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

*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 Vaughan Francis Keesing (Freshwater Ecology) for the NZ Transport Agency and Porirua City Council

Dated: 17 November 2011

REFERENCE: John Hassan (john.hassan@chapmantripp.com)
Nicky McIndoe (nicky.mcindoe@chapmantripp.com)

**STATEMENT OF EVIDENCE OF DR VAUGHAN FRANCIS KEESING FOR THE NZ TRANSPORT AGENCY AND PORIRUA CITY COUNCIL**

**QUALIFICATIONS AND EXPERIENCE**

1 My full name is Vaughan Francis Keesing.

2 I hold a PhD in Ecology from Massey University and a Bachelor of Science with First Class Honours in Zoology, also from Massey University.

3 I am a Member of the Ecological Society of New Zealand.

4 I am currently a Principal and Senior Ecologist of Boffa Miskell Limited (*BML*) in Christchurch. I have worked for Boffa Miskell as a practising ecologist for the last thirteen years.

5 My expertise includes both terrestrial and aquatic ecology. I have researched and prepared ecological assessments with respect to resource consent applications, notices of requirement and for proposed plan changes/ policy statements. I have also presented ecological evidence before Councils, Boards of inquiry and the Environment Court.

6 Recent matters on which I have provided evidence include the Schedule of Significant Natural Areas for Taupo District Council, the Porters Ski field rezoning, the Water Conservation Order hearing for the Hurunui River, Mill Creek, Waitahora and HMR wind farm Environment Court and Board of Inquiry hearings, and the schedule of wetlands of regional significance and associated policies and rules in the West Coast Regional Plan.

7 I have been involved in the development of a number of roading projects, having produced ecological reports and evidence to both Councils and the Environment Court. Some of the larger roading projects I have worked on include the Albany to Puhoi State Highway 1 (SH1) extension, the SH16-18 extension and the SH20 west extension (all in Auckland), and the SH1 MacKays to Peka Peka Expressway (2010) in Wellington. Each has involved field data gathering (fish, invertebrates, plants, water quality, habitat quality), analysis of the data, a values assessment, and an effects assessment. My role has also involved making recommendations as to management of discharges, mitigation options and conditions of consent relating primarily to the monitoring of aquatic ecosystems.

8 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 Agency (*EPA*) in relation to the Transmission Gully Proposal (the *Proposal*).

9 The Proposal comprises three individual projects, being:

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

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

9.3 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.

10 My evidence relates to the NZTA and PCC Projects. It does not relate to the Transpower Project.

11 For the purposes of my evidence the NZTA Project and the PCC Project shall be collectively referred to as the "Transmission Gully Project" (the *TGP* or the *Project*).

12 I am familiar with the area that the Project covers including, in particular, the streams and the State highway and local roading network in the vicinity of the Project.

13 I am the author of the 'Freshwater habitats and species' report (Technical Report 9), which formed part of the Ecological Impact Assessment (Technical Report 11). I am a co-author of Technical Report 11 and of the Proposed Ecological Management and Monitoring Plan (*EMMP*). I am also responsible for carrying out the aquatic systems mitigation assessment (i.e. working out the calculations for the quantum of aquatic mitigation needed), and I presented evidence relating to the freshwater systems values for the Regional Freshwater Plan change request by NZTA which was heard before a Board of Inquiry in July 2011.

14 I have read the current 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. I set out below my data collection, information sources, analysis and assumptions that have influenced the opinions I present.

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

**SCOPE OF EVIDENCE**

15 My evidence assesses the ecological effects of the Project on freshwater features and describes the measures proposed to manage or address those effects. It will deal with the following:

15.1 Background and role;

15.2 Description of methodologies;

15.3 Existing freshwater features and their values;

15.4 Effects of TGP construction and operation on freshwater features;

15.5 Recommended mitigation and monitoring

15.6 Response to submissions;

15.7 Proposed conditions; and

15.8 Conclusions.

**SUMMARY OF EVIDENCE**

16 The Project will cross streams within the catchments of Te Puka Stream, Wainui Stream, Horokiri Stream, Ration Stream, Pauatahanui Stream, Duck Creek, Cannons Creek (Kenepuru system) and a small tributary (and three ephemeral tributaries) of the Porirua Stream[2]. It will affect these streams though direct changes (including loss of stream length, culverting and diversion) and through discharge of contaminants to those, and the Whareroa Stream.

17 A total of 5,286 m of stream will be permanently lost or significantly modified through culverting or through the shortening of stream length associated with diversion. A further 5,132 m of stream will be diverted into new channels and the existing channel reclaimed. This totals some 10,418 linear metres of direct effect to waterways. The changes of habitat type due to culverts and diversions will result in moderate to high adverse effects depending on the stream value.

18 These adverse effects are on regionally significant aquatic systems as well as systems that are of lower value. All of the systems, regardless of their value are already somewhat modified and somewhat tolerant to perturbations.

[2] These streams are shown on the map 9.2, page 4 of Technical Report 9.

19 In my opinion none of the water bodies affected by the Project are of sufficient quality, composition or sensitivity to require "total" avoidance in order to maintain their current values.

20 Effects related to sediment discharge into the streams will need to be well managed as the site as a whole is difficult due to the generally steep and often unstable land and limited valley bottom areas available for capture and treatment. Even with good management it is likely that sediment will still be a significant issue during heavy rain events. Predictions of suspended sediment increase in the streams range from 2 to 43% above the background in a 10 year storm, but there is little predicted stream deposition. While periodic larger discharges are not harmless, they are short term and do not significantly or permanently adversely affect the existing stream communities.

21 It is my opinion that construction effects can be managed to an extent that adverse effects will be sufficiently manageable and not long term.

22 Operational effects in terms of water quality will be generally neutral and, in lower reaches, even beneficial due to treatment being added where there is currently none.

23 I recommend the effects of loss of stream length be mitigated by rehabilitating other sections of streams affected by the Project using the Stream Ecological Valuation (*SEV*) tool to calculate the required extent of rehabilitation mitigation. This SEV approach will ensure the sufficiency of mitigation of adverse aquatic effects because it requires the mitigation to be a water body (i.e. "like for like"), and by default to be at least 1.5 times the linear length affected. While the SEV tool does not consider "special" characteristics of the fauna (such as threatened status), I have developed the Project mitigation with those values in mind so those special fauna and their needs will be catered for in the design of the mitigation.

24 Using the SEV tool, I have calculated that the protection and restoration of 26,500 m of stream is needed to mitigate (or offset) the loss described above. The land available for mitigation provides 30,000 m of stream.

25 No monitoring of the freshwater ecological mitigation actions had been proposed in the Assessment of Environmental Effects (*AEE*) for the Project. This evidence addresses that oversight and presents proposed monitoring and conditions to ensure that monitoring is implemented.

26 With appropriate management (as put forward in the EMMP and as required by the proposed conditions), the proposed diversions have

a strong probability of creating habitat which is as good as, if not better than, aquatic habitat which exists today.

27 The adverse effects of the Project on most streams will be ecologically significant; however, I consider that the proposed mitigation is sufficient to ensure that the functional integrity of the waterways is maintained, and that no fish species are lost. I consider that the ecological enhancements recommended will even result in a net benefit in the medium to long term by raising the ecological health of historically modified streams through retirement, the removal of stock and revegetation (primarily in the Horokiri and Te Puka catchments).

**BACKGROUND AND ROLE**

28 I have been involved in the ecological assessment of freshwater systems for the Project since 2008, during which time I have walked and sampled at places where the proposed road would intersect with the Te Puka, Wainui, Horokiri, Ration, Cannon and Pauatahanui Streams and a tributary of the Porirua Stream, as well as downstream of these points (although I note that I have not viewed every single tributary of the main streams or the upper Pauatahanui Stream catchment). I have also been involved in a number of other stream assessments within Porirua City and the Kapiti District for other projects. I therefore consider myself to be familiar with the Project area and its ecological character.

29 As noted above, I:

29.1 Prepared Technical Report 9 (Freshwater Habitat and Species: Description and Values);

29.2 Assisted in the preparation of Technical Report 11 (Ecological Impact Assessment), including preparing the freshwater effects section and assessing the appropriate level of freshwater mitigation using the SEV tool;

29.3 Assisted in the preparation of the Site Specific Ecological Management Plans (*SSEMP*) for affected streams and the EMMP;

29.4 Recommended consent conditions relating to freshwater ecology;

29.5 Assisted with consultation and stakeholder engagement activities including SSEMP workshops and targeted presentations including to the Department of Conservation (*DOC*);

29.6 Prepared and delivered ecological evidence for the Proposed Plan Change which included caucusing with DOC ecological expert representatives.

30 My assessment of freshwater ecological effects relies on the water quality data provided by and discussed in the evidence of **Ms Malcolm**.

31 My evidence is one of three ecological threads of study for the TG alignment, the others being terrestrial vegetation and fauna and coastal-marine habitats. While all three aspects interact, especially around wetlands and riparian vegetation and at the freshwater-saltwater interface, I have largely left the vegetative and faunal descriptions of wetlands and riparian systems to **Mr Fuller**, and discussion of saltmarshes and discharges of freshwater to the coastal environment to **Dr De Luca**.

**ECOLOGICAL METHODOLOGY**

32 The freshwater investigations and analysis methodologies are fully explained in Technical Reports 9 and 11[3]. I provide a summary here.

33 My assessment of the existing environment involved a review of the New Zealand Freshwater Fish Database (*FFDB*), the River Environments Classification data base, use of (with the addition of data from several other waterways)the fish IBI (Index of Biological Integrity) for the Wellington region[4], and the collection of multiple samples of freshwater fish, aquatic macroinvertebrates, and macrophytes. I also assessed physical habitat parameters including those which are necessary in order to use the SEV[5] tool to calculate required mitigation. SKM measured the majority of water quality parameters and water quantity[6].

34 Aquatic physical habitat measures followed the standardised methods of Harding et al (2009), giving an array of basic measures and observations (e.g. basic water chemistry, substrate, riparian condition etc). Habitat sampling was undertaken at 22 sites (17 SEV sites and 5 geomorphological sites) shown on Figure 9.3 of Technical Report 9 (Aquatic Ecological Values)[7] (as the blue and

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3 Section 3, pages 5-18, Technical Report 9 and Section 2, pages 5-18, Technical Report 11.

4 Joy, M. (2005). A fish index of biological integrity (IBI) for the Wellington Region. Prepared for the Wellington Regional Council by Mike Joy, Massey University.

5 The SEV tool and its application are discussed in the mitigation section of this statement.

6 Technical Report 15, Section 6, pages 25-43.

7 Figure 9.3, Technical Report 9, page 10.

purple colour dots) and one in each of Hawkins Gully and in Belmont Stream, as reference sites).[8]

35 Very detailed measurements of diversion reach geomorphology were undertaken at two reaches, each approximately 1km long, in the Horokiri and Te Puka streams. These data were collected specifically in the areas where engineered road embankment diversions are considered to be required. The purpose was to describe, in detail, the bank widths, morphologies and the substrates to enable the design of diversion channels to at least approximate the existing habitat.

36 The River Environment Classification (REC, NIWA 2004) database was used to plot and measure the different linear lengths of the different River Environment Classes along the affected alignments of all of the waterways. Since the REC system does not recognise first order sections[9] the NZMS 260 TOPO mapped streams were used (put into a GIS layer) and a REC class zero was established to account for the intermittent/ephemeral stream passage ways. Water sheds (catchments) were sized using GIS and topography layers to divide the terrain into the various sub-catchment and catchment areas. The catchment sizes were determined and these sizes assisted in the decisions on requirements for fish passage and presence of fish habitat matrices.

37 Macrophyte (aquatic plant) densities and abundance and species richness were recorded during the physical habitat measurement process (22 sites).[10]

38 At each of 17 sample sites, (Figure 9.3 Technical report 9) a range of characteristics were recorded as required by the SEV field sheet and data system (Rowe et al 2008[11]). The data and analysis were up-dated following work carried out by NIWA (2009-2010) for GWRC, which adapted the SEV system for cobble rather than sediment.

39 Fish were sampled from 35 sites[12] using an EFM300 backpack electro-fishing machine, which attracts and temporarily stuns fish so

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8 Reference sites of good (or typically good) quality are required to establish a base condition for the SEV modelling.

9 A first order stream is the initial, smallest, non-branched, waterway and is typically poorly mapped due to ephemeral, intermittent and perennial complications.

10 Figure 9.3, Technical Report 9, page 10, blue and purple dots.

11 Rowe et al 2008. Stream ecological valuation (SEV): a method for scoring the ecological performance of Auckland streams and for quantifying mitigation. Technical publication No. 32, second edition, June 2008. Auckland Regional Council.

12 Figure 9.3, Technical Report 9, page 10, blue and green dots.

they can be captured. Sampling sites are shown on Map 2[13]. At each sample reach a total of $40m^2$ was sampled (4m sequential lots using a two pass system). All fish netted were identified and measured, then stored in a bucket until the reach was fished, and then returned to their habitats.

40 The sampling returned 9 of the 17 historic species recorded in the freshwater fish database. Those not caught were lower reach species (yellow eyed mullet, triple fin, black flounder and smelt), and I have assumed in my assessment that these are all present for the purposes of assessing effects and developing mitigation. Those fish present in the historic records for the higher catchments but not caught were "rare" occurrences, i.e. short jaw kokopu, giant bully, torrent fish and lamprey.[14]

41 The value of the fish communities was assessed by comparison with other streams in the region. This included evaluation using IBI (the Fish Index of Biological Integrity, (Joy, 2005), and classification following the regional ranking system of Strickland and Quarterman (2001).[15]

42 Aquatic macroinvertebrates (insects, snails, and worms) samples were collected from 21 sites (17 SEV sites and 4 additional sites)[16]. At each sample site three replicates were collected, giving 63 macro-invertebrate samples in total. Communities were sampled using the MfE (2001) sampling protocol C1 (hard-bottomed, semi-quantitative). This involved the use of the national standard kick-sampling protocol 'C1' described by Stark et al (2001).[17] Species were identified to the lowest possible taxa (sufficient for MCI allocation) and abundances were recorded as coded abundances as per Stark 1998 protocol P1, coded abundance.

43 While wetlands have been surveyed and described in the terrestrial flora reports those surveys did not assess small headwater seepage areas such as found at the top of the Horokiri and Te Puka streams at the Wainui saddle. In Technical Report 9I photographed many of these areas and supplied a brief description of their extent, the

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13 Figure 9.3, Technical Report 9, page 10.

14 The Historic records report one capture of short jawed kokopu in 1989, one capture of giant bully in 1962, one capture of Lamprey in 1962 and two records of torrent fish (one in 1962, the other in 1997) all in the Horokiri.

15 Strickland, R, & Quarterman, A 2001. *Review of freshwater fish in the Wellington Region*. Prepared for Wellington Regional Council by Cawthron Institute. July 2001.

16 Figure 9.3, Technical Report 9, page 10, blue dots and three sites in the Cannon's Creek system and one extra site in the Duck Creek ( at the SKM sediment logger).

