>
<thead>
<tr>
<th>Name</th>
<th>Location</th>
<th>Road carried</th>
<th>Obstacle crossed</th>
<th>Bridge type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southern Interchange Overpass</td>
<td>St 1870</td>
<td>Off ramp</td>
<td>Expressway</td>
<td>Overpass</td>
<td>98m long, 14m wide with 4 spans and 45 degree skew</td>
</tr>
<tr>
<td>Poplar Avenue Overpass</td>
<td>St 2740</td>
<td>Poplar Avenue</td>
<td>Expressway</td>
<td>Overpass</td>
<td>71m long, 14m wide with 3 spans and 10 degree skew</td>
</tr>
<tr>
<td>Raumati Road Underpass</td>
<td>St 4500</td>
<td>Expressway</td>
<td>Raumati Road</td>
<td>Underpass</td>
<td>73m long, 30m wide with 3 spans and 35 degree skew</td>
</tr>
<tr>
<td>Ihakara Street Extension Underpass</td>
<td>St 5420</td>
<td>Expressway</td>
<td>Ihakara Street Extension and Wharemauku Stream</td>
<td>Underpass</td>
<td>80m long, 30m wide with 4 spans and 15 degree skew</td>
</tr>
<tr>
<td>Kapiti Road Overpass</td>
<td>St 6380</td>
<td>Kapiti Road</td>
<td>Expressway</td>
<td>Overpass</td>
<td>68m long, 30m wide with 3 spans and 10 degree skew</td>
</tr>
<tr>
<td>Mazengarb Road Overpass</td>
<td>St 7970</td>
<td>Expressway</td>
<td>Mazengarb Road</td>
<td>Overpass</td>
<td>60m long, 30m wide with 3 spans and no skew</td>
</tr>
<tr>
<td>Otaihanga Road Overpass</td>
<td>St 9250</td>
<td>Otaihanga Road</td>
<td>Expressway</td>
<td>Overpass</td>
<td>69m long, 14m wide with 3 spans and 5 degree skew</td>
</tr>
<tr>
<td>Waikanae River Bridge</td>
<td>St 10700</td>
<td>Expressway</td>
<td>Waikanae River and El Rancho access road</td>
<td>River Bridge</td>
<td>282m long, 30m wide with 8 spans and no skew</td>
</tr>
<tr>
<td>Location</td>
<td>St</td>
<td>Type</td>
<td>Description</td>
<td>Size</td>
<td></td>
</tr>
<tr>
<td>-----------------------------------------</td>
<td>-----</td>
<td>------------------</td>
<td>-------------------------------------------------------------------------------------------------------</td>
<td>--------------------</td>
<td></td>
</tr>
<tr>
<td>Te Moana Road &amp; Waimeha Stream Underpass</td>
<td>11900</td>
<td>Expressway &amp; Underpass</td>
<td>Te Moana Road and Waimeha Stream</td>
<td>141m long, 30m wide with 5 spans and 10 degree skew</td>
<td></td>
</tr>
<tr>
<td>Te Moana Interchange Ramp Underpass</td>
<td>11930</td>
<td>On and off ramps</td>
<td>Waimeha Stream</td>
<td>Two 32m long, 12m wide single span with 20 degree skew</td>
<td></td>
</tr>
<tr>
<td>Ngarara Road Underpass</td>
<td>13620</td>
<td>Expressway &amp; Underpass</td>
<td>Ngarara Road</td>
<td>Two 62m long, 17m and 14m wide with 3 spans and 45 degree skew</td>
<td></td>
</tr>
<tr>
<td>Peka Peka Interchange Overpass</td>
<td>16750</td>
<td>Local access road</td>
<td>Expressway Overpass</td>
<td>110m long, 14m wide with 4 spans and 50 degree skew</td>
<td></td>
</tr>
</tbody>
</table>

### b. Structures for other Options and Sub-options

The structures described above for the options and sub-options are the same as for option 3 except as described in the table below.

