NZ TRANSPORT AGENCY
WAKA KOTAHI

Roads of national significance

Ara Tūhono – Pūhoi to Wellsford

FURTHER NORTH

Pūhoi to Warkworth

Freshwater Ecology Assessment Report

August 2013

Pūhoi to Warkworth

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Glossary of abbreviations

Abbreviation	Definition
AEE	Assessment of Environmental Effects
ANZECC	Australian and New Zealand Environment Conservation Council
ARC	Auckland Regional Council
ARP:ALW	Auckland Regional Plan: Air, Land and Water
Condition	Refers either to Designation Condition or Resource Consent Condition
DoC	Department of Conservation
ECR	Ecological Compensation Ratio
MCI	Macroinvertebrate Community Index
MfE	Ministry for the Environment
NGTR	Northern Gateway Toll Road
NZ	New Zealand
NZFFD	New Zealand Freshwater Fish Database
NZTA	New Zealand Transport Agency
OPW	Outline Plan of Works
Project	Ara Tūhono Pūhoi to Wellsford Road of National Significance Pūhoi to Warkworth Section
QIBI	Quantitative Index of Biotic Integrity
RDC	Rodney District Council
RMA	Resource Management Act 1991
RoNS	Roads of National Significance
SEV	Stream Ecological Valuation
SHx	State Highway (number)
SKM	Sinclair Knight Merz
TP10	Auckland Regional Council Technical Publication Number 10: Stormwater Management Devices Design Guideline Manual
TP90	Auckland Regional Council Technical Publication Number 90: Erosion and Sediment Control Guidelines for Land Disturbing Activities
TSS	Total Suspended Solids

Glossary of defined terms

Term	Definition
ARI (Average Recurrence Interval) Event	The average, or expected, value of the periods between exceedances of a given rainfall total accumulated over a given duration.
Auckland Council	The unitary authority that replaced eight councils in the Auckland Region as of 1 November 2010.
Culvert	A pipe designed to convey water under a structure (such as a road).
Discharge	As defined in section 2 of the RMA, includes emit, deposit and allow to escape.
Diversion of Stormwater	Redirecting stormwater from its existing course of flow; causing it to flow by a different route.
Erosion Control	Methods to avoid or minimise the erosion of soil, in order to minimise the adverse effects that land disturbing activities may have on a receiving environment.
Fish Passage	The movement of fish between the sea and any river, including up-stream or downstream in that river.
Grassed Swales	Grassed swales are vegetated areas used in place of kerbs or paved gutters to transport stormwater runoff. They can also temporarily hold quantities of runoff and allow it to infiltrate into the soil.
Groundwater	Natural water contained within soil and rock formations below the surface of the ground.
Intermittent Stream	Intermittent Stream means any stream or part of a stream that is not a Permanent stream. Note: This definition does not include any artificial watercourse (including an irrigation canal, water supply race, canal for the supply for electricity power generation, farm drainage canal) and roadside drain and water-table except where the roadside drain or water-table is a modified element of a natural drainage system.
Motorway	Motorway means a motorway declared as such by the Governor-General in Council under section 138 of the PWA or under section 71 of the Government Roading Powers Act 1989.

Term	Definition
Permanent River or Stream	Permanent River or Stream means downstream of the uppermost reach of a river or stream which meets either of the following criteria: (a) Has continual flow; or (b) Has natural pools having a depth at their deepest point of not less than 150 millimetres and a total pool surface area that is 10m2 or more per 100m of river or stream bed length. The boundary between Permanent and Intermittent river or stream reaches is the uppermost qualifying pool in the uppermost qualifying reach. Notes: (1) This definition does not include any artificial watercourse (including an irrigation canal, water supply race, canal for the supply for electricity power generation, farm drainage canal) and roadside drain and water-table except where the roadside drain or water-table is a modified element of a natural drainage system. (2) Where there is uncertainty over the status of any stream the ARC will provide assistance and advice concerning the steps involved in making that determination. (3) Assessment for determining Permanent rivers or streams and Intermittent streams may be undertaken at any time of the year. Once a reach of a river or stream has been assessed as satisfying the criteria for categorising the stream as an Intermittent stream, upstream of the point of assessment will continue to be considered an Intermittent stream. Details of the assessment should be retained for the purposes of demonstrating the stream's status as an Intermittent stream.
Project Area	From the Johnstone's Hill tunnel portals in the south to Kaipara Flats Road in the north.
Sediment Control	Capturing sediment that has been eroded and entrained in overland flow before it enters the receiving environment.
Settlement	The gradual sinking of the ground surface as a result of the compression of underlying material.

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1. Introduction

This report:

- Identifies the freshwater ecological values of the Pūhoi to Warkworth section of the Ara Tūhono Pūhoi to Wellsford Road of National Significance (RoNS) Pūhoi to Warkworth Section (the Project);
- Identifies potential adverse effects of the Project on those values; and
- Presents recommendations to mitigate these adverse effects.

The principal components of the Project are also summarised.

1.1 Purpose and scope of this report

The purpose of this report is to:

- Identify the freshwater ecological values of the Project;
- Assess the effects of the Project on those ecological values; and
- Recommend mitigation to avoid, remedy or mitigate those effects where necessary.

This Report forms part of a suite of technical reports prepared for the NZ Transport Agency's (NZTA's) Ara Tūhono Pūhoi to Wellsford Road of National Significance (RoNS) Pūhoi to Warkworth Section (the Project). The purpose of this Report is to inform the Assessment of Environmental Effects (AEE) and to support the resource consent applications and Notices of Requirement for the Project.

The indicative alignment shown on the Project drawings has been developed through a series of multi-disciplinary specialist studies and refinement. A NZTA scheme assessment phase was completed in 2011. Further design changes have been adopted throughout the AEE assessment process for the Project in response to a range of construction and environmental considerations.

We anticipate that the final alignment will be refined and confirmed at the detailed design stage through conditions and the outline plans of works (OPW). For this reason, our assessment addresses the actual and potential effects arising from the indicative alignment, but covers the proposed designation boundary area.

Except as noted in this report:

- We consider that the sites we have selected for surveys and testing are generally representative of all areas within the proposed designation boundary; and
- The recommendations we propose to mitigate adverse effects are likely to be applicable to other similar areas within the proposed designation boundary, subject to confirmation of their suitability at the detailed design stage.

1.2 Project description

This Project description provides the context for this assessment. Sections 5 and 6 of the Assessment of Environment Effects (Volume 2) further describe the construction and operational aspects of the Project and should be relied upon as a full description of the Project.

The Project realigns the existing SH1 between the Northern Gateway Toll Road (NGTR) at the Johnstone's Hill tunnels and just north of Warkworth. The alignment will bypass Warkworth on the western side and tie into the existing SH1 north of Warkworth. It will be a total of 18.5km in length. The upgrade will be a new four-lane dual carriageway road, designed and constructed to motorway standards and the NZTA RoNS standards.

1.3 Project features

Subject to further refinements at the detailed design stage, key features of the Project are:

- A four-lane dual carriageway (two lanes in each direction with a median and barrier dividing oncoming lanes);
- A connection with the existing NGTR at the Project's southern extent;
- A half diamond interchange providing a northbound off-ramp at Pūhoi Road and a southbound on-ramp from existing SH1 just south of Pūhoi;
- A western bypass of Warkworth;
- A roundabout at the Project's northern extent, just south of Kaipara Flats Road to tie-in to the existing SH1 north of Warkworth and provide connections north to Wellsford and Whangarei;
- Construction of seven large viaducts, five bridges (largely underpasses or overpasses and one flood bridge), and 40 culverts in two drainage catchments: the Pūhoi River catchment and the Mahurangi River catchment; and
- A predicted volume of earthworks being approximately 8M m3 cut and 6.2M m3 fill within a proposed designation area of approximately 189ha earthworks.

The existing single northbound lane from Waiwera Viaduct and through the tunnel at Johnstone's Hill will be remarked to be two lanes. This design fully realises the design potential of the Johnstone's Hill tunnels.

The current southbound tie-in from the existing SH1 to the Hibiscus Coast Highway will be remarked to provide two way traffic (northbound and southbound), maintaining an alternative route to the NGTR. The existing northbound tie-in will be closed to public traffic as it will no longer be necessary.

1.4 Interchanges and tie-in points

The Project includes one main interchange and two tie-in points to the existing SH1, namely:

- The Pūhoi Interchange;
- Southern tie-in where the alignment will connect with the existing NGTR; and

- Northern tie-in where the alignment will terminate at a roundabout providing a connection with the existing SH1, just south of Kaipara Flats Road north of Warkworth.

2. Statutory and planning context

This section presents background information on Auckland's rivers and streams, and including how they are treated in the statutory and planning context. We note relevant Resource Management Act 1991 (RMA) provisions and other statutory and non-statutory plans which have helped inform our assessment and recommendations for managing freshwater aquatic ecosystems. These recommendations are to ensure that the life supporting capacity of freshwater aquatic ecosystems is safeguarded and that any adverse effects of the Project are avoided, remedied or mitigated. Further details of the specific statutory and non-statutory provisions are set out in the AEE, and summarised in this section.

2.1 Introduction – Auckland context

The Auckland Region contains much smaller rivers and streams than many other places in New Zealand. The characteristics of these water bodies are hugely variable, depending on factors such as geology, topography, land-use and the position of the river/stream in the catchment. The character of a stream in any one location also reflects its position in the catchment. A stream system can be thought of as a continuum, with the head of the stream at one end and the river mouth at the other. In reality, distinguishing the exact location where a stream starts can be extremely difficult. Zones of flowing water, standing water or simply moist ground vary seasonally and from year to year. This variability presents difficulties for consistently managing the use, development and protection of the Auckland Region's river and stream resources. Statutory and non-statutory plans assist with addressing this difficulty.

The Auckland Regional Plan: Air, Land and Water 2010 (ARP:ALW) in particular assists with managing the use, development and protection of the region's river and stream resources by defining and managing rivers and streams into two types: permanent and intermittent.

Permanent rivers or streams are those rivers or streams that provide year round habitat for fish and other freshwater biota. They also provide other instream values, notably regulating water quality and providing pathways for the migratory lifecycle of native fish.

There are approximately 16,650km of permanent rivers or streams in the Auckland Region. Approximately 90% are headwater streams with no more than one tributary and where width is generally less than 2m (Auckland Regional Council, 2010). Even the largest rivers (the Kaipara and Hoteo in Rodney District and the Wairoa River in Manukau City and Franklin District) are small compared to those in other parts of New Zealand. Small streams meandering through numerous short and steep catchments are characteristic of the narrow (30 - 60km wide) Auckland Region.

The values of such streams may not always be immediately apparent from a specific section of stream, particularly where streams have been modified or are degraded. However on a cumulative basis these streams comprise the major part of the region's freshwater environment. Each permanent river or stream therefore plays an important role in contributing to the overall habitat, water quality and connectivity of freshwater bodies at the regional scale.

Intermittent streams are those streams which do not provide permanent or year round freshwater habitat. The ARP:ALW simply defines these as any stream that does not meet the "permanent River or Stream" definition. However, intermittent streams also contribute to catchment hydrology and instream values. The extent of this contribution will vary from stream to stream.

The small scale of river and stream resources in Auckland makes them more susceptible to risk from land activities than larger streams. Small streams are easy to physically modify through channelisation, removal of riparian vegetation, and burying in culverts and pipes. Stream channels in urban areas are often modified and designed to facilitate the drainage of stormwater from roads, houses and buildings. In rural areas, the removal of native riparian vegetation, the introduction of unwanted weed and pest species, unrestricted access for stock and water extractions have all contributed to the degradation of streams. For example, the construction of dams provides water supply benefits to rural and urban users, and enables the restoration, creation or maintenance of natural wetlands. However dams also result in the modification of the natural flow regime and habitat values upstream and downstream of the dams, as well as the area flooded by the dam water. Dams and culverts can also be insurmountable barriers to the movement of native fish, while degraded water quality can reduce the suitability of habitats for freshwater fauna.

Although these modifications have social and economic benefits, the ecological values of streams are important in terms of biodiversity and ensuring the health and wellbeing of ecosystems. Water quality is also important for recreational activities as well as stock and human consumption (water quality matters are addressed in the Construction Water and Operational Water Assessment reports).

2.2 Statutory framework

2.2.1 Resource Management Act 1991

The overriding control on developments such as the Project is the RMA, which is based on the concept of sustainable management of natural and physical resources.

Under section 7 of the Act all persons shall have particular regard to (amongst other things):

> 7(d) *intrinsic values of ecosystems*

2.2.2 National Policy Statement for Freshwater Management 2011

The National Policy Statement for Freshwater Management 2011 (Freshwater NPS) sets out objectives and policies for freshwater management under the RMA. The RMA requires local authorities to amend regional plans to give effect to any provision in a national policy statement that affect those documents.

The Auckland Council has not yet given effect to the Freshwater NPS. As such, with respect to freshwater environments, the NPS provides the following interim measures:

Policy A4

1. *When considering any application for a discharge the consent authority must have regard to the following matters:*

    a. *the extent to which the discharge would avoid contamination that will have an adverse effect on the life-supporting capacity of fresh water including on any ecosystem associated with fresh water; and*

    b. *the extent to which it is feasible and dependable that any more than minor adverse effect on fresh water, and on any ecosystem associated with fresh water, resulting from the discharge would be avoided.*

2.2.3 Auckland Regional Plan: Air, Land and Water (ARP:ALW)

The ARP:ALW manages water quality issues in the Auckland Region. Declining water quality and quantity in rivers and streams and a reduction in their natural character is a significant issue addressed by this Plan.

2.2.4 Non-statutory documents

Several other non-statutory plans, such as the Mahurangi Action Plan and the NZTA Environment Plan, contain objectives and policies relating to water resources in general (NZTA Environment Plan) and the Mahurangi River in particular (Mahurangi Action Plan).

Further details on the relevant statutory and non-statutory framework for freshwater ecology that we have had regard to when undertaking this assessment are set out in the AEE.

3. Methodology

Our methodology consisted of a review of existing data, as well as assessments of representative aquatic habitats.

We evaluated the quality of the freshwater habitats along the indicative alignment by reviewing existing information and undertaking assessments of representative habitats in both the Pūhoi and Mahurangi catchments.

We obtained existing information from the New Zealand Freshwater Fisheries Database (NZFFD), Auckland Council database and a range of publications.

Our assessments of freshwater habitats were undertaken in two stages. The first stage, which was undertaken over the period October 2010 - May 2011, included proposed crossing locations over six representative permanent streams throughout a representative range of land-use types and catchments along the alignment. These initial assessments were supplemented by a second stage of visual assessments of a number of waterways in the vicinity of the proposed culvert locations under low flow (drought) conditions in March-April 2013.

Our assessments involved the collection of basic water quality and ecological data, the latter including such characteristics as stream width, depth, substrate types, aquatic plants, macroinvertebrates and fish.

We collected habitat data following the protocol known as the Stream Ecological Valuation (SEV) methodology. This methodology combines a broad range of physical, chemical and biological functions in a single, standardised, assessment framework that permits us to assess and compare the health of a range of stream types.

3.1 Data review

We initially identified stream crossings along the preferred route identified during the scheme assessment phase for the Project from plans provided by the Project design engineers and/or those shown as a blue line on Topo 50 (1:50,000 national map series) series topographical maps. We also searched the New Zealand Freshwater Fish Database (NZFFD) and reviewed relevant data regarding fish and aquatic habitats within the Pūhoi and Mahurangi catchments from sources such as the then Auckland Regional Council. We also reviewed the existing Auckland Council on-line database of State of the Environment monitoring (Auckland Council Database).

Auckland Council undertakes aquatic biological monitoring at three sites within the Pūhoi and Mahurangi catchments within the vicinity of the indicative alignment, as part of its State of the Environment reporting. These sites are not actually within the proposed designation boundary but are located on relatively substantial permanent waterways, such as the Pūhoi and Mahurangi Rivers in the area of the Project. We consider that the monitoring information obtained at these sites provides an indication as to the quality of the freshwater habitats in this part of the Auckland Region. Details of the biological monitoring sources that we accessed are referenced below in relation to our description of the aquatic ecology of the Pūhoi and Mahurangi catchments.