17 Kick-sampling is a standard aquatic macroinvertebrate sampling technic involving a D-net and disturbance of a known area of waterway substrate up-stream and in front of the net.

primary vegetation cover and whether I considered them to have particular flora, fauna or functional values and therefore values of note in regard to aquatic ecology. None of the seepage areas affected, in my opinion, warranted further aquatic examination.

**EXISTING FRESHWATER FEATURES & VALUES**

44 My evidence below provides brief descriptions of the waterbodies that are likely to be directly affected by the Project and then the analysis of physical habitat, fish and aquatic macroinvertebrate community condition, sensitivity and lastly ecological value.

**Te Puka Stream**

45 Te Puka Stream (also known as "Smiths" stream) has a catchment area of some 3.72 km² (372ha). The stream drains north through a very steep gradient from above the Wainui saddle over 3 km to a triple culvert system under the existing state highway (SH1) and joins the Wainui Stream. In its headwaters it is a poorly defined cobble and boulder base stream under a full forest canopy (the true right arm) and a narrow channelised intermittent creek from the Wainui saddle area. The larger perennial true right arm represents a very natural and pre-disturbance aquatic habitat type (ideal for koaro and banded kokopu). Below the headwater and out of the forest the habitat is very simple and relatively uniform and semi-braided.

**Figure 1: True right arm of Te Puka Stream, natural stream under native forest canopy.**

**Figure 2: Middle reach looking up stream; open, cobble, bare, steep**

**Figure 3: True left Te Puka tributary, ephemeral**

**Figure 4: Lower reach Te Puka near SH1, open, cobble, simple structure, range of existing disturbances.**

**Wainui Stream**

46 The Wainui Stream is a sub-catchment just to the north of the Te Puka. The stream crosses the Project corridor and converges with Te Puka Stream downstream of the Project on the coastal plains, before discharging into the Tasman Sea via an intertidal stream mouth located north of Paekakariki at Whareroa Beach Surf Club Reserve.

47 The Wainui Stream has not been studied in any detail. This is because the Project was to be bridged over the stream and this is the only point of interaction with that stream. This bridge scenario has recently been changed to a culvert scenario. Additional field observations have however, been undertaken and there is an existing perched road culvert downstream of the existing State highway and of the Project (2m above the bed) (as shown in the photograph (**Figure 5**) below) which is a barrier to all up stream fish movements. The state of the channel and water also habitat suggest that the proposed culverting will have a minor, if any, affect on current values. I consider that the proposed general earthworks sediment discharge management regime and the EMMP will adequately address any minor impacts which might occur through culvert construction for the Wainui Stream.

**Figure 5: Wainui stream below the SH1, extreme fish barrier and very little water, note absence of flow**

**Figure 6: Wainui Stream looking downstream of SH1**

**Horokiri Stream**

48 The East branch of the Horokiri stream has a catchment area of some 33.8 km² (3380 ha) and drains from north to south from the hilltops above the Wainui saddle (at around 260m.a.s.l) down into the Pauatahanui Inlet between the Kakaho and the Pauatahanui catchments.

49 This waterbody runs along an alluvial narrow bottom between steep and unstable hills to the west and east for most of its length (that length being around 12,900 m). As the Stream reaches its middle reach, the surrounding hills recede and the alluvial plain in which it sits opens out (adjacent to and within the Battle Hill Regional Park). The East branch of the Horokiri then meets the near equal sized West branch at about the Paekakariki Hill Road, doubling the size of the waterbody. From here, the Stream flows down into the Pauatahanui Inlet reasonably directly as a relatively slow and large lowland river type.

50 The main stem and tributaries of the upper headwaters of the Horokiri east are largely in rough pasture and stock affected, although there are numerous native riparian shrub areas on the main stem. The larger eastern tributaries are in native regenerating shrublands.

51 In the upper catchment the water is clear, the substrate is cobble and relatively clean, but the stream is unprotected from stock.

52 The upper-middle reaches are characterised by a narrowing of the valley and an increase in native treeland type riparian vegetation (mahoe shrub) on steep banks and small terraces over a mild to deeply incised stream passage. Despite the vehicle and stock crossings, the substrate and general form of the stream in this upper-middle section is relatively unmodified, although there is now little wood debris or other forest associated habitat factors present.

53 The middle and lower-middle reaches are deeply incised with native herbs and grasses adhering to the steep tall banks. The top of the bank is largely covered by pastoral grasses. The water generally runs clear in a wide deep set channel as a shallow run and riffle system.

54 In the lowest reaches the river becomes larger and deeper with frequent pools and long runs. The water is often slightly sediment tainted (i.e. with colour) and sands and sediment are common on the benthos. The bank vegetation largely comprises exotic and mixed weeds (willow), shrubs and grasses.

**Figure 7: Horokiri headwaters, note pastoral condition, small undefined channel and cobble substrate.**

**Figure 8: Upper-middle reach of the Horokiri. Note the flat gradient section, pastoral influences, uniform cobble substrate, flood plain size and erodible bank profile.**

**Figure 9: Typical middle reach section of the Horokiri with a gorse mahoe riparian edge and a relatively uniform run flow pattern with medium cobble substrate.**

**Ration Stream**

55 The Ration Stream system is one of the shorter waterbodies within the Project area. It has a total catchment area of around 6.13 $km^2$ (i.e. only nearly 20% of the catchment area of the Horokiri) and is some 4,800m in length.

56 The Ration catchment divides the Horokiri from the Pauatahanui catchment and discharges into the Pauatahanui Inlet off Ration Point through a small oioi reed wetland. A generally flatter catchment, the majority of the middle reach is used for plantation forestry, the lower reaches for life style farming and the upper reaches for beef and sheep farming with numerous intermittent and ephemeral tributaries.

57 Unlike the Horokiri or Pauatahanui Streams, Ration Stream does not have a catchment watershed in higher hill country with areas of native shrubland. Instead its watershed comprises low hills covered with plantation forestry. This forestry is likely to be having an adverse effect on the hydrology of the system.

**Figure 10: A middle reach in the golf course. Note the deep set but small flow and highly managed and modified riparian condition.**

**Figure 11: An upper reach example of the Ration, where it tends to be a wetland/pasture/stream flow pattern with soft substrates and coloured waters with little open water.**

**Pauatahanui Stream**

58 The Pauatahanui catchment is the largest within the Project area at around 43.4 $km^2$ (4,340 ha). The majority of the feeder tributaries arise in the south of the catchment from the hills at an altitude of around 430 m.a.s.l. The main stem has a linear length of around 9,600m.

59 At and below the Project crossing point, the Pauatahanui Stream is a typical lowland stream with a relatively natural meander path, natural flows and a substrate that, while sediment affected, still reflects a natural condition. Flows are reported at anywhere from 55 L/s to 25800 L/s, with an average around 1 cumec (940L/s) (Healy 1980[18]).

**Figure 12: Lower Pauatahanui Stream with blackberry, willows and rank pasture on the banks. Rafts of filamentous algae can be seen on the bed.**

**Duck Creek**

60 Duck Creek has a catchment area of some 10 $km^2$ (1000ha) and drains west through a very steep gradient in its headwaters from 420 m.a.s.l to sea level over a distance of around 7.2 km.

61 By and large the upper catchment is in pasture, with the headwaters (4-5 tributaries) in scattered riparian native shrub and pasture (including a mitigation pre-planted riparian area).

[18] Healy, WB 1980. Pauatahanui Inlet – and environmental study co-ordinated by WB Healy). New Zealand Department of Scientific and Industrial Research. DSIR Information Series 141.

62 The middle-lower section has its contributing catchment land in plantation forest (Silverwood forest) until the creek meets the Whitby Coastal Estate urban area. The catchment is roughly 50% steep to very steep pastoral lands and 50% mixed age and type exotic forest.

63 The stream system includes narrow tributaries that have extensive and near vertical drops into the main stem from both the true left and mostly the true right and thus is restricted to climbing fish only.

64 It is a significant native fish habitat until passage is prevented by a number of perched culverts.

**Figure 13: Middle-upper catchment in the Regional Park, the waterbody is narrow, shallow and supported by the rushland.**

**Figure 14: An example of one of the set of perched culverts in the middle-upper reach (locations shown in the mitigation map).**

**Figure 15: Example of a flatter Duck section in the middle reaches, open, cobble, pasture.**

**Figure 16: One of the true right perched side tributaries of the Duck system in which banded kokopu can still be found.**

**Cannons Creek**

65 Cannons Creek is a tributary of Kenepuru Stream (total catchment area of around 13 $km^2$ or 1300 ha) with a sub-catchment of around 390 ha. Its headwaters lie in Belmont Regional Park at an altitude of approximately 400 m.

66 The stream descends from its headwaters through farmland and regenerating bush for 3.6 km until it joins the Kenepuru. The Cannons Creek system includes the Cannons Creek Lake Reserve which is a small narrow 7.5 ha reserve that is situated at the point where Cannons Creek enters Porirua East. The Lakes Reserve contains two artificial lakes; an upper southern lake and a lower northern lake.

**Figure 17: Example of an upper Cannons reach in open pasture, note the macrophyte edge.**

**Figure 18: Artificial waterbody that is the lower Cannons Creek below the hill section (forested).**

**Figure 19: One of the artificial cascade systems on the middle reach of Cannons.**

**Porirua Tributary**

67 The southern most waterbody affected is a small tributary of the Porirua Stream. This is a short, steep tributary that is intermittent in flow but has a good cover of mahoe- indigenous secondary forest below the road alignment. The tributary is surrounded by pine forest plantation which covers the majority of the sub-catchment of this tributary.

**Figure 20: Middle forested reach of the southernmost tributary of the Porirua, note a small flow at survey, which can dry to no surface water.**

**Waterway ecological values, summary results**

***Physical Habitat***

68 Section 4.2 of Technical Report 9 details the physical characteristics (morphology, substrate, water depths, widths, velocities, habitat types and riparian conditions) of the streams surveyed, and in particular the Horokiri and Te Puka systems. The focus has been on these two water ways because the proposed road runs parallel to, and affects greater lengths of these streams than any others.

69 A physical habitat score for each sampled area (and so representativeness of the affected waterways) was developed. The conclusion of those scores is shown in graphic form in Figure 9-10 of Technical Report 9.[19]

70 All surveyed sites score over 50% of their maximum potential. The scores generally are high for rural and urban land use catchments. The Te Puka upper site, predictably, was near the maximum score and certainly represents the natural condition for a pre-development headwater stream. All other surveyed and potentially affected sites were between 55 and 75%.

71 Of some note is that it is typically the middle reaches and not the lower reaches that are in the relatively poorest condition.

72 With regard to water quality, I collected data required by the SEV system (dissolved oxygen etc) using hand held meters at the time of sampling. Otherwise, water quality in terms of a full analysis of nutrients and contaminants and in regard to matters such as suspended solids were collected and analysed by SKM and that analysis is presented by Ms Malcolm. My consideration of water quality aspects and what that means for the aquatic biota is reliant on her collection and reporting.

***Freshwater Fish***

73 As noted in section 4.5 of Technical Report 9, seventeen species of fish have been recorded in the FFDB from the seven catchments of the Project area. Four of these species are typically found in the lowest reaches (smelt, flounder, mullet, triple fin) and are often associated with tidal parts of the habitat. They were not targeted by my sampling regime for this Project and are assumed to be present permanently or periodically in all of the tidal reaches. Of the remaining 13 species, the sampling programme for this Project has recorded nine. Those not recorded by EFM sampling were lamprey, torrent fish, shortjawed kokopu and giant bully which, as noted in my comments on methodology, have only been recorded on rare occurrences and in my view are unlikely to be present. The following table lists those species found in each waterway.

[19] Page 45, Technical Report 9.

**Table 1: Fish species recognised from each sampled waterway**[20]

| Catchment | Fish species (with threat status indicated) |
|---|---|
| **Te Puka** | Koaro*, red fin bully*, long fin eel* |
| **Horokiri** | Banded kokopu, koaro*, red fin bully*, common bully, long fin eel*, short fin eel |
| **Ration** | Giant kokopu*, long fin eel*, short fin eel, white bait (undefined sp.) |
| **Pauatahanui** | long fin eel, short fin eel, inanga*, common bully |
| **Duck** | Banded kokopu, koaro*, Giant kokopu*, Inanga*, red fin bully*, common bully, long fin eel*, short fin eel |
| **Cannons** | Banded kokopu, Giant kokopu*, Inanga*, red fin bully*, long fin eel*, short fin eel |

* "At Risk" (Townsend et al 2008 ) "Declining" (Allibone et al 2010)

74 Most of the galaxids, the long fin eel and red fin bully present are recognised as "declining" species,[21] meaning all of the streams support "at Risk" (threatened) species.

75 Sampling in the Pauatahanui and Duck Streams found all of the historically recorded species (less estuarine species) with Duck Creek (particularly in its lowest reaches) having a relatively rich fauna of 11 species). In Cannons Creek and Ration Stream, new records have been added to the FFDB. In Kenepuru, bully and inanga were not found.[22]

76 Only half the species in the FFDB records for the Horokiri were sampled in these surveys. The species not found, but historically recorded, are those only reported once or twice over 20 years ago i.e. lamprey, giant bully, torrent fish and shortjawed kokopu. Setting aside the records for these fish (reducing the expected total assemblage to 9 fish), the surveyed species are all those species recorded as typical. The species not sampled in the Horokiri, but often reported in the FFDB were brown trout, giant kokopu, and inanga; all these are species are able to be sampled by a backpack EFM, and all are generally lower stream species, which suggests they may no longer be commonly present.

***Aquatic Macroinvertebrate Communities***

77 In total, 81 different aquatic invertebrate taxa were sampled from the seven catchments of the Project area.[23] Sites consistently

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[20] Table 9-13, Technical Report 9, page 52.

[21] Allibone R, David B, Hitchmough R, Jellyman D, Ling N, Ravenscroft P and Waters J (2010) 'Conservation status of New Zealand freshwater fish, 2009', New Zealand Journal of Marine and Freshwater Research, first published on : 27 September 2010.

[22] This is not considered to be an error related to sampling methodology since Bully are recognised as not being sampled well by EFM.

[23] Refer section 4.6.2 Technical Report 9, page 55.

returned around 30 taxa. Of some note is that generally the surveyed project sites have greater taxa richness than the two reference sites.

78 Compared to the national kick net median sample taxa richness[24] the streams sampled in the Project area are rich in benthic invertebrate species.

79 Inspection of the Ephemeroptera, Plecoptera and Trichoptera (*EPT*) taxa[25] shows that all sample sites have over 10 EPT taxa and a typical range of between 15 and 20 taxa with 5 stream sites having over 25 EPT taxa, typically better than the chosen reference sites.

80 The percentage of a community's abundance that is EPT is an important measure of representativeness (and sensitivity).[26] For most sites over 50% of the community's species belong to one of the three EPT groups, which is a higher than typical result for rural stream types. The lowland sites of Duck Creek and Pauatahanui are the only sampled sites that have less than 50% representation.

81 The sensitivity or community condition indices: MCI and SQMCI scores,[27] in the Project area sites were generally high, being greater than 100 and typically over 120. All sites measured qualify as being at least of "Good" quality with only "possible mild pollution", while many of the sites sampled qualify as being of "Excellent" quality in terms of their MCI scores (i.e. clean).

