Stream	HN_F_Hōteo_1	HN_F_Hōteo_2	HN_F_Hōteo_3
MCI-sb Value	105.6 – Indicative of good water quality		57.7 – Indicative of poor water quality
Fish Species			
Taxa Observed	Shortfin Eel; Longfin Eel; Redfin Bully; UNID Bully; Koura	*Not Sampled*	Shortfin Eel; UNID Eel; Inanga; UNID Bully
Fish IBI	46 - Very good		34 - Fair
SEV Score			
Score	0.675	0.790	0.376
EIANZ criteria			
Value	**Moderate**	**Moderate**	**Low**
Reasons for our assessment	• Riparian vegetation SEA (SEA_T_683) • At Risk – Declining fish species • Invertebrate community dominated by pollution tolerant taxa • MCI-sb score Moderate • EPT species rare • SEV score Moderate • Fish species diverse • Moderate riparian margin with mature canopy species along the true right bank	• Migratory pathway • Riparian vegetation SEA (SEA_T_683 and SEA_T_5541). • At Risk-Declining fish species present within the catchment, • Poor riparian margin with no shade to stream channel • Large 5th order stream draining a predominantly agricultural catchment	• Highly degraded • At Risk-Declining fish species • Invertebrate community dominated by pollution tolerant species • MCI-sb score Low • EPT taxa absent • SEV score Low • No riparian shade or hydrological heterogeneity • Excessive loading of fine sediment

Table 18 - Key freshwater attributes from survey sites HN_F_Hōteo_4, HN_F_TeHana_1 and HN_F_TeHana_2 within the Hōteo North section.

Stream	HN_F_Hōteo_4	HN_F_TeHana_1	HN_F_TeHana_2
Sample Date	7 June 17	15 May 17	10 May 17
Surrounding Land Use	Pasture	Pasture	Pasture
Stream Characteristics			
REC Order	1	1	2
Permanence	Permanent/Intermittent/wetland	Permanent	Permanent
Habitat			
Width (m)	0.15–2.15	0.77–3.5	0.42–1.21
Depth (m)	0.02–0.19	0.2–1.05	0.02–1.28
Substrate Type	Silt/Sand	Silt/sand/cobble/gravel	Silt/sand/cobble/gravel

Stock Access	Yes	No	TLB
Predominant Shade	<10%	51-70%	11-30%
Macrophytes	*Juncus effusus*; starwort	None	Water pepper
Macroinvertebrates			
No. Taxa	17	26	24
EPT Taxa	0	1	2*
Dominant Taxa	Oligochaeta (worm)	Potamopyrgus (snail)	Paracalliope (crustacean)
MCI-sb Value	62.4 – Indicative of poor water quality	71.5 – Indicative of poor water quality	76.1 – Indicative of poor water quality
Fish Species			
Taxa Observed	None	Shortfin Eel; UNID Eel; Banded Kokopu	Shortfin Eel; UNID Eel
Fish IBI	0	32 - Fair	18 - Poor
SEV Score			
Score	0.325	0.664	0.408
EIANZ criteria			
Value	**Low**	**Moderate**	**Low**
Reasons for our assessment	• Highly degraded wetland-like habitat of intermittent or perennial permanence • Invertebrate community dominated by pollution tolerant species • MCI-sb score Low • EPT taxa absent • SEV score Low • No riparian shade or hydrological diversity • Extensive stock damage • Located at top of catchment	• Large stream with native remnant riparian margin • Headwater riparian vegetation SEA (SEA_T_648) (located outside of proposed designation boundary). • Invertebrate community dominated by pollution tolerant taxa • MCI-sb score Low • EPT species Low abundance • SEV score Moderate • Fish species low diversity Good riparian planting with mature canopy of native species	• Small channelised farm stream • Invertebrate community dominant by tolerant taxa • MCI-sb score Low • EPT species low abundance • SEV score poor • Fish species diversity poor • No riparian vegetation • Upstream habitat includes pond with raupo habitat and headwaters in native riparian vegetation

Table 19 - Key freshwater attributes from survey sites HN_F_TeHana_3, HN_F_Mae_1 and HN_F_Mae_2 within the Hōteo North section.

Stream	HN_F_TeHana_3	HN_F_Mae_1	HN_F_Mae_2
Sample Date	6 June 17	6 June 17	6 June 17
Surrounding Land Use	Pasture	Pasture	Pasture
Stream Characteristics			
REC Order	1	1	1
Permanence	Permanent	Permanent/Intermittent	Permanent
Habitat			
Width (m)	0.18-1.66	0-1.87	1.26-2.64
Depth (m)	0.01-0.23	0.1-0.15	0.1-0.63
Substrate Type	Clay/Silt/Sand	Silt/Sand	Silt/Sand
Stock Access	Yes	Yes	Yes
Predominant Shade	11-30%	<10%	71-90%
Macrophytes	*Juncus effusus*; watercress	None	Water Pepper; Watercress
Macroinvertebrates			
No. Taxa	18	12	21
EPT Taxa	1	0	0*
Dominant Taxa	Oligochaeta (worm)	Oligochaeta (worm)	Oligochaeta (worm)
MCI-sb Value	79.4 – Indicative of poor water quality	78.2 – Indicative of poor water quality	61.4 – Indicative of poor water quality
Fish Species			
Taxa Observed	None	None	Shortfin Eel
Fish IBI	-	-	14 - Very Poor
SEV Score			
Score	0.410	0.364	0.398
EIANZ criteria			
Value	**Low**	**Low**	**Low**
Reasons for our assessment	• Permanent headwater watercourse with wetland-like habitat through centre of reach • Invertebrate community dominated by pollution tolerant taxa • MCI-sb score low • EPT taxa low abundance • SEV score poor • No fish present	• Small headwater spring fed permanent or intermittent watercourse with extensive stock damage • Invertebrate community dominated by tolerant taxa • MCI-sb score low • EPT taxa absent • No fish species present • SEV score poor	• Highly degraded permanent watercourse choked with exotic water pepper and with extensive stock damage • Invertebrate community dominated by pollution tolerant taxa • MCI-sb score poor • EPT taxa absent • SEV score poor

Stream	HN_F_TeHana_3	HN_F_Mae_1	HN_F_Mae_2
	• No riparian vegetation • moderate stock damage	• No riparian margin	• Fish diversity Poor • Riparian vegetation limited

Table 20 - Key freshwater attributes from survey site HN_F_Mae_3, outside the proposed designation boundary, in the vicinity of the Hōteo North section.

Stream	HN_F_Mae_3
Sample Date	10 May 17
Surrounding Land Use	Pasture
Stream Characteristics	
REC Order	1
Permanence	Permanent
Habitat	
Width (m)	0.67-2.65
Depth (m)	0.0-0.45
Substrate Type	Silt/sand/cobble/gravel
Stock Access	No
Predominant Shade	11-30%
Macrophytes	None
Macroinvertebrates	
No. Taxa	17
EPT Taxa	1
Dominant Taxa	Paracalliope (crustacean)
MCI-sb Value	65.6 – Indicative of poor water quality
Fish Species	
Taxa Observed	Shortfin Eel; Unidentified Eel
Fish IBI	14 - Very Poor
SEV Score	
Score	0.683
EIANZ criteria	
Value	**Moderate**
Reasons for our assessment	• Historically grazed stream with 16 years of no stock access (discussion with landowner) and riparian planting • Migration pathway to extensively planted headwaters for fish species • Invertebrate community dominated by pollution tolerant taxa • Low MCI-sb score (65.6) • No EPT taxa present • Low SEV score (0.683)

HN_F_Hōteo_1

HN_F_Hōteo_2

HN_F_Hōteo_3

HN_F_Hōteo_4

HN_F_TeHana_1

HN_F_TeHana_2

Figure 4 - Photos of survey sites within the Hōteo North section.

HN_F_TeHana_3	HN_F_Mae_1
	
HN_F_Mae_2	HN_F_Mae_3
	

Figure 5 - Photos of survey sites within the Hōteo North Section.

Freshwater ecological value classification

We classified the current ecological value of each of the sites using the EIANZ criteria outlined in Chapter 2. As outlined in Table 17 to Table 20, we consider that:

- Site HN_F_Hōteo _1 is of moderate ecological value;
- Site HN_F_Hōteo _2 is of moderate ecological value;
- Site HN_F_Hōteo _3 is of low ecological value;
- HN_F_Hōteo _4 is of low ecological value;
- HN_F_TeHana_1 is of moderate ecological value;
- HN_F_TeHana_2 is of low ecological value;
- HN_F_TeHana_3 is of low ecological value;
- HN_F_Mae_1 is of low ecological value;

- HN_F_Mae_2 is of low ecological value; and
- HN_F_Mae_3 is of moderate ecological value.

The reasons for our assessment are outlined in Table 17 to Table 20. Overall we classify the watercourses within the Hōteo North section as of moderately-low value.

The lower Maeneene Stream, where SH1 crosses over, was unable to be assessed on the ground. We assessed this stream through observations of aerial photographs, and based on these observations, we expect that this stream section will be of moderate to high value, and may offer suitable habitat for Inanga spawning.

Summary of freshwater values

Overall, the freshwater ecological values of watercourses within the Hōteo North section are Low, with some Moderate value features. Watercourses are typically highly degraded with stock access and poor water quality from their predominantly agricultural catchments. Some reaches have intact riparian vegetation and/or fencing off from stock. We anticipate, through observation of aerial photography and brief visual assessments, that watercourses affected by the Project and Indicative Alignment that were not surveyed will have similar ecological values to those surveyed. Accordingly, most watercourses are predicted to be of low ecological value.

4.2 Potential effects of roads on freshwater environments, prior to mitigation

4.2.1 Introduction

The construction and operation of roads, particularly state highways, have a number of potential effects that are applicable to the whole Project, regardless of section. Such effects can be broken into construction and operational effects and are outlined in the following sections of this chapter. The quantum, or magnitude of these effects on each section, and across the whole Indicative Alignment (including potential changes in that alignment when the final design is confirmed) are described in detail later in this Chapter and also in Chapter 5.

4.2.2 Construction effects

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

- Bulk earthworks and the associated discharge of construction water;
- Streamworks resulting in the loss of watercourses and habitat quality, including culverting;
- Diversion of existing waterways through newly created stream channels; and
- The construction of bridges and viaducts over watercourses;

These activities have the potential to result in:

- The discharge of sediment laden water into streams with the potential to increase the amount of suspended solids (TSS) and deposit on the streambed;

- Partial or total loss of freshwater habitats;
- Reduction in freshwater habitat quality; and
- Changes to fish passage.

Bulk earthworks and sediment generation

Sediment entering streams is a natural process, with many streams across the proposed designation particularly prone to receiving elevated sediment loads, especially during high flow events, due to the primary catchment uses of agriculture (Warkworth North and Hōteo North sections) and forestry (Dome Valley Forest section). However, the potential movement of large amounts of sediment into watercourses during Project related earthworks may cause additional adverse effects on downstream aquatic habitats.

During earthworks, sediments that are exposed and moved can become suspended in stormwater run-off, with the resulting stormwater becoming turbid (i.e. cloudy or opaque), especially compared to natural conditions. As a result, there is potential for a decline in water quality and aquatic habitat quality, which can include:

- Smothering and infilling of the streambed and stream edge, resulting in a loss of habitat for fish, frogs, invertebrates and periphyton (the food for grazing species);
- Clogging and covering of the gills of invertebrates and fish, reducing the efficiency of oxygen uptake;
- Smothering of aquatic plants, resulting in the loss of habitat for algae and benthic fauna;
- Smothering of stream edge plants that provide inanga spawning habitat;
- Reduction or a cessation of interstitial flow (flows amongst the stream bed substrate/stones) which provides oxygenated water to fish eggs and larval fish;
- Reduced light penetration and visibility through the water column reducing opportunity for growth of plant and algal growth as food and shelter for other biota; and
- A shift in community composition from 'sensitive' taxa (such as mayflies and stoneflies), to more 'tolerant' taxa (such as midge larvae and crustaceans).

The Construction Water Management Design technical report provides details of the indicative construction methodology, proposed erosion and sediment controls (ESCs), and other construction phase mitigation measures designed to reduce sediment laden stormwater discharges from entering the receiving environment. The key sediment control measures to be implemented during construction are:

- Sediment retention ponds (SRPs);
- Decanting earth bunds (DEBs);
- Container Impoundment Systems;
- Super Silt Fences; and
- Flocculation.

The sediment control measures will be located offline, where practicable, to minimise environmental effects. Where the location of a SRP coincides with a permanent stormwater treatment wetland, the wetland area may be used on a temporary basis as a SRP.

Construction and discharge of sediment retention ponds

The construction of the Project requires a large number of sediment retention ponds to collect sediment laden water and treat it before discharging it into existing watercourses. The potential effects of the discharge of sediment laden water is outlined above. Further effects of sediment retention pond discharge are below:

- Potential for fine sediment to enter the watercourse downstream of discharge point;
- Streambed scour at outlet erosion; and
- Potential for device to be overwhelmed during extreme rainfall events, discharging significant volumes of sediment into receiving watercourses.

It is likely that some of the sediment retention ponds may later be converted to stormwater treatment ponds depending on location and functionality.

Stream crossings

Longitudinal construction projects in New Zealand, such as major roads, mean that stream crossings are unavoidable. The number and extent of stream crossings depends on the final alignment and the nature of the watercourses. The Indicative Alignment would require the construction of approximately 69 new culverts totalling approximately 6.2 km in length, and 16 culvert upgrades along the alignment. Following a detailed design process, the final alignment may contain more or less culverts. These new culverts will result in the permanent loss of whole and partial watercourses, as well as residual habitat values, with the potential for further effects including:

- Physical disturbance the waterway and streambed upstream and downstream of the culvert during construction;
- Increase in suspended sediment during construction; and
- Reduction or restriction of fish passage through the watercourse during construction as water is diverted around the immediate area of works.

Where possible, culverts will be constructed off-line in a dry environment and will require an additional approximately 10 m of stream diversion, both upstream and downstream, to tie back into the existing stream channel.

Temporary stream crossings may also be required during the construction phase. These culverts are typically required during part or all of the construction phase, and are removed and the site rehabilitated at the completion of construction. The potential effects of these temporary crossings during the construction phase include:

- Streambed and streambank scour and sediment intrusion downstream of the culvert, owing to increased water velocity at the outlet; and
- Prevention or limitation of fish passage for migratory fish and other aquatic organisms between upstream and downstream sections of the watercourse (unless adequate fish passage is provided).

The placement of culverts reduces the available habitat along the watercourse. However, they still provide a connection between habitats upstream and downstream, allowing the movement of aquatic organisms between the two, presuming adequate fish passage is present.

Loss of waterways, habitat and ecological value

In the absence of mitigation, the Project will result in the loss of some aquatic habitat. Watercourses crossed by the Indicative Alignment will primarily be culverted, with some watercourses diverted and combined to discharge through a single culvert. A number of watercourses that naturally run within the footprint of the Indicative alignment will be diverted and realigned to run alongside the Indicative Alignment. The construction of the Indicative Alignment and the diversion of watercourses has the potential to change catchment hydrology. The potential effects include:

- Permanent loss of habitat through culverting of the watercourses under the Indicative Alignment;
- Permanent loss of habitat through the construction of diversion channels that are shorter than the original watercourse, or elevated above groundwater flows;
- Reduction in quality of aquatic habitat within diversion channels so that overall ecological value is lost;
- Overall reduction in quality of aquatic habitat including temporary habitats; and
- Reduced hydrological variability in diversion channels resulting in a reduction in water flows and a change in hydrological behaviour of the watercourse which will affect habitat characteristics.

Bridges and viaducts

The Indicative Alignment involves the construction of eight bridges/viaducts over watercourses along the Indicative Alignment. The final alignment may contain more or less bridges/viaducts. It is likely that piers or abutments are to be constructed within the stream riparian zone, although the piers will be outside of the bed of the watercourse. The potential effects include:

- Physical disturbance to the riparian margin, and possibly the waterway and streambed during construction; and
- Potential for fine sediment to enter the watercourse.

4.2.3 Operational effects

The major activities associated with the operation of the Project that may affect the freshwater habitats and their associated aquatic organisms are:

- Contaminant run off;
- Stream and riparian zone shading from bridges and viaducts;
- Operation of culverts;
- Increased flood flows;

- Increased temperature of water flowing off impervious areas and stormwater ponds; and
- Increased streambank erosion.

These activities have the potential to result in:

- The discharge of sediment laden water into streams with the potential to increase the amount of suspended solids (TSS) and deposition of sediment on the streambed;
- Increased contaminant runoff;
- Changes to flow regimes;
- Partial or total loss of freshwater habitats; and
- Changes to fish passage.

Contaminant runoff from the road during operation (permanent, indirect)

The operation of the Project has the potential to see contaminants from the road enter freshwater environments through stormwater. Stormwater management is an inherent component of the road design and a variety of techniques are used to minimise the discharge of contaminants to the waterways. Increased contaminants entering waterways have the potential to impact the life supporting capacity of freshwater systems.

Stream and riparian shading from culverts, bridges and viaducts (permanent, indirect)

An indirect effect of the operation of the bridges and viaducts will be the shading of the stream channel and riparian margin below at some, or all, parts of the day from bridge and viaducts, and removal of the light source at all times in culverts. Shading of the riparian zones and watercourse can result in changes to aquatic fauna and flora that may grow within the stream channel or margins, including the riparian zone. Potential effects include:

- Reduction in the productivity of the section of stream in which culverts are placed through the reduction in light; and
- Shading, for both UV light and rain, of the riparian margin and the stream channel which could result in a change to the riparian and/or aquatic community present.

Operation of culverts and stream diversions

Culverts and stream diversions installed as part of the Project have the potential to increase erosion of streambeds and banks, and fragment aquatic habitats. The potential effects include:

- Streambed and streambank scour and sediment release downstream of the culvert owing to increased water velocity at the outlet; and
- Prevention or limitation of fish passage for migratory fish and other aquatic organisms between upstream and downstream sections of the watercourse.
- Change in the flow regime within diversion channels so that the resulting available stream habitat may be significantly different from the original channel.

Fish passage through culverts and stream diversions

Many of our native fish species require access to the sea (diadromous) as part of their life-cycle. The operation of the Project has the potential to fragment aquatic ecosystems by preventing the movement of aquatic species through engineered structures. The potential effects limiting fish passage include.

- Scour at upstream and downstream extents of engineered devices, such as culverts, that prevent movement into the device;
- Flow through the culvert is of a velocity or turbulence higher than the natural stream velocity;
- The culvert gradient and length is impassable by the fish species;
- Failure of fish passage device, such as breaking off of baffles;
- Blockage of engineered devices by flood debris; and
- Incorrectly designed culverts and stream diversions that do not facilitate fish passage.

4.3 Effects of the Project on freshwater values, prior to mitigation

In this section we discuss the direct and indirect effects of the Project on freshwater values. We have retained our assessment of the three sections; Warkworth North, Dome Valley Forest and Hōteo North. As detailed in the Methodology outlined in Chapter 2, we have followed the EIANZ effects assessment. Our effects assessment is presented prior to mitigation.

The harvesting of the Matariki Forest Block will be undertaken prior to the construction of the Project. The harvest will have direct impacts on the freshwater values of streams within the Matariki Forest in the Dome Valley Forest section. It may also have impacts on streams within the Warkworth North and Hōteo North sections as some of the streams have headwaters located within the Matariki Forest. These impacts have only been quantified for the Dome Valley Forest section.

4.3.1 Warkworth North section

Habitat loss

The calculated loss of aquatic habitat resulting from construction of the Indicative Alignment in the Warkworth North section, prior to mitigation, is outlined in Table 21 below. These have been calculated based on the Indicative Alignment, and so the quanta described are a general guide only. The actual quanta of habitat loss may change (more or less), owing to changes to the alignment through detailed design, and differences between the predicted and actual freshwater habitats encountered.

Predicted sediment loads

Predicted increase in sediment loads from the Project within freshwater environments are summarised in the Water Assessment Report (Jacobs, 2019). Increases of 12% and 17%

from existing were predicted for each of the Mahurangi River (Left Branch) and Kourawhero Stream (Table 21).

Water quality

Water quality within the Mahurangi River is described within the Water Assessment Report (Jacobs GHD JV, 2019). The Operational Water -Road Runoff technical report (Jacobs, 2019d) compared the existing and predicted water quality and predicts that total zinc and copper concentrations within the Warkworth North section will all be below ANZECC (2000) guidelines (95% level of species protection in freshwaters) except at the mouth of the Mahurangi River (Table 21). The existing concentration of copper at the mouth of the Mahurangi River is above guidelines and the model predicts a further small increase. There is no predicted change in TPH concentrations as a result of the Project. There are no ANZECC/ARMCANZ (2000) guideline trigger values for TPH in aqueous solutions.

Table 21 - Quantum* of effects of construction and operation of the Indicative Alignment within the Warkworth North section.

Construction Effects	
Sediment Loads	• Predicted average yearly increase of 12% within Mahurangi 'flats' River • Predicted average yearly increase of 17% within Kourawhero Stream
Loss of waterways and habitat	• The Indicative Alignment results in the loss of 6.2 km of stream habitat in the Warkworth North section: • 2 km of permanent streams • 2.5 km of intermittent streams • 1.7 km of ephemeral streams
Stream Crossings (Culverts)	• A total of 17 culverts are to be installed or upgraded within this section, totalling 0.9 km. • 16 (0.8 km) are new culverts • 1 (0.1 km) are upgrades to existing culverts
Diversion of waterways	• 4.4 km of stream diversions are to be undertaken within the section
Bridges and viaducts	• 3 bridges/viaducts will be constructed within this section, totalling 0.3 km (crossing 0.2 km of stream width). • The Warkworth North on ramps and off ramps will cross 0.1 km of stream width.
Bulk earthworks[13]	• Approximately 18.2 ha of earthworks are expected within Mahurangi River (Left Branch) catchment. • Approximately 27.4 ha of earthworks within Kourawhero Stream catchment (including works within Dome Valley Forest section). • Total earthworks of 45.6 ha.
Operational Effects	
Contaminant runoff from the road during operation	• Run off from the Project will all be treated by stormwater treatment devices.

[13] Numbers from Water Assessment Report (Jacobs, 2019), Table 5.

	• Modelling of containments indicates that there may be a small increase in levels. However, all predictions are below ANZECC (2000) guidelines with the exception of copper, which is currently above guidelines (Jacobs 2019). • There is no predicted change in TPH concentrations.
Culverts, bridges and viaducts	• Two bridges (elevated on and off ramps) are proposed to be constructed over the Mahurangi River (Left Branch). These structures will shade the river at some or all times of the day. There is currently an intact riparian zone at both locations with mature native and exotic tree species present, which will be providing some shade to the stream surface. The potential permanent shading of these tree species by the bridge may result in a shift of the vegetation community present.
Notes: * Numbers are indicative only and are based on the Auckland Council Overland Flowpath Layer and current Indicative Alignment and may change.	

Magnitude of effects

The effects described above are applicable to each section along the Indicative Alignment, with the magnitude of the effects determined from the ecological values of the existing environment and the extent of the effect within each Section.

Table 21 above outlines the quantum of effects for the Warkworth North section, based on the effects described. Table 22 below assesses the magnitude of effects at each survey site utilising the EIANZ Magnitude of Effect criteria. These criteria are adapted from the EIANZ guidelines for ecological impact assessment in New Zealand (EIANZ, 2015; see Appendix A).

Table 22 - Assessment of magnitude of effects on freshwater ecological sites surveyed within the Warkworth North section. Surveyed sites are listed in order from south to north.

Site ID	Magnitude of effect (EIANZ criteria)	Reasoning
WN_F_Mahu_1	Low	Based on the Indicative Alignment, a total of four bridges would be constructed across the Mahurangi River (Left Branch) significantly reducing the impact on the River and reducing the loss of aquatic habitat compared to culverts. During operation the bridges/viaducts will shade the stream surface at some/all times during the day. This may limit the growth of aquatic plants and riparian vegetation within these shaded areas, potentially reducing available aquatic habitat and organic matter input. It may also impact the growth of riparian vegetation. The site is of high ecological value.
WN_F_Koura_1	Moderate	The Indicative Alignment upstream of the WN_F_Koura_1 site has a small bridge (Bridge 22) over the Kourawhero Stream. The site itself will not be directly impacted. However, the catchments of upper tributaries will be altered by the large volumes of earthworks. In addition, the downstream channel of the Kourawhero will be diverted through two new channels on either side of the Indicative Alignment.

		These works will result in an overall loss of aquatic habitat and quality.

The design of the Indicative Alignment has avoided impacts on the High Value Mahurangi River (Left Branch) and the upper Kourawhero through the use of bridges and elevated on and off ramps. Some sections of the upper Kourawhero are to be diverted through new, ecologically functioning, channels either side of the Indicative Alignment. Watercourses to be culverted are typically of low ecological value.

The sediment models predict a moderate increase in average TSS loads at sites within the Warkworth North Section; with a 12% and 17% increase a year from existing conditions at the Mahurangi and Kourawhero sites, respectively. The addition of suspended sediment to freshwater environments poses a particular risk within the Upper Kourawhero Stream, owing to the numerous natural wetlands within the system.

Overall, the magnitude of effects on freshwater values within the Warkworth North Section are moderate. The magnitude of effects on the Mahurangi River (Left Branch) are low, with direct effects avoided through the construction of bridges and elevated on and off ramps over the river. The magnitude of effects through the Kaipara Flats area and towards the north of the section are higher, with large sections of watercourse to be diverted and lost within these areas, reducing the overall aquatic habitat available within the section.

Level of ecological effects, prior to mitigation

Overall, the level of ecological effects on freshwater ecological values within the Warkworth North section, prior to mitigation, are moderate (Table 23). These values assume that best practice erosion and sediment controls are in place. The Indicative Alignment crosses the Kaipara Flats area where land use is predominantly utilised for pastoral grazing and lifestyle properties. The Mahurangi River (Left Branch) is crossed four times by the Indicative Alignment (by on-off ramps at the Warkworth Interchange), with effects minimised through the use of elevated bridges. The northern end of the section contains a number of watercourses that are fed by streams and wetlands within the Matariki Forest that will require extensive diversions.

Table 23 - Level of effects on freshwater ecological sites surveyed within the Warkworth North section. Surveyed sites listed in order from south to north.

Site ID	Ecological value	Magnitude of effect	Overall level of effect
WN_F_Mahu_1	High	Low	**Low**
WN_F_Koura_1	Moderate-High	Moderate	**Moderate**

4.3.2 Dome Valley Forest section

Habitat loss

The quantum of effects on freshwater habitats within the Dome Valley Forest section are outlined in Table 24. These have been predicted based on the Indicative Alignment and the quanta described are a general guide only. The quanta may be subject to change prior to construction owing to changes to the Alignment and differences in the predicted and actual freshwater habitats encountered.

Predicted sediment loads

Predicted increase in annual sediment loads from the Project within freshwater environments are summarised in the Water Assessment Report, Jacobs GHD JV, 2019). Annual increases up to 8.7% from existing were predicted for the Waiteraire Stream (Table 24).

Water quality

Water Quality within the wider Hōteo River is described within the Water Assessment Report (Jacobs GHD JV, 2019). The Operational Water -Road Runoff technical report (Jacobs GHD JV, 2019d) compared the existing and predicted water quality at a number of freshwater sites, with treatment metal concentration, to the ANZECC (2000) guideline trigger vales. The model predicted small increases in concentrations of dissolved metals across sites, with total zinc and copper concentrations at the freshwater sites all below ANZECC (2000) guidelines. There is no predicted change in TPH concentrations as a result of the Project. There are no ANZECC/ARMCANZ (2000) guideline trigger values for TPH in aqueous solutions.

Plantation forestry clearance

The Matariki Forest will be felled prior to the construction of the final alignment. As noted above, forest harvesting is a permitted activity under the NES Plantation Forestry. However, the effects of harvesting can have implications for the streams located within the Dome Valley Forest section, with an almost certain decrease in their ecological function and value. The value of the streams at the time of construction of the Project is therefore difficult to predict, with the extent and impact of any change dependent on the forest harvesting methodology employed, among other factors. The modifications to stream values will result from pine tree harvesting both within and outside of the proposed designation boundary. Felling of trees within the proposed designation boundary may result in removal of riparian shade and benefits, while harvesting upstream may result in the sedimentation and intrusion of slash in streams within the proposed designation boundary. Broadly, it is expected that felling of the trees may have, amongst others, the following impacts on streams (Baillie & Neary, 2015; Quinn et al., 2004):

- Decrease in shading to the stream surface, with an increase in stream light levels and possible increase in water temperature;
- Increased sedimentation of the stream, persisting for some years after harvest;
- Increased nutrients entering the stream;
- Increase in periphyton production in response to increased light, temperature and nutrients;
- Possible shift in macroinvertebrate communities from sensitive EPT taxa, to those that are more tolerant of increased temperatures and turbidity; and
- Possible shift in fish fauna towards species more tolerant of higher water temperatures, higher suspended sediment and increased sedimentation.