3.2 Habitat assessments

3.2.1 Introduction

We undertook our aquatic habitat assessments along the indicative alignment in two stages (the scheme assessment phase and the current phase). Because of constraints on access in the scheme assessment phase, we could only examine 16 of the 22 stream crossing sites initially identified along the indicative alignment (Bioresearches, 2011a). We observed that seven of these crossing sites had minimal or restricted flows (October - November 2010) and identified them as potential intermittent watercourses. Our subsequent visual assessment confirmed our view that six of these sites - P2, P3, P5, P6, P8, M21a - were intermittent. We also undertook habitat assessments at five representative sites in permanent watercourses – two in the Pūhoi catchment (P7, P10) and three) in the Mahurangi catchment (M16, M19 and M22) (see Table 5 and drawing FE101).

We chose these five sites as they:

- Were permanent watercourses located along the indicative alignment, within the Pūhoi or Mahurangi catchments;
- Were representative of the two principal land-use types within these catchments (rural and forestry);
- Will be culverted by the indicative alignment; and
- Were within reaches representative of the overall habitat provided by the watercourse.

We also made on the ground, visual assessments of thirty-three potential culvert and bridge sites (Table 5) in association with representatives of Hōkai Nuku.

3.3 Assessment protocol

Our assessment of each of the five representative sites involved the collection of water quality data, a visual assessment of the aquatic plants, sampling of the macroinvertebrates (recognised indicators of aquatic habitat quality) and fish. Each sampling is discussed below. We also recorded general habitat characteristics such as stream width, depth and substrate type.

(a) Water Quality

We measured water temperature, dissolved oxygen and conductivity *in situ* using a pre-calibrated water quality meter (model YSI professional series).

(b) Aquatic Plants

We recorded the dominant species of aquatic plants, and retained samples for laboratory identification.

(c) Macroinvertebrates

We sampled the macroinvertebrate communities (snails, insect larvae) in accordance with the Ministry for the Environment's current "Protocols for Sampling Macroinvertebrates in Wadeable

Streams" (Stark, Boothroyd, Harding, Maxted and Scarsbrook, 2001). We used Protocol "C2: soft-bottomed, semi-quantitative".

Macroinvertebrate samples were preserved by our field scientists in isopropyl alcohol, and returned to the laboratory and sorted using the Protocol "P2 (200 fixed count & scan for rare taxa)" as outlined in Stark et al (2001). Macroinvertebrates were identified to the lowest practicable level and counted by a qualified and experienced taxonomist. Taxonomic richness (the number of taxa) and community composition were also assessed.

The taxonomist calculated biotic indices to assess the ecological condition of the community, namely taxa richness; "EPT" taxa richness and the Macroinvertebrate Community Index (MCI). EPT taxa richness is the number of three generally pollution-sensitive orders of insects (Ephemeroptera or mayflies; Plecoptera or stoneflies; Trichoptera or caddisflies) recorded in a sample. The MCI is based on the average pollution sensitivity scores for individual taxa recorded (Stark, 1998). The recently developed soft-bottomed MCI (MCI-sb; Stark & Maxted, 2007) was calculated, using the protocol developed by Stark & Maxted, for all sites. In this index: MCI scores of >120 are indicative of clean water or 'excellent' habitat quality; 100 – 120 are indicative of 'good' quality or possible mild organic pollution; 80 – 100 are indicative of 'fair' quality or probable moderate pollution; and <80 are indicative of 'poor' quality or probable severe pollution (Stark & Maxted, 2007).

(d) Fish

We sampled the fish using an EFM300 backpack electric fishing machine. A minimum of 30m of accessible stream was fished in one pass. Stunned fish were captured using a combination of stop-and-scoop-nets. All fish captured were identified by the field scientists, counted and their size estimated before being returned to their habitats. We used this information to calculate a Quantitative Index of Biotic Integrity (QIBI), which indicates how intact the fish community is based on altitude and distance inland in comparison to other Auckland stream sites (Joy & Henderson, 2004). In this index scores of 50-60 are 'Excellent', 42-49 are 'Very Good', 36-42 as 'Good', 28-35 as 'Fair', 18-27 as 'Poor', and 6-17 as 'Very Poor'. A score of zero is assigned where no native fish are recorded.

(e) Habitat Characteristics

To supplement the data collected on the water quality, aquatic plants, macroinvertebrates and fish, we collected additional habitat data (16 functions; 31 variables) following the protocol developed by the Auckland Regional Council (ARC) known as the Stream Ecological Valuation (SEV) methodology (Rowe et al, 2008 as amended by Storey et al, 2011).

This methodology combines a broad range of physical, chemical and biological functions in a single, standardised, assessment framework that permits the health of a range of stream types (e.g. small headwater streams, larger low-gradient pastoral streams) to be assessed and compared. The stream's ecological function is ranked 0=poor to 1=excellent. This methodology is regularly reviewed. The most recent review of this methodology (Storey et al, 2011) reduced the number of functions being to 14 and the number of variables from 31 to 28. A comparison of the revised methodology procedure with the earlier (2008) procedure indicates that there is little difference in the overall SEV results however better definition is obtained with the most recent procedure.

3.4 Assessment criteria

3.4.1 Ecological values

As stated in Section 3.3, freshwater ecological values in this Report are based on the SEV procedure in which a broad range of physical, chemical and biological functions of a stream are described (see the SEV Manual for detailed descriptions of these functions) (Table 1). The SEV methodology also incorporates macroinvertebrate indicators (such as MCI, %EPT and taxa richness) and fish QIBI.

Table 1: Ecological functions contained in the SEV Manual

Ecological function	
Hydraulic functions	• Natural flow regime • Floodplain effectiveness • Connectivity for natural species migrations • Natural connectivity to groundwater
Biogeochemical functions	• Water temperature control • Dissolved oxygen levels • Organic matter input • Instream particle retention • Decontamination of pollutants
Habitat provision functions	• Fish spawning habitat • Habitat for aquatic fauna
Biodiversity provision function	• Fish fauna intact • Invertebrate fauna intact • Riparian vegetation intact

As an example of how the SEV scales the physical, chemical and biological functions of a stream, the dissolved oxygen levels maintained (DOM) is scaled based on the indicators of oxygen reducing processes shown in Table 2.

Table 2: Scoring of oxygen reducing processes in the SEV

Status	Indicators of oxygen reducing process	Score
Optimal	• No anaerobic sediment • No odours or bubbling when sediments are disturbed • Little or no macrophyte (in summer) or areas of slow flow, low shade and soft substrate (in winter)	1
Sub-optimal	• No anaerobic sediment • Some bubbling when sediments are disturbed, but no sulphide odour • Moderate macrophyte biomass (in summer), or areas of slow flow, low shade and soft substrate (in winter)	0.75
Marginal	• Small patches of anaerobic sediment present • Some bubbling with sulphide odour when sediments are disturbed • Some sewage fungus may be present • Dense macrophyte biomass (in summer) or large areas of slow flow, low shade and soft substrate	0.5
Poor	• Much black anaerobic sediment • Extensive bubbling with sulphide odour when sediments are disturbed • Surface scums may be present • Abundant sewage fungus	0.25

The SEV methodology assesses the performances of each function (14 functions evaluated as shown in Table 1) compared to reference site conditions, and provides a framework to compile, interpret and report the results in a numeric scoring system (0-1).

As an example, the overall SEV scores of the five reference sites (relatively unmodified streams in bushed catchments in the Albany area of the Auckland Region) were all greater than or equal to 0.90. In contrast, the SEV for the Mahurangi River in exotic forest scored 0.68, the Vaughan Stream (Albany basin) in a rural catchment scored 0.44 and the Botany Creek (East Auckland) in an urban catchment scored 0.25 (Storey et al, 2011).

While the SEV assessment criteria have been developed for permanent streams, Storey (2010) has considered applying this approach to the characterisation of intermittent streams. However, because of the limitations of the application of the SEV methodology to intermittent streams (for example, the lack of flow for part of the year) we visually assessed the intermittent streams. We undertook these assessments under summer drought conditions that prevailed during late summer 2013. Our assessments were based primarily on the descriptors for permanent and intermittent streams presented in the ARP:ALW set out in Section 2.1.

To define the status of the other permanent streams crossed by the indicative alignment (that is streams other than the representative streams that we assessed), we determined the dominant catchment land-use for each stream (forestry or rural). We then attributed the stream a status based on that predominant land use.

An inherent assumption of our method is that a particular permanent stream on the alignment supports water quality, macroinvertebrates and fish species commensurate with those streams in the Auckland Region that flow from that same catchment type (as assessed and recorded by Auckland Council and included in the Auckland Council Database).

In our opinion this assumption is well founded. The Auckland Council Database shows a strong relationship between catchment type and stream status for streams in the Auckland Region that have been assessed by Auckland Council. The results from testing of the five representative streams and visual assessments of other permanent streams are similar to the database results, which validates our approach.

We only assessed the intermittent streams visually and did not undertake comprehensive sampling as in most cases there was no or insufficient water to sample for macroinvertebrates (net sweeps), to undertake electrofishing or set fish traps. We determined their status as intermittent or permanent using the criteria in the ARP:ALW. While we acknowledge that intermittent streams form an integral component of some waterways, their contribution to the overall habitat quality of the waterway depends on the degree to which the intermittent stream is able to sustain a viable aquatic biological ecosystem. During periods when water is present in sufficient amounts to provide a suitable habitat for a diverse aquatic flora and fauna (periphyton, macroinvertebrates and fish) then the intermittent stream forms an integral component of a waterway. However during periods when water is absent from the intermittent stream, this stream is no longer able to support a viable aquatic biological ecosystem, and as such is no longer a viable stream. We acknowledge however that under such "dry" conditions the intermittent stream may contain eggs and resting stages of some stream macroinvertebrates (e.g. ostracods). Therefore, the potential exists for the stream to become a viable aquatic biological ecosystem once sufficient water is present. This factor needs to be considered when the status of the intermittent stream is defined.

We visually assessed the intermittent streams on the indicative alignment under summer low flow conditions in summer 2013 which has been identified as the driest period in the past 70 years. We acknowledge that under the present climatic conditions such droughts are an infrequent event. However, we consider that our evaluation under the prevailing summer low flow conditions is valid. We did not undertake a detailed assessment of the remnant aquatic habitats present in some of the intermittent streams (such as an SEV). We consider, however, that the general absence of adequate water to sustain a viable aquatic biological ecosystem means that the existing ecological condition of the intermittent streams must be regarded as poor. We applied this status to all of the intermittent streams on the indicative alignment. Our evaluation of which streams were intermittent should be confirmed at the detailed design stage.

3.4.2 Conservation Status

The Department of Conservation has developed a system for classifying organisms according to their risk of extinction (Townsend et al, 2008). The conservation status of New Zealand freshwater fish has been updated (Allibone et al, 2010). We compared the freshwater aquatic species recorded in the streams along the indicative alignment to the Department of Conservation data sets to determine the ‘species’ conservation status.

4. Existing aquatic habitats

We present a summary of existing aquatic habitats on a catchment basis (Pūhoi and Mahurangi catchments) in the vicinity of identified stream crossings (bridges and culverts) along the indicative alignment based on the data from the five representative streams we assessed and by our visual assessments of most of the remaining stream crossing locations. This summary includes a record of:

- Physical characteristics (catchment use, stream width, depth, substrate type, aquatic plants);
- In-situ water quality (temperature, dissolved oxygen);
- Macroinvertebrates (insect larvae, snails); and
- Fish species.

The aquatic biological data indicates that the quality of freshwater aquatic habitats along the indicative alignment is typical of aquatic habitats found in the Auckland Region and is primarily determined by the land-use in the associated catchment.

Five aquatic species, namely a freshwater mussel, freshwater crayfish, inanga, redfin bully and the longfin eel, present in these catchments are in gradual decline nationally. These fish species are common throughout the Auckland Region and have been recorded in a wide range of aquatic habitats.

The Project is an extension of SH1 from the NGTR at the Johnstone's Hill tunnels to just north of Warkworth. The alignment passes through two catchments, the Pūhoi catchment in the south, and the Mahurangi catchment in the north. With respect to the State of the Auckland Region Freshwater Report Cards produced by the Auckland Council (Auckland Regional Council, 2010), these two catchments constitute the major part of the Warkworth reporting area.

This section presents a general overview of the state of the environment and biodiversity of freshwater of the Auckland Region, with emphasis on the ecology of those freshwater habitats. This overview is followed by an overall assessment of the ecology of the freshwater habitats in the two Project catchments, based on historical data and the site-specific assessments undertaken on the representative permanent streams that will be crossed by the indicative alignment. We note that we have split up our discussion of representative streams into the two catchments to align with the approach to other technical assessments. The representative streams we surveyed are, however, generally representative of all streams in the Project area. Our discussion goes on to place the quality of the freshwater habitats that will be crossed by the alignment into the context of freshwater habitats in the Auckland Region.

4.1 State of the environment and biodiversity of freshwater habitats in the Auckland Region

The Auckland Region has around 16,650km of permanent rivers, 4,480km of intermittent rivers and 7,110km of ephemeral rivers. Most rivers are relatively small (less than a few metres wide). 63% of rivers flow through non-forested rural land while 21% flow of rivers flow through native forest. Native forest rivers generally have healthy biological communities, but urban streams generally have impoverished fauna (Auckland Regional Council, 2010).

Auckland Council monitors 52 freshwater sites across the Auckland Region, using macroinvertebrates, which are recognised indicators of the quality of freshwater habitats. Macroinvertebrates are suitable as such indicators primarily because of their abundance and diversity, with various species having specific requirements for habitat and water quality (e.g. mayflies - high levels of dissolved oxygen). The diversity and abundance of the macroinvertebrates may be summarised in an index, such as the MCI, with the index score being used to interpret the habitat quality. The MCI scores are discussed above in Section 3.

In the Auckland Region, the MCI scores have been found to range from 44 to 141 (Auckland Council, 2010). Sixteen sites (31%) are classified as excellent; 13 (25%) sites as good; 14 (27%) as fair and 9 (17%) as poor. Most of the 16 excellent sites considered by Auckland Council in 2010 were in rivers that drained from forested catchments (both native and exotic), while only three were from catchments with more intensive land-use types, such as rural and urban.

Rivers in the Auckland Region contain seventeen species of native fish (Table 3). Most of these species are “diadromous” (they need to migrate between freshwater and the sea to complete their life cycle). Thus, a greater number of these species are expected to be found close to the coast and at low elevation. The QIBI used by Auckland Council predicts which fish species should be present at a site based on elevation and distance from the coast, and compares this prediction with the fish species actually recorded at that site (Auckland Regional Council, 2010).

An assessment by the former ARC of the ecological quality of different land-use types in the Auckland Region found that native forest sites were generally good quality (average QIBI = 39.1), exotic forest, pasture and urban sites were fair (respective average QIBI of 33.7, 30.0 and 28.6). The low QIBI scores for pasture and urban sites may be partially attributed to the higher number of man-made barriers to fish passage such as culverts, weirs and dams likely to be present in these catchments (Auckland Regional Council, 2010).

Table 3: Native fish species in the Auckland Region (Auckland Regional Council, 2010)

Common name	Scientific name	Frequency of occurrence (% of sites)	Distribution
Banded kokopu	Galaxias fasciatus	39	Widespread
Shortfin eel	Anguilla australis	37	Widespread
Longfin eel	Anguilla dieffenbachii	33	Widespread
Common bully	Gobiomorphus cotidianus	20	Frequent
Inanga	Galaxias maculatus	17	Frequent
Redfin bully	Gobiomorphus hutton	13	Frequent
Cran's bully	Gobiomorphus basalis	10	Frequent
Giant bully	Gobiomorphus gobioides	3	Sparse
Common smelt	Retropinna retropinna	2	Sparse
Torrentfish	Cheimarrichthys fosteri	2	Sparse
Koaro	Galaxias brevipinnis	1	Rare
Giant kokopu	Galaxias argenteus	1	Rare
Dwarf inanga	Galaxias gracilis	<1	Rare
Black mudfish	Neochanna diversus	<1	Rare
Bluegill bully	Gobiomorphus hubbsi	<1	Rare
Shortjaw kokopu	Galaxias postvectis	<1	Rare
Lamprey	Geotria australis	<1	Rare

The seven most common native fish species in the Auckland Region (banded kokopu, shortfin and longfin eel, common bully, inanga, redfin bully and Cran's bully) have been recorded by the likes of the National Institute of Water and Atmospheric Research (NIWA), Auckland Council and ourselves that have fished these catchments in both the Pūhoi and Mahurangi River catchments. With the exception of Cran's bully, all of these fish species require access to the lowland areas of streams or the sea to complete their life-cycle (they are diadromous, with the juveniles moving upstream into adult habitats).

