Before a Board of Inquiry
Transmission Gully
Notices of Requirement and Consents

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under: the Resource Management Act 1991

in the matter of: Notices of requirement for designations and resource consent applications by the NZ Transport Agency, Porirua City Council and Transpower New Zealand Limited for the Transmission Gully Proposal

between: **NZ Transport Agency**
Requiring Authority and Applicant

and: **Porirua City Council**
Local Authority and Applicant

and: **Transpower New Zealand Limited**
Applicant

Statement of evidence of Dr Sharon Betty De Luca (Marine ecology) for the NZ Transport Agency and Porirua City Council

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Dated: 17 November 2011

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STATEMENT OF EVIDENCE OF SHARON BETTY DE LUCA FOR THE NZ TRANSPORT AGENCY AND PORIRUA CITY COUNCIL

QUALIFICATIONS AND EXPERIENCE

1 My full name is Sharon Betty De Luca.

2 I hold the qualifications of Bachelor of Science (Zoology) and Doctor of Philosophy (Environmental and Marine Science) from the University of Auckland.

3 I am a Principal Ecologist with Boffa Miskell Limited (*BML*) specialising in marine ecology, working primarily in the Auckland, Wellington and Bay of Plenty regions. I have been employed by BML for six years. I have previously worked for City University of Hong Kong (as a Post-Doctoral Fellow) on a variety of research projects focussing on coastal ecology, ecotoxicology, marine microbiology and the development of new techniques for monitoring sublethal stress in marine invertebrates.

4 I am a registered member of The Royal Society of New Zealand, the New Zealand Marine Sciences Society and the New Zealand Coastal Society and have practised as an environmental scientist for the past nine years. I am a Certified Environmental Practitioner with the Environment Institute of Australia and New Zealand and am bound by the Institute's code of ethics. I have published nine scientific papers in peer reviewed international journals.

5 My relevant experience in marine ecology includes:

5.1 Northshore Busway (2007): Preparation of assessment of effects of construction of busway lanes and motorway interchange structure adjacent to and within an area of intertidal habitat in North Shore City. The construction included temporary reclamation of an area of intertidal mudflat;

5.2 Silverdale North Residential Development (2007-2008): Preparation of assessment of effects of the construction of two road bridges across the Orewa River and tributaries and the discharge of construction and operational phase stormwater to tidal areas within the Orewa River and estuary. The construction involved permanent subtidal habitat loss;

5.3 Long Bay Structure Plan Change (2007-2008): Assessment of the potential adverse effects of land use change (from rural to urban) within the Awaruku and Vaughans Stream catchments at Long Bay on the marine ecological values within the receiving environment (Long Bay-Okura Marine Reserve).

The project involved presentation of expert evidence at Environment Court;

5.4 Additional Waitemata Harbour Crossing (2008-2009): Assessment of the effects of construction and operation of a proposed additional crossing of the Waitemata Harbour. The construction phase effects on marine habitat included dredging, disposal of dredge spoil, permanent loss of subtidal and intertidal habitat, reclamation works and disturbance of benthic sediment;

5.5 Waterview Connection (2009-2011). Assessment of the effects of construction and operation of the proposed connection of SH16 and SH20 and widening of the existing SH16 causeway between the Waterview and Te Atatu Interchanges. The construction phase effects on marine habitat included permanent loss of subtidal and intertidal habitat, reclamation works and disturbance of benthic sediment. The project has been approved by a Board of Inquiry;

5.6 Horokiwi Quarry Stormwater Discharges (2009-ongoing): Preparation of an assessment of the effects of stormwater discharged from the quarry via the Horokiwi Stream to the Wellington Harbour. Intertidal and subtidal surveys were carried out to characterise the existing benthic community and assess sediment deposition. Currently, BML are working with the client to improve stormwater treatment efficiency and site management practices.

6 On 15 August 2011 the NZ Transport Agency (*NZTA)*, Porirua City Council (*PCC)* and Transpower NZ Limited *(Transpower)* lodged Notices of Requirement (*NoRs)* and applications for resource consent with the Environmental Protection Authority (*EPA)* in relation to the Transmission Gully Proposal (*the Proposal)*.

7 The Proposal comprises three individual projects, being:

7.1 The 'NZTA Project', which refers to the construction, operation and maintenance of the Main Alignment and the Kenepuru Link Road by the NZTA;

7.2 The 'PCC Project' which refers to the construction, operation and maintenance of the Porirua Link Roads by PCC;[1] and

7.3 The 'Transpower Project' which refers to the relocation of parts of the PKK-TKR A 110kV electricity transmission line between MacKays Crossing and Pauatahanui Substation by Transpower.

[1] The Porirua Link Roads are the Whitby Link Road and the Waitangirua Link Road.

My evidence is given in support of the NZTA and PCC Projects (together the *TGP* or the *Project*). It does not relate to the Transpower Project.

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

9 I am the author of the Marine Habitat and Species: Description and Values report (Technical Report 10) and co-author of the Ecological Impact Assessment Report (Technical Report 11), which formed part of the Assessment of Environmental Effects (*AEE)* lodged in support of the Project. I prepared the draft Estuarine and Coastal Monitoring and Adaptive Management Plan, contained within the draft Proposed Ecological Management and Monitoring Plan (EMMP).

10 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

11 My evidence will deal with the following:

11.1 Background and role;

11.2 Description of methodology;

11.3 Existing marine ecology;

11.4 Effects of construction and operation of the Project on marine ecology;

11.5 Relevant Resource Management Act 1991 (*RMA*) matters;

11.6 Relevant New Zealand Coastal Policy Statement (*NZCPS*) matters;

11.7 Recommended mitigation or compensation;

11.8 Response to submissions;

11.9 Proposed conditions; and

11.10 Conclusions.

SUMMARY OF EVIDENCE

12 I assessed the ecological values of the marine species and habitats within Porirua Harbour and at the mouths of the Wainui and Whareroa Streams based on the existing literature and field surveys. I assessed the potential adverse effects of the construction and operation of the Project on these values.

13 My assessment concluded that the intertidal and shallow subtidal areas within the Pauatahanui Inlet have high ecological values, whereas the central subtidal basins have low ecological values. The Onepoto Arm was considered to have moderate ecological values. The mouths of the Wainui and Whareroa Streams were considered to have high ecological values.

14 In order to determine the effects of construction phase stormwater discharges within the Porirua Harbour, I relied on the hydrodynamic modelling outputs from SKM[2]. The model predicted concentrations of suspended sediment as well as depth and area of deposited sediment, following 2 year, 10 year and 50 year rainfall events under various wind conditions.

15 Suspended sediment in all modelled scenarios was determined to not cause adverse effects on marine ecological values due to sediment dropping out of suspension within 24 hours after the peak of the storm event.

16 Of the modelled scenarios, all but two events were considered to have negligible or low adverse effects on marine ecological values, primarily as sediment deposition was either minimal or largely confined to parts of the harbour with low ecological values.

17 The 10 year rainfall event in the Kenepuru/Porirua catchments, with a 2 year rainfall event elsewhere in the harbour, occurring with strong persistent southerly winds was assessed as potentially resulting in adverse effects of moderate significance, on marine ecological values in the Onepoto Arm due to localised small areas of sediment deposition occurring above biological thresholds in intertidal and shallow subtidal habitats.

18 The 10 year rainfall event in the Duck/Pauatahanui catchments, with a 2 year rainfall event elsewhere in the harbour, occurring with strong persistent northerly winds was assessed as potentially resulting in adverse effects of high significance on marine ecological values of the Pauatahanui Inlet, due to localised small areas of sediment deposition above biological thresholds in intertidal and shallow subtidal habitats.

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[2] Evidence of **Ms Malcolm** and **Mr Roberts** and Technical Report 15.

19 Given the high baseline sediment deposition that the model confirms is currently occurring, the intertidal habitat and to a lesser extent, the near shore shallow subtidal habitat, within the Pauatahanui Inlet must be relatively resilient, as at the majority of sites (in particular of intertidal sites) surveyed the sediment grain size and community composition does not indicate effects from sediment deposition events. The modelling predicts small, localised areas of additional deposition, above baseline, in the two storms that I have assessed to most likely result in significant adverse effects. Thus, the adverse effects related to the Project, if the events identified occur, are likely to small in comparison to baseline and the habitat that may be affected is likely to naturally recover over time.

20 Operational phase stormwater discharges were considered to have negligible effects on marine ecological values, but were recognised as contributing to the long term accumulation of contaminants in the harbour.

21 Construction phase and operational phase stormwater discharges to the Wainui and Whareroa Stream mouths were determined to have negligible adverse effects on marine ecological values due to the high energy environment rapidly removing and diluting the discharges.

22 Simulation of the construction phase discharges over six years and the operational phase discharges over 14 years (the long term simulation), based on the past twenty years of actual weather data, revealed that the Project is likely to contribute 2.5mm per year of sediment to the accumulation in the central subtidal basins. The effect on marine ecological values of this accumulation of sediment was assessed as negligible due to the low ecological values present in these areas. However, it was recognised that the Project is likely to have a small additive contribution to the existing infilling of the harbour.

23 Monitoring of the marine ecological values is proposed both prior to, during and post construction. Additional monitoring will also be triggered by any significant discharges of sediment and/or contaminants due to device failures or large rainfall events. Details are provided in the EMMP and the recommendations for marine monitoring conditions[3].

[3] Paragraphs 138-140 below.