The full extent of these possible impacts is unknown and is dependent on the time between harvest and the construction of the Project. It is likely that there will be a decrease in the ecological functions of the streams, with typical indicators of stream health such as MCI and SEV scores likely to decrease directly after harvesting. The values of these streams affected by the Project will need to be assessed prior to construction to ensure the values are appropriately reflected in the overall mitigation necessary for the Project.

For the purpose of this assessment the ecological value of the streams after harvest has been predicted to be moderate. This is based on our current knowledge of the nature of the waterways visited and assessed, and our view that several key stream quality attributes will remain after harvesting (e.g., hydrological attributes).

Table 24 - Quantum* of effects of construction and operation of the Indicative Alignment within the Dome Valley Forest section.

Construction Effects	
TSS	• Predicted average yearly increase of 8.7% within the Waiteraire Stream. • Predicted average yearly increase of 17% within Kourawhero Stream
Loss of waterways and habitat	The Indicative Alignment crosses 12 km of stream habitat: • 4.4 km permanent stream • 4.6 km intermittent stream • 2.9 km ephemeral stream
Stream crossings (culverts)	A total of 20 culverts are to be installed or upgraded within this Section, totalling 3 km.: • 16 (2.9 km) are new culverts • 4 (0.1 km) are culvert upgrades
Diversion of waterways	• 4.5 km of stream diversions are to be undertaken within the Section
Bridges and viaducts	• No bridges or viaducts will be constructed within this Section.
Bulk earthworks[14]	• Approximately 27.4 ha of earthworks within Kourawhero Stream catchment (including works within Warkworth North section). • Approximately 87.8 h of earthworks within Waiteraire Stream Catchment (including works within Hōteo North section).
Operational Effects	
Contaminant runoff from the road during operation	• Run off from the Project will all be treated within stormwater treatment wetlands. • Modelling of containments indicates that there may be a small increase in levels. • There is no predicted change in TPH concentrations.

[14] Numbers from Water Assessment Report (Jacobs, 2018b), Table 5.

Notes:
* Numbers are indicative only and are based on the Auckland Council Overland Flowpath Layer and current Indicative Alignment and may change.

Magnitude of effects

The effects described above are applicable to the Dome Valley section, with the magnitude of the effects determined from the ecological values of the existing environment and the extent of the effect within the Section. The magnitude of effects has been considered for both the existing ecological values and predicted ecological values after harvesting.

Table 24 above outlines the quantum of effects for the Dome Valley section, based on the effects described. Table 25 below assesses the magnitude of effects at each survey site, using the EIANZ Magnitude of Effect criteria. These criteria are adapted from the EIANZ guidelines for ecological impact assessment in New Zealand (EIANZ, 2018).

The sediment models predict a moderately-low increase in average TSS loads at the test site within the Dome Valley Forest with an average annual increase in sediment loads of 8.7% from existing levels. The addition of suspended sediment to freshwater environments poses a particular risk within the Waiteraire Stream due to the steep slopes and the large area of proposed earthworks within the catchment. This model does not account for any sediment coming from harvesting within the Matariki Forest.

The magnitude of effects on freshwater values within the Dome Valley Forest, based on existing ecological values, prior to mitigation, are high.

The magnitude of effects based on the predicted ecological values following harvest, and prior to mitigation, are moderate at best.

Overall, the magnitude of effects on freshwater values, within the Dome Valley Forest section, prior to mitigation, are high. The Indicative Alignment crosses a large number of watercourses with a high amount of stream loss, stream diversion and culvert installation required along the Indicative Alignment.

Table 25 - Assessment of magnitude of effects on freshwater ecological sites surveyed within the Dome Valley Forest section. Based on existing and predicted ecological values. Surveyed sites listed in order from south to north.

Site ID	Magnitude of effect (EIANZ criteria)	Reasoning
Based on existing ecological values		
DVF_F_Koura_1	High	The Indicative Alignment crosses the head waters of the Kourawhero Stream and requires a large amount of cut and fill, a number of cut off drains, stream diversions and stormwater wetlands to be constructed. This will result in the loss of a large amount of aquatic habitat. The Indicative Alignment crosses the site's headwaters and will likely result in a reduction of water flowing to the site. The site is of high ecological value.

Site ID	Magnitude of effect (EIANZ criteria)	Reasoning
DVF_F_Hōteo _1	High	The Indicative Alignment crosses the headwaters of this site, with a large amount of cut and fill required. A number of cut off drains and a culvert is required. There is a high loss of upstream aquatic habitat. The headwaters of the Site are located in the vicinity of the tunnel under Kraack Hill which may influence groundwater, potentially effecting stream flow. The site is of high ecological value.
DVF_F_Hōteo _2-1	High	The Indicative Alignment crosses the upper reaches of this stream. Extensive areas of cut and fill are required and a large (303 m) culvert is to be installed, essentially piping the habitat. Downstream of the culvert the stream is to be diverted. Large areas of aquatic habitat are to be lost under the Indicative Alignment and for stormwater wetlands within the upper reaches and tributaries of this site. The site is of high ecological value.
DVF_F_Hōteo _2-2	None	The Indicative alignment does not impact this section of stream.
Based on predicted ecological values after harvest *(differences only listed).*		
DVF_F_Koura_1	Moderate	This site is of moderate ecological value.
DVF_F_Hōteo _1	Moderate	This site is of moderate ecological value.
DVF_F_Hōteo _2-1	Moderate	This site is of moderate ecological value.
DVF_F_Hōteo _2-2	None	The Indicative alignment does not impact this section of stream.

Level of ecological effects, prior to mitigation

Overall, the potential effects on freshwater ecological values within the Dome Valley Forest section, based on existing ecological values, are very high. This would be the worst case scenario in terms of level of effects.

The potential effects on freshwater ecological values within the Dome Valley Forest section, based on predicted ecological values following harvesting, but with no mitigation, are moderate (Table 26).

The watercourses are predominantly located within the plantation pine of the Matariki Forest and currently have high ecological value. The Indicative Alignment crosses a large number of watercourses with a high amount of stream loss, stream diversion and culvert installation.

Table 26 - Level of effects on freshwater ecological sites surveyed within the Dome Valley Forest section. Surveyed sites listed in order from south to north. Effects assessed before and after harvesting but with no mitigation.

Site ID	Ecological value	Magnitude of effect	Overall level of effect
Based on existing ecological values			
DVF_F_Koura_1	High	High	Very High
DVF_F_Hōteo _1	High	High	Very High
DVF_F_Hōteo _2-1	High	High	Very High
DVF_F_Hōteo _2-2	High	Nil	Very Low
Based on predicated ecological values after harvesting.			
DVF_F_Koura_1	Moderate	High	Moderate
DVF_F_Hōteo _1	Moderate	High	Moderate
DVF_F_Hōteo _2-1	Moderate	High	Moderate
DVF_F_Hōteo _2-2	Moderate	Nil	Nil

4.3.3 Hōteo North section

Habitat loss

The quantum of effects on freshwater habitats within the Hōteo North section are outlined in Table 27. These effects have been assessed based on the Indicative Alignment and the quanta described are a general guide only. The quanta may be subject to change prior to construction owing to changes to the Alignment and differences in the predicted and actual freshwater habitats encountered.

Predicted sediment loads

Predicted increase in sediment loads from the Project within freshwater environments are summarised in the Water Assessment Report, (Jacobs, 2019). Increases of 0.4% are predicted within the Hōteo River; 4.5% within the Te Hana Creek; and 1.5% within Maeneene Creek. These increases in load are very low and are unlikely to have any significant effect.

Water quality

Water quality within the Hōteo River is outlined within the Water Assessment Report (Jacobs, 2019). The Operational Water - Road Runoff Report (Jacobs, 2019d) compared the existing and predicted water quality at a number of freshwater sites, with treatment metal concentration, to the ANZECC (2000) guideline trigger vales. The model predicted small increases in concentrations of dissolved metals across sites, with total zinc and copper concentrations at the freshwater sites all below ANZECC (2000) guidelines. There is no predicted change in TPH concentrations as a result of the Project. There are no ANZECC/ARMCANZ (2000) guideline trigger values for TPH in aqueous solutions.

Magnitude of effects, prior to mitigation

The magnitude of effects of the Project on freshwater values within the Hōteo North Section, based on the effects described above, are provided in Table 28, and the level of impact, using the EIANZ Magnitude of Effect criteria, are provided in Table 29. These criteria are adapted from the EIANZ guidelines for ecological impact assessment in New Zealand (EIANZ, 2015; Chapter 2).

Table 27 - Quantum* of effects of construction and operation of the Indicative Alignment within the Hōteo North section.

Construction Effects	
TSS	• Predicted average yearly increase of 0.4% within the Hōteo River. • Predicted average yearly increase of 4.5 % within the Te Hana Creek. • Predicted average yearly increase of 1.5 % within the Meneene Creek.
Loss of waterways and habitat	The Indicative Alignment crosses 17.9 km of stream habitat: • 6.7 km of permanent streams • 6.9 km of intermittent streams • 4.3 km of ephemeral streams
Stream crossings (culverts)	A total of 45 culverts are to be installed or upgraded within this Section, totalling 2.9 km: • 37 (2.6 km) are new culverts • 8 (0.3 km) are upgrades to existing culverts
Diversion of waterways	• 9.4 km of stream diversions are to be undertaken within the Section
Bridges and viaducts	• 5 bridges/viaducts will be constructed within this Section, totalling 0.8 km (crossing 0.2 km of stream width).
Bulk earthworks[15]	• Approximately 87.8 h of earthworks within Waiteraire Stream Catchment (including works within Hōteo North Section). • Approximately 62.7 ha of earthworks in the unnamed tributaries of the Hōteo River catchment • Approximately 34.5 ha of earthworks within the Te Hana Creek catchment • Approximately 21.9 ha of earthworks within the Maeneene Creek catchment.
Operational Effects	
Contaminant runoff from the road during operation	• Run off from the Project will all be treated within stormwater treatment wetlands. • Modelling of containments indicates that there may be a small increase in levels. • There is no predicted change in TPH concentrations.

[15] Numbers from Water Assessment Report (Jacobs, 2018b), Table 5.

Notes:
*Numbers are indicative only and are based on the Auckland Council Overland Flowpath Layer and Indicative Alignment and may change.

Table 28 - Assessment of magnitude of effects on freshwater ecological sites surveyed within the Hōteo North Section. Surveyed sites listed in order from south to north.

Site ID	Magnitude of effect (EIANZ criteria)	Reasoning
HN_F_Hōteo _2	Low	A viaduct is to be constructed over the river. Our 'Low' magnitude score assumes that best practises are followed, piers are not located within the streambed or immediate riparian zone and existing riparian vegetation is left in place. Stream channel is currently poorly shaded and the shading of the channel during operation will be the biggest effect, with minimal impacts to the aquatic habitat. The viaduct is to be located downstream of survey site. The site is of high ecological value.
HN_F_Hōteo _1	Low	A viaduct is to be constructed over the Waiteraire Stream and the adjacent SEA. Our 'Low' magnitude score assumes that best practises are followed, piers are not located within the streambed or immediate riparian zone and existing riparian vegetation is left in place. The viaduct is to be located upstream of the survey reach. Shading will be the biggest impact to the stream channel, but will be upstream of the surveyed site. The site is of high ecological value.
HN_F_Hōteo _3	Low	The Indicative Alignment will result in the loss, culverting and diversion of a number of headwater reaches of this Site. The site is of low ecological value.
HN_F_Hōteo _4	High	All aquatic habitat at this site is to be lost under cut and/or fill. A cut off drain is to be created around the toe of the cut/fill but will not provide functioning aquatic habitat. Headwater stream and wetland mosaic habitat of low ecological value. Wetland habitat is assessed within wetland section (HN_W_Hōteo _04)
HN_F_TeHana_1	High	All aquatic habitat at this site is to be culverted and essentially lost. Culvert will result in homogenous habitat and hydrological conditions. Immediately upstream and downstream the stream is to be diverted resulting in temporary loss of aquatic habitat. Stream with remnant mature riparian vegetation, not common in catchment, of moderate ecological value.
HN_F_TeHana_2	Moderate	Survey reach to be infilled and upstream reaches to be diverted through a 182 m culvert. Surveyed stream reach of low ecological value, and stream type common within catchment. Survey Site of low ecological value.
HN_F_TeHana_3	Negligible	Alignment does not cross survey Site or upper reaches of tributary, but crosses within the upper reaches of its catchment. Degraded stream habitat that is common within catchment. Survey Site of low ecological value. Below confluence is site HN_F_TeHana_2.

Site ID	Magnitude of effect (EIANZ criteria)	Reasoning
HN_F_Mae_1	Low	All aquatic habitat at this Site is to be lost under the Indicative Alignment. Small, spring fed, degraded headwater stream habitat of low ecological value.
HN_F_Mae_2	High	All aquatic habitat at this Site is to be culverted in an 82 m culvert, essentially being lost. The upstream reaches of this Site are to be diverted through an extensive 716 m diversion and an additional 165 m culvert. Survey site is of moderate ecological value. Receiving environment is sensitive to additional sediment.
HN_F_Mae_3	None	The Indicative Alignment and project works do not affect this tributary and no effects will occur.

The sediment models predict a low increase in average TSS loads at the test sites within the Hōteo North section, with average sediment load increases of 0.4%, 4.5% and 1.5% from existing conditions predicted at Hōteo River (downstream of the unnamed tributaries), a tributary of Te Hana Creek and the Maeneene Creek, respectively (Jacobs 2019). However, increases in suspended solids may occur in the unnamed pasture tributaries to the north of the Hōteo River viaduct, owing to the risk of flooding.

Overall, the magnitude of effects on freshwater values within the Hōteo North section are moderate. The Indicative Alignment crosses a large number of watercourses with a high degree of stream loss, stream diversion and culvert installations. The magnitude of effects is low on some watercourses through the use of bridges and/or viaducts over the watercourses. There have been some changes to the Indicative Alignment since field surveys were undertaken and some sites are no longer impacted by the Indicative Alignment and/or are within the proposed designation boundary.

Level of ecological effects, prior to mitigation

Overall, the level of ecological effects on freshwater ecological values within the Hōteo North section are low, with some areas of high value features having a higher level of ecological effect (Table 29). The catchments within this section are predominantly used for agricultural stock grazing, with many watercourses accessible by stock. Watercourses are generally highly degraded with poor water quality, limited riparian vegetation and poor quality aquatic habitat available for fauna and flora.

Table 29 - Level of effects on freshwater ecological sites surveyed within the Hōteo North section. Surveyed sites listed in order from south to north.

Site ID	Ecological value	Magnitude of effect	Overall level of effect
HN_F_Hōteo _2	Moderate	Low	**Low**
HN_F_Hōteo _1	Moderate	Low	**Low**
HN_F_Hōteo _3	Low	Low	**Very Low**
HN_F_Hōteo _4	Low	High	**Low**
HN_F_TeHana_1	Moderate	High	**Moderate**

HN_F_TeHana_2	Low	Moderate	**Very Low**
HN_F_TeHana_3	Low	Negligible[1]	**Very Low**
HN_F_Mae_1	Low	Low	**Very Low**
HN_F_Mae_2	Low	High	**Low**
HN_F_Mae_3	Moderate	None[1,2]	**Very Low**

Notes:
1 – Indicative Alignment of works does not cross these streams.
2 - This stream is not within the proposed designation boundary.

4.4 Sensitivity analysis

4.4.1 Spatial sensitivity

Indicative Alignment

The greatest spatial sensitivities to lateral movement of the Indicative Alignment are within the Warkworth North section. At the northern end of the Warkworth North section are the headwaters of the Kourawhero Stream and associated high value wetlands. The movement of the Indicative Alignment westward in this area would result in the loss of at least part of this wetland area and possibly the loss of sections of the Kourawhero Stream headwaters. Further lateral movement of the Indicative Alignment may also result in even greater changes to the water table, thus putting the stream and wetlands at risk. These Priority Ecological Sites are shown in Map Series PES (Map PES02). Also within the Warkworth North section, the movement of the alignment eastward will result in the Indicative Alignment coming closer to the high-value Mahurangi River (Left Branch). This may intrude into the riparian zone of the River, or it may require more bridges/viaducts or even large culverts. This priority ecological site is shown in Map Series PES (Map PES03 no. 1).

An increase in the vertical height of the alignment in the Warkworth North section may also mean batters may be widened and that would intrude into the riparian margins of the Mahurangi River (Left Branch) or the high value wetlands of the upper Kourawhero Stream.

The spatial sensitivity of our assessment for the Dome Valley Forest section is low. The proposed designation and Indicative Alignment pass through Matariki Forest. Any lateral deviation of the Indicative Alignment will essentially take the route through very similar habitat, with the assessment of effects of the construction and operation also similar. The sensitivities for the freshwater environment may be lower if the alignment moved westward. This lateral move would shift the Indicative Alignment upstream towards the headwaters of the tributary streams of the Waiteraire Stream. This movement would mean the Indicative Alignment may cross more streams (meaning more culverts), but they would be smaller and more ephemeral streams (thus avoiding the permanent reaches in the lower catchments).

The Hōteo North section has low spatial sensitivities, owing to the highly modified nature of the catchment. However, a modification to the route eastwards will take the alignment further into the floodplain area; and thus impinging on a significant proposed mitigation area (see Section 5).

4.4.2 Temporal sensitivity

Indicative Alignment

The largest temporal sensitivity of the Project lies around the harvesting of the Matariki Forest within the Dome Valley Forest section. The current existing environment within the Dome Valley Forest will be subject to a high level of ecological effects from the construction of the Project, prior to mitigation. However, as harvesting is currently programmed to occur prior to construction, then the ecological effects of the Project on the freshwater ecological values are likely to be moderate (as the post-harvest ecological values will be lower than current). Field surveys will need to be undertaken prior to construction to better ascertain ecological value immediately prior to Project commencement.

5 RECOMMENDED MITIGATION FOR ECOLOGICAL EFFECTS

Recommended mitigation summary

Section 10 of the AEE sets out an integrated mitigation framework for the Project and provides the context for the ecological mitigation proposed.

Management practices for the construction and operation of major roads are well established in New Zealand. The Transport Agency and its contractors have significant experience in managing effects of major construction projects.

Our strategy for the management and mitigation of effects arising from the Project follows the EIANZ mitigation hierarchy (or effects management hierarchy). The mitigation hierarchy refers to the set of steps that aim to first avoid, then remedy, and then mitigate impacts of development on biodiversity. It is a sequential process, but application in the Project has typically been iterative as the design aspects of the Project have progressed.

The following set of principles were used to help guide the integration of mitigation outcomes for the Project:

- Mitigation should ensure that ecosystems are resilient such that they build structure and function, and enable or enhance their adaptive capacity for the future.
- Mitigation purpose and the outcomes sought should be clearly defined.
- Mitigation is to respond to adverse environmental effects that cannot be avoided or remedied. It is one tool that can be used.
- Mitigation should be a cohesive and integrated package of activities and outcomes.
- A mitigation package should avoid an outcome that results in multi-fragmented partitioning of the environment and instead seek to connect and link systems across the landscape.
- Mitigation should be considered in the wider environmental context i.e., Ki Uta Ki Tai (from mountain to sea).
- Mitigation should link with existing ecosystems to build resilience in existing, restored and constructed environments as applicable.

Plans depicting our proposed mitigation are included in the Ecological Mitigation (EM) Series Drawings in Volume 3 of the AEE. Direct and indirect impacts on several sites of high to very high ecological value have been avoided through the collaborative design of the Indicative Alignment and the Project works. Where practicable, further adjustments and refinements to minimise effects on high value areas will occur in the detailed design phase. We have identified a number of priority ecological sites where we recommend that site-specific attention is given to be avoided as much as practicable, that include: Mahurangi River (Left Branch) and associated riparian margins (SEA), wetlands within the upper Kourawhero Stream catchment, and wetlands within the Hōteo River floodplain. In addition, we recommend impacts upon the Hōteo River be minimised through specific design of a viaduct crossing. We recommend conditions of consent that address the alignment of the route in a number of key priority ecological sites so that impacts on these areas are, as much as is practicable, avoided or otherwise minimised.

Route selection

Avoidance of key ecological features and minimisation of effects has been achieved through careful route selection (for the Indicative Alignment). Multi-criteria analyses (MCA) were used to assess a number of route options, and in relation to various discipline areas including ecology. During the MCA, the key SEAs, habitat for fauna, and aquatic environments were given high value status.

Terrestrial ecological values

Approximately 13 ha of native vegetation will be directly impacted by the Indicative Alignment, out of a total of approximately 119 ha of existing vegetation (i.e., excluding pasture and plantation pine forest) throughout the proposed designation (amounting to some 11% of loss). Of this, approximately 1.5 ha of high value indigenous wetland and kahikatea-dominated swamp forest is directly impacted through clearance. A further 7 ha comprises 'moderate' value vegetation, mostly kanuka forest and scrub and totara-dominated podocarp forest remnants.

In keeping with the mitigation principles for the Project, we recommend mitigation for the loss of indigenous vegetation and wetlands through the enhancement and reinstatement of lowland wetland and kahikatea swamp forest areas. Three areas have been identified by us as being appropriate for wetland enhancement and reinstatement: The Mahurangi River (Left Branch) floodplain, the upper Kourawhero Stream catchment, and the Hōteo River floodplain at Wayby Valley Road. Each of these areas link to existing ecosystems and contribute to the aggregation of mitigation, prevention of fragmented mitigation and building resilience within and between the ecosystems.

When these mitigation measures are implemented the effects of the construction and operation on indigenous vegetation will be minimal.

Fauna management

The high fauna ecological values within the proposed designation boundary are mostly contained within the Dome Valley Forest Section. Threatened and At Risk species such as Hochstetter's frogs, native bats and kauri snails and indigenous lizards have been reported to be present in this area. Recommended mitigation for the loss of habitat for these species will be through avoidance, salvage and relocation (frogs, land snails and lizards if present), the seasonal avoidance of breeding and roost sites, and the retention and rehabilitation of flyways for bats and birds. A management plan approach is recommended for Hochstetter's frogs and bats as these species require specific protocols to be followed.

We are of the view that the proposed avoidance, remediation and mitigation is both sufficient and appropriate for the loss of direct and residual terrestrial ecological values.

Freshwater ecological values

Approximately 27 km of length of intermittent and permanent streams will be directly affected by the Indicative Alignment within the proposed designation boundary (out of a total of approximately 146 km of stream length within the proposed designation boundary). About 18 km of stream diversion channels are also planned which when designed and implemented will retain and in part replace the stream losses, especially in lowland areas. Using standard Stream Ecological Valuation (SEV) protocols, we estimate that this amounts to some 70 km of stream length to mitigate with riparian planting and stock fencing. Approximately 119 km of stream length is available within the proposed designation boundary for mitigation planting. As there is some 119 km of stream length available within the proposed designation there is sufficient flexibility for stream mitigation should the alignment move within the proposed designation.

The harvesting plans for the Matariki Forest indicate that harvesting will have occurred within and around the proposed designation at the time of the anticipated construction of the Project. This activity will reduce the aquatic ecological values and stream function from those existing today. Reduced ecological and functional values provide an opportunity to enhance these values as part of the mitigation required for the Project.

5.1 Introduction

5.1.1 Approach

Our approach to the management of impacts resulting from the Project has been to follow the EIANZ Mitigation Hierarchy. The mitigation hierarchy refers to the set of steps that aim to first avoid, then remedy, and then mitigate impacts of development on ecological values.

For the Project, the application of the hierarchy has been an iterative process as the design aspects of the Project have progressed. We have considered the mitigation required for each of the ecological disciplines (vegetation, fauna and freshwater values) and we have brought all aspects of ecology together to ensure holistic ecological outcomes that maximise ecological benefits.

This chapter has been prepared to present a 'mitigation package' that includes all aspects of the EIANZ Mitigation Hierachy and recommends sufficient management and mitigation to balance potential adverse effects on ecological values identified in each of the preceding ecological assessment chapters.

We note that there is a specific terminology that makes up the EIANZ mitigation hierarchy, which reflects the avoidance, remediation and mitigation of effects, and the offset or compensation for significant residual effects. However, for the purposes of this report we have collectively referred to all of these terms under the umbrella term of a single 'mitigation package'.

The proposed mitigation is based on the assessment of the effects of the Indicative Alignment within the proposed designation boundary. The actual quantum of mitigation may change if the Indicative Alignment shifts within the proposed designation boundary. Further detailed ecological surveys closer to the time of construction will more specifically confirm the required mitigation at the time. We recognise that the final position of the alignment may vary within the proposed designation boundary, and therefore that the quantum of effect and necessary mitigation may vary accordingly. Our recommendations address the potential shift within the designation boundary to ensure the Project does not cause additional effects over those currently anticipated.

We note that management practices for the construction and operation of major roads are well established in New Zealand, and the Transport Agency and contractors have significant experience in managing effects of major construction projects. Current practices and processes in place on the Pūhoi to Warkworth section demonstrate how construction is typically managed and how well established procedures and plans are in place to manage effects.

We have accepted the good practice in place for the Pūhoi to Warkworth section of the road, and view this established practice as a foundation to our approach. For the Warkworth to Wellsford section we aim to build on that experience and practice to provide improvements in the environmental outcomes gained.

5.1.2 Mitigation Strategy

Principles of mitigation for the Project

The following set of principles were used to help guide the integration of mitigation outcomes for the Project as a whole, based on the approach outlined above:

- Mitigation should ensure that ecosystems are resilient such that they build structure and function, and enable or enhance their adaptive capacity for the future.
- Mitigation purpose and the outcomes sought should be clearly defined.
- Mitigation is to respond to adverse environmental effects that cannot be avoided or remedied. It is one tool that can be used.
- Mitigation should be a cohesive and integrated package of activities and outcomes.
- A mitigation package should avoid an outcome that results in multi-fragmented partitioning of the environment and instead seek to connect and link systems across the landscape
- Mitigation should be considered in the wider environmental context i.e., Ki Uta Ki Tai (from mountain to sea).
- Mitigation should link with existing ecosystems to build resilience in existing, restored and constructed environments as applicable.

We consider that the landscape and ecological elements of mitigation are particularly closely integrated, and that the overall Project mitigation outcome is dramatically improved by considering them together. Both disciplines have worked closely together to enable integration and alignment of their respective mitigation proposals.

Mitigation hierarchy

We have been guided on the mitigation hierarchy by the EIANZ guidelines for ecological impact assessment (EIANZ 2018) and relevant sections of the AUP(OP). The AUP(OP) contains policies that describe a mitigation hierarchy around managing effects of activities on indigenous biodiversity values that are identified as significant ecological areas (Policy D9.3), and also Chapters E.15 (Vegetation management and biodiversity) and E.3 (Lakes, rivers, streams and wetlands).

These policies broadly describe the mitigation hierarchy as firstly avoid, then remedy, then mitigate and then consider the appropriateness of offsetting[16] any residual adverse effects that are significant and where they have not been able to be mitigated, through protection, restoration and enhancement measures.

We note that the AUP(OP) sets out a framework for biodiversity offsetting (Appendix 8, AUP(OP)), which is to be read in conjunction with the New Zealand Government Guidance on Good Practice Biodiversity Offsetting in New Zealand document[17].

We consider that the mitigation proposed below is adequate to manage the adverse effects of the Project within the proposed designation boundary. However, we note that although our proposed mitigation package is contained within the proposed designation boundary, the ecological benefits extend beyond these boundaries and will lead to an overall enhancement of ecological outcomes.

As indicated above, we have collectively referred to all components of the mitigation hierarchy using the term "mitigation package".

Route selection and design

Avoidance of key ecological features and minimisation of effects has been achieved through careful route selection (for the Indicative Alignment). Multi-criteria analyses (MCA) were used to assess a number of route options, and weighted the effects of various discipline areas including ecology. During the MCA, the key SEAs, habitat for fauna, and aquatic environments were given high values.