An indication of the distribution of these fish species throughout the Pūhoi and Mahurangi River catchments, based on freshwater habitat assessment surveys reported in the NZFFD (Figure 1 and undertaken over the period 1986 to 2011, is presented in Table 4.)

The ability of fish to migrate upstream is influenced by several factors including swimming ability, water temperature and behaviour (Boubee et al, 1999). In addition to swimming, several indigenous fish species, such as banded kokopu, koaro and eels, have the ability to climb moist surfaces. An example of this climbing ability is presented in Plate I, which shows young koaro (one of the whitebait species) climbing up concrete walls of a velocity barrier in the Wairehu Canal, Central North Island. Young banded kokopu, recorded in the Project catchments, have a similar climbing ability.

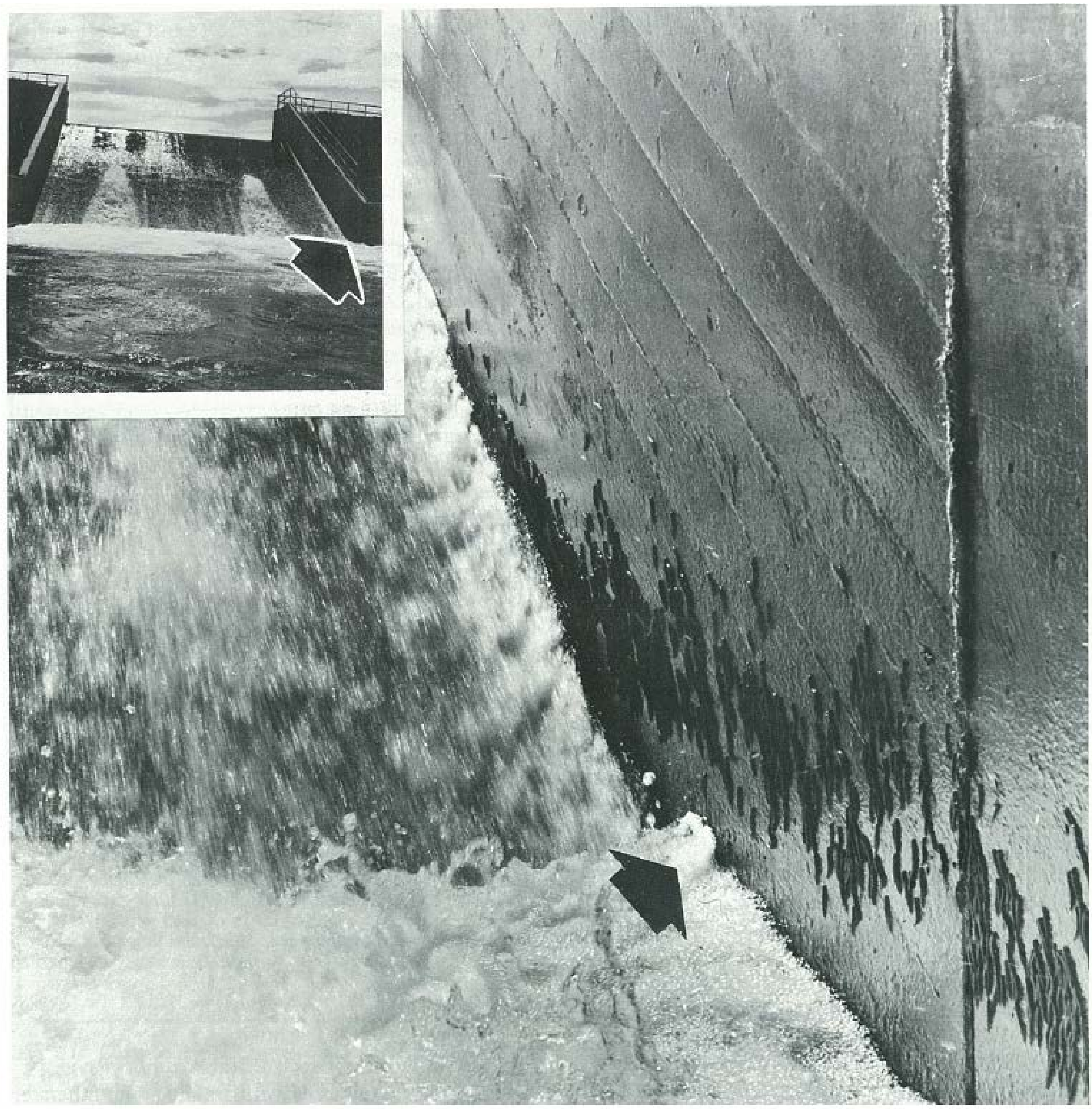

Plate I: Whitebait of the koaro (*Galaxias brevipinnis*) climbing up concrete walls of a velocity barrier in the Wairehu Canal (McDowall, 1990)

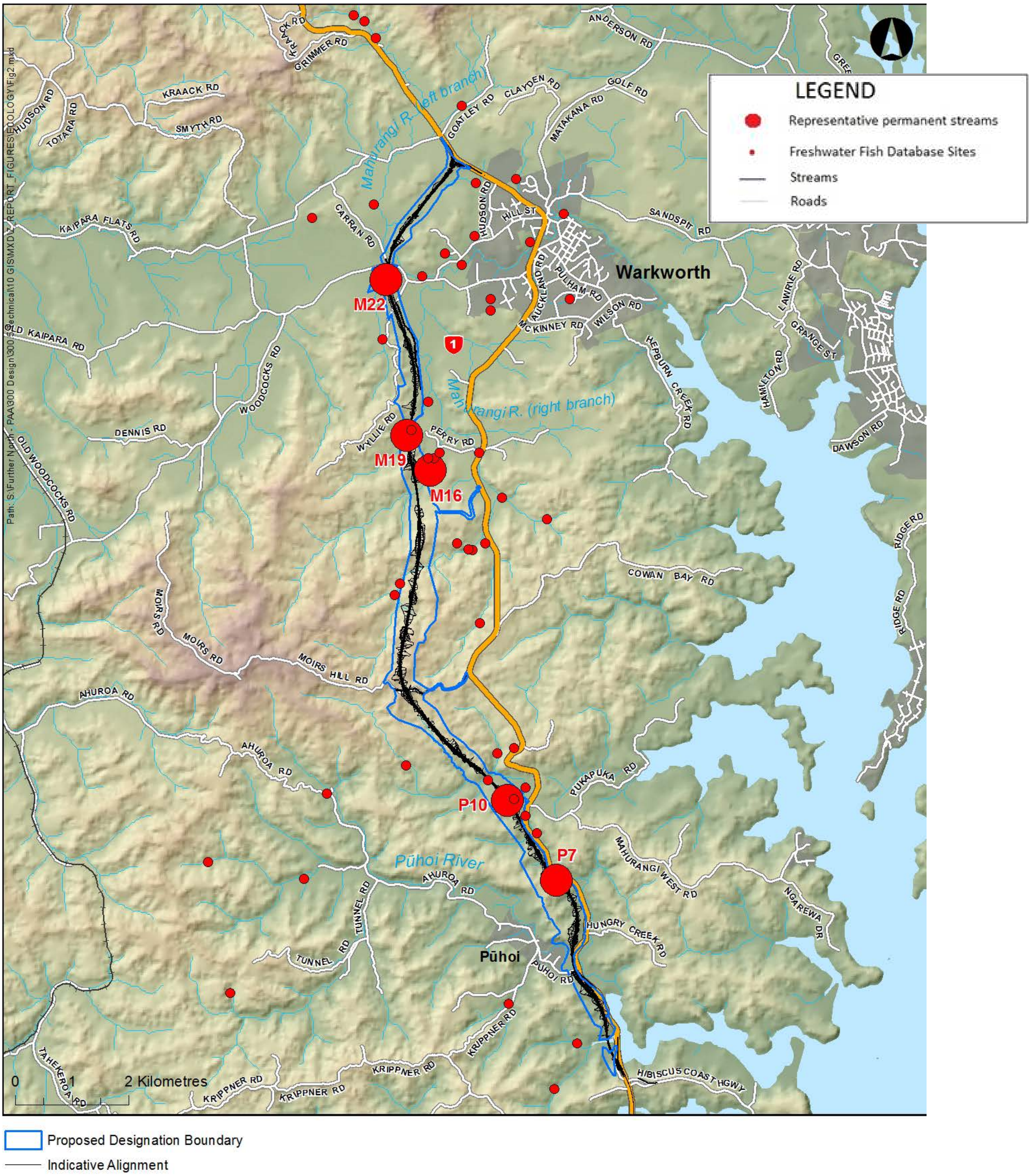

Figure 1: Map of representative streams and Freshwater Fish Database streams in the Pūhoi and Mahurangi Catchments

Table 4: Freshwater Fish Database sites – Pūhoi and Mahurangi River Catchments (1986 – 2011)

				Location			Habitat				Water Quality				Macroinvertebrates		Fish Species	
NZ Reach ID	FFDB Card No.	Survey Date	Surrounding land-use	Altitude (m)	Inland Dist (km)	Topo map ref	Average Width (m)	Average Depth (m)	Dominate Habitat type	Dominate Substrate Type	Temp (°C)	Colour	Clarity	Conductivity (mS/m)	Bottom fauna abundance	Predominant species	Field survey from FFDB Records	Koura found
Pūhoi catchment																		
2002729	3931	3/2001	Rural	20	1.1	E2659600 N6517100	1.5	0.2	Pool	-	15.5	-	-	-	Unknown	Unknown	Banded kokopu	Yes
2002720	3932	3/2001	Rural	5	0.3	E2660000 N6517900	0.9	0.4	Run	-	14.2	-	-	-	Unknown	Unknown	Inanga, Common bully Longfin eel	No
2002662	3928	3/2001	Rural	30	3.8	E2658800 N6518600	1.9	0.6	Pool	-	14.0	-	-	-	Unknown	Unknown	Common bully Inanga Longfin eel Redfin bully	Yes
2002646	2763	3/2001	Native forest	60	11.6	E2653900 N6518800	2.1	0.3	Pool		16.9	-	-	-	Unknown	Unknown	Banded kokopu Longfin eel	Yes
2002509	2764	3/2001	Rural	30	8.7	E2655200 N6520800	4.9	0.6	Pool	-	19.2	-	-	-	Unknown	Unknown	Crans bully Inanga Longfin eel	Yes
2002479	34565	12/4/2011	Native forest	78	11.0	E2653505 N6521104	1.7	0.1	Run	Fine gravel	13.5	uncoloured	Clear	14	Unknown	Unknown	Eel Bully	Yes
2002354	2770	3/2001	Native forest/Rural	30	9.1	E2655600 N6522300	2.5	0.3	Run	-	15.2	-	-	-	Unknown	Unknown	Longfin eel Redfin bully	No
2002297	2766	3/2001	Native forest	60	8.2	E2657000 N6522800	3.4	0.4	Pool	-	17.1	-	-	-	Unknown	Unknown	Banded kokopu Crans bully Longfin eel Redfin bully	Yes
2002366	34549	23/11/2010	Native forest/Exotic forest/Rural	41	6.2	E2658433 N6522535	2.1	0.5	Run	Mud	15.2	Uncoloured	Clear	13	Moderate	Koura	No species found	Yes
2002441	2767	2/2001	Native forest/Rural	20	4.4	E2659300 N6521600	2.8	0.3	Run	-	18.3	-	-	-	Unknown	Unknown	Crans bully Longfin eel	Yes
2002401	10629	2/7/2001	Rural	30	5.4	E2658900 N6522200	0.8	0.2	Run	Coarse gravel	7.9	Uncoloured	Clear	10	Moderate	Other	Shortfin eel Inanga Banded kokopu Crans bully	Yes
2002289	10632	3/7/2001	Native forest/Rural	50	6.4	E2658600 N6523000	5.0	0.5	Run	Mud/Bedrock	7.4	Uncoloured	Milky	13	Moderate	Mayflies	No species found	Yes
2002289	10634	3/7/2001	Native forest/Rural	120	6.5	E2658900 N6523100	0.3	0.1	Run	Mud	11.4	Uncoloured	Milky	14	Low	Caddisflies	No species found	No
2002367	10628	2/7/2001	Rural	30	5.3	E2659100 N6522400	1.2	0.6	Run	Mud	8.2	Uncoloured	Milky	12	High	Snails	Shortfin eel Crans bully Common bully	No
2002403	10627	2/7/2001	Native forest/Exotic forest/Rural	20	4.7	E2659100 N6521900	4.0	0.7	Run	Mud	7.9	Uncoloured	Milky	10	High	Snails	Common bully	No

NZ Reach ID	FFDB Card No.	Survey Date	Surrounding land-use	Location			Habitat				Water Quality				Macroinvertebrates		Fish Species	
				Altitude (m)	Inland Dist (km)	Topo map ref	Average Width (m)	Average Depth (m)	Dominate Habitat type	Dominate Substrate Type	Temp (°C)	Colour	Clarity	Conductivity (mS/m)	Bottom fauna abundance	Predominant species	Field survey from FFDB Records	Koura found
Mahurangi catchment																		
2002104	11048	8/6/1989	Native forest/Exotic forest	100	14.1	E2658300 N6525300	3.0	0.3	Pool	Mud	-	Tea	Milky	-	Low	Mayflies	Longfin eel	Yes
2002078	31317	30/4/2009	Rural	68	12.6	E2658173 N6526584	-	-	-	-	15.6	-	-	20	Unknown	Unknown	Longfin eel Crans bully Bully Eel	Yes
2002079	2386	3/2001	Exotic forest/Rural	75	12.4	E2658400 N6526700	1.0	0.4	Pool	-	17.9	-	-	-	Unknown	Unknown	Crans bully Longfin eel	Yes
2002043	31318	30/4/2009	Exotic forest	77	12.5	E2659489 N6527120	-	-	-	-	14.6	-	-	18	Unknown	Unknown	Longfin eel Eel Crans bully	Yes
2002016	2765	3/2001	Native forest	50	11.5	E2658700 N6527500	1.7	0.4	Pool	-	17.8	-	-	-	Unknown	Unknown	Crans bully Eel Longfin eel Redfin bully	Yes
2001970	17180	24/3/1998	Native forest/Rural	50	10.6	E2658300 N6528300	4.0	0.2	Pool	Bedrock	-	Uncoloured	Clear	-	Unknown	Unknown	Crans bully Longfin eel Shortfin eel	Yes
2002078	3129	22/5/1997	Exotic forest	80	12.9	E2657900 N6526700	7.0	0.2	Pool	Bedrock	-	-	Milky	-	Low	Koura	Crans bully Longfin eel	No
2002078	18562	17/11/1998	Exotic forest/Rural	60	12.7	E2658100 N6526600	2.0	0.1	Riffle	Bedrock	-	-	-	-	Low	Unknown	Eel Crans bully	Yes
2002138	3132	19/4/1996	Exotic forest	110	14.5	E2656800 N6525800	1.0	0.2	Pool/Riffle	Mud	-	Tea	Dirty	-	Unknown	Unknown	No species found	Yes
2002107	3445	13/6/1997	Exotic forest	105	14.2	E2656900 N6526000	1.0	0.1	Run/Riffle	Cobble	-	Uncoloured	Milky	-	High	Mayflies	No species found	Yes
2001936	11047	8/6/1989	Native forest/Exotic forest/Rural	30	7.0	E2657500 N6528200	2.0	0.1	Run/Riffle	Cobble	-	Uncoloured	Clear	-	High	Other	Common bull Redfin bully Longfin eel Shortfin eel	Yes
2001936	3933	3/2001	Native forest/Exotic forest/Rural	50	11.0	E2657400 N6528200	8.2	0.5	Pool	-	16.0	-	-	-	Unknown	Unknown	Crans bully Longfin eel Shortfin eel	Yes
2001936	9151	23/9/1986	Native forest/Exotic forest/Rural	50	7.0	E2657600 N6528300	3.5	-	Pool	Bedrock	11.9	Tea	Milky	-	Moderate	Other	Eel Common bully	Yes
2001933	9844	8/12/1992	Native forest/Rural	50	9.8	E2657100 N6528700	-	-	Run	Bedrock	-	-	Clear	-	Unknown	Unknown	Crans bully Longfin eel Shortfin eel	Yes
2001898	8050	23/9/1986	Native forest/Rural	40	9.1	E2657400 N6529200	2.0	-	Pool	80	11.8	Tea	Milky	-	Moderate	Other	Longfin eel Common bull Redfin bully	Yes
2001795	20777	9/2/2005	Rural	25	4.8	E2658500 N6530800	1.0	0.1	Run	Mud	22.9	Tea	Dirty	-	Unknown	Unknown	No species found	No
2001825	22790	3/2/2005	Urban	50	5.2	E2659900 N6531000	-	-	-	-	-	-	-	-	Unknown	Unknown	Banded kokopu Shortfin eel	Yes

