LAND. PEOPLE. WATER.

Karaponga Stream Hydro Dam

For Karaponga Hydro Limited

Assessment of Effects

Ecological Report

December 2015

REPORT INFORMATION AND QUALITY CONTROL

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1 INTRODUCTION

In 2011 the Bay of Plenty Regional Council approved the transfer of resource consent to Karaponga Hydro Limited for the operation of a "run-of-the-river" power generation scheme associated with a historic dam across the Karaponga Stream. The initial purpose of the resource consent (issued to Lanark Developments Ltd in 1996) was to provide for the redevelopment of the concrete dam, originally built in 1922, and the recommissioning of the associated hydro-electric power scheme. The term of the current permit expires in March 2016, and Karaponga Hydro Limited is seeking a consent renewal to continue the operation of the scheme.

The mainstem of the Karaponga Stream receives flows from tributaries originating in a mixed land-use environment comprising agricultural pastureland, exotic forestry and native bush. Flows in the catchment drain in an easterly direction through a central gully system, where they eventually converge with those of the Mangaone Stream at the corner of Braemar Road and Mangaone Road. The reaches of the subject site (i.e. those which are considered likely to represent the full suite of potential ecological effects of the hydro scheme) arise approximately 2.8km upstream of the confluence with the Mangaone Stream at the reservoir behind the dam, with the lower bounds of the study 1km north of the Mangaone Stream confluence where the Karaponga Stream passes below McIvor Road (see Figure 1).

The purpose of this report is to describe the existing ecological values of the site (focussing on the riparian zone and freshwater habitats), with a view to identifying the potential ecological effects of the ongoing generation of hydro power from the Karaponga dam. Recommendations will also be made regarding appropriate measures to avoid, minimise, mitigate and/or offset any potentially significant adverse ecological effects.

