APPENDIX I

Terrestrial Ecology Assessment –
Ryder Environmental Limited

Trustpower

Mangorei HEPS
Terrestrial Ecology
Assessment of Effects

November 2020

ryder

Trustpower

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Terrestrial Ecology Assessment of Effects

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FINAL

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Cover page: Waiwhakaiho River at the 'Meeting of the Waters'.

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Executive Summary

Trustpower is applying for new resource consents to continue operating the Mangorei Hydroelectric Power Scheme (HEPS). This report assesses the actual and potential effects on terrestrial ecological values of the scheme as currently operated and as proposed under renewed consent conditions.

No changes are proposed to the current suite of consent conditions that relate to hydrological operation of the scheme other than proposed additional flows in response to high water temperature and nuisance periphyton growth.

HEPS infrastructure

The construction of the HEPS required the permanent removal of the terrestrial vegetation and habitat for terrestrial fauna at the locations of the intake; main dam; saddle dam; spillway; power station and outlet canal; parking areas; roading, and outbuildings. However, the ongoing presence of these various structures has negligible effect on terrestrial ecological values because the effects are small and localised, and/or the adjacent vegetation and habitat suggests that these sites, without the HEPS structures, would have low ecological value.

Waiwhakaiho River

Reductions in flow downstream of the intake, and daily flow fluctuations below the tailrace, have probably caused changes in the extent of vegetation immediately adjacent to the wetted edges of the river channel. However, these changes are very limited in spatial extent, and the vegetation appears to have reached a new equilibrium at the land-water interface. Effects of flow on riparian vegetation are therefore of negligible ecological consequence.

Aquatic invertebrate and fish communities, which provide potential prey for birds on the Waiwhakaiho River, have changed as a result of the scheme, with increases and decreases in available habitat, depending on species. It is not possible to say definitively whether these changes will have been detrimental or beneficial for birds. However, the similar or higher abundance of redfin bullies and juvenile trout within the residual reach, and the presence of various species within and upstream of the residual reach river indicate that these species continue to provide prey for birds along the river.

Several sites recognised as significant by the Taranaki Regional Council and/or the New Plymouth District Council are located adjacent to the Waiwhakaiho River downstream of the intake. These are entirely or almost entirely, located outside the immediate varial zones, and are therefore entirely or almost entirely unaffected by flow.

Mangamahoe Stream

Any effects of the Mangamahoe Dam on the riparian vegetation and habitat of Mangamahoe Stream have been overwhelmed by the effects of surrounding land use (notably forestry and agriculture), native regeneration, and exotic weed invasion. In addition, the NPDC dam creates a narrow reservoir, about 300 metres long, which replaces some of the original stream and associated riparian habitat. The surrounding land use continues to determine the composition and structure of the vegetation and habitat along the Mangamahoe Stream, with the ongoing alteration in flow as a result of operation of the HEPS having negligible effects on terrestrial ecology.

Lake Mangamahoe

The formation of Lake Mangamahoe resulted in the inundation and therefore loss of 0.25 km^2 of terrestrial vegetation and habitat, and the concurrent creation of the same area of aquatic habitat. As far as we can ascertain, the land inundated was previously farmland. The creation of Lake Mangamahoe and the associated management of the surrounding land has probably resulted in a net positive effect on terrestrial ecological values, through the development of diverse lakeside vegetation and the habitat it provides for various terrestrial fauna, and through the creation of habitat for waterbirds.

1. Introduction

Trustpower is applying for new resource consents to continue operating the Mangorei Hydroelectric Power Scheme (the scheme or HEPS). This report, which is one of a series of technical assessments, addresses the actual and potential effects of the scheme on terrestrial ecological values. The ongoing effects of the scheme as currently operated and as proposed under renewed consent conditions are considered.

2. Assessment methods

This assessment is informed by site visits and a review of existing information. The potentially affected sites (described below) were visited on several occasions between November 2018 and January 2020. Existing information on terrestrial ecological values was obtained from a range of sources, including the scientific literature, district and regional council reports, and various online sources such as bird and plant databases. These are cited where relevant, below.

3. Existing environment

Potentially affected sites

With regard to terrestrial ecological values, the sites potentially affected by the continued operation of the HEPS are the riparian margins of:

1. The 6-km reach of the Waiwhakaiho River downstream of the intake weir to the Mangorei Power Station and the 'Meeting of the Waters' (in other technical reports sometimes referred to as 'the residual reach').
2. The 11-km reach of the Waiwhakaiho River from the power station/Meeting of the Waters to the sea.
3. Lake Mangamahoe.
4. Mangamahoe Stream downstream of the Mangamahoe dam and spillway.

Locations of key sites are shown in Figure 1, below.