<table>
<thead>
<tr>
<th>Sub-option</th>
<th>Changes to Base Option 3 structures</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCii, &amp;S1Bii</td>
<td>Southern Interchange Overpass is not required</td>
</tr>
<tr>
<td>S1Dii</td>
<td>Southern Interchange Overpass &amp; Poplar Avenue Underpass are not required. Overpass is required at 200 Main Road similar to Southern Interchange Overpass</td>
</tr>
<tr>
<td>S2Bi Check with Geoff</td>
<td>Ihakara Street Extension Underbridge is replaced by Ihakara Street Extension Overbridge which is a 68m long, 14m wide 3 span overbridge to carry Ihakara street Extension over the Expressway, and a single 22m long, 30m wide stream bridge to carry the Expressway over Wharemauku Stream.</td>
</tr>
</tbody>
</table>
Outcome 1 – MOVEMENT

The project provides for people to move efficiently, conveniently and safely throughout the Kapiti District as pedestrians, cyclists or in vehicles.

Contributing Elements:

- **Travel Safety**
  Level of safety provided by option design, safety design of SH1 and local connectors.

- **Vehicles – Level of Service (State Highway)**
  Level of service, movement efficiency and user benefits of local network from traffic model outputs.

- **Vehicles – Level of Service (Local Network)**
  Level of service, movement efficiency and user benefits of local network from traffic model outputs.

- **Integration with Public Transport**
  Level of integration with public transport (train/ bus/ rail/ Paraparaumu Airport). Ability of public transport to safely and efficiently integrate with option design.

- **Integration with Local Destinations**
  Ability for vehicle commuters to conveniently move through-out the District and travel to and from key destinations (Coastlands, Paraparaumu Beach, Kapiti Road Commercial Area, Raumati Village, Waikanae Commercial Centre, Waikanae Beach).

- **Integration with Cycleways**
  Level of integration with cycleways. Ability of cycleways to safely and efficiently integrate with option design.

- **Integration with Pedestrian Access**
  Level of integration with pedestrian access ways. Ability of pedestrian access ways to safely and efficiently integrate with option design.
Outcome 2 – BUILT ENVIRONMENT

The project provides for the integration of infrastructure in the urban environment. The design does not significantly detract from the urban form and the adverse effects on the urban form and features are no more than minor.

Contributing Elements:

- **Visual Impact**
  Visual relationship to the local environment. The extent of visual impact of structures, earthworks, landscaping in relation to context including urban villages, residential, Waikanae River corridor and other public amenity locations.

- **Built Form**
  Relationship to urban form and town centres, including responding to the individual urban identities of Raumati Village, Paraparaumu, Paraparaumu Beach and Waikanae.

- **Impact on Public Areas/Parks/Recreational Areas**
  Significance (positive or negative) of impact on public open space areas.

Outcome 3 – Cultural / Heritage

The project traverses areas with significant heritage and cultural values. The design does not significantly impact on areas of significance.

Contributing Elements:

- **Historic Heritage**
  Significance (positive or negative) of impact on identified heritage (District Plan or NZAA) including buildings, structures, features and archaeological sites.

- **Cultural Sites**
  Significance (positive or negative) of impact on identified cultural sites (District Plan or identified by iwi).
### Outcome 4 – NATURAL ENVIRONMENT

*The project integrates well with the environment and any adverse environmental effects on natural resources and systems such as land, air and water are no more than minor.*

**Contributing Elements:**
- **Land and Vegetation**
  - Extent of environmental impact on land and vegetation.
- **Natural Landscapes & Features**
  - Extent of environmental impact on natural landscapes and features identified as requiring protection by the local and regional plans.
- **Ecological Processes**
  - Extent of environmental impact on natural processes and systems.
- **Surface Water**
  - Extent of environmental impact on surface water resources, including flooding issues around town centre, Waikanae River etc.
- **Groundwater**
  - Extent of environmental impact on groundwater and underground aquifers.

### Outcome 5 – Social

*The project provides for peoples well-being and health and promotes the safe and efficient movement to and from community health and emergency services*

**Contributing Elements:**
- **Air Emissions**
  - Extent of changes to air quality based on fuel consumption and greenhouse gas from traffic model.
- **Noise**
  - The level of noise effects in relation to proximity to noise sensitive activities such as residential areas.
- **Social / Community**
  - The effect on community including well being and displacement

### Outcome 6 – ECONOMIC
The project promotes national, regional and local economic growth.

**Contributing Elements:**

- **National & Regional Economic Growth**
  Consistency with national & regional economic growth policies (e.g., the Wellington Regional Growth Strategy).

- **Local Economic Growth**
  Consistency with local economic growth policy, particularly the impact on local town centres (e.g., KCDC LTCCP, District Plan and Community Outcomes).

---

**Outcome 7 – IMPLEMENTATION TIMEFRAME**

The project is able to be consented and implemented within the project timeline.

