Before a Board of Inquiry
MacKays to Peka Peka Expressway Proposal

under: the Resource Management Act 1991

in the matter of: Notice of requirement for designation and resource consent applications by the NZ Transport Agency for the MacKays to Peka Peka Expressway Proposal

applicant: **NZ Transport Agency**
Requiring Authority

Statement of evidence of **Ann Williams** (Groundwater) for the NZ Transport Agency

Dated: 5 September 2012

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STATEMENT OF EVIDENCE OF ANN WILLIAMS FOR THE NZ TRANSPORT AGENCY

QUALIFICATIONS AND EXPERIENCE

1 My full name is Ann Louisa Williams. I am a Technical Director in the fields of Hydrogeology and Engineering Geology with the firm Beca Infrastructure Ltd (*Beca*).

2 I am a graduate of the University of Auckland with the degrees of Bachelor of Science and Master of Science in Geology (Honours), specialising in Engineering Geology. I have completed post-graduate studies in Resource and Environmental Management and in Hydrogeology. I have 23 years' post-graduate experience in engineering geological and hydrogeological investigations and analysis.

3 I am a past Chair of the New Zealand Geotechnical Society and have the role of Vice-President representing Australasia on the Executive of the International Association for Engineering Geology and the Environment (*IAEG*) for the period 2011 to 2014. I am a Fellow of the Geological Society of London (*FGS*) and member of the International Association of Hydrogeologists (*IAH*), and an associate editor of the international journal, Quarterly Journal of Engineering Geology and Hydrogeology (*QJEGH*).

4 As leader of Beca's geological and hydrogeological teams, I have had a key role in a wide range of projects that have required an understanding of the interaction of water and soil and effects of seepage and groundwater movement. These projects include the following:

4.1 The Kāpiti water supply project for the Kāpiti Coast District Council (*KCDC*) which has the objective of securing an enduring water supply solution to meet Kāpiti Coast's urban water needs for the next 50 years. The option being progressed is 'River Recharge with Groundwater'. My role on the project has been to guide pumping testing of existing wells to improve the understanding of aquifer parameters, direct conceptual 3-dimensional (*3D*) groundwater modelling to check the viability of the selected option, the likely magnitude of effects, potential for saline intrusion and how that might be mitigated. Most recently I have guided my team in development and testing of new investigation bores and updated the models accordingly.

4.2 Guidance of 2-dimensional (*2D*) seepage modelling to provide an assessment of the likely performance of proposed stormwater soakage basins for the Christchurch Southern Motorway Stage 1 (under construction) in the short and longer term and opportunities for management of these. Each group of basins differs but generally includes first flush and attenuation basins, storage, soakage and infiltration.

4.3 Direction of investigations for and 2- and 3D groundwater modelling of a 1200 m long underground railway station (including a 720 m long "Rail Trench") at New Lynn, central Auckland (recently completed). The station was constructed beneath the groundwater table in alluvial deposits overlying interbedded sandstone/ mudstone at variable depth. Modelling was used to assess likely groundwater drawdown, associated settlement effects, excavation inflows, uplift pressures beneath the trench, potential damming of groundwater upgradient of the box and monitoring requirements during construction and in the long-term. I reviewed monitoring data through construction;

4.4 Investigation and development of 2- and 3D groundwater models for a 3 lane motorway tunnel built by cut and cover techniques beneath Victoria Park (Victoria Park Tunnel), central Auckland. This included assessment of likely groundwater drawdown and inflows associated with tunnel construction, assessment of the impact of different tunnel designs on regional groundwater flow and the potential for contaminant migration and saline intrusion. I was the in-team reviewer for groundwater aspects of the design-build phase of the project and monitoring during construction; and

4.5 I was the lead hydrogeologist in a team investigating a 3 km long, shallow 'cut and cover' tunnel and a 4 km long deeper driven tunnel option for a motorway extension beneath a heavily developed urban area of Auckland (the Waterview Connection Project). My tasks included direction of investigations, conceptual and analytical model development, direction of 2- and 3D groundwater modelling to assess likely groundwater drawdown and inflows (including the potential for contaminant transport from old landfills, the potential for saline intrusion and the potential to affect base flow in Oakley Creek), and implications for drawdown-induced ground settlement effects during construction and long-term. I had the role of expert witness Groundwater in support of resource consent applications during the Board of Inquiry hearing, and am now Technical Verifier Groundwater as part of the team contracted by NZTA to complete detailed design and delivery of the twin tunnels as part of that project.

5 In each case these projects required assessment of the effect of different designs on groundwater flow, the potential for contaminant migration or saline intrusion, for altering base flow to adjacent watercourses and affecting existing groundwater supplies and the development of monitoring and mitigation strategies.

6 In addition I have directed investigation and development of groundwater for municipal, commercial and industrial supplies in centres throughout New Zealand.

7 I have also had the role of technical expert in the Environment Court addressing the potential effects of the proposed Waitahora Wind Farm (Manawatu) (which is to be constructed in part on karstic limestone) on groundwater and water supplies.

8 My evidence is given in support of the Notice of Requirement (*NoR)* and applications for resource consent lodged with the Environmental Protection Authority (*EPA)* by the NZ Transport Agency for the construction maintenance and operation of the MacKays to Peka Peka Expressway (*the Project)*.

9 I am familiar with the area that the Project covers and the State highway and local roading network in the vicinity of the Project.

10 I am the reviewer of the Assessment of Groundwater Effects technical report[1] and of the Groundwater (Level) Management Plan,[2] which formed part of the Assessment of Environmental Effects (*AEE)* lodged in support of the Project.

11 I have read the Code of Conduct for Expert Witnesses as contained in the Environment Court Consolidated Practice Note (2011), and I agree to comply with it as if this Inquiry were before the Environment Court. My qualifications as an expert are set out above. I confirm that the issues addressed in this brief of evidence are within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed.

SCOPE OF EVIDENCE

12 My evidence will deal with the following:

12.1 Executive summary;

12.2 Background and role;

12.3 The existing groundwater environment;

12.4 Assessment of effects on groundwater and modelling undertaken;

12.5 Summary of modelled effects on groundwater;

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1 Technical Report 21.

2 Appendix I of the Construction Environmental Management Plan (*CEMP*) (AEE, Volume 4.)

12.6 Proposed mitigation measures;

12.7 Response to submissions;

12.8 Response to section 149G(3) reports;

12.9 Proposed conditions; and

12.10 Conclusions.

EXECUTIVE SUMMARY

13 My evidence describes the potential effects of the proposed Expressway on the existing groundwater regime. Activities that have the potential to alter existing groundwater levels or flow directions are:

13.1 Construction of the Expressway embankments by localised pre-load/ surcharge[3] or excavation and replacement of peat. These activities will alter the hydraulic conductivity of the ground beneath the embankments (that is, the ability of the ground beneath the embankments to transmit water), by consolidating the peat (reducing its hydraulic conductivity and causing a rise in water level on the up-gradient side and a lowering of water level on the down-gradient side) or replacing it with a material of different (higher) hydraulic conductivity, potentially lowering the groundwater level;

13.2 Construction of stormwater devices that, in places, require cuts below the water table. These might change the direction or gradient of groundwater flow or lower or raise the groundwater level; and

13.3 Short term groundwater takes for construction water supply. Groundwater abstraction will lower the groundwater level in the aquifer screened, in the vicinity of the abstraction bore.

14 Fieldwork has included investigation drilling, piezometer installation, in-situ hydraulic conductivity testing and groundwater level monitoring.

15 Two and three-dimensional numerical groundwater modelling has been undertaken to assess the effects of the construction (short term) and operation (long term) of the Project on groundwater flows.

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3 In areas of deep peat deposits, a pre-load embankment and surcharge load will be constructed directly over the existing ground. The purpose of this additional load is to consolidate the underlying peat and thereby reduce the volume of peat excavation and disposal off site.

16 The groundwater regime consists of a series of interbedded aquifers (soils that yield water) and aquitards (soils that do not readily yield water).

17 The near surface soils are geologically young (< 10,000 years) dune sands, with peat (which supports wetlands of high ecological value) developed in the lower lying areas between dunes. The construction of the proposed Expressway has the greatest potential to affect the shallow groundwater system as it will be constructed within and on these shallow soils.

18 Numerical groundwater modelling suggests that overall:

18.1 The proposed Expressway embankment (and associated peat treatment) will result in small (generally 0.3 m but up to 0.6 m) long term changes to groundwater levels and flow directions immediately adjacent to the proposed Expressway, with no discernible change (< 0.1 m) in groundwater levels, flow directions or aquifer through-flow at a distance of 50 m to 70 m from the edge of the Expressway;

18.2 Where stormwater devices are constructed at the approximate existing groundwater level there will be no discernible changes to groundwater levels, flow directions or aquifer through-flows;

18.3 Provided the maintained water level in stormwater devices is less than 0.5 m above or below the existing groundwater level, modelling suggests construction and operation of the devices will result in small (< 0.3 m) changes to groundwater levels and flow directions immediately adjacent to the devices, reducing to no discernible changes in groundwater levels, flow directions or aquifer through-flow at a distance of 50 m from the Expressway;

18.4 Where the maintained water levels are more than 0.5 m above or below the existing groundwater level, construction of a low permeability lining in the ponds will be required to avoid lowering of the groundwater level beneath and adjacent to the storage areas. This applies to wetland OA, wetland 4 and wetland 9 which are located such that the groundwater level changes might otherwise result in deleterious effects on wetlands or private property;

18.5 Expressway construction in the vicinity of the Otaihanga Landfill will result in only small changes in groundwater level and will have no noticeable effect on groundwater gradients and flows. Therefore I consider changes in contaminant migration from the landfill as a result of the proposed Expressway construction would be negligible; and

18.6 Abstraction of water from construction water supply wells is likely to result in changes in groundwater level of less than 0.7 m in the shallow groundwater system close to the wells, with very small associated changes in flow directions and aquifer through-flow in the vicinity of the wells. Such changes will be limited to the construction period (4 years).

19 Given the small scale, magnitude and extent of changes identified, I consider it unlikely that these would result in adverse effects on the groundwater system and the wider environment.

20 A monitoring programme has been initiated to record natural variations in groundwater levels and surface water flows. This monitoring will allow appropriate responses to be triggered once construction begins, should actual effects differ from those anticipated.

21 Overall, I consider any actual or potential adverse effects of the Project on groundwater to be less than minor, with a number of readily available and widely used mitigation options available to effectively manage unexpected effects, should they occur.

22 I have reviewed submissions lodged on the Project relevant to my area of expertise. Nothing raised in those submissions causes me to alter the conclusions reached in my technical assessment of the Project.

BACKGROUND AND ROLE

23 The NZTA retained Beca as part of an Alliance team to assist with the investigation, engineering, planning and construction of the Project and to prepare an assessment of the groundwater effects of the Project. Ms Sian France (Senior Hydrogeologist) and Mr Matthew Anderson (Engineering Geologist), both of whom are part of my team at Beca, undertook field investigations and testing, data analysis, 2- and 3D groundwater modelling and prepared an Assessment of Groundwater Effects (the *Report*) under my direction, and with my review and input.

24 The Report was lodged with the EPA on 20 April 2012 as part of the overall Assessment of Environmental Effects (*AEE*) (Technical Report 21).

25 The Report was informed by, relies upon, and informs other technical reports lodged with the EPA in support of the Project, those reports being primarily:

25.1 Geotechnical Interpretive Report (Technical Report 36);

25.2 Construction Methodology Report (Technical Report 4);

25.3 Assessment of Hydrology and Stormwater Effects (Technical Report 22)

25.4 Assessment of Land and Groundwater Contamination Effects (Technical Report 23); and

25.5 Assessment of Ground Settlement Effects (Technical Report 35).[4]

26 The 2- and 3D groundwater modelling and assessment of groundwater effects uses, as a base, the geological data and model described in the Geotechnical Interpretative Report (Technical Report 36). Modelling includes data obtained from KCDC as part of its work for KCDC in investigation and development of their public (ground) water supply.

27 The proposed embankment construction methodology and extents of preload/ surcharge or excavation/ replacement of peat are set out in Technical Report 4 *Construction Methodology Report*. The approximate locations, volumes and durations of pumping from proposed groundwater bores for construction water supply are also described in Technical Report 4.

28 The locations, purpose and design of the proposed stormwater devices are set out in Technical Report 22 *Assessment of Hydrology and Stormwater Effects*.

29 Details of contaminants that presently reside in groundwater at different locations along the proposed alignment are described in Technical Report 23 *Assessment of Land and Groundwater Contamination Effects*.

30 The 2- and 3D groundwater modelling provides the expected groundwater drawdown profiles that have been used to assess groundwater drawdown-induced ground settlement (described in Technical Report 35 *Assessment of Ground Settlement Effects*) and to assess the effects of the Project on wetland areas in Technical Report 26 *Ecological Impact Assessment*.

31 I have participated in consultation on groundwater matters with the KCDC and Greater Wellington Regional Council (*GWRC*) as the Project has developed.

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[4] All contained within the AEE, Volume 3.