Figure 1. Aerial map showing location of structures and surface waters associated with the Mangorei HEPS.

Ecological context

The HEPS and the above sites are located entirely within the Egmont Ecological District in the Egmont Ecological Region (McEwen 1987). The climate is generally mild, with relatively high humidity and fairly high, evenly distributed annual rainfall. Soils are volcanic and varied, and include deep ash soils, well-drained alluvial soils along rivers, and sandy soils near the coast. Slopes within the broader landscape around the potentially affected sites range from gently undulating to strongly rolling. The Waiwhakaiho River is a narrow, single channel river, typically 10-m to 30-m wide, set within a channel of 20-m to 60-m width. The banks of the river are frequently very steep and well-vegetated (Figures 2 & 3), even where the river passes through the outskirts of New Plymouth (Figure 4). Within the lower reaches of the river, more gently sloping margins are also present in places (Figures 3 & 4).

The vegetation in the wider landscape around the Mangorei HEPS and along the Waiwhakaiho River is typical of the lower slopes of the Taranaki ring plain, comprising predominantly developed pasture with numerous patches of introduced and/or indigenous scrub and forest. Under the Land Environments New Zealand (LENZ) classification system (Leathwick *et al*. 2002) the surrounding landscape is classified as retaining less than 10% of its original indigenous vegetation (i.e. tawa, kohekohe, rewarewa, hinau, podocarp forest).

Waiwhakaiho River

The immediate riparian margins of the Waiwhakaiho River support a mixture of indigenous and introduced vegetation, as illustrated in Figures 2 – 4. At the intake weir, and downstream of the weir for 2.5 km, the margins on the true left of the river are characterised by heavily vegetated steep banks. Mamaku (black tree fern) is prominent (Figure 2), and numerous other indigenous species are present (e.g. tawa, kaikomako, tarata, ti, porokaiwhiri, kawakawa, rangiora, *Olearia* spp., tutu, kiekie, kiokio, harakeke, toe toe, *carex* spp.), as are exotic species including pines, willows, gorse, broom, and a typical diverse assemblage of introduced grasses and herbs.

On the true right of this reach, and along most of the river on both banks, downstream of the weir to the sea, the vegetation is dominated by improved pasture, rough pasture and introduced shrubs and trees. These include the species mentioned above, and many others, particularly within New Plymouth where numerous amenity or 'garden' trees, shrubs and herbaceous exotics species can be found along the river banks (Figure 4). There are, however, patches of vegetation along the river in which indigenous species are dominant or comprise a substantial

component of the vegetation. Several of these are recognised in the operative and proposed District Plans as Significant Natural Areas (SNAs) and/or as Key Native Ecosystems (KNEs) by the TRC. These sites are discussed in further detail, below. It is important to note that, whilst some of these sites may be bounded by the river or lake, they typically also extend some distance from the river or lake, beyond the riparian zone that might conceivably be affected by changes in flow regimes.

Lake Mangamahoe

Lake Mangamahoe was created in 1931 with the construction of the Mangamahoe dam (NPDC 2011, Tonkin and Taylor 2020). The lake and lake shore is owned by Trustpower. The lake shore is managed by the New Plymouth District Council as set out in the *Lake Mangamahoe Management Plan* (NPDC 2011), except for several parcels of land that are owned and managed by Trustpower.

The lake is used for hydroelectricity generation and water supply, and is set within production pine forestry, patches of regenerating indigenous forest (including the species mentioned above), and 'parkland' comprising grassland and amenity plantings of trees, shrubs and herbaceous species (Figure 5). The lake and surrounds provides habitat for at least 40 species of indigenous and introduced water birds (e.g. black swan, paradise shelduck, Australasian shovelor, Australian coot, black shag, little shag, grey teal, Australasian grebe, sacred kingfisher, pukeko, Canada goose*[1], mallard*, mute swan*) and birds of forest/forest-edge/scrub (e.g. kereru, tui, bellbird, fantail, silvereye, grey warbler, magpie*, song thrush*, blackbird*, Eastern rosella*). Two of the indigenous bird species recorded at the lake are classified under the New Zealand Threat classification system (Robertson *et al*. 2017) as *at-risk* or *threatened*: NZ dabchick (*at risk - recovering*) and grey duck (*threatened – nationally critical*). Lake Mangamahoe is a wildlife refuge and is protected under Section 14 of the Wildlife Act 1953.

[1] * indicates introduced species.