<table>
<thead>
<tr>
<th>Timeframe</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>+2 years</td>
<td>-3</td>
</tr>
<tr>
<td>1-2 years</td>
<td>-2</td>
</tr>
<tr>
<td>0-1 year</td>
<td>-1</td>
</tr>
<tr>
<td>0 year</td>
<td>0</td>
</tr>
</tbody>
</table>

**Contributing Elements:**

- **Resource Consent/Planning Approval Process**
  Preliminary planning assessment of likely issues, activity status, planning process.

- **Land Acquisition**
  Preliminary assessment of property acquisition requirements, number and nature of properties required.
## Outcome 8 – Cost

**Option cost relative to Option 2**
**Sub option cost relative to lowest cost sub option for the segment**

<table>
<thead>
<tr>
<th>Value</th>
<th>Cost Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>+2</td>
<td>-5.0% to -7.5%</td>
</tr>
<tr>
<td>+1</td>
<td>-2.5% to -5.0%</td>
</tr>
<tr>
<td>0</td>
<td>-2.5% to +2.5%</td>
</tr>
<tr>
<td>-1</td>
<td>+2.5% to +5.0%</td>
</tr>
<tr>
<td>-2</td>
<td>+5.0% to +7.5%</td>
</tr>
<tr>
<td>-3</td>
<td>+7.5% to +10%</td>
</tr>
</tbody>
</table>

## Outcome 9 – Benefit Cost Ratio

**BCR calculated in accordance with NZTA Evaluation Manual**

**BCR scoring as below, (note BCR of less than 1 score a negative value).**

<table>
<thead>
<tr>
<th>Value</th>
<th>Cost Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.9 to 1.1</td>
</tr>
<tr>
<td>-1</td>
<td>0.7 to 0.9</td>
</tr>
<tr>
<td>-2</td>
<td>0.5 to 0.7</td>
</tr>
<tr>
<td>-3</td>
<td>0.3 to 0.5</td>
</tr>
</tbody>
</table>
## Non Cost Assessment Outcomes

<table>
<thead>
<tr>
<th>Base options</th>
<th>Movement x2</th>
<th>Built Environment</th>
<th>Cultural / Historic</th>
<th>Natural Environment</th>
<th>Social</th>
<th>Economic x2</th>
<th>Implementation Timeframe</th>
<th>Total</th>
<th>Percentage Cost Difference</th>
<th>Cost Estimate</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>-2</td>
<td>-2</td>
<td>-1</td>
<td>-1</td>
<td>2</td>
<td>-3</td>
<td>-5</td>
<td>-1</td>
<td>0</td>
<td>0.64</td>
</tr>
<tr>
<td>1A</td>
<td>2</td>
<td>-3</td>
<td>-2</td>
<td>-2</td>
<td>-2</td>
<td>2</td>
<td>-2</td>
<td>-5</td>
<td>7</td>
<td>-2</td>
<td>0.87</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>-3</td>
<td>-3</td>
<td>-2</td>
<td>-2</td>
<td>2</td>
<td>-3</td>
<td>-6</td>
<td>0</td>
<td>0</td>
<td>0.77</td>
</tr>
<tr>
<td>2A</td>
<td>6</td>
<td>-3</td>
<td>-2</td>
<td>-2</td>
<td>-2</td>
<td>0</td>
<td>-2</td>
<td>-5</td>
<td>8</td>
<td>-3</td>
<td>0.96</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>-3</td>
<td>-2</td>
<td>-2</td>
<td>-2</td>
<td>2</td>
<td>-2</td>
<td>-1</td>
<td>0</td>
<td>0</td>
<td>0.98</td>
</tr>
<tr>
<td>3A</td>
<td>6</td>
<td>-3</td>
<td>-3</td>
<td>-3</td>
<td>-3</td>
<td>-1</td>
<td>-3</td>
<td>-1</td>
<td>0</td>
<td>10</td>
<td>1.01</td>
</tr>
<tr>
<td>3B</td>
<td>6</td>
<td>-3</td>
<td>-3</td>
<td>-3</td>
<td>-3</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0.86</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3C</td>
<td>6</td>
<td>-3</td>
<td>-3</td>
<td>-3</td>
<td>-3</td>
<td>6</td>
<td>-3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>3D</td>
<td>6</td>
<td>-3</td>
<td>-3</td>
<td>-3</td>
<td>-3</td>
<td>6</td>
<td>-3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>3E</td>
<td>6</td>
<td>-3</td>
<td>-3</td>
<td>-3</td>
<td>-3</td>
<td>6</td>
<td>-3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>3F</td>
<td>6</td>
<td>-3</td>
<td>-3</td>
<td>-3</td>
<td>-3</td>
<td>6</td>
<td>-3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