24 In summary, the main risks of the Project to the marine ecological values are the two Q10 rainfall/wind events identified. If one of these events occurs and cannot be directly remedied, additional compensation[4] may be required to take account of short term effects on localised areas of marine habitat.

25 Submissions regarding marine ecology raise issues that mitigation/compensation may be inadequate and that there is insufficient recognition of the high ecology value and national significance of the Pauatahanui Inlet. I provide reaons why I disagree with the concerns raised.

26 I propose conditions be developed that relate to marine ecology that cover monitoring, triggered responses, reporting and intent to minimise the discharge of sediment and contaminants to the marine environment during construction and operational phases of the Project (paragraphs 138-140 below).

BACKGROUND AND ROLE

27 My role in the Project has been to assess the ecological value of the existing marine species and habitats within the Project area (Technical Report 10), to assess the potential effects of the construction and operation of the Project on those values (Technical Report 11) and provide marine ecological input to the draft Ecological Management and Mitigation Plan (EMMP) and proposed consent conditions.

28 I have worked alongside the Project's harbour modelling team (refer to the evidence of **Ms Malcolm** and **Mr Roberts**), in order to obtain data and outputs from the model to inform the assessment of effects on marine ecological values.

29 I have been involved in one meeting with Department of Conservation (*DOC*) staff that was convened in order to discuss the approach to the harbour hydrodynamic modelling and the proposed freshwater mitigation. I had some further email correspondence with Helen Kettles (DOC) following that meeting.

30 My evidence relies on the water quality modelling and assessment with respect to the hydrodynamic modelling and operational phase stormwater (refer to Technical Report 15 and the evidence of **Ms Malcolm**, **Mr Roberts** and **Dr Sim**). My evidence closely links with the evidence of **Dr Keesing** and **Mr Fuller** (see also Technical Report 9 which relates to freshwater ecology, Technical Report 6 which relates to terrestrial vegetation, and Technical Report 8 which relates to avifauna). There is overlap between the marine assessment and the freshwater assessment at stream mouths and

[4] Compensation could include mitigation elsewhere in the harbour that has direct benefit to marine ecological values.

with the vegetation assessment at the coastal saltmarsh fringe. In general though, the marine assessment considers values and effects at and below mean high water spring (*MHWS*). The scope of my evidence incorporates consideration of estuarine bird feeding habitat, whereas estuarine bird populations and communities are considered in the evidence of **Mr Fuller**.

31 There are no physical works in the coastal marine area (*CMA*) and no consents are required under the Coastal Plan. Potential adverse effects relate to the discharge of construction and operational phase stormwater to streams which discharge to the marine environment.

32 Adverse effects of the Project on marine ecological values relate to the potential indirect effects of the discharge of sediment derived from earthworks to the marine environment via streams. A range of measures are proposed for the treatment of erosion, and the capture and treatment of sediment during construction (refer to Techncial Report 15 and the evidence of **Ms Malcolm**). In addition, revegetation has occurred and more is proposed as part of the Project mitigation, which assists with the reduction of sediment discharge to these marine environments.

33 The water quality assessment (Technical Report 15) identified that during rainfall events, earthworks sediment will be carried to streams that discharge to the Porirua Harbour, and to streams that discharge to the Kapiti Coast. My assessment of the effects of the Project on marine ecological values focussed on these marine habitats identified as potentially being affected by construction phase and operational phase stormwater.

METHODOLOGY

34 Assessment of the ecological value of marine species and habitats involved collation of existing data and subsequent collection of field data relating to marine invertebrates, fish, sediment quality, sediment grain size, depth of anoxic sediment, saltmarsh, macroalgae and seagrass within the Porirua Harbour and the Kapiti Coast that may be affected by the Project.

35 Upon completion of the literature review some gaps in the current understanding of the ecological values in certain areas were identified. Within Porirua Harbour information was lacking about sediment quality and biological assemblages within intertidal habitats around stream mouths, shallow subtidal habitats adjacent to stream mouths and central subtidal basins. In addition, little data existed on the ecological values present intertidally at the mouth of the Wainui Stream.

36 Information on intertidal benthic invertebrates, sediment quality and sediment grain size data were gathered using methodology based on the National Estuarine Monitoring Protocol developed by Cawthron (2002),[5] which is accepted by the Greater Wellington Regional Council (*GWRC*) and used by their consultants to monitor other intertidal sites within the Porirua Harbour and Kapiti Coast.

37 Replicate subtidal benthic invertebrate, sediment quality and sediment grain size samples were collected, in accordance with best practice.

38 There are no recognised standards or guidelines for evaluating marine ecological values. In my assessment, I describe marine ecological values as being low, moderate or high based on a number of quantitative and qualitative measures of benthic invertebrate community composition, presence/absence of tolerant and sensitive benthic invertebrate species, sediment grain size, sediment quality, and degree of habitat modification. (Table 10.3,[6] Technical Report 10). I used the characteristics in the table to guide my assessment of the ecological value of the parts of the marine environment within the Project area, considering all the different types of data together. This approach was used at the Board of Inquiry hearing for NZTA's Waterview Connection Project. I consider that not all of the characteristics listed within each ecological value category need to be present in order to assess ecological value. Assessment of what constitutes low, moderate or high benthic invertebrate species richness and diversity is based on my own judgment and experience. A consideration of species sensitivity or tolerance to sediment deposition and organic enrichment forms part of the weight of evidence approach, as sensitive species are typically those lost first due to a disturbance activity and recover/recolonise last, thereby reducing biodiversity.

[5] Cawthron Institute (2002). Estuarine Environmental Assessment and Monitoring: A National Protocol. Report to the Ministry for the Environment, Sustainable Management Fund Project.

[6] Table 10.3 is reproduced in **Appendix A**.

EXISTING ECOLOGICAL VALUES

Context

39 The Porirua Harbour comprises two shallow tidal inlets: the Onepoto Arm (283ha) and the Pauatahanui Inlet (524ha). Maximum water depth in both inlets is approximately 3m. The Inlets have a common access to the sea via a narrow 0.1km wide entrance (Glasby et al. 1990).[7]

40 Approximately 80% of the Onepoto Arm is subtidal, whereas 60% of the Pauatahanui Inlet is subtidal. The ratio of subtidal to intertidal habitat is high compared to other estuaries and tidal inlets. This latter characteristic has important implications for sedimentation patterns, as tidal lagoon estuaries often have central basins that form a sink for fine sediment (Robertson & Stevens 2009[8]; Goff et al., 2003[9]).

41 Pauatahanui Inlet is a nationally significant estuary with high ecological values providing habitat for a range of invertebrates, fish and birds. The Inlet has substantial areas of saltmarsh and contains many protected areas including Pauatahanui Wildlife Management Reserve, Pauatahanui Inlet Wildlife Refuge, Duck Creek Scenic Reserve, Horokiri Wildlife Management Reserve and Ration Point Salt Marsh.

42 The Wainui Stream and Whareroa Stream discharge to high energy open sandy beach habitats on the Kapiti Coast, with the ultimate receiving environment being the Tasman Sea. The beaches of the Kapiti Coast are long, wide and gently sloping (Stevens & Robertson, 2006).[10]

43 In order to assess marine ecological values, the following components were considered individually, and subsequently collectively, within each marine receiving environment i.e. Pauatahanui Inlet, Onepoto Arm, and Wainui/ Whareroa Stream mouths. In the sections to follow I summarise these components for each marine receiving environment.

43.1 Sediment grain size and anoxic sediment depth;

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7 Glasby, G.P., Moss, R.L., Stoffers, P. (1990). Heavy-metal pollution in Porirua Harbour, New Zealand. New Zealand Journal of Marine and Freshwater Research 24: 233-237.

8 Robertson, B. & Stevens, L., 2009. Porirua Harbour Intertidal Fine Scale Monitoring 2008/09. Report prepared to Greater Wellington Regional Council.

9 Goff, J.R., Nichol, S.L., Rouse, H.L., 2003. The New Zealand Coast. Dunmore Press and Whitireia Publishing, Wellington.

10 Stevens, L. & Robertson, B., 2006. Broad Scale Habitat Mapping of Sandy Beaches and River Estuaries on the Western Wellington Coasts. Report prepared by Cawthron Institute for Greater Wellington Regional Council.

43.2 Sediment quality;

43.3 Benthic invertebrate community composition;

43.4 Fish; and

43.5 Saline flora.

Sediment grain size, anoxic sediment depth and benthic invertebrate community composition have been mapped along with storm related threshold sediment deposition due to the Project (Attached as **Appendix B**).

Sediment grain size and anoxic sediment depth

44 Measurement of sediment grain size gives a good indication of degree of "muddiness", with greater muddiness indicating lower ecological values. A greater proportion of fine grain size sediment suggests deposition of sediment from the surrounding catchment. Fine grain sediment is usually associated with higher concentrations of contaminants, as contaminants attach to small organic particles.

45 Sediment grain size distribution varies among sites within each Inlet, but generally intertidal habitats have a greater diversity of sediment grain sizes and are dominated by coarse grain sizes, whereas shallow near shore subtidal habitats have finer sediment, and central subtidal basin habitats comprise very high proportions of silt and clay[11].