In some cases, trade-offs have been made between features. This was most notable for the Mahurangi River (Left Branch) and Hōteo River. In both cases the continuous intact stream riparian margins were retained and impacts avoided, and the benefits of this margin to terrestrial and aquatic biodiversity and function, was valued above some of the fragmented patches of vegetation (e.g., HN_W_Hōteo _01, HN_T_Hōteo _03b)) which are impacted by the Indicative Alignment. We have recommended that, as much as is practicable, these key ecological features should be retained (avoided) for the purposes of the design and build of the final alignment.

Viaducts or bridges have been recommended as a means of minimising ecology impacts on rivers in the following locations:

- Bridge 11 avoids direct effects on the Hōteo River, minimises effects on the riparian margins effects of the Waiteraire Stream, and minimises effects on the SEA).
- Similarly, a short bridge (Bridge 22) over the upper Kourawhero Stream has the benefit of avoiding direct impacts on the stream and minimises the use of stream diversions. Thus, the bridge reduces modifications to the surface and groundwater hydrology and minimises impacts on nearby wetlands.

[16] Definition of Biodiversity offset: *"A measurable conservation outcome resulting from actions designed to compensate for residual, adverse biodiversity effects arising from activities after appropriate avoidance, remediation, and mitigation measures have been applied. The goal of a biodiversity offset is to achieve no-net-loss, and preferably a net-gain, of indigenous biodiversity values" (BWG 2018).*".

[17] New Zealand Government, 2014.

- Minimising the impact of the Indicative Alignment on the wetlands of the Kourawhero Stream is also achieved through the lowering of the alignment to reduce the batter requirements so they do not intrude into the wetland areas.

Accordingly, we recommend that that Bridges 11 and 22 are required to meet specified design criteria to provide for the environmental outcomes outlined above.

5.1.3 Integrated Environmental Mitigation

In line with the Project mitigation principles (outlined in Section 5.1.2), we have approached the mitigation for the potential adverse effects of the Project with a view to maximising integration of the terrestrial, wetland and freshwater environmental ecological outcomes. These outcomes are necessarily linked with other desirable environmental outcomes such as those for landscape and visual outcomes, hydrology, and stormwater management, Section 10 of the AEE provides the overview of the integrated mitigation that incorporates all mitigation outcomes.

Our recommended integrated environmental mitigation approach provides for mitigation to be aggregated in specific locations, rather than spread along the length of the proposed designation. This prevents a 'patchy' mitigation approach (whereby mitigation effort is dotted at irregular intervals along the proposed designation) to a concentrated mitigation effort at selected locations. In addition, our integrated mitigation approach has sought to enhance the ecological corridor benefits across the landscape. We have provided for this by recommending North-South connections across catchment boundaries, river margins and increased and enhanced vegetation patches; and retaining and enhancing opportunities for east-west and lateral movements across the landscape.

Our integrated environmental mitigation approach means that in most cases the ecological mitigation and the landscape mitigation planting take a similar form and is located in the same key locations. Ecology is integrated with landscape to provide a more continuous corridor of vegetation which will benefit biodiversity throughout the proposed designation whilst also providing benefit from a landscape and visual perspective. We have specifically quantified the ecological components of the mitigation planting as follows:

Ecological mitigation planting is based on a gain:loss ratio of:

- 6:1 for High and Very High value indigenous vegetation and wetlands[18].
- 3:1 for Very Low to Moderate value indigenous vegetation and wetlands.

The methodology for assigning High and Very High values (and Very Low to Moderate values) is described in section 2.6. The criteria for identifying Significant Ecological Areas (Schedule 3 AUP(OP)) have been used to interpret the broad significance criteria for the Project (Table 1). The EIANZ evaluation (2015) guidelines have been used for assigning value to both species and habitats (from Very Low to Very High).

Our approach to mitigating for the loss of indigenous vegetation enables flexibility for the Project while providing certainty for the environmental outcome. Modifications to the alignment within the proposed designation boundary made through the detailed design

[18] For example, if 1 ha of high value indigenous vegetation is lost then we will mitigate by planting 6 ha of suitable indigenous species

process can be accommodated based on the assessment of the sites in relation to the defined criteria, and the subsequent calculation of the quantum of mitigation planting required.

We have selected five key locations within the proposed designation boundary as preferred areas for mitigating the impacts of the Project. These are shown in the EM drawing series, Volume 3 of the AEE and specifically listed in 5.2.1.

We have also identified a number of priority ecological sites (PES) that identify the moderate, high, very high value or otherwise sensitive locations that we consider require specific attention to avoid, as much as is practicable. These sites are listed in Table 13 of section 3.4.1, and located on Map Series PES, Volume 3 of the AEE.

A summary of the vegetation mitigation planting for four of these locations is outlined in Appendix G. These mitigation areas are described in more detail below.

5.2 Mitigation for effects on terrestrial and wetland ecological values

5.2.1 Overview

In keeping with the Project mitigation principles and mitigation hierarchy ((Section 5.1.2), we have recommended a mitigation package that has provided for:

- Avoidance, as much as practicable (i.e., Mahurangi River (Left Branch) (SEA_T_2287); Wetlands at WN_W_Koura_02), and
- Minimisation (i.e., minimising impact on SEA at HN_T_Hōteo _02).
- Mitigation (e.g., salvage and translocation of At Risk and protected fauna); and
- Mitigation through planting for the loss of vegetation and habitat biodiversity and functions; and stream enhancements through riparian planting for the loss of stream habitat and biodiversity and functions).

We note that all of the recommended mitigation is provided for within the proposed designation boundary.

The focus for our recommended mitigation strategy is to establish large areas of revegetation that provide a strong landscape framework and habitat creation around key areas that contain existing high value features or provide connections between features. These areas are:

- Mahurangi River (Left Branch) floodplains (Area A, Map Series EM, drawing EM-010);
- Upper Kourawhero Stream and Wetlands extending to Dome Valley (Area B, Map Series EM, drawing EM-011);
- Hōteo River floodplains (Area C, Map Series EM, drawing EM-013).
- Te Hana lowlands (Areas D and E, Map Series EM, drawings EM-014 and EM-015).

We note that the fifth mitigation focus area is located in the Dome Valley forest area and has been identified as a preferred location for fauna mitigation. No specific planting has been proposed for this location at this time.

5.2.2 Mahurangi River (Left Branch)

The structure and layout of the indicative Warkworth Interchange provides opportunity for mitigation riparian floodplain planting and habitat creation alongside the Mahurangi River (Left Branch). The collaborative approach to the development of the Indicative Alignment has resulted in the avoidance of any structures intruding into the Mahurangi River (Left Branch) or its existing riparian margins (SEA_T_2287). The on and off-ramps of the Warkworth interchange are elevated to the extent that they will not result in the loss of the riparian margins, although some tree loss and shading of the riparian margins will occur.

The current configuration of the interchange means that floodplain land will benefit from improvement. The proximity to the Mahurangi River (Left Branch) provides opportunity for greater protection of the true left bank riparian margin of the river, along with extensive riparian floodplain planting. This planting has been considered in the context of flood risk and modelling has shown that based on an assumed planting regime, there is no noticeable increase to either flood extent or depth.

Based on the Indicative Alignment and the proposed mitigation ratios, the Mahurangi River (Left Branch) planting area is 17 ha.

We note that the particular design considerations and mitigation planting ratios are derived from the position of the Indicative Alignment, and the proposed design of the Warkworth interchange. However, our sensitivity analysis suggests that any fundamental shift in the lateral or vertical movement of the alignment will result in similar ecological effects and opportunities provided the relative sensitivity of the location is addressed.

To enable such design changes to occur without increasing environmental effects in this location we therefore recommend:

- maintainenance of the on and off ramps as bridge structures;
- minimising of the removal of vegetation from the riparian margin of the Mahurangi River (Left Branch);
- avoidance of any structures intruding into the Mahurangi River (Left Branch) or its existing riparian margins; and
- planting requirements based on the mitigation planting ratios we have set out in 5.1.3.

5.2.3 Upper Kourawhero Stream catchment

High or very high ecological values have been identified for the terrestrial, wetland, fauna and freshwater components within the proposed designation boundary at the upper Kourawhero Stream catchment. The Indicative Alignment avoids or minimises direct effects on most of these features as much as practicable. There remains some potential for disruption to the hydrology and water table, and sedimentation, within this upper catchment (Jacobs GHD JV, 2019).

Direct hydrological effects on wetland WN_W_Koura_02 have been avoided by our recommended inclusion of a bridge (Bridge 22) across the main stem of the upper Kourawhero Stream, and by lowering the alignment to reduce the batters. This bridge would reduce the need for further extensions of diversions (although there are predicted increases in flood depths resulting from the diversions that are currently proposed in this location). We recommend that a bridge and sensitive water design in the upper Kourawhero Stream catchment which minimises the potential effects on ecology of the wetland system be required.

The recommended requirements for Bridge 22 are that it:

- Spans the upper Kourawhero Stream.
- Prevents any intrusion into wetland WN_W_Koura_02.
- Prevents diversion channels intruding in to or through wetland WN_W_Koura_02.
- Minimises water table changes to wetlands WN_W_Koura_02 to WN_W_Koura_05.

We recommend that the existing wetland areas, WN_W_Koura_02 to WN_W_Koura_05, be improved through weed control, edge/buffer planting of appropriate native species and enhancement planting within the respective wetland types. We note that careful consideration must be given to modifications to surface or groundwater hydrology that may impact on the existing wetlands (Jacobs GHD JV, 2019 WAR), including any realignment of forestry roads.

The considered design and placement of the stormwater treatment wetlands anticipated in the upper Kourawhero Stream catchment has the potential to provide additional water to restored and enhanced mitigation wetlands. The permanent source of treated water to the mitigation wetlands from the stormwater treatment wetlands will be beneficial to the success of the mitigation, and we recommend that a condition of resource consent is prepared that reflects this requirement. In addition, the stormwater treatment wetlands themselves provide ecological benefit, providing habitat for wetland flora and fauna. We recommend that the stormwater treatment wetlands are designed to incorporate ecological and biodiversity function, that can be readily maintained during operations of the road.

Connectivity throughout the upper Kourawhero Stream valley will be enhanced to link with the existing escarpment (flora and fauna; Site DVF-T-Koura_02), the upper tributary wetland valleys (bat and bird flyways), the existing and future vegetation, the diversity of existing and potentially created wetlands, and the downstream floodplains.

Based on the Indicative Alignment and the proposed mitigation ratios, the mitigation planting area of the Upper Kourawhero Stream and Wetlands mitigation area is 10 ha.

To enable such design changes without increasing environmental effects we therefore recommend:

- requirement for Bridge 22 to meet specific environmental outcomes.
- minimising water table changes to wetlands WN_W_Koura_02 to WN_W_Koura_05.
- enhancing wetland areas, WN_W_Koura_02 to WN_W_Koura_05 through weed control, edge/buffer planting, and enhancement planting within the respective wetland types.
- use of treated stormwater to maintain wetland areas WN_W_Koura_02 to WN_W_Koura_05 and/or any newly established wetland.
- planting requirements based on the mitigation planting ratios we have set out.

5.2.4 Dome Valley Forest Section

High or very high existing ecological values have been identified for the terrestrial, wetland, fauna and freshwater components within the Dome Valley Forest Section of the proposed designation boundary (Ecological Survey (ES) Series Drawings). Although current landcover is largely commercial pine forest, this environment provides for high value fauna habitat for long-tailed bats, kauri snails, birds, and potentially lizards, as well as high value freshwater stream habitats with the potential for the presence of Hochstetter's frogs.

As the commercial production forest is expected to have been harvested at the time of the Project construction, the currently existing ecological values will be diminished as a result of the loss of available habitat and the increased potential for sediments to enter the streams. The effects of forest harvesting on ecological values have been well documented (Borkin et al. 2011). Although the NES Forestry provides guidance to minimise the effects of harvesting, the actual level of adverse impacts is difficult to predict.

As a result of the loss of habitat and disturbance to fauna habitat from the Project, we recommend that an area of the proposed designation be set aside for the purpose of:

- Providing a location for the translocation of fauna salvaged within the proposed designation (esp. land snails and lizards).
- Maintaining an east-west link across the proposed designation to allow for the movement and dispersal of fauna and seeds.
- Maintaining a flyway for avifauna and bats to move and disperse across and along the proposed designation.
- Retaining late cycle pine trees where possible for the purpose of providing bat roosts and breeding sites within the designation.

We have identified a preferred location for a 'Fauna habitat and flyway mitigation option' at the southern end of the Dome Valley Forest Section (see EM series plans in the Volume 3 Drawing Set). The identified Fauna habitat and flyway area covers some 61 ha and has the following benefits:

- It encompasses part of the the indicative tunnel location, and thus is the only part of the proposed designation that comprises a length not bisected by the proposed alignment (EM Map Series 02).
- It occurs adjacent to a 'cut' meaning that the mitigation area will be well above and away from the road.
- It encompasses the high-value escarpment feature (DVT_T_Koura_02) which is a known flyway route for birds and bats.
- It connects with features of the upper Kourawhero Stream catchment (see above).
- When integrated with the other proposed mitigation, the Fauna habitat and flyway area extends a length of vegetated ecological connectivity from the Mahurangi River (Left Branch) north to the Hōteo River catchment, encompassing the Dome Valley and Sunnyhill SEAS.

- The Fauna habitat and flyway area retains a vegetated cover for headwater streams of both the Upper Kourawhero Stream and the Upper Waiteraira Stream.
- Managed regrowth in the Fauna habitat and flyway area means that a transition to indigenous vegetation can be achieved over time.
- Pest management will enhance the sustainability of biodiversity within this area.

If at the time of Project initiation, the preferred fauna habitat and flyway area is deemed to be unsuitable, as determined by a suitability qualified person, or is unavailable, then alternative locations will be found.

Setting aside the Fauna habitat and flyway area does not prevent its use for other purposes (e.g., teleco structures) and tracks across the area can be retained for access within and across the area if required.

We recommend that the effects on habitat and disturbance to fauna habitat be provided for in a condition of resource consent that requires setting aside the Fauna habitat and flyway area to:

- Retain old-growth plantation pine trees if possible.
- Provide a location for the translocation of fauna salvaged within the proposed designation boundary.
- Maintain an east-west link across the proposed designation to allow for the movement and dispersal of fauna and seeds.
- Maintain a flyway for avifauna and bats to move and disperse across and along the proposed designation.
- Protect the Fauna habitat and flyway area.

5.2.5 Hōteo River Floodplains

The floodplains of the Hōteo River immediately north of the Dome Valley Forest section (east of the proposed designation at Wayby Valley Road) present an extensive area for potential restoration to floodplain riparian wetlands. This floodplain area within the proposed designation boundary is currently lowland pasture. This area is marked as Mitigation Area C on the EM Map Series.

In this area, restoration planting of a kahikatea-dominated lowland wetland will rehabilitate the ecosystem in line with the criteria outlined by Singers et al. (2017).

A tributary of the Hōteo River (HN_F_Hōteo _3) runs through this section of floodplain. Specific restoration planting of the margins of the stream, in sympathy with the floodplain planting, will enhance the longitudinal (along the stream length) and lateral (restoring connection with the stream floodplain) benefits, especially for stream and wetland aquatic fauna.

However, extensive planting of the floodplains has the potential to hold water during high water levels and increase flooding both within and outside of the proposed designation boundary. In light of this, the type of planting considered for this location has sought to reflect that of a mixed kahikatea-dominated lowland wetland whilst also minimising the potential effects on flooding by including low stature plants and smaller clusters of trees.

The potential effects of mitigation planting on flooding in this area has been assessed and has been found to result in a localised increase in flood depth of up to 150 mm in a 100 year return period event. The localised increase in flooding may impact pastoral land (between the proposed designation boundary and the Hōteo River) which is already prone to flooding. However, there are no direct effects on dwellings (Jacobs 2019).

Based on the Indicative Alignment and the proposed mitigation ratios, the area of the Hōteo River Floodplains Mitigation area is 16 ha. Mitigation planting ratios have been established which enable the mitigation quantum to be modified if the road alignment changes and more or less indigenous vegetation is affected.

5.2.6 Effects on terrestrial and wetland ecological values after mitigation

We have followed the guidance on ecological impact management provided by EIANZ (2015) to plan for the management of effects of the Project, using the Indicative Alignment to estimate quantum of impact. We have established mitigation ratios and like-for-like mitigation planting for the loss of wetlands and terrestrial vegetation. Thus in the event that the alignment changes, there is a direct mechanism to enable the calculation of the appropriate quantum of mitigation.

Avoidance of terrestrial ecological features has been achieved as far as practicable through the collaboriative and multisdisciplinary design process for the Indicative Alignment. The Indicative Alignment will result in the loss of approximately 13 ha of native vegetation, out of a total of approximately 119 ha of existing vegetation (i.e., excluding pasture and plantation pine forest) throughout the proposed designation. Of this, approximately 1.5 ha of high value indigenous wetland and kahikatea-dominated swamp forest is directly impacted through clearance, though the disturbance may result in substantive degradation to the remaining features. A further 8.9 ha compromises 'low-moderate' value vegetation, mostly kanuka forest and scrub and totara-dominated podocarp forest remnants. A full breakdown of all of the areas of vegetation within the proposed designation and those impacted by the Indicative Alignment is provided in Appendix H.

In keeping with the mitigation principles for the Project, mitigation for the loss of indigenous wetland and kahikatea-dominated swamp forest will be the enhancement and reinstatement of lowland wetland/swamp forest areas. Three areas have been identified as being appropriate for wetland enhancement and reinstatement: The Mahurangi River (Left Branch) floodplain, the upper Kourawhero Stream catchment, and the Hōteo River floodplain at Wayby Valley Road. Each of these areas link to existing ecosystems and contribute to the aggregation of mitigation, prevention of fragmented mitigation and building resilience.

These areas amount to some 45 ha of planting to address the residual effects of the loss of 13 ha of indigenous vegetation.

As provided for by the established ratio (Section 5.1.3), the proposed planting amounts to 6x the full amount of high-very high value indigenous vegetation and habitat lost (~1.5 ha), and 3x the amount of low to moderate value indigenous vegetation and habitat lost. Our strategy provides for 'like-for-like' planting of indigenous kahikatea-dominated swamp forest and kanuka forest and scrub and totara-dominated podocarp forest. Added to this extent of planting are the added benefits of the aggregated planting, connectivity and habitat value.

It is recommended that all mitigation areas outlined above are fenced, or stock excluded, protected legally as appropriate, and subject to pest and weed management until they are well-established.

After the implementation of this mitigation planting, stock exclusion, pest and weed management, and protection, we consider that the effects of the Project on terrestrial and wetland terrestrial values is low.

5.3 Proposed mitigation for effects on terrestrial fauna ecological values

5.3.1 Overview

We have noted above (Section 5.2.4) that high or very high ecological values have been recognised for high value fauna habitat for long-tailed bats, kauri snails, birds, and potentially lizards, as well as high value freshwater stream habitats with the potential for the presence of Hochstetter's frogs. We recommend specific management approaches for each faunal type with the purpose of either avoiding critical seasons, salvaging and translocating to prevent mortality, or retaining existing features and habitat for roosting, nesting and dispersal. A single Ecological Management and Mitigation Plan could provide for these elements of fauna management.

5.3.2 Wildlife permits

Native animals including bats, lizards, frogs and some invertebrate species are 'absolutely protected' under the Wildlife Act (1953, s63 (1) (c)), and administered by the Department of Conservation (DOC) and Auckland Council respectively. A Wildlife Act Authority (WAA permit) is required to disturb, handle, catch, release or inadvertently kill native wildlife including lizards, bats and frogs.

Guidelines have been developed to identify and address lizard habitat loss through land development (Anderson et al. 2012). These guidelines identify the procedures involved to meet the legislative requirements for the protection of lizard fauna outside of specific conditions of consent. These procedures include:

- Obtaining wildlife permits from DOC to survey, capture and transfer lizards. A separate permit would be required if lizards were to be held in captivity prior to release. Iwi consultation also forms a part of permit approval.
- Undertaking lizard or lizard habitat surveys.
- Development of a lizard management plan.
- Description of actions to mitigate adverse effects on lizards.

DOC permits are required to handle and translocate lizards over more than 500 m. A translocation plan must be submitted to the DOC Area Office to allow for consultation with interested parties. The translocation plan includes the application for a high-impact permit which allows the applicant to collect, capture and release animals as described in the application and subject to conditions.

A similar approach is relevant to all ground-living and arboreal fauna.

Aquiring Wildlife Permits can take time so applications need to be submitted to DOC well in advance of their implementation. More importantly, our experience suggests that the conditions and requirements of DOC Wildlife permits need to be consistent and aligned with any required authorisations from Auckland Council. We consider that obtaining the relevant DOC Wildlife permits (with conditions) will inform the provisions to be detailed within the proposed Ecological Management and Mitigation Plan, and thus avoid any conflict of purpose, methodology or measurement (including monitoring) of outcomes.

5.3.3 Land-based fauna (snails and lizards)

The objective of land fauna management is to maintain and enhance the population of native land snails and lizards present within the proposed designation boundary by capturing and relocating them to a purposely designed safe habitat. We note that if present, it is unlikely that all native land snails and lizards within the proposed designation will be salvaged. However, implementation of a salvage operation will reduce these unavoidable effects to an acceptable level and provide for the long term security of the relocated fauna. We have grouped the land-based fauna together as the approach to their respective management is similar.

We recommend that:

- prior to commencement of construction, an ecologist checks the likely areas of land snails and lizards within the proposed designation of the Dome Valley Forest Section for the presence of land snail and native lizard species;
- any land snails or native lizards found during such checks be captured and relocated to a suitable recipient site; and
- all methods should follow the most recent best practice guidelines for lizard and snail salvage and relocation respectively.

We have recommended a preferred Fauna Habitat and Flyway Area (Sections 5.2.4 and 5.3.8, and Map Series EM, drawing EM-011) as a fauna recipient site. We recommend that the Fauna Habitat and Flyway Area is fenced (to prevent stock and pig access) and subject to appropriate predator control measures for at least six months prior to the first transfer of fauna, and to continue for at least three years following the final fauna transfer.

5.3.4 Hochstetter's Frogs

Hochstetter's frogs are known to occur in the streams of the Dome Valley Forest section, and there are several records of their presence. We have not surveyed every waterway for the presence of Hochstetter's frogs. Management of frogs will need to be applied to every waterway where suitable frog habitat exists and is impacted by the final road design.

We note that Hochstetter's frogs are susceptible to the loss of habitat from sediment intrusions and siltation of their habitat. As it is anticipated that the commercial pine forest in the Dome Valley Forest section will have been harvested prior to the expected construction timeframe for the Project, there are likely to be notable changes to the stream habitats of Hochstetter's frogs.

The objective of the recommended management of Hochstetter's frogs is to maintain and enhance the population present within the proposed designation by capturing and relocating them to a suitable safe habitat. We note that if present, it is unlikely that all Hochstetter's frogs within the proposed designation boundary will be salvaged. However, implementation of salvage operation will reduce these unavoidable effects to an acceptable level and provide for the long term security of Hochstetter's frogs.

We recommend that:

- prior to commencement of the construction an ecologist checks the likely areas of Hochstetter's frogs within the proposed designation of the Dome Valley Forest Section for the presence of Hochstetter's frogs;
- during works in these area, destructive searches are carried out to salvage any frogs; and
- any Hochstetter's frogs found during such checks be captured and relocated to a suitable recipient site.

We note that currently there are no accepted protocols for the salvage and translocation of Hochstetter's frogs. Conversations with DOC staff have resulted in mixed opinions on whether the successful translocation of Hochstetter's frogs is feasible. Notwithstanding this, we recommend that appropriate protocols be developed and tested in conjunction with DOC prior to the capture and relocation commencing.

As a consequence, and given the uncertainties regarding Hochstetter's Frogs, for the purposes of achieving the aims of Hochstetter's frog management we recommend that a specific Hochstetter's Frog Management Plan (HFMP) is prepared to guide the survey, salvage and relocation of the frogs to include (but not limited to):

- Clear objectives and purpose for the management of Hochstetter's frogs.
- Credentials and contact details of the ecologist/herpetologist who will implement the plan.
- Timing of the implementation of the HFMP, noting seasonal, temporal and weather constraints to avoid breeding and juvenile rearing season as much as possible.
- A description of methodology for survey, capture and relocation of Hochstetter's frogs rescued. This methodology should include implementation of the DOC SOP for 'Native frog hygiene and handling protocols' to reduce the potential for pathogen transmission.
- Identify opportunities to create, enhance and connect Hochstetter's frog habitats within the Project area. Habitat enhancement includes protection from stream sedimentation and pest animal control.
- A description of the relocation site(s) taking into account the potential for resident frogs.
- Post-release monitoring methods and programme of monitoring.

Chytrid fungus

In order to avoid the infection of Hochstetter's frogs with chytrid fungus, we recommend that the DOC Native frog hygiene and handling protocols (Hygiene Protocol DOCDM-214757) are followed to eliminate potential infection routes. This protocol can be included in the HFMP. The key principles of the DOC protocol are:

- Transmission risk can be managed/reduced through good hygiene practices.
- New or disinfected equipment /footwear should be used at every new site.
- New or disinfected equipment should be used for each frog.

Management of chytrid fungus can be included in the Hochstetter's Frog Management Plan.

5.3.5 Avifauna

Birds are highly mobile apart from specific times of year such as the breeding season. As such, when habitat clearance occurs the key objective is to avoid periods when birds are less mobile. Both wetland and bush birds are the avifauna of interest for the Project.

We recommend that:

- Wetland WN_W_Koura_02 where banded rail (classified as At Risk Declining) were detected is avoided as much as practicable by the final alignment. This wetland is within the proposed designation boundary but currently outside the Indicative Alignment.
- Wetland WN_W_Koura_05 consists of two branches and the western most branch is currently within the site of an embankment of the Indicative Alignment. The final alignment should avoid encroaching on the remaining area of this wetland that is within the proposed designation boundary but currently outside the Indicative Alignment.
- The clearance of vegetation (excluding pasture and plantation pine forest) should be conducted outside of the main forest and wetland bird breeding season (September to March inclusive) to avoid the potential disturbance of breeding and nesting birds; or if the clearance of vegetation is necessary during the breeding season, only after pre-clearance surveys by a suitably qualified ecologist confirm that no nesting birds are present).

Note that wetlands WN_W_Koura_02 to WN_W_Koura_05 are listed in Priority Ecological Site map series.

The loss of vegetation within the proposed designation boundary will reduce and fragment bird habitat, and disrupt/lose connectivity corridors used by birds and other fauna. In order to mitigate the actual and potential effects of the Project on the potential values for birds present, we recommend that:

- Pest animal control is undertaken around wetland WN_W_Koura_02 (where banded rail was detected) to reduce the number of pests, particularly stoats and rats which both prey on native birds and their eggs; and pukeko if it is deemed by an ecologist that pukeko numbers are likely to be a predation pressure on At Risk birds and their eggs/young. Wetland WN_W_Koura_02 is an area of 0.8 ha.
- Surveys for wetland bird species (including banded rail, fernbird, Australasian bittern, marsh crake and spotless crake) are carried out in wetlands WN_W_Koura_02 and WN_W_Koura_05 at the beginning of the bird breeding season prior to works commencing.
- The regenerating periphery (WN_T_Koura_02, 28.3 ha) of WN_W_Koura_02 wetlands is retained and revegetated to buffer the potential edge effects on banded rail that will arise from the clearing of nearby habitat (amongst other functions).

- Opportunities to enhance WN_W_Koura_02 wetland habitat are identified including but not restricted to weed control within the wetland and adjacent habitat.
- Appropriate predator control to minimise bird predation is undertaken in the planted mitigation areas, fragmentation mitigation areas and Fauna habitat and Flyway mitigation areas to provide mitigation for areas of high quality habitat that will be cleared for the Project. Although no pest evaluation has been carried out, at this stage we envisage that predator control will target mustelids, wild cats, rats and possums.

5.3.6 Bats

Long-tail bats are known to occur within the proposed designation boundary, with most activity concentrated in the Dome Valley Forest section. However, the lack of opportunity to survey along some parts of the proposed designation (especially in the Hōteo North Section) means that we cannot confirm their presence or absence across all areas of the proposed designation.

Long-tailed bats are listed in the highest threat category nationally (C. F. J. O'Donnell et al., 2018). We recommend that further bat surveys are undertaken in the Warkworth North and Hōteo North Sections prior to construction, in order to gain a more comprehensive understanding of how long-tailed bats are using the landscape.

The objective of management of long-tailed bats is to maintain and enhance their population and as much as practicable to prevent mortality of adults and juveniles of the species.