THE EXISTING GEOLOGICAL AND GROUNDWATER ENVIRONMENT[5]

Geological Setting

32 Tectonic activity in the Project area has resulted in vertical uplift of the greywacke basement rocks forming the Tararua Ranges in the east.

33 The hills have been dissected by glacial and fluvial processes that have eroded the greywacke and re-deposited it as sandy, gravely soils between the hills and the coast in the west.

34 With each large-scale tectonic movement, the river has altered course and slowly migrated north and south across the alluvial fans depositing gravels, sands and silts. Episodic flood events have resulted in finer materials (silts and clays) being deposited further away from the river channels.

35 In seismically quieter times, peat has developed in low lying areas between dunes. Dune sands inter-finger with the peat deposits and rise up to 20 m in elevation along the coast.

Conceptual Geological Model – Expressway

36 A geological model, comprising long-sections and cross-sections of the subsurface geology, has been developed from existing water well drilling records, drilling records from geotechnical investigations undertaken in the area and as part of the Project, and geomorphic interpretation of the surface distribution of sands and peat as well as from published geological maps.

37 The geology of the area is represented as eight stratigraphic units (geological layers) summarised in **Table 1**.

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[5] Further detail is provided in Technical Report 21 at pp 2-9.

Table 1: Key Stratigraphic (and Hydrogeological) Units

Hydrogeological Unit	Description	Thickness (m)
Holocene Alluvium	Alluvial gravel deposits in and around the present course of the Waikanae River and debris deposits (alluvium/ colluvium) from the adjacent greywacke hills	0 to 20
Holocene Peat	Fibrous woody material to amorphous, silty peat, organic silt, organic clay, organic sand	0 to 8
Holocene Sand	Fine to medium dune sand; coastal and inland sand dunes	5 to 30
Pleistocene Sand	Sand deposits that lie below the Holocene sand boundary and include reworked dune, beach and estuarine sands	5 to 40
Pleistocene Silt/Clay	Silt and clay at depth often packed with carbonaceous leaves and wood	0 to 30
Parata Aquifer	Pleistocene sand/gravel and clay-bound gravel; thinning to the south and surfacing at the foothills in the north	10 to 40
Waimea Aquifer	Terrestrial sand/gravel and clay-bound gravels	5 to 40*
Greywacke		Basement
* Base of layer not always encountered (may be thicker in some areas)		

Conceptual Groundwater (Hydrogeological) Model

Hydrogeological Units

38 The key hydrogeological properties (hydraulic conductivity,[6] storativity or specific yield[7]), of each of the stratigraphic units were assessed from in-situ field testing, pumping tests and review of published literature and are summarised in Table 1 of Technical Report 21 (attached as **Annexure A** to my evidence). Because the soils have been deposited in a coastal, alluvial and active tectonic environment, they vary spatially. The effect of soils with properties that vary spatially has been evaluated by sensitivity analyses.

39 The proposed alignment passes through the Waikanae Groundwater Zone (*WGZ*), one of six broad groundwater management zones on the Kāpiti Coast[8]. The key aquifer horizons within the WGZ are the

6 Hydraulic conductivity is the measure of the ability of a soil or rock to transmit water in units of metres per second (m/s).

7 Storativity is the volume of water an aquifer releases from (or takes into) storage. It is a dimensionless measure of how readily a formation will dewater. Specific yield is the amount of water released due to drainage from lowering the water table in an unconfined aquifer.

8 Wellington Regional Council, 1 March 1994: Hydrology of the Kāpiti Coast. Wellington Regional Council Publication WRC/CI-T/G-94/13.

Waimea Aquifer (typically some 80 m to 90 m below ground surface) and the Parata Aquifer (typically some 30 m to 50 m below ground surface), from which water is abstracted for public water supply. Domestic wells generally abstract water from the shallow unconfined aquifers (less than 30 m deep).

40 The Holocene Peat (row 2, Table 1 above), one of the two key hydrogeological units exposed at the ground surface (and therefore directly affected by the Project), is variable in nature, ranging from amorphous[9] organic silt and clay to fibrous woody peat. Generally the peat is more fibrous towards the southern end of the proposed alignment, whilst amorphous peat is more dominant at the northern end. The hydraulic conductivity of the peat is typically of the order of 10^{-6} m/s to 10^{-7} m/s but ranges between 1×10^{-5} m/s and 2×10^{-9} m/s. Field trials[10] indicate that surcharge of the peat could result in compression by a factor of 20 % to 50 %. This might reduce the hydraulic conductivity of the peat by a factor of 1/10 to 1/1000.[11] Because we cannot be certain of the level of hydraulic conductivity reduction, a range of hydraulic conductivity values has been used in analyses to simulate consolidation of the peat.

41 The other key units in the near surface are the Holocene and Pleistocene sands. There is significant overlap in the hydraulic properties of the various shallow dune, alluvial and marine sands, with hydraulic conductivity tending to be of the order of 10^{-5} m/s.

Groundwater Levels

42 Regional groundwater levels have been determined from GWRC monitoring stations within the WGZ (monitoring records since 2005 and some since 1994) and a total of 54 piezometers installed historically and recently along the proposed Expressway Alignment (with regular monitoring since 2010, and with some monitoring since 2007). This data gives us a valuable record of longer term trends in groundwater levels.

43 The data show a seasonal variation in groundwater level with the lowest water levels typically recorded in April (at the end of summer) and the highest water levels recorded in October (at the end of winter).

44 Comparison of water level measurements in the shallow unconfined aquifers with rainfall records from the Waikanae Treatment Plant

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[9] Amorphous peat is peat that contains no recognisable plant remains (Table 2.6 of the Guideline for the Field Classification and Description of Soil and Rock for Engineering Purposes, published by the New Zealand Geotechnical Society Inc. December 2005).

[10] Opus May 2008: Stage 1, Raumati Rd to Te Moana Rd Design and Project Documentation Stage, Geotechnical Report.

[11] Carlsten, P., 1998: Peat, Geotechnical Properties and Up-to-Date Methods of Design and Construction" Varia No.215, Swedish Geotechnical Institute, Linköping.

shows a strong correlation with rainfall events, indicating that the shallow aquifer responds rapidly to rainfall recharge.

Groundwater Flow Direction and Gradient

45 Water level data indicates that the main groundwater flow direction is (not surprisingly) from the foothills in the east towards the coast in the west. This means that the groundwater flow direction is broadly perpendicular to the proposed Expressway.

46 The groundwater gradient is approximately 1:500 along the southern and central sectors of the proposed alignment. Near the northern end of the alignment a steeper gradient of 1:250 is indicated, which may be due to the higher level of the greywacke basement rock in this area.

Surface Water

47 There are a number of surface water features within the WGZ which interact with the shallow and deeper groundwater system in different ways.

48 The Waikanae River has a direct connection with the underlying alluvial gravel aquifer with large losses and gains to and from groundwater indicated by flow gauging. A flow loss of up to 300 l/s from the river to groundwater was calculated by Gyopari (2005)[12] between SH1 and Jim Cooke Memorial Park.

49 The Waimeha and Wharemauku Streams also have a direct connection to groundwater, being almost entirely spring-fed through shallow gravels and sands with flows of 100 l/s to 300 l/s, and 20 l/s to 50 l/s respectively.

50 A large number of wetlands occur within the WGZ. Wetlands and lagoons have typically formed in the low lying areas between dunes where peat has been deposited and where the groundwater level is very close to the surface. Wetlands are generally thought to be points of groundwater "discharge" with flows largely sustained by shallow groundwater. However there is also evidence that some of the wetlands are "recharge" wetlands fed by rainfall run-off perching on the low permeability peat. Data collected and modelling carried out as part of this Project confirms that both types of wetland occur, depending on the particular conditions at each site.

Groundwater Abstraction

51 KCDC records indicate a few thousand domestic garden irrigation wells spread across the populated area between the hills and the coast along the length of the alignment. The pumping schedules and as-built details for these wells are not known and the

12 Gyopari, M., 2005: Investigating the Sustainable Use of shallow groundwater on the Kāpiti Coast. Report prepared for Kāpiti Coast District Council by Phreatos Groundwater Research and Consulting.

abstractions are not metered. The wells are generally thought to be less than 5 m deep and to each abstract 1 – 5 m^3/day. Although the individual take from wells is small, the cumulative volume (which might range between 3,000 and 15,000 m^3/day) is more substantial.

Summary - Conceptual Groundwater Model

52 The groundwater regime consists of a series of interbedded aquifers and aquitards creating a leaky, unconfined to semi-confined aquifer system. The predominant source of recharge is from rainfall, which slowly infiltrates down from the ground surface to the deeper layers.

53 At depth, moderate to high transmissivity terrestrial gravels form the confined Waimea Aquifer and Parata Aquifer. Public water supply wells abstract water for the most part from the Waimea Aquifer as its depth and semi-confined to confined nature gives greater security to the groundwater source and limits effects on overlying aquifers.

54 These deeper aquifers are overlain by a series of unconfined aquifers (river gravels and marine sands with interbeds of silty alluvium) from which domestic irrigation wells commonly abstract water. These sands and gravels are in turn overlain by alluvium and dune sand, with peat developed in the lower lying areas between dunes.

55 The peat ranges from amorphous organic silt to fibrous woody peat of variable permeability and compressibility. The peat is significant in that it supports a series of recharge and discharge wetlands of high ecological value and in that it is compressible (affecting its permeability and hydraulic conductivity) and will settle if the groundwater level (and hence moisture content) within it is lowered below that occurring in normal seasonal variations.

56 The construction of the Project has the greatest potential to affect the shallow groundwater system (i.e. the Holocene sand, peat, and alluvium) because works will be largely carried out within these materials.

ASSESSMENT OF EFFECTS ON GROUNDWATER AND MODELLING UNDERTAKEN[13]

Project Elements That Might Affect Groundwater

57 Construction of the proposed Expressway has the following elements that might result in changes to groundwater flow paths or levels:

[13] Further detail is provided in Technical Report 21 at pp 10-23.

57.1 Embankment construction:

(a) Cuts below the groundwater table, some requiring short term dewatering;

(b) Loss of recharge to the ground surface in the area to be covered by road pavement;

(c) Excavation and replacement of peat with sand; and

(d) Surcharging of peat to accelerate ground settlement.

57.2 Stormwater treatment, storage and attenuation:

(a) Construction of stormwater treatment/ attenuation wetlands;

(b) Construction of swales for the treatment, attenuation and conveyance of surface run-off from the proposed Expressway; and

(c) Earthworks to provide flood storage areas (cuts resulting in permanent lowering of the groundwater level or storage of water above the existing groundwater level, raising the groundwater level around the storage device).

57.3 Installation and pumping of water supply wells to provide a short term source of construction water.

58 Construction of the Project's embankments and stormwater devices, cuts and at-grade activities are limited to the upper, unconfined groundwater system (upper marine sands, alluvium, dune sands and peat) but may cause permanent changes (lowering or rise) in groundwater levels that could result in:

58.1 Consolidation and other aspects of settlement of the peat (addressed in the evidence of **Mr Gavin Alexander**);

58.2 Reduced groundwater through-flow, and groundwater levels in surface water bodies that may change ecological habitats (addressed in the evidence of **Mr Matiu Park**); and

58.3 Changes to direction and flow of groundwater, potentially altering the migration of any leachate that may be currently discharging from the Otaihanga Landfill (addressed in my evidence);

58.4 Reduction of water levels in existing (predominantly domestic) wells (also addressed in my evidence).

Methodology

59 The tools used to assess the potential effects on groundwater are:

59.1 Development of a site specific database from subsurface investigations, groundwater level monitoring and peat excavation trials; and

59.2 2D and 3D groundwater modelling.

60 During the course of historical and recent site investigations, several phases of site investigation have been undertaken comprising:

60.1 102 cored boreholes;

60.2 54 standpipe piezometers;

60.3 48 test pits;

60.4 111 hand augered boreholes; and

60.5 146 cone penetration tests.

61 The site-specific investigation data has been combined with logs from the GWRC well database and input to the computer software Hydrogeoanalyst (*HGA*), a data management and visualisation tool.

62 Water levels recorded in piezometers over the period 2007 to 2012 have also been input to HGA.

63 Excavation and fill trials were carried out on an area of peat adjacent to the proposed Expressway at the end of Greenhill Road (near Peka Peka interchange). The trials allowed:

63.1 The time taken to lower the groundwater level within the excavation and the extent of the drawdown effect beyond the excavation to be recorded; and

63.2 The hydraulic conductivity of the peat to be determined by recording the drawdown effects in adjacent piezometers due to lowering of the groundwater level in the excavation.

64 A series of generic and specific 2D computer groundwater models, a regional 3D computer groundwater model and four site-specific 3D computer groundwater models have been developed to assess the effects of the Project on groundwater.

Groundwater Modelling – Regional 3D Model

65 My team has used 3D groundwater flow modelling to evaluate the aquifer budget (water flowing into and out of the model) and assess the likely regional effects of the construction of the Project on groundwater, wetland and river levels.