46 Figure 1A (a copy of which is attached as part of **Appendix B**) clearly shows that within the Pauatahanui Inlet the central subtidal basin areas (see sites P6, P9-13, P15-16) have a high proportion (>75%) of silt and clay sediment grain size. Nearshore, shallow subtidal habitats are characterised as having a greater diversity of grain sizes, but a predominance of fine sand and very fine sand (>50%) (see sites P1-5, P7-P8). Intertidal habitats adjacent to stream mouths have significantly higher proportions of gravel and coarser sand grain sizes (see sites DUC, PAU, HOR, KAK), providing greater habitat diversity compared to the homogenous sediments of the central subtidal basins. Intertidal sediment grain size at the mouth of Rations Stream however, is finer than the other stream mouths sampled within the Pauatahanui Inlet, with very fine sand comprising almost 50% of the sediment composition and gravel forming only 2% (see site RAT).

47 A similar, but less obvious pattern of sediment grain size distribution is evident within the Onepoto Arm (Figure 1B, a copy of which is attached as part of **Appendix B**). Silt and clay dominate at sites O1 and O6 forming respectively 56% and 90% of the surface

[11] (Figures 1A and 1B, **Appendix B**)

sediment sampled. The other sites sampled close to the stream mouth (POR, O2, O3 and O5) comprised a greater diversity of sediment grain sizes, with medium sand through to gravel comprising between a quarter and half of the sediment. Site O4 in contrast comprised predominantly fine and very fine sand (approximately 88%).

48 Intertidal sediment at the Wainui and Whareroa Stream mouths is dominated by medium size sand, which is typical for this receiving environment along the Kapiti Coast (Stevens & Robertson, 2006), i.e. high energy open sandy beach.

49 Associated with sediment grain size is the depth of oxygenated sediment on top of anoxic sediment, or redox discontinuity layer. In muddy sediments, there is limited penetration of oxygen into the sediment. Sensitive organisms cannot tolerate reduced oxygen in sediment and therefore, anoxic sediment acts as an ecological barrier and contains only the most tolerant of organisms. This relationship within the Pauatahanui Inlet is shown in Figure 1A (**Appendix B**), where the sites that have the greatest proportion of silt and clay typically have the shallowest depth of oxygenated sediment i.e. <1cm within the central subtidal basins. Within the Onepoto Arm, sites located closer to the mouth of the Porirua Stream have a shallow depth of anoxia (<1-2cm), whereas site O4 located further north has deeper oxygenated sediment at the surface (6 cm) (Figure 1B, **Appendix B**).

50 Anoxic sediment was not detected at Wainui Stream mouth, as typically in high energy environments the action of waves and currents pump oxygen into the sediment. Similarly, whilst not sampled, this is highly likely to be the case at Whareroa Stream mouth also. Deep oxygenated sediment is typical of high energy exposed sandy beaches such as those present along the Kapiti Coast.

Sediment quality

51 Surface[12] sediment contaminant data from the literature and analyses undertaken for this Project revealed that amber or red biological effects threshold concentrations[13] were exceeded for common stormwater heavy metals such as copper, lead and zinc within the Onepoto Arm but were rarely exceeded within the Pauatahanui Inlet. High molecular weight polycyclic aromatic

[12] Surface sediment reflects recently deposited sediment. Typically the top 2-3cm is collected for analysis of contaminants.

[13] Based on the former Auckland Regional Council Environmental Response Criteria (ERC) concentrations, which were developed as sensitive early warning indicators for stormwater contaminant concentrations in marine sediments in the Auckland Region. Green concentrations suggest that there are unlikely to be any adverse biological effects, amber concentrations indicate possible adverse biological effects, and red concentrations indicate probable adverse biological effects.

hydrocarbons (HMW PAHs) exceeded amber or red biological effects threshold concentrations at 16% of the sites sampled within the Pauatahanui Inlet, whereas in the Onepoto Arm exceedances were detected at 46% of the sites. This pattern is consistent with the current and historic land uses within the catchments that feed into these estuaries, with the Onepoto Arm being primarily residential and industrial and the Pauatahanui Inlet being primarily rural and residential.

52 The concentration of dichlorodiphenyltrichloroethane (DDT) (and its derivatives), dieldrin and mercury were commonly detected above low level biological effects thresholds[14] in surface sediment in both inlets of the Porirua Harbour. However, these contaminants are not typically associated with stormwater or road runoff, but rather reflect historical pastoral land use practices.

53 Very low concentrations of stormwater contaminants in surface sediment were detected at Wainui and Whareroa Stream mouths reflecting the largely rural catchments and high energy receiving environment (Stevens & Robertson, 2006).

Benthic invertebrate community composition

54 Based on the existing literature and samples collected specifically for this Project in 2009 to 2011, the general pattern of invertebrate community composition is that the intertidal and near shore shallow subtidal habitat has a high diversity and abundance of benthic invertebrates, with many sensitive taxa[15] present. The central subtidal basin areas that are dominated by silt and clay and have a corresponding low abundance and diversity of invertebrates (Figures 2A and 2B, copies of which are attached as part of **Appendix B**).

Pauatahanui Inlet

55 Within the Pauatahanui Inlet intertidal abundance and diversity is significantly higher at intertidal sites than subtidal sites (although less so at Ration Creek (site RAT, Figure 2A, **Appendix B**)). The range of dominant intertidal organisms includes sensitive taxa groups e.g. bivalves and gastropods, as well as oligochaete and polychaete worms, many of which are more tolerant of environmental stress.

[14] Based on ANZECC Interim Sediment Quality Guidelines (2000).

[15] As a generalisation, bivalves and gastropods are more sensitive to disturbance, sedimentation and organic enrichment compared to polychaetes and oligochaetes (see Appendix 10E, Technical Report 10).

56 Many shallow subtidal sampling sites within the Pauatahanui Inlet (P2, P5, P7, P1, and P8) have a range of taxa groups present, but at significantly lower average abundance compared to the adjacent intertidal sites (Figure 2A, **Appendix B**).[16]

57 Subtidal sites located centrally within the Pauatahanui Inlet have a very low abundance of organisms and the dominant taxa is typically polychaete worms, with one or two individual bivalves occasionally present (see sites P6, P10-16, Figure 2A, **Appendix B**). This pattern mirrors the sediment grain size distribution shown in Figure 1A (**Appendix B**).

58 Cockles are an important component in New Zealand's harbours and estuaries (including Porirua Harbour), as they are an important food source for a variety of organisms (including fish and birds), affect the distribution of predator species, affect nitrogen and oxygen fluxes between water and sediment and are an important substrate for other molluscs and for the attachment of algae (Gibbs & Hewitt, 2004;[17] Morley, 2004;[18] this study).

59 Intertidal cockle populations are monitored within the Pauatahanui Inlet on a three-yearly cycle by the Guardians of Pauatahanui Inlet.[19] Whilst historical data suggests cockle populations were significantly higher in 1976, the population has been relatively stable since 1992. The 2010 data indicates that the approximate average density of cockles in the north eastern arm of the Inlet ranges between 25 per $0.1m^2$ at Duck Creek to 55 per $0.1m^2$ adjacent to Horokiri Stream. Lower density of cockles is present at Browns Bay and Camborne (20 per $0.1m^2$ and 5 per $0.1m^2$ respectively). Cockles were detected in many of the core samples collected for this project, predominantly in the intertidal habitats.

Onepoto Arm

60 The intertidal and shallow subtidal benthic assemblage in the Onepoto Arm is less diverse than the Pauatahanui Inlet and has a higher proportion of tolerant species (see Figure 2B, **Appendix B**). However, species that are sensitive to organic enrichment were detected in both inlets. The number of species that have a strong

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16 Note the difference in the vertical axis scale between the intertidal sites (maximum of 75) and the subtidal sites (maximum of 15).

17 Gibbs, M. & Hewitt, J. (2004). Effects of sedimentation on macrofaunal communities: a synthesis of research studies for ARC. Auckland Regional Council Technical Publication 264. 48pp.

18 Morley, M.S., *Seashells of New Zealand*. Auckland: New Holland, 2004.

19 NIWA (2011). Community survey of cockles (*Austrovenus stutchburyi*) in Pauatahanui Inlet, Wellington, November 2010. Report prepared for the Guardians of Pauatahanui Inlet.

sand preference was only slightly higher in samples collected in the Pauatahanui Inlet compared to the Onepoto Arm.[20]

61 Whilst within the Onepoto Arm the patterns are less clear, what can be readily seen in Figure 2B is that the subtidal sites have a low abundance and diversity of organisms, especially sites O1 and O6, which correlates with the highest concentration of silt and clay.

Wainui & Whareroa Streams

62 Wainui Stream discharges to a high energy, open sandy beach, which is characterised by coarse grain size sediment, negligible contaminant concentrations in intertidal surface sediment, and a naturally low abundance and diversity of benthic epifaunal and infaunal organisms. Whilst not quantitatively surveyed as part of this Project, the marine receiving environment at the Whareroa Stream mouth is considered to be similar to that of Wainui Stream based on the existing data.

Fish

63 Fish were not sampled as part of my assessment of the marine ecological values, as the existing literature provides a robust inventory of species likely to be present. Further, as fish are highly mobile they are able to avoid potential short duration non-optimal habitat conditions. The literature indicates that a high diversity of fish have been detected in Porirua Harbour and along the Kapiti Coast, including four At Risk species (inanga, long-finned, lamprey (all declining) and pipefish (sparse, but secure overseas) (Allibone, et al., 2010).[21]

Saline flora

64 The Pauatahanui Inlet and its immediate surrounds contain a variety of habitats including intertidal sandflats, saltmarsh, rushlands and manuka shrubland (Fuller, 1995).[22] Relatively natural estuarine vegetation profiles are present in the eastern part of the Inlet.