In order to avoid potential effects of the Project on bats, we recommend that:

- Surveys for maternity roosts are undertaken in early spring using methods proven to find them (e.g., radio telemetry using acoustic lures).
- A vegetation removal protocol should be prepared which specifies methods for surveying potential roost trees across the alignment, including tall-stature exotic trees that are largely overlooked in our site-by-site assessments.
- Where practicable, avoid identified roost trees and provide buffer planting to mitigate for increased disturbance and changes to microclimate conditions round roosts.
- If bat roosts are identified and cannot be avoided, the vegetation removal protocol should be implemented so to avoid injury or mortality of bats.

In order to mitigate potential effects of the Project on bats, we recommend:

- Include design features into bridges spanning potential commuting corridors (i.e., the Mahurangi River (Left Branch) and the Hōteo River) for the purpose of minimising disturbance to bats. Such design features must include minimising light spill above and below the bridge.
- Where practicable minimise lighting across the alignment, particularly through the Dome Valley Forest section and river crossings. Where road lighting is necessary in these areas, luminaires should be designed to direct light only where it is required to minimise light spillage into the surrounds.
- As much as possible provide early mitigation in order to provide opportunity for vegetation to grow; and/or plant tall stature trees in clusters at specific locations. Early

planting will be particularly important if vegetated hop-overs are employed as a mitigation strategy.

- Where practicable, preserve clusters of existing trees along known and potential bat flyways to assist in maintaining foraging habitat and corridors for bat movements. We note that we have recommended the set-aside of some 61 ha of 'Fauna Habitat and Flyway area'. This area sits between two areas of native vegetation which span the Project and have been recommened to be retained. These areas will provide these attributes for bats. If the 'Fauna Habitat and Flyway Area' is accepted there will be less emphasis required on providing additional mitigation planting.

We note that, where bat roosts are removed during vegetation clearance, artificial roosts could be installed. However, there is limited research on the uptake of artificial roosts by long-tailed bats and trials undertaken in New Zealand have had limited success (DOC, unpublished data). Recent confirmation of bats using artificial bat roosts in Hamilton is positive. However, these roosts have been installed for approximately seven years and there is no evidence of their success in mitigating for roost loss in the immediate term. Consequently, we suggest that if bat boxes are installed they should be used as part of a research tool as part of mitigation for roost loss, and be installed early in the construction phase.

We recommend that an EMMP includes a Bat Management and Monitoring section for the Project that details the above avoidance and mitigation measures. The purpose of the plan is to maintain and enhance their population and as much as practicable to prevent mortality of adults and juveniles of the species.

This plan will guide the identification of bat habitat within the proposed designation boundary and guide vegetation clearance works. Because bats are particularly mobile, the objective of bat management is to:

- prevent the mortality of bats by avoiding the destruction of their habitat at the time they are using it; and
- to maintain or enhance roost opportunities and flyways to enable bats to continue moving amongst the preferred habitat types within the landscape.

We recommend that the EMMP includes an approach that follows the template included in Appendix D: Bat management framework for linear transport infrastructure projects of the Transport Agency research report 623 (Smith et al., 2017).

5.3.7 Connectivity and edge effects mitigation

The construction and operation of the Indicative Alignment within the proposed designation will result in the loss of connectivity between patches of vegetation, and will increase the 'edge' effects of bisecting areas of indigenous vegetation. We recommend mitigation for the loss of connectivity and the edge effects that will also form part of the integrated environmental mitigation framework.

We have recommended mitigation planting within the Mahurangi River (Left Branch) lowlands and the upper Kourawhero Stream catchment that connects these two waterways. We recommend that the area within the proposed designation boundary between these two areas be planted to create a continuous self-sustaining connection between them (Map series EM-011). Planting this area (of some 10 ha) will provide the linkage and thus migratory and dispersal pathways for native fauna and transported seeds of native plants. More importantly, this area forms the boundary between the Mahurangi River (Left Branch) and the upper

Kourawhero Stream catchment (part of the Hōteo River catchment), and the planting will achieve cross-catchment linkage. The benefits of planting between the two catchments is also recognised in the LVEA. We note that should the final alignment be shifted eastwards, this 'mitigation for fragmentation' area will be diminished in size, but that a connection should still be provided for.

Opportunities for connectivity are less prominent in remaining areas of the proposed designation. We have specifically recommended an area of connectivity and edge effects mitigation around wetland HN_W_Hōteo _02 (Map series EV, Volume 3 of AEE). This planting helps reduce the edge effects around the wetland and enhances a patch of vegetation within the broader landscape.

5.3.8 Fauna Habitat and Flyway Mitigation

We recommend that an area (or areas) within the proposed designation boundary in the Dome Valley Forest Section (the Mitigation Area) be set-aside to provide a habitat area for translocating fauna, and to provide an uninterrupted flyway corridor for bat and birds across the proposed designation. The purpose of this set-aside area is to mitigate for the loss of fauna habitat and the disruption and loss of flyways resulting from the proposed designation (i.e. the proposed designation bisecting the east west corridor of bird and bat (and ground fauna).

Our preferred location of the set-aside area is strategic as, in part, it occurs above the proposed tunnel where vegetation clearance is not required for construction of the highway; and it incorporates the natural escarpment at DVF_T_Koura_02. This escarpment is a known existing flyway for birds and bats. Consequently, locating the set-aside area at this location will ensure a permanently vegetated corridor that will retain connectivity across the highway for fauna. In addition, the southern approach to the tunnel requires a substantial 'cut'. This means that the flyway can occur at some height and further away from the road.

The establishment of the 'Fauna habitat and flyway mitigation' provides mitigation for the following potential adverse effect of the Project:

- The severing of east-west flight corridors that bats and birds use to traverse through the Dome Valley plantation forest.
- Fragmenting the populations of less mobile fauna such as kauri snail.
- The loss of potential roost, and breeding sites and habitat for birds and bats by retaining an area of vegetation.

We recommend that the Fauna habitat and flyway mitigation area is fenced from stock intrusions, and pest and weed management practices will improve the habitat for fauna. A managed re-growth strategy (including enhancement planting where necessary) will enable indigenous vegetation to improve over time.

Should the tunnel be re-located during final design, the most important element of the Fauna Habitat and Flyway Area is the avoidance of impacts on the the natural escarpment at DVF_T_Koura_02. In addition, the provision, as much as possible, of vegetation connected to the feature, and at height above the road will continue to meet the objectives of the Fauna Habitat and Flyway Area.

The suitability of the preferred Fauna Habitat and Flyway Area should be confirmed by a suitably qualified, experienced person, during the detailed design process. If an alternative or additional Fauna Habitat and Flyway Area is required, we recommend a location be selected which:

- Provides habitat suitable for fauna found in the Project area including land-based animals, bats and birds.
- Occurs preferably within the Dome Valley section and if not a suitable alternative.
- As much as possible incorporates or occurs in close proximity to DVF_T_Koura_02 or similar existing feature.
- As much as possible is located to avoid bisection by the road.
- As much as possible is located such that the flyway is elevated above the road surface.
- Occurs in proximity to SEAs or other retained native vegetation located east and west of the indicative alignment to enable east-west connectivity.

The area must also be fenced to prevent stock entering and subject to pest and weed control.

5.3.9 Pest Animal and Pest Plant Management

In order to mitigate the potential effects of pest animals and pest plants/weeds that may increase in frequency as a result of the Project, we recommend a Pest Animal and Plant Management Plan that requires the management of pest animals and plants.

The objective of the Pest Animal and Plant Management Plan is to reduce the abundance and harmful effects of pest animals and weeds caused by the Project, during both the construction phase and during the establishment phase of planting at the mitigation sites. We recommend the development of a Pest Animal and Plant Management Plan that includes (but is not limited to):

- Clear objectives to:
  - Identify the pest animal and plant species present and their specific locations within the Project area.
  - Identify areas adjoining or close to the Project surrounds that are harbouring pest plant species that could threaten the Project area including the risk from the existing SH1 corridor.
- The required certifications and skills required by contractors to undertake pest animal and weed control.
- Timing of the implementation of the Pest Animal and Plant Management Plan to optimise the removal of pests and to provide best opportunity for biodiversity to thrive (e.g., during breeding and juvenile rearing).
- A description of the specific methodology for surveying/monitoring of pest animal and plant species to establish species present and their approximate abundance.
- Detail on the methods of control for pest animal species that impact on native fauna and those that impact on native revegetation that may be undertaken as part of any potential mitigation.
- Detail on the methods of control for pestweed species present and those that potentially result from habitat clearance and measures to control the spread of pest

weeds through known dispersal mechanisms including (but not limited to) earthmoving machinery.

- Timing of control for pest animals, particularly when native fauna may be translocated to potential mitigation sites and these sites will require pest control before translocations occur.
- Detailed instructions for contractors to ensure that pest animals and weeds are controlled using the most up to date and appropriate methods available.
- Performance monitoring throughout the construction period.

We recommend that protocols are developed to ensure that earthworks machinery is cleaned and checked prior to arrival on site to avoid or minimise the spread of weeds from other sites.

5.3.10 Biosecurity

Kauri dieback

In order to avoid the spread of kauri dieback into uninfected areas, we recommend the preparation of a Kauri Dieback Biosecurity Plan (KDBP), in consultation with DOC and Auckland Council that includes (but not limited to):

- Identification of the methods for testing and monitoring of all kauri in the designation for the presence of kauri dieback disease;
- A process for identifying and mapping:
    - All kauri within the designation that are not affected by kauri dieback disease ("Unaffected Kauri");
    - All kauri within the designation that are affected by kauri dieback disease ("Affected Kauri");
    - Once the final alignment has been confirmed, all kauri within the designation that are intended for removal as a result of the Project, and their status as Affected or Unaffected Kauri; and
    - Catchments and sub-catchments where kauri are known to be present.
- Methods for the establishing and demarcating on the ground Kauri Quarantine Area(s) (KQA(s)).
- Methods for holding, cleaning and treating the collected soil from personnel and equipment in KQAs and releasing personnel and equipment from KQAs.

We expect that the protocols will be consistent with those approved for the P-Wk section of the route.

Myrtle rust

The status of risk of myrtle rust at the time of construction is unknown. Assuming risk remains the same as at the time of writing, to eliminate potential infection routes we recommend that all plants acquired for the purposes of revegetation (as part of potential mitigation) and landscaping should be purchased from nurseries that are known to be free of myrtle rust. Up to date information on myrtle rust including advice to landowners will need to be sourced more closely to the time of construction and planting.

Plague skink

We recommend that potential vectors for plague skinks are checked to ensure they aren't transported into mitigation areas. All plants acquired for the purposes of revegetation (as part of potential mitigation) and landscaping should be purchased from nurseries that are known to be free of plague skink.

5.3.11 Effects on terrestrial fauna ecological values after mitigation

The loss of some terrestrial fauna in the construction of the Project is unavoidable. We have identified that threatened land snails, lizards, some birds, and long-tailed bats are at risk from direct fatalities, and habitat loss.

We have recommended avoiding specific areas of valuable habitat, but the main mitigation strategy to minimise impacts on the terrestrial fauna is through seasonal management of construction activities, and specific salvage and rescue operations, and the provision of habitat areas (cf, the mitigation areas outlined above).

After the implementation of these mitigation and management measures, we consider that the effects of the Project on terrestrial fauna values is low.

5.4 Mitigation for effects on freshwater ecological values

5.4.1 Background

The loss of watercourses and ecological function during construction of the route through infilling of streams and culverting is unavoidable. As much as is practicable the loss of streams, particularly those of higher ecological value, has been minimised through the location of the Indicative Alignment, sensitivity testing of movement of the final alignment and through the specific recommended bridges and viaducts.

5.4.2 Quantum of freshwater mitigation for stream loss

The loss or modification of watercourses from the Project through infilling of streams and culverting is unavoidable. As much as is practicable, it is recommended that the loss of streams, particularly those of higher ecological value, be minimised through the placement of the final Alignment, i.e., placed upstream to avoid any further loss of downstream permanent stream length. At specific locations (Mahurangi River (Left Branch), Hōteo Viaduct and Upper Kourawhero) the use of stream crossings such as viaducts and bridges is recommended to prevent the loss of streams and their function.

Typically, the Auckland Council SEV assessment is used to undertake the ECR (Environmental Compensation Ratio) calculation, which is used to inform the specific quantum of mitigation that is required for the residual loss of stream habitat function. This ECR is frequently used within the Auckland Region to guide mitigation for streams that are being culverted or infilled. The ECR calculation uses actual and predicted SEV scores of the impact and mitigation sites and includes a time lag factor (that accounts for the time difference between the loss of the watercourse and reaching the completion target for improvement at the mitigation site). The AUP(OP) makes reference to using the SEV (amongst other references) in establishing restoration and enhancement options (Policy E3.3(4) a).

Only a small fraction of the watercourses along the proposed designation were able to be surveyed during this early stage of the Project and the data collected has been used to provide an initial estimate of stream mitigation (based on the indicative alignment). Further surveys will be required once a final alignment design has been completed in order to complete an ECR assessment or similar.

These early estimates are not intended to be used to inform an exact like-for-like freshwater mitigation package. Rather, these estimates were designed to clarify whether sufficient stream length and area would be available within the proposed designation boundary to provide for the likely mitigation extent. Watercourse SEV loss has been calculated (refer Table 30) using the Indicative Alignment; it is important to note that as the alignment may vary at the time of construction, the quantum of loss and mitigation may change.

Table 30 - Overall magnitude of effects on watercourses resulting from the entire Indicative Alignment.

Waterways	
Waterways within the proposed designation boundary	The proposed designation boundary encompasses 145.2 km of watercourses: • 62.0 km of permanent streams • 83.2 km of intermittent streams
Construction Effects	
Loss of waterways and habitat – Indicative Alignment	The Indicative Alignment intersects 27.1 km of stream habitat: • 13.1 km of permanent streams • 14.0 km of intermittent streams
Loss of stream area (using average width from survey sites)	• 2.75 ha of permanent and intermittent stream would be lost under the Indicative Alignment
Stream Crossings (Culverts)	• A total of 82 culverts are to be installed or upgraded within the proposed designation, totalling 6.7 km. • 69 (6.2 km) are new culverts • 16 (approx. 0.5 km) are upgrades to existing culverts
Diversion of waterways	• 18.3 km of stream diversions are to be undertaken within the Section • 20 km of cut-off drains are to be created
Bridges and viaducts	• 8 bridges/viaducts will be constructed, totalling 1 km
Earthworks [19]	• Approximately 270 ha of earthworks footprints across the Project
Note: Numbers are indicative only and may change.	

[19] Earthworks footprint taken from Water Assessment Report, Table 5. The Earthworks footprint is derived from conceptual areas of cut, fill and soil disposal sites.

Overall, there is an estimated linear stream impact on permanent and intermittent streams under the Indicative Alignment of 27.1 km. The Indicative Alignment also results in some 18.3 km of stream diversions. The stream diversions will be created in a manner that will provide at least equivalent function to that of the existing streams if they were restored (to 10m). We note that there is some 118 km of residual stream length within the proposed designation boundary, most of which is available for mitigation purposes (i.e., has nil or little existing riparian vegetation). The extent of stream impact, residual stream length available, and stream length required for mitigation is shown in Table 31.

Following the SEV and ECR protocols[20] the mitigation required within the different sections are:

- Warkworth North: 10.1 km (of 26.8 km of available habitat[21])
- Dome Valley Forest: 24.9 km (of 38.5 km of available habitat)
- Hōteo North: 36 km (of 52.8 km of available habitat)

We are confident that sufficient stream length and area will be available within the proposed designation boundary.

Our estimate of stream availability for mitigation is based on the following assumptions:

- Our experience from the streams visited and assessed suggests that most stream length in the respective Warkworth North and Hōteo North Sections currently have little or nil riparian vegetation.
- Fencing and planting the riparian margins of streams will be the main, although not exclusive, means of improving stream function.
- Fish passage is provided at all times.
- Streams within the Dome Valley Forest Section will have been subject to forest harvest, and the stream margins will be available for riparian planting or enhancement planting, at the time of the Project construction.

Table 31 - Total extent of stream loss and amount of stream length available for mitigation across each section.

Section	Stream impact	Stream length required for mitigation	Stream length available for mitigation
Warkworth North	4.5 km	10.1 km	26.8 km
Dome Valley Forest	9.0 km	24.9 km	38.5 km
Hōteo North	13.5 km	36.0 km	52.8 km
Note: Numbers are indicative only and may change.			

[20] Assumptions for the estimates of stream compensation are provided in Appendix F.

[21] Available habitat has been calculated using the Auckland Council overland flow layer

5.4.3 Recommended freshwater mitigation

Stream crossings and impact on streams

Loss of watercourses

The impact on some watercourses along the Indicative Alignment is unavoidable. As mitigation for the impact, the following is recommended:

- A representative number of streams are to be surveyed for their stream type (permanent/intermittent or ephemeral status) (as per the definition of permanent and/or intermittent stream in the AUP(OP)) prior to any construction.
- A representative number of permanent and intermittent streams are to be surveyed by a freshwater ecologist prior to any construction to understand their ecological value and function.
- The length of watercourses to be lost, and their stream type and ecological function, are to be recorded.
- There shall be no net loss of freshwater ecological function[22].
- Mitigation of stream impacts (area) could be able to take the form of rehabilitated wetland areas, on a case-by-case basis.

Fish salvage

It is necessary to reduce the potential mortality of native fish species during construction through their removal from any areas of streamworks. The salvage and translocation of fish is an appropriate means for avoiding mortality. The objective of fish salvage is to avoid mortality and to maintain the population of native fish of streams within the proposed designation boundary by capturing and relocating them up or downstream within the same catchment.

We recommend the following:

- A Native Fish Relocation Plan (NFRP) should be prepared and signed off prior to any streamworks. The NFRP should include (but not limited to):
  - The methodology for baseline surveys for fish in watercourses.
  - The methodology for the placement of fish exclusion barriers at the upstream and downstream extent of the streamwork site so migration back into the streamworks site is not possible.
  - Credentials and contact details of the ecologist/herpetologist who will implement the plan.
  - Fish trapping and electrofishing methodology.
  - Fish transportation methodology.
  - Location and description of the relocation site.
  - Monitoring of the fish and species of fish relocated prior to dewatering and at dewatering.

[22] As measured by ECR or similar; or ratio by area.

- Fish should be salvaged from all watercourses containing water at the time of streamworks.
- Peak fish migration occurs between September and February and streamworks should be avoided during this time if possible.

Fish passage

A number of migratory fish species are present within the proposed designation boundary including swimming and climbing species. It is necessary to maintain fish passage through culverts to upstream and downstream habitats.

- Fish passage should be maintained through all culverts with viable upstream habitat.
- The type of fish passage (i.e., climbing or swimming species) required for each permanent culvert should be assessed by a freshwater ecologist. At a minimum all culverts should allow for the movement of climbing species if any intermittent or permanent upstream habitat is present.
- Fish passage to be designed following NZTA guidance and New Zealand Fish Passage Guidelines (NIWA 2018).
- New culverts are to be designed to incorporate fish passage, rather than using retrofitting solutions.
- In culverts with steeper gradients fish passage devices such as baffles will need to be considered.
- Consideration should be given to restricting the potential passage of pest fish species if they have been recorded within the stream reach.
- Temporary culverts shall maintain fish passage through them, allowing swimming fish species and other aquatic invertebrates to move through the culvert up and downstream.

An indicative flow chart for fish passage for stream diversion type is shown in Figure 6.

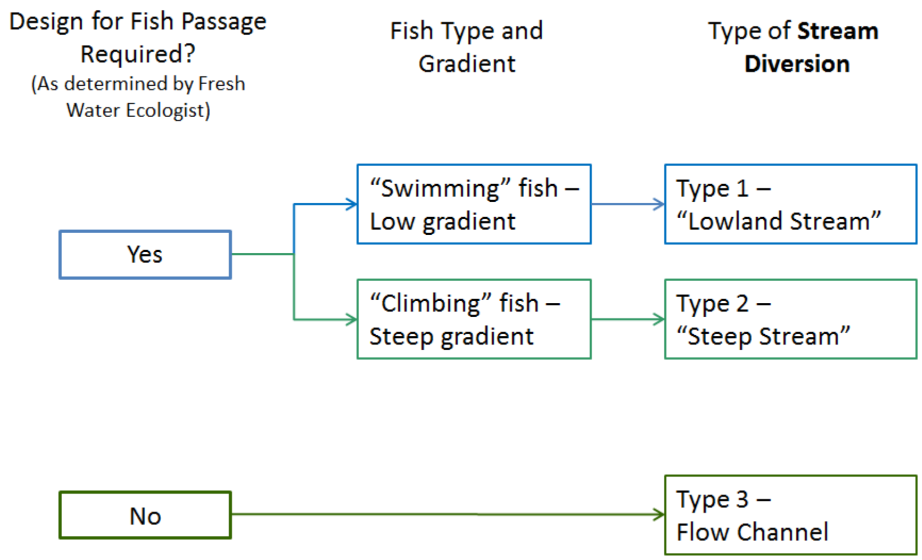

Figure 6 – Flow chart for fish passage within stream diversion types (from Jacobs 2018).

Diversion of waterways

Diversion design

The design of stream diversions must ensure they have good ecological functionality. The design of diversions will follow a hierarchy of avoidance of effects as much as practicable, and design to minimise effects. The following is recommended for stream diversions:

- Stream diversions are to convey clean or treated surface water (i.e., uncontaminated by construction or operational activities).
- The design of the diversion channels should meet ecological objectives through the creation of a range of stable microhabitats for fish and invertebrates, including the creation of stable pool habitats and the inclusion of gravel and cobble habitat, that at least reach a level of stream function to those present at the time that the existing stream(s) are lost.
- Riparian vegetation should extend to at least 10 m either side of the channel and must include low-growing species with overhanging cover.

Where a diversion is required but it is not possible to replicate the habitat value (such as some streams located within the Dome Valley Forest section that are fed by groundwater) then a clean water cut off drain should be created. This clean water cut off drain is not considered to be part of any mitigation for stream impacts and is typically temporary and for construction purposes. Typical cross-sections of stream diversion types are shown in Appendix F.

Jacobs GHD JV (2019) has estimated the total lengths of diversions in the indicative operational stormwater design as:

- Stream Diversion Type 1 (Lowland stream) = 12,707m
- Stream Diversion Type 2 (steep stream) = 5,554m
- Stream Diversion Type 3 (flow channel) = 1,148m

We note that these lengths of stream diversions in the indicative operational stormwater design are not fixed and may change during detailed design.

Bulk earthworks and sediment generation

Catchment wide sediment models have been developed for the Mahurangi catchment and the southern Kaipara Harbour (including Oruawharo River) (Jacobs GHD JV, 2019). The models assume that the existing land cover is the baseline scenario but it is noted that this is a conservative estimate as forestry within this catchment is assessed to be harvested prior to construction thus changing this baseline condition and potentially increasing background sediment concentrations.

The results of the sediment load model show that the following catchments are at risk from elevated sediment intrusions (Jacobs GHD JV, 2019):

- The Kourawhero Stream due to the steep slopes and the natural wetlands within the catchments;
- The Waiteraire Stream due to the steep slopes and the large area of proposed earthworks;

- The unnamed tributaries (H1 and H2) to the north of the Hōteo River viaduct, due to the risk of flooding from the Hōteo River; and
- Te Hana Creek particularly during a large rain event due to the amount of earthworks occurring over the catchment area.

Jacobs GHD JV (2019) place the risk in the context of the steep slopes and existing works in and adjacent to stream systems. This risk will be identified and confirmed through the CESCP process with associated risk management identified.

Sediment entering waterways can have significant impacts on the flora and fauna living within watercourses. This includes:

- Changes to water clarity that effects the ability for fish to feed and follow visual cues.
- Decrease in water clarity effects light penetration and potential plant and algal growth.
- Settled sediment smothering the bed habitat thus reducing habitat for macroinvertebrates and periphyton.

To address these effects, Jacobs (2019) recommends a range of erosion and sediment control measures to minimise the quantum of sediment entering the receiving environment.

These recommendations include the following:

- Sediment and erosion control should reflect best practice and as a minimum the design criteria for all erosion and sediment control measures will be based on TP90, GD05 and the Transport Agency Standards.
- Open area limits will be in place.
- Construction period monitoring of sediment discharges and the implementation of corrective actions where required.
- The development and construction of the culverts are to be undertaken utilising current best practise to minimise the impacts on water quality and instream disturbance.
- Streamworks should ideally be undertaken offline, or should be isolated with water pumped around the area of works.
- Ensure material from vegetation removal does not enter the stream.

The measures and the processes as outlined in the Water Assessment Report (Jacobs GHD JV, 2019), will minimise effects on the freshwater ecological values.

Stormwater discharges

Stormwater treatment and design of the treatment devices is included in Jacobs GHD JV (2018). An outline of what is proposed is provided below.

Constructed stormwater wetlands are proposed as the primary stormwater treatment device for the Project. The Indicative Alignment includes 34 Stormwater treatment wetlands (totalling 198.2 ha, Jacobs 2019) for the Project's impervious surfaces. Stormwater runoff will be collected in the Project's stormwater reticulation and conveyed to the Stormwater treatment wetlands.

The Stormwater treatment wetlands will provide water quality treatment in accordance with GD01 and will also provide hydrological mitigation.

We note that the Stormwater treatment wetlands will be located off-line from existing streams and watercourses. Existing natural wetlands will not be used for the treatment of runoff from the Project. Wetland outfalls will incorporate erosion protection measures to minimise bed scour and bank erosion in the receiving waterway.

The implementation of the following recommendations aims to minimise the impacts of stormwater on freshwater ecological values:

- Stormwater quality treatment for the replacement stage highway is designed to GD01 guidelines;
- Stormwater treatment wetlands to have dense, healthy planting in emergent, littoral and riparian zones in designs which are maintained in operation;
- Stormwater treatment wetlands to include vegetation coverage and partial shading to minimise increases in water temperature;
- Stormwater treatment wetlands to include deeper zones to reduce nuisance plant growth;
- Stormwater treatment wetlands discharging to stream environments to achieve the hydrology mitigation requirements specified in the AUP(OP) (Table E10.6.3.1.1); and
- Design stormwater and culvert outlets to minimise erosion in receiving environments.

Where practicable, we recommend the development of constructed stormwater wetlands in proximity to existing wetlands where the discharge can contribute to sustaining natural wetlands. We also note that the recommendations for constructed stormwater wetlands listed above will provide for improved ecological benefit and aquatic (and avifauna) ecological values.

The development and management of constructed stormwater treatment wetlands as proposed by Jacobs GHD JV (2018) and as recommended above will appropriately minimise effects on freshwater ecological values.

Water quality

The existing water quality at all the freshwater sites is considered to be good in relation to metals, with dissolved concentrations all below the default trigger values except for Copper at the Mahurangi River mouth (Jacobs GHD JV, 2018).

The discharge of contaminants from the operational stages of the Project will be managed and minimised primarily through the use of stormwater treatment wetlands, which treat and reduce the contaminant discharges to the receiving environment (Jacobs GHD JV, 2018).

The modelling undertaken for the Project predicts that without mitigation, small increases in contaminant concentrations at all sites compared to existing will occur. We note that Jacobs GHD JV (2018) conclude that the largest proportional increases in metal concentrations occur in the catchments where the road footprint makes up a large proportion of the overall catchment, such as the Kourawhero Stream, the unnamed tributaries of the Hōteo River, and the Te Hana and Maeneene Creek tributaries.

With the stormwater wetland treatment accounted for the results of the assessment conclude that there will be negligible increases in suspended solids and zinc, and no change in total petroleum hydrocarbon (TPH) as a result of the Project. The results do predict small increases for copper concentrations (0-0.0002mg/L increase in dissolved copper) but below the ANZECC (2000) guideline trigger values for 95th level of species protection in freshwaters[23].

Overall, Jacobs GHD JV (2018) concluded that the magnitude of the change in water quality is very minor or negligible, indicating that the effect has been minimised and is not significant; and a negligible or slight minor contaminant effect on freshwater water quality.

Water temperature

Increases in water temperature can have significant impacts on freshwater ecology and has received much attention in recent times, especially within the Auckland region. Many indigenous aquatic biota are sensitive to elevated temperatures, while several introduced aquatic species are more tolerant of increases in temperature.

Long-term water quality monitoring undertaken by Auckland Council and NIWA in the Hōteo River and Mahurangi River indicates that water temperatures are in the range of 7-16°C in winter (May to September) and 10-24°C in summer (October-April) (Jacobs 2019). Water temperatures can be elevated during warmer summer months, and discharges from stormwater treatment ponds can cause an increase in water temperature (Kelly, 2010). Water temperatures in the range of 25 to 35˚C are routinely recorded downstream of stormwater ponds, particularly in urban areas (Auckland Council, 2013).