82 The SQMCI, which accounts for the abundance of the sensitivity scoring taxa (weighting the score in favour of the most abundant taxa and dampening the effect of "rare" taxa) showed scores ranging is from 4 ("fair" - Probable moderate pollution) through to over 8 (Excellent).

83 Inspection of the proportions of a community's taxa groups showed that by and large there are no notable patterns other than those already noted in relation to the EPT fauna (such as greater numbers of taxa in the stonefly group in the upper reach sites).

84 Duck (Silverwood), Duck Nth and Pauatahanui have a greater representation of "other" fauna (mites, worms, amphipods and

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[24] 14/kick sample (10-90% range = 7-20, Quinn & Hickey 1990).

[25] EPT stands for Ephemeroptera (the mayfly group), Trichoptera (the caddisfly group) and Plectoptera (the stonefly group).

[26] The higher the percentage composition of EPT, typically the more sensitive to poor water and habitat quality the community is and the greater the representativeness of the community (i.e. how like it is to original condition). Over 50% is (in hard bottom systems) considered "good" (representative).

[27] MCI (macroinvertebrate community indices (and quantitative MCI) are indices based on tolerances of different aquatic species to pollution and the community balance of tolerant and non-tolerant species.

Crustacea). This is to be expected in lower reaches with softer substrates and generally higher organic matter accumulations.

***Stream Ecological Valuation (SEV)***

85 As noted in section 4.4 of Technical Report 9, SEV scores across the sample sites of the three main affected catchments (Te Puka, Horokiri and Duck) ranged from 0.547 to 0.681 with the reference sites (Belmont and Battle Hill tributary) scoring between 0.75 and 0.83. The upper Te Puka also falls into the 0.75-0.83 range. These are relatively high indices scores (the maximum is 1) indicating near complete and "natural" functioning of the system.

86 Biodiversity functioning was the poorest scoring factor with several sites scoring below 0.5. Those lower scoring sites are also those with the poorest biometrics scores (i.e. MCI, EPT taxa etc). The lowest scoring sites (<0.6) are the middle reaches of the Te Puka, Horokiri and two of the lower Duck sites. The highest value (>0.7) was recorded in the upper Te Puka site (within the forest) and this could be considered as a representative reference site for the area because of its good quality, condition and higher functional score.

***Analysis of Aquatic Ecological Value***

87 Using the Functional scores of the SEV, the Physical Habitat scores, the fish data and the IBI system results (geared for Wellington Region), the macroinvertebrate community condition, and especially the MCI/SQMCI indices scores, the presence of threatened species and comparison to Regional reference conditions (from GWRC State of the Environment monitoring (Perrie 2008)) I have tabulated a compilation of the data presented above in the following table and combine them to make a final value assessment.

**Table 2: Summary of values of each freshwater aquatic data set and the compiled "value" assessment**

| Stream section | PHA (SEV)[28] | Fish | Aquatic invertebrates | Compilation Ecological value result |
|---|---|---|---|---|
| Lower-middle Te Puka | H | L | H | H |
| Upper Te Puka | H | M | H | H |
| Lower Horokiri (east) | M | H | H | H |
| Middle Horokiri (east) | M | H | H | H |
| Upper Horokiri (east) | M | M | H | M |
| Lower Ration | L | M | L | L |
| Middle Ration | L | L | L | L |
| Lower Pauatahanui | L | H | M | M |
| Lower Duck | M | H | M | M |
| Middle Duck | M | H | H | H |
| Upper-Middle Duck | H | L | H | H |
| Upper Cannon | M | M | H | M |
| Porirua tributary (Linden) | L | L | L | L |

88 The conclusions of my assessment of the streams' ecological values are that:

88.1 In regard to fish population, the Te Puka, Horokiri, Duck Creek, and the lower Pauatahanui Streams have high values of regional importance. The lower Ration and Pauatahanui also have threatened species of fish, but both are substantially more modified and of much less value in their middle and upper reaches;

88.2 The Ration Stream and Porirua tributary have the poorest perennial main stem stream systems and are not regionally significant in terms of their aquatic habitat and representative indigenous aquatic communities and processes;

88.3 The upper Te Puka, Eastern Horokiri and Duck Streams have habitats that are significant for the maintenance of aquatic biodiversity and representative of good aquatic processes in the region;

88.4 The eastern tributaries of the Te Puka and Eastern Horokiri Stream have their headwaters in native forest and have very high habitat values;

88.5 The Whareroa Stream on the plains and before the coastal dunes is a channelised "drain" of low value for all aspects (PHA, fish and macroinvertebrates);[29]

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[28] PHA means physical habitat (water depth, velocity, substrate type etc).

88.6 The regional Freshwater Plan recognises the Horokiri, Ration and Pauatahanui systems as significant waterways. I agree with that classification for the Horokiri and Pauatahanui but not the Ration. I consider however that the Duck should also have been added to that list of significant waterways. Duck Creek however is recognised in Appendix 2 (Table 16) of the Regional Policy Statement as having significant ecosystem values and as a waterbody requiring protection because of those values;

## ASSESSMENT OF ECOLOGICAL EFFECTS

### Construction Effects

89 In the following discussion I summarise the effects associated with construction, i.e.:

89.1 Culverting and associated stream works;

89.2 Diversion and reclamation;

89.3 Temporary culverts;

89.4 Fill disposal sites;

89.5 Sediment discharge and deposition; and

89.6 Discharge of contaminants.

90 These are all different aspects of the loss of aquatic habitat (in linear metres) associated with requirements to establish the toe of the road (supporting batter slope); and of the need for diversions or major habitat change due to the installation of a culvert replacing the existing natural stream bed habitat with a concrete one.

#### *Culverting & Associated Stream Works*

91 The lengths and locations of all proposed culverts are listed in Technical Report 14 (Assessment of Hydrology and Stormwater Effects).[30] To facilitate my analysis I broke the lengths of stream affected by culverting into catchment and into two main hydrological types (i.e. ephemeral-headwater, and intermediate and perennial).

92 There are 112 stream crossings of which 102 are culverted, the remaining 10 are bridged. Of the 102 culverted crossings 43 lie in perennial and intermittent stream bed affecting 5,286 m of aquatic habitat. The remaining 59 culverts lie in ephemeral channels, or in

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29 Data from the MacKays-Peka Peka assessment undertaken by BML, as yet unpublished.

30 Appendix 14.G, Table 27, page 160, Technical report 14, Assessment of Hydrology and Stormwater Effects.

small headwater basins that do not have defined channels and are typically in pasture.[31]

93 Around 47% of the total culverted length is of watershed/ephemeral systems (minor side tributaries) most of which are in the Horokiri and Te Puka systems. These systems have little to no aquatic habitat value and are largely rainwater conveyance systems. Fish passage will be maintained in all those systems with aquatic habitat that require fish passage. Fish passage is discussed in section 6.2 of Technical Report 9.

94 In terms of the main stem simple and correct culvert sizing and installation is all that is required to maintain the existing passage.

95 The steep side tributaries affected (in Te Puka, Horokiri and Duck Creek) which require both culverts and fish passage share similar characteristics. They are steep to very steep; have shingle and loose, rocky substrates, often with intermittent surface flows and generally have small headwater catchments that (typically because of the presence of a forest fragment) provide habitat for small numbers of koaro, banded kokopu and eel species.

96 The tributaries in question generally have sections between the upper pool and forest headwaters (the desired habitat) and the main stem which are steep and stepped, form a cascade, and provide shallow water over a cobble/moss/lichen/macrophyte surface of varying steepness. Through this surface and sub-surface the juvenile banded kokopu, koaro and eel currently move using a combination of swimming, wriggling and climbing. This was proven in the sampling of tributaries in the upper Duck system which were steep and a long way above the main stem but contained banded kokopu.

97 The challenge in this environment is to provide climbable fish passage in the steep and high water velocity environment through a smooth pipe surface over distances often up to 100m and where the inlet or outlet may become disconnected to the stream bed through periodic erosion. Technical Report 9 has a number of suggestions using new systems that I consider are likely to be effective.[32]

***Diversion & Reclamation***

98 The same exercise was carried out for the diversion reaches. These calculations are again by catchment. Forty diversions are proposed, of which 25 lie in perennial and intermittent streams, affecting some

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[31] Table 11-32, Technical Report 11 (Ecological Impact Assessment) page 87.

[32] Section 6.2, specifically section 6.2.2, pages 80-82, Technical Report 9, Freshwater habitats and species.

5,132 m of aquatic habitat. The remaining 15 diversions lie within ephemeral channels or small headwater basins.[33]

99 **Table 3** below[34] shows that the combined length of perennial or intermittent stream affected through culverting, diversion, shortening and associated stream works is around 10,418 m. The catchments most affected are the Te Puka, Horokiri and Ration at over 2km of modification or habitat loss in each.

**Table 3: Combined length of affected waterways (culvert and diversion) in the 8 affected catchments**

| Catchment | Total length of Perennial and intermittent stream affected (m) |
|---|---|
| Wainui | 666 |
| Te Puka | 2,350 |
| Horokiri | 2,004 |
| Ration | 2,147 |
| Pauatahanui | 1,375 |
| Duck | 883 |
| Kenepuru | 298 |
| Porirua | 695 |
| Total | 10,418 |

***Temporary Culverts***

100 There will be a requirement for temporary construction access tracks in the Te Puka and Horokiri catchments. These will require the construction of temporary culverts (typically at existing stream vehicle crossings) to better manage adverse effects on these streams. I have not assessed these as they are small, temporary in nature (they will be in place for approximately 2 years) and the stream bed and margins will be remediated when they have been removed. That remediation, along with correct installation of the culvert and acknowledging that the majority of such areas will be within the areas currently proposed for aquatic habitat (and thereby riparian) rehabilitation means that I consider that these effects will have no lasting adverse effect and only a minor adverse effect through their installation and removal.

***Fill Disposal Sites***

101 There are five proposed fill sites, all located towards the southern end of the alignment. The first fill site lies on a rolling ridgelines above the saddle between Duck Creek and Cannons Creek. The second lies on a flat spur on the south side of Cannons Creek near the Takapu Substation. Both of these fill sites lie in improved pasture. They will take the form of blanketing fills. Neither of these

33 Table 11-33, Technical Report 11 (Ecological Impact Assessment), page 88.

34 Taken from Table 11-34, , Technical Report 11 (Ecological Impact Assessment) page 89.

sites will directly affect perennial, intermittent or ephemeral streams.

102 At the three remaining disposal sites, which are located near the Kenepuru Interchange south of bridge number 22, there are small ephemeral streams and seepages; however, pine litter and colluviated soil from slope erosion has filled the channels already. Subsurface movement of water is apparent, and occasionally it appears over brief sections as a laminar flow over silts, however, there is no perennial or intermittent stream habitat present.

103 The small tributaries that lie near the southern two fill sites are culverted beneath SH1 and the North Island Main trunk line to discharge on slopes above Porirua Stream. The northern most tributary is captured by the residential stormwater system that flows to Ribbonwood Terrace. It is unlikely in my opinion, that these channels provide habitat for native fish or invertebrates of conservational or ecological interest.

104 Accordingly, the fill sites as outlined to date do not have notable or even minor adverse aquatic ecological effects associated with them.

***Sediment Discharge associated with the Project***

105 My analysis has been based on the predictions and calculations set out in Technical Report 15 (Water Quality Effects). That report sets out the results of sediment discharge and management modelling.

106 Many of the mitigation measures proposed are now reasonably standard: e.g. cut off drains around the works; early (first) installation of tributary culverts; use of various surface stabilisation methods (geotextiles, grassing mulching etc); sediment retention devices (typically tanks due to the terrain's steepness); velocity control devices; and establishment of a suitable vegetated waterway buffer. With these measures in place, **Ms Malcolm** predicts that the sediment (in suspension) increase will range from 2 to 43% above the existing background in a 1 in 10 year rain event as shown in the following table.

**Table 4:**[35] **Estimated sedimentation for a Q10 rainfall event and the magnitude of effect to freshwater systems**

| Catchment | Q10 without treatment[36] see Table 11-39 | Q10 with full treatment[37] | Assessment of Impact Magnitude with treatment |
|---|---|---|---|
| Whareroa | 16% | 5% | Negligible |
| Te Puka/Wainui[38] | 98% | 29% | Moderate |
| Horokiri | 47% | 14% | Low |
| Ration | 142% | 43% | Moderate |
| Pauatahanui | 8% | 2% | Negligible |
| Duck | 89% | 27% | Moderate |
| Kenepuru | 34% | 10% | Low |
| Porirua | 7% | 2% | Negligible |

107 Effects of note are anticipated in a Q10 event in the Te Puka/Wainui, the Ration and the Duck.

108 Given that the values in the Te Puka for much of its upper reach are lost through direct effects of construction, this discharge is ecologically un-important. That continues to be the case in the lower Te Puka (below the SH) as that reach is in pastoral lowland which is already tolerant of sediment and exposed to free stock access.

109 For the Ration system, given the poor and highly modified condition of the majority of the Ration Stream, this raised periodic level will also be tolerated along most of its length. However, the deposition of such high loadings in the estuarine interface and lowest reach of this stream is into the current habitat of giant kokopu and migratory fish access between the inlet and freshwater system. Raised sediment in periods of high rain could further adversely affect that habitat and the sustainment of giant kokopu in that area.

110 For similar reasons such an increase in sediment in the lower Duck would be adverse.

111 Having said that, I note that when considering the effect of higher, short term sediment pulses associated with rainfall events such as

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[35] Taken from Table 11-56, Technical Report 11 (Ecological Impact Assessment), page 111.

[36] Refer Table 11-39, Technical Report 11 (Ecological Impact Assessment), page 95.

[37] Refer Table 11-55, Technical Report 11 (Ecological Impact Assessment), page 110.

[38] The Wainui is only affected near the SH and in only a small section and its contribution to the Te Puka/Wainui flow much less than the Te Puka's.

the Q10 predictions, Rowe et al (1987, 2002)[39] showed that even an NTU (Nephelometric Turbidity unit) level of 10,000 NTU (around 800 g/m$^3$ suspended sediment) did not cause fish mortality. A range of other experiments have explored raised sediment (NTU) effects – in all cases high sediments (>1000 NTU) in suspension do not (in the short term) create significantly adverse effects. Adverse effects can occur where there is:

111.1 a sustained high NTU (>20-25 for banded kokopu); or

111.2 a 20% increase on the background average.

112 There is no scientific agreement as to what constitutes an "effect". I have considered it to be a change from a "normal" situation which is sufficient to indicate the potential for a change in a state of habitat or biota.

113 Accordingly, all of those streams predicted to have moderate sediment effects (**Table 4** above) are likely to be "affected" (especially those with banded kokopu and koaro) from time to time during construction (at least during 1 in 10 year storm events). However, the streams should not be affected post construction or for the majority of the construction period. Occasional flushes of sediment are tolerable and the systems typically recover rapidly and well. This is especially so in the steeper gradient streams as are present in the Te Puka, Horokiri and Duck systems.