## Live Sub-options

### Non Cost Assessment Outcomes

<table>
<thead>
<tr>
<th>Base Options</th>
<th>Sub-option</th>
<th>Movement</th>
<th>Built Environment</th>
<th>Cultural / Historic</th>
<th>Natural Environment</th>
<th>Social</th>
<th>Economic</th>
<th>Implementation Timeframe</th>
<th>Total</th>
<th>Cost Estimate</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-3 S1Atcii</td>
<td>1</td>
<td>-2</td>
<td>-1</td>
<td>-2</td>
<td>-3</td>
<td>0</td>
<td>-3</td>
<td>-10</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1-3 S1Bii</td>
<td>2</td>
<td>-2</td>
<td>-1</td>
<td>-2</td>
<td>-2</td>
<td>0</td>
<td>-3</td>
<td>-8</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1-3 S1Dtsi</td>
<td>-1</td>
<td>1</td>
<td>0</td>
<td>-1</td>
<td>-3</td>
<td>0</td>
<td>-1</td>
<td>-5</td>
<td>13</td>
<td>-1</td>
<td></td>
</tr>
</tbody>
</table>

### Sector 1

#### 1-3 S2Aii

<table>
<thead>
<tr>
<th>Movement</th>
<th>Built Environment</th>
<th>Cultural / Historic</th>
<th>Natural Environment</th>
<th>Social</th>
<th>Economic</th>
<th>Implementation Timeframe</th>
<th>Total</th>
<th>Cost Estimate</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>-1</td>
<td>-1</td>
<td>-2</td>
<td>1</td>
<td>-1</td>
<td>-3</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

#### 1-3 S2Bi

<table>
<thead>
<tr>
<th>Movement</th>
<th>Built Environment</th>
<th>Cultural / Historic</th>
<th>Natural Environment</th>
<th>Social</th>
<th>Economic</th>
<th>Implementation Timeframe</th>
<th>Total</th>
<th>Cost Estimate</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>-1</td>
<td>-1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

### Sector 2

#### 1-3 S3Aii

<table>
<thead>
<tr>
<th>Movement</th>
<th>Built Environment</th>
<th>Cultural / Historic</th>
<th>Natural Environment</th>
<th>Social</th>
<th>Economic</th>
<th>Implementation Timeframe</th>
<th>Total</th>
<th>Cost Estimate</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>-2</td>
<td>-3</td>
<td>-2</td>
<td>-2</td>
<td>1</td>
<td>-3</td>
<td>-9</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

### Sector 3

#### 1-3 S3Bi

<table>
<thead>
<tr>
<th>Movement</th>
<th>Built Environment</th>
<th>Cultural / Historic</th>
<th>Natural Environment</th>
<th>Social</th>
<th>Economic</th>
<th>Implementation Timeframe</th>
<th>Total</th>
<th>Cost Estimate</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>-3</td>
<td>-3</td>
<td>-3</td>
<td>-1</td>
<td>1</td>
<td>-3</td>
<td>-9</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>-3</td>
<td>-3</td>
<td>-1</td>
<td>-3</td>
<td>-1</td>
<td>-3</td>
<td>-9</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>-3</td>
<td>-3</td>
<td>-1</td>
<td>-3</td>
<td>-1</td>
<td>-3</td>
<td>-9</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

### Sector 4

#### 1-3 S4E

<table>
<thead>
<tr>
<th>Movement</th>
<th>Built Environment</th>
<th>Cultural / Historic</th>
<th>Natural Environment</th>
<th>Social</th>
<th>Economic</th>
<th>Implementation Timeframe</th>
<th>Total</th>
<th>Cost Estimate</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-1</td>
<td>-1</td>
<td>-2</td>
<td>-1</td>
<td>0</td>
<td>-1</td>
<td>-6</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

#### 1-3 S4F

<table>
<thead>
<tr>
<th>Movement</th>
<th>Built Environment</th>
<th>Cultural / Historic</th>
<th>Natural Environment</th>
<th>Social</th>
<th>Economic</th>
<th>Implementation Timeframe</th>
<th>Total</th>
<th>Cost Estimate</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-1</td>
<td>-1</td>
<td>-1</td>
<td>-1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

