BEFORE A BOARD OF INQUIRY
PEKA PEKA TO NORTH ŌTAKI EXPRESSWAY PROJECT

In the matter of the Resource Management Act 1991

And

In the matter of a notice of requirement and resource consent applications by the NZ Transport Agency for the Peka Peka to North Ōtaki Expressway Project

And

In the matter of a notice of requirement by New Zealand Railways Corporation / KiwiRail Holdings Limited (trading as KiwiRail) for the realignment of a section of the North Island Main Trunk railway line through Ōtaki

STATEMENT OF EVIDENCE OF PATHMANATHAN BRABHAHARAN
(GEOTECHNICAL ENGINEERING) ON BEHALF OF THE APPLICANTS

12 July 2013
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QUALIFICATIONS AND EXPERIENCE

1. My name is Pathmanathan Brabhaharan.

2. I am Technical Principal, Geotechnical & Earthquake Engineering, and Infrastructure Resilience at Opus International Consultants Limited (“Opus”). I am also Resource Group Manager for the Wellington Geotechnical Engineering and Resilience Group, in the Wellington Civil Engineering Team of Opus.

3. I have the following qualifications and experience relevant to the evidence I shall give:

   (a) Bachelor of Science of Engineering with Honours, specialising in Civil Engineering, from the University of Peradeniya, Sri Lanka (1982).

   (b) Master of Science of Engineering in Foundation Engineering from the University of Birmingham, United Kingdom (1986).

   (c) Master of Business Administration from Deakin University, Australia (1998).

   (d) Chartered Professional Engineer in New Zealand.

   (e) I have 30 years' experience in Geotechnical, Earthquake and Civil Engineering and Risk Management, in New Zealand, United Kingdom, Malaysia, Singapore and Sri Lanka.

   (f) I have been based in Wellington and have practised in New Zealand since 1989 (over the past 24 years), and during this period have provided geotechnical advice, design, investigations and construction monitoring for a variety of infrastructure projects, and in particular for motorways, expressways, highways, roads and bridges.

   (g) I was a member of the Learning from Earthquakes Team from the NZ Society for Earthquake Engineering that carried out reconnaissance of the damage to the built and natural environments in the Sichuan Province of China, as a result of the Richter Magnitude 8 Wenchuan Earthquake in May 2008, and presented findings to the profession.

   (h) I was engaged by the NZ Transport Agency (“NZTA”) to carry out field reconnaissance of damage to highways and bridges and to gather and report lessons on geotechnical aspects of the observed performance, following the 2010 Magnitude 7.1 Darfield Earthquake and the 2011 Magnitude 6.3 Christchurch Earthquake that affected Canterbury. I have been actively involved in the emergency response and recovery after the 2010-2011 Canterbury Earthquake Sequence, and continue to be involved in developing repair and reconstruction solutions.

   (i) My experience includes a variety of highway projects in the Wellington, Nelson-Marlborough and other Regions, which have involved design and/or construction of large earthworks in geological conditions similar to those encountered along the Peka Peka to Ōtaki route, including:
(i) the Western Link Road, between Raumati South and Waikanae (sand and inter-dunal peat deposits), for the design and consenting stages;

(ii) double tracking of the NIMT railway line between MacKays Crossing and Waikanae (sand dunes and inter-dunal peat deposits with localised greywacke rock), for design and consenting stages and as reviewer for the construction stage;

(iii) Transmission Gully expressway (sand dunes and inter-dunal peat deposits at the north end, estuarine deposits at State Highway ("SH") 58, alluvium at the southern end and along the many stream valleys, and predominantly greywacke rock), for the preliminary geotechnical investigations and assessment, scheme assessment, development of designs for consents, assessment of environmental effects and preparation and presentation of evidence at the Board of Inquiry;

(iv) SH 58 Realignment between Pauatahanui and Judgeford (alluvium and greywacke rock), for the detailed design and construction stages;

(v) Wellington Inner City Bypass (alluvium and complex groundwater regime), for development of the scheme, detailed design, construction and maintenance management; my role included detailed assessment of the groundwater regime and its interaction with the road structures, development of solutions to mitigate and risks and monitoring during construction to demonstrate compliance;

(vi) the Basin Reserve Improvements in Wellington (alluvium and complex groundwater regime), for the scheme development and assessment and currently for the consenting stage; this included assessment of effects of construction on the groundwater regime;

(vii) SH 6 Stoke Bypass, Nelson (soft estuarine deposits and alluvium), for the route development, consenting, design and construction stages;

(viii) SH 2 Kaitoke to Te Marua Realignment (soft alluvial deposits and dense terrace gravels), for the route development, consenting, detailed design and construction stages;

(ix) SH 60 Ruby Bay Bypass (soft estuarine deposits and dense alluvial gravels), for the route development, consenting, detailed design and construction stages; and

(x) Christchurch Southern Motorway (liquefiable and compressible alluvium), as reviewer for the scheme development, detailed design and construction stages.

(j) I led the earthquake hazard assessment and mapping studies, including liquefaction and slope failure hazards for the Wellington region (1992-1995), which resulted in the publication of earthquake hazard maps for the Wellington
This included the Kāpiti area through which the proposed Expressway passes.

(k) I have also led a number of studies to assess the resilience and develop risk management strategies for the State highways in the Wellington Region and the local authority road networks in Kāpiti Coast, Wellington City, Hutt Valley, Upper Hutt, and Porirua. The resilience of priority roads within the greater Wellington area under earthquake and / or storm conditions have been assessed as part of these studies.

(l) I was involved in a study for the NZTA to identify critical sections along SH 1, SH 2 and SH 58 that would be affected in a major earthquake in the region, develop emergency response plans and in particular assess the likely time required to reopen the coastal route between Pukerua Bay and Paekakariki.

(m) I have advised the Wellington Lifelines Group in the consideration of emergency access following a major earthquake in the region.

(n) I have provided geotechnical engineering input to the seismic assessment and retrofit of bridges throughout New Zealand, including development of innovative retrofit solutions for abutments. This has included the seismic and scour assessment of the Ōtaki River Bridge on SH 1, development of mitigation measures and construction.

4. I am a member of a number of relevant associations including:

(a) Fellow of the Institution of Professional Engineers New Zealand;

(b) New Zealand Society for Earthquake Engineering;

(c) New Zealand Society for Risk Management;

(d) New Zealand Geotechnical Society, and am affiliated to the International Society for Soil Mechanics and Geotechnical Engineering and the International Society for Rock Mechanics; and

(e) Structural Engineering Society.

5. I confirm that I have read the 'Code of Conduct' for expert witnesses contained in the Environment Court Practice Note 2011. My evidence has been prepared in compliance with that Code. In particular, unless I state otherwise, this evidence is within my sphere of expertise and I have not omitted to consider material facts known to me that might alter or detract from the opinions I express.

BACKGROUND AND ROLE

6. My evidence is given in relation to the notices of requirement and resource consent applications lodged by the NZTA and KiwiRail for the Peka Peka to North Ōtaki Expressway (the "Expressway") and North Island Main Trunk ("NIMT") Railway realignment (together, the "Project").
7. I have been responsible for geotechnical engineering input to the Project since 2010, in the development of the scheme, in the scoping of geotechnical investigations, reviewing the data from the site investigations carried out by AECOM (2011), reviewing a geotechnical assessment report prepared by a team led by me (Opus, 2011), and overseeing groundwater monitoring since 2011.