***Discharge of contaminants to freshwater***

114 It is unlikely that contaminants from earthworks and general construction will affect the streams given the proposed use of spill precautions and bunded reserves for refuelling and storage of materials etc. Nevertheless, I recommend that the Construction Environmental Management Plan contain management conditions to address spill minimisation, protocols for managing accidental discharges, and bunding of storage area and refuelling sites.

115 There is a low probability of water quality issues arising during construction through disturbance of sites that may contain contaminants. The Aurecon report (2011)[40] assessed the potential for such sites and suggested that there are nine sites with moderate or higher risk but only three sites with potential ecological contaminant issues: Golden Coast Nurseries, Pauatahanui Inlet Garden Supplies facility, and the gun range near the Porirua

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[39] Rowe, DK, Dean, TL, 1998. Effects of turbidity on the feeding ability of the juvenile migrant stage of six New Zealand freshwater fish species. NZJ Marine and Freshwater Research, 32: 21-29.

Rowe, DK, Suren, AM, Martin, M, Smith, JP, Smith, B, Williams, E, 2002. *Lethal Turbidity levels for common freshwater fish and invertebrates in Auckland Streams*. NIWA Client Report ARC 02283.

[40] Technical Report 16, Contaminated land assessment, page 16.

Stream. The Aurecon report (and as explained by **Ms Maize**) makes detailed reference as to how these sites are to be treated and how escape of any contaminants will be avoided. The report also addresses the longer term management of contaminants removed including ecological consultation for its long term disposal.

**Operational Effects**

116 In the long term, large roads can be major sources of TSS, metals, volatile suspended solids, nutrients and Polyaromatic hydrocarbons (PAH).[41] These elements can be directly toxic or system stressors.

117 Stormwater from SH58 and Grays Road between Plimmerton and the Project alignment currently discharges directly to the harbour without treatment. The movement of this traffic to the TGP provides the opportunity to provide treatment prior to discharge and for there to be mixing before arrival at the harbour.

118 SKM[42] has modelled the current trend in Zinc and Copper in key streams (and estuary) along the alignment. With the array of proposed treatments of stormwater there is predicted to be some but only a little change in metal contaminant loading between that of the current measured amounts and that in 2031 (20 years on).[43] A small overall increase in zinc (2%) and copper (1%) is expected in the Pauatahanui Inlet. In addition, the distribution of the contaminant load is predicted to change. Decreases or no change in metals loads are predicted at the mouths of the Browns and Kakaho streams and small watercourses draining to the Pauatahanui inlet of the harbour. Small increases in metal loads are expected at the mouths of the Duck, Pauatahanui, Ration and Horokiri streams.

119 In Technical Report 14, SKM predict increases in Total Petroleum Hydrocarbons (TPH) in the Duck, Horokiri, Kenepuru, Pauatahanui and Ration streams.[44] The treatment devices proposed are effective at removing TPH, but the increases predicted are, as a proportion of the existing TPH, still high in some catchments.

120 Decreases in TPH loads are expected on the Kapiti Coast at both the mouths of Wainui/Te Puka and the Whareroa streams.

121 Most of the streams within the Project area are predicted to fail the ANZECC 95% test for Zinc in 20 years time without the Project.[45]

41 References in Technical Report 14, such as Lee, BC, Matsui, S, Shimize, Y & Matsuda, T (2005). Characterizations of the First Flush in Stormwater. Runoff from an Urban Roadway. Vol 26(7) pg 773-782.

42 Technical Report 14, section 17, operational modelled effects, page 151.

43 Technical Report 14, section 17, Section 17.1.3 and Figures 15.64- 15.65, pages 156, 157.

44 Technical Report 14, section 17.6 page 171 and Figure 15.78, page 172.

45 Technical Report 11, Section 11, Table 11-46 , page 100.

Discharges from the Project are only predicted to increase baseline levels above the ANZECC 95% trigger for Ration Stream. Given the Ration's current condition and generally low sensitivity, such an increase, even to the more sensitive lower reaches (where giant kokopu can still be found) should not result in measureable biological change.

**MANAGEMENT, MITIGATION AND MONITORING**

122 In this section of my evidence, I will discuss the various management, mitigation and monitoring measures which I recommend to address the effects identified in the previous section. I commence with a comment on steps taken during Project shaping to avoid effects, and then discuss the mitigation of effects on stream habitat, including in particular the significant stream rehabilitation proposed (under the SEV assessment). After that I will address measures to mitigate/offset Project effects on freshwater fauna, for sediment discharge, mitigation for operational stormwater discharge and temporary culverts. Finally, in this section I will discuss the monitoring I propose, including monitoring of mitigation success.

**Avoidance**

123 During planning and project shaping of this route, efforts were made to limit the number of crossings, culverts and diversions. These changes are also explained by **Mr Nicholson**, **Mr Edwards** and **Ms Rickard** in their evidence. One major action was to move the alignment from the eastern side of Horokiri/Te Puka valley to the West, avoiding the larger and better tributaries. Another was to bridge all major waterways, although this has subsequently been reduced through a need to design for earthquake damage. In addition, during construction, efforts should continue to limit impacts to streams. This includes culverting temporary construction access tracks and reinstating the stream bed once works are complete. It also includes retention of as much riparian vegetation as is practically possible, as this is an important component of the stream habitat, reduces stream bank erosion, and assists with entrapment of overland sediment.

**Mitigation of Effects on Freshwater Habitat**

***SEV Rehabilitation Assessment***

124 The assessment of quantitative mitigation requirement for streams for the Project has applied an SEV (Stream Ecological Valuation) analysis. This process ensures that any permanent loss of stream is offset by stream rehabilitation elsewhere. The SEV tool applies an automatic 1.5x scale up in terms of the extent of stream affected to the extent rehabilitated. This scale up accounts for the time it takes for riparian vegetation to establish before environmental benefits occur (and other establishment issues), as well as an additional calculation based on the difference in potentials of the affected and mitigation stream and the likely outcome of the management

proposed. This assessment does not identify values such as the presence of threatened fish species, but those aspects can be covered through mitigation success monitoring (discussed later). The mitigation "package" in addition to the SEV requirements, also includes the associated beneficial effects of the terrestrial vegetation/habitat mitigation (as described by **Mr Fuller**), and this is especially so in the Te Puka, Horokiri and potentially the Duck Creek catchments.

125 Although the SEV methodology was specifically designed by NIWA for Auckland streams (in conjunction with the Auckland Regional Council), the principles can be readily adapted to other regions and stream types. A slight adaptation has been made by NIWA for use of the SEV in the Wellington Region (at the request of Greater Wellington Regional Council) to accommodate a waterbody's shift in substrate from soft bottomed to cobble bottomed.

126 There are three purposes for which the NIWA-Auckland Regional Council developed SEV can be usefully employed:

126.1 For the collection of a uniform, standardised set of quantitative physical habitat parameters;

126.2 As an analysis system that is formalised and contextualises the results of the measures of stream parameters to allow the comparison of a system's function relative to a reference (top quality) system's function; and

126.3 By providing a system (although still subjective) to approximate the environmental loss and required spatial /quality area for environmental balance or gain (the offset).

127 The SEV is not an assessment of values or effects process – it is a system to estimate relative functional condition, which can assist an analysis of ecological value.

128 There are however, a number of notable current shortcomings with the SEV system:

128.1 To perform well, a well measured set of appropriate reference sites is required. In heavily modified areas (such as the west coast of the Wellington Region), such sites can be difficult or even impossible to obtain;

128.2 The system relies on presence or absence data for biota rather than a measure of species diversity or abundance (this can have considerable effect on analysis and outputs);

128.3 The establishment of the current (and affected) stream's potential value assumes (unrealistically) that current land uses and levels of adverse effect would, in the absence of any driver, cease, thus portraying an unrealistic potential value;

128.4 The SEV tool operator is required to have a mitigation site in mind and measured, rather than discover what requirements are needed first;

128.5 The calculation of the compensation or offset requires considerable opinion in setting potential effects and the additive values that might be attained; and

128.6 There is an assumption that actions to mitigate/enhance water bodies are inherently limited in their success and so a default multiplier is built into the calculation (that being 1.5).

129 That said, the SEV system allows the collection of quantitative, robust, targeted, function related aquatic data in a standardised format. It provides a very useful functional comparison of tested streams against either the "natural state" reference or against a best remaining state. The SEV and ECR calculation systems provide a stable and useful platform for the discussion and consideration of functional loss and the level of required functional gain (mitigation). It is, however, a functional measure and not a measure of ecological conservation value (without a specific focus on species). By default however, habitat function and conservation value are correlated. In regard to mitigation, a correlated gain in conservation values is virtually guaranteed from the functional gains driven by the SEV mitigation.

***Efficacy of SEV for the Project***

130 The SEV system was used to test the mitigation requirements for the following scenarios related to the Project and in perennial flow habitats:

130.1 The functional values lost due to culverting and the remaining value in a culvert channel;

130.2 The functional values lost and gained in stream diversions;

130.3 Removal of a fish barrier (perched culvert) to reinstate fish passage to an upper catchment section; and

130.4 Enhancement of a general side tributary by the mitigation land management change proposed (in the Horokiri system).

131 These scenarios were run to allow estimates of stream ecological function gained and lost by changes to the physical structure of a stream or management /restorations proposed.

132 The SEV offset values were attained using Duck Creek, Te Puka and Horokiri sections as templates representing the wider habitat types. Duck Creek was used in the fish passage modelling as this is where the upper catchment will benefit from actions proposed to retrofit existing culverts with fish passage issue. Horokiri and Te Puka were used for the diversion modelling as these areas are where much of the main stem diversions will be installed. Horokiri was also used in the stream loss modelling (as a good quality rural stream template), making the assessment conservative in that it uses a good quality rural stream as the template. The resultant Environment Compensation Ratios (*ECRs*) produced by these modelled scenarios are based on the assumptions regarding the potential condition of the stream reach (i.e. without the Project), and after-mitigation results of the stream reach, using reference site values as a guide.

133 The following table (**Table 5**) presents ECRs for each scenario. Where appropriate, I have averaged and/or rounded the various ECRs.

**Table 5: Calculated ECRs**

| Scenario | ECR |
|---|---|
| Correcting fish barrier culverts in Duck | -1.5 |
| Horokiri-Te Puka diversions | 1.7 |
| Culverting flat sections | 2.2 |
| Culverting steep sections | 4.1 |
| Complete loss of stream sections | 6 |

134 The SEV formula calculates total replacement of functional values, based on a "no net loss" approach. While this is a sustainable approach, a satisfactory mitigation solution may also be achievable at a lower threshold which recognises that some adverse effects may be acceptable. Accordingly, the mitigation calculated using SEV may be greater than what is required under the Resource Management Act 1991.

135 When assessing the effects and mitigation from the Project, I have applied these ratios to the analysis of stream condition and extent for all of the sections that require loss by diversion (in-filling) and culverting. Those sections that are to be bridged were not considered because they typically do not involve aquatic habitat loss or direct effects other than potential sediment discharge or minor bed disturbances.

***Mitigation for effects on fresh water habitat***

136 Around 10,418 m of perennial or intermittent stream are predicted to be directly and physically adversely affected by the Project, as well as a number of small scale temporary effects related to temporary culverts required for construction purposes. Potentially a

further unknown quantity of stream is affected by sediment discharge during construction, although those effects cannot be known at this time and will require monitoring to establish if the management of sediment is as effective as predicted (or better).

137 The proposed mitigation actions are largely centred on the upper Horokiri and Te Puka and have a focus of reconstruction of physical stream way and riparian revegetation. In addition there are a number of pre-planted riparian areas associated with the Duck, Pauatahanui and Ration systems. These areas were identified in 1995 as areas of riparian revegetation that would assist the waterways. At each site approximately 1.6 ha or 1,900 linear meters of stream way was planted out with native broadleaf early-middle successional native plants. These areas have grown substantially in the interceding 10 years. All are now 3-5m tall secondary forest areas with closing canopies. I sampled in several of the Duck tributaries, including one with this pre-planting where I caught a number of banded kokopu. I anticipate that there are likely to be many more banded kokopu in the pre-planted area than above or below it, or in adjacent tributaries.

138 Based on the ECR ratios and the linear lengths of different effects I have calculated the linear lengths of offset mitigation required (**Table 6**).[46] As noted above, the 10,418 m of adversely affected stream length requires 26,504 m of mitigation.

**Table 6: Calculation of ecological aquatic compensation requirements**

| Scenario effect | Affected length (linear m) | ECR Ratio | Calculated "mitigation" Required (linear m) |
|---|---|---|---|
| Culvert steep | 409 | 4.1 | 1,677 |
| Culvert flat | 3,208 | 2.2 | 7,058 |
| Culvert armouring | 860 | 1.7 | 1,462 |
| Culvert stream loss | 809 | 6.0 | 4,854 |
| Diversion length | 4,039 | 1.7 | 7,029 |
| Diversion armouring | 500 | 1.7 | 870 |
| Diversion stream loss | 593 | 6.0 | 3,555 |
| **TOTAL** | **10,418** | **TOTAL** | **26,504** |

139 I have chosen to focus mitigation for stream effects on the Horokiri and Te Puka streams where both substantial land retirement and stream enhancement is possible, and where the largest proportion of the adverse effects to freshwater ecological values will be. I consider it less appropriate to create small isolated sites along the route and within each affected catchment, even noting the existing

[46] Table 6 is taken from Technical Report 11, Freshwater Table 11-53, page 108.

benefits I have seen related to those other pre-planted areas. However, in terms of supporting a large and stable aquatic biodiversity I consider it best and even necessary to protect a large area and one especially with the headwaters included.

140 The goal of the freshwater mitigation is to achieve a long term ecological benefit by securing most of the Horokiri and Te Puka head waters and upper catchment and removing the current degrading practices of land use. In total I have mapped out and proposed a total linear length of around 30,000 linear metres (stream and riparian). This is in addition to the 31 ha of pre-planted riparian mitigation. I consider that my proposed approach is appropriate given the scale of stream effects that will occur.

141 There are three basic types of mitigation treatment proposed. They are:

141.1 **Diversion Construction***:* A significant part of the mitigation is the correct ecological design and construction of the new stream channels related to the permanent diversions, especially in the Te Puka (where over 1km must be fully rebuilt) and the Horokiri. It is entirely inappropriate to create straight, batter sloped drains. During the field investigations I gathered detailed information on the morphology of the streams that will be diverted. This information will be used in the design and construction of the diversion and a detailed diversion methodology and measures of success developed prior to those diversions (an example of such is appended to the EMMP). The design will deal with the fundamental characteristics of all stream diversions (i.e. alignment, sinuosity, width, profile, bank and bed treatment (substrate), water depths and velocities).

141.2 **Culvert Design***:* All culverts in perennial or intermittent streams, with a grade <20%, will be embedded to allow streambed habitat to pass through them (i.e. accumulate substrate). There are a number of accepted methods for the design of these culverts, which will also ensure fish passage and these guides should be consulted and followed as appropriate (e.g. TP 31 ARC). For most of the steeper tributaries, especially on the western side of the road, which require culverts under the road to connect to the main stem, a new design fish passage is proposed and uses climbing thread and a separate passage.[47] Monitoring post construction will be required to ensure current passage is maintained.