#### 1-3 S4Ai

<table>
<thead>
<tr>
<th>Movement</th>
<th>Built Environment</th>
<th>Cultural / Historic</th>
<th>Natural Environment</th>
<th>Social</th>
<th>Economic</th>
<th>Implementation Timeframe</th>
<th>Total</th>
<th>Cost Estimate</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-1</td>
<td>-1</td>
<td>-1</td>
<td>-1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sector 1</td>
<td>Base Options</td>
<td>Sub-option</td>
<td>Description</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------</td>
<td>--------------</td>
<td>------------</td>
<td>-------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1--3</td>
<td>S1A</td>
<td></td>
<td>Southern tie-in at MacKays Crossing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1--3</td>
<td>S1Bi</td>
<td></td>
<td>South facing/north facing ramps south of Poplar Ave with additional local road tie-in. Alignment located west of the Steiner School (located within existing designation)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1--3</td>
<td>S1Bi</td>
<td></td>
<td>South facing ramps at Poplar Ave. Alignment located west of the Steiner School (located within existing designation)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1--3</td>
<td>S1Bi</td>
<td></td>
<td>South facing ramps, including local road over bridge in QE park. Alignment located west of Steiner School</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1--3</td>
<td>S1Ci</td>
<td></td>
<td>South facing/north facing ramps south of Poplar with additional local road tie-in. Alignment located east of the Steiner School</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1--3</td>
<td>S1Di</td>
<td></td>
<td>Ties in at 200 Main Road. South facing ramps. (this option includes variations 1E and 1F). Local service road runs parallel to SH1.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sector 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3D</td>
<td>S2Ai</td>
<td></td>
<td>Follows existing designation. South facing ramps at Raumati Road and north facing ramps at Kapiti Road. One way auxiliary lanes for local traffic - as per Option 7.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T3, T6, T9</td>
<td>S2Av</td>
<td></td>
<td>Follows existing designation. Interchange at Kapiti Road.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T1, T2, T8</td>
<td>S2Bi</td>
<td></td>
<td>No interchanges</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>S2Bi</td>
<td></td>
<td>Interchange at Mazengarb.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sector 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1--3</td>
<td>S3F</td>
<td></td>
<td>Straight line alignment from Otaihanga (near Peka Peka). Possible interchange at Otaihanga Road &amp; interchange at Te Moana Road.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>S4A</td>
<td></td>
<td>Follow existing designation. North facing ramps at Peka Peka.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1--3</td>
<td>S4B</td>
<td></td>
<td>Straight line alignment from Otaihanga. North facing ramps at Peka Peka.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1--3</td>
<td>S4C</td>
<td></td>
<td>Alignment close to urban growth boundary. North facing ramps at SH1 (south of Peka Peka).</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1--3</td>
<td>S4D</td>
<td></td>
<td>Deviation from the designation south of urban growth edge and ties into existing highway 2km south of Peka Peka.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Assessment comments for workshop 15 sept