We note that the stormwater treatment wetlands proposed for the Project will have substantial vegetation coverage and shading and are less likely to result in increased temperatures. Provided they are well shaded, evidence indicates that exceedances of the AUP(OP) technical limit of 25°C from stormwater treatment wetlands are infrequent (Auckland Council, 2013).

Jacobs GHD JV (2019) conclude that effects of the Project on changes in temeperature in the larger rivers, such as the Mahurangi River, Hōteo River and Oruawharo River, are likely to be negligible, as the area of road discharging to these rivers is relatively small compared with the catchment, and the stormwater treatment wetlands will be designed to prevent large increases in temperature.

Jacobs GHD JV (2019) goes on to suggest that changes to the temperature of small tributary streams, such as Kourawhero Stream, the unnamed Hōteo tributaries, and Te Hana tributaries, could occur due to the discharges from stormwater treatment wetlands. The effect of this is expected to be minor due to their localised extent and temporary duration, and will be dependent on the condition of the receiving environment.

The risk of increases in temperature will be managed by providing shading to wetlands, and the proposed riparian planting as mitigation for stream losses. We recommend that a condition of consent requires that, as much as possible, the constructed stormwater treatment wetlands are required to provide shading to reduce water temperatures.

The recommendations for the design of the constructed stormwater treatment wetlands listed above will minimise the effects of elevated temperature on the freshwater receiving environments.

[23] For "2046 traffic with Project, with treatment" (Jacobs 2018).

5.4.4 Effects on freshwater ecological values after mitigation

We have followed the mitigation hierarchy as provided for in the AUP(OP) to plan for the management of impacts from the Project, using the Indicative Alignment to estimate quantum of impact.

The impact on stream length is unavoidable and therefore mitigation for the impact is necessary. For the Indicative Alignment, some 27 km of length of intermittent and permanent streams will be directly affected by the Project within the proposed designation boundary. About 18 km of diversion channels are planned which will replace the stream losses, especially in lowland areas. Using standard Stream Ecological Valuation (SEV) methods and ecological compensation ratios (ECR) this amounts to some 71 km of additional stream riparian planting (allowing for planting the stream margins 20 m either side of watercourses selected for mitigation).

We recommend a condition of consent that requires that a Stream Ecological Compensation Plan (SECP) be prepared in advance of the construction of the Project, and that this plan details all the methods, and locations for stream mitigation, based on on the final actual alignment.

We note that there is some 118 km of residual stream length within the proposed designation boundary. We are confident that sufficient stream length and area will be available within the proposed designation in order to mitigate for the impact on stream length resulting from the alignment within the proposed designation.

With mitigation for the loss of freshwater ecological values established and implemented, the effects on streams resulting from the Project is expected to be Low.

5.5 Summary of proposed mitigation

A summary of the proposed mitigation package for the effects within the proposed designation boundary (based on the Indicative Alignment) on ecological values discussed above is provided in Table 32.

Table 32 – Summary of proposed mitigation.

Potential ecological effects of Project	Activity	Anticipated outcomes and benefits
Avoid, as far as practicable, within the proposed designation boundary		
Mahurangi River (Left Branch) (WN_T_Mahu_01 (SEA_T_2287) Hōteo River (HN_W_Hōteo _02 (SEA_T_685)	Avoid, as far as practicable, the loss of vegetation within riparian zone. Avoid, as far as practicable, activities within the streambed.	Riparian zones and SEAs intact.
On-site Biodiversity Mitigation **Effects of permanent vegetation loss**		
Permanent loss of 0.88 ha of very high/high value indigenous vegetation.	Vegetation planting of 5.3 ha of lowland podocarp Kahikatea/Totara forest and flax. Pest and plant management prior to establishment. Stock and pig--proof fencing.	New areas planted in indigenous vegetation. Planting to be aligned with Threatened ecosystems of Auckland Region (Singer et al. 2017). Exclusion of stock will allow natural regrowth. Removal of browse pressure on palatable species/ seed predation will enhance dispersal opportunities and forest regeneration processes Weed management until planting is established. Pest management will also limit incursions of pest species into the planted areas providing foundation for fauna colonisation and dispersal. Habitat for colonisation by native fauna. New plantings will be protected with appropriate legal mechanism.

Potential ecological effects of Project	Activity	Anticipated outcomes and benefits
Permanent loss of 8.92 ha of very low-moderate value indigenous vegetation.	Vegetation planting of 27 ha of lowland podocarp Kahikatea/Totara forest. Pest and weed management to establishment. Stock and pig--proof fencing.	
Permanent loss of 0.64 ha of very high/high value wetland. Permanent loss of 2.45 ha of very low-moderate wetland.	Wetland enhancement planting of 3.9 ha of lowland wetland. Pest and weed management to establishment. Stock and pig--proof fencing. Wetland enhancement planting of 7.4 ha of lowland wetland. Pest and weed management to establishment. Stock and pig--proof fencing.	
On-site mitigation- fragmentation and edge effects		
Fragmentation/increased edge effects for remaining indigenous vegetation: Edge effects may increase opportunities for weed encroachment into indigenous ecosystems surrounding the Project Site. Increased edge environment may alter vulnerability of some fauna to predation.	Planting of 10 ha of vegetation to provide improved connectivity between remnant forest patches. • 10 ha of podocarp/scrub planting connecting planting areas A and B • Connects across Mahurangi River and Kourawhero catchment boundary • N-S linkage • Strengthens connection between upland Dome Valley and lowland Mahurangi River and Kourawhero floodplains	Biodiversity benefits for movement and dispersal of native fauna and seeds.

Potential ecological effects of Project	Activity	Anticipated outcomes and benefits
	• Pest and weed management to establishment. • Stock and pig--proof fencing. Planting of 8 ha of vegetation to decrease edge effects at wetland HN_W_Hōteo _02, and strengthen connectivity within the Hōteo River catchment. • 10 ha of lowland wetland planting • Pest and weed management to establishment. • Stock and pig--proof fencing.	
Loss of habitat/roost sites/breeding sites for indigenous fauna from vegetation clearance. Loss of flyway feeding and dispersal routes for birds and bats.	Area (or areas) within the Indicative Alignment of the Dome Valley Forest Section be set-aside to provide a habitat area for translocating fauna, and to provide an uninterrupted flyway corridor for bat and birds across the proposed designation. Preferred location identified proximal to escarpment DVF_T_Koura_02. Plantation management plan for the regrowth of native vegetation. • Pest and weed management to establishment. • Stock and pig--proof fencing. N-S connection of Kourawhero Stream and Waitaire Stream catchments. • Pest and weed management. • Stock-proof fencing.	Opportunity for managed re-growth to act as habitat for translocated native fauna). Provision of roost and breeding locations for indigenous long-tail bats. Provision of roost and breeding locations for native birds. Maintains connection East-West and between SEAs. Preferred location maintains connection North-South to Dome Valley SEA. Preferred location integrates with fragmentation mitigation planting south to the Mahurangi River (Left Branch) providing corridor for movement and dispersal of fauna and seeds. Removal of browse pressure on palatable species/ seed predation will enhance dispersal opportunities and forest regeneration processes.

Potential ecological effects of Project	Activity	Anticipated outcomes and benefits
Mortality of indigenous fauna from vegetation clearance.	Seasonal constraints to vegetation clearance, fauna salvage protocols and fauna relocation areas detailed in relevant consent conditions. NB: Plantation forest in the Dome Valley Section already harvested prior to construction. Pest and weed management of translocation area(s). Stock-proof fencing to prevent incursions from stock.	Reduces mortality of indigenous fauna. Enables potential natural dispersion of fauna.
Modification of 27 km of stream length: • Culverts • Diversions	Improvements by riparian planting and fencing to some 71 km of stream length (as calculated using standard SEV protocols and based on assumptions associated with Indicative Alignment).	Stream enhancements improve stream function, diversity and habitat. Management of stormwater flows and sediment discharges will minimise adverse effects on the receiving environment and assist in reducing further erosion and damage caused by scour and high peak flows arising from changes to the natural hydrological regime.
Prevention of fish passage as a result of culverts or diversions.	Fish passage provided at all culverts where upstream fish habitat is available as applicable for climbing and/or swimming fish. Application of National Fish Passage Guidelines.	Fish passage provided where appropriate.

5.6 Summary of positive ecological effects

Following the implementation of management protocols and mitigation, the Project results in a number of positive ecological effects which are set out below:

- Reduced contaminant loads to the Mahurangi River (Left Branch) and the Hōteo River catchments as a result of capture and treatment of stormwater runoff compared to the existing SH1.
- Aggregated mitigation providing integration of ecosystems to provide greater resilience.
- Improved pest and pest weed control at selected locations to improve the adaptive capacity of ecosystems.
- Improved N-S connectivity including between the Mahurangi River (Left Branch) and the upper Kourawhero Stream catchments.
- Maintenance of flyway connectivity N-S and E-W within the proposed designation where vegetation is retained.
- Maintenance and enhancement of populations of land snails, lizards, Hochstetter's Frogs, birds and bats in mitigation areas.
- Planting mitigation areas to achieve a positive increase in threatened indigenous ecosystems of the Auckland region.
- Increase in riparian planting for the protection and enhancement of water quality and aquatic habitat.

6 CONCLUSION

The Project is situated within a rural production landscape dominated by pastoral farming and plantation forestry. Ecological features within this landscape are generally fragmented, relatively small and isolated, and frequently modified and degraded as a result of historic and current land use practices.

Following the implementation of the proposed ecological mitigation, the Project results in a number of positive ecological effects that set out to improve the connectivity and enhance the ecosystems across the landscape. Positive benefits include a greater integration and connection of ecosystems to provide improved dispersal corridors for movement of wildlife and transport of seeds, an increase in area of some of Auckland's threatened indigenous ecosystems, protection of areas with predator control for wildlife, and improved water quality and aquatic ecosystems in the streams and rivers along the route. These positive outcomes mitigate the effects of the Project and provide substantial ecological benefit.

The Indicative Alignment within the proposed designation will result in the clearance of all or part of ~27 bush and wetland ecological features in total, comprising 13 ha of forest remnants, approximately 1.5 ha of these features are high/very high ecological value. Indirect impacts, for example edge effects and changes to the water table, may cause further degradation to remnants of partially cleared features. In addition, construction may have potential adverse effects on wide-ranging fauna (e.g., birds and bats) that utilise small habitat patches throughout the landscape, and on existing populations of significant fauna that persist in environments that have been converted to rural production (e.g., lizards in patches of woody debris, kauri snails and Hochstetter's frogs in pine plantations). Such effects are difficult to quantify given the cryptic and/or widely dispersed characteristics of these populations, and require a precautionary approach when developing mitigation provisions. Nevertheless, we have recommended a managed area be set aside for the translocation of wildlife and to act as a flyway corridor for birds and bats.

Approximately 27 km of intermittent and permanent streams will be directly affected by the Project within the proposed designation boundary. Most of the affected watercourses are within Warkworth North and Hōteo North sections of the Project and are generally small, low-quality tributaries degraded by pastoral land use. Some 18 km of diversion channels will be retained, and in part replace, the stream losses (primarily in lowland areas).

The proposed integrated mitigation approach for the Project considers landscape, visual and cultural aspects along with terrestrial, wetland and freshwater environmental ecological outcomes by focusing revegetation, fauna habitat enhancement and stream restoration within a few large areas that contain existing high value features. The purpose of this mitigation approach is to provide a cohesive, landscape-wide habitat framework. We have selected five key locations along the proposed designation as preferred areas for mitigating for the impacts of the Project, as listed below;

- Mahurangi River (Left Branch) floodplains;
- Upper Kourawhero Stream and Wetlands extending to Dome Valley;
- Dome Valley Forest (preferred fauna mitigation location);
- Hōteo River floodplains.
- Te Hana lowlands

The proposed mitigation has followed the mitigation hierarchy and identifies features and areas within the proposed designation boundary that any future alignment needs to avoid any impacts due to their significance.

Our sensitivity analysis has shown that a small number of features are sensitive to spatial (lateral or vertical) amendments to the Indicative Alignment. We have identified and mapped these features and recommended conditions of consent that provide, as much as is practicable, avoidance of effects on these features (see section 3.4.1, Table 13).

We have drawn on the ecosystem classification of the Auckland regions (Singers et al., 2017) to inform the mitigation planting and habitat rehabilitation. In this way, not only does the proposed mitigation provide for the impacts of the Project; over time it returns some threatened significant ecosystems and habitats to the Auckland region. The integration into larger areas of mitigation provides greater resilience, diversity and connectivity within and between ecosystem types; as well as potentially across catchments (Mahurangi River (Left Branch) and the Hōteo River catchments). The replanting provides habitat for some of the fauna types, and connects potential flyways for birds and bats. The integrated mitigation framework is supported by fencing and stock exclusion, pest and weed management controls, monitoring, and protection (via covenants or similar).

We consider that the ecological mitigation presented provides sufficient and acceptable mitigation for the ecological impacts of the overall Warkworth to Wellsford project. We consider that the mitigation proposed will lead to an overall enhancement of ecological diversity, function and connectivity in the region. As a result, with the proposed mitigation, the effects of the Project on the ecological values will be low.

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APPENDICES

APPENDIX A: Additional Terrestrial Methods

APPENDIX B: Additional Freshwater Methods

APPENDIX C: Avifauna Records

APPENDIX D: Bat Records

APPENDIX E: Freshwater Ecological Results

APPENDIX F: Stream Channel Diversion Design

APPENDIX G: Vegetation mitigation planting

APPENDIX H: Vegetation Areas within proposed designation

APPENDIX A: ADDITIONAL TERRESTRIAL METHODS

Methods

The methods outlined below provide additional detail to those methods outlined within Chapter 3.1.1.

Herptofauna (Lizards and Frogs)

Desktop Review

A brief literature review was carried out to identify previous lizard records within the vicinity of the Project site. Sources included the Terrestrial Ecology Assessment for the Pūhoi to Warkworth Section of the New Zealand Transport Agency's (NZTA) 'Ara Tūhono Pūhoi to Wellsford Road of National Significance' (Further North Alliance, 2013) and the DOC Bioweb Database (2 June 2017) and Auckland Council's records (29 March 2017).

Preliminary vegetation maps were used to identify key habitat types which informed the design of a baseline lizard survey and included review of previous aerial photography to assess likelihood of occupancy based on previous land use and habitat connectivity. Sites for further survey were selected on the basis of being representative of the available lizard habitats within the proposed designation boundary and their spatial distribution across the Site (i.e. north-south coverage). They included both edge and interior habitats and, where possible, within or adjacent to the footprints of the proposed (and existing) roads and/or development areas. The purpose of our survey was to confirm the presence of lizards and to fill gaps in location of surveys, rather than to undertake a full population assessment.

Field Survey Methods

Lizard surveys were carried out in predominantly fine, warm weather, at sites not previously assessed, or those that we considered warranted further survey effort. Further surveys will be carried out in December 2017 and January 2018 pending site access.

Manual searching was carried out opportunistically within the proposed road footprint and known earthworks extent. Natural debris (i.e. logs and leaf litter) were targeted for manual searching. We note that natural debris was typically uncommon within the road and earthworks footprint and was often smothered in pine litter, or overgrown with grass.

Spotlighting – key potential gecko habitats were surveyed at night using powerful handheld spotlights (LED Lenser 7.2, Buffalo River handheld spotlight), headlamps (LED Lenser H7.2) and binoculars (Leica 10 x 42). The trunks, branches, foliage and crevices of suitable trees were searched between 8.30 pm and 11.00 pm on calm dry nights.

Limitations of lizard survey methodology

Lizard survey methods currently available have poor detection rates as a consequence of typically low population densities, species' cryptic colouration, difficulty in surveying preferred habitats and behaviour/activity patterns. As such, even an intensive lizard survey will not detect all individuals in the population or, possibly all species present.

Lizard survey methods are strongly weather dependent, and surveys were carried out in fine weather when lizards are most likely to be active. A description of specific limitations associated with survey methods (as described in Department of Conservation Inventory and Monitoring Toolbox: Herpetofauna (Hare 2013; Lettink 2013; Hare 2012; Lettink and Monks 2016)) are understood by the herpetologists

Avifauna

Desktop review

New Zealand Bird Atlas data from the Ornithological Society of New Zealand (OSNZ 2007, derived from surveys undertaken in 1999-2004) was obtained for four 10 km x 10 km 'grid squares' within which the Indicative Alignment is located. The Bioresearches 2011 report on bird surveys in habitat within and adjacent to the Indicative Alignment was also reviewed. The Significant Ecological Area overlay from Auckland Council was used to identify suitable habitat for threatened or At Risk bird species where field surveys effort should be focused.

Field survey methods

The main purpose of the proposed bird surveys was to identify what birds (both resident and transient species) are using the habitat at the site and the value of this habitat to those species. We note that the intent of our survey was to establish an index of bird species and abundance utilising the Project area, and selected survey methods appropriate for this objective (refer Dawson & Bull 1975). We were not endeavouring to obtain an absolute measure of resident bird population densities within the Project area, as a reliable assessment of this would have require a detailed mapping of territories and nest sites over multiple seasons. The proposed survey timing (late spring/early summer) was planned to coincide with a time of year when many bird species are expected to be most abundant and conspicuous. Several more transient species like kaka and red-crowned parakeets may utilise the site for short periods of time and as such may be difficult to detect.

The methods used for surveying native bird species in habitat within and adjacent to the Indicative Alignment are all commonly used for detecting forest and wetland species as well as more transient species. The specific methods used (for surveys already completed and those still to be carried out) included 5MBCs, deploying ARDs, call-back surveys and incidental observations.

5MBCs – these consisted of recording all avifauna species seen and heard during the count period (Dawson & Bull 1975). Individual birds were recorded once; the first time they were seen or heard. Counts began no earlier than 1.5 hours after sunrise. Each count lasted five minutes and was preceded by a five-minute stand down period to allow activity to settle following observer arrival. To limit observer variability all counts were carried out by the same person and counts were undertaken on days with similar weather conditions with wet and windy conditions avoided. Individual locations for 5MBC were spaced at least 200 m apart.

Acoustic surveys – these are widely used to sample avian communities for ecological research (Shonefield & Bayne 2017). ARDs (Version B.2) were used during these surveys to enhance the potential detection of bird species from 5MBCs undertaken during daylight hours as well as monitoring for nocturnal species. This model of ARD has an effective detection radius of up to 200 m subject to background noise. ARDs are most useful when utilised in conjunction with 5MBCs (that involve visual and call identification) as ARDs rely on birds to call or make distinctive wing flapping noises.

Night time monitoring with ARDs enabled species like morepork and possibly long-tailed cuckoo to be identified whilst the early morning and evening monitoring captured the dawn chorus and crepuscular activity. Acoustic files were analysed using the software package RavenLite (Version 2.0) and the location and species of all detected birds was recorded. Wide-ranging and transient species may be visiting the site for specific resources like fruiting or flowering trees or cavities in mature trees and micrositing ARDs at these sites has the potential to improve the detection probability of these species.

ARDs deployed at wetland sites were programmed to record daily from 5:00 am until 8:00 am and then from 5:30 pm to 8:30 pm. ARDs deployed at forest sites were programmed to record daily from 5:00 am until 8:00 am and then from 9:00 pm to 1:00 am.

Call-back surveys – these surveys involved playing the recorded call of a single bird species for 45 seconds and then listening for a response call for the following 30 seconds. This was repeated three times for each target bird species. Following the three repeated call-backs for a single species, a 30 second interval was left before playing the calls of another species. Digital audio files of bird calls were broadcast using a Samsung phone linked via Bluetooth to a UE Boom 2 Portable Bluetooth Speaker.

Incidental observations – During site surveys any bird species of note that were seen or heard were recorded. A pair of binoculars (Bushnell 10 × magnification, 42 mm objective lens) were used to identify bird species during incidental observations and 5MBCs during the site survey.

Our fauna specialist accompanied the Project botanist during the site walkovers to assess the availability and quality of habitats for native fauna at each site. Variables taken into account for avifauna during these assessments included:

- size of site;
- the vegetation assemblage; its structure and intactness of the canopy tiers;
- diversity of the vegetation community;
- provision of microhabitats for foraging, roosting and nesting; and
- landscape connectivity to other habitat features;

Based on the above assessment, our fauna specialist, in consultation with the avifauna specialist, decided which sites would have the highest likelihood of containing Threatened or At Risk native birds and should therefore be surveyed.

Bats

Desktop review

Long-tailed bats have been recorded in multiple locations across Rodney and the wider Auckland Region. A literature review was carried out to identify previous records within the vicinity of the proposed designation boundary. Literature sources include:

- Auckland Long-tailed Bat Monitoring 2017: Bat Distribution Model Testing (Boffa Miskell, 2017);
- Auckland Long-tailed Bat Survey 2015: Report of Findings (Boffa Miskell, 2015);

- Long-tailed Bat Surveys in the Auckland Region 2014 (Bioresearches, 2014); and
- Assessment of Terrestrial and Aquatic Ecological Effects: Warkworth to Wellsford (Bioresearches, 2011).

Further to the sources listed above, records from previous Boffa Miskell bat surveys in northern Auckland were also reviewed.

Site visits

Our fauna specialist accompanied the Project botanist during the site walkovers to assess the availability and quality of habitats for native fauna at each site. Variables taken into account for bats during these assessments included:

- size of site;
- the vegetation assemblage; its age and structure;
- provision of microhabitats for foraging, roosting and drinking; and
- landscape connectivity to other potential bat habitats.

Based on the above assessment, our fauna specialist decided which sites would have the highest likelihood of containing bats and should therefore be surveyed.

Hochstetter's Frogs

Desktop review

A literature review was carried out to identify previous native frog records within the vicinity of the proposed designation boundary. Literature accessed included DOC Bioweb Database (2 June 2017) and Auckland Council's records (29 March 2017). Prior to 2015 there were three searches for Hochstetter's frog within or in general proximity along the designation - in 1995 (Boffa Miskell, 1997 – only in pine plantation areas), in 2012 (Boffa Miskell, 2012 – only in native bush) and in 2010 - 13 (Further North Alliance, 2013 - only in pine plantation areas) as part of the New Zealand Transport Agency's (NZTA) 'Ara Tūhono Pūhoi to Wellsford Road of National Significance' project (Bioresearches 2011, Further North Alliance, 2013). The latter involved systematic searches by qualified herpetologists of 28 streams or headwaters within the pine plantation forests of the Moir Hill and Matariki Forest areas. As Moir Hill, to the south of the Warkworth to Wellsford sector of the Ara Tūhono Pūhoi to Wellsford Road, is a similar forested area, we were able to draw on additional surveys undertaken in this area for our assessment (Boffa Miskell 2016).

Field survey methods

As the Dome Hill Forest Section is the only area with suitable habitat and where the species has been located previously, our survey focused on these areas. The purpose of our survey was to confirm the presence of frogs and to fill gaps in location of surveys, rather than to achieve a full population assessment.

Frog survey methods comprised slowly walking up streams and tributaries within the proposed survey areas, and searching under loose rocks and debris within the splash zone of the stream, and within fractures in the faces of waterfalls. Given the cryptic behaviour and appearance of Hochstetter's frogs, potential habitats were assessed and described regardless of whether frogs were recorded or not.

Limitations of frog survey methodology

Frog survey methods have many of the same limitations as lizard survey methods (Chapter 4.2.4). Observer experience and undertaking surveys in suitable weather is very important in assessing frog presence. A description of specific limitations associated with survey methods (as described in Department of Conservation Inventory and Monitoring Toolbox: Herpetofauna (Hare 2013; Lettink 2013; Hare 2012; Lettink and Monks 2016)) are understood by the herpetologists.

APPENDIX B: ADDITIONAL FRESHWATER METHODS

Methods

The methods outlined below provide additional detail to those methods outlined within Chapter 3.1.2.

Stream Ecological Valuation

Although not a required assessment, the SEV is the accepted methodology utilised in Auckland for assessing the functionality of permanent and intermittent streams for the purposes of informing compensation for stream loss or modification (Auckland Council 2016). The SEV uses a set of fourteen qualitative and quantitative variables to assess the integrity of stream ecological functions (Auckland Council 2011; Table 33). Data collection consists of a comprehensive assessment of the in-stream and riparian environment. This assessment includes a fish survey, aquatic macroinvertebrate sampling and cross-sections of the stream to measure width, depth and substrate, as well as using qualitative parameters for reach-scale attributes.

The SEV methodology recommends that a stream reach (or length) of 20 times the average stream width is surveyed, with a minimum length of 50 metres recommended. Surveyed reaches for this study were all 50 metres in length, with cross-sections every five metres.

Table 33 - Summary of the 14 ecological functions used to calculate the SEV Score (from AC 2011).

Hydraulic functions:	Biogeochemical functions:
Processes associated with water storage, movement and transport: • Natural flow regime • Floodplain effectiveness • Connectivity for species migrations • Natural connectivity to groundwater	Relates to the processing of minerals, particulates and water chemistry: • Water temperature control • Dissolved oxygen levels maintained • Organic matter input • In-stream particle retention • Decontamination of pollutants
Habitat provision:	**Biotic functions:**
The types, amount and quality of habitats that the stream reach provides for flora and fauna: • Fish spawning habitat • Habitat for aquatic fauna	The occurrence of diverse populations of native plants and animals that would normally be associated with the stream reach: • Fish fauna intact • Invertebrate fauna intact • Riparian vegetation intact

This data is analysed using a series of formulae in order to produce an SEV score of between 0-1, where a 0 is a stream with no ecological functionality and 1 is a pristine stream with maximum ecological function. Accepted interpretation of SEV scores is provided in Table 34.

Table 34 - Interpretation of SEV scores (Adopted from Golder Associates, 2009).

Score	Category
0 - 0.40	Poor
0.41 – 0.60	Moderate
0.61 – 0.80	Good
0.81+	Excellent

The application of the SEV methodology to intermittent streams has recently been tested through field trials, with the suitability of this method confirmed (Auckland Council 2016). The recommended season for SEV assessments of intermittent streams is between July and October, following a minimum of two months of winter flows.

The SEV assessments carried out to inform this Report were undertaken outside (in our case prior to) this preferred timeframe, and were undertaken between 9 May – 7 June 2017. However, the SEV assessments followed a sustained period of unusually high rainfall in March and April (Auckland Council Hydrotel – Mahurangi RAWS Forest Rainfall Depth Gauge), so we consider that the measurements are representative of wet winter conditions.

New Zealand Freshwater Fish Database (NZFFD)

The NZFFD is a database with over 34,000 freshwater fish observations dating back over 20 years. The database is publicly accessible and is populated by data from professionals. The database not only records fish species but also some invertebrate species that are commonly observed while undertaking fishing, such as freshwater mussels, freshwater shrimp and the freshwater crayfish koura.

Biological Indices

Macroinvertebrate Community Index

The Macroinvertebrate Community Index (MCI) score is a biotic index that can be used as an indicator of stream water quality. It relies on the fact that biological communities are a product of their environment – with different organisms having different habitat preferences and pollution tolerances (Stark & Maxed 2007). The MCI involves assigning tolerance values to all taxa based on their tolerance to pollution. Taxa that are characteristic of pristine conditions score higher than taxa that are predominantly found in polluted conditions, where 0.1 is the lowest and 10 is the highest. The final MCI scores are calculated using presence-absence data, with the score range from 0 to 200. The streams with no taxa present a score zero and streams in exceptionally pristine conditions score 200 (Table 35; Stark 1993).

The MCI-sb is a variation on the MCI designed for streams with a predominantly soft substrate (soft bottom), with adjusted taxa tolerance values. The MCI-sb is analogous with the MCI score. We used MCI-sb for all streams surveyed, due to the predominantly sandy/silty stream beds present across all sites.

Table 35 - MCI score interpretations (Stark & Maxted 2007).

Quality Class	Descriptions	MCI or MCI-sb Score
Excellent	Clean Water	> 119
Good	Doubtful quality or possible mild pollution	100 - 119
Fair	Probably moderate pollution	80-99
Poor	Probably severe pollution	<80

Biological metrics

The following metrics were also calculated for each site surveyed:

- Taxa richness - a count of the total number of different taxa present at each site.
- EPT taxa richness - the number of taxa present from within three pollution-sensitive orders of insects; **E**phemeroptera (mayflies), **P**lecoptera (stoneflies) and **T**richoptera (caddisflies). The purse-caddisfly species Oxyethira and Paroxyethira were excluded from EPT calculations as they are considered to be generally pollution tolerant as they have low tolerance values.
- Fish Index of Biotic Integrity, or Fish IBI - is a measure of how intact the native fish community is within a stream reach or stream. Utilising a number of metrics including altitude and distance inland, and a large background of data from sites across Auckland, a number of between zero and sixty is calculated (Storey et al 2011). IBI categories are listed in Table 36.