8. I provided comment on the geotechnical and earthquake hazards associated with various alternative routes that were considered as part of the development of the Project (discussed in the evidence of Ms Sylvia Allan). I was also involved in workshops to develop the alignment, and provided input to the development of the alignment taking into consideration the geotechnical engineering issues along the route.

9. I have worked with other designers and experts, in particular with Opus designers in the development of the road geometric alignment and bridge designs, with Mr John Turner in the assessment of the effects on the wetlands, with Mr Derek Holmes on the construction issues, and with Ms Rebecca Beals on the issues relating to conditions.

10. I had a meeting with Dr Christopher Christoffel and Mr Fred MacDonald to discuss the Project, together with Mr Ulvi Salayev from the NZTA and Mr Mark Edwards from Opus, and visited various areas of the site to discuss their opinions on the route. The purpose of the meeting was to share and exchange information and local knowledge of the project area, and to gain an understanding of Dr Christoffel's geophysical work that identified faults north of the area;

11. I prepared the technical report on Geotechnical Engineering and Geology dated March 2013, which is Technical Report 4 in volume 3 of the Assessment of Environmental Effects Report ("AEE").

12. In preparing my evidence I have also:

(a) visited the site to observe the site conditions; and

(b) attended workshops with other designers and experts to discuss the Project.

13. My evidence draws on Technical Report 4, an earlier Geotechnical Interpretative Report,\(^1\) and the evidence of Mr Turner and Mr Holmes.

SCOPE OF EVIDENCE

14. My evidence addresses the geotechnical aspects of the Project, namely:

(a) the geology of the Project area;

(b) the Project's important contribution to improving route security, and how the Project design has factored in natural hazards;

(c) other geotechnical aspects of the Project design; and

\(^1\) Opus, 2011, prepared as part of the scheme assessment for the Project.
(d) environmental effects and proposed mitigation in relation to:

(i) groundwater and aquifers;
(ii) ground settlement;
(iii) wetlands;
(iv) bridge foundation works; and
(v) sand dunes.

EXECUTIVE SUMMARY

15. The Project area comprises:

(a) sand dunes and inter-dunal peat deposits underlain by older beach deposits;
(b) recent alluvium deposited by the Ōtaki River, Waitohu Stream and other streams;
(c) the older alluvial terrace; and
(d) the glacial and inter-glacial deposits underlying the site.

16. The geotechnical conditions along the route have been closely considered in the development of the Project.

17. The Expressway, in conjunction with the Transmission Gully expressway, will considerably improve the resilience of access into and out of Wellington. This is important given that the existing routes into Wellington have poor resilience, and the Wellington region is likely to be isolated in the event of a large earthquake. This will severely restrict the ability to respond to and recover after such an earthquake event.

18. Therefore one of the important considerations in the development of the Project has been to enhance resilience along this section of the transport corridor, where my previous studies had indicated that the existing SH1 is vulnerable to damage during large earthquakes (particularly to the Ōtaki River Bridge and to the existing SH1 carriageway as a result of liquefaction).

19. From a geotechnical engineering perspective, there are potential minor adverse effects arising from the Project works, which can be readily addressed through traditional approaches. The comprehensive set of conditions proposed will adequately address these effects, and I consider that the residual effects associated with geotechnical engineering aspects of the Project will be negligible.

GEOLOGY OF THE PROJECT AREA

20. A key part of my role as the geotechnical advisor to the Project has been to assess the existing geological context for the Project, which has formed the basis of my input
to the Project design and my assessment of the Project's environment effects. A brief summary of the detailed geotechnical information considered is set out below.

21. In broad terms, the geology of the Project area comprises the following major units of importance to the construction of the Project – the sand dunes and inter-dunal peat deposits underlain by older beach deposits; recent alluvium deposited by the Ōtaki River, Waitohu Stream and other streams; the older alluvial terrace and the glacial and inter-glacial deposits underlying the site. A more detailed description of the geology along the route is presented in Technical Report 4, and the Plan Set in Volume 5, and a summary geology map is presented in Figure A1 of Annexure A.

22. The geology along the Project route can be summarised as follows:

(a) The whole area is underlain at depth by greywacke rocks of Triassic Age, but this rock will not be encountered by any of the proposed works and is not of relevance to the design and construction of the Project.

(b) From the southern end of the Project, where the Expressway joins with the MacKays to Peka Peka expressway, sand dunes and inter-dunal swamps (including peat deposits) are present to Mary Crest.

(c) North of Mary Crest and up to just south of the Ōtaki River, the Project will be located on a geologically older (Pleistocene Age) alluvial terrace comprising dense sandy and silty gravels.

(d) The Project alignment crosses recent alluvium (Holocene Age) associated with the Ōtaki River from just south of the river bank to the Ōtaki township.

(e) Just north of the Ōtaki township, the Project will cross another section of sand dunes and inter-dunal swamp deposits skirting along the margin of the older alluvial terrace.

(f) The Project will then cross a young alluvium associated with the Waitohu Stream, and rejoin with the existing SH1 north of Waitohu Stream.

23. My geological assessment has also encompassed the groundwater regime in the Project area. Key aspects of that regime are summarised in the "Environmental Effects and Mitigation" section of my evidence.

ROUTE SECURITY AND NATURAL HAZARDS

24. A very important consideration in the design of the Project has been how it responds to natural hazards, and indeed a key benefit of the Project is its contribution to improving the security of the roading network in the event of a natural disaster. These aspects are discussed in this section of my evidence.

The existing seismic environment in the Wellington region

25. New Zealand is located at the boundary of the Australian and Pacific Plates, with the plate boundary located on the western side of the South Island and the eastern side of
the North Island. The subduction zone associated with the plate boundary crosses from the west to the east under the Cook Strait area and the Wellington region. As such, Wellington is in an area of high seismicity, with a number of active faults and a subduction zone capable of producing large earthquakes of Richter magnitude 7 to 8.

26. Among the major active faults in the region are the Wairarapa Fault (which ruptured in 1855, leading to a Richter magnitude 8 earthquake), the Wellington Fault (which runs through Wellington and the Hutt Valley) and the Ohariu Fault / Northern Ohariu Fault (which runs through Porirua and Kāpiti).

27. The proposed MacKays to Peka Peka expressway project is likely to cross the active Ohariu Fault, just south of the Expressway. The active Northern Ohariu Fault is located near the proposed Expressway, and although the fault shown on the geological maps stop just short of the Expressway, it is possible that it may cross the Expressway in the vicinity of the cross-corridor bridge at Te Horo.

Wellington earthquake hazard studies

28. Earthquake induced liquefaction hazards in the Wellington Region were assessed and mapped in a study I led for Wellington Regional Council in 1992-1993. The study identified the areas in the region which were at risk of significant liquefaction and ground damage in the event of moderate to large earthquakes.

29. The study showed that the sections of SH1 between Peka Peka and Mary Crest are prone to a moderate liquefaction hazard with potential for subsidence, and the section between the Ōtaki River and Waitohu Stream generally with a variable liquefaction hazard. The remaining section from Mary Crest to south of the Ōtaki River is not prone to liquefaction (refer Figure A2, Annexure A).