[47] Technical Report 9, section 6.2.1, page 81.

141.3 **Land retirement & Riparian revegetation (as required by the SEV method)***:* Removal of the existing land use practices (stock, ploughing and nutrient additives), legal protection and physical enhancements are proposed to large extents of waterways and their riparian margins. This is in addition to and merged with the terrestrial vegetation and habitat mitigation areas discussed by **Mr Fuller** in his evidence. The wider terrestrial (catchment) mitigation also has wider beneficial implications for the waterways and estuary, through reduced land management effects nutrients, erosion etc. I discuss the mitigation benefits of this approach below.

142 In the following sections I will explain more about what is recommended to mitigate for habitat loss, effects on fauna, for sediment discharge and for stormwater discharge.

143 Removal of the existing land use practices (stock, ploughing, nutrient additives etc), legal protection and physical enhancements will all substantially improve the waterways values. Riparian revegetation is one of the main aspects of the physical improvements. I have recommended that it involve the mass planting of robust native species adapted to riparian conditions including flood flows and temporary inundation. The replanting will involve some enrichment planting with future canopy species (kahikatea, pukatea, swamp maire, totara).

144 Given the shape of the banks, their height and width and the profile of the wider catchment, the riparian revegetation should occupy an area 20m wide either side in the main stems of Te Puka and Horokiri systems down to the edges of the NZTA controlled properties. The wider forest revegetation mitigation proposed by **Mr Fuller** merges with the riparian zone.

145 Table 3[48] of the Proposed Ecological Management & Monitoring Plan lists a range of suitable plants to be used in the riparian areas as well as expected growth rates.

146 The revegetation (in Te Puka and Horokiri) is proposed to be active (i.e. via direct planting) over a 7km length (and 20 m width) along the main stem of each stream. This equates to around 28 ha of planting of native riparian vegetation. Most of the remaining 23,000m of stream mitigation (required by the SEV) is achieved by the protection and removal of current "harming" influences (such as stock) from the numerous tributaries to the Horokiri so that with appropriate weed management[49] the shrublands of the steep hills

48 Table 3: Recommended Riparian Species & Growth Rates, section 4.6, EMMP, page 17.

49 Stipulated in section 3.3 of the EMMP.

will then spread and natural regeneration will be achieved and the condition of those tributaries suitably enhanced.

147 Mitigation locations are shown in the maps of Appendix 11.J, figures 11.11a to 11.11i, pages 169 – 176, Technical Report 11.

**Mitigation for effects on fresh water fauna**

148 During construction a range of actions are recommended that will reduce the adverse effects of construction to aquatic fauna, these are:

148.1 Considered and specific water discharge treatment processes to maintain as best as possible water quality[50];

148.2 Expert ecological involvement in detailed design and installation of culverts and associated infrastructure (rip rap) to ensure passage but also encourage culvert habitat;

148.3 Capture and movement of fish during culvert installation and diversions or any water draining or blocking activity;

148.4 Timing of works in stream beds to minimise adverse effects on peak movements of migrating fish (Spring Migration 1 Oct -30 Dec; Autumn Migration 1 April – 30 May) but with flexibility to carry out works for short prescribed periods within these periods;

148.5 Retrofitting six existing perched culverts in Duck Creek which are currently barriers to fish passage.

149 The maintenance of water quality and limiting faunal adverse effects is promoted through the effects monitoring programme. In this programme, which is purposefully adaptive, the construction engineers monitor and regulate the sediment control devices measuring turbidity discharges from control devices and the receiving stream environment. That process allows them to recognise failures and potential failures and to take steps to fix those failures in communication with the Project ecologists.

150 Within the receiving environment I have proposed a calendar and event based series of aquatic habitat and biota monitoring. Throughout the construction and post construction period that monitoring will seek to test the aquatic macroinvertebrate communities (composition, stability of QMCI) and compare those measures against the "before" condition (the baseline). Such an approach was successful in the West Wind Windfarm project.

[50] Refer Technical Report 15 (Assessment of Water Quality effects), section 3.2 and 3.3, pages 17-19.

151 In regard to the aquatic mitigation, the establishment of suitable habitat and its colonisation (including culvert habitat) or community enhancement will be confirmed by the mitigation success monitoring programme (this "success" programme is further discussed in the Monitoring mitigation success section of my evidence, below).

152 In this programme (in some locations an extension of the effects monitoring), aquatic macroinvertebrate communities and fish communities will be used in a pre- and post construction comparison to examine the communities' composition and sensitivity indices. A control/s will be used where such suitable controls can be found. At this stage, two potential controls stand out: in the middle Kakaho and upper Pauatahanui.

153 During the operation of the road, water quality is again the primary aquatic issue and its adverse effect is proposed to be reduced by treatment of the stormwater run-off along the routes, but especially in the Horokiri, Duck and Te Puka catchments. Furthermore, post construction monitoring of fish passage is required to ensure the designs used are effective and that the culverts and constructed fish ladders continue to operate to their design standards.

**Mitigation for sediment discharge**

154 The predictions are that generally in "normal" rain events no sediment discharges will affect the streams. In 1 in 2 year events small amounts of sediment could affect the streams, in a 1 in 10 year event, even with the storm water ponds and other proprietary treatment devices, including wetland polishing,[51] there will be areas of heightened sediment discharge. That discharge will not settle on the bed in most places in the freshwater system,[52] but will discharge to the estuarine system. A range of actions are recommended to reduce adverse effects on freshwater habitat. These are:

154.1 Staging of works and establishment of a maximum open earth worked in any one catchment area at any one time (Onepoto Arm - 17.25 ha, Pauatahanui arm - 40ha, and in the Duck a maximum of 14.25).[53] While mainly a safe guard for the marine system, such limitation can also benefit freshwater systems of each catchment;

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[51] See Technical Report 14, Appendix 15.CC, pages 469-471.

[52] Technical Report 14, appendix 15.T, Figures T.2-T.33, pages 328-362.

[53] Proposed consent conditions E1 and E2, page 524, AEE set area limits on earthworks.

154.2 Erosion management and sediment control to exceed regional guidance;[54]

154.3 Risk management plan, including earthworks stabilisation procedures, for significant storm event monitoring and response.[55]

155 The revegetation and restoration of native vegetation in the Horokiri, Te Puka and also the Duck will have wider positive effects; it will reduce the "natural" surface run off of sediments to the waterways. In Technical report 15[56] there is a calculation that the background levels in the Duck catchment will fall by 9.7%, 3.6% in Horokiri, 9.0% in Te Puka/Wainui, and 0.5% in Kenepuru, once those catchment areas proposed to be revegetated are retired (including enrichment) and once vegetation has matured sufficiently (i.e. approximately 15-20 years from planting / retirement, although benefits will accrue immediately from retirement from stock use).[57]

**Temporary Culverts**

156 Subject to suggested conditions S.1 to S.14, I do not believe that the installation of temporary access culverts will lead to significant adverse effects. Condition S.2 of the proposed conditions sets out a need for the consent holder to prepare and submit detailed design plan and a construction methodology. This documentation proposed by condition S.2 should address:

156.1 A limit on the time the culvert shall be in place;

156.2 that where reasonably practical all temporary culverts will be installed at existing crossings to minimise riparian effects and bank effects;

156.3 That Culvert design will follow ARC TP131[58] protocols to ensure fish passage is maintained;[59]

156.4 That following removal, remedial action will include substrate cleaning, bank reformation and stabilisation (gabions or riprap to prevent erosion and undercutting); and

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[54] Proposed condition E3, page 524, AEE describes the erosion and sediment control, supported also by E4, E5 and to an extent all of the "E" proposed conditions.

[55] Refer specifically to proposed condition E5, page 524, AEE.

[56] Technical Report 15, Page 98, table 15.26.

[57] Refer Table 15-26 Technical Report 15 – Water Quality Effects, page 99.

[58] Auckland Regional Council (now Auckland Council) Technical Publication 131: Fish passage guidelines for the Auckland Region, June 2000.

[59] This goal is identified in proposed condition WS.4.

156.5 That riparian revegetation will be carried out over the section affected after construction.

**Summary of Potential Effects on Aquatic Habitat after proposed Mitigation**[60]

157 The table below summarises potential effects on aquatic habitat after proposed mitigation has been implemented.

***Table 7: Direct Effects on Freshwater Habitat - Loss or Modification***

| Description | Predicted Impact | Significance of Impacts without mitigation | Proposed Mitigation | Significance of Residual Impact after mitigation |
|---|---|---|---|---|
| High Value Stream Habitat | | | | |
| Upper & Mid Te Puka | Major loss and modification of stream bed & riparian habitat of high value through extensive diversion. | Very High | Extensive stream restoration and riparian planting / design principles to require matching in-stream habitat types, substrates, velocities. | Midterm neutral |
| Middle Horokiri East | Major loss of stream bed & riparian habitat of high value | Very High | Areas of stream restoration and riparian planting / design principles to require matching in-stream habitat types, substrates, velocities.<br>Extensive protection, retirement and revegetation of high value streams with riparian cover and advance regeneration. | Long term moderate positive |
| Upper and Middle Duck | Major loss of stream bed & riparian habitat of high value | Moderate | Existing early retirement areas provide 1.6 ha of riparian planting in this catchment (1,100 m of stream)<br>Retrofit fish barrier culverts to provide fish access to 3,000m of unused habitat | Long term moderate positive |
| Moderate Value Stream Habitat | | | | |
| Lower Te Puka / Wainui | Minor loss of stream bed through diversion and culverting | Moderate | Mitigation achieved through land retirement and revegetation of riparian margins. | Mid term neutral |
| Upper Horokiri East | Major loss of stream bed & riparian habitat of moderate value. | Low | Mitigation achieved through land retirement and revegetation of riparian margins. | Midterm neutral |
| Lower Pauatahanui | Minor loss of stream bed & riparian habitat of moderate value through diversion & bridging. | Low | Existing early retirement areas provide 1.3 ha of riparian planting in this catchment (360 m of stream). Retirement and revegetation of Lanes Flats including kahikatea river corridor and stormwater treatment wetlands.<br>Revegetation Lanes Flats | Midterm Low positive |
| Lower Duck | No loss | Low | NA | NA |

[60] Taken from Table 11-71, page 130, Technical Report 11.

| *Table 7: Direct Effects on Freshwater Habitat - Loss or Modification* | | | | |
|---|---|---|---|---|
| Description | Predicted Impact | Significance of Impacts without mitigation | Proposed Mitigation | Significance of Residual Impact after mitigation |
| Upper Cannon | Minor modification of stream bed & riparian habitat of moderate value through bridging. | Low | Riparian revegetation following bridge construction | Neutral |
| Low Value Stream Habitat | | | | |
| Ration Stream | Major loss of stream bed & riparian habitat of low value. | Moderate | Existing early retirement areas provide 2.4 ha of riparian planting in this catchment (499 m of stream) / Areas of diversion to be restored. | Midterm neutral |
| Porirua Stream (tributaries) | Minor loss of stream bed & riparian habitat of low value | Low | Proposed mitigation in Horokiri as compensation for this loss. | Midterm neutral |
| Indigenous Fish | Eight species that occur in study area with threat status (Declining).<br>Possible effect on passage of migratory species.<br>Will be habitat reduction through extensive culverting thus reduced local populations.<br>Potentially detrimental habitat changes with diversion.<br>Potential for fish mortality during reclamation of stream channels. | Very High | Design of fish passage, diversions, culvert installation according to ecological principles.<br>Retirement and Revegetation of stream and riparian habitat.<br>Removal of stock.<br>Timing of works to avoid peak movements.<br>Post construction monitoring of fish passage.<br>Innovative culvert design.<br>Replacement of perched culverts in Duck Creek to reinstate fish passage to upper catchment.<br>Capture and translocation of fish during culvert installation and diversions. | Long term positive in Horokiri, upper Duck and Pauatahanui. |

**Indirect impacts of construction - sediment discharge to freshwater**

158 The table below summarises the indirect impacts of construction from sediment on freshwater before and after mitigation.

| *Table 8: Indirect Effects on Freshwater Habitat – Construction Sedimentation* | | | | |
|---|---|---|---|---|
| Description | Predicted Impact | Significance of Impacts without mitigation | Proposed Mitigation | Significance of Residual Impact after mitigation |
| High Value Stream Habitat | | | | |
| Te Puka | Habitats dominated by sensitive taxa, likely to be very high short term effects without treatment.<br>Effect diminishes from point of source. | Very High | Erosion management and sediment control to exceed regional guidance.<br>Intensive monitoring of water quality and aquatic habitat, and adaptive management of erosion and sediment devices. | High but short term only |
| Middle Horokiri East | As above | Moderate | As above | Moderate short term |

| *Table 8: Indirect Effects on Freshwater Habitat – Construction Sedimentation* | | | | |
|---|---|---|---|---|
| Description | Predicted Impact | Significance of Impacts without mitigation | Proposed Mitigation | Significance of Residual Impact after mitigation |
| Upper and Middle Duck | As above | Very High | As above | High but only short term |
| Moderate Value Stream Habitat | | | | |
| Upper Horokiri East | Habitats affected by existing land uses with a mix of sensitive and resilient species more able to cope with moderate changes to environment. | Moderate | As above | Low |
| Lower Duck | As above | Very High | As above | Very Low |
| Lower Pauatahanui | As above | Low | As above | Low |
| Upper Cannon | As above | Moderate | As above | Low |
| Low Value Stream Habitat | | | | |
| Ration Stream | Lower value habitats with existing sediment issues, dominated by resilient species. | Moderate | As above | Very Low |
| Porirua Stream (tributaries) | As above | Low | As above | Very Low |

**Monitoring construction effects**

159 I have recommended[61] a process of adaptive management based on monitoring results for dealing with additional erosion and sediment control, and for the design and installation of culverts and diversions. Adaptive management[62] will require detailed monitoring, the results of which feedback into the design and ongoing management. This approach is also supported and discussed in the evidence of **Mr Gough**. It is an appropriate regime in this case (for the sediment discharge issues) because the actual and predicted effects are estimates only, because it cannot be known with certainty how well the defences will perform and actual effects may differ from those predicted, in particular effects may be much less than those predicted by modelling (which takes a conservative approach). Adaptive management will ensure that mitigation measures are monitored and adapted as necessary to ensure mitigation success.

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61 Refer Proposed mitigation and monitoring programme (August 2011), section C, sub-section 4, page 32-34 and section D parts 1 and 2.

62 A process of information feedback from monitoring informing management regimes such that analysis of results of management can cause a change in the management. Adaptive management is often used in a situation when it is not clear what or if management is required, often because effects of an action are not completely predictable.

160 This adaptive management process will include baseline surveys, monitoring through construction and for a couple of years post construction of:

160.1 Continuous (via a logger) water quality (turbidity) near treatment device discharges;

160.2 Aquatic benthic macroinvertebrate community composition and "quality" downstream of effects and discharges, calendar monitoring and event monitoring as triggered by the device discharge monitoring;

160.3 Sediment deposition (lower Horokiri and Te Puka and Duck Creek before the lower, private lands);

160.4 Culvert installation and fish passage maintenance monitoring;

161 Monitoring results analysis must obviously include plans for responses to any potential discharge of contaminants to streams or adjacent land, such as fuel, lubricant, cement; or to any monitoring result indicating issues of concern.