66 The regional model:

66.1 Covers an area of 22.5 km by 11.0 km, and comprises 14 layers, representing the eight hydrogeological units described earlier in my evidence;

66.2 Has cell dimensions of 40 m x 40 m in the vicinity of the proposed Expressway, widening to 400 m x 400 m at the outer bounds of the model;

66.3 Includes rivers, streams and drains that act as groundwater sources or groundwater sinks;

66.4 Has individual recharge zones differentiated by soil type and land use and an average annual rainfall of 1311 mm/year (calculated from GWRC records over the period 2000 to 2010) applied;[14] and

66.5 Was calibrated using recorded average static water levels for existing wells, in-situ hydraulic conductivity test results from peat trials, a transient series of seasonally varying water levels and corresponding rainfall, a conceptual water balance and general flow patterns.

67 A series of sensitivity checks were undertaken which identified that the regional model is relatively insensitive to changes in hydraulic conductivity in the upper three layers (alluvium, peat and sand) and to small changes in rainfall recharge.

68 The potential effects of the Project were modelled by:

68.1 Simulating potential changes in peat hydraulic conductivity due to surcharging and consolidation (decrease in hydraulic conductivity) or excavation and replacement of the peat with sand (increase in hydraulic conductivity);

68.2 Removing rainfall from the area of the proposed Expressway (as all rainfall will be directed to swales and stormwater devices for treatment and controlled discharge to rivers);

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[14] The recent historical record of rainfall is used to establish the current groundwater regime and then the Expressway and associated works are added and the model re-run to determine what effect these structures have on the groundwater regime.

68.3 Simulating the introduction of the proposed new stormwater storage areas and wetlands; and

68.4 Simulating abstraction from the construction water supply wells.

69 Both steady state and transient models were developed; the steady state to consider average long term (operational) effects and a transient model to consider the cumulative effect of both the proposed Expressway and climate extremes such as high or low rainfall.

Groundwater Modelling: Site-Specific 3D Groundwater/ Stormwater Interaction Models

70 Three smaller, more detailed 3D flow models were developed to consider in more detail the interaction between the proposed man-made wetlands and storage areas and the existing groundwater regime (changes in flow direction, gradient and water levels), and the effects of proposed peat treatment methodologies arising from the Project. The areas for which detailed models were prepared are those in which the greatest changes in water levels were proposed and/or where existing groundwater conditions are already problematic, specifically:

70.1 Wetland OA/ OB (existing ecological area);

70.2 Flood offset storage areas 2, 3A and wetland 3 (Wharemauku Stream and proposed flood offset area); and

70.3 Wetland 9 (El Rancho ecological and cultural area).[15]

71 A fourth site-specific model was developed to consider the interactions of the Otaihanga Landfill and adjacent wetlands with the proposed Expressway construction.

72 These smaller models:

72.1 Have an area of 1 km^2 to 2.5 km^2, and comprise the same 14 layers and unit distribution as the regional model;

72.2 Have a cell size of 2.5 m x 2.5 m (or less) immediately adjacent to the proposed Expressway and stormwater devices, widening to 10 m x 5 m at the outer bounds of the models;

72.3 Consider streams and drains that occur in each of the modelled areas;

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[15] The wetlands are shown in Technical Report 21, Appendix 21.F.

72.4 Have rainfall recharge applied via recharge zones differentiated by soil type and land use as per the regional model; and

72.5 Use hydrogeological parameters that match those determined through calibration of the regional model, with boundary conditions varied to achieve calibration.

73 The potential effects of the Project were modelled by:

73.1 Simulating potential changes in peat hydraulic conductivity due to surcharging (decrease in hydraulic conductivity) or excavation and replacement of the peat with sand (increase in hydraulic conductivity);

73.2 Removing rainfall from carriageway areas (as all rainfall will be directed to swales and stormwater devices for treatment and controlled discharge to watercourses); and

73.3 Simulating the controlled water levels in man-made storage areas and wetlands.

74 As for the regional model, both steady state and transient models were developed. An 8 year rainfall record available for the period 2003 – 2011 was used in transient analyses. This period includes a wet 2004 and a drought in 2005 which allowed comparison of effects at each of these time steps.

Groundwater Modelling – 2D Groundwater Models

75 A series of 2D flow models oriented perpendicular to the proposed Expressway were developed to assess the potential effects of embankment construction on aquifer through-flow and groundwater levels. The models specifically look at the potential effects of peat excavation and replacement, or peat surcharge.

76 Generic 2D flow models were also developed to assess how typical drawdown curves might change with variations in peat thickness.

77 Because the 2D sections cannot consider 3D flow effects they tend to over-estimate the magnitude and extent of drawdown; for this reason, it is important to consider the results of the 2D models and 3D models together.

78 For the detailed 2D models, the spatial distribution of the 14 layers is that developed for the regional 3D model using HGA. For the generic models a simple, uniformly layered profile of peat overlying sand was modelled with the thickness of the peat varied in 0.5 m increments. Hydrogeological parameters were those calibrated for the regional 3D model.

79 Immediately adjacent to the proposed Expressway, a cell width of less than 2 m is used, widening to 30 m at the outer bounds of the models.

80 The 2D models were calibrated to available water level data and checked to see that areas of known flooding were simulated. The generic models assume a flat groundwater table at the surface. Rainfall recharge was applied to both model types as for the 3D regional model.

81 The potential effects of the Project were modelled by:

81.1 Simulating potential changes in peat hydraulic conductivity due to surcharging (decrease in hydraulic conductivity) or excavation and replacement of the peat with sand (increase in hydraulic conductivity); and

81.2 Removing rainfall from the area of the proposed Expressway (as all rainfall will go to swales and stormwater devices for controlled discharge to rivers).

SUMMARY OF MODELLED EFFECTS ON GROUNDWATER

Effects of the Expressway

82 Numerical modelling suggests that overall the proposed Expressway will have a very small effect on existing groundwater levels and flow directions.

83 Both 2D and 3D groundwater modelling indicate that peat treatment (either surcharging or excavation and replacement) will alter groundwater levels by typically less than 0.3 m (but up to 0.5 m) immediately adjacent to the proposed Expressway, reducing to 0.1 m at a distance of 50 m to 70 m from the edge of the embankment in the upper layers of the soil profile only, with no discernible change in flow directions. In the case of surcharging, a small rise in groundwater levels up-gradient may occur (although the modelling suggests that reduced rainfall recharge to the proposed Expressway area counters any small rise in water level for no net change overall); in the case of excavation and replacement, a small lowering of groundwater levels may occur.

Effects of Stormwater Devices

84 Where construction of stormwater devices results in a lowering of groundwater levels (i.e. flood storage areas 2, 3A and wetland 3 at Wharemauku) a maximum drawdown of 0.6 m is likely immediately adjacent to the stormwater devices, reducing to 0.1 m of drawdown some 200 m to 300 m from the ponds depending on variations in ground conditions. Locally this is expected to have a small effect on groundwater flow directions, but overall, the effects on flow gradients and directions are not discernible. However, the expected

drawdown could result in ground settlement, and this is discussed in the evidence of **Mr Gavin Alexander**.

85 Where the maintained water level in stormwater devices is more than 0.5 m above or below the existing groundwater level, and the device is in relative proximity to wetlands or private homes, modelling suggests constructing a low permeability lining in the ponds will be required to avoid lowering of the groundwater level beneath and adjacent to the storage areas or raising the groundwater level beneath and adjacent to the storage areas, respectively. This is the case at wetland OA, wetland 4 and wetland 9 where groundwater level data[16] suggests a constructed clay (or compacted peat) lining of minimum thickness 0.5 m and maximum hydraulic conductivity 1×10^{-7} m/s (or other product to achieve a similar reduction in groundwater through-flow) would be needed.

86 All other stormwater wetlands are at levels close to the existing groundwater levels and no discernible effects are expected.

Effects of Construction Water Supply Abstraction

87 The proposed abstraction of groundwater for construction water supply from a series of 9 bores that will be developed progressively as construction proceeds along the Expressway will result in a short term (i.e. no longer than the 4 year length of the construction period) groundwater drawdown of up to 2 m at each bore within the Parata Aquifer (the aquifer from which abstraction is proposed), with the cone of depression typically reducing to less than 0.1 m at less than 1 km. Abstraction at rates of up to 750 m^3/day from any single bore and a maximum of 1990 m^3/day in total from any group of bores pumping at any one time, is proposed as described in the evidence of **Mr Andy Goldie**. Some minor drawdown (less than 0.7 m) may also occur in the overlying and underlying aquifers in the vicinity of each well, and this effect would be temporary and muted in the overlying peat, where it occurs.

88 Modelling indicates that groundwater levels are likely to recover to 80 % of pre-construction levels within 1 day of ceasing pumping. The drawdown estimates are conservative because they are based on continuous pumping and do not consider the significant recovery that will occur between periods of intermittent pumping.

89 Each bore will be pumping tested once it is completed and the actual extent of effects confirmed by analyses submitted to GWRC (proposed consent conditions BC.3 – BC.6 and GT.1 to GT.5).

Combined Effects

90 Modelling suggests that overall changes to the groundwater budget are unlikely to be discernible. Groundwater contribution to rivers

[16] Ongoing monitoring of groundwater levels may indicate a greater natural range than is currently indicated which could mean that a lining is not needed.

and streams may reduce by up to 1.5 % (peak) as a result of the construction water take over the limited period of that take (being a number of months).

91 Due to the relatively limited extent of drawdown resulting from proposed Expressway construction and the lining of stormwater wetlands that would result in a lowering of the groundwater level by more than 0.5 m (which modelling indicates might be deleterious to the existing environment), there will be no discernible long term effects on groundwater contributions to rivers and streams.

92 The exception to this is the Wharemauku Stream where groundwater that would have directly discharged to the stream will instead be discharged to flood offset areas 2 and 3A[17] before being directed to the stream. Although this would be a non-consumptive take, modelling predicts that groundwater base flow over a length of 600 m alongside the pond will be reduced by 17 %.

93 Modelling suggests there will be no discernible effect on water levels in natural wetlands in the long term, due to the relatively limited extent of drawdown resulting from the proposed Expressway and the lining of the stormwater wetlands in areas where long term effects might otherwise have occurred.

94 As changes in groundwater levels, gradients and flow are expected to be very small, the potential for changes in contaminant migration as a result of the Project is also very small. Both regional and site-specific 3D groundwater modelling of the proposed Expressway in the vicinity of the Otaihanga Landfill indicate no noticeable change in groundwater levels, gradients and flow as a result of proposed Expressway construction. I therefore consider changes in contaminant migration from the landfill as a result of proposed Expressway construction to be negligible.

95 The results of numerical modelling indicate a maximum change in water level of up to 0.2 m within up to six existing wells.[18] This level of drawdown is unlikely to have an adverse impact on the yields of existing wells.

96 The six existing wells are identified in the GWRC wells database, however well depth is only given for two of these: one is 70 m and would not notice a 0.2 m water level change; the other is 10 m deep and is a monitoring bore and would not therefore be affected by the drawdown. I understand two of the remaining 4 bores are operated by the Waikanae Christian Holiday Park, one of which is 37 m deep and would not therefore be affected by 0.2 m of drawdown. GWRC

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17 Technical Report 21, Appendix 21.F, section F3 and Figures F1, F1b, F2b, F7, F7b, F8, F8b.

18 Wells R26/7163, R26/5176, R26/5555, R26/6811, R26/5147 and R26/7056 identified in the GWRC wells database.

has indicated[19] that all current takes on its system are more than 18 m deep except for three used for irrigation only. While no specific details are available for the remaining 3 bores, it is most likely that if they are more than 18 m deep, they will be able to tolerate a further 0.2 m of drawdown. However, should these wells be very shallow low yield wells with surface pumps, the yield from them may possibly be affected by a small amount. Pump adjustment or a temporary replacement supply by tankering of water from the construction bore, may be required.

97 A summary of the assessed effects of the Project on groundwater levels (from both 2D and 3D modelling) for all sectors is given in Table 2.