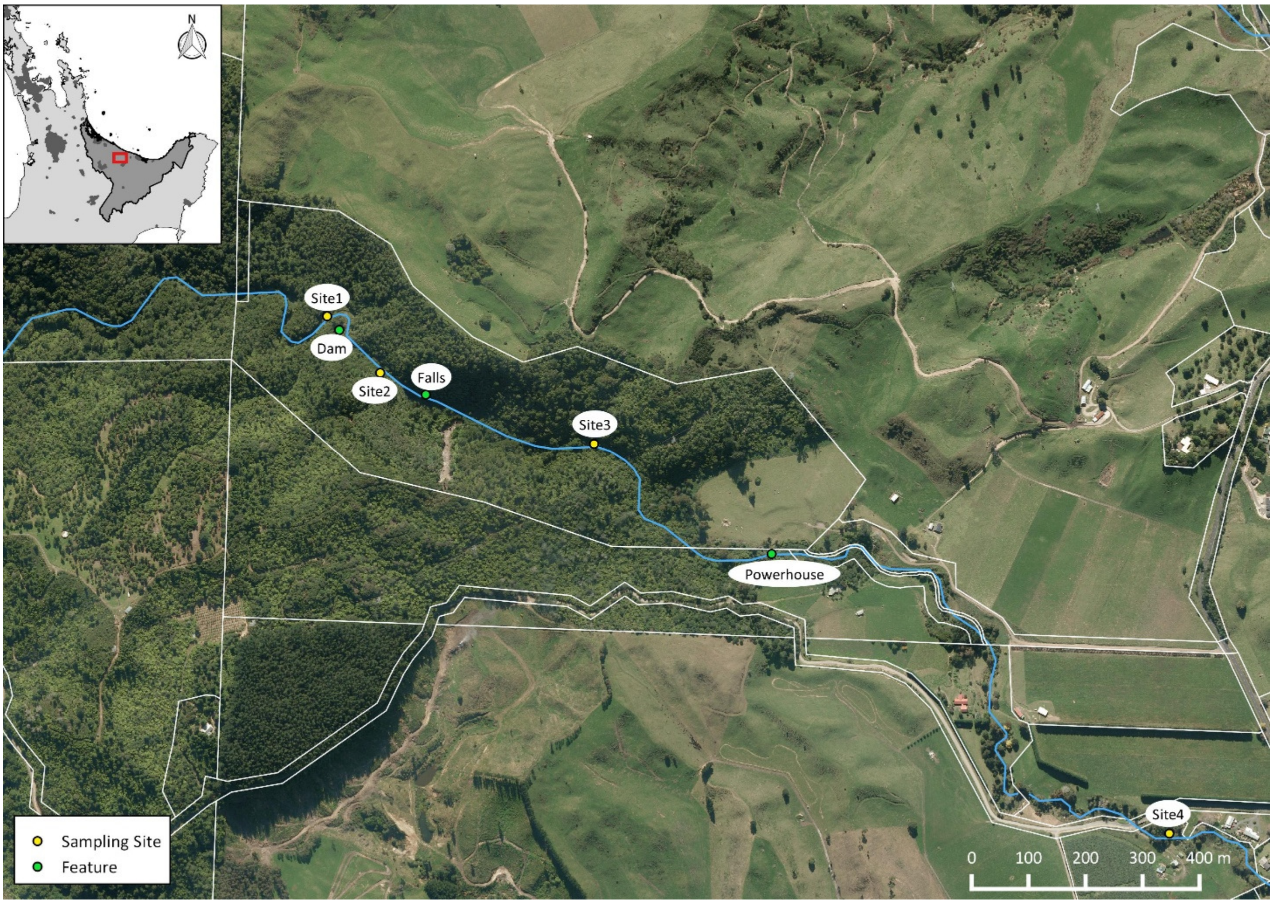

Figure 1: Site overview and sampling locations.

2 METHODOLOGY

2.1 Vegetation

The terrestrial vegetation of the site was surveyed on 15 and 16 October 2015 as part of a site visit, following an initial desktop assessment using high quality aerial imagery sourced from LINZ. During the site visit, native and exotic plant species and communities were recorded, and a qualitative assessment of vegetation habitats was conducted. The assessment included areas of vegetation on site in the vicinity of the riparian zone, focusing on the botanical and ecological value of identified plant communities.

2.2 Terrestrial Wildlife

Vegetation and habitat within the site was assessed by a qualified ecologist with regard to habitat quality for terrestrial and arboreal (tree-dwelling) herpetofauna (lizard) species. Lizard populations were also surveyed by way of brief habitat searches during the site visits conducted on 15 and 16 October 2015. Habitat searches for ground dwelling lizards involve inspecting areas of the riparian zone likely to be utilised by native lizards as shelter. Examples of lizard retreats include beneath dense vegetation, logs and rock.

Bird populations on site were surveyed through incidental observations during the site visits. In addition to bird surveys, vegetation present within the gully was also assessed in relation to habitat provision for avifauna.

2.3 Freshwater Habitats

The ecological and habitat values of the watercourses within the site were surveyed during the site visits on 15 and 16 October 2015. The surveys were undertaken during a period of mostly fine weather, following a day with occasional showers (less than 1mm each day in the previous 48hours), and following a previously dry week, with no rainfall occurring (BOPRC rainfall gauge: Tarawera at Hogg Road).

Various components of the aquatic ecosystem within the site were sampled at representative locations throughout the study reach; namely below the power house, above the power house but downstream of the large waterfall, upstream of the waterfall but below the dam, and above the dam (see Figure 1). The fish community was surveyed, as well as macroinvertebrates (snails, insect larvae etc.), which are established indicators of habitat quality and are easily sampled. Information on aquatic vegetation, general habitat characteristics, such as substrate type, and stream depth was also collected and photographs were taken at each site.

The macroinvertebrate sampling was carried out within the four sampled stream reaches in accordance with the Ministry for the Environment's "Protocols for Sampling Macroinvertebrates in Wadeable Streams" (Stark, Boothroyd, Harding, Maxted and Scarsbrook, 2001). Protocol C1: hard-bottomed, semi-quantitative was utilised as the stream substrates were dominated by boulders and pumice gravels. Substrate sampling was augmented by sampling trailing streamside vegetation, where present. The sample was immediately preserved in 70% isopropyl alcohol, returned to the laboratory and sorted using Protocol 'P3: full count with sub-sampling option' (Stark et al., 2001). Macroinvertebrates were then identified by an experienced taxonomist to the lowest practicable taxonomic level and counted to enable biotic indices to be calculated.

A range of biotic indices were calculated, namely the number of taxa (taxa richness), the percentage of Ephemeroptera (mayflies); Plecoptera (stoneflies) and Trichoptera (caddisflies) recorded in a sample (%EPT) and the Macroinvertebrate Community Index (MCI). EPT are three orders of insects that are generally sensitive to organic or nutrient enrichment, but excludes *Oxyethira* and *Paroxyethira* as these taxa are not sensitive and can proliferate in degraded habitats. The MCI is based on the average sensitivity score for individual taxa recorded within a sample. Sensitivity scores for taxa in hard-bottomed streams (MCI; Stark & Maxted, 2007) were used for the stream as the substrate at this site was generally boulder or gravel dominated. MCI scores of >120 are indicative of 'excellent' habitat quality, 100 - 119 are indicative of 'good' habitat quality, 80 – 99 are indicative of 'fair' habitat quality and <80 are indicative of 'poor' habitat quality (Stark & Maxted, 2007). Raw macroinvertebrate data are presented in Appendix A.