**BASE OPTION DESCRIPTION**

<table>
<thead>
<tr>
<th>Base options</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BASE OPTION DESCRIPTION</strong></td>
<td><strong>Comments</strong></td>
</tr>
<tr>
<td></td>
<td>key points which influenced your assessment)</td>
</tr>
<tr>
<td>1A South-facing ramps south of Poplar Ave, north-facing ramps at Peka Peka.</td>
<td>- Score due to noise, quality and displacement effects associated with interchange footprint.</td>
</tr>
<tr>
<td>1B South-facing ramps south of Poplar Ave, local crossing at Weggery Dr, south-facing ramps at Peka Peka.</td>
<td>- Score due to noise, quality and displacement effects associated with the additional river crossing.</td>
</tr>
<tr>
<td>2A South-facing ramps south of Poplar Ave, full interchange at Otaihanga Road, north-facing ramps at Peka Peka.</td>
<td>- Score due to noise, quality and displacement effects associated with the additional river crossing.</td>
</tr>
<tr>
<td>3A South-facing ramps south of Poplar Ave, north-facing ramps at Peka Peka.</td>
<td>- Score due to noise, quality and displacement effects associated with the additional river crossing.</td>
</tr>
<tr>
<td>3B South-facing ramps south of Poplar Ave, north-facing ramps at Peka Peka.</td>
<td>- Score due to noise, quality and displacement effects associated with the additional river crossing.</td>
</tr>
<tr>
<td>3C South-facing ramps south of Poplar Ave, north-facing ramps at Peka Peka.</td>
<td>- Score due to noise, quality and displacement effects associated with the additional river crossing.</td>
</tr>
<tr>
<td>4A South-facing ramps south of Poplar Ave, local crossing at Weggery Dr, north-facing ramps at Peka Peka.</td>
<td>- Score due to noise, quality and displacement effects associated with the additional river crossing.</td>
</tr>
<tr>
<td>4B South-facing ramps south of Poplar Ave, full interchange at Otaihanga Road, north-facing ramps at Peka Peka.</td>
<td>- Score due to noise, quality and displacement effects associated with the additional river crossing.</td>
</tr>
<tr>
<td>5A South-facing ramps south of Poplar Ave, local crossing at Weggery Dr, north-facing ramps at Peka Peka.</td>
<td>- Score due to noise, quality and displacement effects associated with the additional river crossing.</td>
</tr>
<tr>
<td>5B South-facing ramps south of Poplar Ave, full interchange at Otaihanga Road, north-facing ramps at Peka Peka.</td>
<td>- Score due to noise, quality and displacement effects associated with the additional river crossing.</td>
</tr>
<tr>
<td>5C South-facing ramps south of Poplar Ave, north-facing ramps at Peka Peka.</td>
<td>- Score due to noise, quality and displacement effects associated with the additional river crossing.</td>
</tr>
<tr>
<td>6A South-facing ramps south of Poplar Ave, north-facing ramps at Peka Peka.</td>
<td>- Score due to noise, quality and displacement effects associated with the additional river crossing.</td>
</tr>
<tr>
<td>6B South-facing ramps south of Poplar Ave, full interchange at Otaihanga Road, north-facing ramps at Peka Peka.</td>
<td>- Score due to noise, quality and displacement effects associated with the additional river crossing.</td>
</tr>
<tr>
<td>6C South-facing ramps south of Poplar Ave, full interchange at Kapiti Road.</td>
<td>- Score due to noise, quality and displacement effects associated with the additional river crossing.</td>
</tr>
</tbody>
</table>

- **Score due to** noise, quality and displacement effects associated with interchange footprint.  |
- **Score due to** noise, quality and displacement effects associated with the additional river crossing.  |
- **Score due to** noise, quality and displacement effects associated with the additional river crossing.  |
- **Score due to** noise, quality and displacement effects associated with the additional river crossing.  |
- **Score due to** noise, quality and displacement effects associated with the additional river crossing.  |
- **Score due to** noise, quality and displacement effects associated with the additional river crossing.  |
- **Score due to** noise, quality and displacement effects associated with interchange footprint.  |
- **Score due to** noise, quality and displacement effects associated with the additional river crossing.  |
- **Score due to** noise, quality and displacement effects associated with the additional river crossing.  |
- **Score due to** noise, quality and displacement effects associated with the additional river crossing.  |
- **Score due to** noise, quality and displacement effects associated with the additional river crossing.  |
- **Score due to** noise, quality and displacement effects associated with the additional river crossing.  |
- **Score due to** noise, quality and displacement effects associated with the additional river crossing.  |
- **Score due to** noise, quality and displacement effects associated with the additional river crossing.  |
- **Score due to** noise, quality and displacement effects associated with the additional river crossing.  |
- **Score due to** noise, quality and displacement effects associated with the additional river crossing.  |
- **Score due to** noise, quality and displacement effects associated with the additional river crossing.  |
- **Score due to** noise, quality and displacement effects associated with the additional river crossing.  |
- **Score due to** noise, quality and displacement effects associated with the additional river crossing.  |
- **Score due to** noise, quality and displacement effects associated with the additional river crossing.  |
- **Score due to** noise, quality and displacement effects associated with the additional river crossing.  |
- **Score due to** noise, quality and displacement effects associated with the additional river crossing.  |
UNLIKELY TO BE CONSENTABLE AS IT DIVIDES QE PARK IN TWO. RECREATIONAL IMPACTS TOO HIGH TO CONTINUE.

SECTORS

BASE SECTOR 1

1.1.3 S4C South-facing ramps on Poplar Ave. - Aligns located west of the Steiner School.  
  (S) - Score due to significant air quality and noise effects of having expressway ramps at Poplar Ave.  
  (BE) - Visual effects similar to S4E and S4F  
  (S) - Score due to minor air quality, noise and property effects.  
  (IT) - May not achieve timeframe because of effects on QEII Covenanted wetland  
  (S) - Score due to significant property displacement and noise effects.