162 Table 28.2 in the AEE[63] lists the effects against a proposed mitigation and a proposed monitoring or action requirement, whether a consent condition is required and the source report of the information or draft measure of action or monitoring system. This table, together with the Proposed EMMP, forms the basis for the monitoring of ecological effects required.

**Monitoring Mitigation success**

163 Following on from the works to establish the riparian plants, recreate the bed and banks of new waterways (Diversions) and the retro-fixing of passage barrier culverts; a measurement of aquatic system improvement is required to establish the gains achieved for the freshwater system by the mitigation actions. The EMMP appended to the AEE included a general monitoring programme which included aspects related to rehabilitation / improvement and that require monitoring, such as diversion success. However, it was not explicit in the plan that such monitoring was targeting mitigation success.

164 The gains that will be achieved by the proposed mitigation are first and foremost the protection of freshwater habitat from land use effects adjacent to the waterway in the upper Horokiri and Te Puka, i.e. the removal of stock access, and thereby a decrease in bank

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[63] Table 28.2 Proposed mitigation and monitoring, chapter 28, page 470: Transmission Gully project assessment of Environmental Effects, BECA August 2011.

erosion, sediment deposition and a reduction in nutrient input. The second element is the improvement of the waterway as habitat by providing an increase in good organic matter input – the addition of native leaf material, and wood debris (fish cover). The third aspect is the corresponding aquatic biota community improvement (better invertebrate and fish communities).

165 In order to record these mitigation improvements (success) a dedicated monitoring programme is recommended and a condition of consent should be added to those proposed conditions at or around or within E.25 (page 530, AEE).

166 The aquatic mitigation monitoring programme should include the following parameters (all elements require a comparison of before and after measures):

166.1 Bank erosion rate (specific locations in the Horokiri, and Te Puka) (at least a 6 month measurement period after completion of the road );

166.2 Sediment deposition (logged NTU in the lower-middle Horokiri and Te Puka and Duck Creek before the lower private lands) (at least a one year post road completion (in the Horokiri and Te Puka catchments);

166.3 Riparian edge development in the Horokiri and Te Puka (closure of canopy, seedling establishment, shade and organic rain measures[64]) (at least a three year post completion of the road parameter);

166.4 Nutrient concentrations (Total N and other N products and Total P and DRP), via water quality measures in the middle Horokiri and Te Puka (Quarterly over a period of 5 years post road completion);

166.5 Native species leaf matter quantity (Ash free Weight of organic matter samples from drift litter net collections (Bi annual samples over at least a 5 year period post completion of the road) in the Horokiri and Te Puka;

166.6 Woody debris indices (indices of small, medium and large woody debris) (an annual survey over a 10 period post road completion) in the Horokiri and Te Puka;

166.7 Macroinvertebrate community – taxa richness, composition and QMCI in the wider waterway (a Bi-annual three year set

[64] Organic rain refers to organic biomass, such as leaves, twigs and invertebrate matter, that falls from trees into water.

of measures post road completion) in the Horokiri and Te Puka;

166.8 Diversion reach community re-establishment, tested by a, periphyton measure, aquatic benthic invertebrate community composition measure and a fish presence measure (parameter Bi annual set of measures over three years post diversion completion) in the Horokiri and Te Puka;

166.9 Fish species presence and abundance in set reaches of Te Puka and Horokiri and in the middle Duck reach (bi annual measure over three years post road completion);

166.10 Monitoring of upper Duck Creek to ensure improved fish passage is providing anticipated benefits (one year parameter).

167 Measurement of these parameters set against a pre-activity background will allow a measure of the success of the mitigation. In the Te Puka diversion (and Horokiri ones too) extensive new river systems will be created and the measure of success is relatively straightforward. Specifically, a measure of colonisation of those new habitats by periphyton, macroinvertebrates, and fish. It also involves the measure of the created physical habitat in the form of stability of the new banks, accumulation of leaf and wood debris, the velocity and the development of the riparian revegetation.

168 The success targets for the new aquatic habitats are the existing community composition, abundances, presence of fish species etc. For each diversion and for several locations on the Horokiri a series of targets (including "threatened" species) can be extracted from the existing data and in discussion with DOC and the Regional Council formulated into a specific mitigation monitoring plan. Review and remedial actions would be included in such a plan.

**RESPONSE TO SUBMISSIONS**

169 The **Kapiti Coast District Council** (*KCDC*) submission set out that Council's concern that the Project will have a very high impact on the Te Puka Stream resulting from a 1.2km diversion, extensive culverting and the potential for sediment discharge during construction.

170 KCDC is correct to note that the affected sections of Te Puka Stream have high and moderate ecological values and that significant adverse effects are unavoidable and require mitigation.

171 In KCDC's opinion there is insufficient mitigation of adverse effects on the Te Puka Stream and they question whether it is possible to destroy such ecological values and successfully re-create them.

172 The difficulty in re-establishing the upper-middle Te Puka is acknowledged in the proposed EMMP,[65] and which also acknowledges the potential that the Project will involve "new science" around stream diversions and rehabilitation.[66]

173 That does not mean that a mitigation and rehabilitation programme cannot succeed and I consider that the programme proposed for TePuka Stream will succeed. I have been involved with and am aware of other work undertaken that has successfully diverted streams and resulted in good ecological values being achieved (e.g. Stebbings Stream (Churton Park), an un-named stream of the Whangateau harbour, South Omaha, and Oteranga Stream at West Wind windfarm).

174 I note that Project design has already taken steps to protect the Te Puka Stream. The SAR process resulted in several important changes to the route alignment, the most significant being the decision to move the alignment from the east to the west slopes of the Te Puka and upper Horokiri valleys. This significantly reduced effects on the Te Puka stream. However, following studies of roading in the Chinese Sichuan earthquake zone (as explained in the evidence of **Mr Brabhaharan**), the Project engineers removed most of the vertical retainers, cantilevered sections, and short viaducts and expanded the road supporting slopes, with the effect that those slopes encroached significantly into the stream in the upper-middle (1.2km) section. Encroachment was so frequent that any attempt to make numerous diversions and retain some of the existing channel needed to be abandoned.

175 A new stream alignment was considered the only viable option but that brought significant logistical problems related to the topography

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[65] Section 9, page 23 Proposed EMMP: "diversions".

[66] Introduction, section 6, page 7, last bullet point, Proposed EMMP.

of the adjacent land, the natural flow path and the "desire" of water to go where it will, the substrate type, both from an infiltration point of view but also erosion and habitat aspects, the number and severity of falls required and the need to avoid under cutting the road batter toe slopes.

176 The plan for the reformation of the Te Puka is complex as it is a challenging rebuild with complex topography. An SSEMP has been prepared to specifically focus on the rebuild of Te Puka Stream (and is explained by **Mr Gough** in his evidence). In essence the proposal is to create a new stream bed and banks through the array of topography north of its current bed (and outside of the native forest (at or about the existing vehicle track).

177 The creation of this new stream bed will require the cutting of an entirely new bed, through ridges and other features. The challenge will be to create a stable channel morphology that is neither straight, nor smooth, nor uniform and to establish a meander with fish climbable drop structures, a set of velocities within the existing regime's experience, and an array of aquatic habitat features (e.g. pools, runs, riffles).

178 Having studied the Te Puka in some detail, I consider that such a rebuild, while challenging, can be done and will be effective even if it requires the use or artificial materials in some locations (i.e. concrete).

179 The key aspects are the resultant velocities, the heterogeneity of the surfaces and substrates, the inclusion of mixed size cobble substrates, and the development of climbable drop structures.

180 While I refer to "new Science" in the EMMP, and in my evidence, in regard to the reconstruction of the waterway in Te Puka (a 1.2km reach), I do not mean to suggest that the reconstruction of a stream passage has not been successfully done before or that construction methods do not already exist to create a serviceable channel and climbable falls. What I mean is that the reconstruction of a functional waterway has not previously been undertaken in such a steep and challenging landform as the Te Puka, with the goal of ensuring an equal or better biological diversity.

181 The primary challenge for the Te Puka rebuild is that it is not simply a matter of digging a new channel. Given the steepness and the limited area available for reconstruction there will need to be a range of techniques used from digging a channel to creating artificial channel sections as well as the creation of a number of drop structures connecting a series of less steep sections (the current stream, while steep, has a continuous grading downstream). The challenge will be to contain the stream within a new channel with a

suitable cobble base and hyporheic zone[67] and create drop structures that will allow the current native fish species to gain passage all the way up and into the native bush headwater.

182 I consider that there is a substantial opportunity to add significant habitat diversity to that which currently exists. However, the design and build will be difficult and need consideration and care. Drop structures such as the one at White Bridge, Arthurs pass (illustrated in the photo below) are the type of structure to offer climbing fish passage, that I envisage will be employed in the Te Puka.

183 The unknown aspect ("new science") is the flora and faunal recolonisation success and speed. The durability of the artificial sections that may be required is also uncertain. There is as yet, very little evidence on the recolonisation success of re-created stream channels. However, BML has been monitoring the success of re-establishment of the aquatic community in the Otehaunga stream which was affected by the West Windfarm project. Two years into the recolonisation of a new stream reach and we had proof that the base of the invertebrate community and fish species had returned and after three years macro-invertebrate communities had reached a steady state, while fish populations continue to improve.

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[67] The hyporheic zone is the area beneath a stream bed substrate, where there is a mixing of shallow groundwater and surface water. The zone is important for aquatic macroinvertebrates, and as a refugia for most aquatic fauna in dry periods or floods.

184 The reason for my confidence in the Te Puka situation is the proximity of the native bush to the proposed new channel and the quality and condition of the up-stream section that will supply, through drift of organic matter and invertebrate species. Indeed, one advantage of the repositioning is the close proximity of the northern slope native forest, which will instantly add mature riparian benefits to the new system.

185 Once built the whole Te Puka stream section will require substantial robust monitoring to measure the re-establishment of habitat factors (e.g. organic matter accumulation) as well as the animal communities and the progress of up-stream migrating fish.

186 A range of actions are available to further assist recolonisation should monitoring indicate any issues.

187 KCDC is correct to note that the "new science" (experimental rebuild approach) will need significant engineering and ecological monitoring through its construction and early operation as well as some longer term mitigation success monitoring. This would be covered and achieved through the proposed mitigation success monitoring plans (which I have recommended above should be added to the consents conditions).

188 Below the 1.2 km section of significantly affected stream, the direct effects of the Project are less severe and relate largely to the bridged crossing in the lower section. Otherwise, in addition to the reformation of a new channel and the revegetation of that channels' riparian system (inclusive of all the in-stream additions), the whole Te Puka riparian system gets revegetated and enhanced, and with the majority of the slopes also falling into the terrestrial mitigation (as explained in **Mr Fuller's** evidence) regime and so secure further the valley bottom stream and its future condition.

189 KCDC suggest that the recommendations for mitigation are effectively an offset for unavoidable long-term adverse effects. I disagree. While significant in scale and effect the proposed solution is nevertheless a mitigation (i.e. a lessening of the adverse effect) by re-establishment of the aquatic habitat at the general location of the affected habitat.

190 KCDC was also concerned that some of the "offsetting" was located near the Horokiwi end of the route "far beyond the district boundary". That mitigation located in the Horokiri relates to effects within that catchment. The adverse effects on the Te Puka Stream are fully mitigated within the Te Puka system.

191 KCDC submit that in the absence of (in its opinion) adequate mitigation, the impacts on the Te Puka Stream are so high as to provide strong justification for declining consent.

192 I do not agree. While I have valued the Te Puka as of high value I do not consider that the Te Puka is so unique or its values so high that the significant adverse effects that will occur should cancel the Project. Furthermore, I consider that in the long term the re-establishment of the Te Puka middle reach will return (and gain) aquatic values. The most valuable aquatic habitat is in the upper Te Puka above the proposed works and it is not adversely affected. To a large extent in regard to fish species (of which the middle reach ranks as of medium value[68], it is the connectivity between the lower and upper reaches that is of most immediate importance. The existing high values of the affected habitat and benthic fauna will eventually be returned under the proposed mitigation, especially with the headwaters unaffected and protected.

193 I do agree with KCDC's comment that: "success of the proposed mitigation depends on high levels of commitment, expertise and performance by the consent holder and contractors and rigorous monitoring and reporting, sustained over many years".

194 KCDC also noted that the EMMP does not refer to territorial local authorities in regard to monitoring, reporting, compliance or consultation, though they have statutory responsibilities and a vital interest in the environmental outcomes of the Project.

195 I see no reason why KCDC should not have a role in the formation of ecological mitigation and monitoring plans[69] related to the Te Puka (and Wainui).

196 KCDC also requires as a condition of consent that an on-going independent peer review by a freshwater ecologist of the proposed mitigation of adverse effects on the Te Puka Stream be undertaken to assess the adequacy of the proposed mitigation. KCDC considers that this review should also examine the extent to which the proposed offsetting for damage to the stream will achieve the best ecological outcomes, particularly in respect of the offsetting that is located beyond the district boundary. As I have already noted, the offsetting does not relate to the effects on the Te Puka Stream, which are mitigated with the catchment. Otherwise I consider this submission fits with my advice to install a mitigation success monitoring plan and condition to that effect (as above noted above under measuring mitigation success).

197 KCDC also seek performance criteria, including long-term monitoring and reporting requirements that should be specified for consent holders and contractors responsible for implementing mitigation and management measures to address adverse ecological effects. Again I agree, but note that these requirements would be

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68 Table 9-20, page 77, Technical report 9.

69 Condition E.25 and any new mitigation success monitoring.

within the mitigation and monitoring plans which the conditions (currently E.25) require to be produced.

198 The Wellington Regional Council submission[70] notes freshwater ecology as an issue that it wishes to focus on. The submission does not however clarify what that Council's concerns are, and accordingly I am not presently able to respond to it.

199 Mr Shapleski[71] queries why avoidance of effects is not possible, and what steps are being taken to mitigate effects. In the context of freshwater ecology, the need to construct the motorway over parts of existing stream alignments, means it is not possible to avoid all effects on those streams. However, as I have noted above in response to Kapiti Council, the revised motorway alignment has been dictated, in part, by the need to avoid the Te Puka to the extent possible. Where avoidance is not possible, I have recommended a series of mitigation steps, which I have discussed in the mitigation section of this evidence.

200 The submissions of **C J Sheridan and A D Osborne, G & M Milner, J Li, J E Gray, D & J Barnes and S B Hill & J S Grace**[72] (all Rangatira Road residents), describe (in brief) the stormwater receiving gully wetland/stream eastward of the dwellings (at chainage 27000 to culvert P06) and its regeneration in the absence of stock, with the reported presence of eel and nesting birds.

201 The submitters go on to discuss ecological aspects of concern to them, including the possible loss of the regenerating stream/wetland including through sedimentation, loss of fish passage and long term change in the future potential of the stream/wetland if the valley entrance is changed.