To identify the range of fish species utilising the Karaponga Stream in the vicinity of the hydro operation, a combination of trapping and netting was undertaken. Eight Marmite and cat biscuit-baited box traps (to target both native galaxids and bullies) were deployed at each of the four sample sites (Figure 1) and left overnight before being removed and checked for fish. Hand-netting of overhanging bankside vegetation and submerged debris was also undertaken of habitats within the study reaches on both 15 and 16 October 2015. All fish captured were identified, their size estimated and counted before being returned to their habitats. The body of reporting conducted on the stream and hydro scheme to date was reviewed, and the New Zealand Freshwater Fish Database (NZFFD) was searched for the catchment to identify any additional fish records from the area.

3 RESULTS

3.1 Vegetation

The vast majority of the vegetation within the forested gully central to the site can be classified as mature native podocarp/broadleaf forest. Throughout most of this area the land slopes sharply down to the Karaponga Stream mainstem at the gully floor (Figure 2, left). Rewarewa (*Knightia excelsa*), tawa (*Beilschmiedia tawa*), kohekohe (*Dysoxylum spectabile*) and kanuka (*Kunzea robusta*) are the dominant canopy species, with an understory comprising a diverse range of common native trees and shrubs. Species recorded included putaputaweta (*Carpodetus serratus*), mamaku (*Cyathea medullaris*), kawakawa (*Piper excelsum* subsp. *excelsum*), ponga (*Cyathea dealbata*), hangehange (*Geniostoma ligustrifolium* var. *ligustrifolium*), pate (*Schefflera digitata*), fivefinger (*Pseudopanax arboreus*), karamu (*Coprosma robusta*), red matipou (*Myrsine australis*), rangiora (*Brachyglottis repanda*), gully tree fern (*Cyathea cunninghamii*), wheki (*Dicksonia squarrosa*), pigeonwood (*Hedycarya arborea*), shining karamu (*Coprosma lucida*), soft tree fern (*Cyathea smithii*), wheki-ponga (*Dicksonia fibrosa*), wineberry (*Aristotelia serrata*) and seedling tawa. Juvenile white rata (*Metrosideros perforata*) was also sighted growing on the trunks of several large trees. Occasional emergent individuals of mahoe (*Melicytus ramiflorus*) occur on the upper gully slopes, with native climbing species such as kiekie (*Freycinetia banksii*) and supplejack (*Ripogonum scandens*) commonly growing down steep rock faces. Rasp fern (*Blechnum parrisiae*) and kiokio (*Blechnum novae-zelandiae*), frequently occur in dense stands amongst the climbers and native seedlings established on the steeper banks where larger trees are unable to persist.

Figure 2: Native vegetation of the gully (left), which the penstock passes through along a narrow section of track on the true left bank (right).

A track runs alongside the penstock on the upper slopes of the gully's true left bank, providing access to the upstream gully habitats from Karaponga Reserve. Species more common in open areas such as whau (*Entelea arborescens*), akeake (*Dodonaea viscosa*), kapuka (*Griselinia littoralis*) and cabbage tree (*Cordyline australis*) were sighted in light wells at the track edge, especially in the sections of track near to the reserve. Some low level weed invasion is also present in these lower track sections with discrete patches of blackberry (*Rubus fruticosus* agg.), wattle (*Paraserianthes lophantha*) and Japanese honeysuckle (*Lonicera japonica*) occasionally identified. Juvenile gum trees (*Eucalyptus* spp.), likely self-seeded from the mature individuals present in the Karaponga Reserve pastureland were also common. Weed and exotic presence becomes rare as the track narrows and continues upstream away from the reserve and into the forested gully interior.


Figure 3: Karaponga Reserve pastureland looking towards the gully (left). Access track near the reserve (right).

The reservoir formed by the dam lies in an area of the gully where the landform slopes in a more gentle manner than further downstream, although the vegetated cover is generally similar in composition. The pumice-dominated geology of the surrounds contributes a significant source of light-weight, mobile sediment into the headwaters of the Karaponga Stream, and the build-up of this material has almost completely infilled the reservoir proper. The accumulated sediment has been colonised by several native grasses and rhizomatous plants such as toetoe (*Austroderia fulvida*), rautahi (*Carex geminata*) and *Juncus* spp., as well as a range of opportunistic exotics such as Yorkshire fog (*Holcus lanatus*), blackberry, and Chinese privet (*Ligustrum sinense*). The native shrub koromiko (*Hebe stricta* var. *stricta*) was also established on the reservoir infill.

Following exit of the gully complex and downstream of the power house, the Karaponga Stream flows through land utilised as grazing pasture and lifestyle properties. Accordingly, the vegetation of the riparian zone has a higher exotic component, although overhead cover of the channel is still of relatively good quality. The stream channel through this area has been fenced from stock over much of its length, and rank exotic pasture grasses dominate the groundcover. Occasional ponga, cabbage tree, kiokio, hangehange, karamu, mahoe, red matipou, and rautahi are present within the understorey, which is supplemented by a range of exotics including wattle, willow (*Salix* spp.), *Acacia* spp., and radiata pine (*Pinus radiata*). The majority of the riparian zone is fenced, preventing stock from accessing the channel throughout the lower reaches and damaging the riparian environment.