65 The Horokiri Wildlife Management Reserve, Pauatahanui Inlet Wildlife Refuge, Pauatahanui Wildlife Management Reserve and Duck Creek Scenic Reserve contain regionally rare saltmarsh, rushland and saline herbfield communities. Approximately 9.7% of the Pauatahanui Inlet margins (primarily in the east) are vegetated with saltmarsh, of which 5.6% is rushland (*Juncus krausii* and *Apodasmia*

[20] Appendix 10E, Technical Report 10.

[21] Allibone, R., David, B., Hitchmough, R., Jellyman, D., Ling, N., Ravenscroft, P., Waters, J. (2010). Conservation status of New Zealand freshwater fish, 2009. New Zealand Journal of Marine and Freshwater Research, 1-17.

[22] Fuller, S. (1995). Designation of Inland Route (Transmission Gully) Assessment of Ecological Impacts. Report to Porirua City Council, Wellington.

similis). Saltmarsh distribution in the harbour was mapped in 2007 by Stevens & Robertson (2008).[23]

66 Intertidal seagrass covers approximately 41 ha in the Pauatahanui Inlet (mapped by Stevens & Robertson, 2008), with the plants reported to be lush and healthy. Subtidal seagrass distribution has not been mapped and was not detected in the Pauatahanui Inlet during the surveys carried out for this Project.

67 Saltmarsh covers only 0.3% of the margins of the Onepoto Inlet (Stevens & Robertson, 2008) due to the highly modified harbour edge. Intertidal seagrass however, occurs over approximately 17ha. Seagrass was detected at subtidal sampling site O4, but due to poor visibility the extent of the patch was not discernable.

68 Small areas of saltmarsh wetland are present adjacent to Wainui and Whareroa Stream mouths.

Summary of Existing Marine Ecological Values

69 Both inlets contained relatively diverse invertebrate assemblages and species that are known to be sensitive to organic enrichment and to silt and clay. The composition of sediment grain varied amongst sites in each of the inlets, with some sites in each Inlet having a high proportion of silt and clay and some having a high proportion of sand and gravel. These differences are largely due to different historic and current land use practices influencing the runoff and deposition of terrigenous[24] sediment, in addition to having somewhat different hydrodynamic environments. Sediment contaminants were significantly higher in the Onepoto Arm compared to the Pauatahanui Inlet, primarily due to the land use activities occurring within the catchments. Further, habitat modification is more extensive in the Onepoto Arm, compared to the Pauatahanui Inlet.

70 My assessment of marine ecological values revealed a dominance of high values in the Pauatahanui Inlet, whereas moderate values dominated in the Onepoto Arm, as summarised in Tables 1 and 2[25] below.[26]

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[23] Stevens, L. & Robertson, B. (2008). Porirua Harbour Broad Scale Mapping 2007/2008. Report to Greater Wellington Regional Council.

[24] Terrigenous sediment is defined as sediment/soil originating from the land.

[25] Technical Report 10, Section 8.0, Page 69.

[26] See also Table 10.3, **Appendix A**.

Table 1: *Ecological values of the Pauatahanui Inlet*

Ecological value	Characteristic
Low	• Central subtidal basin areas comprise 75-100% anoxic silt and clay at most sites surveyed. • Benthic invertebrate diversity and abundance, within the central subtidal basins, is low.
Moderate	• Near shore shallow subtidal surficial sediments typically comprise approximately 50-70% very fine sand and silt/clay. • Habitat modification limited.
High	• Intertidal and near shore subtidal benthic invertebrate communities typically highly diverse with high species richness. • Intertidal and near shore subtidal benthic invertebrate communities contain many taxa that are sensitive to organic enrichment and mud. • Intertidal surficial sediments typically comprise no more than approximately 50-70% very fine sand and silt/clay. • Depth of oxygenated surface sediment typically >1.0cm in intertidal and shallow subtidal habitats. • Common stormwater contaminant concentrations in surface sediment rarely exceed low effects threshold concentrations. • Estuarine habitat connected to saltmarsh habitat in parts of the Inlet. • Habitat and feeding areas for birds and fish are extensive. • Important/keystone species present i.e. cockles. • Seagrass beds present (but patchy).

Table 2: *Ecological values of the Onepoto Arm*

Ecological value	Characteristic
Low	• Elevated concentration of common stormwater contaminants in surface sediment (above ISQG-High or ARC-red effects threshold concentrations). • Habitat highly modified.
Moderate	• Benthic invertebrate community typically has moderate species richness and diversity. • Benthic invertebrate community contains taxa that are sensitive to organic enrichment and mud. • Depth of oxygenated surface sediment varies between<1-6 cm. • Habitat and feeding areas for birds and fish present, but modified or limited.
High	• Intertidal and shallow subtidal surficial marine sediments generally comprise <50% very fine sand and silt/clay. • Seagrass beds present, but patchy.

71 Overall, I conclude that the Pauatahanui Inlet generally has high marine ecological values in the intertidal and near shore subtidal areas and moderate to low ecological values in the central subtidal basins, whereas the Onepoto Arm has moderate marine ecological values throughout.

72 There has been modification to Porirua Harbour in the past, including the construction of the marina, roading and bridges, discharge of contaminants from rural, urban and industrial land uses and the runoff of sediment laden water from earthworks. The Pauatahanui Inlet has suffered significant sedimentation events in the past due to earthworks and subdivision. Despite these modifications and discharges, the ecological values of the Porirua Harbour, remain high in the intertidal and shallow subtidal habitat within the Pauatahanui Inlet and moderate in the Onepoto Arm, suggesting that the majority of adverse effects have largely been temporary and these habitats have some resilience.

73 Wainui and Whareroa Stream mouths could not be assessed using the estuarine characteristics in Table 10.3[27] (Technical Report 10) as the receiving environment is an open sandy high energy beach not a low energy estuary. I conclude that whilst the abundance and diversity of organisms is low at these sites, the ecological values are high and the risks of degradation if low due to the hydrodynamic environment of the ultimate receiving environment.

ASSESSMENT OF EFFECTS OF THE PROJECT ON MARINE ECOLOGICAL VALUES

74 The Project may affect marine ecological values indirectly during the construction phase due to discharged stormwater from earthworks areas and during the operational phase due to discharged road runoff. There are no physical works in the CMA and no consents are sought under the Coastal Plan. Construction phase and operational phase effects are considered separately below.

Construction Phase - Stormwater Discharges

75 When rainfall events occur during construction of the Project treated stormwater (and associated residual sediment) arising from the open earthworks areas will be discharged to land and to streams which ultimately discharge to the Porirua Harbour and beaches of the Kapiti Coast. The sediment associated with these construction phase discharges has the potential to adversely affect intertidal and subtidal marine flora and fauna, through increased sediment deposition and concentration of total suspended sediment (*TSS*).

[27] Table 10.3 is reproduced in **Appendix A**.

Biological Effects Thresholds for Deposited and Suspended Sediment

76 The effect on marine organisms and habitats of the discharge of sediment-laden water to marine environments relates to both suspended sediment and deposited sediment. Effects on marine organisms are a factor of volume of sediment (concentration of suspended sediment and depth of deposited sediment) and duration of exposure, and further depend on the nature and values of the existing receiving environment.

77 Many research studies, primarily laboratory based, have been undertaken on the effects on the deposition of sediment on marine invertebrates.[28] This scientific literature suggests that where sediment deposition persists for a period longer than a few days the most sensitive benthic invertebrate species may be adversely affected at 5-10mm deposition and a larger number of benthic invertebrate species may be adversely affected at >10mm deposition, potentially affecting invertebrate community composition. The most tolerant benthic marine species may only be affected at even greater depths, particularly organisms inhabiting silt and clay habitat within the central subtidal basin areas.

78 I have taken a conservative approach however, and have applied the same potential biological effect thresholds across all marine habitats within the harbour. Therefore, 5-10mm and >10mm sediment deposition depths are used as conservative biological effects thresholds in my assessment summarised below.

79 Similarly research studies have been undertaken on the tolerance of some marine organisms to increased TSS.[29] Of the most sensitive species tested, pipi (*Paphies australis*), horse mussel (*Atrina zealandica*) and a tubeworm (*Boccardia* sp.) suffered measureable sublethal adverse effects when exposed to TSS concentrations between 75-80g/m^3, with horse mussels affected after 3 days exposure, tubeworms after 9 days exposure and pipi after 13 days exposure. Bivalve shellfish (wedge shell (*Macomona liliana*) and cockles (*Austrovenus stutchburyi*)) experienced adverse effects at 300 and 400 g/m^3 respectively, after 7-9 days exposure. Therefore, in my assessment summarised below I have used a TSS

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[28] See discussion of the scientific literature, page 112 of Technical Report 11.

[29] Ellis, J., Cummings, V., Hewitt, J., Thrush, S., Norkko, A. (2002). Determining effects of suspended sediment on condition of a suspension feeding bivalve (*Atrina zelandica*): results of a survey, a laboratory experiment and a field transplant experiment. *Journal of Experimental Marine Biology and Ecology 267*:147–174.

Hewitt, J., Hatton, S., Safi, J., Craggs, R. (2001). Effects of suspended sediment levels on suspension feeding shellfish in the Whitford embayment. Report prepared for Auckland Regional Council.