30. Earthquake induced slope failure hazards were also assessed and mapped by a combined Opus-GNS Science team that I led for the Wellington Regional Council in 1993-1995. Our study confirmed that earthquake induced slope failures are a major hazard for the region, but not a significant hazard along the Peka Peka to Ōtaki Project corridor.

Resilience of current access routes into Wellington

31. Following a large local earthquake, access into Wellington will likely be prevented for a long period of time along the western access corridor, due to closure of SH1 as a result of large landslides between Pukerua Bay and Paekakariki, and liquefaction and lateral spreading along the Porirua Harbour section (Brabhaharan et al, 2012). Access from the east along SH2 will also be closed due to landslides in the Rimutaka Hill section. The Wellington region is likely to be isolated, and this will severely restrict the ability to respond to and recover after such an earthquake event. Construction of the Transmission Gully expressway is likely to significantly improve this access along the western corridor into Wellington (Brabhaharan, 2011).
32. However, access through the Kāpiti Coast district is also likely to be affected, as the Ōtaki River Bridge is not resilient in large earthquakes, and damage to that structure could close the western corridor. Also, while continued access is likely to be available, liquefaction could lead to partial failures of embankments south of Mary Crest and lead to single lane access.

**Route security of the Expressway**

33. This Project, in conjunction with other Roads of National Significance projects along the northern corridor such as the Transmission Gully expressway, provides an important opportunity to improve the security of access into and out of Wellington, after large local earthquake events, storms, or tsunami.

34. Because the Wellington region is an area of high seismicity, liquefaction hazards, with steep terrain and a number of active faults, total elimination of earthquake-associated hazards is not possible. Accordingly, the focus for this Project has been on developing an alignment, road form and concept design that would enhance resilience of the route and hence improve route security to an appropriate level.

35. It is impractical to avoid crossing the active Ohariu Fault or Northern Ohariu Fault along the western corridor access into Wellington. This is because of the terrain, and this active fault traversing the western corridor obliquely in a southwest to northeast direction (refer Figure A1, Annexure A). The focus has therefore been on ensuring that rupture of this fault does not severely compromise the security of the route. The Expressway crosses an extension of the Northern Ohariu Fault at Te Horo on an embankment (as opposed to a viaduct or bridge structure). This crossing is slightly south of the bridge over the Expressway at Te Horo.

36. Although a possible rupture of the Northern Ohariu Fault could be associated with a displacement of approximately 4 m horizontal and 1 m vertical, the displacement is likely to be distributed because of the less distinct nature of the fault trace at this location. Continued access could therefore be possible after a Northern Ohariu Fault rupture event, or limited access can be quickly restored within hours to days by earthmoving machinery. Long-term, full access can then be restored by further earthworks. In comparison, a bridge or a viaduct would take a longer time (some years) to reconstruct following damage or collapse due to fault rupture. A similar approach was adopted in the consented design for the Transmission Gully expressway (Brabhabaran, 2011).

37. The design philosophy described above, and adopted for crossing active faults was reinforced by my observations of damage to highway infrastructure in the 2008 Wenchuan Earthquake. There I observed two roads, one where the road crossed the fault on a bridge where there was still no access six months after the earthquake, and another road, where access had been quickly restored by ramping across the fault using earthworks, see Figure B1, Annexure A.

38. The Project design proposes that the swamp deposits comprising peat and potentially liquefiable sand deposits under embankments will be largely excavated and replaced...
with dense fill resistant to liquefaction. This would reduce the risk from any liquefaction induced damage to the Expressway to an acceptable level. The geotechnical investigations also confirmed the low liquefaction hazards where the Expressway is built on the terrace as well as recent alluvium.

39. It is proposed that the new bridges across Ōtaki River, as well as other bridge crossings, will be built to current seismic standards, which will make them resilient to earthquakes (particularly so when compared to the existing bridges on SH1).

**Projected route security performance**

40. I have assessed the resilience of the proposed design concept for the Expressway, through an assessment of the likely availability state in a local Richter Magnitude 7.5 earthquake event. This data is presented in map format in Figure B1, Annexure A.

41. The availability state map shows how the Project route will perform in a very large earthquake event. The Expressway is expected to remain open after a large earthquake, with some limited road deformation from liquefaction along some sections. I consider the Project route performance level in such large earthquakes to be appropriate, and a significant improvement on the existing situation.

42. The route will also perform much better in small to moderate earthquake and storm events, which are more frequent. In the event of an earthquake with a rupture along the Northern Ohariu Fault and damage to the Expressway embankment, the embankment will be able to be quickly restored within days by earthmoving machinery, if the access is affected by the rupture.

43. In my view, the Expressway (in conjunction with the Transmission Gully expressway) will considerably improve the resilience of access into and out of Wellington, compared to the existing routes.

**OTHER GEOTECHNICAL ASPECTS OF THE PROJECT DESIGN**

44. I have been closely involved in advising the Project designers of geotechnical considerations that need to be taken into account in the design of the Project. In addition to considerations relating to earthquake risk and resilience, discussed above, key aspects of the design influenced by geotechnical considerations are summarised below.

**Cut slopes**

45. The Project will require the formation of cuttings in the dune sand of up to 20 m high. The cut slopes will be formed at a slope of between 20 to 25 degrees (approximately), with 3 m wide benches at 10 m height intervals. This is consistent with the observed stable slopes of 15 to 25 degrees in dune sand. The erodible dune sand materials will be protected by re-vegetation soon after construction, using appropriate plant species, and geotextile erosion protection matting will be used as necessary to facilitate erosion protection in the early period after construction and the establishment of vegetation.
46. The cuttings up to 12 m high in the terrace alluvium between the Ōtaki River Bridge and Te Horo will be formed at a slope of about 40 degrees. These cut slopes will also be re-vegetated soon after construction to minimise erosion.

47. The top of the cuttings in all materials will be rounded in the vertical plane, and the longitudinal edges of the cuttings in the horizontal plane, to ensure stability of the edges of these cuttings and to ensure that the cut slopes blend in with the natural landscape.

48. Conditions are proposed (as presented through the evidence of Ms Rebecca Beals) to achieve appropriate stabilisation and contouring of all cut slopes, as discussed further below.

**Embankments**

49. Embankments up to 8 m high are proposed for the Expressway construction, and will be built in areas underlain by alluvium and inter-dunal swamp deposits.

50. The embankments will be constructed using materials from the cuttings in the dune sand and terrace alluvium. Additional fill materials may be obtained by forming flatter cut slopes or widening the berm beside the road carriageways. Where there is a shortage of fill materials, additional borrow materials may be able to be obtained from borrow sources in the eastern foothills or potential quarry sites in the Kāpiti area (as discussed in the evidence of Mr Holmes).

51. Embankment side slopes of about 25 to 30 degrees or flatter are proposed, depending of the type of fill materials. These slopes will give an adequate stability for embankments founded on competent foundations.

52. Where embankments are located over compressible soft soils such as peat, ground improvement measures will be used, as discussed below.

**Ground improvement**

53. Ground improvement measures will be necessary where embankment or bridge abutments are underlain by soft compressible deposits.

54. In most cases, the ground will be improved by excavating and removing the poor ground, such as peat, and replacing it with well compacted coarse gravel fill. This will enable the consequences of the poor ground such as settlement or liquefaction to be mitigated efficiently.