NZ Reach ID	FFDB Card No.	Survey Date	Surrounding land-use	Location			Habitat				Water Quality				Macroinvertebrates		Fish Species	
				Altitude (m)	Inland Dist (km)	Topo map ref	Average Width (m)	Average Depth (m)	Dominate Habitat type	Dominate Substrate Type	Temp (°C)	Colour	Clarity	Conductivity (mS/m)	Bottom fauna abundance	Predominant species	Field survey from FFDB Records	Koura found
2001795	20776	9/2/2005	Rural	20	4.7	E2658500 N6531000	0.4	0.1	Run	Mud	20.1	Tea	Dirty	-	Unknown	Unknown	Eel	No
2001824	3131	22/5/1997	Rural	50	8.2	E2656600 N6530300	1.5	1.0	-	Mud	-	-	Milky	-	Low	Unknown	Eel	No
2001684	34553	29/10/2010	Native forest/Rural	46	8.2	E2656451 N6532675	2.5	0.6	Run	Mud	13.5	Uncoloured	Clear	13	Moderate	Other	Shortfin eel Common bull Inanga	Yes
2001631	2272	2/2001	Rural	50	10.8	E2658000 N6534400	4.0	0.5	Pool	-	19.5	-	-	-	Unknown	Unknown	Crans bully Shortfin eel	No
2001516	2273	2/2001	Native forest	70	12.6	E2656100 N6536000	1.5	0.2	Run	-	17.2	-	-	-	Unknown	Unknown	Crans bully Longfin eel	Yes
2001506	8835	3/11/2000	Native forest/Exotic forest	60	12.4	E2656300 N6535900	2.0	0.2	Pool/Riffle	Cobble	12.9	Uncoloured	Clear	-	High	Mayflies	Longfin eel Crans bully	No
2001532	8838	3/11/2000	Native forest/Exotic forest	60	12.0	E2656500 N6535600	0.8	0.1	Pool	Bedrock	12.5	-	Clear	-	High	Mayflies	Longfin eel	Yes
2001696	29388	14/12/2006	Urban	35	6.4	E2658253 N6533043	1.0	0.4	-	-	-	-	-	-	Unknown	Unknown	Redfin bully	No
2001658	29398	8/3/2007	Urban	30	3.8	E2658960 N6533114	1.2	0.5	-	-	-	-	-	-	Unknown	Unknown	Common bull	No
2001658	29393	20/3/2007	Urban	7	2.9	E265537 N6532436	1.0	0.2	-	-	-	-	-	-	Unknown	Unknown	Inanga	No
2001711	30734	26/11/2009	Urban/Native forest/Scrub	20	2.6	E2659800 N6532500	-	-	Still	Bedrock	-	Tea	Milky	-	Moderate	Snails	Longfin eel Shortfin eel Common bull	No
2001706	29386	14/12/2006	Rural	25	5.3	E2658222 N6532108	1.2	0.6	-	-	-	-	-	-	Unknown	Unknown	Gambusia	No
2001787	18250	19/2/2003	Native forest/Exotic forest/Rural	35	5.8	E2657700 N6531800	1.0	0.3	Run	Mud	16.8	Tea	Milky	-	High	Other	Shortfin eel Eel	No
2001789	18025	19/2/2003	Native forest/Farming	20	5.4	E2658000 N6531600	0.6	0.2	Run	Mud	16.8	Uncoloured	Milky	-	High	Other	Eel Crans bully Shortfin eel	No
2001738	30732	26/11/2009	Urban	20	3.6	E2659200 N6532000	-	-	Pool	Cobble	-	Tea	Milky	-	Moderate	Snails	Common bull Shortfin eel	No
2001794	2383	2/2001	Rural	30	6.3	E2657300 N6531400	10.6	0.4	Pool	-	20	-	-	-	Unknown	Unknown	Crans bully Eel Longfin eel Shortfin eel	Yes

Mitchell and Boubee (1989) have developed a locomotory classification for some of New Zealand's freshwater fish species, which divided these species into four groups:

1. Anguilliforms - eels, juvenile banded kokopu, koaro and torrentfish.

2. Climbers - lamprey, eels, juvenile kokopu, koaro, shrimp, common and redfinned bullies.

3. Jumpers - trout, salmon, smelt, inanga and some kokopu species.

4. Swimmers - inanga, smelt, grey mullet and juvenile bullies.

For the purposes of this assessment we grouped the species that may be affected by the Project into climbing and swimming fish. We did this grouping on the basis that there is some overlap in the locomotory classification. With respect to those fish species recorded in the Pūhoi and Mahurangi catchments, the Anguilliforms (eels, juvenile banded kokopu) and Climbers (eels, juvenile banded kokopu, common and redfin bullies) were grouped as Climbers, while inanga and Cran's bullies were grouped as Swimmers because of their inability to climb any significant instream obstacles.

Jumpers, such as trout and salmon, are not present in the streams that will be crossed by the indicative alignment.

Among the native fish recorded in the vicinity of the indicative alignment, the longfin eel, inanga and redfin bully are in gradual decline (Allibone et al, 2010). Our examination of NZFFD records indicates that native fish species dominate the fish fauna of the Pūhoi and Mahurangi River catchments with only three exotic species recorded - common carp, grass carp (both farmed in private ponds at Genesis Aquaculture, Perry Road) and mosquito fish, the latter being recorded in the Mahurangi River catchment.

4.2 Pūhoi River catchment

The Pūhoi River catchment comprises some 5,252ha and extends from the mouth of the Pūhoi River to Moirs Hill to the northwest (Rodney District Council, 2010). The land-use comprises a combination of native and production forest and pasture. The Pūhoi River, which flows largely through the centre of the catchment, is the principal freshwater system in the catchment. This river is supplemented in its lower reaches by the inflow from the Hikauae Creek. Several tributaries flow directly into the lower reaches of the Pūhoi River. However, the majority of tributaries that cross the alignment flow into the Hikauae Creek that flows along the eastern edge of the existing SH1.

This catchment comprises the Pūhoi, Hungry Creek and Schedewys Hill Sectors. The indicative alignment has structural crossings for 19 freshwater streams and two estuarine waterbodies (refer to Drawing FE-101). Of the freshwater streams, we identified thirteen streams (68%) as intermittent and six (32%) as permanent (Table 5).

The catchment sizes of the intermittent streams that will be culverted as part of the Project ranged from 0.64ha (P10a) to 26.93ha (P8) with a mean size of 10.3ha, while the catchment sizes of permanent streams culverted ranged from 2.47ha (P6a) to 93.92ha (P9) with a mean size of 27.8ha.

With respect to the intermittent streams within the indicative alignment, culvert lengths ranged from 55m (P10a) to 262m (P3) which we calculated to have a mean length of 125.5m, while the culvert lengths in the permanent streams ranged from 75m (P6a) to 146m (P11b/c) which we calculated to have a mean length of 101.5m (Table 5).

Table 5: Ecological, catchment, culvert and fish passage data for the indicative alignment

New Culvert ID	Sector	Culvert Size (mm)	Culvert Length (m)	Upstream Level (m)	Downstream Level (m)	Grade (%)	Catchment Size (ha)	Ecological Reference	Ecological Status	Fish Passage	Passage Type
ON ALIGNMENT											
BRIDGE - OKAHU VIADUCT	Pūhoi							P1	Estuarine	N/A	"Swimming"
Culvert 63800	Pūhoi	1600	165	5	1	2%	13.81	P2	Intermittent	None	None
Culvert 63500	Pūhoi	1800	262	12	3	4%	16.70	P3	Intermittent	None	None
Culvert 63000	Pūhoi	1350	92	9	5	5%	7.97	P3a	Intermittent	None	None
BRIDGE - PŪHOI VIADUCT	Pūhoi							P4	Estuarine	N/A	"Swimming"
Culvert 61900	Hungry Creek	1600	99	26	25	1%	12.43	P5-VA	Intermittent	None	None
Culvert 61600	Hungry Creek	1800	62	25	24	2%	19.82	P6-VA	Intermittent	None	None
Culvert 61300	Hungry Creek	1200	75	27	20	9%	2.47	P6a-VA	Permanent	None	None
Culvert 61100	Hungry Creek	1350	81	20	12	10%	10.08	P7-VA	Permanent	None	None
Culvert 60800	Hungry Creek	1950	127	20	15	4%	26.93	P8-VA	Intermittent	None	None
BRIDGE - WATSON ROAD OVERPASS	Hungry Creek							P9-VA	Permanent	N/A	"Climbing"
Culvert 60200	Hungry Creek	3060	104	18	14	4%	93.92	P9-VA	Permanent	Baffle	"Climbing"
Culvert 59900	Hungry Creek	1200	65	32	27	8%	0.80	P9b	Intermittent	None	None
Culvert 59800	Hungry Creek	1600	121	28	21	6%	9.31	P9a-VA	Intermittent	None	None
BRIDGE - HIKAUAE VIADUCT	Hungry Creek							P10	Permanent	N/A	None
Culvert 59400	Hungry Creek	1200	55	48	45	5%	0.64	P10a-VA	Intermittent	None	None
BRIDGE - SCHEDEWYS VIADUCT	Hungry Creek							P11-VA	Permanent	N/A	"Swimming"
Culvert 58700	Schedewys Hill	1600	116	91	64	23%	2.51	P11a-VA	Intermittent	None	None
Culvert 58400	Schedewys Hill	1600	146	103	67	25%	4.87	P11b/c-VA	Permanent	None	None
Culvert 57600	Schedewys Hill	1600	137	135	119	12%	10.76	P11f-VA	Intermittent	None	None
Culvert 57400	Schedewys Hill	1350	96	156	132	24%	10.27	P11g-VA	Intermittent	None	None

New Culvert ID	Sector	Culvert Size (mm)	Culvert Length (m)	Upstream Level (m)	Downstream Level (m)	Grade (%)	Catchment Size (ha)	Ecological Reference	Ecological Status	Fish Passage	Passage Type
ON ALIGNMENT											
Culvert 57200	Schedewys Hill	1600	235	162	138	10%	2.38	P12-VA	Intermittent	None	None
Culvert 56700	Moirs Hill Road	1600	123	181	164	14%	3.99	M13	Intermittent	None	None
Culvert 56400	Moirs Hill Road	1200	97	179	170	10%	3.68	M13a-VA	Intermittent	None	None
Culvert 56100	Moirs Hill Road	1200	84	173	162	13%	1.58	M13b-VA	Intermittent	None	None
Culvert 55300	Moirs Hill Road	2550	81	135	130	6%	33.81	M13d-VA	Permanent	Baffle	"Climbing"
Culvert 54700 ARCH	Moirs Hill Road	Arch (8534 Span, 4267 Height)	258	80	78	1%	345.81	M15	Permanent	Natural Bed	"Climbing"
Culvert 53800	Moirs Hill Road	1600	70	106	106	1%	11.38	M15a-VA	Intermittent	None	None
Culvert 53000	Perry Road	1600	175	65	51	8%	4.27	M16a	Intermittent	None	None
BRIDGE - PERRY ROAD VIADUCT	Perry Road							M16	Permanent	N/A	"Climbing"
BRIDGE - KAURI ECO VIADUCT	Perry Road							M18/19-VA	Permanent	N/A	“Swimming”
Culvert 51900	Perry Road	1200	77	53	46	8%	1.15	M19a	Intermittent	None	None
Culvert 51600	Perry Road	1200	84	47	43	5%	6.62	M19b	Intermittent	None	None
Culvert 51300	Perry Road	1800	172	41	34	4%	13.57	M19c	Intermittent	None	None
Culvert 51000	Perry Road	1600	124	40	35	4%	6.15	M21a-VA	Intermittent	Baffle	"Climbing"
Culvert 50800	Perry Road	1200	94	43	36	7%	2.23	M21b-VA	Permanent	None	None
Culvert 50500	Perry Road	1200	92	43	39	4%	3.72	M21c-VA	Intermittent	Baffle	"Swimming"
Culvert 50200	Perry Road	1600	109	38	35	2%	7.64	M21d-VA	Intermittent	Baffle	"Swimming"
BRIDGE - WYLLIE ROAD OVERPASS	Perry Road							M21e	Intermittent	N/A	"Swimming"
Culvert 49500 ARCH	Perry Road	Arch (7315 Span,	104	32	31	1%	195.15	M22-VA	Permanent	Natural Bed	"Swimming"

New Culvert ID	Sector	Culvert Size (mm)	Culvert Length (m)	Upstream Level (m)	Downstream Level (m)	Grade (%)	Catchment Size (ha)	Ecological Reference	Ecological Status	Fish Passage	Passage Type
ON ALIGNMENT											
		3658 Height)									
BRIDGE - WOODCOCKS ROAD VIADUCT	Carran Road							M23/24-VA	Permanent	N/A	"Swimming"
BRIDGE - CARRAN ROAD FLOOD RELIEF BRIDGE	Carran Road							-	Permanent	N/A	"Swimming"
Culvert 48000	Carran Road	1350	45	34	34	1%	8.25	M23a-VA	Permanent	None	"Swimming"
Culvert 47700	Carran Road	1350	71	33	33	0%	6.46	M23b-VA	Permanent	None	"Swimming"
Culvert 47400	Carran Road	1600	60	36	34	4%	11.43	M23c-VA	Permanent	Baffle	"Swimming"
Culvert 47200	Carran Road	1200	61	41	37	6%	2.31	M23d-VA	Intermittent	Baffle	"Climbing"
ON SH1 ALIGNMENT											
Culvert 700SH1S	Carran Road	1600	69	41	36	7%	8.77	SH1-700	Intermittent	None	None
PROPERTY ACCESS ROAD (Off Wyllie Road)											
Culvert 100A	Perry Road	1050	22	32	31	2%	5.04	PA100A-VA	Intermittent	Baffle	"Swimming"
Culvert 200A	Perry Road	900	21	32	32	1%	8.63	PA200A-VA	Intermittent	Baffle	"Swimming"
Culvert 500A	Perry Road	900	33	36	34	5%	5.54	PA500A-VA	Intermittent	Baffle	"Swimming"
BRIDGE - PROPERTY ACCESS ROAD OFF WYLLIE ROAD	Perry Road							PA900A-VA	Permanent	N/A	"Swimming"

NOTE:
N/A = Not Applicable (bridges will not influence fish passage)
VA = Visually Assessed

4.2.1 Intermittent streams

Intermittent streams are those streams that contain flowing water for most of the year, but cease flowing or dry completely for a period of days or weeks in a year of average rainfall. These streams are characterised by poorly defined flow paths and very limited aquatic habitat suitable for aquatic plants, macroinvertebrates or fish.