202 I have not been to the upper reaches of this stream/wetland, I inspected the stream from its Porirua River junction to the motorway. I assessed the system as being ephemeral in terms of its connecting flows under the existing motorway to the Porirua River. In large part this will be due to the extensive area of the stream within pine forest. Pine forest absorbs a considerable quantity of shallow ground and surface water from streams.

203 I accept that the wetland / stream area may contain eels and it will be an area for some wetland related birds to nest such as pukeko and mallard duck. I suspect that the water is held up to a degree up stream of the pine forest patch and that is what maintains the "wetland".

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70 Submission 62.

71 Submitter 26.

72 Submitters 31, 36, 51, 52, 62 and 63.

204 The upper wetland area is likely to be well outside of the Project designation; and the road and batters themselves are very close to the existing road and within the ephemeral channel area. The road will cause a culvert to be placed within the channel and, as with all of the culverts installed in waterways within this Project, it will be installed ensuring fish passage is possible. Eel will continue to access the wetland while the wetland/stream itself will not be affected.

205 **The Pauatahanui Residents Association's** submission (submission 37) states that the Association has concerns over some of the potential adverse effects on freshwater, including on Horokiri Stream, Ration Stream, Pauatahanui Stream, and Duck Creek.

206 Their submission however, provides no other details in regard to what those concerns may be. I am confident that the potential adverse effects on the listed streams have been appropriately avoided or mitigated as the Association requests.

207 **Whitby Coastal Estates Limited (*WCE*)** (submission 60) in its submission stated that it has some concerns with water quality and freshwater ecology in Duck Creek. Specifically the submitter does not want the works for TG to undermine their own stream works and actions to protect water quality and freshwater ecology, which are being undertaken as part of WCE's site development.

208 WCE want sediment and erosion control programmes to include ponds designed to accommodate a Q5 rainfall event with mandatory chemical flocculation. **Mr Gough** and **Ms Malcolm** address these points and I note that the standard applied by the Project is in fact higher than that wanted by WCE.

209 WCE also request additional monitoring sites, specifically an additional impact monitoring site downstream of the Waitangirua Link Road. I understand WCE's concern given the extent of stream works they are involved in and the array of monitoring and mitigation (using the SEV model as the determinator) that they are responsible for in Duck Creek. BML ecologists are assisting them and GWRC in that work and in monitoring those potential adverse effects. BML has positioned the control site above WCE's works but below the Waitangirua Link road crossing, and so potentially this will cease to be a suitable control for their works (of course that is dependent on timing and when WCE work is completed and when Project work starts in the Duck Catchment).

210 I support the submitter's desire to have a monitoring point below the proposed Waitangirua Link Road and consider that a monitoring site at that location would have been required in any event under the monitoring plan under the EMMP, to be further developed as required by condition E.25.

211 The submitter also discusses the addition of "choker" dams up the Duck Creek to cause increased sediment trapping and some flood management along the alignment. In general such small dams may improve sediment management but they would also cause an increase in fish passage barriers to migrations up stream and they would change areas of flowing river habitat currently present into different (and potentially less valuable) still water (or pond) habitat. Given Duck Creek's native fish species value and the mitigation actions proposed to increase their passage, introduction of choker dams would undermine this benefit and represent further aquatic habitat modification.

**The Department of Conservation**

212 In their submission the Department of Conservation (*DOC*) raises 5 primary freshwater ecological concerns. Specifically, DOC considers that:

212.1 There are a number of inaccuracies and deficiencies in the Applications in respect of potential effects on freshwater habitats and fauna including conflicting information about the number of culverts and the length of water course that will be lost or modified;

212.2 The works may create a barrier to fish passage as a result of the length of culverts and length of fish ladders; rendering habitat above these structure inaccessible to native fish species;

212.3 The proposal has under-estimated the value of ephemeral/intermittent streams;

212.4 The mitigation proposed is inadequate and lacks clarity about the methodology used to determine which culverts should provide fish passage;

212.5 Given the freshwater values, the use of the SEV model is not the most appropriate method to quantify aquatic biodiversity offset, in part because it is only applicable to permanent streams. As a result a lower compensation ratio may have been calculated

213 Furthermore at paragraph 25 DOC states that the proposal is contrary to some provisions of the Regional Freshwater Plan (*RFP*), particularly policy 4.2.13 which seeks to protect the nationally threatened indigenous aquatic plants identified in Part B of Appendix 3 of the RFP, and to protect nationally threatened freshwater fauna, in the water bodies identified in Part A of Appendix 3 of the RFP. Part A of appendix 3 in this case identifies the following waterways affected by the Project:

213.1 The Horokiri Stream and the Ration Stream and their tributaries upstream of the respective coastal marine boundaries (Species recorded are: Shortjawed Kokopu, Giant Kokopu, and Banded Kokopu);

213.2 The Pauatahanui Stream and its tributaries upstream of the coastal marine area boundary (Species recorded are: Giant Kokopu and Banded Kokopu);

213.3 Duck Creek and its tributaries upstream of the coastal marine area boundary (Species recorded are: Shortjawed Kokopu, Giant Kokopu, and Banded Kokopu).

214 I shall address these points one by one and in the order in which they are listed above.

***Inaccuracies and deficiencies in the Applications***

215 I have stated and shown in **Table 6** of my evidence above that there are 409m of steep gradient culverting, 3208m of "flat" gradient culverts, and 809 m of lost stream due to the length and positioning of proposed culverts, totalling some 4,426 linear meters (113 culverts) of culverted aquatic habitat (as well as a further 860 m of armouring) that in my opinion, requires mitigation. The total culverted length is 9,400 m. Most of that additional length (the difference between 9,400 and 4,426) is for ephemeral waterways and minor crossings of boggy pasture, which, in my opinion, do not require ecological mitigation.

216 That length estimate is based on the engineers drawings (and spread sheets) of culverts required and the lengths are their calculations supplied to me. Appendix 14.F, Table 27 (culvert details) of Technical Report 14 (SKM 2011) lists all of the proposed culverts by catchment.

217 I have checked my spread sheet from which I made calculations and that of Technical Report 14 (Table 27, Appendix 14.F). There is one discrepancy in the number of culverts, I had 15 in Te Puka and Technical Report 14 has 14.

218 Furthermore, in my assessment in Technical Report 9, I did not consider culverts in the Wainui Stream (there are four totalling 355m in length), or the one culvert in the Collins. For the Wainui this was initially because the stream was to be bridged rather than culverted, but I also had noted that the stream has no fish passage due to the existing perched road culvert and very limited aquatic habitat because of the drying effect of the pine plantation and the small catchment. I do not consider it necessary to include the loss of habitat associated with the Wainui culverts given their condition. I note, further, that there is currently a 4000m excess in the

proposed mitigation (30,000m) relative to that calculated as required (approximately 26,000m).

219 Collins is also a small, and pastoral dominated, lower catchment system with a small and likely ephemeral stream (I have had no access to the Collins stream itself, so I cannot confirm the above from a field inspection).

***Works may create a barrier to fish passage***

220 DOC considers that the works may create a barrier to fish passage as a result of the length of culverts and length of fish ladders; rendering habitat above these structure inaccessible to native fish species.

221 The installation (and works) in the perennial streams (and main stems) will not create fish barriers. They will be installed as directed and guided by Technical Publication (ARC TP 131), they will have an appropriately experienced aquatic ecologist to monitor that instalment and there will be post installation monitoring to establish passage. Consent Conditions S.2, E.29, S.14 and WS.4 all require that fish passage be maintained with the construction and operation of culverts. I note, however, that none of those consent conditions requires a suitably qualified ecologist to review the final design or to check the installation and none of the consent conditions reference TP131. I recommend that this omission is addressed.

222 BML has been monitoring the culverts installed in the ALPURT highway since 2007. In that monitoring we (the Auckland office ecologists) have monitored the culverts for habitat colonisation by aquatic macroinvertebrates and fish and up stream of the culvert for passage. Over the last three years the results show that culverts (fitted with flow baffles) of up to 200m long have become colonised by a range of fish and invertebrates for some distances inside the culvert and the fish species present (eel, banded kokopu, red fin bully, inanga and koura, continue to be found up stream of the culverts.

223 Culvert installation in the Nukumea Stream occurred in 2006 as part of the ALPURT project. The culvert is 168 m long. The results of fish sampling above the culvert over the years post installation, are noted below.

| Nukumea Stream | TOTAL 2011 | 2010 | 2008 | 2007 | 2004 |
|---|---|---|---|---|---|
| Banded kokopu | 122 | 136 | 77 | 40 | 80 |
| Redfin bully | 31 | 55 | 62 | 30 | 23 |
| Longfin eel | 4 | 8 | 0 | 3 | 0 |
| Inanga | 2 | 5 | 0 | 1 | 1 |
| Giant bully | 2 | 0 | 0 | 0 | 1 |
| Koura | 58 | 251 | 85 | 82 | 68 |
| TOTAL | 161 | 204 | 139 | 74 | 105 |

224 The longest culverts were in the West Hoe stream (installed in 1999) at 234 m, and the results of sampling for that culvert are noted below.

| West Hoe Stream | TOTAL 2011 | 2010 | 2008 | 2007 | 2004 |
|---|---|---|---|---|---|
| Banded kokopu | 45 | 108 | 66 | 35 | 140 |
| Redfin bully | 50 | 38 | 17 | 13 | 8 |
| Longfin eel | 5 | 10 | 0 | 3 | 2 |
| Inanga | 2 | 54 | 0 | 1 | 116 |
| Giant bully | 0 | 1 | 0 | 0 | 0 |
| Common bully | 0 | 0 | 0 | 2 | 0 |
| Koura | 8 | 59 | 29 | 36 | 9 |
| TOTAL | 57 | 211 | 83 | 54 | 266 |

225 The data and observations suggest that adult inanga pass the longer culvert distance but juveniles do not pass as well. Banded kokopu pass the 168m culvert but do not pass the 234m culvert as well. Red fin bully and eel have no difficultly passing through long culverts.

226 The data suggest 120m culverts are passed by all species, but culverts over 200 m restrict Inanga, and reduce banded kokopu but have no affect on eel and koura.

227 There are 8 culverts in the alignment that are proposed to be over 150m, and two are over 200m. They are listed in several places including Technical report 14 and shown in the drainage plans submitted. The AEE at table 7.5 on page 163 shows the culvert length data. The culverts of length that could cause some passage issue are:

| Catchment and culvert ID number | Length |
|---|---|
| Wainui (W1) | 155 |
| Te Puka (T14) | 245 |
| Horokiri (H2) | 266 |
| Ration (R14) | 153 |
| Duck (D1) | 195 |
| Duck (D5) | 154 |
| Duck (D6) | 164 |
| Duck (D9) | 167 |

228 Of these culverts, three stand out as potential concerns for fish passage based on length: T14 (at the top of the Te Puka system) and H2, at the top of the Horokiri system. Both these culverts collect the headwater tributary of each system. Both are not perennial parts of the main waterway, and neither requires fish passage (there is no fish habitat above the proposed culverts). D1, the other culvert of length that could cause issue (but also D5,6 and D9) does not affect the main stem of Duck Creek. Passage in these tributaries is largely for eel, banded kokopu and bully and monitoring will be required to assess the response of the banded kokopu.

229 As for the steep slope culverts (primarily in Horokiri with a few in Te Puka), I am of the opinion, having walked those tributaries, that it is highly unlikely that they support fish. They where surface dry in late spring (2010) when I examined them. There are only a few that may have an eel or a banded kokopu in them. The presence of fish could be verified by further sampling, but in any case the only potential passage for these culverts must be via a climbing system. The one I propose involves an experimental mussel spat climbing rope system. This climbing system is shown in published material to facilitate climbing native fish over 1 to 2 m. Such a system has not however, been tried over the distances required in the Project (50m). Given the betterment of the aquatic habitat in general throughout the Horokiri and Te Puka, if such climbing passage systems fail I consider that the risk and loss of those very minor habitat areas would be fully mitigated in any case.

***Under-estimation of the value of ephemeral/intermittent streams***

230 There are a range of published papers reporting headwater stream research and the biological values of these systems. That array of papers focuses largely on aquatic macroinvertebrate communities and in most cases involve sampling water (requiring there to be some flow or pool habitat).

231 The majority of those publications note a lower taxanomic richness in the headwater flowing sections and pools than in perennial systems.[73]

232 The taxonomic composition has been found to generally be low and to vary within study areas in headwaters. The accumulative result of many headwater stream communities can be important at a landscape scale.[74] Clarke et al 2008 also concluded that middle order reaches had highest taxa richness. Clarke et al 2010 also in a study of headwater contributions show that macroinvertebrates occupying debris dams in three headwater streams with a gradient of flow permanence (perennial, intermittent, and ephemeral) show that mean taxon richness and abundance in debris dams were lower in the intermittent and ephemeral streams than in the perennial stream, and that the length of time without connected surface flow appeared to produce different patterns in community composition.

233 However, they also show that during wet periods, mean taxon richness, abundance, and community composition can be similar among the three streams. There was evidence for a strong effect of permanence of flow on taxon richness, abundance, and evenness within debris dams. Taxa from the perennial stream were extremely efficient at colonizing seasonally dry nearby streams. Differences in assemblage structure between these temporary and permanent headwater streams may only arise seasonally and also appear related to flow permanence.

234 Recently Storey et al (2011) report on a study investigating the differences between headwater habitats and their biodiversity "values".[75] In essence they show that what they consider were intermittent headwaters and probably ephemeral ones with a mud base when in pastoral landscapes (without riparian woody

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[73] Storey, R; Quinn, J 2008. Composition and remporal changes in macroinvertebrate communities of intermittent streams in the Hawke's bay, New Zealand. NZ Journal of Marine and Freshwater Research 42:109-125.

Smith, H; Wood, PJ; Gunn, J 2003. The influence of habitat structure and flow permanence on invertebrate communities in Karst spring systems. Hydrobiologia 510: 53-66.

Progar, RA; Moldenke, AR 2002. Insect population from temporary and perennially flowing headwater streams in western Oregon. Journal of Freshwater Ecology 17: 391-407.

Clarke, A; MacNally, R; Bond, N; Lake, PS 2010. Flow permanence affects aquatic macroinvertebrate diversity and community structure in three headwater streams in a forested catchment. *Canadian Journal of Fisheries and Aquatic Sciences*, 2010, 67:(10) 1649-1657.

[74] Clarke, A; MacNally, R; Bond, N; Lake, PS 2008. Macroinvertebrate diversity in headwater streams: a review. Freshwater Biology 53:1707-1721.

[75] Storey, RG; Parkyn, S; Neale, MW; Wilding, T; & Croker, G 2011. Biodiversity values of small headwater streams in contrasting land uses in the Auckland region. New Zealand Journal of marine and Freshwater research, 45(2): 231-248.

vegetation) have significantly lower taxonomic richness than perennial systems and that those fauna, are represented by and large by snails, worms and fly larvae and do not have the EPT fauna of the perennial or even hard bottom flowing intermediate systems. While they and others show that intermittent systems do have indigenous biodiversity values, all of that research still shows that the drier systems when in simple pastoral landscapes do not have the values of more flowing water streams.