Table 2: Summary of Drawdown Effects

Wetland/ Offset Storage Area/ Section	Sector	Drawdown Up to (m)	Mounding Up to (m)	Extent of Effect Up to (m)
Wetland OA	1	0.5	-	< 20 - 40
Offset storage area 2, 3A and wetland 3	2	0.6	-	200 - 300
Embankment construction between offset storage area 2 and 3 - wetland 5	2	0.2	-	immediately adjacent
		< 0.05	-	down gradient
		-	0.2	immediately adjacent
		-	<0.05	10 – 20 up gradient
Embankment construction (general)	1 - 4	0.5		Immediately adjacent
		<0.1		50 – 70
Wetland 5	2	0.2	-	immediately adjacent
		0.1	-	25
Offset storage area 6	3	0.1	-	50 - 100
Wetland 8	3	0.5	-	immediately adjacent
		0.1	-	50 – 100
Offset storage area 9A	3	0.1	-	immediately adjacent
Wetland 9	3	0.3	-	immediately adjacent
		0.1	-	20 - 30

19 Greater Wellington Regional Council Key Issues Report dated 11 June 2012, page 29, paragraph 175.

Wetland/ Offset Storage Area/ Section	Sector	Drawdown Up to (m)	Mounding Up to (m)	Extent of Effect Up to (m)
Wetland 10	3	0.2	-	immediately adjacent
		0.1	-	50 - 100
Offset storage area 13 and 13A	4	0.2	-	immediately adjacent
		0.15	-	up to 600
		< 0.05	-	up to 1,600

Proposed mitigation measures

98 In order to mitigate and/or avoid adverse effects on groundwater by the Project, the following measures have been put in place, or are available if needed, or are proposed:

98.1 Strategies used in the proposed Expressway design to date;

98.2 Other construction strategies, if needed; and

98.3 A proposed monitoring regime.

Avoidance and Mitigation

99 A number of strategies have been used in the proposed Expressway design to address and mitigate anticipated effects on groundwater. These include:

99.1 Managing the shape and depth of stormwater devices to limit effects on groundwater according to the site-specific ground conditions. For example, wider shallower flood offset storage areas 2 and 3A (in Sector 2) mean that about 0.5 m of lower permeability peat can be retained below the excavation to control water ingress and the extent of groundwater drawdown;

99.2 Lining and other refinements to the design of stormwater devices that would otherwise result in a permanent lowering of the water level of more than 0.5 m thickness below the existing water table in areas where this could have deleterious effects;

99.3 Optimisation of construction activities, such as the use of a larger number of construction water take wells, spread out along the proposed alignment each taking a small volume at different times depending on the construction programme, rather than fewer wells pumping continuously at a higher rate;

99.4 Limiting the open length of excavation to reduce the volume and period of any localised dewatering; and

99.5 Use of a starter layer in all preloading embankment construction as a drainage blanket to limit damming effects up-gradient of surcharged peat.

Construction Strategies

100 Strategies[20] that can be used during the construction phase of works to limit the amount of drawdown and associated effects, should drawdown exceed that anticipated, include:

100.1 Monitor groundwater level, flow and quality and respond appropriately;

100.2 Alter the excavation methodology to reduce the period of time that excavations are drained;

100.3 Alter the peat treatment methodology to balance drawdown / damming effects;

100.4 Use active drainage measures beneath embankments (e.g. directionally drilled pipe) to facilitate flow through the embankment;

100.5 Redirection of treated surface water to wetlands or surface water bodies to encourage recharge;

100.6 Where short term yield from a private water supply well is affected, water from the construction wells could be tankered to users, or alternatively it might be necessary to deepen the private well to allow it to access a greater length of aquifer; and

100.7 Controlled recharge of groundwater to limit the amount of drawdown.

Proposed Monitoring

101 As part of the Project, monitoring of groundwater levels, ground surface elevations (settlement) and surface water flows will be undertaken to confirm the results of predictive modelling, and to refine models if early monitoring indicates that actual behaviour is different to that anticipated.

102 Monitoring will also serve as a trigger to initiate more comprehensive monitoring and/ or implementation of mitigation measures should that prove necessary.

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[20] These strategies are set out in the Groundwater (Level) Management Plan (Appendix I of the CEMP).

103 A draft Groundwater (Level) Monitoring Plan (*GMP*) has been prepared, which forms part of a comprehensive suite of environmental controls within the CEMP.[21] The groundwater monitoring programme will include a combination of:

103.1 Installation of standpipe piezometers (single and paired) in proximity and at distance from the proposed Expressway to monitor changes in groundwater levels (as set out in Appendix A of the GMP);

103.2 Baseline monitoring data recorded in advance of works to obtain seasonal and annual variations;

103.3 Flow monitoring of the Wharemauku Stream up-gradient and down-gradient of proposed flood storage areas 2 and 3A and wetland 3 (in Sector 2) to check modelled losses and gains;

103.4 Monitoring of key indicators of mobile contaminants in selected bores down-gradient and below landfills (as detailed in the Contaminated Soils and Groundwater Management Plan;[22]

103.5 Monitoring of spring flows at Te Puna o Rongomai (in Sector 3);

103.6 Establishment of various trigger levels (called Alert and Action levels[23]) with appropriate remedial action plans; and

103.7 A system of review to determine at what stage after construction, monitoring can be reduced or cease.[24]

RESPONSE TO SUBMISSIONS

104 I have reviewed those submissions (more than 120) that raise matters relating to groundwater. There are some key themes, and I have therefore grouped my responses on the basis of these themes. Many cover matters already addressed in my evidence, and I have therefore focused my responses on issues or particular areas where further explanation helps to clarify my findings on the matter raised.

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[21] See Appendix I of the CEMP.

[22] See Appendix K of the CEMP.

[23] Alert and Action levels are trigger levels established from the data collected in monitoring bores prior to commencement of construction. The Alert level is established to check that changes in water level are comparable with modelled levels and if exceeded, the frequency of data collection is increased; the Action level is to avoid the occurrence of adverse effects that might result from groundwater drawdown (or mounding) in excess of modelled levels and, if exceeded, triggers mitigation.

[24] CEMP Appendix I - GMP, section 5.1.4, c.

105 The key themes are around:

105.1 The Expressway might result in damming of water, exacerbating existing flooding issues, in particular on the eastern side;

105.2 That Technical Report 21 indicates that the effects on groundwater are negligible or would not be noticeable, whereas the Ecological Assessment identifies that even small changes to water levels could be significant to some wetlands;

105.3 The length of the monitoring period prior to and following construction;

105.4 That the yield or quality of existing privately owned water bores or public water supply wells might be affected;

105.5 That piling might affect aquifers;

105.6 That the Expressway, associated stormwater devices and construction water supply wells might result in draw-in of saline water or flooding due to climate change; and

105.7 That the Expressway results in increased exposure to tsunami.

Damming of Water and Exacerbation of Flooding

106 Several submitters[25] are concerned that the Expressway might act as a barrier to groundwater flow and exacerbate already high water levels and periodic flooding, in particular on the up-gradient (eastern) side of the Expressway and in the vicinity of Rata Road.

107 As I have described in my evidence, where the surcharging methodology is used, a small rise in groundwater levels up-gradient might be expected to occur. However modelling shows that the reduced rainfall recharge to ground over the Expressway counters this small rise in water level, with no resultant change in water level overall. I note that the peat is underlain by sand and that modelling shows that groundwater flow 're-routes' beneath the consolidated peat. Therefore, I consider that the potential for exacerbated periodic flooding due to increased groundwater levels is unlikely to occur, and submitters need not be concerned about this issue.

108 The exception to this is in the area between the Wharemauku Stream and Kāpiti Road, where a rise in groundwater level of 0.2 m is expected immediately adjacent to the upgradient (eastern) side of

[25] Including Mr & Mrs Davies (184), Mrs Ashford (198), Dr & Mrs Dearden (261), Ann Laing (337), Mr Mackay (402), residents of the Shalom Community (487), Waikanae On One (514), Mr Short and Ms Schwass (531), Ms O'Sullivan (675), Errolyn Jones (709) and Mr & Mrs Harris (713).

the Expressway, reducing to 0.05 m within 10 m to 20 m. There are no houses in this area.

109 The Paraparaumu/Raumati Community Board (501) has requested that monitoring of water levels be carried out along Rata Road. I confirm that a series of monitoring bores have been installed between the proposed wetland and storage areas and Rata Road (2012/BH03, 2011/BH213 and 2012/BH24) approximately as shown on Plan GT-GW-104 in the GMP (Appendix I of the CEMP). The bores will be monitored prior to (monitoring is already underway), during and following construction.

110 Mrs Ashford (198), J Sijbrant of Shalom Community (487), Ms O'Sullivan (675) and Mr and Mrs Harris (713) all specifically raise concerns that flooding will affect their properties. Mrs Ashford's property is on the western side of the Expressway and may experience a small lowering of groundwater levels that might reduce the amount of flooding on her property. Homes of members of the Shalom Community and of Ms O'Sullivan are located sufficiently east and west of the Expressway (respectively) that groundwater levels at their properties would not alter. Wetlands 8 and 9, located to the north and south of Mr and Mrs Harris' property, have been designed to avoid changes to the groundwater level as far as possible. No change to groundwater level is expected at Mr and Mrs Harris' property.

Uncertainty and Effects on Wetlands

111 A number of submitters are concerned that adverse effects on wetlands could occur as a result of even small changes in groundwater levels resulting from Expressway construction.

112 For example, KCDC (682) writes (at paragraph 72) that "*The decision and conditions need to reflect the more conservative findings and views of the ecological impact assessment in the AEE, rather than the findings of groundwater effects. The uncertainties associated with the groundwater modelling require a precautionary approach*."

113 The Raumati South Residents Association Inc. (707) suggests there is a contradiction between the findings of the groundwater assessment and the ecological assessment.

114 I note that my assessment is of the effects of the various elements of the Project on groundwater levels and flow directions; my assessment is not of the effects of groundwater level changes on wetland ecology. My finding is that groundwater level changes will be small or negligible. The assessment of whether such changes are potentially harmful to the wetland ecology is made by **Mr Matiu Park**. Mr Park has identified that it is possible in some cases, that even small changes in groundwater levels may be deleterious. I therefore conclude that there is no contradiction between the

groundwater and the ecological assessments and that one is not more conservative than the other.

115 A number of submitters endorse comments made in the submission by KCDC (682) or raise issues also raised by KCDC.[26] The Department of Conservation (468), GWRC (684), Raumati South Residents' Association Inc (707) and the Waikanae Christian Holiday Park (477) submit on groundwater effects on particular wetlands or seek specific outcomes. I comment on each of these by submitter below.

Kāpiti Coast District Council (KCDC) (682)

116 In expressing its concern about potential hydrological/ hydrogeological disturbances to high-value wetlands, KCDC submits (paragraph 62) that "*the nature and magnitude of effects on shallow groundwater flows and levels remain uncertain, particularly on a local scale*."

117 I agree that the models developed are necessarily a simplification of actual ground conditions and that the interaction of surface water and groundwater in the quite variable ground conditions that occur along the Kāpiti Coast is complex. However, I consider that the groundwater modelling carried out can be used to reasonably assess the likely effects on groundwater levels beneath the wetlands, in particular because the expected changes are small and are focussed immediately adjacent to the Expressway, rapidly reducing with distance from the Expressway. Where a body of water exists, these small drawdowns will be evened out over that wider body, resulting in no noticeable drawdown. I note also that monitoring of groundwater levels to date has shown that groundwater levels vary seasonally, in places over a range of more than 1.5 m. I have described in my evidence above the various models, model checks and calibrations carried out to assess effects on groundwater.

118 Nevertheless, I accept that the actual distribution of the different soil types and associated water body inter-connections can never be fully known. It is for this reason that I have proposed a programme of monitoring as set out in the Groundwater Management Plan and in proposed conditions. Both DOC (468) and KCDC (682) accept that uncertainty cannot be fully removed and identify that a robust monitoring and mitigation plan is therefore important.

119 As I describe later in my evidence, the conditions that I proposed with respect to groundwater monitoring were unintentionally missed from the set of proposed conditions submitted with the lodged application. They are now included in **Annexure B**. In my opinion, these conditions (GD.1 to GD.8) are appropriate. Amongst these conditions I propose that groundwater level monitoring data be

[26] Including Dr & Mrs Dearden (261), DOC in part (468), Mr Gradwell (481), Anna Carter (656), Raumati South Residents Association (707), Jocelyn Prvanov (716).

reviewed by both a hydrogeologist and an ecologist (proposed condition GD.5).

120 At paragraphs 69(a) and 70, KCDC requests that wetland hydrological studies be carried out for each high ecological value wetland with extended baseline monitoring. It is my understanding that hydrological modelling carried out under the guidance of Mr Graham Levy and ecological assessments carried out by Mr Matiu Park have either already been completed or are proposed through the draft Ecological Management Plan and associated conditions.

121 At paragraph 71, KCDC sets out the following requests for conditions that are relevant to groundwater, and to which I respond:

121.1 Conditions to ensure long-term post-construction monitoring – I have already proposed[27] a 3 year period of monitoring post-construction, which could be modified depending on the findings of monitoring;

121.2 Conditions to provide KCDC with a formal role in contributing to the review of the monitoring programme – I understand this would be a review of the final GMP and EMP prior to lodgement for certification with the GWRC. I agree that this would be appropriate and could be specified in these plans. I do not consider it necessary to also specify this check in the conditions.

Department of Conservation (DOC)(468)

122 DOC identifies the Waikanae River Mouth and Waimanu Lagoons, Te Harakeke/ Kawakahia Wetland, Kawakahia Swamp Forest, Nga Manu Nature Reserve and Ngarara Bush as being of high value and seeks additional monitoring effort in these wetlands to ensure appropriate and successful mitigation, should it be needed. I consider that the monitoring requirements set out in proposed conditions GD.1 to GD.8 (**Annexure B**) are appropriate; I refer specifically to my discussion above of proposed condition GD.5.