55. Where the thickness of the poor ground is deeper than approximately 3 m, excavation, removal, and replacement becomes difficult, particularly where the groundwater levels are high. In this situation, the poor ground will be partially excavated and removed, to a depth of approximately 3 m, leaving behind a limited thickness of remaining poor ground. Such conditions may be encountered at localised areas south of Mary Crest. The remaining poor ground may still cause ongoing settlement. Preloading the ground with a surcharge using additional earth fill will be used to make the majority of
the settlements occur during construction. After a period of time during construction, the additional earth fill will be removed and the embankment and road construction completed. This will minimise post-construction settlements. The exact depth of practical removal and preloading will be ascertained during detailed design and construction. The settlement will be monitored using instrumentation that will be installed for that purpose.

**Bridges**

56. The bridges required for the Project will be founded on deep piled foundations into the underlying dense alluvial gravel and sand materials, or supported on reinforced soil wall abutments.

57. Large diameter bored piles are likely to be suitable for the bridges, to take the piles through intermediate dense layers, to found at depth below potentially liquefiable ground and below the scour depth at the river locations. Bored piles are preferable to driven piles because their construction generates less noise. Where bridges are founded in dune sand or alluvial sands, however, driven piles may be used, where that would not cause significant noise or other issues for residents (I understand from discussions with Dr Chiles, for example, that appropriate structures for the alternative option of driven piles may be those at Mary Crest and Waitohu Stream).

58. Reinforced soil walls may be used to support the abutments of bridges, such as those at Mary Crest and Te Horo.

**ENVIRONMENTAL EFFECTS AND MITIGATION**

**Introduction**

59. As discussed above, a key positive effect of the Project is that it will considerably improve the resilience of the roading network access into and out of Wellington, compared to the existing routes.

60. In this section of my evidence I discuss the following potential adverse geological or geotechnical effects of the Project, and the proposed measures for addressing them:

(a) Project earthworks leading to a permanent lowering of groundwater levels;

(b) temporary lowering of groundwater levels during construction;

(c) potential effects on wetlands or other ecological areas from changes in the groundwater regime;

(d) effects arising from the abstraction of water for construction activities;

(e) effects arising from ground settlement (i.e., compression of land during or post-construction leading to localised subsidence);

(f) effects arising from works needed to construct bridge foundations; and

(g) effects of works in sand dune areas.
61. Many of these potential geotechnical issues relate to groundwater and aquifers, because construction works can affect groundwater levels or the natural state of aquifers. This may in turn have ecological effects, or may affect the access to groundwater of other users.

62. The Project area, in the northern Kāpiti district, comprises four groundwater zones defined by Greater Wellington Regional Council (“GWRC”) in 2008, and aquifers as summarised in Table 1.

Table 1 – Groundwater Zones and Aquifers

<table>
<thead>
<tr>
<th>Groundwater Zone</th>
<th>Aquifer</th>
<th>Depth (m below ground)</th>
<th>Type</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waitohu Groundwater Zone</td>
<td>Aquifer One</td>
<td>2 - 10</td>
<td>Unconfined²</td>
<td>Permeable river gravels with groundwater levels influenced by stream flow.</td>
</tr>
<tr>
<td></td>
<td>Aquifer Two</td>
<td>2 - 30</td>
<td>Semi-confined³</td>
<td>Brown gravel and sand and some blue sand. Discontinuous layers of peat, clay, clay bound gravel and sand form semi-confining layers.</td>
</tr>
<tr>
<td></td>
<td>Aquifer Three</td>
<td>40 - 45</td>
<td>Confined⁴</td>
<td>Blue gravels and sand underlain by peat and clay. Low yielding and poor water quality.</td>
</tr>
<tr>
<td></td>
<td>Aquifer Four</td>
<td>50 - 60</td>
<td>Confined</td>
<td>Sand layer with some blue gravels.</td>
</tr>
<tr>
<td></td>
<td>Aquifer Five</td>
<td>60 - 75</td>
<td>Confined</td>
<td>Poorly sorted clay bound gravels and sand. Low yielding.</td>
</tr>
<tr>
<td>Ōtaki Groundwater Zone</td>
<td>Aquifer One</td>
<td>11</td>
<td>Unconfined</td>
<td>Brown river gravels with some silt and sand overlain by 4 m of sands, silts and clays. Strong hydraulic connection to Ōtaki River.</td>
</tr>
<tr>
<td>(narrow zone along Ōtaki River flood plain)</td>
<td>Aquifer Two</td>
<td>11 - 19</td>
<td>Semi-confined</td>
<td>Low permeability sands.</td>
</tr>
<tr>
<td></td>
<td>Deeper Aquifers</td>
<td>Below 35</td>
<td>Confined and artesian.</td>
<td>Recharge from infiltration of river water and rainfall in upper catchment.</td>
</tr>
<tr>
<td>Hautere Groundwater Zone</td>
<td>Layer 1</td>
<td>10 - 30</td>
<td>Unconfined</td>
<td>Lay bound gravels divided by discontinuous lenses of silts and clays.</td>
</tr>
<tr>
<td>(South of Ōtaki River and between SH 1 and Tararua Ranges)</td>
<td>Layer 2</td>
<td>40 - 70</td>
<td>Semi-confined</td>
<td>High degree of connectivity with the shallow aquifer above. Groundwater with high concentrations of iron.</td>
</tr>
<tr>
<td></td>
<td>Layer 3</td>
<td>90 - 150</td>
<td>Semi-confined</td>
<td>Groundwater with high concentrations of Boron.</td>
</tr>
</tbody>
</table>

² Unconfined aquifers are near surface aquifers which are not confined by a lower permeability layer (aquiclude).
³ Semi-confined aquifers are overlain by lower permeability layers which are discontinuous and do not provide a full separation from the overlying aquifers.
⁴ Confined aquifers are at depth and are overlain by a lower permeability layer, which separates this aquifer from that above.
<table>
<thead>
<tr>
<th>Groundwater Zone</th>
<th>Aquifer</th>
<th>Depth (m below ground)</th>
<th>Type</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coastal Groundwater Zone (South of Ōtaki River, and between coast and SH1; wave cut cliff marks boundary with Hautere Groundwater Zone)</td>
<td>Aquifer One</td>
<td>5 - 30</td>
<td>Unconfined (becoming semi-confined with depth)</td>
<td>Brown and blue sands and gravels.</td>
</tr>
<tr>
<td></td>
<td>Aquifer Two</td>
<td>35 - 56</td>
<td>Confined</td>
<td>Brown gravels. Dips towards coastline and the south.</td>
</tr>
<tr>
<td></td>
<td>Aquifer Three</td>
<td>65 - 110</td>
<td>Confined</td>
<td>Layers of sands and gravels.</td>
</tr>
<tr>
<td></td>
<td>Aquifer Four</td>
<td>164 - 172</td>
<td>Confined</td>
<td>Brown gravels.</td>
</tr>
</tbody>
</table>

63. From the north end of the Project to the south end, the Project will cross the Waitohu and Ōtaki Groundwater Zones, the Hautere Groundwater Zone between the Ōtaki River and Mary Crest, and then the Coastal Groundwater Zone south of Mary Crest.