1.1.3 S4D South-facing ramps - Including local road over bridge in QE Park.  
  (S) - Score due to air quality, noise and property effects.  
  (BE) - Interchange at Te Moana will have significant visual effects and change to the semi rural/suburban character of the area.  
  (S) - Score due to significant effects on El Rancho Christian Holiday Camp (providing recreational land to the community).  
  (S) - Score due to minor air quality, noise and property effects.  
  (S) - Score due to significant property displacement and noise effects.  
  (S) - Score due to significant effects on El Rancho and Osbournes Swamp wetlands (identified ecological and QEII eco-sites).  
  (NE) - Significant effects on QEII Eco-site (Raumati South peatlands - moderate value).  
  (NE) - Minor effects on QEII Covenanted wetland.

Base sector 2

1.2.3 S3A Follow existing designation through the section.  
  (S) - Score due to minor air quality, noise and property effects.  
  (NE) - Significant effects on El Rancho and Osbournes Swamp wetlands (identified ecological and QEII eco-sites).  
  (IT) - Likely to achieve timeframe but KCDC and local residents may oppose Ihakara Street I/C.  
  (S) - Score due to minor air quality, noise and property effects.  
  (S) - Score due to significant property displacement and noise effects.

1.2.3 S1Cii South facing ramps, including local road over bridge in QE park.  
  (S) - Score due to significant effects on 1) El Rancho Christian Holiday Camp (providing recreational land to the community).  
  (S) - Score due to significant property displacement and noise effects.

1.2.3 S1Ciii South facing ramps, including local road over bridge in QE parks.  
  (S) - Score due to significant effects on 1) El Rancho Christian Holiday Camp (providing recreational land to the community).  
  (S) - Score due to significant property displacement and noise effects.

1.2.3 S1Ci Southern tie-in at MacKay's Crossin
  (S) - Score due to significant effects on 1) El Rancho Christian Holiday Camp (providing recreational land to the community).  
  (S) - Score due to significant property displacement and noise effects.

1.2.3 S2Bii Interchange at Mazengarb.  
  (S) - Score due to significant effects on 1) El Rancho Christian Holiday Camp (providing recreational land to the community).  
  (S) - Score due to significant property displacement and noise effects.

1.2.3 S3D Crosses river via existing designation - east of Urupa, west of Maketu (straighter alignment).  
  (S) - Score due to significant effects on El Rancho Christian Holiday Camp (providing recreational land to the community).  
  (S) - Score due to significant property displacement and noise effects.

1.2.3 S3C Sub-option to removed from current live list.  
  (S) - Score due to significant effects on El Rancho Christian Holiday Camp (providing recreational land to the community).  
  (S) - Score due to significant property displacement and noise effects.

1.2.3 S4C South-facing ramps on Poplar Ave. - Aligns located west of the Steiner School.  
  (S) - Score due to significant effects on El Rancho Christian Holiday Camp (providing recreational land to the community).  
  (S) - Score due to significant property displacement and noise effects.

1.2.3 S4D South-facing ramps - Including local road over bridge in QE Park.  
  (S) - Score due to significant effects on El Rancho Christian Holiday Camp (providing recreational land to the community).  
  (S) - Score due to significant property displacement and noise effects.

1.2.3 S4E Alignment has a minor encroachment on the QEII covenants and stays within Maypole vicinity of Otaihanga Landfill complex.  
  (S) - Score due to significant effects on El Rancho Christian Holiday Camp (providing recreational land to the community).  
  (S) - Score due to significant property displacement and noise effects.

1.2.3 S4F Alignment avoids QEII covenants and other wetland areas.  
  (S) - Score due to significant effects on El Rancho Christian Holiday Camp (providing recreational land to the community).  
  (S) - Score due to significant property displacement and noise effects.

1.2.3 S4B South-facing ramps, including local road over bridge in QE park.  
  (S) - Score due to minor air quality, noise and property effects.  
  (BE) -  Interchange at Te Moana will have significant visual effects and change to the semi rural/suburban character of the area.  
  (S) - Score due to significant effects on El Rancho Christian Holiday Camp (providing recreational land to the community).  
  (S) - Score due to significant property displacement and noise effects.