Nicholls, P., Hewitt, J., Halliday, J. (2003). Effects of suspended sediment concentrations on suspension and deposit feeding marine macrofauna. Auckland Regional Council Technical Publication No. 211, Auckland Regional Council.

concentration of 75mg/m^3 occurring for longer than 3 days as a highly conservative trigger to indicate potential adverse effects on sensitive marine organisms

Kapiti Coast

80 Stormwater discharges to the Kapiti Coast via the Wainui and Whareroa Streams will be treated to NZTA's internal stormwater treatment guideline standard[30] prior to discharge to the environment.[31] Given the high energy receiving environment of the Kapiti Coast beaches at Wainui and Whareroa, I do not consider that there will be any adverse effects on marine ecological values at these sites, as residual sediment and associated contaminants contained in treated construction phase stormwater are expected to be rapidly removed from the stream mouths and diluted in the wider Tasman Sea receiving environment.

Porirua Harbour

81 Modelling has been undertaken of the baseline sediment movement into Porirua Harbour and the potential increase in sediment discharged to the harbour in treated stormwater as a result of runoff from maximum open earthworks during construction, in a Q2, Q10 and Q50 rainfall event under various persistent wind conditions. The modelling focussed on the streams that have the greatest earthworks in their catchments during the construction phase of the Project, these being Pauatahanui, Horokiri, Kenepuru and Porirua Streams and Duck Creek. The patterns of sediment deposition and TSS vary from catchment to catchment depending on many factors, including the underlying geology, soil, slope, land use, and the proximity of the discharge point to the harbour taking into account mixing as set out in Technical Report 15 and the evidence of **Ms Malcolm**.

82 The rainfall events modelled by **Ms Malcolm** that I have used in my assessment of effects on the marine ecological values included:

82.1 a 2 year event (Q2) in all catchments at the same time;

82.2 a 10 year (Q10) event in the Kenepuru and Porirua Stream catchments with a 2 year elsewhere;

82.3 a 10 year event in the Duck Creek and Pauatahanui catchments with a 2 year event elsewhere; and

82.4 a 10 year event in Horokiri catchment with a 2 year event elsewhere.

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30 NZTA (2009), Draft Stormwater Treatment Standard for State Highway Infrastructure.

31 Evidence of **Ms Malcolm** and **Mr Martell**.

83 All events were modelled using the worst case open area (i.e. maximum earthworks). As wind has a strong influence on where in the harbour sediment is ultimately deposited each of these rainfall events were modelled three times; under persistent calm wind conditions, persistent south-southeast wind and persistent north-northwest wind.

84 The 50 year (Q50) rainfall event was also modelled under the various wind regimes (refer Technical Report 15 and the evidence of **Ms Malcolm**). As **Ms Malcolm** notes, a Q50 event is beyond the scope of sediment and erosion management tools. If a Q50 event occurred under baseline conditions (i.e. without the Project), an extremely large volume of sediment would be deposited in Porirua Harbour, smothering most if not all of the organisms and resulting in highly significant adverse effects on marine ecological values. The sediment contribution from construction of the Project would form a very small proportion of the total sediment that would be discharged during a Q50 event. In my opinion, the additional sediment discharged to the harbour in a Q5O event from Project related open earthworks would make a negligible contribution to the adverse effects that would occur under baseline conditions (i.e. without the Project).

Assessment of deposited sediment arising from Q2 and Q10 events

85 For the Q2 and Q10 rainfall events modelled, between 615ha and 718ha of benthic habitat (from an estimated total of 800ha of intertidal and subtidal habitat in the harbour, i.e. 76-90%), receive less than 3mm of sediment, and is considered to not result in adverse effects on marine ecological values.

86 Under baseline conditions (i.e. without the Project), the Porirua Harbour receives a significant volume of sediment during rainfall events. The hydrodynamic modelling of various storm events indicates that there is approximately a 5-6% increase in areas affected by sediment deposition one day after the peak of the rainfall event. For example, in a two year rainfall event under calm wind conditions in the Pauatahanui Inlet, under baseline conditions, the area of harbour that receives >3mm of sediment from the catchments modelled is approximately 108ha. Under the same rainfall and wind conditions, during peak construction of the road, this area increases by 5.5% to 114ha.[32]

[32] Data provided by SKM.

87 Most benthic marine organisms can withstand the deposition of sediment for a few days by temporarily shutting themselves off from the environment e.g. closing valves, burrowing, and ceasing feeding. As noted previously, my assessment has considered sediment deposition persisting 3 days after the peak of each storm event modelled, as this is considered to be when measureable adverse effects may start to occur in certain species.

88 I have assessed the predicted suspended sediment and deposited sediment resulting from a number of modelled rainfall and wind combinations. In my assessment of the Q2 and Q10 rainfall events modelled (Technical Report 11)[33] I have considered the locations and area of Porirua Harbour that receive sediment during such events and which results in those areas being pushed into potential biological effects threshold depths i.e. 5-10mm and to >10mm. For example, under baseline conditions, a certain event may result in a part of the harbour receiving 4mm of deposited sediment. Assuming the same event occurs during peak construction of the Project the area receiving 4mm already may receive an additional 1mm of sediment, which pushes that area above potential biological effects thresholds for the most sensitive species. Areas of the harbour that under baseline conditions receive >10mm during each storm event, and may receive additional sediment if the event occurs during construction of the Project, are considered to not incur additional adverse effects.

89 Following identification of the areas that are predicted to be pushed into biological effects threshold depths of sediment, I then assessed the sensitivity of those areas to deposition. For example, central subtidal basins are considered not to be particularly sensitive to deposition, whereas intertidal and shallow near shore subtidal areas are more sensitive to deposition, due to the ambient benthic sediment grain size, depth of anoxia and biological communities supported. I present deposition data (see Table 3 below) and maps (Figures 3A-11, **Appendix B**) showing the two rainfall/wind events that I assessed as potentially having significant adverse effects, in addition to a few other rainfall/wind events that I have assessed as having low or negligible effects as a comparison. I have not presented all combinations of rainfall and wind events modelled that were considered to have low or negligible adverse effects.

[33] Section 10.1.7**,** pages 112-120.

Table 3: *Modelled Deposition of Project-related Sediment in Intertidal and Subtidal Marine Habitats within Porirua Harbour (ha)*

	Intertidal		Subtidal	
	5-10mm	**>10mm**	**5-10mm**	**>10mm**
2 Year (Both Inlets)				
Southerly	0.2	0.0	5.3	2.0
Northerly	0.1	0.1	3.4	0.7
Calm	0.2	0.1	5.9	1.2
10 Year (Pauatahanui Inlet only)				
Horokiri Southerly	1.1	-0.8	-3.4	0.2
Horokiri Northerly	-2.3	-1.7	13.7	6.5
Horokiri Calm	0.2	0.1	7.7	7.5
Duck Northerly	3.9	0.0	-1.0	3.4
10 Year (Onepoto Arm only)				
Kenepuru Southerly	1.8	1.0	-5.4	1.3

90 The Q2 rainfall event occurring in all catchments simultaneously during the peak earthworks period is predicted to result in, at three days after the peak of the event, between 3.5-6.1 ha of additional harbour area receiving 5-10mm deposition, and between 0.8 and 2.0 ha of additional harbour area receiving >10mm deposition (see Table 3 above and Table 15.43 page 126 of Technical Report 15). Under calm conditions, almost all of the sediment is deposited subtidally. Under N-NW and S-SE wind conditions, very small areas of intertidal habitat around the mouth of Duck Creek and Pauatahanui Stream also receive sediment above threshold depths. Figures 3A-5B (**Appendix B**) show the new areas of harbour above threshold depths and the benthic invertebrate abundance data collected for this Project. It is clear from these maps that the majority of sediment deposited in the harbour arising from the peak earthworks during a 2 year event settles in the low value central subtidal areas, with at most 0.3ha of intertidal habitat affected (Table 3). Accordingly, I have assessed the sediment deposition predicted to arise from the 2 year event to have low significance with respect to marine ecological values.

91 For most of the 10 year rainfall events under the various wind conditions, the resultant increased area of harbour that is predicted to receive sediment (three days following the rainfall event) at the thresholds considered (i.e. 5-10 mm and >10 mm) are considered to have minor and acceptable effects on marine ecological values (Table 3 above and Figures 6-8, **Appendix B**). Where the effect is considered to be low or negligible, this is due to the deposition occurring primarily within the subtidal basin areas that accumulate fine sediment during rainfall events and are characterised as having lower ecological values due to the accumulation of fine anoxic

sediment and the low diversity and abundance of benthic invertebrates supported. For example, Figure 6 (**Appendix B**) shows that for a 10 year event in the Horokiri Stream catchment under calm wind conditions, the majority of sediment is deposited subtidally in low value habitat, with only small areas of sedimentation in the intertidal and shallow subtidal areas (see Table 3 above).

92 I note that Technical Report 11 contained some errors related to the assessment of rainfall events that I would like to correct at this time.

92.1 Table 11-62, should state "Low" not moderate for Assesment of Impact Significance for Horokiri Stream mouth and "Moderate" for Porirua Stream mouth (not "low").

92.2 12.1.4 Porirua Harbour
Paragraph should read "The adverse effects of the Transmission Gully Project on the Porirua Harbour are restricted to 10 year rainfall events or greater which coincide with the maximum period of earth works, and winds blowing continuously for a period of up to three days. If these events occur they can lead to high adverse effects in parts of Pauatahanui Inlet in and around the mouths of Duck Creek and Pauatahanui Inlet or moderate effects in and around the mouth of Proirua Stream in the Onepoto Inlet.

93 However, there are two 10 year rainfall event and wind combinations that I consider may have adverse effects on marine ecological values of a moderate-high significance. These events are:

93.1 A 10 year rainfall event in the Kenepuru and Porirua Streams, with maximum earthworks open, and a wind blowing from the S-SE, which could have a moderately significant adverse effect on the marine ecological values of localised areas of the Onepoto Arm (Table 3 above, Figure 9, **Appendix B**).