**Potential permanent groundwater drawdown due to cuttings**

*Proposed activity*

64. Relatively large-scale earthworks in cut are proposed from Stations 1000 m to 1750 m and Station 10,250 m to 10,600 m of the Project area. In those locations, however, the proposed excavations will generally be formed above the groundwater levels, and therefore the proposed construction of the Expressway will have a negligible effect on the groundwater table. Likewise, in most places elsewhere along the Project alignment, the proposed earthworks are not expected to give rise to adverse effects in terms of permanent groundwater drawdown. However, the cuttings proposed between Station 3,900 m and 5,300 m could potentially impact on groundwater, for a short section between 4,100 m and 4,400 m, as discussed below.

65. Between Station 4100 m to 4400 m, the Expressway level is at an elevation (reduced level, or "RL") of between about RL 16.9 m and 18.3 m. Allowing for subsoil and pavement drainage measures, the reduced level of the base of these measures that can potentially impact on the groundwater is between about RL 15.9 m and 17.3 m.

66. Boreholes BH 108 and BH 114 were located in this area with piezometers installed for groundwater monitoring, the locations of which are shown in the Plan Set, in order to inform my assessment of potential effects on groundwater. Monitoring of these piezometers over a full year between May 2012 and April 2013 indicate that the shallow groundwater levels in this area are as shown on **Illustration 1**, and summarised below.

67. Groundwater levels indicated by the piezometer installed in BH 108 during the summer/autumn months of late November 2012 to June 2013 fluctuate between RL 13.3 m and 15.7 m, which are well below the base of any drainage measures associated with the Expressway (at this location), at RL 16.4 m. Only during the winter / spring months of July to November 2012, a rise in the groundwater levels was recorded up to between RL 17.4 and 18.1 m – that is, about 1 m to 1.7 m above the base of the drainage measures associated with the proposed Expressway.
68. The groundwater levels recorded at the piezometer at BH 114 indicate that the groundwater in this location fluctuates from below 13.2 m to 16.13 m, which are below the base of the Expressway drainage measures across all seasons.

69. While it is recognised that the piezometer monitoring was only over a relatively limited period (of one year), it does cover all seasons in a year, and the results give an indication of the groundwater level fluctuations in the area. The groundwater levels are continuing to be monitored and will in time provide a detailed record of groundwater levels in the area.

Illustration 1 – Monitoring of Groundwater Levels in Borehole BH 108 and BH 114 south of the Ōtaki River Crossing

70. The groundwater monitoring indicates that the Expressway is only likely to restrict the rise in the groundwater levels typically in the winter / spring period of July to November. That is, the construction of the Expressway and the associated drainage measures will limit the rise of groundwater during the wet winter – spring months, and will have no effect on the base groundwater levels during the summer – autumn period. The limited effect on the groundwater regime will be in the unconfined aquifer in the Hautere Groundwater Zone.

Potential effects

71. The unconfined aquifer (Layer 1) extends to 10 – 30 m depth below the ground surface. A maximum 1 m to 1.7 m limitation to the rise of groundwater levels in the wet winter-spring seasons locally (over a 300 m length) will have a negligible influence on the groundwater flow and direction.

72. The Expressway will have no effect on the groundwater in the summer – autumn months when the need for groundwater abstraction from any existing water wells is likely to be greatest.

73. I have identified, from the GWRC database, the actual and potential groundwater abstraction wells within an approximate distance of 500 m upstream and 500 m downstream of the Expressway, in the vicinity of the section of potential groundwater effects discussed above (ie between Station 4,100 m and 4,400 m). The locations of the consented groundwater abstraction wells, and possible unconsented wells (as
indicated by consents for the drilling of bores), are summarised in Tables 2 and 3. These are shown in Illustration 2.

Table 2 – Groundwater abstraction wells as indicated by GWRC database

<table>
<thead>
<tr>
<th>Consent Number</th>
<th>Consent Type</th>
<th>Depth (m)</th>
<th>Expiry Date</th>
<th>X</th>
<th>Y</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>WGN060343</td>
<td>Water Use</td>
<td>20/08/2016</td>
<td>1781183</td>
<td>5484185</td>
<td>No well log found</td>
<td></td>
</tr>
<tr>
<td>WGN000154</td>
<td>Water Use</td>
<td>10</td>
<td>9/05/2015</td>
<td>1781083</td>
<td>5484086</td>
<td>Corresponds with Well No. S25/5275 (see table 3)</td>
</tr>
<tr>
<td>WGN070168</td>
<td>Water Use</td>
<td>30.78</td>
<td>9/03/2017</td>
<td>1780476</td>
<td>5483163</td>
<td>Corresponds with Well No. S25/5256 (see table 3)</td>
</tr>
</tbody>
</table>

*“Screens” can be fitted at the depth of the target aquifer to allow water into the bore while preventing the walls from collapsing inward. The bottom of the screen in this table is the deepest point at which water is abstracted, and the top of the screen is the uppermost point.*
Illustration 2 – Consented and Potential groundwater abstraction wells within 500 m of the Expressway Excavation and Drainage between Station 4,100 m and 4,400 m.

74. The closest groundwater abstraction well (WGN 000154) in the GWRC database is shown to be at a distance of 15 m on the terrace, and is a 10 m deep well for the Arcus Irrigation Works. Local inquiries indicate that the well is in fact located some 300 m away from the proposed Expressway cuttings, close to the Ōtaki River at a much lower elevation of RL 12 m. At this location, the well is likely to be located in the unconfined Aquifer One of the Ōtaki Groundwater Zone which is connected to the Ōtaki River, and the groundwater at this location will be recharged from the Ōtaki River.

75. The proposed Expressway excavation is located 300 m away, likely to be in the Hautere Groundwater Zone which is recharged from rainfall further uphill. The effect of the Expressway limiting the rise in winter-spring groundwater levels by 1 m to 1.7 m at a higher elevation of about 16 m is likely to have a negligible (if any) effect on the abstraction from the Arcus Irrigation Works water well, because the well will be recharged from the adjacent Ōtaki River.

76. Other abstraction wells in the GWRC database (WGN 060343 and WGN 070168), ie for which resource consent has been granted, are close to the Ōtaki River or are sufficiently far from the earthworks for the Expressway that might impact on the groundwater, and hence they will not be affected by the drawdown in groundwater.

77. There may be permitted water takes near the Project works which do not require resource consents for water abstraction, and some of these are shallow. As there is
no official record of such takes, it is difficult to know where they may be, although further ground-truthing work will be undertaken prior to construction commencing (as discussed below). Nonetheless, any adverse effects on these water takes are likely to be small given:

(a) that the Expressway construction will not result in the groundwater level being drawn down below the base summer – autumn groundwater levels;

(b) the small scale of the drawdown arising from the Project, with a maximum 1 m to 1.7 m limitation to the rise of groundwater levels in the winter-spring period; and

(c) the likely distance of the water wells from the Project works, and their likely location at a lower elevation to the west of the existing SH1 in the Coastal Groundwater Zone, see Illustration 2.

78. The effects on these water wells are therefore likely to be non-existent or negligible.

Mitigation measures

79. To confirm my assessment of the potential effects on local water abstraction, an area within a 500 m distance of the Expressway excavation between Stations 4,100 m and 4,400 m will be surveyed prior to construction, and details of those abstractions compiled. These bores will be monitored prior to and during construction to assess any effects on them arising from the Project works. In the unlikely event that any bore is affected, they will be replaced by a deeper bore that provides the same yield.