3.2 Terrestrial Wildlife

A total of eleven native and four exotic bird species were recorded during the site visits. All species were designated either "Not Threatened" or "Introduced and Naturalised" under the most recent threat classification list (Robertson et al, 2013). Native species present included common birds of forested environments, although the avifauna field surveys are not considered exhaustive in that they were limited to two days. Accordingly, further species are expected to be present, including nocturnally active birds (e.g. morepork) and seasonal visitors to the area.

The "At Risk - Recovering" North Island kokako (*Callaeas wilsoni*), is known to utilise habitats within the Karaponga Reserve the adjoining native forest, and the corridor of forest extending further to the west. The Manawahe Kokako Trust, in partnership with the Department of Conservation and local Council, maintain a pest control program focussing on the management of rat and possum populations to help support the long-term viability of the area as kokako habitat. These actions will have significant flow-on benefit for other native fauna utilising the vegetation of the gully complex, including native North Island robin which are also present within the forest of the Karaponga Reserve. North Island robin spend a large portion of their foraging time at ground level, and are particularly susceptible to predation, especially by ship rats. Karearea (New Zealand falcon; classified as "Threatened – Nationally Vulnerable") have also been recorded from the area (Bancroft & Bancroft, 2011).

The structural diversity of the vegetation is sufficient to provide breeding and foraging resources for a wide range of native birds, emphasised by the diversity recorded during the surveys. Nectar feeders and frugivores are likely to congregate in the area during the flowering and fruiting periods of native trees. Rewarewa flowers are likely to be a locally important resource, as the species forms a large component of the canopy and flowers October to December, coinciding with the key nesting period for avifauna.

Overall the values of the gully forest in relation to avifauna are high, with good quality habitat for forest bird species provided throughout the mature native vegetation. The grassed amenity areas were occupied by birds common to pastureland habitats, including magpie, swamp harrier and chaffinch. Several pheasant and California quail were heard calling from the wooded margins of this area.

Table 1: Avifauna recorded utilising the Karaponga Stream gully 15 and 16 October 2015.

Scientific Name	Common Name	Threat Status (Robertson et al. 2013)
Anthornis melanura	Bellbird	Not Threatened
Callipepla californica	California quail	Introduced and Naturalised
Chrysococcyx lucidus	Shining cuckoo	Not Threatened
Circus approximans	Swamp harrier	Not Threatened
Fringilla coelebs	Chaffinch	Not Threatened
Hemiphaga novaeseelandiae	Kereru	Not Threatened
Gerygone igata	Grey warbler	Not Threatened
Gymnorhina tibicen	Magpie	Introduced and Naturalised
Petroica macrocephala	Tomtit	Not Threatened
Phasianus colchicus	Common pheasant	Introduced and Naturalised
Prosthemadera novaeseelandiae novaeseelandiae	Tui	Not Threatened
Rhipidura fuliginosa placabilis	North Island fantail	Not Threatened
Todiramphus sanctus	Sacred kingfisher	Not Threatened
Turdus merula	Blackbird	Introduced and Naturalised
Zosterops lateralis lateralis	Silvereye	Not Threatened

Copper skink (*Oligosoma aeneum*) was identified from several locations alongside the penstock access track within the native forest of the gully (Figure 4). Whilst this species is not uncommon throughout its range, copper skinks, like all native lizards, are an absolutely protected species under the Wildlife Act (1953). The vegetation on site appears to provide habitat of sufficient quality to support native geckos, although targeted nocturnal surveys would be required to confirm their presence.

Wallaby are known from the site, and deer are also likely to be present (Bancroft & Bancroft, 2014). Both species browse the understory, and significant damage to this vegetation tier occurs elsewhere within the wider gully corridor (Bancroft & Bancroft, 2014). Pigs have also been recorded from surrounding area, although are likely to be at low densities (Bancroft & Bancroft, 2014).

Figure 4: Kereru roosting near the power house (left). The low-growing vegetation along the penstock track supports native copper skink (right).

3.3 Freshwater Habitats

3.3.1 UPPER STUDY REACHES – RESERVOIR AND DAM STRUCTURE (SITE 1)

Within the bounds of this investigation (see Figure 1), the Karaponga Stream is generally a fast-flowing, clear watercourse, with a high level of overhead cover. The headwaters of the stream arise within a mixed land-use environment comprising pastureland, exotic forestry and native bush. The history of volcanic activity of the region characterises the local geology, with erosion-prone pumice dominating the soil of the area. The resulting low-density surface level soils are prone to erosion, and the upper reaches of the stream experience significant loading of abrasive, highly mobile sediment – evident by the infilling of the reservoir behind the dam. Much of the accumulated sediment behind the dam has been colonised by sedges, grasses and plants tolerant of periodic inundation (described further in Section 3.1), rendering the bulk of this material relatively stable. What remains of the stored volume is diminutive, effectively returning the original reservoir footprint into a low-gradient channel. Incoming flows pass through an intake screen before entering the penstock, with the residual flows spilling over the dam face (Figure 5, left), or discharged via a compensation valve at the base of the dam during low flow as per compensation requirements specified under the current consent. Spill flow over the dam face increases significantly during rain events, and high levels of suspended sediments, dominated by pumice, are swept downstream via flow both over the spillway and through the penstock (J. Berryman, pers. comm.).