93.2 A 10 year rainfall event in the Duck Creek and Pauatahanui Stream, with maximum earthworks open, and a strong wind blowing from the N-NW, which could have highly significant adverse effects on marine ecological values of localised areas of the Pauatahanui Inlet (Table 3 above, Figure 10, **Appendix B**).

Q10 Kenepuru/Porirua

94 Under this scenario, sediment deposition predominantly occurs in the intertidal and shallow subtidal area to the west of the Porirua Stream mouth. Ecological values in this general area are considered to be lower than in the Pauatahanui Inlet due to higher contaminant

concentrations in sediment and lower invertebrate diversity and abundance. However, the deposition of >10mm of sediment over 2.7ha[34] of marine habitat in the Onepoto Arm is sufficient to significantly affect the invertebrate community composition through a loss of sensitive species. Both intertidal and subtidal monitoring is proposed in this area as part of the proposed Estuarine Quality Monitoring Methodology & Adaptive Management Plan (part of the Ecological Management and Monitoring Plan (*EMMP*) required by condition E.24, and the draft EMMP submitted with the AEE).

95 I have conservatively assessed the potential adverse effect from this deposition to be of moderate significance due to the deposition largely occurring in intertidal and shallow subtidal areas of the Onepoto Arm that have moderate ecological value (Table 3, Figure 9).

96 The probability of a ten year rainfall event in the Kenepuru/Porirua catchments occurring with a southerly wind during the peak 2 year construction period is approximately 7% (with 95% confidence intervals of 3% to 14%).[35]

Q10 Duck Creek/Pauatahanui

97 A Q10 rainfall event in the Duck Creek and Pauatahanui catchments, with a 2 year event in the catchments results in 2.9ha increase in area of deposition 5-10mm depth, and a 3.0ha increase in area of deposition >10mm depth in the Pauatahanui Inlet alone[36]. Intertidally, this deposition includes areas adjacent to Duck Creek, Pauatahanui Stream, Kakaho Stream and to the east of Kakaho Stream, where ecological values are high. If this rainfall and wind scenario occurs during peak construction, and deposition of sediment 5-10mm occurs in the areas predicted, there may be some mortality of sensitive species, including cockles.

98 Within the Pauatahanui Inlet deposition in the >10mm threshold above baseline occurs primarily in the near shore shallow subtidal habitat adjacent to, and to the west of Duck Creek (Figure 10, **Appendix B**). Invertebrate community composition is likely to be adversely affected in these areas, including cockle beds. Saltmarsh and seagrass are not considered likely to be adversely affected from an event of this nature due to being outside the main deposition areas and TSS dissipating rapidly. Both intertidal and subtidal monitoring is proposed in these areas as part of the Estuarine Quality Monitoring Methodology & Adaptive Management Plan which is proposed to be part of the EMMP (see the draft EMMP submitted with the AEE).

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[34] Table 15.45, Page 127, Technical Report 15.

[35] See Appendix 11.M to Technical Report 11 and the evidence of **Dr Dalice Sim**.

[36] Table 15.45, Page 127, Technical Report 15.

99 I have conservatively assessed that the significance of the potential adverse effect resulting from sedimentation is high, due to there being predicted deposition intertidally and in the shallow subtidal habitat in the Pauatahanui Inlet that have high ecological values (Table 3, Figure 10, **Appendix B**).

100 The probability of a 10 year rainfall event occurring in the Duck Creek/Pauatahanui Stream catchment with a northerly wind during the peak two year construction is 12% (with 95% confidence intervals of 4% to 13%).[37]

101 Whilst these events are considered to be unlikely (Table 15.4, of Technical Report 15), the consequences of the events on small areas of the Porirua Harbour are considered ecologically significant, particularly in the near shore habitats due to their high ecological value.

102 It is important to place these potential significant adverse effects in context. That is, they comprise only 5-6% of the sediment that is deposited in the harbour currently without the Project being constructed. Under the existing situation, without construction of the Project, the modelling shows that deposition of sediment in Porirua Harbour is above effects thresholds over very large areas. Therefore, under the existing situation, large rainfall events occur and have occurred in recent years, resulting in deposition in intertidal and shallow subtidal habitats. However, these habitats appear, in the short term (less than 5 years), to recover and retain their high values. It is likely that deposited sediment is relatively quickly remobilised to the central subtidal areas, and that benthic marine organisms recolonise areas that may have suffered acute effects from smothering, relatively quickly also.

103 The additional areas of intertidal habitat that may receive sediment during the two specific Q10 events that I have assessed as potentially having significant adverse effects on marine ecological values are small and localised i.e. the adverse effects are predicted to occur over small areas (and very small proportions) of high value habitat. The majority of intertidal habitat remains unaffected by the Project and therefore I consider that adverse effects on estuarine bird feeding habitat are negligible.

104 My assessment is conservative in that I have considered the predicted additive effects of the Project above baseline during small and large storms (which are more of a worst case situation). I conclude that the additional effects of the Project on sediment deposition in the harbour should either of the specific Q10 events identified occur, whilst comprising a small proportion of the total

[37] See Appendix 11.M to Technical Report 11.

sediment deposition occurring, remain of moderate to high significance given the value of the habitats that may be affected.

Assessment of total suspended sediment arising from Q2 and Q10 events

105 The concentration and distribution of TSS throughout the Porirua Harbour under a variety of rainfall events and wind conditions has been modelled (refer Technical Report 15 and the evidence of **Ms Malcolm**). The results indicate that in the combined 2 year and combined 10 year rainfall event situation (i.e. simultaneous rainfall events in the Duck/Pauatahanui, Horokiri and Kenepuru/Porirua catchments simultaneously), almost all sediment drops out of suspension within 24 hours. Suspended sediment at three days post the peak of the rainfall event is zero in all rainfall/wind scenarios. Therefore, adverse effects on marine ecological values from increased TSS as a result of the Project are highly unlikely to occur due to the concentration not being high enough and not being sustained for a long enough period. As noted above most organisms are able to withstand increased TSS for a few days by temporarily shutting themselves off from the environment e.g. closing valves, burrowing, cessation of feeding. From the existing literature, even the most sensitive marine organism will not be affected by TSS resulting from the Project.

Operational Phase

Contaminants

106 Operational phase effects of the Project on marine ecological values are indirect and relate to the discharge of sediment and associated contaminants contained in treated stormwater arising from the new road. Changes to copper and lead loadings within the marine environment due to the Project have been modelled[38]. The results indicate that there is predicted to be a 2.8% increase in the load of zinc and a reduction in the load of copper discharged to the Pauatahanui Inlet, whereas both copper and lead decrease in the Onepoto Arm and the relevant open sandy beaches of the Kapiti Coast. This is a result of a reduction in traffic on Grays Road and SH58, with this traffic moving to the Project alignment where road runoff is treated.

107 Decreases in total petroleum hydrocarbon loads are expected overall in the Onepoto Arm of the harbour, in addition to the Kapiti Coast at the mouths of Wainui and Whareroa Streams. However, an overall increase in TPH load of approximately 20% is expected in the Pauatahanui Inlet at the mouths of Duck Creek and Pauatahanui, Ration and Horokiri Streams. The large percentage increase in the Pauatahanui is primarily due to the low TPH loads currently found in these streams. Therefore a 20% increase of a low TPH load is still a

[38] Technical Report 15, Appendix 15.BB Contaminant Load Model Results – Coastal Areas.

low TPH load[39]. Assuming that most of the TPH load is likely to be polycyclic aromatic hydrocarbons (PAHs) from vehicles, then the ANZECC ISQG and ARC ERC thresholds can be applied to monitor for changes in sediment concentrations. Currently, the concentration of PAHs in surface sediment in the Pauatahanui Inlet is significantly below guideline values except for one intertidal site adjacent to Browns Stream[40]. Monitoring of surface sediment for PAH concentration forms part of the marine monitoring plan contained in 4 sitesthe EMMP.

108 The two high molecular weight (HMW) PAH maps presented in my assessment reported erroneously the data collected by Stephenson and Mills (2006). These figures have been reproduced and are presented in **Appendix C**.

Long-Term Simulation

109 The long term simulation models the distribution and accumulation of sediment within the Porirua Harbour over a 20 year period, both with and without the Project using actual weather data from the past twenty years (Technical Report 15 and the evidence of **Ms Malcolm**). The "with Project" scenario incorporates construction phase stormwater and associated sediment over a 6 year construction period in addition to operational phase stormwater and associated sediment over a 14 year period.

110 The long term simulation model indicates a difference in bed deposition depth in the subtidal basin areas of up to 5 cm that is attributable to the Project (see Figure LTS-4[41]). In the Pauatahanui Inlet sediment is accumulated in the central subtidal basins, whereas in the Onepoto Arm accumulation is in the southern subtidal area (see Figures 11A and 11B, **Appendix B**). Over 20 years, the maximum depth of deposition of sediment of 5 cm amounts to a maximum deposition of 2.5 mm per year due to the Project.

111 The average increase in sediment accumulation in the Pauatahanui Inlet is estimated at 0.1mm/yr to 0.2mm/yr.[42]

112 The area affected by sediment accumulation under baseline conditions, plus additional area affected due to the Project are shown in Table 4 below. The percentage of additional areas affected within the Onepoto Arm due to the Project is 0.78%, whereas the increase in area affected is 1.6% in the Pauatahanui Arm.