(a) Streams affected by the Project

To the south of the Project area, the indicative alignment includes structural crossings for intermittent streams (P2, P3 and P3a) from three average-sized catchments of 13.81ha, 16.70ha and 7.97ha respectively. These streams drain grazed pasture and have minimal riparian shading.

Plate 11: Intermittent stream, lower Pūhoi River catchment – vicinity of P2

To the north of the Pūhoi River, the balance of the intermittent tributaries of the Hikauae Creek (Hungry Creek Sites P5, P6, P8, P9a, P9b, P10a, P11a, P11f, P11g and P12) drain forestry plantation pine blocks owned by Asia Pacific Forestry. These intermittent tributaries have catchments that range from 0.64ha (P10a) to 26.93ha (P8).

The 13 intermittent streams identified in the Pūhoi River catchment that will be culverted have smaller catchments (mean: 10.3ha) than the permanent streams (mean: 27.8ha) identified.

(b) Physical characteristics/habitat quality

Overall, we characterised all 13 intermittent streams as poor quality habitat, low banks with poorly defined flow paths, generally soft substrate, and very limited aquatic habitat suitable for aquatic plants, macroinvertebrates and fish. The intermittent streams in the lower Pūhoi River catchment also had little riparian vegetation, which results in any open water areas being subject to solar radiation with consequential heating. While those streams in the forestry area are well shaded by the pine forest, they contain little free-standing water and thus very limited aquatic habitat available for colonisation by instream organisms such as macroinvertebrates and fish. The proximity of the intermittent streams in the southern part of the Pūhoi River catchment to the Hikauae Creek in particular, indicates that under flowing conditions some migrating fish species (assuming no significant obstacles are present) may be able to access these streams.

4.2.2 Permanent streams

(a) Streams affected by the Project

We recorded four permanent streams (P6a, P7, P9, P11b/c) in the Pūhoi River catchment that will be culverted, and two permanent streams (P10 and P11) will be crossed by viaducts (Hikauae and Schedewys) (Table 5). We used two streams that we considered to be generally representative of the permanent streams in this catchment based on land-use primarily supplemented by our assessments of the permanent streams in the Mahurangi catchment to characterise the habitat quality, namely P7 and P10. We assessed these two streams using standard aquatic biological procedures (MCI, SEV and electrofishing). The results of these assessments are summarised in Table 6.

(b) Physical characteristics/habitat quality

Our assessments determined that, based on the MCI (Table 6), the habitat quality of streams P7 and P10 varied between poor and fair (MCI scores of 75 and 96 respectively). Based on the limited physical habitat present in P7, combined with the downstream falls that limited fish species able to use this tributary to one species (banded kokopu a recognised "climbing" fish), we consider the habitat in this tributary to be of poor quality. Although the stream P10, a tributary of the Hikauae Creek, is largely in a rural catchment and contains a soft substrate (unsuitable for a number of macroinvertebrate species) we assessed the quality of this habitat to be fair due to the presence of aquatic weed, which provides habitat suitable for some species of macroinvertebrates, and also the linkage of this tributary with the larger Hikauae Creek.

(c) In-situ water quality

Our in-situ measurements of temperature and dissolved oxygen indicated that these two streams were cool and well oxygenated - 80% (P10) and 94% (P7), and we considered the smaller stream (P7) to be spring fed.

(d) Macroinvertebrates

We recorded thirteen macroinvertebrate taxa in the smaller stream (P7), including the common mayfly (*Deleatidium*), the caddisfly (*Polyplectropus*), the common freshwater snails (*Potamopyrgus* and *Planorbis*), the waterbug (*Microvelia*), in association with isopods, amphipods, ostracods, mites, chironomid (midge) larvae, dragonfly larvae, a leech and fly larvae.

The larger stream (P10) contained twelve macroinvertebrate taxa, including three from the generally sensitive EPT (Ephemeroptera; Plecoptera; Trichoptera group of insects (mayflies, stoneflies, caddisflies). Koura (freshwater crayfish) were also abundant.

(e) Fish

We only recorded one fish species, a banded kokopu, in the smaller stream (P7). We attributed this lack of species to the presence of a small waterfall in the lower reaches of this stream, which acts as a barrier to upstream migration by non-climbing species, such as inanga. The small and shallow nature of this stream also limits available habitat for fish. In contrast, the larger stream (P10) provided habitat for a range of fish species, including banded kokopu, Cran's bully, inanga and shortfin eel. We considered that this contrast was due in part to the linkage of stream P10 with the larger Hikauae Creek. We ranked the diversity of fish species as "very good" (Table 6).

Table 6: Aquatic biological assessment data from representative permanent streams in the Pūhoi and Mahurangi River catchments

Survey Site	Survey Date	Surrounding Land Use	Location	Habitat				Water Quality			Macroinvertebrates				Fish Species			SEV Score
			Topo map ref	Average Width m	Average depth m	Substrate type	Aquatic Plants	Temp °C	Dissolved Oxygen mg/L	Dissolved Oxygen % saturation	No. of taxa	EPT taxa	Dominant taxa	MCI	Field Survey	FFDB Records (nearby sites)	Fish IBI	(2008 version)
Pūhoi River																		
P7	20 May 2011	Native bush/pine forestry	E21748981 N5958953	0.6	0.1	Clay/ bedrock	None	12.9	9.3	94	13	2	Mayflies	75 Poor	Banded kokopu	-	24 Poor	0.66
P10	23 Nov 2010	Rural	E1748267 N5960455	1.0	0.1	Mud	Watercress, Willow weed	13.8	8.3	80	12*	3	Amphipods	96 Fair	Banded kokopu	Crans bully Inanga Shortfin eel	42 Very good	0.53
Mahurangi River																		
M16	28 Oct 2010	Rural / pine forestry	E1746889 N5966274	3.4	0.3	Mud	None	13.5	10.5	101	17*#	8	Midge larvae	123 Ex	Longfin eel Eel Common bully	Longfin eel Shortfin eel Redfin bully Cran's bully Common bully	46 Very good	0.84
M19	28 Oct 2010	Rural	E1746517 N5967018	1.9	0.25	Mud	None	13.7	9.1	88	16*#	4	Sandfly larvae	104 Good	Longfin eel Eel Crans bully	Longfin eel Shortfin eel Redfin bully Cran's bully Common bully	32 Fair	0.77
M22	27 Oct 2010	Rural	E1746042 N5969572	2.8	0.3	Mud	Willow weed, Ludwigia, Ottelia, Watercress, Pond weed, Starwort,	16.9	8.6	89	7	1	Amphipods	52 Poor	Shortfin eel Common bully	Eel Common bully Redfin bully	22 Poor	0.54

* Freshwater crayfish (koura) present # Freshwater mussels present

4.3 Mahurangi River catchment

The Mahurangi River drains a 58km^2 (5824ha) catchment comprising steep hills and gently rolling lowlands. The catchment a number of sub-cacthchments, which include the northern and southern sub catchments of 14km^2 (Mahurangi Left Branch) and 25km^2 (Mahurangi Right Branch) respectively, which join the Mahurangi River mainstem to flow into the Mahurangi Harbour at Warkworth. The catchment land-use is predominantly grazed pasture in the lowland area, with plantation and native forest on the hill country. The catchment ranges from Moirs Hill in the south to Dome Hill in the north.

The Mahurangi River catchment comprises the Moirs Hill, Perry Road and Carran Road Sectors. The indicative alignment includes structural crossings for 17 intermittent streams and 12 permanent streams (refer to Drawing FE-101 and Table 5) through this catchment.

4.3.1 Intermittent streams

As with the intermittent streams in the Pūhoi River catchment, the intermittent streams in the Mahurangi River catchment cease flowing or dry completely for a period of days or weeks in a year of average rainfall. The intermittent streams located within the pine forest in the southern part of this catchment are characterised by poorly defined flow paths and very limited aquatic habitat suitable for aquatic plants, macroinvertebrates and fish. We observed that the flow paths of most of these streams are covered with pine needles and associated organic litter from the pine forest in which they are located.

Many of the more northern intermittent streams in this catchment are located in pasture, and have well defined flow paths, but limited riparian cover (comprising grasses) and almost stagnant water under low flow conditions. As with a number of the intermittent streams in the Pūhoi River catchment, a number of the intermittent streams in the Mahurangi River catchment are close to a tributary of the Mahurangi River. Therefore, under flowing conditions, migrating fish species may be able to use these streams.

(a) Intermittent streams affected by Project

The streams located in the southern part of the Mahurangi River catchment predominantly flow from forested catchments (primarily exotic forest), while those in the northern part of the catchment flow from predominantly rural catchments. The catchment areas of the intermittent streams range from 1.15ha (M19a) to 13.57ha (M19c).

Of the 17 intermittent streams being crossed by the indicative alignment, one (M21e) will be bridged. The remainder will be culverted.

The 16 intermittent streams that will be culverted by the indicative alignment have significantly smaller catchments (mean: 5.88ha) than the seven permanent streams that will be culverted (mean: 86.16ha). One intermittent stream (M21e) will be bridged.

(b) Physical characteristics / habitat quality

The intermittent streams associated with the forested catchments generally have poorly defined flow paths, a soft muddy substrate and provide limited aquatic habitat for aquatic plants, macroinvertebrates and fish (Plate III). While the intermittent streams in the northern rural catchments of the wider Mahurangi River catchment have more defined flow paths and support some aquatic plants, they also contain generally soft muddy substrates and are poor quality aquatic habitats (Plate IV).

Plate III: Intermittent stream in pine forest, Mahurangi River catchment – vicinity of M13a

Plate IV: Intermittent stream in rural catchment, Mahurangi River catchment – vicinity of M23a

The intermittent streams in the Perry Road and Carran Road Sectors, located in pasture, also largely contain soft (mud) substrate. However, their proximity to the Mahurangi River however indicates that although these streams may generally be poor quality aquatic habitats, they are likely to act as pathways for "climbing" migrating fish (such as banded kokopu and eels) to access smaller headwater streams in the upper catchment. These streams also support "swimming" fish species (such as the inanga), which are predominantly found in such lowland streams close to the sea.

4.3.2 Permanent streams

(a) Streams affected by Project

Of the 12 permanent streams in the Mahurangi catchment that will be crossed by the indicative alignment, seven (M13d, M15, M21b, M22 and M23a-c) will be culverted while five (M16, M18/19, M23/24, (Carran Road Flood Relief Bridge) and PA900A) will be crossed by viaducts/bridges (Table 5). We assessed one of these streams that will be culverted (M22) plus two permanent streams that will be bridged (M16, M18/19) using standard aquatic biological procedures (MCI, SEV and electrofishing) to enable the quality of these streams to be evaluated and compared to other permanent streams in the Auckland Region. These streams were representative of those within the Mahurangi River catchment that are located within exotic and native forest (M18/19 and M16) and rural (M22) catchments. Although one of these streams will be bridged (M16), we undertook a detailed assessment of this stream, as it contained a ribbon of native vegetation and had the potential to be a high quality aquatic habitat (Plate V).

Plate V: Permanent stream in native forest catchment, Mahurangi River catchment - vicinity of M16.

(b) Physical characteristics/habitat quality

The habitat quality of the three representative streams that we assessed, based on the MCI scores, vary from poor (M22) to excellent (M16), with MCI scores of 52 and 123. The lower habitat quality recorded for M22 is due to the influence of the development of the catchment of this stream for agriculture. This catchment use is also reflected by the SEV scores of 0.84 (M16 - native forest), 0.77 (M18/19 - rural/exotic forest) and 0.54 (M22 - rural catchment).

Streams M16 and M18/19 are located in catchments developed for agriculture/forestry and contain remnants of native forest, and the quality of these habitats are good (M18/19) and excellent (M16).

(c) In-situ water quality

All of the streams are well oxygenated (88% - 101% saturation), with those in the forested catchments (M16 and M19) being cooler than the stream in the rural catchment (M22).

(d) Macroinvertebrates

Both of the predominantly forested streams contain a moderate diversity of macroinvertebrates (16 for M18/19 and 17 for M16). Four of the macroinvertebrate taxa from M18/19 and eight from M16 are from the generally sensitive EPT group of taxa. In contrast, the rural stream (M22) contains a much lower diversity (seven taxa) of macroinvertebrates, all generally considered to be tolerant of degraded habitat conditions.

(e) Fish species

Both of the streams with a forest riparian zone and upper forested catchment (M16 and M18/19), support diverse populations of fish, including shortfin and longfin eels, and Cran's, common and redfin bullies (Table 6). These streams also support populations of freshwater crayfish and mussels, which are indicative of good quality habitat. The QIBI indicates that the range of fish species is very good (M16) and Fair (M18/19).

In contrast, the rural stream (M22) supports common and redfin bullies and the shortfin eel. The QIBI of 22 for this stream indicate that this range of species is poor.

4.4 Relative value of permanent streams along Project route

To place the relative value of the permanent streams along the indicative alignment into perspective in relation to streams within the Auckland Region, we compared the results of our ecological monitoring of the permanent streams representative of the Project area with the results of the ecological monitoring of streams in the Auckland Region undertaken by the Auckland Council.

The ecological monitoring data obtained by the Auckland Council from one site on the Pūhoi River (Site No. 7012) and two sites on the Mahurangi River (Site Nos: 6850 and 6862 - one on each of the main tributaries) are presented in Table 7 and Figure 2.

Table 7: Auckland Council stream monitoring data

Mahurangi at Trappit – Site No: 6862

Reference	Year					
	2008	2009	2010	2011	2012	Mean
Total Richness	23	23	26	19	16	21
EPT Richness	8	8	12	7	6	8
% EPT Richness	0.35	0.35	0.46	0.37	0.38	0.38
MCI_{sb}	125	119	128	130	115	123
$SQMCI_{sb}$	7.9	7.6	7.3	7.7	8.3	7.8

Mahurangi LTB – Site No: 6850 (Forestry)

Reference	Year									
	2004	2005	2006	2007	2008	2009	2010	2011	2012	Mean
Total Richness	23	24	15	34	29	28	34	39	29	28
EPT Richness	10	11	6	17	10	13	14	11	11	11
% EPT Richness	0.43	0.46	0.40	0.50	0.34	0.46	0.41	0.28	0.37	0.41
MCI	104	116	109	109	97	107	99	89	99	103
SQMCI	5.6	6.4	5.5	4.9	4.7	6.0	4.6	4.2	6.4	5.4

Pūhoi – Site No: 7012

Reference	Year									
	2004	2005	2006	2007	2008	2009	2010	2011	2012	Mean
Total Richness	14	12	30	11	40	23	20	32	21	23
EPT Richness	5	4	7	5	11	10	9	14	8	8
% EPT Richness	0.36	0.33	0.23	0.45	0.28	0.43	0.45	0.44	0.38	0.37
MCI	113	105	105	122	108	119	118	123	110	114
SQMCI	6.0	6.6	6.9	4.4	5.9	6.4	6.4	5.9	5.8	6.0