3.3.2 UPPER STUDY REACHES – DOWNSTREAM OF DAM, UPSTREAM OF WATERFALL (SITE 2)

Whilst the reservoir has a bed substrate dominated by pumice sands, the directed flow channelled by the dam and associated infrastructure in conjunction with a higher gradient below the dam has facilitated downstream reaches with rapid flows and bed substrate comprising large volcanic boulders and exposed bedrock (Figure 5, right). The overhanging vegetation and stable boulders provide some instream habitats and occasional refuge pools for aquatic fauna, especially at the channel margins and bank edges. The dense riparian vegetation of these reaches additionally provides a high degree of channel shading, contributing significant benefits to water quality through temperature control. Despite this, the habitat provided is likely to be challenging for long-term occupation by instream fauna, with the rapid flows essentially creating a series of falls and cascades regularly scoured by the mobile suspended pumice transported from upstream. At the time of this survey, it was evident the mobile pumice sands infilled any protected crevices and gaps beneath/between boulders and woody debris. Most aquatic biota require some form of stable instream retreat/habitat – including migrating fishes. Earlier surveys conducted within these reaches indicate flows are likely to fluctuate seasonally (Charles Mitchell & Associates, 2013; Tiney & Donovan, 2009), further limiting the availability of stable habitat for aquatic biota. Further downstream, the mainstem flow descends into the gully, and a waterfall of considerable height (approximately 30m) is present, providing a natural barrier to non-climbing fish species.

Figure 5: View of the dam spilling water, with the remnant flow spilling over the structure face (left). Rapid flows of the reaches below the dam (right).

Figure 6: Small falls section downstream of the main waterfall (which was inaccessible at the time of survey for health and safety reasons).

3.3.3 LOWER STUDY REACHES – DOWNSTREAM OF WATERFALL, UPSTREAM OF POWERHOUSE (SITE 3)

Following passage over the falls, the mainstem of the Karaponga Stream flows through the more gentle gradient lower gully, and the channel becomes generally wider and flows less rapid. The substrate becomes increasingly dominated by pumice sands through these wider, slower-flowing reaches. Boulders and woody debris are consistently present - although in most locations are at least partially concealed by pumice sand. Channel shading remains high, with the native forest gully vegetation extending to the powerhouse. Several groundwater springs and seeps, as well as some small tributaries, drain into the Karaponga mainstem through the lower study reaches, contributing approximately 8 L/s additional flow to the channel (Palmer, 2015). Water clarity at the time of survey was excellent, consistent with the upper reaches of the Karaponga Stream.

3.3.4 LOWER STUDY REACHES – DOWNSTREAM OF POWERHOUSE (SITE 4)

Downstream of the powerhouse, the Karaponga Stream exits the vegetated gully and flows into land utilised for stock grazing and lifestyle properties. The stream retains a relatively swift flow, although the rapids sections observed further upstream caused by the higher flow gradients and instream boulders/large woody debris no longer occur. The banks are comprised of pumice sands rather than dominated by boulders and cobble-based material, with the channel cutting deeper into this easily eroded material and creating shelved banks. Undercutting of these banks have formed a degree of stable habitat for aquatic fauna not present further upstream of the Karaponga, and these environments therefore provide habitats more suitable for long-term occupation by native fish. Whilst in these lower study reaches the stream flows through farmland and pastures where stock is grazed, fencing of the channel was consistent. Despite the riparian vegetation of these reaches lacking the ecological and botanical diversity of the upstream gully environment, continued fencing has facilitated lush pasture growth, encouraged the growth of overhanging bankside vegetation, and allowed for occasional patches of natural regeneration to occur (Figure 7, right).

Figure 7: Lower in the gully the channel widens (left), and flows become gentler past the powerhouse (right).