Mangamahoe Stream

The Mangamahoe Stream carries a small flow 1.4 km from the Mangorei HEPS spillway to its confluence with the Waiwhakaiho River. It is typically 1 – 2 metres wide, with some wider pools. The existing NPDC dam, constructed in 1918 and unrelated to the operation of the HEPS, creates a small reservoir, approximately 300 m long and up to 30 m wide (*c.* 0.5 ha), which provides habitat for some waterbirds. In its upper and lower reaches, the stream is densely vegetated with forest and shrubland growing to the margins and forming a near closed canopy (Figure 6). This vegetation is dominated by pine forest but also supports a diverse sub-canopy of exotic and indigenous species similar to those found around Lake Mangamahoe. A central 600-m section of the stream flows through farmland, and here the riparian vegetation comprises mainly rough pasture.

Figure 2. Mixture of exotic and indigenous vegetation types in the vicinity of the Waiwhakaiho River at the intake weir (foreground).

Figure 3. Vegetation/riparian habitat at the Meeting of the Waters, immediately downstream of the Mangorei HEPS tailrace.

Figure 4. Waiwhakaiho River in New Plymouth, near Raiomiti Street (near the New Plymouth Badminton Club).

Figure 5. Lake Mangamahoe and surrounding mixture of exotic and indigenous vegetation, including production forestry.

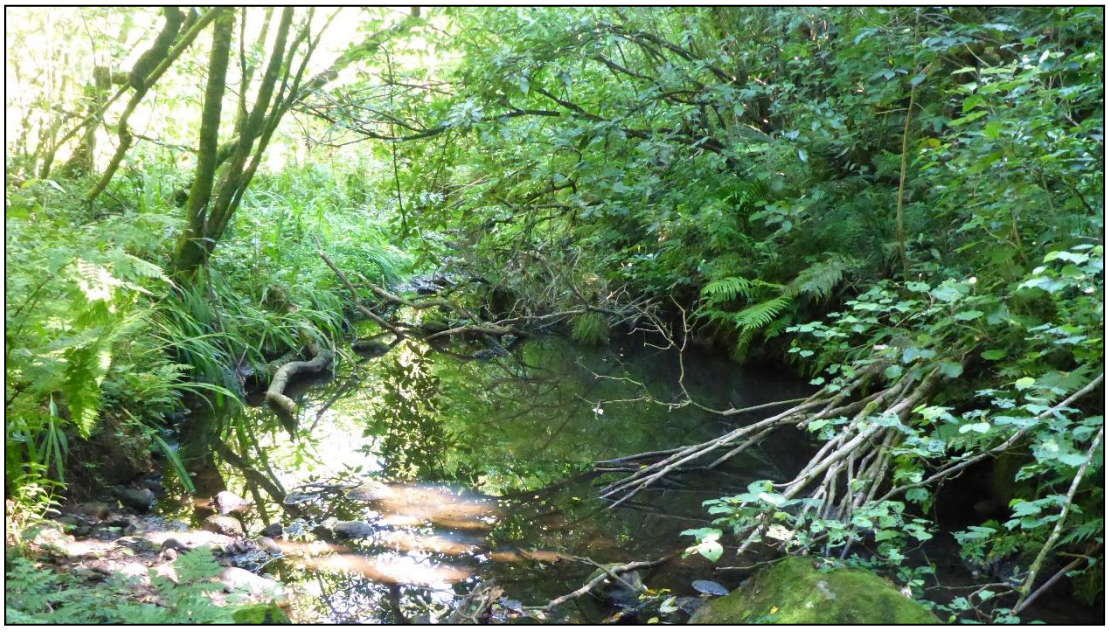

Figure 6. A pool in the Mangamahoe Stream, downstream of the Mangorei HEPS spillway.

4. Significant Natural Areas

Operative and Proposed District Plans

The Operative District Plan does not identify any SNAs in the vicinity of the reach of the Waiwhakaiho River potentially affected by the HEPS, nor in the vicinity of Lake Mangamahoe or Mangamahoe Stream.

The Proposed New Plymouth District Plan (PNPDP) was notified on 23 September 2019. The PNPDP identifies areas of significant indigenous vegetation as Rural Significant Natural Areas in Schedule 6, and Urban Biodiversity Areas in Schedule 7[2].

Schedule 7 lists two SNAs on the Waiwhakaiho River within the reach potentially affected by the HEPS (sites 258 and 260). Site 258 is located on the true right of the river near the Royal Heights cul-de-sac, off Queens Road and approximately 7.5 km downstream of the power station. This SNA is contiguous with a QE2 covenant (Covenant No. 5-06-379) to the south, also along the river margin. The vegetation at Site 258 is described in Schedule 7 as:

*'Indigenous forest on a steep bank. The stand comprises a canopy of kohekohe (*Dysoxylum spectabile*) to approximately 25 metres tall, with occasional karaka (*Corynocarpus laevigatus*), pukatea (*Laurelia novae-zelandiae*), māhoe (*Melicytus ramiflorus *subsp.* ramiflorus*), and local emergent rewarewa (*Knightia excelsa*). There are patches of mamaku (*Cyathea medullaris*).*

*Mixed indigenous-exotic forest occurs on the river terrace. The canopy comprises kohekohe, tarata (*Pittosporum eugenioides*), and mamaku, to approximately 12 metres tall. There are a few emergent rewarewa (Knightia excelsa) and patches in the canopy are dominated by crack willow (*Salix x fragilis*, not indigenous).*

No less than approximately 400 trees are present.'