Suboptions are QEII covenants and other wetland areas.  
  (S) - Score due to significant effects on El Rancho Christian Holiday Camp (providing recreational land to the community).  
  (S) - Score due to significant property displacement and noise effects.

1.2.3 S1A Follow existing designation - As wide as possible through QE Park.  
  (S) - Score due to minor air quality, noise and property effects.  
  (BE) -  Interchange at Te Moana will have significant visual effects and change to the semi rural/suburban character of the area.  
  (S) - Score due to significant effects on El Rancho Christian Holiday Camp (providing recreational land to the community).  
  (S) - Score due to significant property displacement and noise effects.

DELETED SUB-OPTIONS

DELETE SECTOR 1

1.1.1 S1D Straight-line alignment from Otaihanga (near Peka Peka).  
  (S) - Score due to minor air quality, noise and property effects.  
  (IT) - Strong opposition from school local residents and possibly GWRC because of scale of impact.  
  (S) - Score due to significant property displacement and noise effects.

1.1.1 S1E South-facing ramps, including local road over bridge in QE Park.  
  (S) - Score due to air quality, noise and property effects.  
  (BE) -  Interchange at Te Moana will have significant visual effects and change to the semi rural/suburban character of the area.  
  (S) - Score due to significant effects on El Rancho Christian Holiday Camp (providing recreational land to the community).  
  (S) - Score due to significant property displacement and noise effects.

1.1.1 S2A South-facing ramps - Including local road over bridge in QE Park.  
  (S) - Score due to significant effects on El Rancho Christian Holiday Camp (providing recreational land to the community).  
  (S) - Score due to significant property displacement and noise effects.

1.1.1 S3A South-facing ramps - Including local road over bridge in QE Park.  
  (S) - Score due to significant effects on El Rancho Christian Holiday Camp (providing recreational land to the community).  
  (S) - Score due to significant property displacement and noise effects.

1.1.1 S4A Fatally flawed due to location through QEII covenants and ecological areas.

1.1.1 S4B South-facing ramps, including local road over bridge in QE park.  
  (S) - Score due to significant effects on El Rancho Christian Holiday Camp (providing recreational land to the community).  
  (S) - Score due to significant property displacement and noise effects.

1.1.1 S4C South-facing ramps, including local road over bridge in QE park.  
  (S) - Score due to significant effects on El Rancho Christian Holiday Camp (providing recreational land to the community).  
  (S) - Score due to significant property displacement and noise effects.

1.1.1 S4D South-facing ramps, including local road over bridge in QE park.  
  (S) - Score due to significant effects on El Rancho Christian Holiday Camp (providing recreational land to the community).  
  (S) - Score due to significant property displacement and noise effects.

1.1.1 S4E South-facing ramps, including local road over bridge in QE park.  
  (S) - Score due to significant effects on El Rancho Christian Holiday Camp (providing recreational land to the community).  
  (S) - Score due to significant property displacement and noise effects.

1.1.1 S4F South-facing ramps, including local road over bridge in QE park.  
  (S) - Score due to significant effects on El Rancho Christian Holiday Camp (providing recreational land to the community).  
  (S) - Score due to significant property displacement and noise effects.

1.1.1 S4G South-facing ramps, including local road over bridge in QE park.  
  (S) - Score due to significant effects on El Rancho Christian Holiday Camp (providing recreational land to the community).  
  (S) - Score due to significant property displacement and noise effects.
Score comparison from Multi Criteria Analysis

**Cost/V Non Cost Comparison**

- **Most Feasible**
- **Least Feasible**

**Non Cost / BCCF Comparison**

- **Most Feasible**
- **Least Feasible**

### Table

<table>
<thead>
<tr>
<th>Score</th>
<th>Estimated Non Cost</th>
<th>Estimated Cost</th>
<th>Score</th>
<th>Estimated Non Cost</th>
<th>Estimated Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.5</td>
<td>0</td>
<td>2</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>IA</td>
<td>5</td>
<td>0</td>
<td>2A</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>0</td>
<td>5</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>JA</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>1</td>
<td>3A</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>2B</td>
<td>1</td>
<td>5</td>
<td>3C</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>3A</td>
<td>1</td>
<td>3</td>
<td>3D</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>JA</td>
<td>1</td>
<td>5</td>
<td>3F</td>
<td>3</td>
<td>0</td>
</tr>
</tbody>
</table>

The diagrams show the comparison of cost and non-cost factors for different scores, indicating how they align with feasibility criteria.