Table 36 - Attributes and suggested integrity classes for the Auckland Fish IBI (Storey et al. 2011.)

Total IBI Score	Integrity Class	Attributes
50-60	Excellent	Comparable to the best situations without human disturbance; all regionally expected species for the stream position are present. Site is above the 97th percentile of Auckland sites
43-49	Very Good	Site is above the 90th percentile of all Auckland sites species richness is slightly less then best for the region
36-42	Good	Site is above the 70th percentile of Auckland sites but species richness and habitat or migratory access reduced some signs of stress
28-35	Fair	Score is just above average but species richness is significantly reduced habitat and or access impaired
18-27	Poor	Site is less than average for Auckland region IBI scores, less than the 50th percentile, thus species richness and or habitat are severely impacted
6-17	Very Poor	Site is impacted by human activities or migratory access almost non existent

Total IBI Score	Integrity Class	Attributes
0	No Fish	Site is grossly impacted or access non existent

Multi-variate Statistics

Multivariate statistical procedures were performed on the macroinvertebrate data set using PRIMER-E (version 6). All multivariate analysis was undertaken on community data that was log (x+1) transformed and a Bray-Curtis similarity matrix was created. Multivariate analysis included the use of *non-metric Multidimensional Scaling (nMDS). T*he relative proximity of sites on the nMDS ordinations (or bi-plots) indicates how similar communities are, with those closer together being more similar than those further apart. Stress values on the ordination indicate how reliably the result are plotted in two-dimensions, with lower stress values more desirable (stress <0.05 = excellent; <0.1 = good; <0.2 useful; >0.3 poor).

Definitions

AC Overland Flow Path (OLFP)

The OLFP was created by the Stormwater Hydraulic Modelling team at AC in 2013 and predicts the path stormwater takes, in a rain event, as it flows downhill over land. The flow path layers are available on ACs GeoMAPS GIS viewer and indicate the extent and location of permanent, intermittent and ephemeral stream reaches.

New Zealand Freshwater Fish Database (NZFFD) records

The NZFFD is run by the National Institute of Water and Atmospheric Research (NIWA) and contains over 34,000 freshwater fish observations from around New Zealand. Observation records include the fish species observed, their abundance, length, sampling methods, observer and location, as well as a physical description of each site. Records are contributed voluntarily by staff from NIWA, the Department of Conservation, regional councils, environmental consultants, universities, fish and game councils, other crown research institutes, schools and members of the public. The data is publicly available to access.

River Environment Classification (REC)

The REC system was developed for use across all New Zealand rivers. It is a GIS-based system that classifies rivers at a range of spatial scales on the basis of six different hierarchical levels. Four of these levels are related to the catchment (climate, source of freshwater flow, geology and land cover) and two are focused on specific sections of the river (position of the section of the river within the catchment network and the landforms of the valley in which the river section is located). The classification system also determines the streams network position – or stream order. The stream order is the numerical position of a tributary or section of a river within the entire network. Headwater streams are assigned a stream order of 1. When two tributaries of the same stream order meet, the order increments by one for the next section downstream. If two sections meet where one section has higher order than the other, the next section downstream has the same order as the highest upstream section (Environment Foundation 2015; MfE 2004).

APPENDIX C: AVIFAUNA RECORDS

OSNZ Records

Table 37 - OSNZ Records

Species	Conservation status
Australasian bittern	Threatened Nationally Critical
Australasian gannet	Not Threatened
Australasian harrier	Not Threatened
Australasian little grebe	Not Threatened
Australasian pied stilt	Not Threatened
Australian magpie	Introduced
Banded dotterel	Threatened Nationally Vulnerable
Banded rail	At Risk Declining
Black shag	At Risk Naturally Uncommon
Black stilt	Threatened Nationally Critical
Black swan	Introduced
Black-billed gull	Threatened Nationally Critical
Blackbird	Introduced
Brown quail	Introduced
Brown teal	At Risk Recovering
California quail	Introduced
Canada goose	Introduced
Caspian tern	Threatened Nationally Vulnerable
Cattle egret	Not Threatened
Chaffinch	Introduced
Eastern bar-tailed godwit	At Risk Declining
Eastern little tern	Not Threatened
Eastern rosella	Introduced
Fantail	Not Threatened
Feral goose	Introduced
Feral turkey	Introduced
Fernbird	At Risk Declining
Goldfinch	Introduced
Greenfinch	Introduced
Great knot	Not Threatened
Grey duck	Threatened Nationally Critical
Grey teal	Not Threatened
Grey warbler	Not Threatened
Hedge sparrow	Introduced
House sparrow	Introduced
Kookaburra	Introduced
Large sand dotterel	Not Threatened

Species	Conservation status
Lesser knot	Threatened Nationally Vulnerable
Little black shag	At Risk Naturally Uncommon
Little shag	Not Threatened
Mallard	Introduced
Morepork	Not Threatened
Myna	Introduced
New Zealand dabchick	At Risk Recovering
New Zealand dotterel	At Risk Recovering
New Zealand fairy tern	Threatened Nationally Critical
New Zealand kingfisher	Not Threatened
New Zealand pigeon	Not Threatened
New Zealand pipit	At Risk Declining
New Zealand scaup	Not Threatened
New Zealand shoveler	Not Threatened
North Island Kaka	At Risk Recovering
North Island robin	At Risk Declining
NZ tomtit	Not Threatened
Paradise shelduck	Not Threatened
Peafowl	Introduced
Pied shag	At Risk Recovering
Pukeko	Not Threatened
Red-billed gull	At Risk Declining
Red-crowned parakeet	At Risk Relict
Redpoll	Introduced
Reef heron	Threatened Nationally Endangered
Ring-necked pheasant	Introduced
Rock Pigeon	Introduced
Royal spoonbill	At Risk Naturally Uncommon
Shining cuckoo	Not Threatened
Silvereye	Not Threatened
Skylark	Introduced
Song thrush	Introduced
South Island pied oystercatcher	At Risk Declining
Southern Black-backed gull	Not Threatened
Spotless crake	At Risk Declining
Spur-winged plover	Not Threatened
Starling	Introduced
Tufted guineafowl	Introduced
Tui	Not Threatened
Turnstone	Not Threatened
Variable oystercatcher	At Risk Recovering
Welcome swallow	Introduced

Species	Conservation status
Whimbrel	Not Threatened
White heron	Threatened Nationally Critical
White-faced heron	Not Threatened
White-fronted tern	At Risk Declining
Wrybill	Threatened Nationally Vulnerable
Yellowhammer	Introduced

Avifauna Records from ARDs

Table 38 - Avifauna Records from ARDs

Species	ARD01	ARD02	ARD03	ARD04	ARD05	ARD06	ARD07	ARD08	ARD09
Banded rail									+
Shining cuckoo	+	+			+	+		+	+
Fantail	+	+	+	+	+	+	+	+	
New Zealand kingfisher	+	+		+	+	+	+	+	+
Morepork	+	+	+	+	+	+	+	+	+
Kereru				+					
Pukeko	+		+		+	+			+
Tomtit	+								
Silvereye	+	+	+		+	+	+	+	+
Tui	+	+		+	+	+	+	+	+
Swamp harrier			+	+					
Grey warbler	+	+		+	+	+	+	+	+
Paradise shelduck			+						
Cooks petrel	+		+	+			+		
Skylark							+		
Spur-winged plover	+			+	+	+		+	
Myna				+	+				
Eastern rosella	+	+			+	+	+	+	
Blackbird	+		+		+	+			+
Chaffinch		+			+	+	+		

Species	ARD01	ARD02	ARD03	ARD04	ARD05	ARD06	ARD07	ARD08	ARD09
Thrush	+	+	+	+			+		
Yellow hammer				+			+		
California Quail	+								

Avifauna records from 5MBCs

Site visit 1

Table 39 - Avifauna Records from 5MCDS during Site Visit 1.

	Site number														
Species	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**
Shining cuckoo						1			1	1		1	1	1	
Fantail		1	1		1	1	1			1	1	1		2	1
New Zealand kingfisher	1	1	1							1	1	2	1	1	1
Silvereye			1												
Tui		1				1	1					2	1		1
Swamp harrier		1										1	1		
Grey warbler		1	1	1		3	2	2	2	1	1	1		1	
Myna		1	1			1									
Eastern rosella				2		1						1	1	3	1
Blackbird	1					1		1		3					1
Chaffinch	2	1	1		1	7	3	1	1	4	1				
Thrush		1						1							

	Site number														
Species	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**
Yellow hammer								1	1						
Feral turkey		2													
Australian magpie			1									1	1	1	

Site visit 2

Table 40 - Avifauna Records from 5MCDS during Site Visit 2.

	Site number														
Species	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**
Shining cuckoo				1	1	1		1	1	1		1	1	1	
Fantail		2		2	2	1	1		1	2	3	1		1	1
New Zealand kingfisher		2	1	1	1	1	2			2	1	2	1	2	
Silvereye		1	1			1			2	1					1
Tui		1	2	2	1	3	1	1				2	2		1
Swamp harrier			1				1					1	1		

	Site number														
Species	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**
Grey warbler		1	1	1	2	1	2	2	1	1	1	1		1	1
Myna		2													
Eastern rosella		1			2		2				1	2	1	1	
Blackbird	2			1		1	2	1		2					1
Chaffinch	1	2	3		2	3	3	2	2	1	2	3		2	
Thrush		1		1		1		1							
Yellow hammer			1						1						
Feral turkey															
Australian magpie	1		1			1						1	1	1	

APPENDIX D: BAT RESULTS

Table 41 - Summary information and results of the acoustic bat survey.

Section	ABM ID	Date Set	Recorder Type	Nights Deployed	Nights Analysed	Total No. of Passes	Mean No. of Passes per Night	% of Nights with Passes
Warkworth North	WN_W_Koura_02	28-Sep-17	Acoustic Rec ARM v1.2	21	19	6	0.32	32%
Dome Valley Forest	A1	15-Dec-17	Song Meter SMZC	27	24	19	0.79	42%
	A2	15-Dec-17	Song Meter SMZC	27	24	29	1.2	67%
	B1	15-Dec-17	Song Meter SMZC	27	No Data			
	B2	15-Dec-17	Song Meter SMZC	27	24	0	0	0%
	C1	15-Dec-17	Song Meter SMZC	27	24	40	1.7	46%
	C2	15-Dec-17	Song Meter SMZC	27	24	12	0.5	8%
	D1	15-Dec-17	Acoustic Rec ARM v1.2	27	24	123	5.1	83%
	D2	15-Dec-17	Acoustic Rec ARM v1.2	27	24	213	8.9	88%
Hōteo North	E1	20-Dec-17	Song Meter SMZC	22	19	0	0	0%
	E2	20-Dec-17	Song Meter SMZC	22	19	0	0	0%
	HN_T_Hōteo _02	20-Dec-17	Song Meter SMZC	22	19	0	0	0%
	HN_W_Hōteo _02	20-Dec-17	Song Meter SMZC	22	19	0	0	0%
	HN_T_Hōteo _03	20-Dec-17	Song Meter SMZC	22	19	0	0	0%

APPENDIX E: FRESHWATER ECOLOGICAL RESULTS

CHARACTERISTICS OF FRESHWATER ENVIRONMENTS

E.1 Warkworth North

Instream Habitat

Riparian cover at site WN_F_Koura_1 is typical of surrounding stream reaches with only a handful of exotic shrub species present along the stream reach: providing limited shade. The WN_F_Mahu_1 site had a more extensive riparian margin than WN_F_Koura_1, with large native and exotic canopy trees present with a more complex understory and groundcover. This riparian margin was fenced off from grazing stock and is typical of the lower reaches of the Mahurangi River (Left Branch). Erosion was evident at both sites; with those at site WN_F_Koura_1 likely caused by stock damage.

Typical of smaller tributaries within the area is their straightening and deepening of to provide sufficient drainage to the surrounding pasture. This is evident (through satellite imagery and incidental observations) at many watercourses within the Section. Surveys were unable to be undertaken on any straightened or deepened watercourses within the Warkworth North section.

Macroinvertebrate Communities

The macroinvertebrate community present at WN_F_Koura_1 returned an MCI-sb score of 103.5, which indicates a good water quality of the stream but may be subject to some mild pollution. This score may be influenced by the headwaters of the Kourawhero located within the Matariki Forest, and the steep banks preventing stock access to this section of the stream.

The macroinvertebrate community surveyed at the WN_F_Koura_1 site was dominated by small worms (Oligochaeta) (see Figure 7). These worms are found in almost all freshwater habitats from pristine streams to highly polluted waterways (Landcare Research 2017). A total of 22 taxa was present, including mayflies (Ephemeroptera), caddisflies (Trichoptera), damselflies (Odonata), beetles (Coleoptera), flies (Diptera), molluscs and crustaceans, amongst others.

We recorded a total of six of the generally sensitive EPT taxa, including the Double Gill Mayfly and the Stick Caddis. These EPT taxa were found in low abundance.

In addition to worms, the sandfly larvae *Austrosimulium* (Diptera) and the common snail *Potamopyrgus* (a mollusc) were also dominant species. The freshwater crayfish, Koura (a crustacean), were also relatively abundant. The good MCI score, high abundance of pollution tolerant species and the presence, but relatively low abundance, of EPT species is indicative of a stream of moderate-high ecological value.

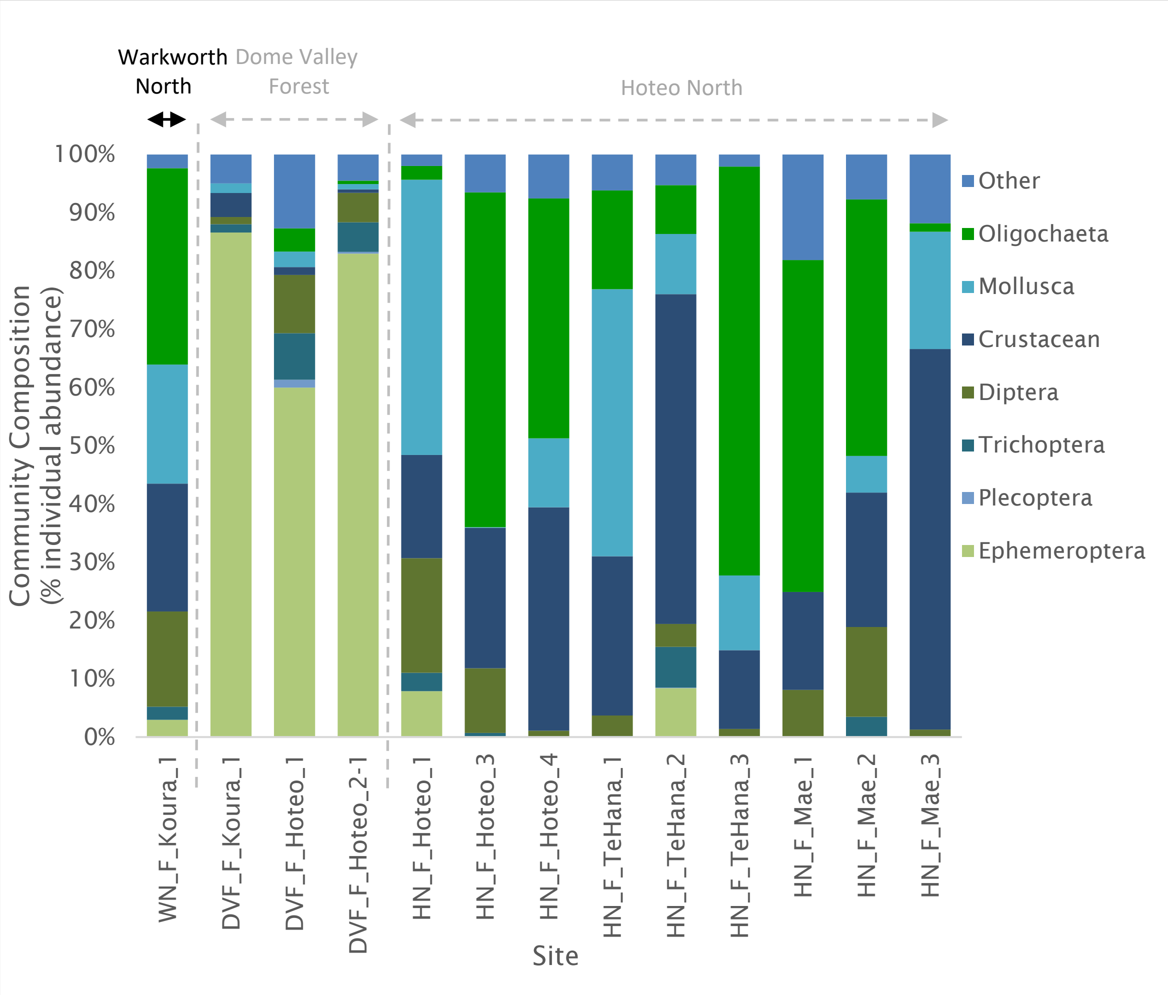


Figure 7 - Macroinvertebrate community assemblage present at Warkworth North survey site WN_F_Koura_1, grouped by taxa type. For comparative purposes, the figure shows data for all sites surveyed within the entire length of the proposed designation boundary, with Warkworth North Section Sites denoted by bold text.

A bi-plot of macroinvertebrate data from all sites surveyed in our assessment is shown in Figure 8. The bi-plot shows sites of most similarity in macroinvertebrate communities clustered together and those least similar furthest apart in the plot. The bi-plot indicates that the macroinvertebrate community within the Kourawhero Stream (WN_F_Koura_1) is most similar to communities recorded within the Te Hana Catchment, within the Hōteo North section. This result reflects the modified nature of the stream (WN_F_Koura_1) and its surrounding pastoral land use. Macroinvertebrate samples were not undertaken at site WN_F_Mahu_1.

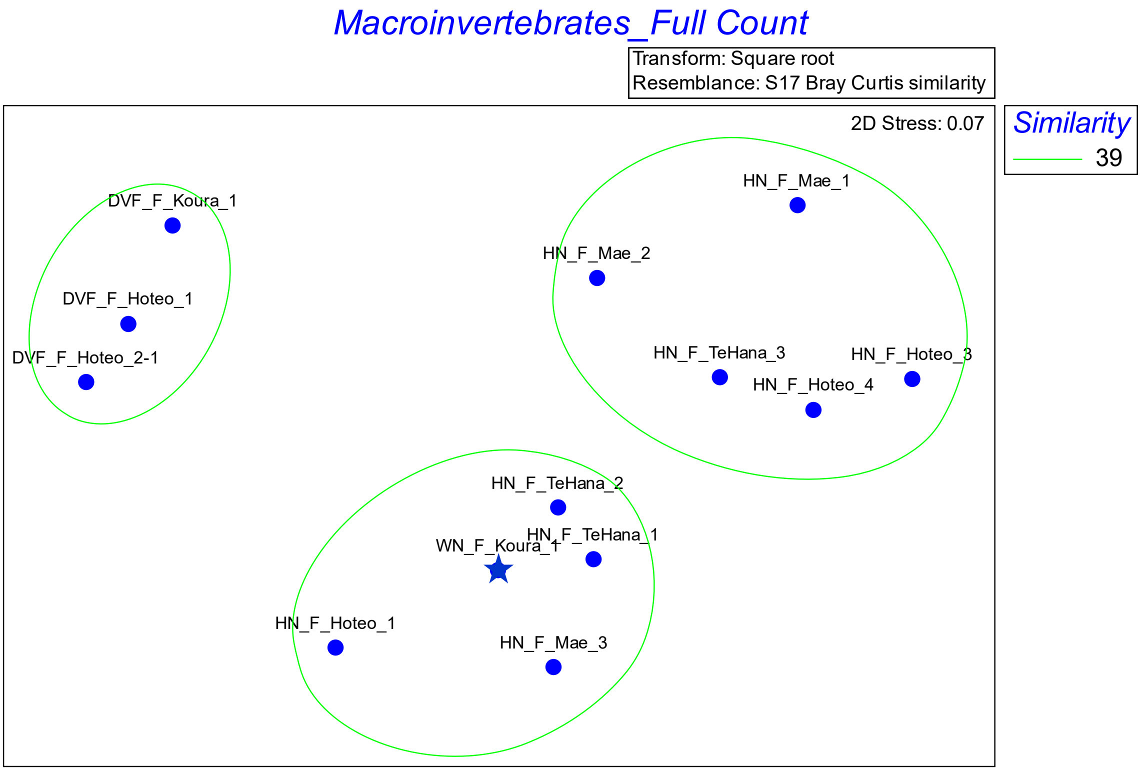


Figure 8 - A nMDS ordination plot of macroinvertebrate communities (n=1) across all section sites. Sites grouped together within the green lines share at least 39% similarity in community composition. Stars indicate sites within the Warkworth North section.

The freshwater crayfish, koura, was also recorded during fishing at site WN_F_Koura_1. A search of the NZFFD of the Kourawhero sub-catchment recorded the presence of the koura and the freshwater shrimp. A search of the Mahurangi River (Left Branch) recorded the presence of the koura, freshwater mussel and freshwater shrimp. The freshwater mussel is of particular conservation interest as it has a threat status of At Risk – declining.

Fish Communities

We carried out electric fishing at Site WN_F_Koura_1, and observed good diversity with five different species observed: shortfin and longfin eel, banded kokopu and the common bully. The longfin eel has a threat status of At risk – declining. The IBI score for site WN_F_Koura_1 (IBI=54) reflects the fish community as excellent and comparable to the best situations without human disturbance (Storey et al., 2011). No fishing was undertaken at site WN_F_Mahu_1.

The NZFFD search of the Kourawhero Stream catchment returned 27 records with a total of seven different fish species and three invertebrate species (described in Chapter 5.1.4 above) recorded. Of particular conservation interest within the catchment is the presence of inanga and torrentfish – which have a threat status of At Risk – declining.

The IBI score for the Kourawhero Stream site (IBI=54) reflects the fish community as excellent and comparable to the best situations without human disturbance (Storey et al., 2011).

NZFFD searches of the Mahurangi River (Left Branch) catchment resulted in 45 fish records, (which can include both multiple abundances and multiple species, See Appendix A –

Freshwater Values Map). A total of seven different fish species and three invertebrate species (described in Chapter 5.1.4 above) were recorded across the catchment indicating good diversity. Of particular conservation interest within the catchment is the presence of inanga and redfin bully– both of which have a threat status of At Risk – declining.

Stream Ecological Valuation Scores

The SEV assessment at Site WN_F_Koura_1 returned a score of 0.489. This score indicates a moderately healthy stream and is within the typical range of scores seen for streams within rural catchments in Auckland (Storey et al., 2011). This site had no stock damage and was fed with water from high-value streams within the Matariki Forest. It is likely that other watercourses within the section may have similar, or slightly lower SEV scores than the sampled site owing to the potential comparatively lower ecological function.

E.2 Dome Valley

Instream Habitat

Watercourses within the Dome Valley Forest section are predominantly located within the Matariki Forest, amongst plantation pine. The surrounding catchments are predominantly plantation pine, with the occasional forestry road. A portion of the catchment area of Site DVF_F_Hōteo _2-1 encompasses a motocross park when not required for use as a forestry skid site.

Riparian margins across the three sites were similar, with plantation pine canopy and a number of native species that had become established closer to the stream channel. Native species included black tree ferns, pate/seven-finger, and hangehange. The herbaceous ground cover parataniwha was abundant in patches in the upper reaches of watercourses sites, particularly surrounding cascades and waterfalls. The pest plant African club moss was abundant along stream margins and banks, in addition to a variety of bryophyte (mosses, liverworts and hornworts) species. All stream channels had large amounts of fine silt and abundant debris jams (small stream blockages typically consistency or logs/twigs/leaf matter) along the survey reach. Erosion was evident at all three survey sites, with recent bank slumping evident along some stream banks. With movement upstream, towards the ridgelines, the streambeds typically become harder with an increase in bedrock and boulders, with many cascades and waterfalls present.

Macroinvertebrate Communities

The MCI-sb scores at all sites were >119, indicating excellent, clean water.

Macroinvertebrate communities present across the Dome Valley Forest sites were dominated by mayflies (Ephemeroptera) (Figure 9). Mayflies are an EPT taxa and are generally associated with sites with good habitat and high water quality. A number of other taxa were present, including stoneflies (Plecoptera), caddisflies (Trichoptera), flies (Diptera), molluscs and crustaceans, amongst others.

The number of taxa present at each of the three sites was similar, with between 19 and 22 taxa present. EPT taxa were present, and dominant, across each of the sites, with between 7 and 9 EPT taxa present at the survey sites, accounting for 69-88% of individuals present. Freshwater crayfish, koura, were also abundant across each of the sites.

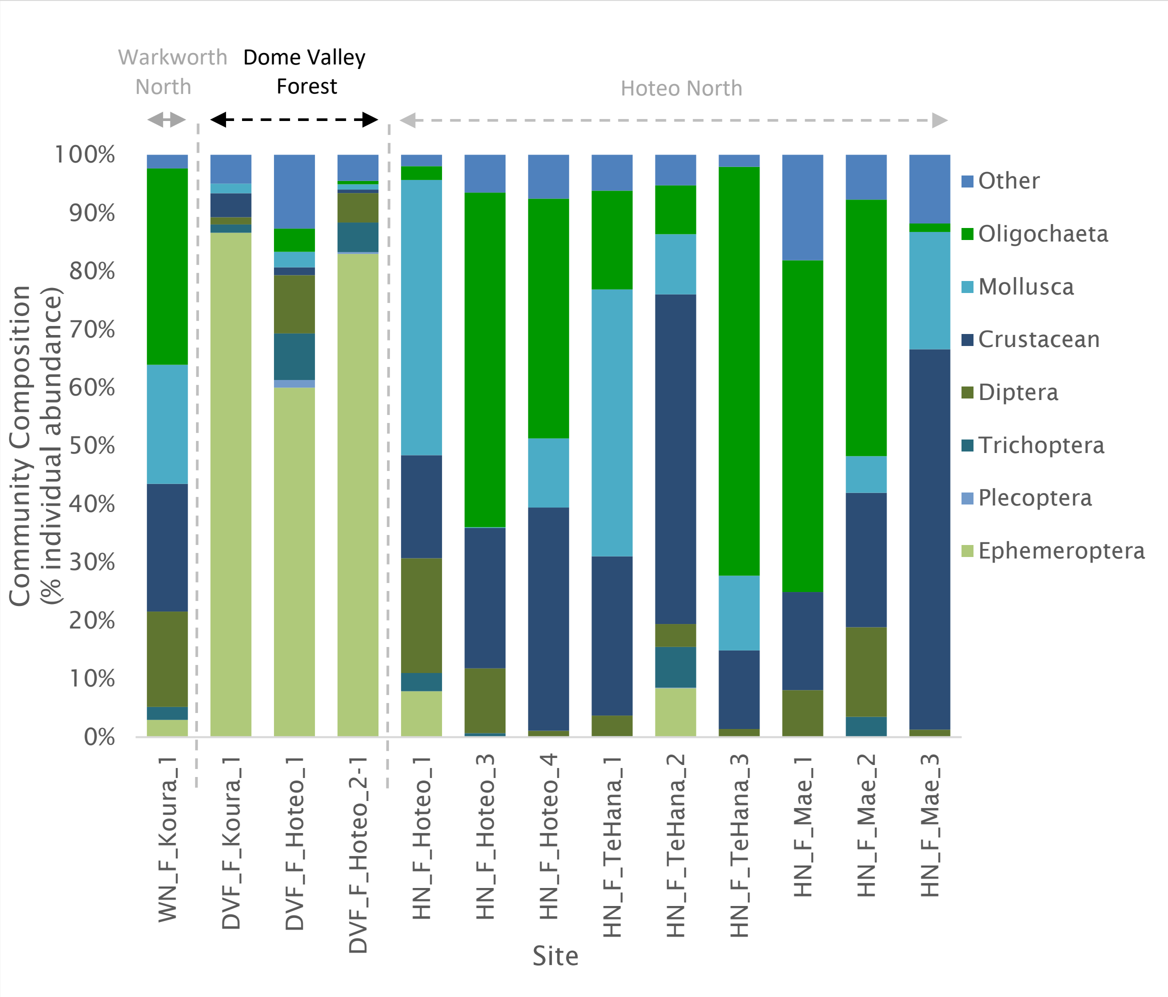


Figure 9 - Macroinvertebrate community assemblages present at Dome Valley Forest section sites, grouped by taxa type. For comparative purposes, the figure shows data for all sites surveyed along proposed designation boundary, with Dome Valley Forest Section Sites denoted by black text.