Site 260 is located in Burgess Park on Hydro Road, on the true left of the Waiwhakaiho River and immediately upstream of the 'Meeting of the Waters'. This is not described in the District Plan. It is on the opposite side of the river from the DOC Meeting of the Waters Scenic Reserve, which is also listed as a Key Native Ecosystems (KNE) by the TRC (described below).

[2] Online version of the PNPDP viewed at https://districtplan.npdc.govt.nz/eplan/# on 27 April 2020.

A further site near to (60 metres from the river at its closest point), but not immediately adjacent to, the river is identified as a Rural SNA. This is Site 259 which is located in farmland, near Smart Road on the true right. The vegetation is not described in the District Plan.

Upstream of the intake weir and Lake Mangamahoe are several Rural SNAs along tributaries of the Waiwhakaiho River or the lake. The terrestrial ecological values of these are not potentially affected by the HEPS, but the sites are noted here for completeness: site 365 (Kamahi forest, mahoe-(mamaku) scrub along Albert Road, Egmont Village Junction Road, and Kent Road; site 366 (not described in PNPDP); site 367 (not described) on Albert Road and Mangawara Road, and site 368 [Mamaku-mahoe-(kamahi) scrub, kamahi forest along Mangawarawara Stream].

Significant trees

The operative and proposed district plans identify a number of 'significant trees' along the Waiwhakaiho River, all introduced species, except for a group of rimu. These trees (or groups of trees) have retained the same numbers in the proposed plan as in the operative plan, but the proposed plan distinguishes between individual trees and groups of trees. Thus, in the immediate vicinity of the Meeting of the Waters, near the power station, the PNPDP identifies three 'notable tree groups' (sites 159 – 161) comprising introduced species: two Californian redwoods (*Sequoia sempervirens*), 15 London plane trees (*Platanus x acerifolia*), and 100 Chinese fir trees (*Cunninghamia lanceolata*). It also identifies one 'notable tree' at this general location, an English oak, (*Quercus robur*) at site 162. At 361 Junction Road New Plymouth, the operative and proposed district plans list two notable trees or tree groups: one plume cedar (*Cryptomeria japonica elegans*) at Site 165, and eight rimu (*Dacrydium cupressinum*) at site 166.

Taranaki Regional Council - KNEs

The Taranaki Regional Council maintains an inventory of sites with indigenous biodiversity values of regional significance (KNEs, TRC 2006). Two KNEs are identified within the reach potentially affected by the Mangorei HEPS. The largest is the 33.5-ha Meeting of the Waters Scenic Reserve located at the junction of the Waiwhakaiho River and Mangorei Stream, 8 km south-east of New Plymouth on State Highway 3. This scenic reserve is administered by the Department of Conservation. The TRC (2006) describes it as supporting '*an excellent example of lowland podocarp broadleaved forest*'. The vegetation is described as '[*t*]*he predominant vegetation type is totara (*Podocarpus totara*)/tawa (*Beilschmiedia

tawa*) forest. Large totara, matai (*Prumnopitys taxifolia*), miro (*Prumnopitys ferruginea*) and rimu (*Dacrydium cupressinum*) are emergent over a canopy dominated by tawa. In the southern portion of the Reserve, matai is the predominant emergent podocarp. Other species locally important in the canopy include white maire (*Nestegis lanceolata*), black maire (*Nestegis cunninghamii*), titoki (*Alectryon excelsus*), and kamahi (*Weinmannia racemosa*). The understorey is quite open with common species being* Coprosma rhamnoides *and* Lophomyrtus obcordata*. Hybrids between* Lophomyrtus obcordata *and* Lophomyrtus bullata *present. There is also an area of regenerating mixed broadleaved forest – shrubland in the south-western portion of the Reserve. The wood rose* Dactylanthus taylori*, a species identified as 'Chronically Threatened (Serious Decline), was recorded here historically and may still be present.'*

The other KNE is Canaan Bush, described by TRC as a 2.7-ha *'remnant of semi-coastal forest* [on private land] *adjacent to another[3] 2.1 ha of NPDC owned reserve which borders the Waiwhakaiho river'.*

'The ecosystem type is classified as WF13, Tawa, kohekohe, rewarewa, hinau, podocarp forest. The remnant is an example of cutover forest with a reasonable canopy cover and regenerating undergrowth. The site provides good connectivity to other Key Native Ecosystems in the area including Umutekai bush, Welbourn school bush and Dorset road bush.