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[39] Section 17.9.2, Technical Report 15.

[40] Sorensen & Milne, 2009.

[41] Technical Report 15.

[42] Evidence of **Ms Malcolm**.

Table 4: *Harbour area affected by long term sediment accumulation*

	Area affected under existing baseline		Additional area affected with Project	
Depth of Sediment	**Onepoto Arm (ha)**	**Pauatahanui Inlet (ha)**	**Onepoto Arm (ha)**	**Pauatahanui Inlet (ha)**
>100mm	57.68	114.18	0.09	1.09
>200mm	3.76	57.80	0.39	1.11
>300mm	0	32.12	0	1.09

113 Additional sediment accumulation in the long term due to the Project has some small additive adverse effects on the ecological values and functioning of the Porirua Harbour in the long term. However, the areas where sediment is predicted to accumulate are characterised as having low ecological values and the percentage increase above baseline is small. My conclusion regarding the long term sediment accumulation is that the significance of the impact on marine ecology values is low to very low.[43] However, the Project related sediment contributes to the cumulative effect of sedimentation in the harbour.

114 The total area of existing land that is proposed to be retired and/or revegetated as mitigation for loss of terrestrial vegetation and impacts on streams is 426 ha[44]. This proposed revegetation has additional benefits for Porirua Harbour, as it will assist in reducing the volume of sediment entering the harbour, offsetting the additional sediment relating to the Project modelled in the long term simulation, in the medium to long term i.e. the period it takes for the plantings to become established and mature[45].

RELEVANT RMA MATTERS

115 In my opinion, neither the construction nor operation of the Project will affect the life-supporting capacity of the Porirua Harbour or the Wainui and Whareroa Stream mouths. In large rainfall events, under certain wind conditions, small areas of high value intertidal and shallow subtidal habitat within the Porirua Harbour may suffer adverse effects in the short term. However, the harbour is large, and the area that may be affected is small, and the potential increase in sediment deposition will not affect the functioning or life-supporting characteristics of the harbour.

116 Whilst the Pauatahanui Inlet and parts of the Kapiti Coast contain areas of significant indigenous saltmarsh, this vegetation will not be adversely affected by the Project. The Pauatahanui Inlet is a

[43] Table 11-63, page 120, Technical Report 11.

[44] Table 2, page 17, EMMP.

[45] Table 15.26, Technical Report 15.

nationally significant estuary and provides habitat for a range of indigenous fauna. However, appropriate protection of the Inlet, commensurate with its values and status, has been provided for through the Project design. While my assessment states that small, localised areas of high value marine habitat may be adversely affected if specific large rainfall and wind events occur during peak construction, these small areas will naturally remediate themselves in the short term (i.e. within 5 years) without affecting the ability of the habitat to support the existing populations and communities of indigenous fauna.

117 A high level of treatment will be provided for both construction and operational phase stormwater. However, two large rainfall and wind events, if occurring during peak construction, have been identified in my assessment as potentially resulting in significant, albeit small and localised, adverse effects on marine ecology values in the short term over and above the much larger baseline deposition. I do not consider that stormwater discharges due to the two significant events identified in my assessment would adversely affect the aquatic life of the Porirua Harbour as a whole. The effects on marine organisms and habitats that I identified are predicted to occur at a much smaller scale and not affect the overall aquatic life of the marine environments assessed.

RELEVANT NZCPS MATTERS

118 I have considered Policy 11(Indigenous biological diversity) in relation to the potential effects of the Project. Whilst two storm events have been identified from the hydrodynamic modelling to potentially result in a significant adverse effect on intertidal and shallow subtidal marine organism and habitats in the Porirua Harbour, the effects are predicted to occur, if at all, over small localised areas. I do not consider that the Project has significant adverse effects on the Porirua Harbour, nor either Inlet. I consider that the Project will not adversely affect the biodiversity of the coastal environments involved in the Project and that the objectives of Policy 11 are met.

119 I have considered Policy 22 (Sedimentation) and believe that the requirements have been met by the Project. Sedimentation has been extensively modelled and assessed and the impacts on the coastal environment have been thoroughly examined. The increase in sedimentation of the Porirua Harbour that is predicted to occur in the long term is insignificant in comparison to the baseline sedimentation currently occurring in the harbour. Proposed vegetation removal controls and the treatment of construction and operational phase stormwater are robust and appropriate to significantly reduce sediment loadings prior to discharge.

120 I have considered Policy 23 (Discharge of contaminants) and believe that the management of discharges to coastal water bodies has been developed with regard to the items listed in 1(a) through to 1(f) and 4(a) to 4(d).

RECOMMENDED MITIGATION/COMPENSATION

121 If a large storm occurs in the critical catchments during peak earthworks, resulting in the deposition of terrigenous sediment attributable to the Project, in intertidal or shallow subtidal habitats, at depths that exceed ecological thresholds, there are minimal effective remedial actions that can be taken. Manual removal of sediment from benthic habitats can cause additive disturbance and adverse effects to marine organisms and in my opinion should only be considered if deposition is catastrophic i.e. deposition of sediment greater than 50mm over a high proportion of the habitat.

122 Natural coastal physical and biological processes, such as tidal exchange, wave action, and bioturbation have the ability to remediate areas of terrigenous sediment deposition in relatively short time frames (e.g. within a few years). Given the high baseline sediment deposition that the model predicts is currently occurring, the intertidal habitat and to a lesser extent, the near shore shallow subtidal habitat, within the Pauatahanui Inlet must be relatively resilient, as at the majority of sites surveyed the sediment grain size and community composition does not reflect effects from sediment deposition events. The modelling predicts small, localised areas of additional deposition, above baseline, in the two storms that I have assessed to most likely result in significant adverse effects. Thus, the adverse effects related to the Project, if they occur, are likely to small in comparison to baseline and the habitat that may be affected is likely to naturally recover over time.

123 If a significant deposition of terrigenous sediment, that is attributable to the Project, occurs in high value marine habitats during peak earthworks as predicted in the two Q10 storms discussed above, compensation would therefore only be required for the short term loss of ecological values, activity and functioning, until there is significant natural recovery. I recommend that a condition of consent be developed requiring NZTA to develop (in conjunction with the appropriate regulatory authorities and community groups) appropriate mitigation or compensation that is commensurate with the degree of effect actually detected. Such mitigation/compensation should reflect the existing strategies and plans for improvement of the ecological values of the Porirua Harbour.

Proposed Monitoring

124 As the options for intervention to remediate sediment deposition within sensitive marine environments are limited, the primary opportunity for management of the risk of sediment discharge to the marine environment rests with monitoring and adaptive management of the site, systems for erosion control, the capture and treatment of sediment laden water, and its discharge[46].

125 In addition to erosion and sediment control device monitoring and early warning storm actions, both routine and triggered ecological monitoring is proposed[47].

126 Routine monitoring will be carried out at approximately nine intertidal and nine subtidal sites on a 6 monthly basis, with at least four sampling runs (two summer and two winter) occurring in the two-three years leading up to construction, and then continuing throughout the construction period and at least three years post construction. The location of the proposed monitoring sites has been guided by the modelled sediment deposition areas coupled with the location of valued fauna and habitats. Monitoring comprises infaunal and epifaunal benthic invertebrates, depth of anoxic sediment, sediment grain size and sediment quality using the same methodology as was used in the original marine ecological assessment.[48]

127 Further marine habitat monitoring shall be undertaken in the event of "trigger event" occurring. The EMMP defines trigger events and describes the further investigatory work to be undertaken with the aim of determining whether there is a cause and effect relationship between the ecological effect and the construction of the Project. Remedial measures, if any, are to be agreed with the relevant Council staff and other affected parties[49].

128 Additional monitoring may be triggered by device failure, contaminant spill, identification of a sedimentation event, and event based responses to rainfall. A similar suite of parameters to those included in the routine monitoring surveys will be included in the triggered monitoring response. The response content and scale will be specific to an event and will inform adaptive management actions.

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[46] Lodged conditions E.1 - E.38, Proposed Conditions (paragraphs 138-140), draft EMMP.

[47] Draft EMMP, Proposed Conditions (paragraphs 138-140).

[48] Technical Report 10, Draft EMMP, Proposed Conditions (paragraphs 138-140).

[49] Draft EMMP, Proposed Conditions (paragraphs 138-140).

RESPONSE TO SUBMISSIONS

Community Groups

129 The Guardians of the Pauatahanui Inlet Inc[50], the Pauatahanui Inlet Community Trust[51], and the Paremata Residents Association Inc[52], raise similar submissions in respect of marine ecology issues, and the submission of the Pauatahanui Residents Association[53] endorses the Trust's submission. The submitters summarise their concerns relating to the discharge of sediment and contaminants predicted to occur during the construction and operational phases of the Project. The submitters recognise that the existing stormwater treatment methods and technology will not remove all sediment and contaminants from either the construction phase or the operational phase stormwater prior to discharge, and that therefore it is not possible to avoid all adverse effects of the Proposal directly.