123 DOC suggests a longer period of pre-construction monitoring (2 years rather than the 1 year proposed in the conditions). I do not consider that necessary. Establishment of the pre-construction monitoring piezometers set out in the draft GMP (and required by the proposed conditions) is now almost complete. This means that in many cases pre-construction monitoring of newly installed piezometers will be able to take place for 18 months or more before the works approach. While I agree that a longer monitoring period would allow more comprehensive understanding of the wider natural variations in wetland levels, I note that the longer record of monitoring of the GWRC monitoring stations (with records since 2005 and some since 1994), and the 54 piezometers installed

27 See condition GD.7, **Annexure B**.

historically and more recently along the proposed Expressway Alignment that have had regular monitoring since 2010 (and some monitoring since 2007), will also be considered.

124 DOC considers that the five wetlands of higher ecological value (set out above) should be monitored for a period of 5 years following construction. (This is instead of the 3 years required in proposed condition GD.7, which was inadvertently omitted from the set of lodged conditions, along with the remaining conditions in the GD.1 – GD.8 set and conditions WS.5 – WS.7). DOC also recommends an opportunity to review, should effects become evident. I identified a 3 year period because this is about 1 year following stabilisation of water levels as predicted by groundwater modelling. However, I have spoken with Mr Park and concur that, given the potential sensitivity of the ecologically significant wetlands in close proximity to the Project, a 5-year post-construction monitoring period could be accepted for those wetlands outlined in the GMP. I note that three of the five high value wetlands identified by DOC are well outside the area of potential effects on groundwater. I have proposed an amendment to condition GD.7 (**Annexure B**) accordingly.

125 DOC is seeking that NZTA fund a "Wetland Ecology Review Panel" comprising at least three independent experts. The panel would, amongst other things, review existing studies on the wetlands and advise on parameters to be monitored, advise on the preparation of the GMP and EMP, review the results of monitoring, and make recommendations for further monitoring and mitigation.

126 Aside from the proposed monitoring that is yet to take place, it is my understanding that this task has already been carried out by Mr Park and that the requirement in condition GD.5 - that water level monitoring data be reviewed by both a hydrogeologist and ecologist – will ensure that interaction between groundwater and ecological experts continues and that data reviews can still be considered in a timely manner. **Mr Matiu Park** responds further to this submission in his evidence.

Greater Wellington Regional Council (GWRC) (684 and Without Prejudice Discussion Document)

127 On 22 August 2012, the GWRC produced a without prejudice Discussion Document to provide further detail on the matters raised in its submission (684). GWRC's broad concern around groundwater in its submission is the need for further information on effects on groundwater in certain areas, including consequential effects on wetland and stream function, and water tables in Queen Elizabeth Park. Its without prejudice Discussion Document centres around effects on the groundwater table and surface water within Queen Elizabeth Park. However the comments are general in nature.

128 I note that the proposed works commence at the northern end of Queen Elizabeth Park and are largely above the ground surface and along the existing SH1 alignment. However, the excavate-and-replace methodology for embankment construction is proposed at this location and therefore the effects on groundwater are likely to be a drawdown of up to 0.5 m immediately adjacent to the Expressway on its Park side, rapidly reducing to less than 0.1 m at 50 m to 70 m from the Expressway. A series of piezometers has been installed and monitored in this area that show seasonal variations of up to 1 m. I do not therefore anticipate any noticeable effects on groundwater in the Park and this is supported by the regional 3D groundwater model. I have responded to more specific issues raised in GWRC's Key Issues Report later in my evidence.

Raumati Beach Residents Association (RSRA) (707)

129 The RSRA (707) submission endorses the KCDC submission (682) and re-states many of the points made in that submission; I have not addressed these issues again. It supports the proposed water level monitoring and the processes and methodologies for mitigation and monitoring of wetlands but suggests they need 'refinement'. I consider the groundwater monitoring and mitigation already proposed and the conditions set out in **Annexure B** (which were not available to the RSRA at the time of preparing its submission) are appropriate and I do not see the need for them to be refined.

130 The Association seeks that the GMP and EMP reference one-another and are better integrated. The Plans currently cross-reference one another; however I agree that it will be important to carry this through into any changes to the Plans as they develop. I note that the full set of conditions that I propose (**Annexure B**) is intended to achieve such integration.

131 The RSRA also seeks improved understanding of the Raumati Manuka Wetland, Raumati Peatlands and Poplar Ave Wetland. In terms of groundwater, I confirm that a site-specific 3D groundwater model has been developed and reported for this area and a series of monitoring piezometers has been (and are being) established to check existing and long term water levels in this area. They are 2011/BH301 (shallow and deep piezometers), 2011/HA WM2, 2012 BH01 (shallow and deep piezometers) and 2012/BH02 (proposed shallow and deep piezometers), 2011/BH302 (shallow and deep piezometers), all shown on Drawing GT-GW-103 of the GMP.[28] Mr Park advised on the location of these monitoring piezometers and I therefore consider that these wetlands have received the consideration sought.

Other Areas

132 The Waikanae Christian Holiday Park (477) has concerns for the "El Rancho" wetland, and Waikanae On One (514) has concerns for the

[28] Appendix I of the CEMP.

nearby area between the Waikanae River and Waimeha Stream. **Mr Graham Levy** addresses these areas in his evidence and response to submissions. In terms of groundwater, this area has also been considered by way of a site-specific 3D groundwater model.[29] It is proposed to line the stormwater device (wetland 9) in this area to avoid altering current water level variation in this area. I do not consider any other action is needed in this area.

133 Ruth Mackenzie (046) was concerned that effects on groundwater in the vicinity of the Nga Manu wetland had not been addressed in Technical Report 22. This is because Technical Report 22 addresses surface water (hydrological) effects; groundwater effects (including effects on groundwater in the vicinity of the Nga Manu wetland) are addressed in Technical Report 21.

Otaihanga Landfill

Short and Schwass (531)

134 Mr Short and Ms Schwass (531) own land in proximity to the Otaihanga Landfill and are concerned that groundwater flow directions might alter as a result of Expressway construction. A site-specific 3D groundwater model of the Otaihanga Landfill area was developed to consider the effects of the Expressway and stormwater devices on groundwater flow. The model[30] indicates that flow is toward the northwest, that particle travel times within the shallow peat layer would not be altered as a result of Expressway and stormwater device construction (3 m/year in both cases), and that travel times within the deeper sand layer might increase by a small amount (27 m/year compared with 25 m/year). In summary, flow paths would not alter.[31]

Kāpiti Coast District Council (682)

135 KCDC's submission (682) contains a section on contaminated land in which it expresses concern that any change "*…in ground or surface water levels or discharge of sediment during construction will impede the wetland's efficiency as a natural treatment facility*" and that the culvert proposed to link the truncated wetland might create a route for leachate to migrate off-site.

136 The reason the pre-load-and-surcharge methodology for Expressway construction was selected over the excavate-and-replace methodology at this location was to avoid disturbing existing flows and contaminants derived from KCDC's landfill that might be held in in-situ materials. However, as described in Technical Report 23 and the evidence of **Mr Kerry Laing**, the levels of contaminants in shallow groundwater on the up-gradient side of the Expressway are low and in the shallow soils recovered from boreholes are

29 Reported in Appendix F4 of Technical Report 21.

30 Reported in Appendix F, Table F17, Technical Report 21.

31 Figure F9, Technical Report 21.

comparable with background levels. While consolidation of peat beneath the Expressway might result in a one-off increased release of any contaminated groundwater from the pore spaces, the embankment will in the longer term form a medium through which any leachate in groundwater is likely to achieve increased treatment.

137 The matter of the culvert is discussed in the evidence of **Mr Graham Levy**.

138 As I described above when responding to Mr Short and Ms Schwass' submission on the Otaihanga Landfill, we have used particle tracking to demonstrate that existing groundwater flow paths, in both the peat and the sand, will not be altered and that the rate of travel of groundwater from the landfill area will not alter as a result of Expressway construction. I am satisfied that the Expressway will not alter leachate transport from the site and I do not therefore consider that NZTA should be required to address the pre-existing leachate discharge issue from the landfill.

Effects on Existing Bores

139 There is concern amongst private bore owners that their ability to abstract water might be lost or reduced,[32] or that water in private bores or the aquifer in general might be contaminated by earthworks.[33]

140 With the exception of submitters 477 and 531, modelling shows that none of these bores would be affected by drawdown resulting from construction and operation of the Expressway or stormwater devices. A small drawdown of 0.1 m to 0.2 m could occur at the Waikanae Christian Holiday Park (477) bores and at the Short & Schwass bore (531). However we understand that these bores are sufficiently deep that a 0.2 m drawdown would not be noticeable and would not affect operation of the bores.

141 Mr Short & Ms Schwass (531) submit that the issue of supplying construction water has not been addressed. While the exact position of construction water supply bores is not yet known and the bores have not yet been drilled and tested, every effort will be made to avoid development of a well in proximity to existing wells. As set out in the GMP and proposed conditions BC.1 to BC.6 and GT.1 to GT.6 (**Annexure B**), each construction bore will be tested and the effects assessed and submitted to GWRC for approval before abstraction can take place. I note further that the aquifer targeted is the deeper semi-confined Parata aquifer in order to limit interference with typically shallow privately owned wells.

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32 Ms Hager & Mr Laird of Leinster Avenue (056), Mr Bills of Peka Peka Road (243), the Waikanae Christian Holiday Park (477), Mr Short and Ms Schwass of Killalea Place (531), Mr Craig & Ms Anderson of Datum Way (678).

33 Dr Hare (150), Mr Edbrooke (517) and Mr & Mrs Harris (713).

142 I am confident that the sediment and erosion control measures proposed by **Mr Graeme Ridley** will sufficiently contain sediment mobilised during earthworks so as to prevent an increase in turbidity or dissolved solids in private bores.

143 Miss Baterbee (223) expresses concern that the Expressway might affect public water supply wells. While no effects on yield of the bores is anticipated, KCDC (682) also seeks avoidance or mitigation of effects on public water supply wells. Indicative modelling carried out indicates that a drawdown of up to 0.5 m could occur in the deeper Waimea aquifer in which most of the public water supply wells are constructed, at the point of the construction water take, rapidly reducing with distance from the bores. This amount of drawdown would not affect KCDC's ability to abstract water from its wells. Transient modelling indicates that water levels recover to within about 80 % of pre-pumping levels within a day of ceasing pumping. As I describe above and in the proposed conditions BC.1 to BC.6 and GT.1 to GT.6 (**Annexure B**), each construction bore will be tested and the effects assessed and submitted to GWRC for approval before abstraction can take place. Discussions with KCDC are also underway to consider optimal shared water use opportunities.

144 The Expressway is aligned close to KCDC's public water supply wells K7, Kb12 and K10. KCDC (682) is seeking that these wells, and access for maintenance, be retained. K10 was in the position of the proposed Te Moana interchange, but the design of the interchange has been adjusted to avoid this well. I therefore confirm that all of these public water supply wells, and access to them to allow their proper operation and maintenance, will be preserved.

Piling

145 Some submitters, for example Dr Hare (150) and Mr Moore (507), expressed concern that bridge piling might result in disruption to or contamination of aquifers. I understand that use of two pile types is currently proposed: large diameter bored piles and driven steel H-piles. The piles would be installed in accordance with normal construction practises to a depth of about 20 m, well above the depth of the aquifer systems from which KCDC abstracts water for public water supply.

146 The completed piles will be installed tight against the formation (H-piles are driven into the ground and bored piles are filled with concrete in-situ) and would have only a very local effect on groundwater flows (the pile forms an obstruction around which groundwater will flow).

147 Minor leaching of cement to the shallow groundwater will occur for a short period before the concrete used to construct the piles "goes off". However, this would result in a highly localised elevated pH environment around the pile itself (within 10's to 100's of mm)

which will reduce as the free lime leaching off the surface of the concrete reacts with the surrounding soils. This will be a short-lived effect, perhaps days to weeks at most, depending on the grain-size of the surrounding soils and the rate of groundwater movement through them. I note that this is not so different from a new concrete water supply reservoir, which is flushed through a couple of times before being put into supply.

Saline Intrusion

148 Ms Hager and Mr Laird (056), Mr White (255), and K Pivac (536), express concern that the Project might result in salinisation of aquifers. While a small drawdown in groundwater levels on the down-gradient side of the Expressway is expected, this rapidly reduces to approximately no drawdown within about 100 m of the Expressway or stormwater devices. The exception to this is offset storage area 2, 3A and wetland 3, where effects are expected to extend for 200 m to 300 m. Nevertheless, the effects reduce to nil well before the coastline and the Project will not result in draw-in of saline water to aquifers.

Climate Change

149 A number of submitters[34] and Prof. Manning (687) in particular, raise the issue of climate change. Climate change has been addressed by **Mr Levy** in his evidence and in his responses to submissions. He found flood risk to be insensitive to even much higher sea level rises, and has tested cross-culverts for storm run-off well above the climate change recommendations.

150 Climate change has not been considered in groundwater modelling. This is because the purpose of the modelling is to assess the changes to the groundwater regime that might result from Expressway construction and as far as possible, to avoid changes to that existing regime.