80. Conditions are proposed, as annexed to the evidence of Ms Beals, which will ensure that there is no permanent change to the ability of any existing bore owners to abstract water from their existing groundwater supply bores. In particular, an outcome proposed to be achieved by the NZTA (across the whole of the Project works) is that "there shall be no permanent changes to the ability of existing bore owners to abstract water from their existing water supply bores".

Potential temporary groundwater drawdown during construction

Proposed activity

81. Excavation and removal of soft compressible peat and silt deposits up to 3 m depth, primarily in the inter-dunal swamp areas south of Mary Crest, and localised pockets near the NIMT railway near County Road, would involve temporary groundwater level lowering by up to about 3 m depth.

Possible effects

82. The temporary groundwater level drawdown will have negligible effect on the environment given the rural land use in these areas comprising paddocks for grazing of stock.
83. The closest consented groundwater abstraction wells are located outside the 'local zone of influence' of this temporary groundwater drawdown, and in my opinion the effects on groundwater abstraction from these wells will be negligible.

Mitigation measures

84. The groundwater levels will nonetheless be monitored to confirm that the groundwater drawdown does not affect a wider area and affect abstraction from water wells. The proposed resource consent conditions require this, through information required to be provided in the relevant Site-Specific Environmental Management Plans ("SSEMPs"), and provide for a replacement water supply in the unlikely event that any adverse effects are experienced.

Wetlands and other ecological areas

85. The evidence of Mr John Turner describes how the existing Ōtaki Railway Wetland, formed by poor drainage across the existing rail and road embankments, is of limited quality, with significant ongoing degradation, and will be further affected by the construction of the Project. Two new wetlands, one on a narrow wetland strip adjacent to the Railway Wetland and one west of County Road, will be created as part of the Project.

86. The temporary groundwater drawdown to excavate and remove soft deposits in the Ōtaki Railway Wetland area is not likely to have a long term effect on the wetlands to be created subsequently. To ensure that these wetlands are not drained by the potentially permeable soils used to construct the embankment fill, a zone of low permeability soils will be placed between the embankment and the wetlands. Also low permeability materials will be used to replace the peat and soft ground excavated and removed.

87. Another new wetland will be created adjacent to the Mary Crest bush. Because the ground falls away to the west where the water course is currently located, a low embankment with a weir will be required to retain water in the wetland area and surplus water can flow through the weir during wet weather conditions.

88. The groundwater level will be lowered temporarily during construction to facilitate the excavation and removal of soft ground in this area, prior to construction of the low embankments required for the Expressway. The duration of such drawdown is only likely to be between a few days to a few weeks. This drawdown will not have any effect as the wetland will be created after the embankment construction is completed.

89. Potentially higher permeability materials used for construction of the embankment and replacement of the excavated soft ground may pose a risk of loss of water from the wetland. Therefore lower permeability fill materials will be used to backfill the soft ground removed and a zone of lower permeability materials will be placed between the Expressway embankment and the wetland.
90. The existing Mary Crest bush area is a feature located to the north of low lying areas requiring excavation and replacement of soft ground. While significant parts of the bush are on higher ground formed by sand dunes, there are lower lying wetter areas associated with the bush. As Mr Turner explains in his evidence, the bush is unlikely to be affected by the temporary lowering of groundwater associated with excavation and replacement of soft ground in the low lying areas under the Expressway embankment located to the south, but specific monitoring is proposed through the proposed conditions.

Ground settlement

Proposed activities and possible effects

91. In summary, possible ground settlement effects are as follows. Firstly, subsidence of the ground may occur due to groundwater drawdown associated with permanent excavations, such as the up to 1 m to 1.7 m groundwater drawdown between Station 4,100 m and 4,400 m. However, given the low compressibility of the dense terrace alluvium in the area, the level of any subsidence will be negligible, and any effects from such subsidence will also be negligible, given that the areas in question are rural farmland in pasture.

92. Subsidence may also occur due to temporary groundwater drawdown associated with excavation and removal of peat and soft ground in the inter-dunal swamp areas. The subsidence will be small given the short duration of the temporary groundwater drawdowns (of a few days to a few weeks), and any effects of such subsidence will be negligible given that these areas are wetlands or rural paddocks used for grazing.

93. Settlement of the ground due to compression by fill embankments is likely where the underlying soft ground is not excavated and removed. Elsewhere the settlement will be small. Most of the soft deposits are proposed be excavated and removed and replaced with good gravel fill. However, given that peat deposits of more than 3 m thickness are present in an area south of Mary Crest, the soft materials will be partially excavated and removed, with the remaining peat at depth remaining in place. This area will be preloaded with a surcharge and this will lead to settlement of the Expressway embankment as well as the immediately adjacent areas. Again, given that the land use in this area consists of paddocks used for grazing, the effects of such settlements will be negligible. However, the adjacent existing SH1 and possibly the NIMT railway line are likely to experience some settlement.

Proposed mitigation

94. Settlement of adjacent facilities such as existing SH1 and NIMT railway line will be monitored by regular surveying of settlement stations installed for that purpose during construction. Any development of cracks in the road surface will also monitored, and any settlement will be repaired. Minor repairs such as sealing of cracks and repair of the pavement will be carried out during construction, and the road pavement subject to damage will be repaired.
95. Any settlement of the railway line will be rectified by re-levelling the railway tracks using ballast where tolerances are exceeded. This will be carried out in conjunction with KiwiRail. These mitigation measures are prescribed in the proposed designation conditions appended to the evidence of Ms Beals.

*Overall effect*

96. The overall effects of settlement are minor and, through the mitigation measures proposed, can be readily managed.

*Water abstraction for construction*

*Proposed activity*

97. As discussed in the evidence of Mr Holmes, approximately 300 cubic metres per day (300,000 litres per day) of water will be required for construction activities such as dust suppression and fill compaction.

98. The consented water wells\(^6\) proposed for the construction of the MacKays to Peka Peka Expressway will be used to provide water for the southern areas of the Project.

99. In addition, four groundwater abstraction wells are proposed to provide water for construction activities in different areas of the Project. These wells will be at the following locations (see Illustrations 19 – 22 in Technical Report 4):

(a) south of Mary Crest;

(b) in the vicinity of the proposed Te Horo Overbridge near Mangaone Stream;

(c) north of Ōtaki River; and

(d) south of Waitohu Stream.

100. The water wells will be drilled to depths of greater than approximately 35 m to 40 m, into the confined or semi-confined aquifers, to provide adequate water quantities, and minimise the effect on surface groundwater bodies and shallow permitted water takes.

*Possible effects*

101. These locations have been chosen to be at least 250 m away from existing consented groundwater abstraction wells, to avoid any adverse effects on those wells.

102. The groundwater for construction will be obtained from deep wells to below 35 m to 40 m penetrating into the confined and semi-confined aquifers, and therefore will have negligible effects on the surface water bodies.

103. Detailed investigations have not yet been carried out at the locations of the proposed groundwater abstraction wells. Should consent be granted, pump tests will be carried out when the water wells are drilled to assess the yield of the wells, and any effects on the existing nearby water wells. The water wells that may potentially be affected will

\(^6\) The grant of consent is subject to an appeal to the High Court.
be monitored during groundwater abstraction and, in the unlikely scenario of any owner of permitted or consented water wells being affected by loss of water from wells, alternate water supplies will be provided during construction while their usual water take is affected. The proposed conditions provide for such a replacement supply.

Bridge foundation works

Proposed activity and effects

104. The bridges will be generally founded on bored piles. Some potential effects of the pile construction are set out below.