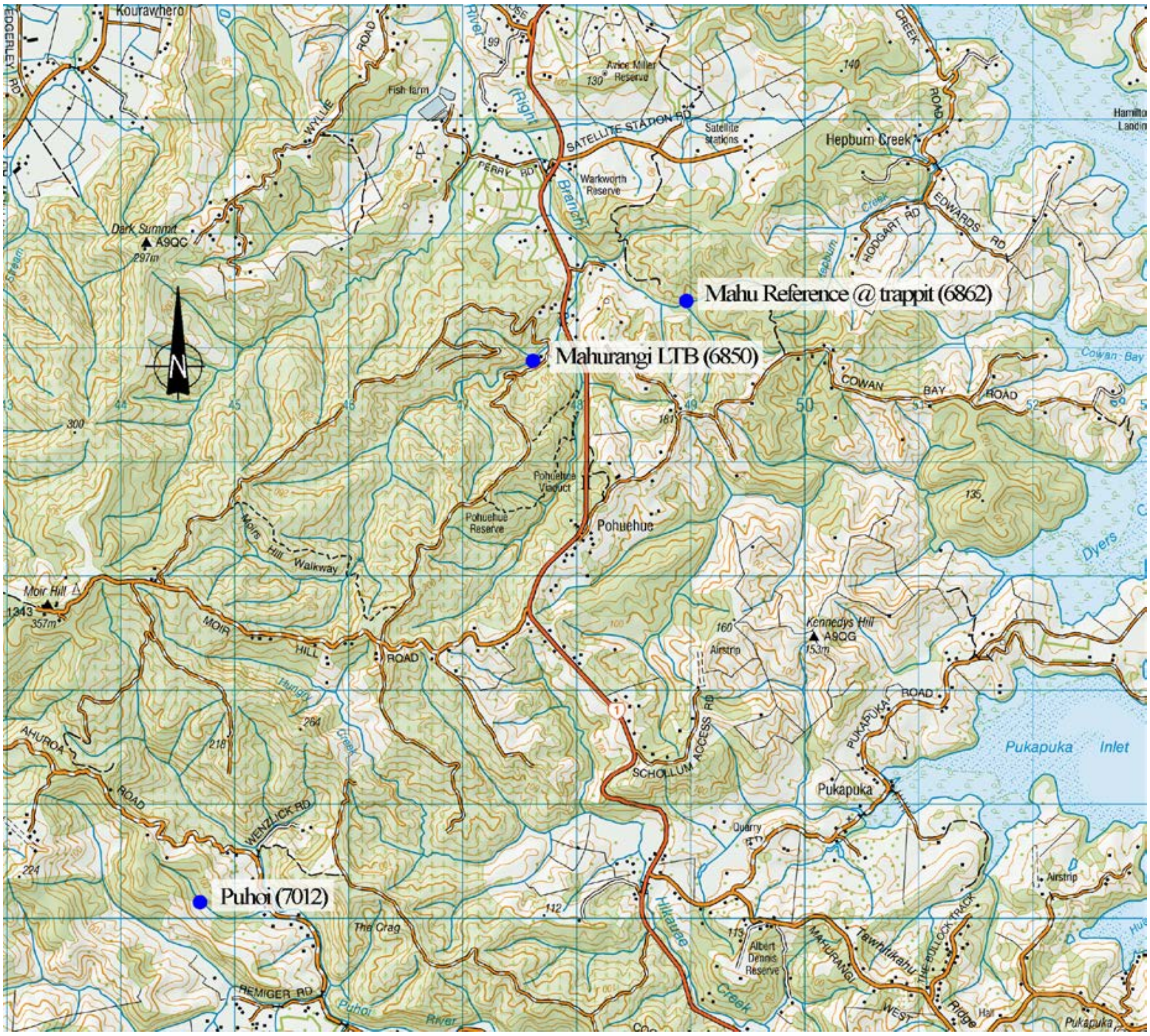

Figure 2: Auckland Council stream monitoring sites

A comparison of the data we collected for the permanent streams in the Pūhoi and Mahurangi River catchments (Table 7) with the Auckland Council data indicates that the habitat quality of the permanent streams of the Pūhoi River along the indicative alignment is lower than that of the Pūhoi River in particular. However, M16 and M18/19 were similar to other streams in the Mahurangi River catchment (as indicated by the MCI).

Table 8: Stream assessment data – 2010 monitoring.

		Pūhoi Catchment	Mahurangi Catchment	
	P10	M16	M18/19	M22
Total Richness	12	17	16	7
EPT Richness	3	8	4	1
MCI	96	123	104	52

We also compared the SEV values of the monitoring sites in the Pūhoi and Mahurangi River and the SEV values for the permanent streams that are representative of those crossed by the indicative alignment (Table 9). This comparison indicates that, apart from the stream in the Perry Road Sector that contained an excellent quality habitat, the habitat quality of all of the other Project streams was less than that of the Pūhoi and Mahurangi River monitoring sites.

Table 9: Comparative SEV data for Pūhoi and Mahurangi Rivers and streams along the indicative alignment

Site	SEV
Pūhoi River	
(Site No. 7012)	0.82
Mahurangi River	
- LTB (Site No. 6850)	0.68
- @ Trappit (Site No. 6862)	0.81
Pūhoi River Catchment	
(P7)	0.66
(P10)	0.53
Mahurangi River Catchment	
(M16)	0.84
(M18/19)	0.77
(M22)	0.54

Our comparison of the indicative alignment freshwater ecological MCI and SEV assessment data with MCI and the range of SEV values that have been recorded from streams associated with various land-use types in the Auckland Region (Auckland Regional Council, 2010) indicates that the indicative alignment streams almost reflect the predominant land-use in those parts of the Pūhoi and Mahurangi River catchments through which the indicative alignment will pass (Table 10).

Table 10: Relative MCI and SEV values for streams along the indicative alignment and land-use types

Alignment Stream	MCI	SEV	Land-use	MCI	SEV[1]	
Pūhoi						
- P7	75 (U)	0.66	Native Forest	124.5	Native Forest	0.89-0.96
- P10	96 (R)	0.53	Exotic Forest	119.8	Exotic Forest	0.68-0.91
Mahurangi						
- M16	123 (NF)	0.84	Rural	95.2	Rural	0.32-0.83
- M18/19	104 (R/EF)	0.77	Urban	77.6	Urban	0.25-0.81
- M22	52 (<U)	0.54				

[1] Source – Storey, *et al.* (2011)

The two highest MCI values recorded in our recent assessment (Mahurangi River catchment - M16 and M18/19) and the one site in the Pūhoi River catchment (P10) reflect the predominant land-use types in their catchments of forest and rural respectively (Table 8). The lowest MCI values recorded in rural land (M22) indicates that this stream has been significantly degraded by land-use practices, while the low MCI value recorded for the partially forested stream (P7) was due largely to the overall marginal ranking of this stream as a permanent habitat.

Previous ARC research of the vegetation removal operations (forest harvesting) within the Mahurangi River catchment highlights the significant mass movement of sediment that occurs in these catchments. The ARC has found a direct linkage between the earthworks phase of the forestry harvesting activities with large sediment yields (see Construction Water Assessment Report section 3).

We used the relationship between the existing ecological condition of a stream (i.e. very good, good, fair and poor) and its dominant catchment land-use developed for streams in the Auckland Region, to define the existing ecological condition of the alignment streams not covered by detailed assessments. A summary of this information is presented in Tables 11 and 12, which are discussed in the subsequent sections of this Report. The ecological condition of the permanent streams ranges from good to poor. Those flowing from forested catchments in the mid-section of the indicative alignment (P9 to M18/19) are in better ecological condition than those in the southern (P7) and northern (M21b to M23c) sections where the catchments are relatively small, rural and the land is used for grazing. We rate the ecological quality of all of the intermittent streams along the indicative alignment as poor (Table 11), which in our opinion, is an inherent characteristic of such streams that are devoid of water for part of the year.

4.5 Conservation status

Two macroinvertebrate species that we recorded in permanent streams crossed by the indicative alignment (the freshwater mussel (kakahi) and crayfish (koura)) and two fish species (inanga and redfin bully) are in gradual decline nationally (see DOC classifications). The longfin eels (also recorded in streams in the Pūhoi and Mahurangi River catchments) are at risk nationally. The distribution of these fish species in the Auckland Region is described as widespread (longfin eel) and frequent (redfin bully and inanga) (Table 3).

5. Assessment of effects – construction water discharges and construction works

We assessed the effects of construction water discharge activities associated with the Project on the streams in the Pūhoi and Mahurangi catchments.

The main findings of this assessment are that the construction water discharges will result in an increase in the total suspended solids (TSS) concentrations in parts of the streams. The effects of such increases on the aquatic biota are will be minor. In particular:

- We do not expect a significant increase in the periphyton in the receiving streams as a result of increased nutrient inputs.
- Most of the permanent streams examined along the alignment are colonised by macroinvertebrates that are able to tolerate elevated TSS concentrations; and
- The effects on native fish species will be minor given they are also tolerant of the predicted levels of TSS.

We also assessed the main construction works activities (spoil sites and stream works). We consider that the effects arising from these activities will be minor:

- Spoil sites will result in the loss of aquatic habitat, however the extent of that loss is minor, as the proposed stream diversions will replicate lost aquatic habitat;
- Culverting will result in a significant loss of stream habitat, however, fish passage design and riparian planting will mitigate this adequately. Fish passage is discussed in more detail in the operational effects section.

For the purposes of assessing the effects of the Project on freshwater ecosystems our assessment has been divided into two stages: (1) construction water discharges and works and (2) operation. We have used information from the Construction Water Assessment Report and the Operational Water Assessment Report as the basis of our assessment.

This section deals with construction water discharges and works and:

- Summarises the principal activities associated with Project construction that have the potential to affect freshwater habitats;
- Identifies the aquatic organisms present in the freshwater habitats that we consider may be at risk from Project construction activities; and
- Examines the potential effects of the construction of the Project on those aquatic organisms and the freshwater habitats.

We consider operational effects in section 6.

5.1 Construction activities and potential effects

The principal activities associated with construction of the Project that may affect freshwater habitats and aquatic organisms are:

- Cut and fill (that is the formation of the road platform through ridges and valleys) runoff - formation of the road platform through ridges and valleys;
- Construction water treatment and discharge;
- Associated stream works, such as filling, realignment and culverting; and
- General construction activities, e.g. trucking, works in watercourses, habitat disturbance.

All of these activities may result in:

- Changes in water quality arising from the movement of soil with the potential to increase the amount of suspended solids (measured as TSS) entering the streams in the vicinity of the construction activities and depositing in the streams;
- The total or partial loss of freshwater habitat (e.g. in the areas where spoil sites, stream diversions or culverting are intended to take place); and
- Changes to fish passage (the reduction in the ability of organisms, primarily fish, to move throughout streams, as a result of the placement of culverts).

The details of the construction activities that will be undertaken along the indicative alignment, the treatment proposed for any runoff and the increase in the concentrations of TSS that will occur in the streams along the indicative alignment are set out in the Construction Water Assessment Report (section 6). TSS are the principal contaminant in these discharges. Therefore, the emphasis in our assessment relating to construction water is on examining the changes in TSS that will occur in the streams as a result of the construction discharges.

We also address habitat loss and stream loss and modification arising from the construction works and methods to manage these activities using data from the Operational Water Assessment Report.

5.1.1 Construction water effects

This section summarises the existing range of TSS concentrations that occur in streams in the Pūhoi and Mahurangi River catchments, and the increases that will result during construction of the Project. We also note recent data on the range of TSS concentrations that are tolerated by native fish species and macroinvertebrates present in the streams that will be crossed by the alignment. We also assess effects of the construction discharges on the ecology of the streams affected by the indicative alignment.

(a) Existing water quality

Overall, existing Auckland Council data and the Project monitoring data identify that water quality is reasonably good across the freshwater catchments (Construction Water Assessment Report, section 6). These data indicates that under low flow conditions the water is generally clear, cool, well oxygenated, with a slightly acidic pH and low concentrations of TSS and nutrients. Under elevated flow conditions, however, the water becomes turbid (as a result of elevated concentrations of TSS), and the concentrations of nutrients increase. Such changes are typical of streams in the Auckland area (Construction Water Assessment Report, section 3).

(b) Predicted sediment in waterways arising from construction of the Project

Examination of the changes in the TSS that are predicted to occur in a two year Average Recurrence Interval (ARI) event during the five year construction period show that the peak TSS concentration may increase from the present peak of approximately:

- 2,200 - 2,800 mg/L to approximately 4,000 – 6,000 mg/L in the upper hilly catchments; and
- From 1,300 - 2,000 mg/L to a peak in the order of 1,500 - 2,100 mg/L at the river mouths (Construction Water Assessment Report, section 3).

These peaks are predicted to last for around one hour as a result of the steep hydrograph indicating that the streams peak and subside rapidly (Construction Water Assessment Report, section 3).

Some 95% of the sediment will be removed in the sediment retention ponds and this will largely comprise the larger grain sized material (Construction Water Assessment Report, section 7). Accordingly, the sediment that will be discharged to the receiving waters will be fine grained material and therefore will be readily mobilised in the streams. Under discharge conditions of elevated stream flows, this fine grained sediment will be largely moved through the streams into the marine environment where it will be deposited once reaching the saline water.

Examination of existing stream sediment transportation and deposition indicates that in the Pūhoi River catchment some 50% of the background sediment load is expected to be deposited in the river network and floodplain. In the Mahurangi River catchment, some 52% of the background sediment is expected to be deposited in the river network and floodplain. As an example, the Construction Water Assessment Report indicates that for the Pūhoi River catchment upstream of P10 the amount of sediment is expected to increase by 37% as a result of the Project (Construction Water Assessment Report, section 7). The Construction Water team has also identified that there is a 92% chance of a 2 year ARI in any given year and an 11% chance of five 2 year ARI events occurring in the five year construction period (Construction Water Assessment Report, section 7).

(c) Potential effects of sediment deposition in freshwater

The effects of sediment on aquatic ecosystems arise from sediment being deposited on areas of hard substrate, smothering instream organisms (a 'habitat' effect). The discharge and accumulation of fine sediment on hard streambeds may reduce the abundance and diversity of macroinvertebrates by increasing drift, smothering and abrasion, of both them and their periphyton (algae) food supply. The extent to which this effect occurs is dependent on the tolerance these organisms have to high concentrations of sediment. In general, elevated concentrations of sediment results in the composition of the macroinvertebrate population changing from "sensitive" clean water organisms such as mayflies, to those "tolerant" organisms such as midge larvae, that are able to live in degraded aquatic habitats (i.e. habitats that contain elevated concentrations of sediment, nutrients and organic material). Such a change may occur as a result of the loss of food (benthic algae) for grazing macroinvertebrates, or as a result of an increase in the amount of sediment in the water and the clogging of the filtering mechanisms (e.g. fine hairs on the legs of some mayflies) which reduces the ability of these organisms to obtain the required food from the passing water.

For the Project waterways, we consider that habitat effects from sediment would be no more than minor. While some of the residual sediment that will be discharged on a falling hydrograph (as the flow of the receiving water decreases) has the potential to be deposited in the stream, such deposition will occur in areas of the stream where the velocity decreases, that is the pools where the gradient of the stream decreases. The ecological effect of the addition of some fine sediment to such pool environments is low. Such pools already contain a soft sediment substrate and therefore do not form suitable habitats for periphyton (algae) or many of the largely sedentary macroinvertebrate species, such as caddisfly and mayfly larvae which may be grazers or filter feeders, all of which require a hard substrate on which to develop, graze or reside. The need for a hard substrate means that such pool habitats do not generally support sensitive macroinvertebrate species.

(d) Potential effects of TSS in freshwater

TSS can also have an effect on aquatic ecosystems through reducing water quality to a point where it affects habitats or aquatic species – the biota of Auckland streams (Kelly, S. 2010) (a 'water quality' effect). According to Rowe et al (2009) the turbidity levels (an indication of TSS concentrations) recorded in some Auckland streams after heavy rain can be relatively high (>10,000 Nephelometric Turbidity Units (NTU)). A recent assessment of the relationship of turbidity (a measurement of the clarity of the water reported as NTU) with TSS concentrations in Auckland streams (Water Quality Monitoring Report, section 4) found that this relationship was 1:1, that is 1 NTU = 1 mg/L TSS.

We also note that many streams in the Auckland Region periodically experience high sediment loads. In addition, elevated sediment levels were a feature of the streams in the pine forest catchments of the southern part of the Mahurangi River catchment during harvesting of those forests prior to 1999. As a result historically the aquatic biota present in these streams has been subject to significantly elevated levels of TSS, and the species recorded, namely those tolerant of a wide range of habitat conditions, such as elevated TSS, reflect such exposure during the harvesting of the forest.

We consider that any effects from TSS on fish species are likely to be no more than minor. A number of New Zealand's freshwater fish have been found to be largely unaffected by sub-lethal turbidity levels (Rowe *et al.* 2000). Relatively low turbidity levels of >25 NTU appear to cause juvenile migratory banded kokopu to reduce feeding rates, reduce upstream migration rates and increase their avoidance reaction. Inanga and common bullies also reduced their feeding rates, but were considered to be less sensitive to turbidity than banded kokopu. Shortfin and longfin elvers (young eels) and redfin bullies showed no avoidance behaviour even at turbidity values of 1,100 NTU (Kelly, 2010).