235 In my assessment I valued tributaries with intermittent and perennial flow as being represented by the samples I took and (in keeping with the scientific literature) those tributaries with some level of native woody riparian vegetation and some form of surface stable flow are considered of at least moderate if not high value while those generally dry, steep, short, small, stock grazed sub-catchment ones in open pasture (such as along the western Horokiri valley slopes) are considered to be of much lesser ecological value (low value). I do not consider that that is an under-estimation of their value.

236 In the following photographs I illustrate some of those side tributaries I considered as ephemeral and as possibly intermittent in the Te Puka and Horokiri.

**Te Puka system western (true left) side tributaries**

**Ephemeral (middle)**

**Ephemeral tributary (upper)**

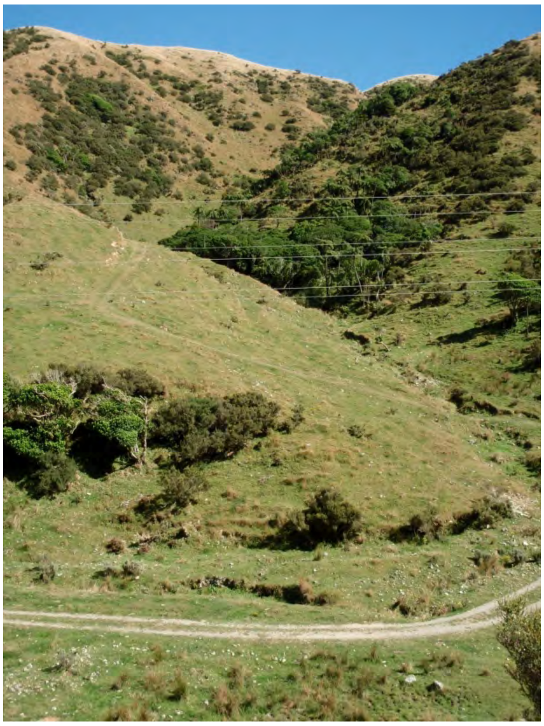
**Intermittent (middle-upper)**

**Ephemeral (lower)**

**Horokiri side tributaries**

**Ephemeral tributary (upper-middle)**

**Ephemeral tributary near confluence**



**Ephemeral but possible intermittent tributary (upper)**

**Under the Mahoe canopy**

**Ephemeral tributary**

**Ephemeral tributaries along the lower-middle western Horokiri system**

**Ephemeral tributary**

**Ephemeral tributary**

237 Regardless of their aquatic ecological value, the adverse effects of the Project are the installation of steep culverts in the lower reaches of the ephemeral tributaries and the road supporting bund and cuts, removing around 20% of the total linear length of those small channels. There remains therefore the greater part of most of the ephemeral tributaries in all cases other than several of the smallest and driest in the Te Puka catchment on the western slopes. In my

opinion any invertebrate or plant values that could be found in those systems, or simply the representation of those systems is sustained.

***Mitigation proposed is inadequate and lacks clarity***

238 DOC state that the mitigation proposed is inadequate and that it lacks clarity about the methodology used to determine which culverts should provide fish passage.

239 In regard to that issue I note the following rationale that I used to determine which culverts will require fish passage

240 I took the culvert list (produced by SKM in Technical Report 14) and ascribed each to an ephemeral / headwater condition or an intermittent / perennial condition based on flow data, catchment size and field observations of the proposed culvert position.

241 Having ascribed a "flow" condition I examined my data and field notes to determine the quantity and quality of up-stream aquatic habitat. This involved visiting most of the side tributaries along the western sides of the Te Puka and Horokiri and Duck systems. I assumed that all main stem and perennial flows required fish passage. That compiled knowledge was used to determine the need for fish passage. Where there is little to no water and or very limited surface water pooling, there is no need for fish passage. Nevertheless I have taken a cautious approach and have recommended fish passage strategies for tributaries that I do not consider actually have stable fish populations in them.

242 In summary I have recommended that 35 of the 125 culverts require fish passage and 82 do not. I am undecided on 8, but have recommended that they be designed to have fish passage as though that was required, to account for this uncertainty.

***SEV model is not the most appropriate method***

243 The last primary concern raised by DOC is about the use of the SEV model to quantify aquatic biodiversity offset. DOC consider that, given the freshwater values, the use of the SEV model is not the most appropriate method to quantify aquatic biodiversity offset, in part because it is only applicable to permanent streams. As a result, DOC is concerned that a lower compensation ratio may have been calculated.

244 The very purpose of the SEV tool, as is stated in the introduction to the SEV manual (Rowe et al 2008), is to establish a tool for calculating Environmental Compensation and to "ensure that there is no net loss of ecological value".

245 The SEV tool ensures the sufficiency, in ecological terms, of the offset because it requires the offset to be a water body (i.e. "like for

like") and by default to be at least 1.5 times the linear length affected (i.e. "no net loss").

246 While there are flaws in the SEV tool, it is still a developed tool (developed and tested by NIWA in 2008-2011) that delivers a positive gain result for a near as like for like compensation. It does have biodiversity components, it has fish species components, it has spawning components and invertebrate diversity and sensitivity components.

247 During the Plan change hearing, DOC expert, Dr Graham Ussher suggested the SEV should be replaced with methodologies listed by the Biodiversity Offsets Programme (*BOP*). I am familiar with the developing BOP models for offsetting, having recently used a prototype developed by Dr Theo Stevens (DOC) in the HMR wind farm case. I consider the model is no more useful, is more complicated, has as many assumptions, and is no more diversity focused, than the outcome of the SEV tool (model).

248 In my opinion the SEV tool provides an aquatic ecosystem functional and condition focus for environmental compensation that ensures an over compensation. And, in protecting habitat and habitat quality (as opposed to "Biological Diversity"), SEV assures the presence of existing individual species and provides the best focus on creating a situation for recolonising species such as diminished threatened fish species.

***Policy 4.2.13 of the RFP***

249 The last aspect of DOC's submission I address is policy 4.2.13 of the RFP. As I stated in my plan change rebuttal evidence[76] and in the evidence I present above on fish presence, the short jawed kokopu has only been recorded **once** in the Horokiri in 1989. I do not consider, given the habitat present that that species remains in the Horokiri or in the Duck Rivers. Furthermore I do not consider, based on the level of disturbance and poor habitat in the majority of the Ration that the Ration stream has the aquatic habitat condition to support any of the "threatened" species noted in Appendix 3 of the RFP, other than in its mouth (Coastal boundary). Lastly the RFP refers to banded kokopu as a "threatened" fish, which it is not, as per the most recent "threat" status assessment and National publication (Allibone et al 2010).

250 Nevertheless, in all waterways I sampled and report on, there is at least one "threatened"[77] and often two species of fish (giant kokopu, long fin eel, red fin bully, inanga or koaro). These species are not distributed evenly throughout the waterways but are sporadic and related to aquatic habitat conditions, for example the giant kokopu

76 Paragraph 46, page 8, Rebuttal Evidence of Dr Vaughan Keesing, June 13, 2011.

77 Allibone et al 2010.

are generally coastal and found in the lower reaches, while the koaro are headwater" fish typically in forested reaches.

251 The policy seeks the protection of nationally threatened indigenous aquatic plants and nationally threatened freshwater fauna (animals), not their habitat per se. The proposed adverse effects are limited (at least as much as has been made possible) in extent and in no waterway is the entire, or even a large proportion of aquatic habitat removed or diminished as to be unusable. Also the areas of effects are not foci of most of the remaining "threatened" fish (inanga, giant kokopu, koaro) which are in the lower and upper catchments, generally outside of the directly affected areas. Furthermore, and directly related to protection of the fauna, the proposed conditions[78] and draft management plans[79] requiring trap and relocation of fish species (no threatened aquatic plant species have been recognised in any of the waterways affected), as well as the wider mitigation / offsetting being proposed.

252 Given the above, I do not consider that the application is contrary to policy 4.2.13 of the RFP.

**PROPOSED CONDITIONS**

253 In regard to the protection of freshwater the critical aspects of the consent conditions revolve around the following aquatic ecosystem needs:

253.1 Ensure there is a suitable stream quality and aquatic habitat monitoring plan (building on the proposed EMMP) for pre, during and post construction monitoring. This includes the establishment of site specific "reasonable" mixing zones and the gathering of sufficient baseline (minimum 2 years (2 of each season)) on rainfall event size and sediment release, and aquatic community composition;

253.2 Ensure that there is an appropriate hierarchy of ecological indicators and water quality triggers and design of storm event disaster plan including what needs to be done when trigger levels and adverse effects are measured. Those trigger levels should be (and are best) set following collection of the proposed base line data (such as is required in the EMMP) and in consultation with the Regional Council (and any other relevant stake holder). There are a range of potential sediment discharge trigger values (such as 25 NTU or 20% over the baseline) and the correct one for the systems needs to be established. Likewise the tolerance for

[78] Condition S.9, 10.

[79] Proposed Ecological Management and Monitoring Plan (August 2011), Section 10.28, page 26.

change (the natural dynamic) should be established prior to effects monitoring of the macroinvertebrate communities to form that trigger. Condition E.25 requires the preparation of an EMMP which addresses the above trigger values and systems (which will require baseline monitoring);

253.3 Have a suitably qualified ecologist advise on all fish passage culvert designs at each final location and test for passage post installation;

253.4 Develop the full mitigation plan (from the proposed EMMP start) and ensure it is enacted correctly;

253.5 Develop and assist in the stream diversion creation plans, so as to ensure their form and function is correct;

253.6 Develop the full mitigation monitoring plan, to ensure targets are achieved or else appropriate actions are undertaken (in line with my comments above about monitoring mitigation success).

254 In my opinion, the consent conditions proposed in chapters 29 and 30 (the Designation conditions and the Resource Consent Conditions), appropriately cover the requirements listed above (aside from the need to specifically undertaken mitigation success monitoring, as discussed).

255 The conditions related to the designation (section 29 of the AEE) do not involve aquatic ecological matters specifically. However, they do require the preparation of a CEMP (Construction environmental management plan) and that plan has ecological protection aspects related to freshwater that will be sufficient to control of sediment runoff and protect against discharge of contaminants.

256 In the Resource consent conditions (section 30 of the AEE) there are also conditions relating to ecological matters and specifically to freshwater matters. I was involved in the preparation and review of these conditions and note the following:

256.1 The General conditions section includes G.12 which requires the need for a Construction Environment Management Plan. The CEMP proposed has satisfactory requirements to manage Stormwater run-on and off (G.15, G.16, G.19);

256.2 There is frequent address of sediment issues throughout the consent conditions in a number of places, but G.33 (2) site management, includes a range of procedures to ensure minimisation of sediment inputs to streams and the recording and management of processes that ensure that target is met;

256.3 The proposed conditions on the earthworks consent include a number of conditions related to fresh water and its protection, including E.3 (erosion and sediment control and the development of a plan (E.4)), as well as in E.15(d) event based criteria to measure at the outlet of treatment ponds, and E.18 (use of flocculent). Site specific environment plans (SSEMPs) are required by condition E.20. I have read these conditions and consider that they are sufficient to enable good management in regard to potential aquatic habitat threats (i.e. discharge of contaminants).

257 The Consent conditions address the mitigation required generally in S.5 with the requirement of the preparation of and implementation of a revegetation and mitigation strategy for the stream modifications and structures. It states that the revegetation and mitigation strategy shall include, but not be limited to:

257.1 Details, methods, timing and responsibilities for revegetation of all exposed areas of stream bank or dewatered channel or culvert fill slopes as a result of the consent, including methods for the protection of such areas;

257.2 Planting plan and schedules;

257.3 Monitoring and maintenance processes and procedures, including replacement of dead plants, for a period of three years from completion of construction.

258 In most cases the conditions cover those aquatic ecological requirements I think are necessary. However, I consider they could be improved by including a requirement that 26,000 linear metres of mitigation is required. This quantum is noted in Table 28.2 of the AEE, and could be added to condition E.22(e).

259 In addition, I consider that the conditions could be improved by requiring a mitigation monitoring plan (adding to E.25) that monitors the mitigation success (as discussed above) and directs the minimum content for that plan.

260 Such a new condition of consent should identify the development of a Mitigation Plan, for all mitigation aspects, based on my (and Mr Fullers and Dr De Luca's evidence, and the Technical Reports) and include the identification of the measure of mitigation success and what actions must occur following review findings that they are not occurring.

261 Targets are suggested in my discussion of monitoring mitigation success above, but the key targets are primarily biodiversity (stabilisation, and diversity) increase. The plan will need to recognise the time required for certain aspects of success to be

measurable. For example, it is only after 10 years that there is likely to be a measurable increase in native plant leaf litter presence, and woody debris, as well as a measurable increase in EPT diversity and general community composition.

**CONCLUSIONS**

262 A total of 5,286 m of stream will be permanently lost or significantly modified through culverting or shortening of stream length associated with diversion, and a further 5,132 m of stream will be diverted into new channels and the existing channel reclaimed. This totals some 10,418 linear metres of direct effect to waterways. The changes of habitat type due to culverts and diversions will result in moderate to high adverse effects depending on the stream value.

263 These adverse effects are on regionally significant aquatic systems as well as systems that are of lower value. All of the systems, regardless of their value are somewhat modified and somewhat tolerant to perturbations.

264 In my opinion none of the water bodies affected by the Project are of sufficient quality, composition or sensitivity to require avoidance of adverse effects in order to maintain their current values.

265 Effects related to sediment discharge into the streams will need to be well managed and it is likely that sediment will still be a significant issue during heavy rain events for short periods of time. Predictions of suspended sediment increase in the streams range from 2 to 43% above the background in a 10 year storm, but there is little predicted stream deposition.

266 While periodic larger discharges are not harmless, they are short term and do not significantly or permanently adversely affect the existing stream communities.

267 It is my opinion that construction effects can be managed to an extent that adverse effects will be sufficiently small and not long term.

268 Operational effects in terms of water quality will be generally neutral and, in lower reaches, even beneficial due to treatment being added where there is currently none.

269 Using the SEV tool, I have calculated that the protection and restoration of 26,500 m of stream is needed to mitigate (or compensate) for the loss described above. The land available for mitigation provides 30,000 m of stream. Investigations confirm that there is sufficient waterways that can be controlled by NZTA on site with the appropriate potential to achieve the mitigation required.

That mitigation has a strong potential to create a net aquatic ecological stream gain for the area.

270 With appropriate management (as put forward in the EMMP), the proposed diversions have a strong probability of creating as good, if not better, aquatic habitat as that that exists today and the culverts can be installed without fish passage being affected.

271 The adverse effects of the Project on streams will be ecologically significant, but generally in the short term only. I consider that the proposed mitigation is sufficient to ensure that the functional integrity of the waterways are maintained, and that no fish species or their access will be lost. I consider that the ecological enhancements recommended will, in the long term, result in a net benefit by raising the ecological health of historically modified streams through retirement, the removal of stock and revegetation (primarily in the Horokiri and Te Puka catchments).

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