105. Ground settlement may be caused by vibration when pile casings are driven or vibrated into the ground. There are no buildings in close proximity of any of the proposed bridge foundations, however, and therefore the effects will be negligible.

106. Changes to the aquifer system may occur if piling into a confined aquifer, resulting in pressurised artesian water flowing into the upper unconfined aquifers. The unconfined aquifers are deep where the bridge piles are proposed at Waitohu Stream Bridge (Waitohu Groundwater Zone), Ōtaki River Bridges (Ōtaki River Groundwater Zone) and Te Horo (Hautere Groundwater Zone). The shallow aquifers that are within the depth likely for piles (of less than 30 m) are unconfined and semi-confined, and already have significant connectivity. Therefore the effects on the groundwater regime will be low.

107. Piling could potentially lead to spilling of concrete and grout leading to contamination of the water courses, without proper management techniques being employed.

Proposed mitigation

108. Care will have to be taken when piling adjacent to existing SH1 and NIMT railway to monitor and remedy any settlement from vibration. Visual monitoring is appropriate for this purpose.

109. There are no buildings in close proximity that could be affected by the construction of the proposed bored piles.

110. The groundwater conditions, and in particular the presence of any artesian groundwater within the depth of piles, will be confirmed during the site investigations undertaken to inform the detailed design. In the unlikely scenario that artesian groundwater conditions are encountered at depths to be penetrated by the piles, these will be managed through a raised casing above ground level, and use of double telescopic casing with a reduction in pile diameter with depth, to minimise leakage past the pile. Such an approach has been effectively used in my experience at other river bridge structures.
111. Care will have to be taken during pile construction and concreting of piles to avoid contamination of water courses. I anticipate that measures to achieve this will be set out in the relevant SSEMPs.

**Overall effect**

112. In my view the overall adverse effects of bridge piling works on groundwater or aquifers will be minor, if indeed there are any, taking into account the mitigation measures proposed.

**Sand dunes**

*Current state*

113. The sand dunes comprise fine to medium sand, which is very prone to erosion. Observation of existing sand dunes in the Project area shows that vegetation is effective in minimising wind and water erosion.

114. Cuttings are proposed in dune sands south of Mary Crest and north of Ōtaki township. Dune sand excavated from cuttings will also be used as fill to construct embankments.

**Proposed mitigation**

115. The following appropriate measures will be used to minimise erosion:

(a) rounding of the vertical and horizontal edges of the cuttings;

(b) re-vegetation as soon as possible after formation of the cuttings and embankments, and maintenance of vegetation during the early stages after construction, with the type of vegetation to be carefully selected to suit the local coastal dune sand environment; and

(c) installation of erosion protection geotextile matting or placement of topsoil or peat on the slope surfaces, as appropriate.

**Overall effect**

116. The adverse effects of erosion can be managed and minimised with the above mentioned management measures.

**Overall conclusion**

117. In my opinion I am satisfied that the overall environmental effects of the proposed works in relation to geotechnical engineering issues are minor, and can be readily mitigated through conventional methods as outlined in my evidence above, and provided for in the conditions proposed by Ms Beals.

**RESPONSE TO SECTION 149G(3) KEY ISSUES REPORTS**

118. In this section of my evidence I discuss some matters highlighted in the key issues reports prepared for GWRC and the Kāpiti Coast District Council ("KCDC").
Greater Wellington Regional Council

Water abstraction for construction

119. GWRC infers that Technical Report 4 states that four bores are proposed with a maximum rate of take of 35 litres per second, and a maximum volume of 300 m$^3$ (300,000 litres) per day per bore. I confirm that the total water requirement for construction is 300 m$^3$ per day, and this will be obtained from four proposed water wells for construction purposes, and from some of the water bores consented for the MacKays to Peka Peka project. Therefore the water take from each water well will be less than, and possibly considerably less than, 300 m$^3$ per day.

Effect of abstractions on existing water users

120. GWRC queries the effects of the proposed extraction of 300 m$^3$ per day of groundwater during construction of the Project. Across the whole Project, that quantity of water (0.1 Mm$^3$ per year) is a very small percentage of the safe yield for the aquifers in the District indicated by GWRC. Further, the proposed abstraction wells have been positioned at least 250 m away from potential existing water takes to minimise the effects, as discussed above. As noted in paragraphs 97-103 of my evidence above, the effects of the proposed extraction of groundwater for construction on the existing users will be assessed further following drilling and pump testing of the proposed water wells, and existing wells will be surveyed and monitored during water abstraction. The proposed conditions are designed to ensure that existing takes will be surveyed and monitored prior to and during water abstraction to ensure they are not affected and, if any existing users are affected, alternate water supply will be provided.

121. As outlined in paragraphs 100 and 102 of my evidence, the effects of water abstraction on surface water bodies are likely to be negligible because the water will be abstracted from confined and semi-confined aquifers at depths greater than 35 m to 40 m.

"Diversion" of water

122. In its report GWRC queries whether possible changes to the groundwater regime could lead to effects on water supply, flooding of neighbouring properties, lowering of water levels in rivers, lakes and wetlands and lowering of groundwater levels on neighbouring properties. I have largely addressed these points in my evidence above; potential effects on water supply are discussed at paragraphs 64-84, potential effects on wetlands are discussed at paragraphs 85-90, effects on adjacent land is discussed at paragraphs 64-84 and 91-96, and effects on surface water bodies are discussed at paragraphs 97-103. I do not consider that the effects of the Project on groundwater will lead to flooding of neighbouring properties.

123. As discussed at paragraphs 64-84 above, the effect of the earthworks associated with the Expressway construction on the groundwater regime will be minor, as works are only likely to affect (by 1 m to 1.7 m) the rise in groundwater levels during the winter –
spring season. Works will not affect the base groundwater levels in the summer – autumn period when the groundwater demand is greatest. The conditions proposed ensure that any existing groundwater wells will be surveyed and monitored during construction, to confirm that any effects on groundwater users are negligible. In the unlikely event of adverse effects, these will be proactively addressed.

124. I have discussed at paragraphs 81-90 above how the temporary drawdown of groundwater during construction to allow excavation and replacement of the soft ground will only have a short duration effect on groundwater levels, and in my view the effects of this operation will be negligible both to neighbouring land and the wetlands. This is confirmed by Mr Turner in his evidence from an ecological perspective.

125. Overall, in my opinion, the effects of potential changes to the groundwater regime will be minor, and conditions are proposed in Ms Beals’ evidence to address any adverse effects.

Kāpiti Coast District Council

Groundwater

126. KCDC’s report has raised groundwater as a key issue that needs to be addressed. I recognise that groundwater is a key issue for the Project and the district, and have addressed the potential effects of the proposed works on groundwater in paragraphs 61 to 103 of my evidence above, and in my response to GWRC’s key issues report.

Natural hazards and resilience

127. KCDC raises natural hazards and resilience as a key issue. As discussed in my evidence above, the proposed Expressway will enhance the resilience of access through the Peka Peka to Ōtaki area and, together with other RoNS projects (eg Transmission Gully), will enhance access in the Wellington Region, particularly in the event of small to large earthquakes.

128. In my opinion, the Project will enhance resilience of transport access through the area and in the region, and this is a key benefit of the Project.

