Assessment of Ecological Effects – Invertebrates

December 2017

Landcare Research

Technical Report 7c

NZ TRANSPORT AGENCY WAKA KOTAHI

Mt Messenger Bypass

New Zealand Government

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Contents

Glossary

Term	Meaning
AEE	Assessment of Effects on the Environment Report
AWA	Additional works area
DOC	Department of Conservation
Eastern Ngāti Tama forest block	The area of land largely owned by Ngāti Tama located east of existing SH3, including the Project footprint, approximately 3,098ha in size
EcIA guidelines	Environmental Impact Assessment guidelines
EIANZ	Environment Institute of Australia and New Zealand
ELMP	Ecology and Landscape Management Plan
North Taranaki Ecological District	Part of the Taranaki Ecological Region, encompasses approximately 259,750ha, including the Project footprint
Parininihi	The area spanning the Waipingao Stream catchment located to the west of existing SH3, approximately 1,332ha in size
Project	The Mt Messenger Bypass project
Project footprint	The Project footprint includes the road footprint (i.e. the road and its anticipated batters and cuts, spoil disposal sites, haul roads and stormwater ponds), and includes the Additional Works Area (AWA) and 5m edge effects parcel.
RMA	Resource Management Act 1991 and amendments
RTC	Residual trap catch
SH3	State Highway 3
Transport Agency	New Zealand Transport Agency
TRC	Taranaki Regional Council
Wider Project area	An area approximately 4,430ha in size which encompasses Parininihi and the Ngāti Tama Eastern forest block, and includes the Project footprint.

Executive Summary

The New Zealand Transport Agency (Transport Agency) is proposing to develop a new section of SH3, north of New Plymouth, to bypass the existing steep, narrow and winding section of highway at Mt Messenger. The Mt Messenger Bypass project (the Project) comprises a new section of two lane highway, some 6km in length, located to the east of the existing SH3 alignment.

The overarching ecological aim for the Project is to ensure no net loss of biodiversity values, or to achieve a net benefit of biodiversity values, in the medium term.

To assess the ecological effects of the Project on terrestrial invertebrates, this report:

a Identifies and describes values of terrestrial invertebrates in the Project footprint and wider Project area;

b Describes the potential effects of the Project on terrestrial invertebrates arising from construction, operation and maintenance, and

c Recommends measures to avoid, remedy or mitigate potential adverse effects.

A number of adverse ecological effects on terrestrial invertebrates (and other ecological values) have been avoided through the selection of the Project alignment avoiding Parininihi. Further avoidance, and reduction of effects, has occurred through the alignment optimisation process (which is ongoing). The potential adverse direct effects of the Project on the terrestrial invertebrate communities are most likely to occur during the construction phase and vegetation removal. Including vegetation loss associated with construction, the Project footprint will result in the loss of a total of 44.4ha which is indigenous dominant or mixed exotic/ indigenous dominant. Within this area 19.466ha of primary vegetation communities are present, and 13.826 and 11.117ha of secondary scrub/forest and rushland, sedgeland mosaic respectively.

The assessments in this report are based on a detailed desktop literature and database review, discussions with experts, and limited habitat assessment of Parininihi (in the Waipingao catchment) and across parts of the Project footprint.

The invertebrate fauna is 'typical' of communities inhabiting native forests of the southern North Island and northern South Island. No invertebrate species identified or found in the wider Project area are on the Threatened Species List. However, this result may be due, at least in part, to limited studies. While not expected, it is possible that invertebrate species that are of conservation value are present within the Project footprint. However, the likelihood of this occurring is low and the amount of vegetation loss (44.4ha) is approximately 1% of the forest within the wider Project area (4,430ha). Any loss associated with the Project is therefore likely to have a minimal effect on any local population.