Flora

The main canopy of the remnant is dominated by pukatea, tawa, kohekohe, puriri and rewarewa. The lower canopy is dominated by mahoe, pigeonwood and tree ferns. A good mix of seedlings and saplings are present including kawakawa, mapou, pate and kanono. A variety of native ferns are also present in the groundcover, including large numbers of the 'regionally distinctive' jointed fern and the 'at risk' kingfern. The area is classified as an 'Acutely Threatened' land environment (F5.2b).

Fauna

Bird life in the remnant is fairly typical for the margin of the New Plymouth urban area. Native birds such as tui, kereru, fantail, and grey warbler are present. Good habitat exists for native reptiles including epiphytes, loose bark, abundant foliage, leaf litter and forest ground cover. The site will contain a diverse range of invertebrates which may include notable species such as Peripatus*.'*

[3] [This other site is listed as SNA site 259 in NPPDP, and is also a QEII National Trust covenant].

5. Assessment of effects

Summary of terrestrial values

Although highly modified, the vegetation along the riparian margins of the Waiwhakaiho River, Mangamahoe Stream and Lake Mangamahoe is valuable from a terrestrial ecological perspective. These margins support a diversity of indigenous plant species, albeit frequently in combination with various introduced plant species. As well as being of value in itself, this vegetation provides valuable habitat for indigenous and introduced birds, lizards, and invertebrates within a landscape dominated by farmland. It contributes to, and provides 'connectivity' with, a wider network of habitat fragments within the region. Some of the more substantial and/or more intact stands of vegetation are recognised as SNAs, KNEs, QE2 covenants, and/or DOC reserves, as discussed above.

Vegetation adjacent to water, such as along the Waiwhakaiho River, Mangamahoe Stream and Lake Mangamahoe, provides additional value compared with vegetation within an entirely terrestrial setting. This is because it provides breeding, feeding and/or roosting habitat for various fauna associated with water. For example, for birds that feed over or in the water, such as kingfisher, fantails, and various waterfowl, gulls, terns and wading birds, or that breed near water such as waterfowl and shags. Similarly, riparian margins provide habitat for the terrestrial life history stages of some aquatic invertebrates, such as adult damselflies and dragonflies.

HEPS infrastructure

The construction of the HEPS required the permanent removal of the terrestrial vegetation and habitat for terrestrial fauna at the locations of the lake; intake; main dam; saddle dam; spillway; power station and outlet canal; parking areas; roading, and outbuildings. In the overall context of the scheme, the ongoing presence of these various structures has negligible ecological effect because the effects are localised within small areas, and/or the adjacent vegetation and habitat at each location, and thus the likely vegetation if the structures did not exist, does not have high ecological value.

Hydrological effects

In general, changes in flow have the potential to directly affect the terrestrial ecological values of rivers and lakes through two main mechanisms:

a) **Varial zones**. Fluctuations in water level and thus in the extent of the wetted edges of rivers results in a 'varial zone' that is inundated at varying frequencies[4] (Hoyle et al. 2016). At one extreme, confined waterways with steep banks and stable flows, such as canals, typically have a clear delineation between the terrestrial and aquatic ecosystem, with only a very narrow varial zone (in the order centimetres to tens of centimetres wide). Conversely, unconfined waterways with low-gradient channel water edges and variable flows, such as the expansive braided gravel rivers of the South Island can have wide variable zones (metres to tens of metres wide). Similarly, ecological communities at lake margins will transition from permanently submerged aquatic communities through a varial zone of emergent/periodically inundated communities, through to entirely terrestrial communities (Johnson 1972; de Winton and Schwarz, 2004). Plants and animals within the varial zone need to be able to cope with varying environmental conditions. This may give rise to relatively low ecological diversity (e.g. along active gravel river margins), but may also result in specialised ecological communities, such as lake edge turfs (Johnson and Rogers, 2003).

b) **Floods**. Floods are a more extreme manifestation of flow variation, and can affect the substrates and thus the vegetation and habitat within the riparian margins of rivers, beyond the normal extent of the varial zone. Large floods in particular can have dramatic short-term effects by mobilising substrates and removing vegetation/habitat, in some cases profoundly altering river geomorphology.

Indirectly, changes in flow may affect terrestrial values by affecting the species composition and/or abundance of aquatic invertebrates and fish that provide prey for birds that feed in or over water (O'Donnell *et al*. 2016).