3.3.5 AQUATIC BIOTA

A search of the New Zealand Freshwater Fish Database (NZFFD) returned nine records for the Karaponga Stream upstream of the confluence with the Mangaone Stream. Shortfin eel (*Anguilla australis*), longfin eel (*Anguilla dieffenbachii*), inanga (*Galaxias maculatus*), torrentfish (*Cheimarrichthys fosteri*), redfin bully (*Gobiomorphus huttoni*), giant kokopu (*Galaxias argenteus*), lamprey (*Geotria australis*), freshwater crayfish (koura; *Paranephrops*) and the introduced rainbow trout (*Oncorhynchus mykiss*) were all identified from the stream below the powerhouse. The upper reaches of the Karaponga Stream had a lesser diversity of fish fauna, notably dominated by species with some degree of climbing ability. Longfin eel, redfin bully, banded kokopu (*Galaxias fasciatus*) and rainbow trout were recorded within the reaches upstream of the powerhouse. Markedly, only banded kokopu and longfin eel (the most proficient of the migratory climbers) have been found upstream of the large waterfall, and are likely the only species capable of surmounting this significant obstacle and occur in the upstream catchment.

The dam itself constitutes a partial barrier to the movement of fish upstream, although a basic fish passage device was installed as per the original redevelopment works (under Lanark Developments Ltd). Notwithstanding this, NZFFD records and various surveys of aquatic fauna conducted under the previous iterations of the hydro scheme have indicated longfin eel are likely the only fish species able to currently access habitats upstream of the dam (Mitchell, 1995; Mitchell & Donald, 1995; Mitchell, 2000; Tiney & Donovan, 2009; Charles Mitchell & Associates, 2013). This access is additionally only available to the eels as juveniles, as the elver life phase is the only stage where animals possess the climbing ability to scale such a significant instream obstacle (McDowall, 2000). Additionally, migrating juvenile fish typically require recovery habitat in between swimming bouts. The constant infilling by pumice dominated sediments of recovery habitat for fish beneath/between stable instream structures, means upstream migrations are likely to be particularly challenging for most fish species. Low numbers of native fish upstream of the waterfall further illustrates the challenging nature of the uppermost study reaches, and ongoing seasonal monitoring of the dam face and fish passage device as per the current consent has failed to detect any elvers or juvenile galaxids in these areas (Caldwell, M, personal communication by email. 6th November, 2015). Notwithstanding this, occasional large individual longfin eel have been observed within pool habitats near the dam (J. Berryman, pers. comm.).

The fish surveys conducted at the four study locations during this investigation recorded only two species, with longfin eel of size range 450mm-550mm identified both at Site 4 downstream of the powerhouse, and near Site 2 upstream of the falls but downstream of the dam. A rainbow trout of size approximately 200mm was incidentally observed near the powerhouse discharge outlet.

The macroinvertebrate communities recorded from the four sample sites within the Karaponga Stream were generally diverse, with Site 2 (downstream of the dam, upstream of waterfall) having the highest total number of taxa and Site 3 (downstream of waterfall, upstream of powerhouse) having the lowest total number of recorded species (Table 2). Despite fluctuation in species richness, all samples contained a high portion of the sensitive EPT taxa, comprising mayflies, stoneflies and caddisflies. Mayflies were common throughout, with *Zephlebia* was comprising 25-65% of sample abundance for the four sites. *Zephlebia* rely on algae and other organic matter present on rock/debris surfaces as a food source, and the stable boulder habitats generally present throughout the study reaches provide such a niche. The mayfly *Coloburiscus* was found in high proportions at Site 2 and Site 3, representing 21% and 39% of the respective total abundance within the samples taken at these sites. *Coloburiscus* larvae exploit waterborne food resources, and their filter feeding strategy makes them particularly reliant on well aerated flows with good levels of overhead cover. Site 4 had the caddisfly *Pycnocentria* as the most frequently recorded taxon, comprising 35% of sample abundance. The larvae of *Pycnocentria* build cases from fine sand grains, and its dominance in the lowest reaches is likely reflective of the fine pumice bed sediment prevalent in the lower Karaponga Stream.

The macroinvertebrate communities at all sampled sites were dominated by taxa that prefer high water quality, and MCI scores at all four sites were greater than 120, and indicative of 'excellent' habitat quality throughout the study reaches.

Table 2: Summary of macroinvertebrate sample metrics from samples collected within Karaponga Stream (15 October 2015)

Macroinvertebrate Metric	Site 1	Site 2	Site 3	Site 4
Number of Taxa	22	25	14	23
EPT Value	12	12	11	14
Number of Individuals	206	224	197	284
% EPT	84	87	96	93
% EPT Taxa	55	48	79	61
MCI Value	125	126	141	120
QMCI Value	6.8	7.5	7.7	6.6

Figure 8: Longfin eel captured during the freshwater survey.

4 ECOLOGICAL VALUES AND ASSESSMENT OF ENVIRONMENTAL EFFECTS

Karaponga Hydro Limited is proposing to continue the operating scheme of the current consents, maintaining the dam and using the structure to take up to 800 L/s of flow from the upper Karaponga Stream for the purpose of power generation. This take is directed to the powerhouse through the 930m long penstock, and discharged following passage through the turbine. A compensation flow of at least 10L/s is additionally discharged/spilled from the dam to provide habitat for aquatic fauna during periods of low flow.