In terms of toxicity of TSS, tests carried out upon several fish species three of which (banded kokopu, redfin bully and inanga), are present in the Pūhoi and Mahurangi River catchments, have shown that while inanga survival declined above turbidity levels of 1,000 NTU, nearly all redfin bullies and banded kokopu survived at turbidity levels of up to 40,000 NTU (Rowe et al, 2009).

The structure of macroinvertebrate populations may also be altered as sensitive species (e.g. mayflies) are replaced by species more tolerant of higher TSS concentrations. While the feeding and migration of some juvenile fish species (e.g. banded kokopu) may be affected by relatively low levels of turbidity (NTU>25), adults of this species along with redfin bullies are able to tolerate very high levels of turbidity (up to 40,000 NTU).

It should be noted that many diadromous native fish species migrate upstream in response to "freshes" (small increases in flow). It would appear that this is a response to an increase in the amount of freshwater flowing into the sea. As the juvenile stage of these fish (e.g. eels, whitebait) initially develop in the sea (e.g. eels spawn off the coast of Tonga and move down to the New Zealand coast in the prevailing marine currents) they require a stimulus to enter freshwater. This stimulus is provided by such freshes or minor flood events. Associated with many of these events is an increase in the TSS concentration of the freshwater. So, while such increases in TSS may reduce the amount of upstream migration that occurs (in association with the increased flow and water velocity), many of the native species are able to either avoid such situations by delaying their migration or moving into "clean" streams. The significant upstream migrations that follow such "freshes" are often the focus of whitebaiters.

(e) Contaminated water discharge effects

The potential also exists for cement contaminated water with elevated pH levels to enter the Project waterways. I understand it is recommended that any such contaminated water be treated by measures such as onsite treatment tanks with the water pH tested before discharge, or the water removed from the site through the use of sucker trucks and treated elsewhere (Construction Water Assessment Report - Section 6). As a result of such treatment the effects of any cement contaminated water discharged on the freshwater aquatic biota will be less than minor.

(f) Conclusion on construction water discharge effects

While some of the periphyton (algae) will be removed from the hard-substrate by sediment abrasion as a result of the Project, the impact on the overall primary productivity of the streams will be minor because very few of the alignment streams contain a hard-substrate (which provides habitat for periphyton).

The Project discharges will occur for the most part in the lower sections of these streams. As most of the sediment discharged from the Project treatment ponds will pass through these streams under the high flow conditions that will prevail during the discharge of this stormwater, only relatively small areas of the hard-substrate will be smothered by residual sediment.

While the discharged sediment contains nutrients, the concentrations of Total Nitrogen (TN) and Total Phosphorus (TP) are only predicted to increase by small amounts (0.3 mg/L and 0.1 mg/L) respectively (Construction Water Assessment Report, section 7). Such increases will not cause a material increase in the periphyton in the receiving streams.

In high quality streams the discharge of significant amounts of sediment and the resultant high concentrations of TSS in the stream water, have the potential to alter the macroinvertebrate population by removing the "sensitive" macroinvertebrates that are unable to tolerate high TSS concentrations. As most of the permanent streams along the alignment that we examined are colonised by macroinvertebrates that are able to tolerate elevated TSS concentrations (2,200 - 2,800 mg/L), we consider the discharge of treated stormwater from Project construction activities on macroinvertebrate populations in the respective streams will be minor.

The elevated levels of TSS predicted for a short-term 2 year ARI event (i.e. 4,000 - 6,000 mg/L for 2 hours) has a high probability of occurring during the five year construction period (Construction Water Assessment Report, section 7). The 50 year ARI event, which has a 10% chance of occurring in a five year construction period, would generate peak TSS concentrations of 7,500 – 12,500 mg/L (Construction Water Assessment Report, section 7). Such events are more likely to occur during the winter months than at any other time of the year. Such conditions are likely to occur following the main period of upstream migration (September - February) of the native fish species such as the banded kokopu, upstream migrating eels (elvers), and redfin bullies that are residents of the alignment streams. As stream concentrations of up to 40,000 mg/L have been shown to be tolerated by these species, then we consider effects of such discharges on these fish populations will be minor.

We note that a large rainfall event (magnitude unspecified) which occurred in March 2007, resulted in extensive and thick deposits of sediment in three streams on the NGTR project. An assessment of the effects of this event indicated there were no significant effects on the receiving environments below the confluences of two of the streams, although physical effects, namely the deposition of sediment in parts of the streams, were significant (Boffa Miskell – memo to NGA, 2007).

To address some uncertainty in predicting potential effects of sedimentation on aquatic life from large rainfall events, we recommend a condition requiring an ecological assessment (macroinvertebrate and fish sampling) to be undertaken by a qualified ecologist following significant rainfall events during construction. That assessment should identify any significant impacts arising from construction sediment on aquatic life and recommend appropriate actions to rectify the loss.

5.1.2 Construction work effects

Development of the Project will require the construction and placement of 40 culverts and 11 bridges. Several spoil sites will also be required. While the bridges are intended to be constructed so that no part of the bridge will be located in the stream, the culverts will be placed in the streams and will result in the partial loss of stream habitat.

The culverts that will be placed in streams will primarily be relatively small concrete pipes, although at three locations larger arch culverts will be used (Table 5). In summary, there will be a net change in habitat of –905m (Permanent Streams) and –3,388m (Intermittent Streams) in the Pūhoi River catchment and –883m (Permanent Streams) and –3,763m (Intermittent Streams) in the Mahurangi River catchment (Operational Water Assessment Report, section 3).

(a) Potential effects – stream diversions and spoil sites

The Project will require cut and fill activities to be undertaken in the various catchments along the alignment. These activities will require the disposal of excess material (fill) at a number of locations (spoil sites) along the alignment. Such disposal will result in the infilling of valleys and the subsequent burial of streams within those valleys.

While measures, such as stream diversions, will result in the formation of new watercourses within those valleys, there will be an overall loss of stream habitat. Details of the development of the spoil sites and the stream diversions are presented in the Operational Water Assessment Report, section 7.

In addition, the principal potential effect of culverts on streams is to reduce the productivity of the section of stream in which they are located. This effect results from a reduction in the amount of light able to reach the streambed and sustain the primary productivity on which the stream ecosystem is based.

In our opinion it is important to recognise that the principal component of the aquatic habitat, namely the water, remains within that section of the stream. The presence of this water not only sustains any aquatic organisms that may enter the culvert but also enables mobile freshwater organisms such as fish, to continue to be able to move throughout the stream. Also, the water may sustain any filter feeding organisms, such as mayflies, that may be present in the culvert.

In addition, a culvert will significantly alter and reduce the quality of the aquatic habitat in the section of stream in which it is placed. However, that section of the stream will continue to be an integral component of the overall stream system and enable the stream to act as an integrated continuum. Aquatic organisms will continue to move throughout the stream. Upper sections of the stream (that is upstream of the culvert), will continue to provide a habitat for organisms, such as fish and macroinvertebrates, that are able to move upstream either through (swimming - fish) or past (flying - adult insects) the culvert. The culvert will also continue to act as a source for those organisms capable of colonising sections of the stream downstream of the culvert (following flood events that are known to cause a reduction in these populations of these organisms, macroinvertebrates in particular).

The effect of the loss of habitat from stream diversions and spoil sites is in our opinion, no more than minor. As noted, the culverting of streams will continue to allow the stream to function as a whole. The effects of the stream diversions will also be mitigated by the proposed riparian planting that will be undertaken in relation to the culverted permanent streams and the stream diversions associated with the spoil sites (Operational Water Assessment Report, sections 3 and 7).

Our opinions are based on the premise that the culvert placed in the stream will not act as a barrier to the movement of aquatic organisms. For example, by not using perched culverts which are separated vertically from the stream bed. This separation prevents organisms such as fish from moving upstream through the culvert.

Through our input from an early stage of the current assessment process, the requirement for unrestricted passage throughout the stream has been a prime consideration in the design of the culverts to be placed across the indicative alignment. To ensure that passage throughout the stream is not impeded, specific measures such as baffles (designed to facilitate the upstream passage of fish in particular) have been incorporated in the design of the culverts associated with this Project (Operational Water Assessment Report, sections 3 and 7).

Because design measures have been incorporated in most of the indicative alignment culverts, the impact of these culverts on the alignment streams will be kept to a minimum.

6. Assessment of effects – operational activities

We assessed the effects of the operational activities associated with the Project on the streams in the Pūhoi and Mahurangi catchments.

- Culverting - the placement of the required culverts will result in a significant loss of stream habitat, however, fish passage design and riparian planting will mitigate this adequately.
- Stormwater discharges - while these will contain contaminants, the discharges will have a minor effect on the stream ecosystems, as the quality of the stormwater will meet the ANZECC guidelines.

This section:

- Summarises the principal activities associated with the Project's operation that have the potential to affect freshwater habitats;
- Identifies the aquatic organisms, primarily fish, present in the freshwater habitats within the Project area that we consider to be at risk; and
- Examines the potential effects of the operation of the Project on those aquatic organisms and the freshwater habitats.

6.1 Operational activities

The principal activities associated with the operation of the Project that may affect freshwater habitats and aquatic organisms relate to:

- Elevated concentrations of contaminants in the stream downstream from stormwater discharges and changes in waterflow; and
- Culverting.

To assess the potential effects of these operational activities we have examined the operational design data and specifically the reduction in the ability of organisms, primarily fish, to move throughout the stream as a result of the placement of culverts. We have also reviewed the increase in concentrations of potential contaminants in streams as a result of the discharge of stormwater (Operational Water Assessment Report, section 8).

(a) Potential effects of stormwater discharges

The new highway's stormwater has the potential to contain elevated concentrations of sediment, trace metals (zinc, copper) and total hydrocarbons - all of which have the potential to affect freshwater aquatic organisms (Operational Water Assessment Report, section 8). The existing quality of the existing freshwater in the streams affected by the Project area is good, with metals and contaminants well below ecological trigger values (Operational Water Assessment Report, section 8).

With the increase in contaminants associated with motorway runoff, increases in contaminants are predicted at all sites. With wetland treatment, the Operational Water team predicts that the water quality for total and dissolved copper and zinc will be well below the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC) guideline values (ANZECC & ARMCANZ, 2000) (Operational Water Assessment Report, section 8).

The ANZECC water quality guidelines are used as a general tool for assessing water quality and are the key to determining water quality objectives that protect and support the designated environmental values of water resources. These guidelines have been derived with the intention of providing some confidence that there will be no significant impact on the environmental values if they are achieved. Exceedance of the guidelines indicates that there is potential for an impact to occur.

To determine whether the operational activities associated with the Project will have an adverse impact on the freshwater resources of the Pūhoi and Mahurangi River catchments, the Operational Water team compared the quality of the stormwater discharges with the appropriate ANZECC guidelines (Operational Water Assessment Report, section 8). The details of this comparison are presented in the Operational Water Assessment Report, section 8.

Our examination of these data indicates that none of the ANZECC guideline values for freshwater quality will be exceeded as a result of the Project. Given this situation, the stormwater discharges associated with the operation of the new highway will have a minor effect on the freshwater aquatic environments into which the Project's stormwater will be discharged.

6.1.2 Potential effects on water flow

(a) Culverting

The Project culverts have sufficient capacity for design flows. In general they will be concrete pipes, however larger concrete arch culverts are proposed for three crossings of main tributaries of the Mahurangi River. The effects of these culverts on water flow will be minor (Operational Water Assessment Report, section 8).

(b) Development of spoil sites

Our analysis of the flow data and the stream diversions associated with the spoil sites indicates that the overall effect of the Project on the receiving catchments, namely the Pūhoi and Mahurangi River catchments, will be negligible (Operational Water Assessment Report, section 8).

(c) Stormwater discharges

The effects of changes in stormwater quantity from the Project on the existing environment with respect to attenuation will be minor (Operational Water Assessment Report, section 8). In general while structures such as motorways have the potential to alter flow patterns in some catchments, the diversion of flows from hard surfaces into sediment ponds attenuates flows in the lower catchment, thus minimising the physical effects of any additional water from the catchment.

6.1.3 Potential effects on water quality

(a) Culverting

The effects on water quality as a result of the operation of the culverts as part of the Project will be minor and short-term. There may be some ongoing sediment entering waterways while cuts and fills stabilise, however, this sediment will be limited and progressively flushed through the stream during periods of elevated flow. On that basis, the overall effects on water quality from culverting will be minor. The operation of the culverts will not affect the water quality of the streams.

(b) Stream diversions

Permanent diversions and flow channels will be required to manage surface water. The stream diversion type for each site has been decided by a best practicable option approach designed to minimise adverse environmental effects by recreating aquatic habitats that replicate existing stream profile and length as much as practically possible (Operational Water Assessment Report, sections 3 and 7). These diversions will for a short period create some sedimentation until they stabilise. However, as with the placement of culverts, any sediment that enters the stream as a result of this activity will be minor and short-term and flushed downstream. The overall effects on water quality will therefore be minor. Once the diversion has stabilised and the associated riparian planting developed, the diversions will not affect the water quality of the streams.

6.1.4 Potential effects on fish passage

As long linear ecosystems, streams are particularly vulnerable to fragmentation by the construction of barriers such as dams, bridges and culverts. In the case of New Zealand streams, such barriers can significantly affect the ability of native fish species that require access to the sea (18 diadromous species out of 35 indigenous species), to migrate between fresh and saltwater, for the most part as juveniles, as part of their life-cycle.

While structures such as culverts may influence the movement of freshwater organisms other than fish (e.g. insects), such effects have been found to be localised and do not have a significant effect on the general distribution of these organisms throughout streams (Vaughan, 2002). With respect to our assessment of the effects of bridges and culverts on streams that cross the indicative alignment, we placed emphasis on assessing the potential effect of these structures on the movement of the diadromous fish species present in these streams.

Single span bridges, where no part of the bridge structure enters the water, are the best means of ensuring fish passage. In terms of a hierarchy of preference, this type of structure is followed by a multiple span bridge, single barrel arch culvert, single barrel circular culvert, multiple barrel culvert, box culvert and Ford (Stevenson, C., Baker, C. 2009). The final selection of the preferred stream crossing structure for a particular stream is dependent on such factors as fish passage requirements, and the hydrological and physical characteristics of the particular site.

A number of potential solutions for maintaining passage for indigenous fish through culverts have been addressed by NIWA and the Department of Conservation (Boubee *et al.*, 1999) and more recently by the former ARC (Stevenson, C., Baker, C. 2009). This information forms the basis of the examples of culverts that will be developed on the alignment to facilitate the upstream migration of the indigenous fish species in these catchments (Operational Water Assessment Report, sections 3 and 7).

(a) Bridges and Culverts

The design for the indicative alignment indicates that there will be 11 bridges and 40 culverts (Operational Water Assessment Report, section 3). Of the culverts, 11 have been identified as being in streams where fish passage is required (Table 5).

As the bridges are intended to be constructed with no part of the bridge structure in the waterway, these bridges will not impede the movement of fish through the streams over which they pass.

In those streams where fish passage is required, the culvert design has incorporated features, such as baffles and weirs, in line with recent design data (Stevenson, C. Baker, C. 2009) to facilitate the upstream passage of fish species such as banded kokopu, shortfin and long fin eels, and redfin bully present in these catchments (Operational Water Assessment Report, sections 3 and 7). These measures will ensure that the Project will not have an adverse effect on the migration of fish throughout the Pūhoi and Mahurangi River catchments. Our conclusion is supported by the results of Boffa Miskell's recent monitoring (2007 -2011) of the effects of the Northern Gateway Toll Road (NGTR) on freshwater habitats. The results of macroinvertebrate and fish monitoring has indicated that the NGTR project has not had any consistent adverse effects on the ecological health of the Otanerua, Nukumea or West Hoe. The differences recorded between the control and impact streams/sites were considered to be primarily due to differences in the intactness of riparian/catchment vegetation. These differences were believed to reflect factors unrelated to motorway construction or operation, such as natural environmental variation. Our recent experience also supports this conclusion. We have found banded kokopu and eels in a pond at the upper end of an 880m long stormwater culvert (pers. obs.). The culvert was devoid of design features, such as baffles, to assist upstream migration of fish Streams (Boffa Miskell Limited, 2011).