A bi-plot of macroinvertebrate data from all sites surveyed in our assessment is shown in Figure 10. The bi-plot shows sites of most similarity in macroinvertebrate communities clustered together and those least similar furthest apart in the plot. The bi-plot indicates that the macroinvertebrate communities from sites surveyed in the Dome Valley Forest section are clustered together and are therefore most similar to each other rather than other sites throughout the proposed designation boundary. This result reflects the similarity of the stream character surrounding land use throughout the Dome Valley Forest section and their high abundance of EPT taxa.

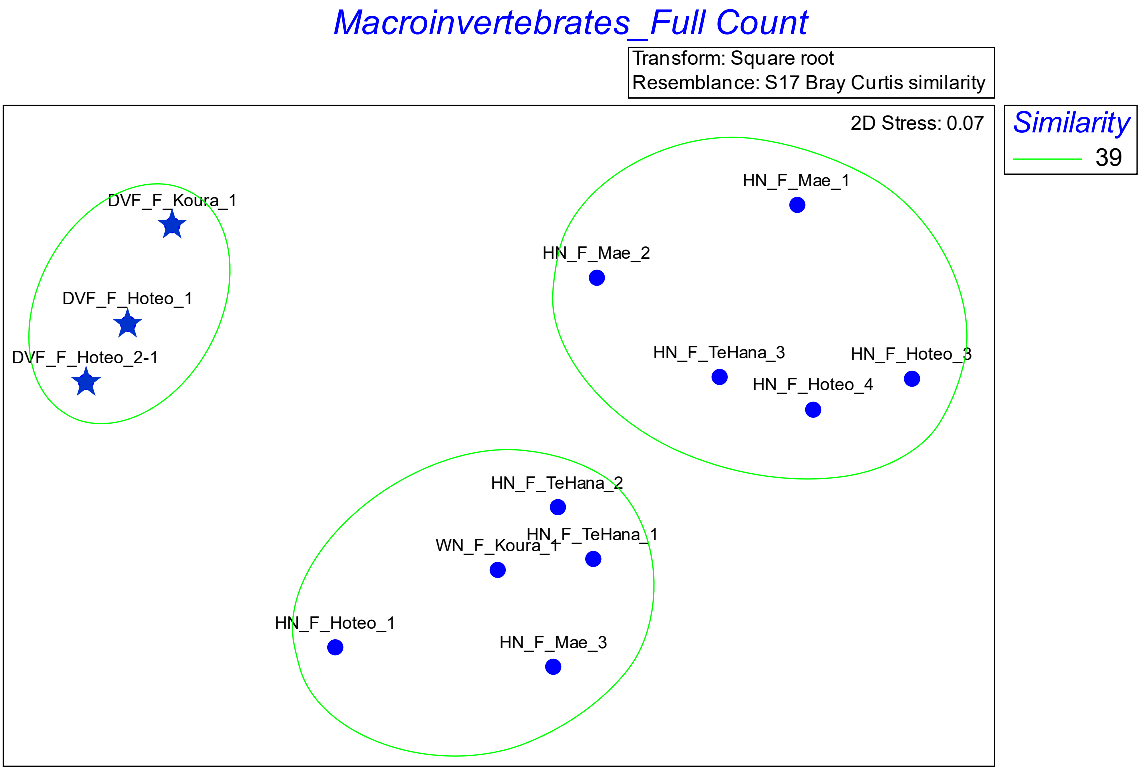


Figure 10 - nMDS ordination plot of macroinvertebrate communities (n=1) across all section sites. Sites grouped together within the green lines share at least 39% similarity in community composition. Stars indicate sites within the Dome Valley Forest section.

The freshwater crayfish, koura, was also recorded during fishing at each of the survey sites. A search of the NZFFD of the Hōteo River catchment recorded the presence of the koura, freshwater shrimp and freshwater mussel. This freshwater mussel is of conservation interested as it has a threat status of At Risk – Declining.

Fish Communities

Three fish taxa were observed at each site, with longfin eel and banded kokopu present at all sites (See Figure 11). The redfin bully was observed at site DVF_F_Hōteo _1 and the common bully at sites DVF_F_Hōteo _1 and DVF_F_Hōteo _2-1. The longfin eel and redfin bully both have a threat status of At risk – declining. The fish IBI was highest at site DVF_F_Hōteo _1, being within the Excellent category (IBI=56), but always very good (IBI>44) (Storey et al., 2011).

A search of the NZFFD returned a total of 281 records from within the Hōteo River catchment. These records include 12 fish species and three invertebrate species (Appendix E; Table 44). Of particular conservation interest within the catchment is the presence of longfin eel, inanga, torrentfish and the redfin bully, all of which have a threat status of At Risk – declining. Gambusia (previously known as mosquito fish) was also recorded within the catchment and this species is listed as an unwanted organism.

Figure 11 - Photos of some of the fish observed during surveys within the Dome Valley Forest section.

Stream Ecological Valuation Scores

SEV scores for all three sites within the Dome Valley Forest section were > 0.61, indicating good functionality. Site DVF_F_Hōteo _1 scored 0.820, indicating excellent functions. These SEV scores are within the upper extent of SEV scores, and are consistent with the scores that would be expected within an exotic forest. Site DVF_F_Hōteo _1 has a SEV score comparative to those occurring in pristine native forests. Watercourses within similar attributes within the proposed designation boundary, in the Dome Valley Forest section, are likely to have similar SEV scores that reflect a comparable high ecological function.

Other watercourses under the Indicative Alignment within the Dome Valley Forest section are likely to have similarly high scores.

SEV assessments were undertaken by Bioresearches (2011) at three sites within the Dome Valley Forest area in 2010. These SEV surveys were all undertaken on streams within the Matariki Forest with SEV scores of 0.65, 0.78 and 0.83. These scores are consistent with the results from the current surveys.

Site DVF_F_Hōteo _2-2

Habitat

The riparian margin had plantation pine canopy with native and exotic vegetation establishing along the stream margin. Native species included tree ferns, pate/seven-finger, mahoe and hangehange.

Channel substrat was variable, with areas of bedrock channel interspersed with areas of silt/sand and gravels. Hydrological heterogeneity was high with run, riffle, chute, cascades and waterfalls present along the SEV reach. With movement upstream there were numerous large waterfalls, up to approximately 8 m in height.

The MCI-sb scores at the SEV site was 115, indicating good water quality.

Macroinvertebrate Communities

The macroinvertebrate community present at survey site DVF_F_Hōteo _2-2, was dominated by the mayfly nymph *Deleatidium*. Mayflys are an EPT taxa and are generally associated with good water quality. A total of 29 taxa were present including mayflies (Ephemeroptera), caddisflies (Trichoptera), beetles (Coleoptera), flies (Diptera), molluscs and crustaceans, amongst others.

A total of nine of the generally sensitive EPT taxa were recorded, including the single gill mayfly, double gill mayfly and the net-building caddis. EPT taxa accounted for 80% of individuals present. This high abundance and diversity of EPT taxa is an indicative of a stream of high ecological value.

Freshwater crayfish were also present at the site, with four individuals recorded during electric fishing.

Fish Communities

Two fish species were recorded at the SEV site: shortfin eel and redfin bully. Redfin bully have a threat status of At risk – declining. The fish IBI score was 38 and considered to be 'good'. No exotic fish species were recorded during the survey.

Stream Ecological Valuation Scores

The score for the SEV site was 0.783, indicating good ecological functionality. This SEV score is within the upper extent of SEV scores recorded from streams within plantation pine forests, and is consistent with those expected in mature exotic forests. SEV scores from other watercourses within the Dome Valley Forest section have similar SEV scores of 0.761-0.820.

Freshwater Ecological Value Classification

We consider that the watercourse was of high ecological value.

E.3 Hōteo North

Instream Habitat

The Hōteo North section is predominantly rural, with all sites except Site HN_F_Hōteo _1 having upstream catchments that were primarily grazed pasture. The upstream catchment of Site HN_F_Hōteo _1 is predominantly forested, incorporating both plantation pine forest within the Matariki Forest and regenerating native forest within the Dome Valley (Sunnybrook Scenic Reserve and Dome Forest).

Riparian vegetation was limited across most watercourses under the Indicative Alignment within the Hōteo North section with the majority having no riparian margin, with some limited stream shade provided by topography or overhanging pasture grass.

A small number of sites with riparian margins were surveyed. Site HN_F_Hōteo _1 had an extensive riparian margin along its true left bank, with the adjacent SEA (SEA_T_683) providing a complex riparian habitat with overhanging mature vegetation including mature totara and willow trees. Site HN_F_TeHana_1 had an intact native riparian margin, providing high levels of shading with large mature totara, nikau and mahoe, amongst others. The riparian margin at site HN_F_Mae_3 had benefited from native planting and weed control, resulting in a regenerating predominantly native margin.

Stream substrates of the watercourses along the proposed designation boundary comprised predominantly silt-sand, with many channels having excess loads of fine sediment and significant bank erosion. Bank erosion was heightened at those sites where stock had access to the watercourse, with trampling and pugging of the banks and stream channel common place. At a number of sites this resulted in stream channels that were flat and wide with wetland plants such as *Juncus* sp. abundant, and no clear flowing water channel.

Macroinvertebrate Communities

With the exception of Site HN_F_Hōteo _1, the macroinvertebrate communities at all sites within the Hōteo North section had MCI-sb scores <80, indicating poor water quality with probable severe pollution. Site HN_F_Hōteo _1 had a higher MCI-sb value of 105.6, indicating doubtful water quality or possible mild pollution.

Macroinvertebrate communities across the Hōteo North section showed a lot of variation in community composition. Across all sites oligochaete worms were the most abundant group, followed by molluscs and crustaceans, with the dominant taxa being seed shrimps, the amphipods *Paracalliope* and the mud snail *Potamopyrgus* (Figure 12).

The number of taxa present varied between 12 and 26 taxa. The highest number of taxa occurred at site HN_F_TeHana_1 (26 taxa), and the lowest at site HN_F_Mae_1 (12 taxa).

The presence of EPT taxa within macroinvertebrate communities was low across all sites. The highest presence of EPT taxa was recorded at site HN_F_Hōteo _1 (EPT=5), while no EPT taxa were present at sites Hoeto_5, HN_F_Hōteo _4, HN_F_Mae_2, or HN_F_Mae_1. EPT species abundance (i.e., the number of individuals of EPT species recorded) was highest at sites HN_F_TeHana_2, where 97 EPT individuals were recorded, followed by site HN_F_Hōteo _1 where 28 EPT were recorded.

The single gill mayfly, axehead caddis, and double gill mayfly where the most abundant EPT species. The freshwater crayfish, koura, was recorded at site HN_F_Hōteo _1.

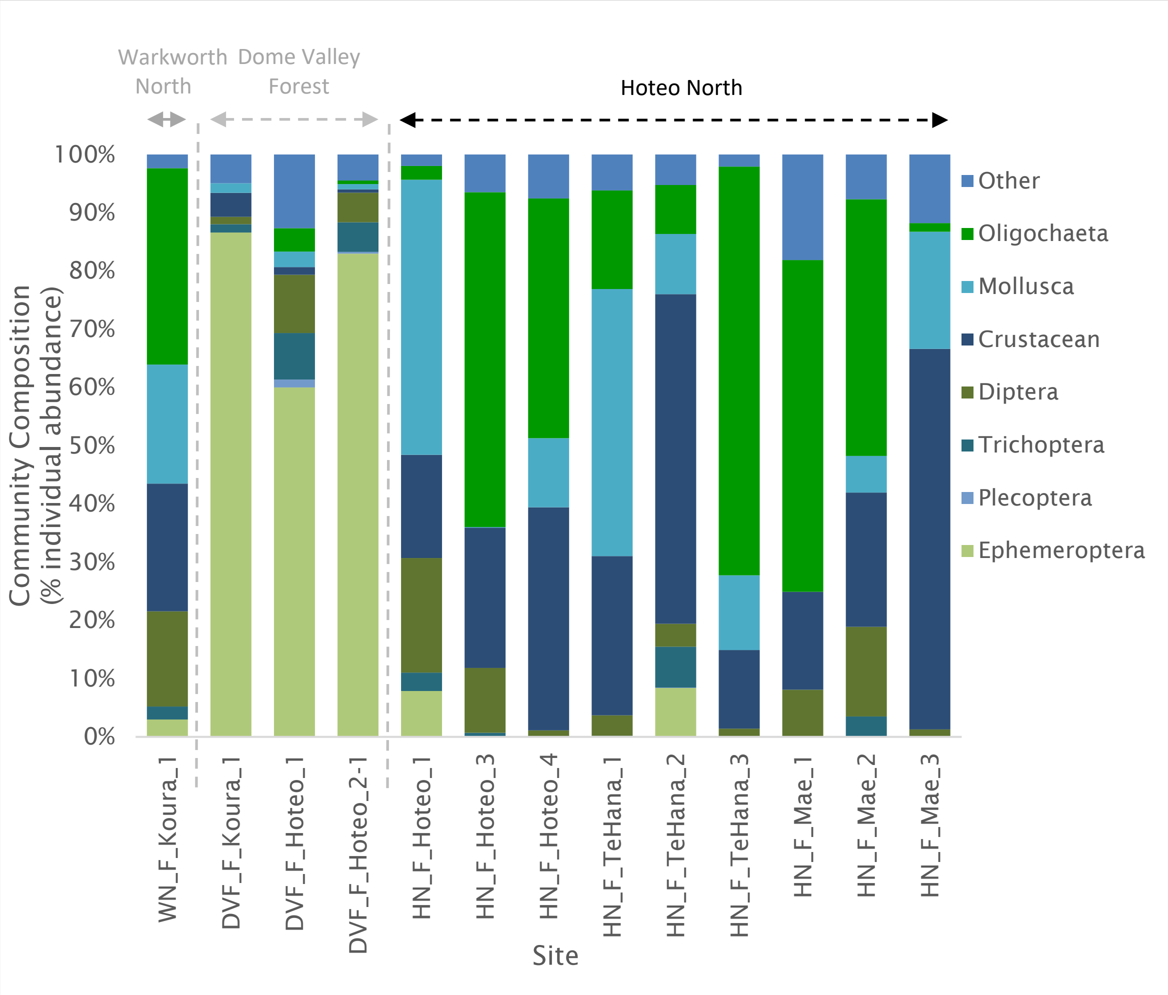


Figure 12 - Macroinvertebrate community assemblages present at Hōteo North section sites, grouped by taxa type. For comparative purposes, the figure shows data for all sites surveyed along the proposed designation boundary, with Hōteo North section Sites denoted by black text.

As for the previous Sections, a bi-plot of macroinvertebrate data from all sites surveyed in our assessment is shown in Figure 13. The bi-plot shows sites of most similarity in macroinvertebrate communities clustered together and those least similar furthest apart in the plot. The bi-plot indicates that the macroinvertebrate communities from sites surveyed in the Hōteo North Section are highly variable, with all sites sharing only 31% similarly in community composition. Two overlapping groups can be distinguished (at 39% similarity), with those in the group of HN_F_Mae_1, HN_F_TeHana_3, HN_F_Hōteo_4 and HN_F_Hōteo_3 and HN_F_Mae_2 all having macroinvertebrate communities where Oligochaete worms are the dominant species. The community present at site WN_F_Koura_1, from the Warkworth North Section, is grouped with communities from the Hōteo North section. This result reflects the broad range but overall similarity of the stream character and prevailing pastoral land use throughout the Hōteo North section.

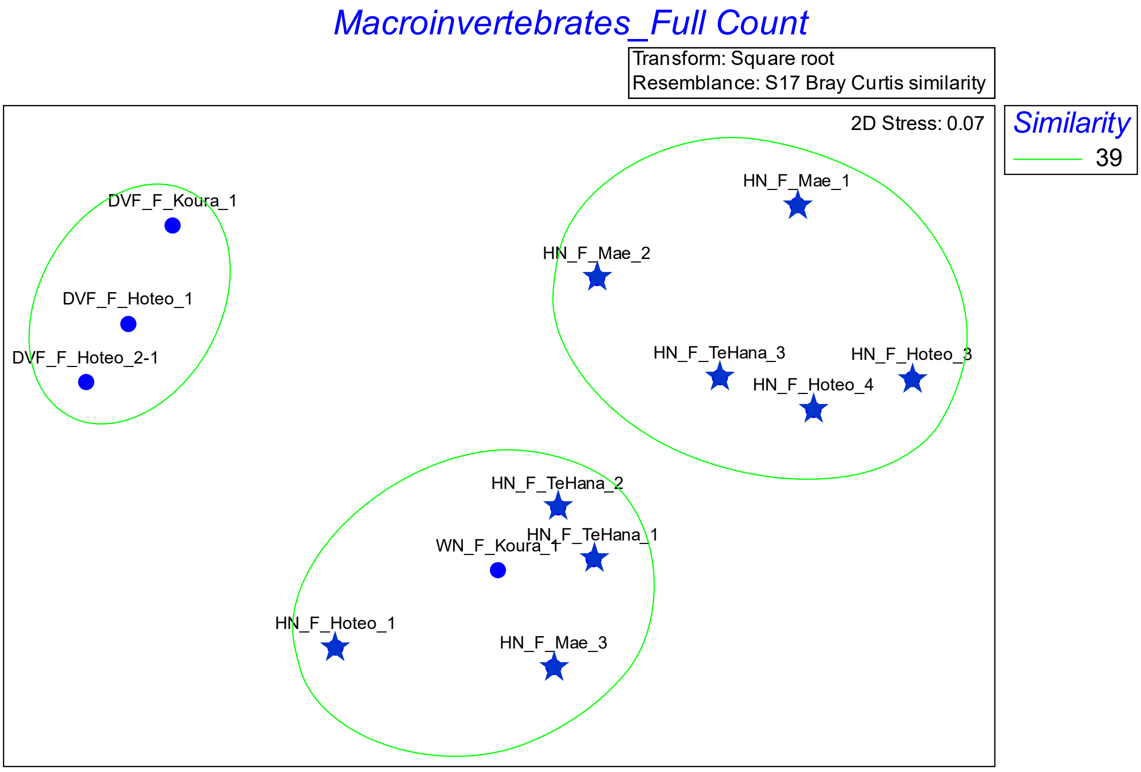


Figure 13 - nMDS ordination plot of macroinvertebrate communities (n=1) across all Hōteo North section sites. Sites grouped together within the green lines share at least 39% similarity in community composition. Stars indicate sites within the Hoeto North section.

A search of the NZFFD of the Hōteo River catchment recorded the presence of the koura, freshwater shrimp and freshwater mussel. This freshwater mussel is of conservation interested as it has a threat status of At Risk – Declining.

Fish Communities

Electric fishing was undertaken at each of the SEV survey sites. Five fish species were recorded across the sites; shortfin and longfin eel, the whitebait species inanga and banded kokopu and redfin bully. Longfin eel, inanga and redfin bully are important species with a threat status of At risk – declining. There was much variation in the fish IBI scores, varying from Very Good (HN_F_Hōteo _1) to Very Poor (Mae_, HN_F_Mae_3), with no fish species were recorded at sites HN_F_Hōteo _4, HN_F_TeHana_3 or HN_F_Mae_1 (Storey et al., 2011).

The NZFFD was searched for records within the Hōteo River catchment, the Te Hana Creek catchment and the Maeneene Creek catchment. Within the Hōteo River catchment there was a total of 281 records (Table 43, Table 44).

There was as single record from the Te Hana Creek catchment, with only the shortfin eel recorded. There were no NZFFD records from within the Maeneene Creek catchment.

Stream Ecological Valuation Scores

Four sites (HN_F_Hōteo _3, HN_F_Hōteo _4, HN_F_Mae_2, HN_F_Mae_1) all scored an SEV score of less than 0.40, indicating poor ecological function. Two sites (HN_F_TeHana_2, HN_F_TeHana_3) scored between 0.40-0.60 indicating moderate ecological function. Three sites scored between 0.60-0.80 (HN_F_Hōteo _1, HN_F_TeHana_1, HN_F_Mae_3) indicating good ecological function, with site HN_F_Mae_3 having the highest SEV score within the Hōteo North section (0.683). These scores are typical of rural catchments with high variability between watercourses.

Those watercourses that had SEV scores indicative of 'poor' ecological function tended to have very low shading and extensive stock damage. Watercourses of 'moderate' SEV scores had more limited stock access and had overhanging pastoral grasses or *Juncus* sp. providing some shading to the channel. Watercourses classified as 'good' all had stock excluded and had a riparian margin present with canopy height trees providing varying levels of overhead shade.

SEV assessments were undertaken by Bioresearches (2011) at two sites within the Hōteo North area in 2010. The location of the two sites were very close (i.e. within 50 metres) of two sites within this survey, with site WN_F_Hōteo _1 the same as Bioresearches (2011) site H41, and site WN_F_Hōteo _3 very close Bioresearches H43 site, but on a different tributary. Site WN_F_Hōteo _1/site H41 had a score of 0.675 in this survey, and returned a score of 0.64 in 2010. While site WN_F_Hōteo _3/site H43 had score of 0.376 in this survey, it returned a score of 0.49 in 2010.

Watercourses with similar attributes within the proposed designation boundary, in the Hōteo North section, are likely to have similar SEV scores to those observed during the Project.

E.4 Raw Results

Freshwater Fish Species List

Table 42 - Freshwater Fish Species observed during Project surveys.

Common Name	Species	Threat Status (Goodman et al. 2014; Grainger et al. 2014; 2 Collier and Grainger 2015)
Longfin eel	Anguilla dieffenbachii	At risk – Declining
Shortfin eel	Anguilla australis	Not threatened
Banded kokopu	Galaxias fasciatus	Not threatened
Inanga	Galaxias maculatus	At Risk – Declining
Cran's bully	Gobiomorphus basalis	Not threatened
Common bully	Gobiomorphus cotidianus	Not threatened
Redfin bully	Gobiomorphus huttoni	At Risk – Declining
Koura	Paranephrops spp.	Not Threatened (Paranephrops planifrons)

Common Name	Species	Threat Status (Goodman et al. 2014; Grainger et al. 2014; 2 Collier and Grainger 2015)
Freshwater shrimp	Paratya curvirostris	Not threatened
Freshwater mussel	Echyridella menziesi (Hyridella menziesi)	At Risk – Declining
Yelloweye mullet	Aldrichetta forsteri	Not threatened
Australian longfin eel	Anguilla reinhardtii	Non-resident Native
Torrentfish	Cheimarrichthys fosteri	At Risk – Declining
Gambusia	Gambusia affinis	Introduced and Naturalised Unwanted Organism 2

NZFFD Results

Table 43 - NZFF Database entries for Sites Koura_1 and Mahu_1

Koura_1 – *Kourawhero Stream*	Mahu_1 – *Mahurangi River (Left Branch)*
Longfin eel Shortfin eel Banded kokopu Inanga Cran's bully Common bully Koura Freshwater shrimp Freshwater mussel Torrentfish	Longfin eel Shortfin eel Banded kokopu Inanga Cran's bully Common bully Redfin bully Koura Freshwater shrimp Freshwater mussel

Table 44 - NZFFD Database entries for the Hōteo River Catchment, which includes the Kourawhero Stream.

Common Name	
Yelloweye mullet Shortfin eel Longfin eel Australian longfin eel Torrentfish Banded kokopu Inanga Cran's bully	Common bully Redfin bully Gambusia Brown trout Koura Freshwater shrimp Freshwater mussel

Table 45 - NZFFD Database entries for the Te Hana Creek Catchment.

Common Name
Shortfin eel

SEV Tables

Table 46 - SEV Results from Surveys for the Project.

Function	WN_F_Koura _1	DVF_F_Koura _1	DVF_F_Hōteo _1	DVF_F_Hōteo _2-1	HN_F_Hōteo _1
Natural Flow Regime	0.62	0.89	0.99	1.00	0.90
Floodplain Effectiveness	0.08	0.59	0.72	0.72	0.60
Connectivity for natural species migrations	1.00	1.00	1.00	1.00	1.00
Natural connectivity to groundwater	0.77	0.89	0.97	1.00	0.83
Hydraulic Functions	**0.62**	**0.84**	**0.92**	**0.93**	**0.83**
Water temperature control	0.06	0.52	0.48	0.32	0.28
Dissolved oxygen levels	1.00	1.00	1.00	1.00	1.00
Organic matter input	0.00	1.00	1.00	1.00	0.45
Instream particle retention	0.80	0.96	1.00	1.00	0.80
Decontaminati on of pollutants	0.21	0.46	0.61	0.50	0.46
Biogeochemic al Functions	**0.41**	**0.79**	**0.82**	**0.76**	**0.60**
Fish Spawning Habitat	0.05	0.18	0.45	0.51	0.50
Habitat for aquatic fauna	0.55	0.84	0.86	0.86	0.70
Habitat Provisions Functions	**0.30**	**0.51**	**0.66**	**0.68**	**0.60**

Function	WN_F_Koura _1	DVF_F_Koura _1	DVF_F_Hōteo _1	DVF_F_Hōteo _2-1	HN_F_Hōteo _1
Fish Fauna Intact	0.90	0.80	0.93	0.73	0.77
Invertebrate Fauna Intact	0.76	0.82	0.78	0.74	0.71
Riparian Vegetation Intact	0.05	0.70	0.68	0.68	0.45
Biodiversity Provision Functions	**0.57**	0.77	**0.80**	**0.72**	**0.64**
SEV Score	**0.489**	**0.761**	**0.820**	**0.790**	**0.675**

Table 47 - SEV Results from Surveys for the Project.

Function	HN_F_Hōteo _3	HN_F_Hōteo _4	HN_F_TeHana _1	HN_F_TeHana _2	HN_F_TeHana _3
Natural Flow Regime	0.76	0.53	1.00	0.27	0.79
Floodplain Effectiveness	0.16	0.26	0.38	0.20	0.18
Connectivity for natural species migrations	1.00	1.00	1.00	1.00	1.00
Natural connectivity to groundwater	0.68	0.83	1.00	0.71	0.78
Hydraulic Functions	**0.65**	**0.66**	**0.85**	**0.54**	**0.69**
Water temperature control	0.00	0.08	0.68	0.10	0.20
Dissolved oxygen levels	0.60	0.68	1.00	1.00	0.68
Organic matter input	0.00	0.00	0.50	0.00	0.00
Instream particle retention	0.64	0.66	1.00	0.20	0.66
Decontamination of pollutants	0.25	0.60	0.45	0.36	0.60
Biogeochemical Functions	**0.30**	**0.26**	**0.73**	**0.33**	**0.43**
Fish Spawning Habitat	0.05	0.05	0.18	0.40	0.05

Function	HN_F_Hōteo_3	HN_F_Hōteo_4	HN_F_TeHana_1	HN_F_TeHana_2	HN_F_TeHana_3
Habitat for aquatic fauna	0.24	0.35	0.85	0.64	0.42
Habitat Provisions Functions	**0.15**	**0.20**	**0.51**	**0.52**	**0.23**
Fish Fauna Intact	0.57	0.00	0.53	0.30	0.00
Invertebrate Fauna Intact	0.21	0.12	0.33	0.46	0.28
Riparian Vegetation Intact	0.10	0.12	0.39	0.09	0.12
Biodiversity Provision Functions	**0.29**	**0.08**	0.42	**0.28**	**0.13**
SEV Score	**0.376**	**0.325**	**0.664**	**0.408**	**0.410**

Table 48 - SEV Results from Surveys for the Project.

Function	HN_F_Mae_2	HN_F_Mae_3	HN_F_Mae_1
Natural Flow Regime	0.53	1.00	0.80
Floodplain Effectiveness	0.23	0.70	0.20
Connectivity for natural species migrations	1.00	1.00	1.00
Natural connectivity to groundwater	0.83	1.00	0.67
Hydraulic Functions	**0.65**	**0.93**	**0.67**
Water temperature control	0.52	0.34	0.08
Dissolved oxygen levels	0.68	1.00	0.68
organic matter input	0.05	1.00	0.00
Instream particle retention	0.20	1.00	0.60
Decontamination of pollutants	0.46	0.52	0.39
Biogeochemical Functions	**0.38**	**0.77**	**0.35**
Fish Spawning Habitat	0.05	0.12	0.05
Habitat for aquatic fauna	0.45	0.78	0.35

Function	HN_F_Mae_2	HN_F_Mae_3	HN_F_Mae_1
Habitat Provisions Functions	**0.25**	**0.45**	**0.20**
Fish Fauna Intact	0.23	0.23	0.00
Invertebrate Fauna Intact	0.21	0.23	0.18
Riparian Vegetation Intact	0.13	0.65	0.10
Biodiversity Provision Functions	**0.19**	0.37	**0.09**
SEV Score	**0.398**	**0.683**	**0.364**

Stream Mitigation Quantum Assumptions

A number of assumptions were made about the freshwater habitats within the proposed boundary to allow the calculation of the ECR ratios. These assumptions are listed below.