The lower reaches of the Karaponga Stream have been affected by the various iterations of the dam and power generation schemes since the 1920's, however the most recent ecological assessments conducted have focussed on fish populations and provision of passage for migrating animals over the dam (Mitchell, 1995; Mitchell & Donald, 1995; Mitchell, 2000; Tiney & Donovan, 2009; Charles Mitchell & Associates, 2013). The results of the surveys conducted as part of this investigation indicate that native fish diversity and abundance is affected by low upstream habitat availability and accessibility limitations as a result of natural migration barriers and the regular channel scouring and fine sediment loading from the pumice-dominated soils of the area. Notwithstanding the challenging environment for native fish, aquatic habitats can be generally classified as high value. Macroinvertebrate communities indicated that the Karaponga Stream retains excellent water quality throughout the study reaches, and instream fauna is likely resilient to the mobile substrate – a natural feature of the surrounding geology and subsequently the stream, regardless of the presence of the dam. The riparian zone associated with the Karaponga Stream (especially the upper Karaponga within the gully) additionally provides high quality habitat for both locally and nationally important terrestrial fauna. The operation of the hydro scheme in its current form has negligible impact on these terrestrial values.

Landuse upstream of the gully and dam on occasion affects water quality, with previous felling of plantation pines and agricultural operations removing vegetation (and subsequently filtration functions), increasing sediment inputs to the stream during high rainfall events (J. Berryman, pers. comm.). These sediment inputs in the past have created considerable functioning issues for the hydro scheme, with the abrasive nature of the sediment wearing the original penstock lining and components of the turbine (J. Berryman, pers. comm.). The operational constraints caused by the inundation of sediment around the intake structure of the dam has led to upgrading works by Karaponga Hydro Limited. One feature added by the company includes a valve-controlled discharge system to remove sediment from the associated intake structure following storm/high rainfall activity and the associated high flows. Flow can be manually diverted to spill at the foot of the dam, effectively allowing dispersal of the sediment-laden water throughout the upper reaches. This activity is more in alignment with the natural functioning of stream flows in the catchment during high rainfall events, as flow and associated suspended sediment is able to spread throughout the system rather than be funnelled rapidly downstream to accumulate in the slower flowing reaches around and below the powerhouse.

A key consideration of the previously consented hydro scheme with regard to the Karaponga Stream ecology is provision of migration routes for climbing fish species able to naturally traverse the waterfall. The fish pass present currently was installed in accordance with the original dam redevelopment consent, and was generally designed for an operating scheme where the reservoir would be dredged to increase storage capacity, and spill over the dam would likely only occur during flood flows (Mitchell, 1995). Accordingly, the fish passage entrance in the current operating environment presents a somewhat cryptic target for migrating juvenile fish, as the run-of-the-river generation scheme means the spillway flows are likely to attract any elvers or native fish towards the dam face, rather than the more subtle flows around the pass entrance. A revision of the original fish passage consent conditions in recognition of the change of scheme to a "run-of-the-river" operation added additional management requirements. The following condition was removed:

"6.1. The Grantee shall install a native fish pass on the dam in general accordance with Figure 3 in the "Charles Mitchell and Associates" (July 1995) report submitted with the application for this consent."

And replaced with the new conditions below:

"6.1. The consent holder shall arrange for and undertake a further evaluation of native fish present between the waterfall and dam face by an appropriately qualified fisheries biologist in the year 2005. This report should be submitted to Environment BOP within six months of completion. If the evaluation reveals native fish present then it shall also make recommendations on how these can be transferred to upstream of the dam on an ongoing basis.

6.2. If the evaluation above in 6.1 reveals elvers and/or other native fish are accessing the dam face, then the manual transfer of fish shall be undertaken in accordance with the independent biologist's recommendation.

6.3. The Grantee shall install a spillway apron on the dam in general accordance with Figure 3 in the "Charles Mitchell and Associates" (July 1995) report submitted with the application for this consent if it is revealed that elvers and/or other native are accessing the dam face. This spillway apron shall be installed within twelve months of the biologist report if it reveals that manual transfers are necessary as detailed in 6.2 above."

Tiney & Donovan (2006) completed the required report as per the new condition 6.1 above, and recommended that manual transfers of longfin eel be implemented. Subsequent to this recommendation, ongoing monitoring of the dam face has been conducted, although to date no elvers or juvenile fish have been found in this area (Charles Mitchell & Associates, 2013; Caldwell, M, personal communication by email. 6th November, 2015). Monitoring of fish populations elsewhere within the affected reaches of the Karaponga (as per a separate but related consent condition 8.3) has resulted in the capture of some older longfin eel, and these animals were relocated upstream of the dam, despite not naturally being able to do this at the life stage they were caught at (Charles Mitchell & Associates, 2013). Ongoing manual transfer of adult eels is considered unnecessary if sufficient fish passage assistance for juveniles is provided, although the lack of elvers at the dam face has meant there is no resulting requirement for the spillway apron as described in condition 6.3.