Tsunami

151 Concerns have been raised by a number of submitters that the majority of the Expressway will be in a tsunami hazard zone or that it will increase exposure to tsunami.[35]

152 I prepared a memorandum addressing tsunami to inform the Project planning team (attached as **Annexure C**). Tsunami risk to the Kāpiti Coast has been evaluated and evacuation zones developed by GWRC and KCDC together with Civil Defence. The Expressway crosses the inland extent of the "Yellow" zone (1:2500 year return period or "maximum credible" tsunami) at two locations, Waikanae River and Te Moana interchange over Te Moana Road and the

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[34] Ms Hagar & Mr Laird (056), Ruth Love (470), Mr Cherry (492), Dr Wilson (545).

[35] Including Ms Bull (016), Ms Bunch (124), Mr & Mrs Lattey (466), Save Kāpiti Inc. (505), Mr Nauta & Ms Jones (600), Ms Beechy (663), Professor Manning (687), Mr & Mrs Harris (713).

Waimeha Stream. In both cases the Expressway crosses these areas as long span bridges that will allow an inland surge of water up the waterways beneath them. **Mr Graham Levy** describes how tsunami floodwaters might resolve in these areas.[36]

153 There is currently no evacuation route identified by KCDC that utilises the Waikanae River crossing area. The Expressway will pass over Te Moana Road and will not impede evacuation on this road toward the designated assembly area at Waikanae Park. I therefore conclude that the Expressway will not alter the tsunami risk to residents on the Kāpiti Coast in the vicinity of the Expressway.

RESPONSE TO SECTION 149G(3) KEY ISSUES REPORTS

KCDC Report

154 The section 149G(3) report prepared by KCDC *(the KCDC Report)* notes[37] that if the assessment of effects on groundwater is incorrect, irreversible effects on wetlands might occur. As I set out earlier in my evidence, a number of groundwater modelling approaches have been adopted to assess effects of the Project on groundwater and these assessments indicate a similar level of effects. Nevertheless, a comprehensive monitoring regime is proposed as set out in the draft Groundwater Level Monitoring Plan[38] and in proposed consent conditions attached to my evidence (**Annexure B**). The purpose of the monitoring, which includes collaborative assessments of data by a suitably qualified hydrogeologist and ecologist, is to check for adherence to the Project's guiding objectives, which are to ensure the natural flows in wetlands are not impeded and that the hills to coast groundwater flow is not impeded. The purpose of the monitoring is also to introduce mitigation measures if actual effects differ from those anticipated.

155 The KCDC Report identifies[39] that the monitoring of groundwater levels post-construction and the identification of mitigation options that could be effectively implemented (should effects occur following completion of construction activities), is important. I agree. As noted earlier in my evidence, post-construction monitoring is proposed for a period of one to three years (depending on the location of the monitoring point) following completion of construction. Groundwater modelling carried out shows this period would well exceed that needed for groundwater conditions to stabilise, however provision is made for on-going monitoring where conditions have not stabilised. Mitigation options are identified in section 6 of the GMP and a review process is set out in section 7 of the GMP to consider implementation of new techniques or

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36 Paragraphs 129 and 130 of Mr Graham Levy's evidence.

37 Pages 8 to 9.

38 CEMP Appendix I – GMP, section 5.2 in particular.

39 At pages 9 to 10 and page 45.

methodologies. It is my view that the monitoring period and mitigation opportunities identified will address KCDC's concerns.

GWRC Report

156 The section 149G(3) report prepared by GWRC *(the GWRC Report)* sets out its understanding of current groundwater use and allocation.[40] GWRC concludes that perhaps 10% of the Parata aquifer, the aquifer from which it is proposed that groundwater would be taken for construction water supply, is currently allocated and that it is unlikely that the proposed groundwater takes will interfere with any of the public water supply wells.[41] I agree with this assessment. GWRC notes, as we describe in Technical Report 21, that there are a large number of both consented and permitted takes from the shallow Waikanae sand/gravel aquifer. I can confirm that these takes, including 3000 wells abstracting at the maximum permitted take of 5 m^3/day, have been considered in 3D groundwater modelling.[42]

157 As described earlier in my evidence, the Expressway is most likely to affect the shallow groundwater system as the works will largely be carried out within the near surface soils. The GWRC Report points out that therefore the shallow permitted wells are the most likely to be affected by the works.[43] I agree, and it is for this reason that modelling has considered the positions of all wells, including those abstracting water as a permitted activity, that are in the GWRC wells database and the potential drawdowns that might be experienced in those in proximity to the works. It indicates that only the six wells (specifically described earlier in my evidence)[44] would be affected by a potentially noticeable drawdown (greater than 0.1 m).

158 The GWRC Report notes that there is a community water supply well at El Rancho Christian Camp that is 37 m deep and abstracts water at a rate of 1.56 l/s, and a second well at the site used for irrigation.[45] These wells are likely to be wells R26/5147 and R26/7056 identified in our modelling as being potentially affected by increased drawdown of up to 0.2 m[46] as a result of the Project. If these wells are in the order of 37 m deep, then it is most unlikely that a drawdown of 0.2 m will affect their yield.

[40] Paragraphs 171 to 176.

[41] Paragraph 174.

[42] Appendix F, Technical Report 21, Assessment of Groundwater Effects.

[43] Paragraph 176.

[44] At paragraph 95 and 96.

[45] Paragraph 175.

[46] Section F4.4, Appendix F, Technical Report 21, Assessment of Groundwater Effects.

159 The GWRC Report notes[47] that once any construction water supply bores have been drilled, a pumping test to determine any interference effects will be needed and the applicant will need to ensure that any effects on existing takes are avoided or remedied. I agree with this approach and have drafted consent conditions to ensure that this work takes place (proposed conditions BC.3 to BC.6 and GT.1 to GT.6, attached at **Annexure B**).

160 The GWRC Report draws attention[48] to the contingency measures identified for the Project, should the works nevertheless affect a bore owner's ability to abstract water from his bore. These are set out in the GMP.[49]

Conclusion

161 As explained above, the key issues reports do not raise any groundwater issues that have not already been addressed in Technical Report 21 or my evidence.

RESPONSE TO THE BOI'S SECTION 92 REQUEST

162 I have reviewed the section 92 RMA request made by the BoI (by letter dated 7 August 2012) and in this section of my evidence I will address groundwater matters identified in Appendix One under the heading Land and Water matters.

163 The relevant part of the request states: *"Potential effects of the balance of groundwater level changes on water availability for allocation, and the identification of potentially affected users."*

164 In response, I confirm that the groundwater modelling carried out indicates that changes to the overall water budget in the long term are small (less than 1 %), and that groundwater to the coastal zone would not be altered as a result of construction or operation of the Expressway, its associated stormwater devices or short term pumping for construction water take. Modelling indicates that the groundwater contribution to rivers and streams may reduce by up to 1.5 % (peak) as a result of the short term construction water take.[50]

165 GWRC indicates that the allocation limit in the shallow alluvial aquifer is about 1.5 million m^3/yr[51] and that about 50 % of this is being taken currently. If the Project reduced the availability by 1 %, this would be a reduction of 15,000 m^3/yr, and would not meaningfully alter the available allocation of this water.

47 Paragraph 175.

48 Paragraph 184.

49 Appendix I of the CEMP.

50 Appendix F1, Technical Report 21, Assessment of Groundwater Effects.

51 Page 28 and 29 of GWRC Key Issues Report.

166 As I describe above, GWRC considers that less than 10% of water in the Parata aquifer (the aquifer from which it is proposed that groundwater would be taken for construction water supply) is currently allocated (i.e. approximately 400,000 m^3/yr of a total allocation limit of 5.3 million m^3/yr). Construction water usage would not exceed 1990 m^3/day in total from any group of bores pumping at any one time. If abstraction were to take place at this maximum rate, 365 days per year (which it will not as water for dust suppression is not needed on rainy days), a temporary annual take of just over 700,000 m^3/yr would be needed. This take combined with the existing take would leave most of the available water in the aquifer for allocation.

167 I also describe above[52] that up to 6 existing wells could be affected by the Project (assuming construction pumping wells are located at the sites assumed at this stage). At least three of these wells are known to be sufficiently deep that it is most unlikely that the drawdown induced by the Project would be noticed. Once each construction water supply bore has been drilled, a pumping test to determine any interference effects will be carried out and any effects on existing takes will be avoided or remedied. I have proposed consent conditions to ensure that this work takes place (proposed conditions BC.3 to BC.6 and GT.1 to GT.6, attached at **Annexure B**).

168 I therefore conclude that the Project will not affect water availability for allocation, either during construction or in the long term, and that any effects on existing bores (should these be found to occur) will be avoided or remedied.

PROPOSED CONDITIONS

169 Mr Paul Goff, Ms Sian France and Mr Mark Utting, all senior hydrogeologists in my team at Beca, have prepared a draft GMP,[53] which I have contributed to and reviewed.

170 Proposed consent conditions G.19, G.29 and G.30 require that the draft GMP be finalised, submitted through the CEMP, and then implemented.

171 As set out above and noted in condition G.29, the purpose of the GMP is to address minimum standards that must be complied with, and outline best practicable options for groundwater management for the Project. It is intended as a framework for the development of groundwater level management practices and procedures to limit adverse effects of the Project on the environment. Condition G.29 specifies what information the GMP is to include.

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52 Paragraphs 157 – 160 of my evidence.

53 Appendix I to the CEMP, submitted as part of the Project application.

172 The potential for effects on the environment to occur can best be measured by recording changes in groundwater levels in piezometers installed in proximity to the works, and responding by implementation of suitable mitigation measures if pre-set action levels (established from pre-construction monitoring and agreed with GWRC) are reached.

173 The GMP will be updated, with the necessary consenting authority approval, throughout the course of the Project to reflect material changes associated with construction techniques or to the natural environment. A process for agreement and updating of all of the management plans as part of the Project is set out in conditions G.15 to G.19.[54]

Updated proposed conditions

174 In the documentation lodged with the AEE, the NZTA included a set of proposed consent conditions.[55] This included proposed groundwater conditions which I recommended would be appropriate to attach as conditions to the consents sought.

175 Some of the conditions I recommended were inadvertently omitted from the set lodged, being conditions WS.5 – WS.7 and GD.1 – GD.8. I have therefore now included a full set of the proposed groundwater conditions in **Annexure B** to my evidence, including conditions WS.5 – WS.7 and GD.1 – GD.8 which are shown in redline. That full set also shows (in redline) various changes now proposed to the lodged conditions.

176 I will briefly summarise what those conditions provide.

177 Proposed conditions G.19, G.29 and G.30 remain as lodged (and are discussed above).

178 Lowering of the groundwater level around flood offset storage areas 2, 3A and wetland 3 is expected to reduce the amount of groundwater which naturally discharges to the Wharemauku Stream (a reduction of about 17 %) and Drain 7 (a reduction of about 13 %) over a length of about 600 m. The groundwater that would have naturally discharged to the stream will instead discharge to the flood offset area and will then be redirected to the stream further down-gradient. I have proposed conditions WS.5 to WS.7 which set out requirements for flow monitoring up-gradient and down-gradient of flood offset storage areas 2, 3A and wetland 3, to check that flows to the Wharemauku Stream are not adversely affected and trigger mitigation to be designed should adverse effects occur.

54 And also proposed conditions DC.7 to DC.11.

55 AEE, Chapter 33.

179 Proposed groundwater take conditions:

179.1 Proposed conditions GT.1 to GT.6 remain essentially as lodged. However GT.3 part c) was a repetition of GT.3 part a) and has therefore been deleted. The English of the new part c) has been improved.[56]

180 Proposed groundwater diversion conditions:

180.1 Proposed conditions GD.1 to GD.8 set out requirements for monitoring of groundwater levels that will be used to compare actual groundwater conditions against those expected from modelling and how baseline levels will be established.

180.2 Because of the sensitivity of some wetlands, I have proposed condition GD.5 which requires that groundwater monitoring data from bores installed in or adjacent to wetlands be reviewed by both a hydrogeologist and a freshwater ecologist to ensure that the ecological effects of changes in groundwater levels are also considered.

180.3 As noted earlier in my evidence, in response to DOC's submission and discussions with Mr Park, I have recommended a 5-year post-construction monitoring period in proposed condition GD.7 for those wetlands of high importance outlined in the GMP.

CONCLUSIONS

181 The guiding objectives for the Project have included ensuring that both the hills to coast groundwater flow and natural flows in wetlands are not impeded.

182 Elements of the proposed Expressway that have the potential to affect groundwater are construction of the Expressway embankments by localised surcharge/ pre-load or excavation/ replacement of peat (that alters the permeability of the ground beneath them), construction of stormwater devices (that in places require cuts below the water table) and short term groundwater take for construction water supply.

183 Because the construction of the Expressway is developed in the near surface soils, it has the greatest potential to affect the shallow groundwater system developed in these soils.

184 Two and three-dimensional groundwater modelling (calibrated to the findings of geotechnical investigations, water level monitoring, rainfall data and pumping test data) has been carried out to assess

56 Refer **Annexure B**.

the effects of the short term construction and long term operation of the proposed Expressway on regional and local groundwater flows.

185 The modelling suggests that in the longer term the proposed Expressway embankment (and associated peat treatment used in its construction) will result in small (typically less than 0.1 m within 50 m to 70 m of the Expressway) long term changes to groundwater levels and flow directions, with no discernible changes in aquifer through-flow.