This assessment has been carried out on a conservative, precautionary basis. Accordingly, the ecological value of the Project footprint for terrestrial invertebrates is assessed as 'High' (despite no 'threatened' or 'at risk' species being present or expected to be present within the Project footprint). The unmitigated magnitude of effect is classified as 'Low' to 'Moderate' (despite approximately 1% of the available habitat in the wider Project area being affected by the Project). A 'value' assessment of 'High' combined with an unmitigated 'magnitude of effects' assessment of ‘Low’ to 'Moderate' correlates to an conservative overall level of unmitigated effects of 'High', when applying Step 3 of the EcIA guidelines.

The actual unmitigated effects of the Project on terrestrial invertebrates are likely to be lower than what has been conservatively assumed because:

- The invertebrate fauna is ‘typical’ of communities inhabiting native forests of southern North Island and northern South Island.
- The ecological condition of the forest within the proposed route is considered poorer, with fewer palatable plant species, compared to the nearby Parininihi.
- Approximately 1% of the available habitat in the wider Project area will be affected by the Project.
- It is likely that the taxa most affected by mammalian predation are already extinct in the Mt Messenger area.

In any event, a range of ecological mitigation and offset measures are proposed for the Project. These measures include pest control, habitat enhancement and restoration planting, as well as measures that specifically target invertebrates. As there is a strong correlation between invertebrate assemblages and habitat structure, enhancements to habitat quality will benefit invertebrates.

Overall, taking into account these measures, it is considered that any effects of the Project on invertebrates are likely to be negligible in the medium term.

1 Introduction

1.1 Purpose and scope of this report

This report forms part of a suite of technical reports prepared for the NZ Transport Agency's (Transport Agency) Mt Messenger Bypass project (the Project). Its purpose is to inform the Assessment of Effects on the Environment Report (AEE) and to support the resource consent applications and Notice of Requirement to alter the existing State Highway designation, which are required to enable the Project to proceed.

This report assesses the ecological effects on terrestrial invertebrates of the Project as shown on the Project Drawings (AEE Volume 2: Drawing Set).

To assess the ecological effects of the Project on terrestrial invertebrates this report will:

a Identify and describe terrestrial invertebrate habitat characteristics and values in:

   (i) the Project footprint (which is defined for the purposes of this assessment of effects on terrestrial invertebrates in section 2.3.2); and

   (ii) the wider Project area (Section 3);

b Describe the potential effects of the Project on terrestrial invertebrates arising from construction, operation and maintenance (Section 4); and

c Recommend measures to avoid, remedy or mitigate potential adverse effects.

1.2 Project description

The Project involves the construction and ongoing operation of a new section of State Highway 3 (SH3), generally between Uruti and Ahititi to the north of New Plymouth. This new section of SH3 will bypass the existing steep, narrow and winding section of highway at Mt Messenger. The Project comprises a new section of two lane highway, approximately 6 km in length, located to the east of the existing SH3 alignment (Figure 1.1, Figure 1.2 and Figure 1.4).

The primary objectives of the Project are to enhance the safety, resilience and journey time reliability of travel on SH3 and contribute to enhanced local and regional economic growth and productivity for people and freight.

A full description of the Project including its design, construction and operation is provided in the AEE (Volume 1) and accompanying Drawing Set (Volume 2).