It is likely that the challenge of reaching the dam face for juvenile fish, in conjunction with the punctuated nature of the current point monitoring, means that if animals do indeed reach the dam, it is in too few numbers to detect. Rather than continue with a labour intensive, and so far largely ineffective manual transfer system, it is recommended that alternative fish passage devices are installed to supplement the current fish pass. In consideration of the physiological requirements to access the dam face, provision of additional fish pass devices is only considered necessary for the support of climbing species. Juveniles of both banded kokopu and longfin eel can climb wetted mussel spat rope overhanging considerable vertical drops which would otherwise be insurmountable (David et. al 2014). Ropes could be anchored to the dam spillway in a manner such that fish which may be attracted to the dam face can locate and utilise them to continue their upstream migration. Fish passage via spat ropes could be further enhanced utilising the residual channel flow. Directed residual flows (i.e. as discharged via pipe) would provide a clear pathway for juvenile fish moving upstream, and could be used to attract fish to the spat ropes, especially during periods of low flow. Suspended pumice within flows over the spat rope will likely wear the material over time. Periodic inspections, and if required repair or replacement of these ropes, should be built in to the regular maintenance schedule for the dam. Provision of downstream access for migrating adult longfin eel (which return to the sea to breed at the end of their life cycle) is considered unnecessary in this case. Animals attempting downstream migrations over the 5.7m high dam may face risk of injury and/or death, although any successful migrants must then attempt to safely navigate down the 30m high waterfall, which is considered to be a far greater risk to their survival.

In summary, the re-consenting of the Karaponga hydro scheme in the manner proposed will continue an activity which has existed in some form for over 90 years. Stream health and terrestrial habitat values of the gully and the riparian zone are high, and it is expected that the mode of operation will maintain these high ecological values, owing to the sympathetic management regime proposed, the abiotic features of the Karaponga Stream, and the nature of the surrounding catchment. Notwithstanding this, opportunity exists to provide simple improvements to enhance fish passage over the dam, which will increase the value of the area to native fish species that would otherwise be able to naturally access the upper catchment.

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Appendix A:

Raw Macroinvertebrate Data

Taxa	MCI Score	Site 1 Upstream	Site 2	Site 3	Site 4 Downstream
Mayfly Ameletopsis	10	1			
Mayfly Austroclima	9			1	10
Mayfly Coloburiscus	9	9	48	76	8
Mayfly Deleatidium	8		13	7	
Mayfly Nesameletus	9		2	1	
Mayfly Zephlebia	7	133	66	49	92
Stonefly Acroperla	5	2	12	19	5
Stonefly Austroperla	9	10	21	7	1
Stonefly Megaleptoperla	9			3	
Stonefly Zelandobius	5	4	3	6	19
Stonefly Zelandoperla	10		2		
Caddisfly Hudsonema	6	2			10
Caddisfly Hydrobiosis	5	1			2
Caddisfly Oeconesidae	9		3		1
Caddisfly Orthopsyche	9		17	10	2
Caddisfly Plectrocnemia	8				1
Caddisfly Polyplectropus	8	3			2
Caddisfly Psilochorema	8	1			
Caddisfly Pycnocentria	7	4	6	11	100
Caddisfly Triplectides	5	2			11
Caddisfly Zelolessica	10		1		
Dragonfly Antipodochlora	6	3			
Dobsonfly Archichauliodes	7	1	2		2
Beetle Dytiscidae	5		1		1
Beetle Hydrophilidae	5	8	10		
Beetle Ptilodactylidae	8	1	2		
Beetle Staphylinidae	5		3		
True Fly Austrosimulium	3		1		2
True Fly Orthocladiinae	2		2		6
True Fly Paralimnophila	6		1		
True Fly Polypedilum	3				1
True Fly Tanypodinae	5				2
True Fly Tanytarsini	3	4	1	3	2

Taxa	**MCI Score**	**Site 1 Upstream**	**Site 2**	**Site 3**	**Site 4 Downstream**
Collembola	6		1		
Crustacea Isopoda	5	1		1	
Crustacea Talitridae	5	7			
MITES	5	1			
SPIDERS Dolomedes	5	4	4	3	1
Mollusc Potamopyrgus	4	4	1		3
OLIGOCHAETES	1		1		
Number of Taxa		22	25	14	23
EPT Value		12	12	11	14
Number of Individuals		206	224	197	284
% EPT		83.50	86.61	96.45	92.96
% EPT Taxa		54.55	48.00	78.57	60.87
MCI Value		124.55	125.60	141.43	120.00
QMCI Value		6.77	7.50	7.68	6.63

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