RESPONSE TO SUBMISSIONS

Sharyn Sutton (102855)

129. Ms Sutton’s submission states that the Project will result in drawdown of groundwater levels and cause ground settlement over an area extending well beyond the footprint of the designation, and that there is considerable uncertainty over the magnitude of settlements and the consequent adverse effects.

130. I have considered the potential for settlements due to construction of the Expressway, and this is discussed in paragraph 91 to 96 of my evidence. I show that settlement will be negligible in most areas, except where construction on soft ground requires preloading in localised areas, and that the effects of such localised settlements are minor. I also outline mitigation measures to address the effect on adjacent facilities.
131. In my opinion, the potential for settlements is small and localised, and appropriate mitigation measures have been proposed to address this possibility.

132. Ms Sutton also states that because SH1, the railway line and the proposed Expressway will be side by side, then it is more likely that all three will be disrupted in an earthquake at the same time, leaving no access north of Wellington.

133. The resilience of the route in a large earthquake has been assessed, and I have summarised this assessment in paragraphs 33 to 43 of my evidence. The disruption to access will depend not just on the proximity of the routes, but also on the hazards along the route, the road form and the measures that are taken to mitigate the hazards.

134. Active faults cross the Kāpiti district, and transport routes (regardless of their locations) will need to cross them. As stated in paragraphs 35 to 37 of my evidence, the locations of active faults and the nature of the crossing has been carefully considered, and the Expressway has been designed in a manner to minimise the disruption.

135. Overall, I am of the opinion that the Expressway will be resilient to natural hazards, including earthquakes, and access can be quickly restored after an earthquake event, regardless of the proximity of the Expressway to SH1 and the NIMT railway line.

**Arcus Road Water Scheme Ltd (102872)**

136. Mr Robertson on behalf of the Arcus Road Water Scheme queries the potential use of explosives associated with the Project works, and their potential effect on the scheme’s groundwater bore.

137. Taking into account the geological conditions along the route, in my view there is no need to use explosives for the construction of the Expressway, and no explosives are proposed in its construction. The materials encountered along the route can be excavated, placed and compacted without the need for explosives. Therefore, there will be no risk to their water bore from the use of explosives.

138. Mr Robertson also confirms that the Arcus Road Water Scheme draws water from a bore adjacent to the Ōtaki River (GWRC consent number WGN 000154), as discussed in paragraphs 74 and 75 of my evidence above.

**Kent Duston – Rational Transport Society (102857)**

139. The submission of Mr Duston on behalf of the Rational Transport Society states that "the effects on hydrology of building a major road across peat systems have not been adequately addressed. Those changes will pose a risk to the road construction itself, other landuses, and natural remnants (particularly wetlands)."

140. I have addressed these concerns in the body of my evidence above. The Expressway only crosses localised areas of peat, particularly in the section south of Mary Crest. The groundwater and settlement issues associated with construction in areas of peat
are addressed in paragraphs 81 to 96 of my evidence. In my view the localised peat areas can be effectively crossed by excavation and replacement of the peat or preloading of deeper peat areas, and the adverse effects on the environment will be minor and can readily be mitigated.

**Gyllian and Barry Hart (102865)**

141. The submission of Mr and Ms Hart states that they are opposed to the construction of bores, and the taking and use of groundwater. Paragraphs 97 to 103 of my evidence address the issues associated with the abstraction and use of groundwater for construction and their effects, and the mitigation measures in the proposed conditions.

**Wayne Stevens (102866)**

142. Mr Stevens’ submission seeks comfort that the Project will not affect his water bore, which will be relatively close to the Project works.

143. In my view the bore is not likely to be affected, for the reasons discussed in my evidence above. The existing bore will be monitored, however, to ensure that it remains operational and, in the unlikely event of adverse effects, an alternative water bore will be provided.

**Greater Wellington Regional Council (102880)**

144. GWRC's submission comments on a number of issues raised in its key issues report, which I have addressed above.

145. GWRC queries the characterisation in my assessment of the hydrogeological environment; I have sought to provide clarification in paragraphs 61-63 of my evidence above. I agree with GWRC’s submission that groundwater levels fluctuate seasonally; the groundwater fluctuations I have observed are discussed in paragraph 69 of my evidence above, which confirms a seasonal fluctuation in line with the information provided by GWRC.

146. My assessment of the potential effects on groundwater levels, the environment and surface water, in respect of which GWRC has raised various queries, is summarised in paragraphs 64-103 of my evidence above. To reiterate, for the reasons discussed above my view is that the Project's potential adverse effects in respect of groundwater are minor. Ongoing groundwater monitoring, testing of the abstract levels, and settlement monitoring will be carried out during construction, and any unlikely adverse effects will be mitigated (appropriately, in my view) as provided for in the proposed conditions.

147. Further, in my view the adverse effects on surface water bodies from abstraction of water for construction of the Project will be negligible (if any) because the water will be abstracted from the deep confined and semi-confined aquifers below 35 m to 40 m depth. Also, the excavations required to construct the Expressway to the south of the Ōtaki River will only affect the rise of groundwater levels in winter-spring periods, and are not likely to affect surface water bodies.
Kāpiti Coast District Council (102892)

148. I note KCDC's concerns to ensure that the Project's effects on the groundwater regime are understood, monitored, and mitigated. I believe the effects are well understood and will be appropriately monitored and mitigated.

149. I have presented an assessment of the groundwater regime, the impact of the proposed works on groundwater, and the proposed monitoring and mitigation measures, in paragraphs 61 to 103 of my evidence.

150. In particular the hydrogeological environment is described, and an assessment has been made of the effects of peat replacement (paragraphs 81-84), installation of drainage (61-80), dewatering during construction (81-96), and groundwater abstraction for construction water supply (97-103).

151. The extent of peat replacement and preloading is modest for this Project, and is confined to small areas south of Mary Crest. I note that on this Project the majority of the works are carried out on the surface of recent and old alluvial terraces and well above the groundwater levels. Only in localised areas will the proposed Project interact with the existing groundwater regime.

152. In my evidence above I discuss why the effects of the Project construction will be minor, and the effects of groundwater abstraction for construction will be assessed further following the drilling of the water wells and pump testing. Monitoring is proposed to verify the effects on existing groundwater takes in the area, and conditions are proposed to ensure that any unlikely adverse effects will be mitigated through the provision of alternate water supplies.

CONCLUSION

153. In my opinion, the Expressway will enhance the resilience of access through the district, and together with other RoNS projects (eg Transmission Gully), the route will significantly enhance the security and reliability of access into the Wellington Region in natural hazard events such as large earthquakes and storms.
154. The effects of geotechnical engineering aspects of the Project on the environment will be minor or negligible. In particular the effects of construction on the groundwater regime will be localised and minor, and potential adverse effects can be effectively managed through routine measures as provided for in the proposed conditions.

Pathmanathan Brabhaharan

12 July 2013
References:


Brabhaharan, P (2011). Transmission Gully Project. Statement of Evidence of Pathmanathan Brabhaharan (Brabha) (Geology and geotechnical engineering) for the NZ Transport Agency and Porirua City Council, before a Board of Inquiry. 18 November 2011.


ANNEXURE A – FIGURES

Figure A1 - Geology and Active Faults along the Route
Figure A2 – Earthquake Induced Slope Failure and Liquefaction Hazards along the Route
Figure B1 – Availability State for Large Local Richter Magnitude 7.5 Earthquake