130 The submitters seek additional mitigation or compensation measures to ensure that there are no overall adverse effects on the harbour in the long term. The measures suggested by the submitters (such as reducing sediment entering the harbour from other sources) would assist with reducing the discharge and accumulation of sediment and contaminants in Pauatahanui Inlet. However, the treatment of discharges from sources other than the Project or other existing state highways is outside the direct influence and control of NZTA. Treatment of other highways that discharge into the Porirua Harbour, where currently there is no treatment provided (e.g. SH58) would provide benefit to the Pauatahanui Inlet, however, based on my assessment, this additional mitigation is not required (although it could form part of a compensation should either of the two Q10 events which I have identified occur and results in the level of effects predicted by the model). It is important to consider the Project in the context of the high baseline flows of sediment, and the untreated discharges that currently enter the Pauatahanui Inlet. The potential effects of the Project are small in comparison and any consideration of mitigation and compensation needs to be commensurate to the potential effect due to the Project, not due to a range of other historic and ongoing activities affecting the harbour.

131 In my opinion, only if a sediment deposition event, such as the two Q10 rainfall and wind events identified in my assessment, were to occur during peak construction, would further mitigation or compensation be required (depending on the nature of the deposition that eventuates). As intervention in marine

[50] Submission No. 32.

[51] Submission No. 35.

[52] Submission No. 42.

[53] Submission No. 37.

environments to remove sediment from sensitive habitats is likely to cause more damage than benefits, compensation may be more appropriate. However, such compensation should be considered only if significant adverse effects occur due to the Project.

Rational Transport Society

132 The submitter[54] raises concerns regarding significant impacts on Pauatahanui Inlet and its wetlands and seeks that the application be declined. My assessment considered the saltmarsh wetlands associated with the Inlet, and concluded that there would be no adverse effects on these habitats. Significant adverse effects on small localised areas within the Pauatahanui Inlet were identified in my assessment as potentially occurring if two Q10 rainfall events associated with specific strong wind conditions were to occur during peak construction. I considered (conservatively) that the areas of sediment deposition above biological effects threshold depths within intertidal and shallow subtidal habitats were significant, even though based on existing deposition and harbour functioning, effects from such deposition events are restored through natural processes in the short term (<5 years). As such, I do not agree with the Rational Transport Society that the application be declined on the basis of impacts on the Pauatahanui Inlet.

Director General, Department of Conservation

133 The Department[55] summarises the ecological values of the Pauatahanui Inlet and raise the following concerns with respect to marine ecology:

133.1 The assessment of effects does not adequately address potential effects on high value species, such as estuarine birds (and their feeding habitats);

133.2 The Applicant's approach does not reflect the high threshold of protection that the NZCPS places on areas such as the Pauatahanui Inlet;

133.3 DOC is not confident that the effects identified are likely to have only negligible or moderate effects on the ecological values of the Inlet and that the effects will be adequately avoided, remedied or mitigated.

134 Effects on estuarine birds are considered by Mr Fuller in his assessment. Effects on the feeding habitat of estuarine birds are considered in my assessment and evidence. I concluded that the adverse effects that may arise due the deposition of sediment arising from the Project, should one of two Q10 rainfall and wind events occur during peak construction, whilst occurring within high

[54] Submission No. 49.

[55] Submission No. 43.

ecological value habitat where estuarine birds may feed, were small in area, localised and likely to naturally restore in the short term (<5 years). I therefore do not consider that the potential effects of even the two Q10 rainfall and wind events that I have identified, will have adverse effects on estuarine bird feeding habitat. Vast areas of the Inlet are available for estuarine birds to feed within and this does not significantly change due to the Project even under these worst case scenarios.

135 My assessment and evidence recognises the high ecological values of the Pauatahanui Inlet and my evidence considers the relevant policies of the NZCPS. I remain convinced that the high values of the Inlet are adequately considered and protected.

136 I remain confident that the effects identified in my assessment and evidence are likely to be negligible or low where stated. Where effects have been identified has potentially having moderate or high significance (i.e. modelled sediment deposition above biological effects thresholds in high value intertidal and shallow subtidal habitats occurring during certain Q10 rainfall and wind events), and cannot be avoided or remedied, appropriate mitigation or compensation can be developed, depending on the degree of effect that eventuates. DOC further recommend a condition of consent be developed to ensure that effects on the ecological values of the Pauatahanui Inlet are no more then de minimis. However, if a Q10 rainfall event occurs, during peak construction, in the Kenepuru/Porirua catchments with strong southerly winds or in the Duck/Pauatahnui catchments with strong northerly winds, the deposition predicted by the hydrodynamic modelling is considered to have moderate or high significance adverse effects respectively.

137 Finally, I note the Departments' submission that wildlife affected by the Proposal is also protected under the Wildlife Act. This is true for birdlife, but it is generally not true for marine species, as only a small number of specified species are protected. Schedule 7A of the Wildlife Act lists the marine species that are declared to be animals and includes cartilaginous fish, bony fish and skates and rays which may at times be present in the Porirua Harbour and the Tasman adjacent to the Kapiti Coast. However, my assessment concludes that effects on mobile aquatic organisms such as fish (plus rays and skates) would be negligible. In any event I understand that to the extent approval is required from DOC under the Wildlife Act, the NZTA will need to seek that separately outside this Resource Management Act process.

PROPOSED CONDITIONS

138 I have commented on the proposed conditions that were submitted with the application to the EPA.

139 I recommend that conditions specific to the monitoring programme (including both routine and triggered monitoring) for the marine environment be developed to cover the minimum requirements for the revised EMMP, the qualifications of the contractor undertaking the marine monitoring, the experimental design of the monitoring programme, the timing of monitoring, measures and metrics to be monitoring (e.g. benthic invertebrate community composition, sediment quality, sediment grain size), proposed monitoring sites, reporting requirements and processes for action if an adverse effect is detected. In addition, conditions for erosion and sediment control discharge quality monitoring to ensure that there is a rigorous process to be followed with clear lines of responsibility if discharge quality fails to meet the agreed standard. Such conditions will ultimately assist with protection of marine ecological values. The recommended conditions will be incorporated into the revised proposed marine monitoring programme, which forms part of the EMMP.

140 In addition, I have proposed minor amendments (or similar) to some of the conditions that were lodged with the application, as follows:

140.1 Condition E.22 (f) within Ecological Management Objectives, should include Porirua Harbour and Kapiti Coast marine environments;

140.2 Condition E.24 (a)(ii) should not form part of the EMMP, but should form part of the Erosion and Sediment Control Plan (ESCP);

140.3 Condition E.26 (b). The data and results of the ecological monitoring will not be recorded in a log held on site, but a log of each ecological monitoring site visit should be held on site; and

140.4 Condition E.26 (c) should be altered to read "Ecological monitoring will occur in dry and wet weather when safe to do so".

CONCLUSIONS

141 The marine species and habitats assessed for the Project include the nationally significant Pauatahanui Inlet (Porirua Harbour), the Onepoto Arm of the Porirua Harbour, and the mouths of the Wainui and Whareroa Streams. High ecological values have been ascribed to the Pauatahanui Inlet intertidal and shallow subtidal habitats, whereas low values are present within the central subtidal basin areas. The marine ecological values of the Onepoto Arm are assessed as moderate, while the mouths of the Wainui and Whareroa Streams are considered to have high ecological values.

142 Potential effects of the Project on marine ecological values are indirect during both the construction and operational phases of the Project.

143 During construction potential effects may occur from the discharge of terrigenous sediment from open earthworks areas to the Porirua Harbour and the Kapiti Coast.

144 There are high existing background loads of sediment deposited in Porirua Harbour, with the Project increasing the sediment loads delivered during rainfall events by approximately 5-6% on average.

145 Discharges to the open high energy sandy beaches of the Kapiti Coast are considered to be rapidly removed from the stream mouths and diluted, and not result in adverse effects.

146 Discharges to the Porirua Harbour during peak earthworks have been modelled under various rainfall and wind events. TSS does not remain in suspension long enough to cause adverse effects under any rainfall/wind scenario. Most rainfall/wind scenarios modelled result in minimal deposition of sediment above biological effects thresholds in high value marine habitats, with the majority of deposition occurring in the lower value central subtidal basin areas.

147 Two 10 year rainfall events under specific wind conditions were considered to potentially result in adverse effects on marine organisms and habitats, due to sediment deposition above threshold depths occurring in high value intertidal and shallow subtidal habitats. Options to remediate or mitigate sediment deposition in marine habitats are limited. However, given the high background sediment loads entering these high value areas currently, and the persistence of high ecological values in these areas, natural processes must act to remove sediment from these areas (to the central subtidal basins) and remediate them over relatively short time frames (i.e. <5 years).

148 Operational phase effects include the discharge of treated stormwater, containing residual sediment and associated

contaminants. A high level of stormwater treatment is proposed, recognising the values of the receiving environment. The load of stormwater related heavy metals discharged to the Porirua Harbour is predicted to decrease, whereas the load of TPH will decrease in the Onepoto Arm but increase above the low baseline in the Pauatahanui Inlet. However, the load of TPH discharged remains low. Sediment quality monitoring for PAHs is proposed, to determine changes in contaminant concentration above the existing low baseline. Effects on marine species and habitats from operational phase stormwater discharges are predicted to be negligible.

149 Operational phase stormwater contaminants and sediment contribute to the long term accumulation within the Harbour, primarily within the central subtidal basins.

150 Long term simulation of harbour sedimentation during the construction and operational phases of the Project suggests that over 20 years, 50mm of sediment accumulated in the central subtidal basins may be attributable to the Project. Whilst this accumulation is unlikely to have adverse effects on marine species or habitats, it contributes to the existing rate of infilling of the estuary.

151 In summary, the main risks of the Project to the marine ecological values are the two Q10 rainfall/wind events identified. If one of these events occurs, additional compensation may be required to take account of short term effects on localised areas of marine habitat.

Sharon Betty De Luca
17 November 2011