186 Where stormwater devices are constructed at the approximate groundwater level there will be no discernible changes to the existing groundwater regime. Where the devices are constructed above or below the existing groundwater level and modelling indicates a change in groundwater level might result that would be deleterious to the existing environment, they will be lined to limit such interactions.

187 Modelling suggests that the construction groundwater take (from a series of 9 bores to be developed progressively along the alignment) is likely to result in small changes to groundwater levels, flow directions and aquifer through-flow, but such changes will be limited to the 4-year construction period.

188 A water level monitoring programme has been established to record natural variations in groundwater levels in the vicinity of the proposed Expressway and I have set out suggested monitoring during and following construction in Appendix I of the CEMP which will allow appropriate responses to be triggered should actual effects differ from those anticipated.

189 I therefore consider that the effects of the Project on groundwater will be no more than minor and can be effectively managed by mitigation measures and consent conditions, should monitoring indicate changes that differ from those anticipated.

Ann Williams
5 September 2012

ANNEXURE A: TABLE 1 OF TECHNICAL REPORT 21

Table 1: Key Hydrogeological Units and Their Properties

Hydrogeological Unit	Description	Thickness (m)	Depth (mRL)	Adopted Hydraulic Conductivity (m/s)	Adopted Storativity / Specific Yield
Holocene Alluvium	Alluvial gravel deposits in and around the present course of the Waikanae River and debris deposits (alluvium/colluvium) from the adjacent greywacke hills	0 to 20 (thickest at foothills and river bed)	Surface or beneath cover of peat/sand	$K_h = 3 \times 10^{-3}$ $K_v = 3 \times 10^{-5}$	Sy = 0.3
Holocene Peat	Fibrous woody material to amorphous, silty peat, organic silt, organic clay, organic sand	0 to 8 (typ. up to 4 at alignment)	Surface	$K_h = 4 \times 10^{-6}$ $K_v = 1 \times 10^{-7}$	Sy = 0.5
Holocene Sand	Fine to medium dune sand; coastal and inland sand dunes	5 to 30	Surface to 8	$K_h = 5 \times 10^{-5}$ $K_v = 5 \times 10^{-5}$	Sy = 0.001
Pleistocene Sand	Sand deposits that lie below the Holocene sand boundary and include reworked dune, beach and estuarine sands	5 to 40	10 to -105	$K_h = 5 \times 10^{-5}$ $K_v = 1 \times 10^{-5}$	Sy= 0.05
Pleistocene Silt/Clay	Silt and clay at depth often packed with carbonaceous leaves and wood	0 to 30	0 to -60	$K_h = 1 \times 10^{-6}$ $K_v = 1 \times 10^{-7}$	$S = 3 \times 10^{-4}$
Parata Aquifer	Pleistocene sand/gravel and clay-bound gravel; thinning to the south and surfacing at the foothills in the north	10 to 40	-10 to -20	$K_h = 5 \times 10^{-4}$ $K_v = 2 \times 10^{-5}$	$S = 1 \times 10^{-4}$ to 4×10^{-4}
Waimea Aquifer	Terrestrial sand/gravel and clay-bound gravels	5 to 40*	-20 to -100	$K_h = 5 \times 10^{-4}$ $K_v = 1 \times 10^{-4}$	$S = 5 \times 10^{-5}$ to 4×10^{-4}
Greywacke		Basement rock	0 - > -100 m	Modelled as impermeable or inactive zone	
* Base of layer not encountered in all boreholes (therefore may be thicker in some areas)					

ANNEXURE B: PROPOSED CONSENT CONDITIONS

Following are conditions which I have referred to in my evidence. In summary:

- G.19: as lodged in the application;
- G.21: proposed amendment to delete repetitive language;
- G.29 – G.30: as lodged in the application;
- WS.5 – WS.7: inadvertently omitted from the lodged application;[57]
- BC.1 – BC.6: as lodged in the application, except for proposed amendments to BC.1 and BC.2;
- GT.1 – GT.6: as lodged in the application, except for proposed amendments to GT.1 and GT.3; and
- GD.1 – GD.8: original groundwater conditions inadvertently omitted from the lodged application. Amendment proposed to GD.7 (shown in yellow).

Proposed consent conditions (general)[58]

	Management Plans - General
G.19	The management of key environmental effects associated with the construction phase of the Project shall be detailed within environmental management plans that are included in the appendices to the CEMP (draft Plans were submitted with the applications). The finalised management plans shall be submitted to the Manager for certification at least 15 working days before the commencement of construction. Works shall not commence until the consent holder has received the Manager's written certification for the management plan(s). This suite of management plans consist of: a) Erosion and Sediment Control Plan b) Groundwater (Level) Management Plan c) Settlement Effects Management Plan d) Contaminated Soils and Groundwater Management Plan e) Ecological Management Plan
	Construction Environmental Management Plan
G.21	The certification~~)~~ shall confirm that the CEMP (and its appendices) ~~shall confirm that the CEMP~~ gives effect to the relevant conditions and that includes details of: a) Staff and contractors' responsibilities

57 Refer AEE, Chapter 33.4. I note that lodged conditions WS.5-WS.8 will need to be renumbered accordingly.

58 AEE, Chapter 33.2.1.

	b) Training requirements for employees, sub-contractors and visitors; c) Environmental incident and emergency management (including the procedures required under condition G.9); d) Communication and interface procedures; e) Environmental complaints management (required under Condition G.8); f) Compliance monitoring; g) Environmental reporting; h) Corrective action; i) Environmental auditing; and j) CEMP review. The CEMP shall also confirm construction methodologies and construction timeframes, including staging.
	Groundwater (Level) Management Plan
G.29	The consent holder shall finalise, submit and implement through the CEMP, the Groundwater (Level) Management Plan (GMP) to be submitted to the Manager for certification at least 15 working days prior to works commencing. The purpose of the management plan is to address the minimum standards, outline the best practicable options for groundwater management and procedures to minimise the effects on groundwater levels. The GWMP shall include information regarding: i. the schedule of groundwater monitoring bores identifying piezometer depth, screen length and geological unit; ii. the locations of groundwater monitoring bores shown on plans; iii. the locations of monitoring stations on the Wharemauku Stream and Drain 5; iv. monitoring frequency; v. monitoring methods; vi. reporting requirements; vii. alert and action programmes; viii. response management; and ix. review procedures.
G.30	At least 15 working days before submitting the GMP to GWRC for certification the consent holder shall submit a copy of the draft GMP required by Condition G.29 KCDC for comment. Any comments received shall be supplied to the Manager when the GMP is submitted, along with a clear explanation of where any comments have not been incorporated and the reasons why.

Proposed consent conditions for earthworks and discharges to land[59]

	General Conditions
WS.5	Flow monitoring stations shall be established at the approximate locations on the Wharemauku Stream and Drain 5 identified in Appendix A of the Groundwater Management Plan (CEMP, Appendix I). The exact location of the gauges shall be determined based on stream bed conditions such that they record the full range of flows as far as practicable.
WS.6	The flow monitoring required by Condition WS.5 shall record in-stream flows at 15 minute intervals (if feasible) for a period of: a) 12 months prior to commencement of excavation of flood offset storage areas 2, 3A and wetland 3 b) During construction of flood offset storage areas 2, 3A and wetland 3; and c) Up to 12 months following completion of flood offset storage areas 2, 3A and wetland 3, or a shorter period if no effects on base flows are recorded.
WS.7	The consent holder shall, within 10 working days of completion of flood offset storage areas 2, 3A and wetland 3, advise GWRC in writing, of the date of completion.

Proposed consent conditions for borehole construction and groundwater take[60]

	General Conditions – Borehole Construction
BC.1	The location, design, implementation and operation of the monitoring bore(s) shall be in general accordance with the resource consent application and theits associated plans and documents, and outlined in Condition G.1. contained in the Groundwater Management Plan (CEMP, Appendix I).
BC.2	Within one month after completion of all monitoring bore installations, the consent holder shall submit to the Manager a copy of the borehole logs and details of the piezometer installations.
BC.3	Within one month after completion of each water supply well, the consent holder shall submit to the Manager a copy of the driller's bore log form as completed by the driller who constructed the bore(s) and details of the well installation.
BC.4	The bore(s) shall be constructed and maintained in accordance with the New Zealand Environmental Standard for Drilling of Soil and Rock (NZS 4411:2011).

59 AEE, Chapter 33.4.

60 AEE, Chapter 33.5.

BC.5	In the event of a bore(s) being decommissioned or abandoned, the bore will be backfilled in accordance with NZS 4411:2011.
BC.6	Is so requested by the Manager, the permit holder shall make their bore available for the monitoring of water levels and water quality.

	General Conditions – Groundwater Take
GT.1	The location, design, implementation and operation of the groundwater takes shall be in general accordance with the consent application and its associated the plans and documents, and outlined in Condition G.1. contained in the Groundwater Management Plan (CEMP, Appendix I).
GT.2	The rate at which water is taken from each water supply bore shall not exceed 275,000 m3/year at 800 m3/day and a maximum pumping rate of 35 litres/sec.
GT.3	The consent holder shall undertake the following: a) install and maintain a water meter on each water supply bore take prior to the commencement of the take and for the duration of the abstraction from the point of take. The water meter shall measure both cumulative water abstraction and the instantaneous rate of take, and be capable of providing a pulse counter output; b) The water meter shall be calibrated to ensure that the error does not exceed +/- 5%. The water meter shall be installed in accordance with manufacturer's specifications; c) The permit holder shall install and maintain a water meter on the point of take XXX by XX (for existing takes with no meters) or prior to the commencement of the take (for a new take). The water meter shall measure both cumulative water abstraction and the instantaneous rate of take, and be capable of providing a pulse counter output. d)c) The permit holder shall ensureCalibrate the water meter shall be calibrated to ensureso that the error does not exceed +/- 5%. The water meter shall be installed and maintained in accordance with manufacturer's specifications.
GT.4	A stepped rate pumping test shall be carried out in each new water supply bore to determine the volume of water that can be abstracted from the bore.
GT.5	Within 3 months of the completion of each pumping test, the consent holder shall submit a report to the Manager, which contains but need not be limited to, the following information: a) Presentation of and analysis of the collected pumping test data b) Use results to simulate drawdown at any potentially affected neighbouring boreholes c) An assessment of the potential effect on nearby streams / wetlands; and d) An assessment on the risk of saline intrusion.

GT.6	If so requested by the Manager, the consent holder shall make its bores available for monitoring of water levels and water quality.

Proposed consent conditions for groundwater diversion

	Conditions – Groundwater Diversion
GD.1	The location, design, implementation and operation of the activity shall be in general accordance with the consent application and its associated plans.
GD.2	The consent holder shall: a) Install and maintain the groundwater monitoring boreholes shown in Appendix A of the Groundwater Management Plan (GMP) (CEMP, Appendix I) for the period of monitoring specified in this consent b) Monitor groundwater levels in the groundwater monitoring boreholes shown in Appendix A of the GMP (CEMP, Appendix I) and keep records of the water level measurement and corresponding date in accordance with the GMP. These records shall be compiled and submitted to GWRC at three monthly intervals c) Monitor groundwater levels monthly in existing boreholes and in newly installed monitoring boreholes shown in Appendix A of the GMP (CEMP, Appendix I) (required as part of this consent) for a period of at least 12 months (where practicable) before the commencement of construction. The variability in groundwater levels over this period, together with the monitoring trends obtained during the investigation and detailed design phases, will be used to establish seasonal groundwater level variability and establish trigger levels.
GD.3	Prior to the commencement of construction, and then at 3 monthly intervals during construction, the consent holder shall review the results of monitoring as compared with expected effects on groundwater levels assessed from groundwater modelling. This review will consider the final construction methodology and progress at the time of the review. The output of the first review shall be used to define the expected range of groundwater levels at each borehole and check the potential for damage to structures due to ground settlement. A factor for natural seasonal variability shall be allowed for in this review based on the monitoring completed under Condition GD.2.
GD.4	From the commencement of construction, the consent holder shall monitor groundwater levels in each borehole at a minimum of monthly intervals and records shall be kept of each monitoring date and the corresponding water level in each borehole. In addition, all boreholes located within 200 metres of the advancing construction face shall be monitored twice weekly. These records shall be compiled and submitted to GWRC at 3 monthly intervals.