The specific hydrological effects of the current flow regimes of the HEPS are described in detail in the hydrology report (Tonkin and Taylor 2020). No changes are proposed to the current suite of consent conditions that relate to hydrological operation of the scheme other than proposed additional flows in response to high water temperature and nuisance periphyton growth. The key hydrological effects of potential relevance to terrestrial ecology are summarised in Table 1, below.

[4] https://niwa.co.nz/freshwater-and-estuaries/research-projects/braided-river-morphodynamics-and-invasive-exotic-vegetation

Table 1. Key hydrological effects of the Mangorei HEPS. The summary information in this table is extracted from the hydrology report prepared by Tonkin and Taylor (2020), and from the aquatic ecology report prepared by Ryder Environmental (2020).

Site	Comments (based on recent operational regime 2013 to 2020)
Waiwhakaiho River from intake to power station tailrace	
• Diversion of up to 10 m^3/s from the Waiwhakaiho River	Diversion of up to 10 m^3/s from the Waiwhakaiho River has resulted in reduced flow between the river intake and the tailrace confluence ('Meeting of the Waters'), 5.9 km downstream. The diverted water is not permanently lost but is returned to the river (via the tailrace) where it flows for another 11 km before reaching the sea. Flows increase naturally within this reach as a result of inflows. At the downstream end of the reach, flow is at least 82 L/s higher than immediately downstream of the intake. Most of the time, flows in the residual reach are higher than the consented residual flow, with median flows immediately downstream of the intake ranging from 804 L/s to 1,355 L/s and at the downstream end of the residual reach from 1,036 L/s to 1,429 L/s (see Table 4.1 in the aquatic ecology report). Mean flow in the residual river is reduced by 3.5 m^3/s (46%) compared with pre-existing (7.6 m^3/s), and the block of flow removed comprises baseflows up to moderately high flows, resulting in reduced and prolonged low flows.
Waiwhakaiho River from tailrace to the sea	
• Modified flow regime in lower river	The maximum generation discharge from the Mangorei HEPS tailrace to the Waiwhakaiho River at the Meeting of the Waters is just under 10 m^3/s. The Mangorei HEPS consent also requires that a continuous generation flow release of at least 0.95 m^3/s be maintained to the lower river between 8:00 am and 6:00 pm each day (Consent 2053-3.2 Special condition 1). When the power station is unable to generate during the day (for example from a network or station outage) a bypass valve is opened to release a flow of 1.15 m^3/s (Tonkin and Taylor 2020). Flows within the river at the Meeting of the Waters can range from 0.48 m^3/s (0.95 m^3/s during daylight hours) to 10 m^3/s within a day depending on scheme operation. The variation in generation outflow continues downstream in the lower Waiwhakaiho River with only minor attenuation (smoothing) of the generation pulse, reflected in river level variation of up to around 450 mm, as measured at Rimu Street (Tonkin and Taylor 2020). Tributary inflows also contribute water to the lower river downstream of the Mangorei HEPS discharge, and at Rimu Street low flows are in the range of 1.8 to 2.1 m^3/s (Table 4.5, Tonkin and Taylor 2020). This is similar to the low flow range upstream of the

Site	Comments (based on recent operational regime 2013 to 2020)
	Mangorei HEPS intake, where flows range from 2.0 to 2.1 m^3/s (Table 4.5, Tonkin and Taylor 2020). Median flows are higher at Rimu Street than Upstream, and flood flows are similar at both sites (Table 4.5, Tonkin and Taylor 2020).
• Potential effects from daily flow ramping	With the diurnal fluctuation in the river flow, there is a complementary fluctuation in the river level (up to around 450 mm as measured in the Waiwhakaiho River at Rimu Street).
Mangamahoe Stream	
• Diversion of Mangamahoe Stream	The dam effectively diverts flow from the Mangamahoe Stream catchment (8.1 km^2) into the lake for hydro-electric generation and water supply use. Inflow to the residual reach of the Waiwhakaiho River from Mangamahoe Stream comprises spill flows, leakage and seepage from the dam, and runoff from the remaining 1 km^2 catchment below the dam.
• Attenuation of flood flows	Transient flood storage in the lake has the potential to reduce the magnitude of peak flood flows from the Mangamahoe Stream catchment compared with the pre-existing environment. However, this effect diminishes with increasing flood size.
Lake Mangamahoe	
• Inundation of land	The lake occupies an area of about 0.25 km^2.
• Increased flow to Lake Mangamahoe	Diverted flow from Waiwhakaiho River has increased the flow volume to the Mangamahoe Stream catchment (and thus the lake) seven-fold compared with pre-existing conditions, though without substantially increasing the flood flows.
• Lake level fluctuations	Daily ramping of generation results in a complementary diurnal fluctuation in lake levels that has an amplitude that varies from as little as 120 mm during summer low flows to over 400 mm for normal flow periods.