The longest Project culvert is 262m, with the majority of the culverts (90%) less than 200m in length (Operational Water Assessment Report, section 3). The 15 culverts through which fish passage is required will be fitted with design features, such as baffles, that will facilitate fish passage. On that basis, in our opinion such culverts will not be an impediment to fish passage. Such features will ensure that the effects of the Project on fish passage will be no more than minor.

The provision of fish passage through the four culverts on the permanent streams (P9, M23a, M23d and M23c) is an obvious requirement, as these are permanent aquatic habitats which may be colonised permanently by a range of aquatic organisms that move throughout the waterway. The provision of fish passage on seven of the intermittent streams (M21a, c, d; M23d, PA100, PA200A, PA500A) is based in one situation on the potential of the upstream habitat (M21c) to act as habitat. Access to the headwaters is presently blocked by a farm dam. The close proximity of the streams (M23d, PA100A, PA200A, PA500A – Table 5) to branches of the Mahurangi River, enables these streams to act as habitats for fish resident in or migrating from, the Mahurangi

River. Drop structures required at the upstream ends of two culverts (47,700 and 48,000) on streams M23b and M23a, respectively will prevent upstream access for swimming fish (Operational Water Assessment Report, section 8). This reduction in habitat for swimming fish in these two streams is not considered significant due to the limited habitat upstream of the culvert locations.

(b) Stream Diversions

Stream diversions will be designed to minimise environmental effects (Operational Water Assessment Report, sections 7 and 8). The existing stream profile and length will be replicated as much as practically possible. The fish species likely to access these mainly headwater areas of the streams are "climbers". The effect of the proposed diversions on fish passage will therefore be no more than minor.

Prior to in-stream works proceeding we recommend that the section of stream that will be affected by these works be isolated (using stop-nets) and fish present in this section be caught and translocated to a suitable aquatic habitat preferably within the stream's catchment. The stop-nets should be retained within the stream until the works are completed, to ensure that no fish enter this section of the stream.

6.1.5 Effects of operational activities

In summary, the operational effects of the Project on habitats, water flow, water quality and fish passage of freshwater streams crossed by the new highway will be no more than minor, on the basis that:

- The loss of stream habitat as a result of culverting will be mitigated by riparian planting of the existing streams as discussed in the Operational Water Assessment Report;
- The effects of the operation on water flow will be negligible;
- The quality of the stormwater will ensure that the quality of the receiving waters will be suitable for instream organisms, such as fish; and
- The design of the culverts to facilitate fish passage will ensure that effects of the Project on fish passage will be minor.

7. Mitigation

Riparian planting should be undertaken as mitigation for the loss of freshwater aquatic habitats of permanent streams through culverting on an equivalence basis.

Fish should be recovered from sections of streams that will be subject to in-stream works and relocated using standard relocation procedures.

We have identified the principal adverse effect of the Project on freshwater ecology as the culverting of sections of streams. While 40 culvert locations have been identified on indicative alignment streams, only 11 (28%) of those streams have been identified as permanent. We propose riparian planting as mitigation for the modification of these sections of permanent stream freshwater aquatic habitats through culverting on an equivalence basis.

We have also identified loss of aquatic habitat with respect to streams associated with the spoil sites. This loss of aquatic habitat has been addressed through the development of diversions, which will recreate existing stream profile and length and include a 10-20m riparian zone (Operational Water Assessment Report, sections 3 and 7). The aim of this mitigation is to replicate the existing stream habitat and profile.

We consider that prior to the culverting of a stream or formation of a spoil site and diversion channel, fish present in the section of stream subject to the activity should be recovered and transferred to a section of stream outside of the works area. We consider the details of the procedures that should be used to relocate fish in these instances should be formulated in a condition, which also addresses procedures that will be implemented to ensure migrating fish species are protected from the potential effects of in-stream works during the main migration period.

As stated, five permanent streams on the indicative alignment were subject to an SEV. These SEVs were undertaken to enable the status of these streams to be compared to other streams in the Auckland Region associated with similar catchment land-use types. While this is one use of the SEV, in our experience it is common for the SEV data to be used in assessing the amount of mitigation that should be applied to a situation, such as culverting, where there is a partial loss of stream habitat. Such an approach involves the development of an Ecological Compensation Ratio (ECR). The ECR takes the existing status of the stream habitat in a section of stream to be altered by an activity such as culverting, and compares it to a control stream habitat. The amount of aquatic habitat required to be enhanced is then typically defined.

In the case of the streams that will be culverted by the Project, we do not consider that it is appropriate to undertake an ECR to determine the degree of mitigation appropriate to offset the effects of the culverting. In our opinion the ECR approach to mitigation should only be applied when all other measures for appropriate mitigation have been evaluated and discarded (Storey et al, 2011). The ECR approach to mitigation is not necessary for the Project, in our opinion. This is because several measures will minimise and mitigate the effects of the Project on freshwater aquatic habitats. Such measures include the design of the culverts to facilitate fish passage, and the formation of new diversion streams to replace sections of streams lost under spoil sites.

As we have indicated, culverting does reduce the quality of the habitat in which the stream is located; but it does not result in the complete loss of that habitat, which is usually the situation where the ECR approach is applied.

Also, in our opinion mitigation should be of a type and of a magnitude similar to the effect of the activity. In this case the effect of culverting is affects on habitat. The appropriate mitigation should therefore be undertaken as close as possible to the affected habitat.

The fact that most of the streams (29 streams/72%) that will be culverted are intermittent, further supports our view that the use of the ECR to determine the level of mitigation for the culverting of intermittent streams in this Project is inappropriate (Storey, 2010). However, the status of these streams should be assessed prior to the final decision about culverting, in particular the requirement to provide fish passage, to confirm our earlier assessment of which streams were intermittent (bearing in mind we undertook those assessments in drought conditions).

Bearing these factors in mind, we consider that the appropriate level of mitigation for the culverting of the streams along the alignment is replacement of the riparian habitat equivalent to that removed by the placement of the culverts. Preliminary evaluation of the length of streams within the indicative alignment suggests that most of the mitigation could be undertaken in several specific catchments e.g. the Upper Hikauae Creek catchment, south of Moirs Hill, within the indicative alignment. We recommend that this mitigation be required by a condition specifying that riparian planting be undertaken within the designation and where practicable within the complete catchment of a stream or river, to ensure that the benefits of the mitigation are maximised.

8. Conclusions and recommendations

The Project will cross a number of intermittent and permanent streams typical of those of the Auckland region. These streams contain a paucity of aquatic fauna, including three fish species that are in gradual decline (inanga, redfin bully and the longfin eel).

The principal potential effects of the Project on the freshwater habitats are a reduction in water quality, as a result of stormwater discharges, a loss of aquatic habitat, as a result of culverting, and disruption to fish passage.

The effects of these activities will be minor as:

- The treatment of the construction stormwater will ensure that the quality of the stormwater discharged, as a result of increased TSS, will be reduced for a short period and be tolerated by the resident fish species;
- The operational stormwater will meet the ANZECC guidelines for the protection of freshwater aquatic life;
- Riparian planting will mitigate the effects of the loss of aquatic habitat by culverting; and
- Fish passage will be provided through culverts where adequate upstream habitat is available.

Site-specific aquatic habitat assessments (SEV plus fish populations assessment) should be undertaken in the permanent streams that will be culverted.

Post-construction monitoring of culverted streams should be undertaken.

Riparian planting should be undertaken at a level commensurate with the amount of stream habitat lost through culverting.

Fish transfers should be undertaken prior to any in stream works occurring.

8.1 Conclusions

The Project will cross a number of intermittent and permanent streams in the Pūhoi and Mahurangi River catchments.

The habitat qualities of these streams are typical of those of the Auckland Region, and reflect the catchment land-use.

These streams contain very few aquatic plants. Macroinvertebrates tolerant of a wide range of habitat conditions and a number of diadromous native fish species (three of which are in general decline), are also present.

The principal potential effects of the Project on freshwater ecology are the reduction in water quality as a result of construction and operational activities, the loss of stream habitat, as a result of the formation of spoil sites and culverting, and disruption to fish passage.

The principal freshwater ecological effect of the construction activities will be increases in the concentration of TSS in some of the streams. Increases will for the most part be short-term and the dominant fish species resident in the streams are tolerant of high concentrations of suspended solids for short periods of time. Such discharges will have a minor effect on populations of fish in these streams.

Operational activities have the potential to increase the concentrations of contaminants such as trace metals, in the streams. As the concentrations of such contaminants will be significantly less than the ANZECC guidelines, these discharges will have a minor effect on the habitat quality of the streams.

The potential disruption to fish passage will be mitigated by the culverts being designed to ensure that the diadromous fish species will be able to migrate throughout the streams. A management plan should be required to ensure that the prescribed mitigation, in the form of culverts adapted for fish passage, will be effective and sustain diadromous fish populations.

Assuming such mitigation, the overall effects of the Project on the freshwater aquatic habitats is minor.

8.2 Summary of effects

Tables 11 and 12 summarise the effects we have assessed for each of the stream crossings depending on whether they are permanent or intermittent.

Table 11: Permanent stream evaluations

Stream	Culvert length	Land-use	Existing ecological value	Significance of Project effects				Overall effect
				Water quality	Habitat	Water flow	Fish passage	
P6a	51	Forest	Good	Minor	Minor	Minor	Minor	Minor
P7*	81	Forest	Poor	Minor	Minor	Minor	N/a Limited fish access	Minor
P9 Bridge/Culvert	104	Forest	Good	Minor	Minor	Minor	N/a Bridge/ minor	Minor
P10*	N/A	Rural	Fair	Minor	Minor	Minor	N/a Bridge	Minor
P11	N/A	Rural	Fair	Minor	Minor	Minor	N/a Bridge	Minor

Stream	Culvert length	Land-use	Existing ecological value	Significance of Project effects				Overall effect
				Water quality	Habitat	Water flow	Fish passage	
P11b	145	Forest	Good	Minor	Minor	Minor	Minor	Minor
M13d	80	Forest	Good	Minor	Minor	Minor	Minor	Minor
M15	219	Forest	Good	Minor	Minor	Minor	Minor	Minor
M16*	N/A	Rural/ Forest	Very Good	Minor	Minor	Minor	N/a Bridge	Minor
M18/ 19*	114	Rural/ Forest	Good	Minor	Minor	Minor	Minor	Minor
M21b	75	Rural	Poor	Minor	Minor	Minor	Minor	Minor
M22*	104	Rural	Poor	Minor	Minor	Minor	Minor	Minor
M23	N/A	Rural	Poor	Minor	Minor	Minor	N/a Bridge	Minor
M24	N/A	Rural	Poor	Minor	Minor	Minor	N/a Bridge	Minor
M23a	51	Rural	Poor	Minor	Minor	Minor	Minor	Minor
M23b	46	Rural	Poor	Minor	Minor	Minor	Minor	Minor
M23c	61	Rural	Poor	Minor	Minor	Minor	Minor	Minor
PA900A	N/A	Rural	Poor	Minor	Minor	Minor	Minor	Minor

NOTE:
* = Streams Assessed
N/A = Not Applicable (bridges will not influence fish passage)

Table 12: Intermittent stream evaluations

Stream	Culvert length	Land-use	Existing ecological value	Significance of Project effects				Overall effect
				Water quality	Habitat	Water flow	Fish passage	
P2	134	Rural	Poor	Minor	Minor	Minor	Minor	Minor
P3	218	Rural	Poor	Minor	Minor	Minor	Minor	Minor
P3a	92	Rural	Poor	Minor	Minor	Minor	Minor	Minor
P5	66	Forest	Poor	Minor	Minor	Minor	Minor	Minor
P6	40	Forest	Poor	Minor	Minor	Minor	Minor	Minor
P8	126	Forest	Poor	Minor	Minor	Minor	Minor	Minor
P9b	65	Forest	Poor	Minor	Minor	Minor	Minor	Minor
P9a	121	Forest	Poor	Minor	Minor	Minor	Minor	Minor
P10a	55	Rural	Poor	Minor	Minor	Minor	Minor	Minor
P11a	99	Forest	Poor	Minor	Minor	Minor	Minor	Minor
P11f	135	Forest	Poor	Minor	Minor	Minor	Minor	Minor
P11g	96	Forest	Poor	Minor	Minor	Minor	Minor	Minor
P12	228	Forest	Poor	Minor	Minor	Minor	Minor	Minor
M13	129	Forest	Poor	Minor	Minor	Minor	Minor	Minor
M13a	101	Forest	Poor	Minor	Minor	Minor	Minor	Minor
M13b	96	Forest	Poor	Minor	Minor	Minor	Minor	Minor
M15a	67	Forest	Poor	Minor	Minor	Minor	Minor	Minor
M19b	57	Rural/ Forest	Poor	Minor	Minor	Minor	Minor	Minor
M19c	161	Rural	Poor	Minor	Minor	Minor	Minor	Minor
M21a	126	Rural	Poor	Minor	Minor	Minor	Minor	Minor

Stream	Culvert length	Land-use	Existing ecological value	Significance of Project effects				Overall effect
				Water quality	Habitat	Water flow	Fish passage	
M21c	78	Rural	Poor	Minor	Minor	Minor	Minor	Minor
M21d	109	Rural	Poor	Minor	Minor	Minor	Minor	Minor
M21e	N/A	Rural	Poor	Minor	Minor	Minor	N/a Bridge	Minor
M23d	61	Rural	Poor	Minor	Minor	Minor	Minor	Minor
Pa100A	29	Rural	Poor	Minor	Minor	Minor	Minor	Minor
Pa200A	27	Rural	Poor	Minor	Minor	Minor	Minor	Minor
PA500A	15	Rural	Poor	Minor	Minor	Minor	Minor	Minor
SH1700	69	Rural	Poor	Minor	Minor	Minor	Minor	Minor

The adverse effects caused by the loss of stream habitat will be mitigated by appropriate riparian planting as suggested.

8.3 Summary of Recommendations

Prior to the culverting of a stream, a habitat assessment, preferably an SEV plus an assessment of the fish population, should be undertaken to confirm whether the stream is permanent and that, where practicable, the proposed culvert be designed to facilitate the passage of those fish species resident in the stream. This assessment would constitute the "base-line" against which any habitat changes can be assessed.

Prior to the commencement of the works in sections of permanent streams where fish are present, fish should be recovered and transferred to another section of that stream. The stream section should then be isolated by stop-nets to prevent fish entering that section of the stream during construction. Fish recovery and relocation procedures should be required through a condition attached to the consent for works in sections of permanent streams.

Where practicable, instream works should be undertaken outside the migration period for native fish species of September - February. Where this is not practicable, fish recovery and stream isolation procedures should be implemented through conditions.

Riparian planting should be undertaken along a length of permanent stream equivalent to that culverted to replace the lost habitat on an equivalent basis. Such planting should be undertaken within specified catchments within the designation.

We recommend a condition requiring an ecological assessment (macroinvertebrate and fish sampling) to be undertaken by a qualified ecologist following significant rainfall events during construction. That assessment should identify any significant impacts arising from the construction sediment on aquatic life and recommend appropriate actions to rectify the loss if any.

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Appendix A. Fish species recorded

Indigenous (Native)

Banded kokopu	*Galaxias fasciatus*
Common bully	*Gobiomorphus cotidianus*
Cran's bully	*G. basalis*
Inanga	*Galaxias maculatus*
Longfin eel	*Anguilla dieffenbachii*
Redfin bully	*Gobiomorphus huttoni*
Shortfin eel	*Anguilla australis*
Kakahi (freshwater mussel)	*Hyridella sp.*
Koura (freshwater crayfish)	*Paranephrops sp.*

Introduced (Exotic)

Goldfish	*Carassius auratus*
Grass Carp	*Ctenopharyngodon idella*
Mosquitofish	*Gambusi affinis*