GD.5	Monitoring bores installed in or adjacent to wetlands shall be reviewed on a monthly basis to determine if there is any effect of the works on water levels within them. The results shall be jointly reviewed by a hydrogeologist and a fresh water ecologist and included in the 3 monthly groundwater reports provided to GWRC.
GD.6	Monitoring data obtained pursuant to Condition GD.4 shall be compared to the expected groundwater levels for each borehole. Where groundwater level triggers are exceeded the appropriate actions as set out in the GMP shall be undertaken and the GWRC notified advising of the exceedance, the risk of adverse effects on wetlands or ground settlement that might cause damage to structures, and details of the actions undertaken.
GD.7	The consent holder shall continue to monitor groundwater levels in each borehole at monthly intervals for a period for up to 12 months following completion of Expressway construction, then 3 monthly thereafter for a further 24 months, or a lesser period (except in the case of piezometers in or adjacent to high value wetlands in proximity to the Project which shall continue to be monitored for 48 months following the initial 12 month period), if groundwater levels in any particular borehole show either: a) Recovery of the groundwater level to within 0.3 m of the pre-construction groundwater level as recorded in accordance within Condition GD.3 b) A trend of increasing groundwater level in at least 3 consecutive monthly measurements; or c) An equilibrium in the groundwater level, allowing for the seasonal variation, has been reached In which case monitoring at that borehole may cease, subject to written approval of GWRC.
GD.8	The consent holder shall, within 10 working days of completion of the Project construction, advise the GWRC in writing, of the date of completion.

ANNEXURE C: MEMORANDUM "A BRIEF ASSESSMENT OF TSUNAMI HAZARD" DATED 13 JANUARY 2012

To:	Graeme Spargo	**Date:**	13 January 2012
From:	Ann Williams	**Our Ref:**	
Copy:	Lucy Coe		
Subject:	A Brief Assessment of Tsunami Hazard		

1 Introduction

Tsunami are a series of waves generated in the ocean by large disturbances of the sea floor such as displacements on faults beneath the sea during earthquakes or large landslides under or into the ocean. In the deep ocean, tsunami travel at speeds of several to many hundreds of kilometres per hour, but they are usually less than half a metre high. As they move into shallow water they slow down, the distance between wave crests lessens and the waves increase in height.

Tsunami are described in terms of their maximum run-up height above mean sea-level. The area affected by tsunami depends in part on the run-up height and in part on the slope of the land. Areas of the Kapiti Coast that are low-lying will therefore be more vulnerable to tsunami.

Tsunami waves come ashore as steep breaking walls of water or as fast-rising water levels and may rush in for many minutes, penetrating far inland up rivers and along low-lying coasts.

2 Tsunami Risk on the Kapiti Coast

The Kapiti Coast is at risk from both near field tsunami (local earthquake source) and far field tsunami (distant source such as Solomon Islands, South America or Alaska).

In the case of a local earthquake source, there will be very little warning and the wave could be large.

In the case of far field earthquakes, it is likely that there will be some warning that might allow evacuation (perhaps 1 to 3 hours in the case of a Solomon Islands or up to 14 hours in the case of an earthquake off the coast of South America) and the wave size is likely to be smaller.

In preparing for possible future tsunami, GWRC, KCDC and Civil Defence have worked with GNS Science Ltd to develop Tsunami Evacuation Zones for the Kapiti Coast. The evacuation zones are coloured Red, Orange and Yellow. The evacuation zones are developed from computer modelling that considers the range of possible sources, the elevation of the land or presence of rivers and distance inland.

The Red zone is the lower-lying ground closest to the shore which is potentially at risk from any noticeable tsunami.

The Orange zone is based on the probabilistic wave height with a 500 year return period, from all far field (regional and distant) sources.

The Yellow zone is based on the probabilistic wave height with a 2500 year return period (described by GNS (2009) as a “maximum credible event”), considering all sources.

3 Tsunami Risk at the Expressway

The Expressway alignment is superposed on the established Tsunami Evacuation Zones in Figure 1 attached. It shows that the Expressway crosses the inland extension of the Yellow zone (1:2500 year tsunami) in two places, where modelling by GNS Science has indicated that a tsunami could travel up the Waikanae River and the Waimeha Stream.

The proposed Expressway crosses both of these rivers (and Te Moana Road) by long span bridges to allow for a 1:2500 flood event and breach of the Waikanae stopbanks and would therefore allow an up-river surge. In the case of the Waikane River crossing the approaches are located on unzoned land or at the boundary of the Yellow zone with unzoned land, and the bridge crosses the river at the narrowest part of the zone.

KCDC has identified evacuation routes and assembly areas (Figure 2). The Expressway in the vicinity of the Waikanae River yellow zone does not cross any evacuation route. The evacuation route from the coast up Te Moana Road to the assembly area at Waikanae Park will not be impeded by the Expressway which will cross Te Moana Road as an overpass. The Te Moana Bridge will be designed to withstand shaking from a 1:2500 year earthquake.

4 Conclusion

Tsunami risk to the Kapiti Coast has been evaluated and evacuation zones developed by GWRC and KCDC together with Civil Defence. The Expressway crosses the inland extent of the “Yellow” zone (1:2500 year return period or “maximum credible” tsunami) at two locations, Waikanae River and Te Moana interchange over Te Moana Road and the Waimeha Stream. In both cases the Expressway will be long span bridges that will allow an inland surge of water up these waterways. There is currently no evacuation route identified by KCDC that utilises the Waikanae River crossing area. The Expressway will pass over Te Moana Road and will not impede evacuation on this road toward the designated assembly area at Waikanae Park. It is therefore concluded that the Expressway will not alter the tsunami risk to residents on the Kapiti Coast in the vicinity of the Expressway.

Ann Williams

Technical Director – Engineering Geology and Hydrogeology

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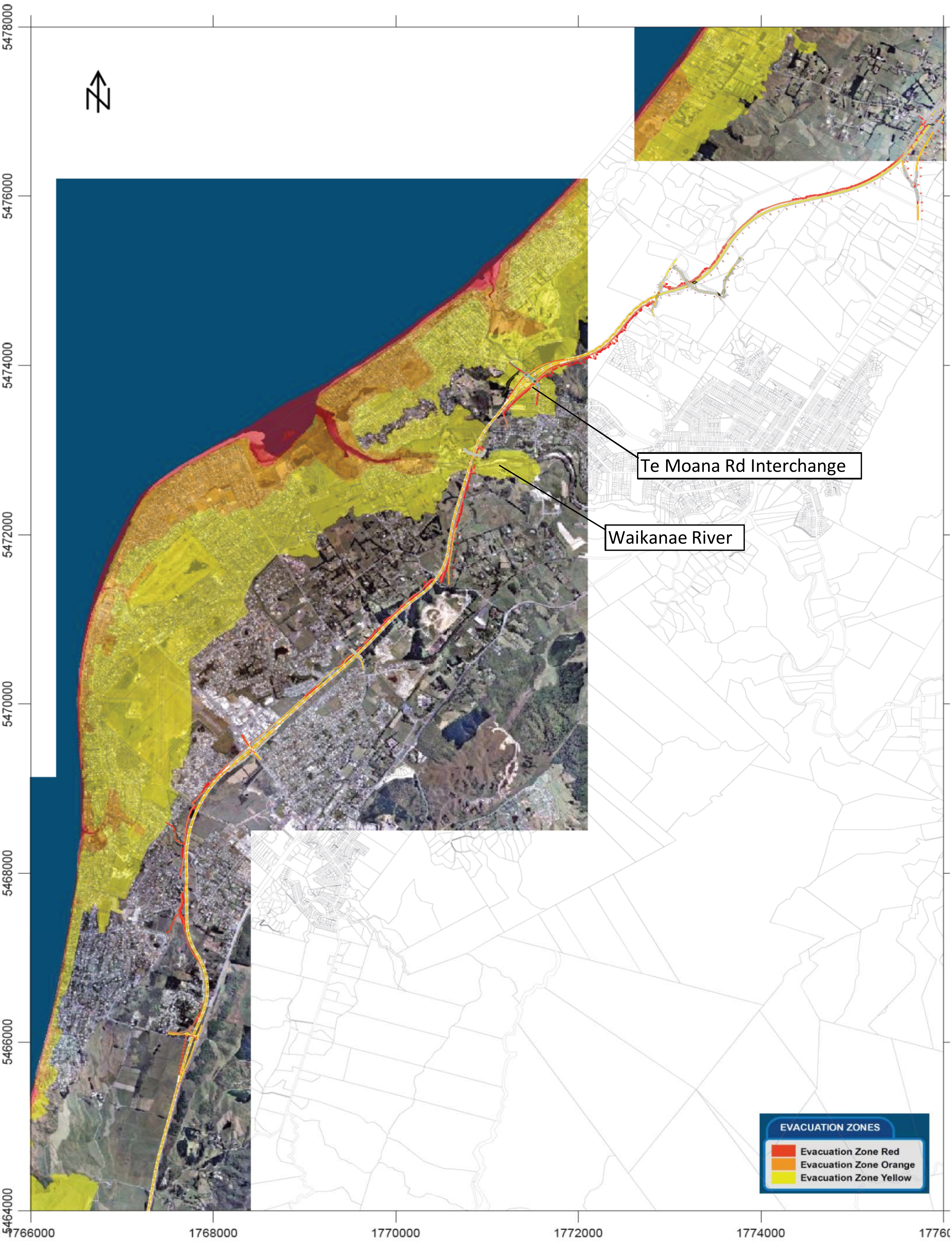

Tsunami Evacuation Zones - M2PP Overlay

MacKays to Peka Peka

Figure 1

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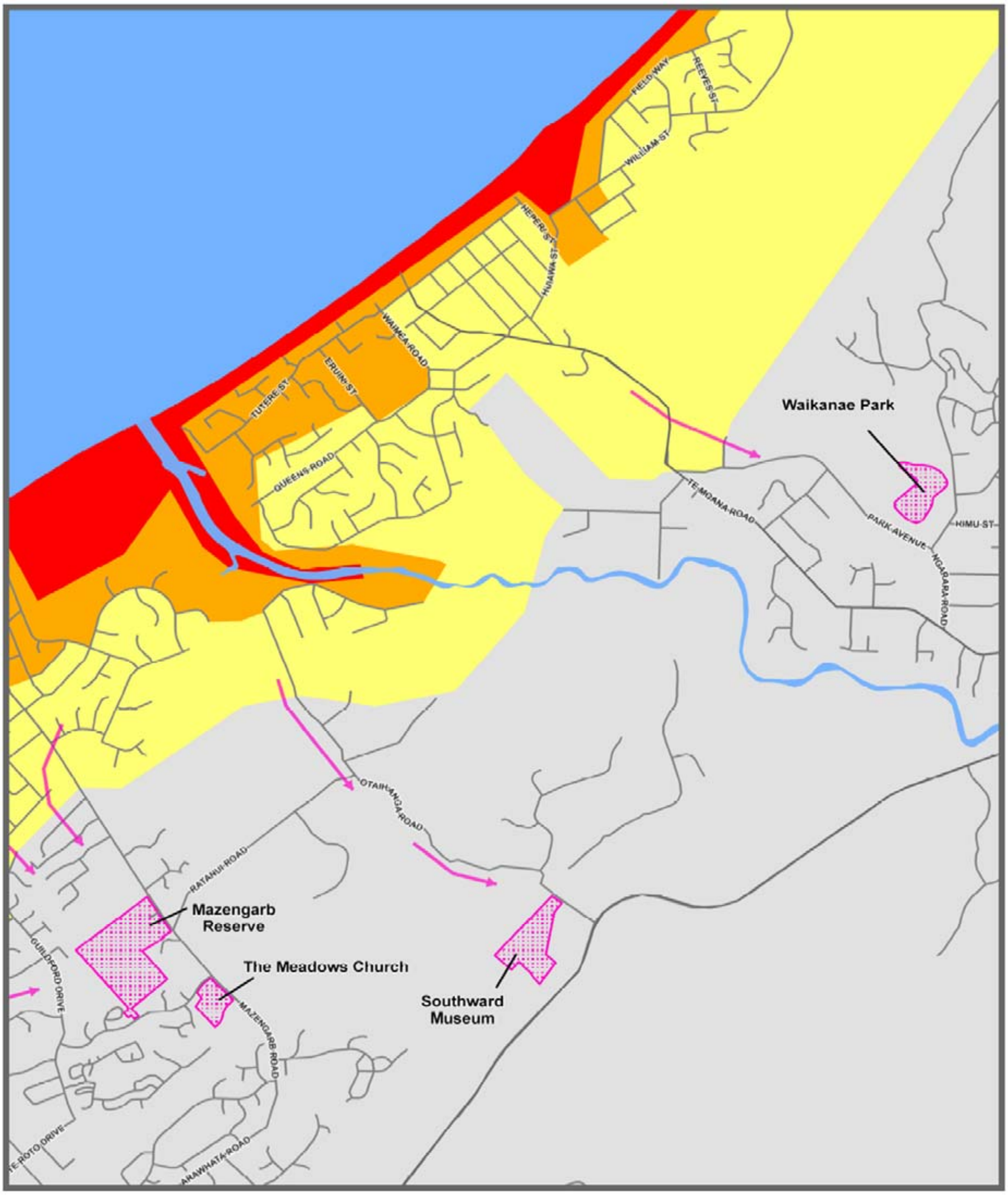

Tsunami Evacuation Zones - Waikanae

Red Evacuation Zone
Orange Evacuation Zone
Yellow Evacuation Zone
Assembly Areas

Scale A4 1: 25000
Date Printed: August 2010

0 250 500 1,000 1,500 Meters

KĀPITI COAST DISTRICT COUNCIL
me huri whakamuri, ka titiro whakamua

Tsunami Evacuation Zones

MacKays to Peka Peka **Figure 2**