- The Auckland Council Overland Flow Path (OLFP) layer was used to estimate the extent of watercourses within the proposed designation boundary and under the indicative alignment.
- The OLFP can be used as a guidance for the permanence of the watercourse. Separating the watercourses into three contributing catchment sizes that can be correlated to permanence classification of; ephemeral (2000 m^2 to 4000 m^2); intermittent (4000 m^2 to 30,000 m^2); and permanent (30,000 m^2 and above). These are the basis of our assessment.
- The OLFP uses an algorithm to map these watercourses based on land contours, catchment size and
- Owing to the large scale of the Project it was not possible to ground-truth all of these OLFP watercourses.
- The SEV score used within the mitigation calculations was selected to be the closest to the average SEV score from all surveys within each section.
- Only one SEV was undertaken within the Warkworth North section.
- The SEVi-I score used was 0.2. This is considered the standard score of a culvert by Auckland Council.
- The SEVi-P score is calculated as the median stream within the section, with best practise mitigation planting to 10m.
- The SEVm-P score is the same as the SEVi-P score. This is because they are both based on a typical median stream within the section.
- The SEVm-C score is the median SEV score within the section.
- The diversion channels will have ecological value and function equivalent to that of the restored streams within each section.
- Stream widths (including diversions) was based on the average stream width recorded from all SEV surveys within each section.
- The area of the diversions was taken off the mitigation area required after the full calculation had been run.

- Stream diversions are assumed to have the same SEV function gain as restoration planting on existing streams. i.e. they do not go from an SEV of 0 to x, they are score at the current value of the median stream within each section.
- The ECR calculations include the 1.5 multiple time lag factor, as is standard.

Assumption Risk

- The OLFP tends to overestimate the length of stream present within flatter areas such as the Hōteo North.
- The OLFP tends to underestimated the length of stream present within steep areas such as within the Dome Valley Forest.
- During the survey of all streams prior to construction, the median SEV may be significantly different from that estimated from the current surveys. This may result in more mitigation restoration being required than is available within the proposed designation boundary. This is unlikely to happen owing to the highly conservative approach to the calculations that were undertaken.
- If stream widths are greater than those surveyed for this AEE, then the estimate of quantum of mitigation required may increase.

Macroinvertebrate Community Data

Table 49 – SEV Results from Surveys for the Project

Taxa	Site													
	WN_F_Koura_1	DVF_F_Koura_1	HN_F_TeHana_1	HN_F_TeHana_2	HN_F_TeHana_3	DVF_F_Hōteo_1	DVF_F_Hōteo_2-1	HN_F_Hōteo_1	HN_F_Hōteo_3	HN_F_Hōteo_4	HN_F_Mae_2	HN_F_Mae_3	HN_F_Mae_1	DVF_F_Hōteo_2-2
Ephemeroptera														
Acanthophlebia		4												
Austroclima						1	11	2						96
Coloburiscus		24				2	44							15
Deleatidium	2	68		96		13	126	1						816
Ichthybotus		7												8
Neozephlebia							44							1
Nesameletus		1												1
Zephlebia	22	316				74	53	17						384
Plecoptera														
Acroperla				1			1							
Spaniocerca						2								
Trichoptera														
Orthopsyche		7				9	15							7
Oxyethira				80					5		5			
Paroxyethira									1					
Polyplectropus	1													
Psilochorema	1				1	1	1							4
Pycnocentria								1						
Triplectides	15		1					7				1		
Zelandoptila	1					2	1							
Odonata														
Austrolestes			1											

Taxa	Site													
	WN_F_Koura_1	DVF_F_Koura_1	HN_F_TeHana_1	HN_F_TeHana_2	HN_F_TeHana_3	DVF_F_Hōteo_1	DVF_F_Hōteo_2-1	HN_F_Hōteo_1	HN_F_Hōteo_3	HN_F_Hōteo_4	HN_F_Mae_2	HN_F_Mae_3	HN_F_Mae_1	DVF_F_Hōteo_2-2
Xanthocnemis			1	30				3				4		
Antipodochlora	1													
Hemiptera														
Microvelia			3									1		
Megaloptera														
Archichauliodes						2	4							3
Coleoptera														
Elmidae		4				13	2	1						2
Hydraenidae						1								
Hydrophilidae	2	1	1	5	3					4			1	
Liodessus					2					19				
Ptilodactylidae		8												8
Scirtidae		1	1											
Staphylinidae														2
Diptera														
Austrosimulium	128		1	12	1	3	6	36			10	12		
Ceratopogonidae														2
Chironomus			2	21	1				80		3		11	
Corynoneura			2		2					2	1			
Culicidae			1							6				2
Eriopterini		2				7	8	1						2
Limonia														1
Molophilus	1												6	
Muscidae													1	
Orthocladiinae				7	11			4		4	6		7	3
Paradixa						1					1			11
Paralimnophila	2	1	1											
Polypedilum			13	3			2	7	16					15
Sciomyzidae												1		
Stratiomyidae				1							1	1		
Tabanidae		1				4								1
Tanypodinae	1	1		1										
Tanytarsini					1		1	2						
Tipulidae		1												
COLLEMBOLA	4	1	10	1	2					1	2	96		12
Crustacea														
Copepoda			3						48	13	3	2		
Halicarcinus								4						
Isopoda	1	2	1	6	1	2				4	16		1	2
Ostracoda			4	32	144				160	400	9	5	48	
Paracalliope	176	9	144	608			2	39			5	752		80
Paraleptamphopus		9	3	1	18								3	2
Paratya								2						
ACARINA	9	9	2	18	13	3	8	1	6	48	2	19	21	64
MOLLUSCA														
Latia								2						

Taxa	Site													
	WN_F_Koura_1	DVF_F_Koura_1	HN_F_TeHana_1	HN_F_TeHana_2	HN_F_TeHana_3	DVF_F_Hōteo_1	DVF_F_Hōteo_2-1	HN_F_Hōteo_1	HN_F_Hōteo_3	HN_F_Hōteo_4	HN_F_Mae_2	HN_F_Mae_3	HN_F_Mae_1	DVF_F_Hōteo_2-2
Lymnaeidae	4		2	1					1					
Physella (Physa)			2	5	10					54	3			
Potamopyrgus	160	8	256	112	121	4	3	118		41	6	224		64
Sphaeriidae	1				24					34		10		
OLIGOCHAETA	272		96	96	848	6	2	6	496	448	63	17	176	48
HIRUDINEA	1		10	3					5					
PLATYHELMINTHES	2		5	2			1		44	6	1	10		
RHABDOCOELA											1		22	
NEMATODA					5					2	1		12	1
NEMERTEA			1							2	3	5		
COELENTERATA														
Hydra				1					1		1	2		
Number of Taxa	22	22	26	24	18	19	20	19	12	17	21	17	12	29
Total individuals	807	485	567	1143	1208	150	335	254	863	1088	143	1162	309	1657

APPENDIX F: STREAM CHANNEL DIVERSION DESIGN

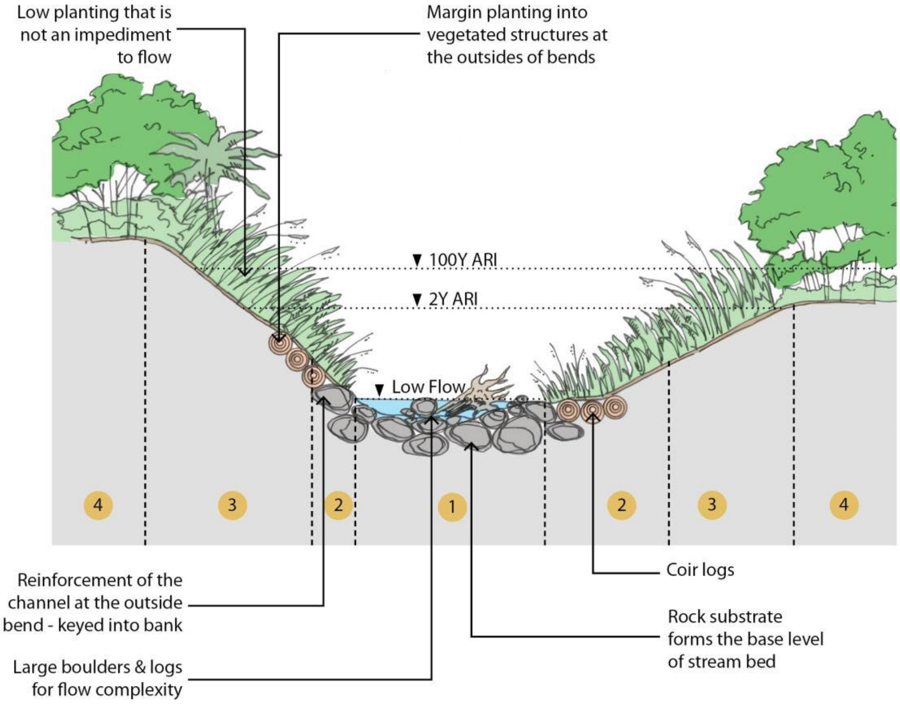


Figure.14 -Stream Diversion Type 1 – Lowland stream cross section

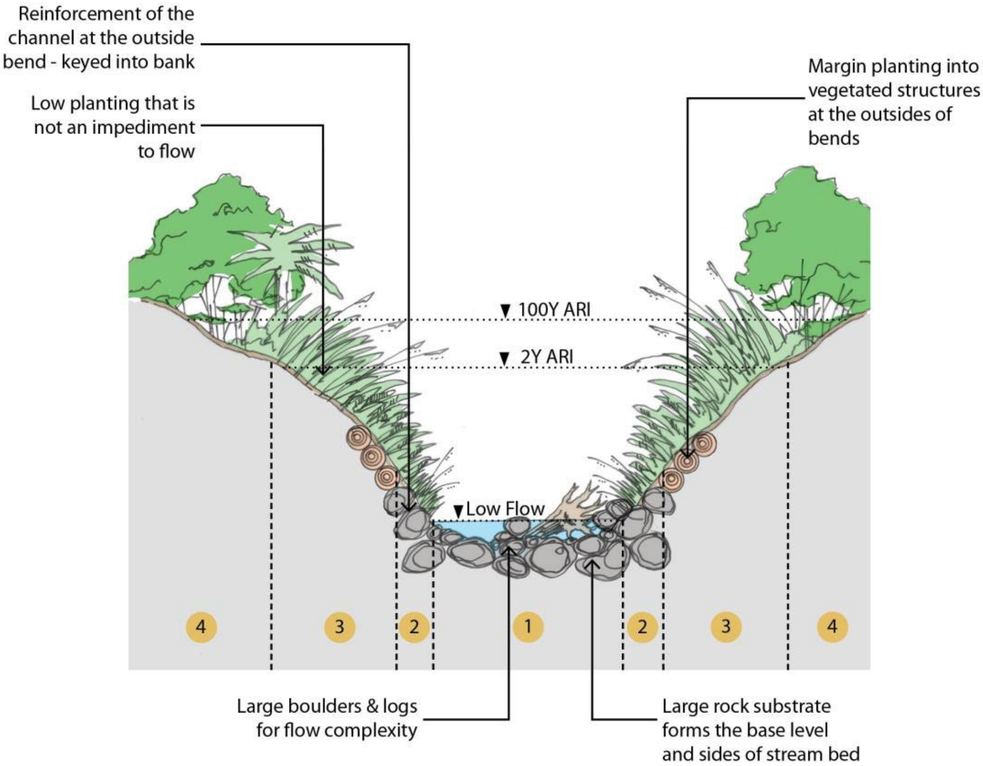
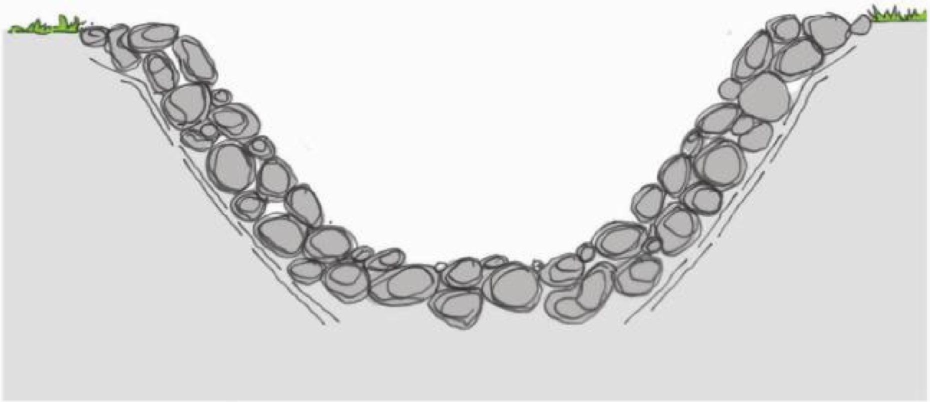
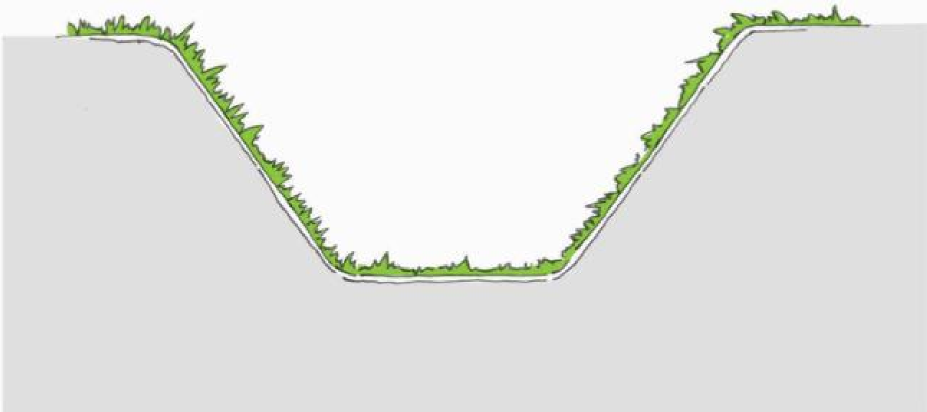


Figure 15 - Stream Diversion Type 2 – Steep stream cross section



Rock-Lined Flow Channel for High Flow and/or Steep Gradients



Grass-Lined Flow Channel for Low Flow and/or Flat Gradients

Figure 16 - Stream Diversion Type 3 – Flow channel cross section

APPENDIX G: VEGETATION MITIGATION PLANTING

Vegetation type	Value	Mahu	Koura	Hōteo	Te Hana	Total	Ratio	Mahu	Koura	Hōteo	Te Hana	Total
	Vegetation Loss (ha)#							Mitigation Planting (ha)				
Podocarp/ scrub	H-VH	0.00	0.03	0.85	0.00	0.88	6	0.00	0.18	5.10	0.00	5.28
Remainder	L-M	2.37	2.96	2.42	1.18	8.92	3	7.11	8.88	7.26	3.54	26.79
TOTAL						9.80						32.07
Wetlands	H-VH	0.00	0.39	0.26	0.00	0.65	6	0.00	2.34	1.56	0.00	3.90
Wetlands	L-M	0.00	0.66	0.57	1.22	2.45	3	0.00	1.98	1.71	3.66	7.35
TOTAL						3.10						11.25
TOTAL ALL						**12.90**						**43.32**

Notes:
Loss and mitigation planting numbers may vary slightly from figures in the text and Appendix H due to rounding errors.

APPENDIX H: VEGETATION AREAS WITHIN THE PROPOSED DESIGNATION AND AFFECTED BY THE INDICATIVE ALIGNMENT (IA).

Feature_ID_REVISED	Habitat	Notes	Area_Ha	Ecological Values	Affected by IA	Area Affected by IA	High - Vhigh Ecological Values effected by IA	Low-Mod Ecological Values effected by IA	Wetland Total	Wetland Area Effected by IA	Wetland High - Vhigh Ecological Values effected by IA	Low-Mod Wetland Ecological Values effected by IA
Dome Valley Section												
DVF_T_Hōteo _01	Exotic forest	Remnant plantation pine - Not surveyed	0.774	Low	No							
DVF_T_Hōteo _01	Exotic forest	Remnant plantation pine - Not surveyed	0.769	Low	Yes	0.769		0.769				
DVF_T_Hōteo _02	Manuka, kanuka scrub	Not Wetland? - High value - Surveyed from the boundary	10.432	Moderate	No							
DVF_T_Hōteo _03	Exotic forest	Bat Roost Potential - High	4.463	Moderate	No							
DVF_T_Koura_01	Kauri, podocarp, broadleaved forest	Native Vegetation 7	8.045	Very High	No							
DVF_T_Koura_01	Kauri, podocarp, broadleaved forest	Native Vegetation 7	0.029	Very High	Yes	0.029	0.029					
DVF_W_Koura_01	Exotic wetland	Wetland 25	0.838	Moderate	No				0.838			
Hōteo North Section												

Feature_ID_REVISED	Habitat	Notes	Area_Ha	Ecological Values	Affected by IA	Area Affected by IA	High - Vhigh Ecological Values effected by IA	Low-Mod Ecological Values effected by IA	Wetland Total	Wetland Area Effected by IA	Wetland High - Vhigh Ecological Values effected by IA	Low-Mod Wetland Ecological Values effected by IA
HN_T_Hōteo _01	Anthropogenic totara forest	Wetland 12	0.721	Low	No				0.721			
HN_T_Hōteo _01	Anthropogenic totara forest	Wetland 12	0.028	Low	Yes	0.028		0.028	0.028	0.028		0.028
HN_T_Hōteo _01	Anthropogenic totara forest	Wetland 12	0.342	Low	Yes	0.342		0.342	0.342	0.342		0.342
HN_T_Hōteo _02	Taraire, tawa, podocarp forest	Native Vegetation 6 - Surveyed in part	10.97	Very High	No							
HN_T_Hōteo _03a	Kahikatea, pukatea forest	Native Vegetation 5	1.825	High	No							
HN_T_Hōteo _03a	Kahikatea, pukatea forest	Native Vegetation 5	0.579	High	Yes	0.579	0.579					
HN_T_Hōteo _03b	Machaerina sedgeland	Native Vegetation 5	0.492	Moderate	No							
HN_T_Hōteo _03b	Machaerina sedgeland	Native Vegetation 5	0.259	Moderate	Yes	0.259		0.259				
HN_T_Hōteo _04	Kahikatea treeland	Native Vegetation 10	0.148	Low	Yes	0.148		0.148				

Feature_ID_REVISED	Habitat	Notes	Area_Ha	Ecological Values	Affected by IA	Area Affected by IA	High - Vhigh Ecological Values effected by IA	Low-Mod Ecological Values effected by IA	Wetland Total	Wetland Area Effected by IA	Wetland High - Vhigh Ecological Values effected by IA	Low-Mod Wetland Ecological Values effected by IA
HN_T_Hōteo _05	Kahikatea treeland	Native Vegetation 11 - Surveyed from roadside	0.075	Low	No							
HN_T_Hōteo _05	Kahikatea treeland	Native Vegetation 11 - Surveyed from roadside	0.047	Low	Yes	0.047		0.047				
HN_T_Hōteo _06	Kauri, podocarp, broadleaved forest	Native Vegetation 4 - Surveyed from roadside	0.487	Moderate	Yes	0.487		0.487				
HN_T_Hōteo _07a	Kauri, podocarp, broadleaved forest	Native Vegetation 3 - Surveyed from boundary	0.682	Low	No							
HN_T_Hōteo _07a	Kauri, podocarp, broadleaved forest	Native Vegetation 3 - Surveyed from boundary	0.113	Low	Yes	0.113		0.113				
HN_T_Hōteo _07b	Anthropogenic totara forest	Native Vegetation 3 - Surveyed from boundary	0.119	Low	No							

Feature_ID_REVISED	Habitat	Notes	Area_Ha	Ecological Values	Affected by IA	Area Affected by IA	High - Vhigh Ecological Values effected by IA	Low-Mod Ecological Values effected by IA	Wetland Total	Wetland Area Effected by IA	Wetland High - Vhigh Ecological Values effected by IA	Low-Mod Wetland Ecological Values effected by IA
HN_T_Hōteo _07b	Anthropogenic totara forest	Native Vegetation 3 - Surveyed from boundary	0.596	Low	Yes	0.596		0.596				
HN_T_Hōteo _08	Kahikatea forest	Native Vegetation 2	0.881	High	No							
HN_T_Hōteo _08	Kahikatea forest	Native Vegetation 2	0.27	High	Yes	0.27	0.27					
HN_T_TeHana_01a	Anthropogenic totara forest	Native Vegetation	0.238	Low	No							
HN_T_TeHana_01a	Anthropogenic totara forest	Native Vegetation	0.476	Low	Yes	0.476		0.476				
HN_T_TeHana_01b	Exotic wetland	Wetland 3 - Surveyed in part	0.521	Low	No				0.521			
HN_T_TeHana_01b	Exotic wetland	Wetland 3 - Surveyed in part	0.104	Low	Yes	0.104		0.104	0.104	0.104		0.104
HN_T_TeHana_02	Kauri, podocarp, broadleaved forest	Not surveyed	4.249	Moderate	No							

Feature_ID_REVISED	Habitat	Notes	Area_Ha	Ecological Values	Affected by IA	Area Affected by IA	High - Vhigh Ecological Values effected by IA	Low-Mod Ecological Values effected by IA	Wetland Total	Wetland Area Effected by IA	Wetland High - Vhigh Ecological Values effected by IA	Low-Mod Wetland Ecological Values effected by IA
HN_T_TeHana_02	Kauri, podocarp, broadleaved forest	Not surveyed	0.707	Moderate	Yes	0.707		0.707				
HN_W_Hōteo _01	Flaxland	Wetland 11	0.408	High	No				0.408			
HN_W_Hōteo _01	Flaxland	Wetland 11	0.258	High	Yes	0.258	0.258		0.258	0.258	0.258	
HN_W_Hōteo _02	Kahikatea forest	Wetland 9	2.854	Very High	No				2.854			
HN_W_Hōteo _03	Exotic wetland	Hōteo _7_Wetland	0.242	Low	No				0.242			
HN_W_Hōteo _03	Exotic wetland	Hōteo _7_Wetland	0.202	Low	Yes	0.202		0.202	0.202	0.202		0.202
HN_W_TeHana_01	Exotic wetland	TeHana_1_Wetland	1.669	Low	No				1.669			
HN_W_TeHana_01	Exotic wetland	TeHana_1_Wetland	0.5	Low	Yes	0.5		0.5	0.5	0.5		0.5
HN_W_TeHana_02	Exotic wetland	Wetland 2	0.005	Low	No				0.005			
HN_W_TeHana_02	Exotic wetland	Wetland 2	0.616	Low	Yes	0.616		0.616	0.616	0.616		0.616
Warkworth North Section												

Feature_ID_REVISED	Habitat	Notes	Area_Ha	Ecological Values	Affected by IA	Area Affected by IA	High - Vhigh Ecological Values effected by IA	Low-Mod Ecological Values effected by IA	Wetland Total	Wetland Area Effected by IA	Wetland High - Vhigh Ecological Values effected by IA	Low-Mod Wetland Ecological Values effected by IA
WN_T_Koura_01a	Kahikatea, pukatea forest	Wetland 18 - Surveyed from boundary	0.307	High	No				0.307			
WN_T_Koura_01a	Kahikatea, pukatea forest	Wetland 18 - Surveyed from boundary	0.267	High	Yes	0.267	0.267		0.267	0.267	0.267	
WN_T_Koura_01b	Exotic forest	Wetland 18 - Surveyed from boundary	1.891	Low	No				1.891			
WN_T_Koura_01b	Exotic forest	Wetland 18 - Surveyed from boundary	0.098	Low	Yes	0.098		0.098	0.098	0.098		0.098
WN_T_Koura_01c	Kanuka scrub/forest	Wetland 18 - Surveyed from boundary	2.601	Moderate	No				2.601			
WN_T_Koura_01c	Kanuka scrub/forest	Wetland 18 - Surveyed from boundary	0.332	Moderate	Yes	0.332		0.332	0.332	0.332		0.332

Feature_ID_REVISED	Habitat	Notes	Area_Ha	Ecological Values	Affected by IA	Area Affected by IA	High - Vhigh Ecological Values effected by IA	Low-Mod Ecological Values effected by IA	Wetland Total	Wetland Area Effected by IA	Wetland High - Vhigh Ecological Values effected by IA	Low-Mod Wetland Ecological Values effected by IA
WN_T_Koura_02	Kanuka forest	Native Vegetation 9 - Surveyed in part	25.314	Moderate	No							
WN_T_Koura_02	Kanuka forest	Native Vegetation 9 - Surveyed in part	2.925	Moderate	Yes	2.925		2.925				
WN_T_Koura_02	Kanuka forest	Native Vegetation 9 - Surveyed in part	0.032	Moderate	Yes	0.032		0.032				
WN_T_Koura_03	Kahikatea, pukatea forest	Upstream Wetland 16 - Not surveyed	1.328	Moderate	No				1.328			
WN_T_Mahu_01	Kauri, podocarp, broadleaved forest	Adjacent SEA 7 - Not surveyed	16.47	Moderate	No							
WN_T_Mahu_02	Kauri, podocarp, broadleaved forest	Native Vegetation 8 - Surveyed	2.76	Moderate	No							
WN_T_Mahu_02	Kauri, podocarp, broadleaved forest	Native Vegetation 8 - Surveyed	1.77	Moderate	Yes	1.77		1.77				
WN_T_Mahu_03	Kauri, podocarp, broadleaved forest	Not surveyed	0.237	Moderate	No							

Feature_ID_REVISED	Habitat	Notes	Area_Ha	Ecological Values	Affected by IA	Area Affected by IA	High - Vhigh Ecological Values effected by IA	Low-Mod Ecological Values effected by IA	Wetland Total	Wetland Area Effected by IA	Wetland High - Vhigh Ecological Values effected by IA	Low-Mod Wetland Ecological Values effected by IA
WN_T_Mahu_03	Kauri, podocarp, broadleaved forest	Not surveyed	0.57	Moderate	Yes	0.57		0.57				
WN_T_Mahu_04	Kauri, podocarp, broadleaved forest	Bioresearches Site 8 - Not surveyed	0.753	Moderate	No							
WN_T_Mahu_04	Kauri, podocarp, broadleaved forest	Bioresearches Site 8 - Not surveyed	0.025	Moderate	Yes	0.025		0.025				
WN_W_Koura_01	Exotic wetland	Wetland 19	0.901	Moderate	No				0.901			
WN_W_Koura_01	Exotic wetland	Wetland 19	0.223	Moderate	Yes	0.223		0.223	0.223	0.223		0.223
WN_W_Koura_02	Raupo reedland	Wetland 17A	0.759	Very High	No				0.759			
WN_W_Koura_03	Exotic wetland	Wetland 17	1.1	Moderate	No				1.1			
WN_W_Koura_03	Exotic wetland	Wetland 17	0.006	Moderate	Yes	0.006		0.006	0.006	0.006		0.006
WN_W_Koura_04	Exotic wetland	Wetland 16	0.822	Moderate	No				0.822			
WN_W_Koura_05	Raupo reedland	Wetland 24	0.456	High	No				0.456			
WN_W_Koura_05	Raupo reedland	Wetland 24	0.119	High	Yes	0.119	0.119		0.119	0.119	0.119	

Feature_ID_REVISED	Habitat	Notes	Area_Ha	Ecological Values	Affected by IA	Area Affected by IA	High - Vhigh Ecological Values effected by IA	Low-Mod Ecological Values effected by IA	Wetland Total	Wetland Area Effected by IA	Wetland High - Vhigh Ecological Values effected by IA	Low-Mod Wetland Ecological Values effected by IA
		Total All Vegetation	118.33			12.90	1.52	11.38	20.52	3.10	0.64	2.45
		Vegetation minus wetlands	97.81			9.80	**0.88**	**8.92**				
		Wetlands	20.52							3.10	**0.64**	**2.45**