Tonkin and Taylor (2020) also note that:

> *'flow diversion from the Waiwhakaiho River is not expected to have a material effect on the morphology of the river channel, either in the residual river or in the lower river downstream of the tailrace. This is because the maximum flow able to be diverted of 10 m^3/s represents only a small percentage of the flood flows generally considered to be responsible for morphological change, i.e. floods around the mean annual flood size, which is about 350 m^3/s for the lower Waiwhakaiho River (see Table 2.8). That is, a reduction of up to 10 m^3/s in the flood flow is not expected to have an effect on morphological processes. Further, under current consent conditions, the diversion is required to cease when river flow at SH3 exceeds 85 m^3/s.'*

Waiwhakaiho River

Intake to tailrace (Meeting of the Waters)

The diversion of flow between the intake and tailrace results in a smaller river, with, on average, a reduced wetted area. Because of the steep banks of this reach of the river, the average reduction in wetted area and thus increase in terrestrial habitat at the channel margins is small – in the order of centimetres to tens of centimetres. It is likely that riparian vegetation (native and introduced) will have colonised some of this new edge habitat. However, the small potential increase in riparian vegetation will probably have been offset to some degree by the ongoing effects of floods, which continue to pass down the river almost entirely unaltered, as noted by Tonkin and Taylor (2020).

Tailrace to the sea

The variation in generation flow (typically daily) results in downstream river level variation of up to around 450 mm, as measured at Rimu Street in New Plymouth. This daily inundation and exposure results in a mostly unvegetated varial zone along the river margins. As with the river upstream of the tailrace, however, floods flows remain essentially unaffected.

Along both of the above reaches, it is likely that there have been slight changes in the extent of riparian vegetation at the river edges, over scales of centimetres to tens of centimetres, as a result in changes to, and ongoing variation in, flow since the commencement of operation of the scheme. However, the vegetation along the margins appears to have reached a new equilibrium at the land-water interface, and effects of flow on riparian vegetation are of negligible ecological consequence.

The aquatic ecology assessment (Ryder 2020) describes how the operation of the HEPS has resulted in changes to aquatic invertebrate and fish communities, which from part of the diet of some bird species. The changes include increases in availability of habitat for some aquatic species, and decreases in habitat for other species. Ryder (2020) state that '*recent fish community surveys have confirmed that brown trout, inanga, redfin bullies, longfin eels and torrentfish are all present within the residual river reach. Densities of juvenile trout and redfin bullies in the residual reach are also similar to or higher than that elsewhere in the river. In addition, banded and shortjaw kokopu, brown trout, koaro, lamprey, redfin bullies, torrentfish and both longfin and shortfin eels have all previously been recorded upstream of the residual reach, indicating that passage for these species through the residual reach and fish pass to the river upstream of the Mangorei HEPS intake is maintained.'*

It is not possible to know whether these changes in aquatic communities will have affected birds that prey on them, whether adversely or positively, because this would require highly detailed understanding of the food requirements and foraging behaviour of birds. The similar or higher abundance of redfin bullies and juvenile trout within the residual reach, and the presence of various species within and upstream of the residual reach river indicate that these species continue to provide prey for birds along the river.

Significant sites, KNEs etc.

The various significant sites described above are either entirely or almost entirely, located outside the immediate varial zones, and are therefore entirely or almost entirely unaffected by flow. Instead, the vegetation and habitat within the broader riparian margins is most strongly affected by surrounding land management practices. In particular, there appears to be a general improvement in the terrestrial ecological values along waterways as a result of riparian fencing to exclude stock, combined with active revegetation efforts, and, in some places, formal protection as mentioned above. Despite their proximity to the water, the riparian margins of the above sites are essentially terrestrial ecosystems and are therefore almost entirely unaffected by flow in the Waiwhakaiho River.

Mangamahoe Stream

The Mangamahoe Stream flow would have been altered by the by construction of a dam in 1914, a second dam in 1918 (the 'NPDC dam'), and again by construction of the Mangamahoe Dam in 1931 (photos of these dams are presented in the Aquatic Ecology report, Ryder Environmental 2020). The existing NPDC dam, which is unrelated to the operation of the HEPS, creates a small reservoir, approximately

300 m long and up to 30 m wide (*c.* 0.5 ha), which provides habitat for some waterbirds.

However, any effects of the Mangamahoe Dam on the riparian vegetation and habitat of Mangamahoe Stream have been overwhelmed by the effects of surrounding land use (notably forestry and agriculture), native regeneration, and exotic weed invasion. In addition, the NPDC dam creates a narrow reservoir, about 300 metres long, which replaces some of the original stream and associated riparian habitat. The surrounding land use continues to determine the composition and structure of the vegetation and habitat along the Mangamahoe Stream, with the ongoing alteration in flow as a result of operation of the HEPS having negligible effects on terrestrial ecology

Lake Mangamahoe

The formation of Lake Mangamahoe resulted in the inundation and therefore loss of 0.25 km^2 of terrestrial vegetation and habitat, and the concurrent creation of the same area of aquatic habitat. We are aware of no specific information about the land use or vegetative cover prior to formation of the lake. However, the *Lake Mangamahoe Management Plan* (NPDC 2011) states that:

> *The lake was formed through damming the Mangamahoe Stream gully in 1931 for hydro power generation. In the same year, the lake was used as a town water supply. Forestry developed around the lake as a means of promoting water quality to reduce surface soil erosion into the lake.*

The NPDC website[5] states that land for the lake was purchased in 1920, and, with regard to the land around the lake, that

> *In order to protect the steep hillside from eroding, development planting was undertaken and shelterbelts were planted to protect the pine trees growing in what is now the Mangamahoe Forest.*

From these sources, and given the history of early agricultural development of Taranaki, it seems likely that construction of the dam resulted in inundation of farmland (pasture) and perhaps some remnant or regenerating native vegetation along Mangamahoe Stream.

[5] https://www.newplymouthnz.com/Residents/Attractions-and-Recreation/Walkways/Lake-Mangamahoe. Viewed 2 September 2020

Today, Lake Mangamahoe and environs are managed as a catchment of the water supply for New Plymouth, production forestry, a reservoir for hydroelectric power generation, and provide a valuable resource for recreation. The current vegetation and habitat of the lake and environs is a product of this management. As noted above, the lake and environs provide valuable habitat for a diversity of introduced and indigenous plants and animals, including numerous waterbirds.

Overall, the creation of Lake Mangamahoe and the associated management of the surrounding land has probably (if the site was previously farmland, as surmised above) resulted in a net positive effect on terrestrial ecological values, through the development of diverse lakeside vegetation and the habitat it provides for various terrestrial fauna, and through the creation of habitat for waterbirds.

6. Summary

HEPS infrastructure

The construction of the HEPS required the permanent removal of the terrestrial vegetation and habitat for terrestrial fauna at the locations of the intake; main dam; saddle dam; spillway; power station and outlet canal; parking areas; roading, and outbuildings. However, the ongoing presence of these various structures has negligible effect on terrestrial ecological values because the effects are small and localised, and/or the adjacent vegetation and habitat suggests that these sites, without the HEPS structures, would have low ecological value. The presence of Lake Mangamahoe has probably resulted in a net positive effect on terrestrial ecological values.

Waiwhakaiho River

Reductions in flow downstream of the intake, and daily flow fluctuations below the tailrace, have probably caused changes in the extent of vegetation immediately adjacent to the wetted edges of the river channel. However, these changes are very limited in spatial extent, and the vegetation appears to have reached a new equilibrium at the land-water interface. Effects of flow on riparian vegetation are therefore of negligible ecological consequence.

Aquatic invertebrate and fish communities, which provide potential prey for birds on the Waiwhakaiho River, have changed as a result of the scheme, with increases and decreases in available habitat, depending on species. It is not possible to say definitively whether these changes will have been detrimental or beneficial for birds. However, the similar or higher abundance of redfin bullies and juvenile trout within the residual reach, and the presence of various species within and upstream

of the residual reach river indicate that these species continue to provide prey for birds along the river.

Several sites recognised as significant by the Taranaki Regional Council and/or the New Plymouth District Council are located adjacent to the Waiwhakaiho River downstream of the intake. These are entirely or almost entirely, located outside the immediate varial zones, and are therefore entirely or almost entirely unaffected by flow.

Mangamahoe Stream

Any effects of the Mangamahoe Dam on the riparian vegetation and habitat of Mangamahoe Stream have been overwhelmed by the effects of surrounding land use (notably forestry and agriculture), native regeneration, and exotic weed invasion. In addition, the NPDC dam creates a narrow reservoir, about 300 metres long, which replaces some of the original stream and associated riparian habitat. The surrounding land use continues to determine the composition and structure of the vegetation and habitat along the Mangamahoe Stream, with the ongoing alteration in flow as a result of operation of the HEPS having negligible effects on terrestrial ecology

Lake Mangamahoe

The formation of Lake Mangamahoe resulted in the inundation and therefore loss of 0.25 km^2 of terrestrial vegetation and habitat, and the concurrent creation of the same area of aquatic habitat. As far as we can ascertain, the land inundated was previously farmland. The creation of Lake Mangamahoe and the associated management of the surrounding land has probably resulted in a net positive effect on terrestrial ecological values, through the development of diverse lakeside vegetation and the habitat it provides for various terrestrial fauna, and through the creation of habitat for waterbirds.

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