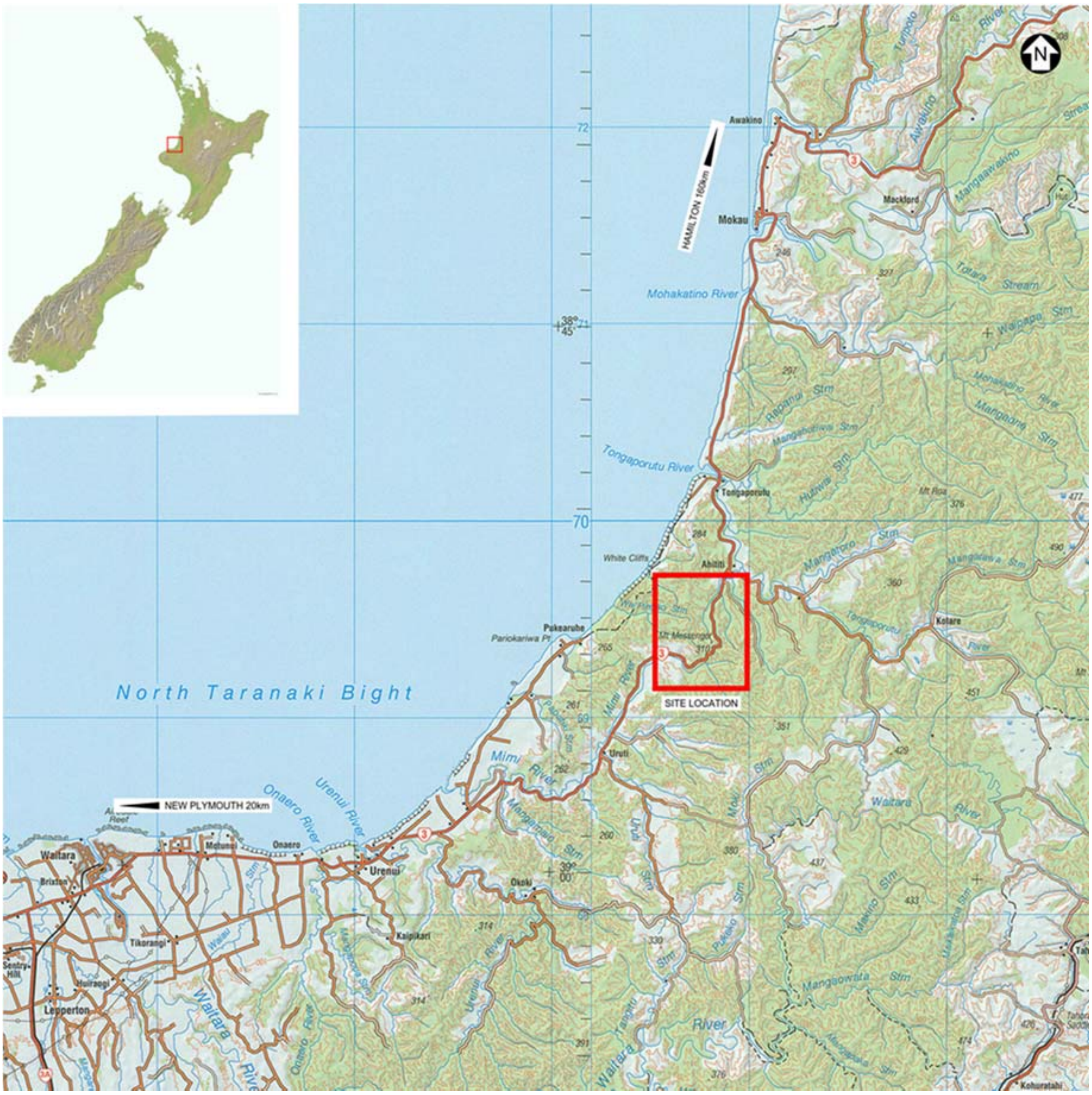

Figure 1.1 – Location of the Project in the Taranaki Region

1.3 Ecological aim for the Project

The overarching ecological aim for the Project is to ensure no net loss of biodiversity values, or to achieve a net benefit of biodiversity values, within the medium term. The ecologists engaged to provide advice and assessments in respect of the Project have been closely involved in recommending measures, including route selection and design features, to achieve this aim. The ecological aim for the Project will ultimately be achieved through a range of measures to avoid, remedy or mitigate effects on ecological values, including in particular through:

- A robust and transparent understanding of effects through detailed desktop and field assessments, as well as inputs from key stakeholders including Ngāti Tama, the Department of Conservation and New Plymouth District Council;
- Demonstrable efforts to avoid, remedy or mitigate potential adverse effects, through:

- The selection of a route option that avoids the generally higher ecological value land to the west of the existing SH3. The Project ecologists played an important role in the route selection process.
- The use of structures (i.e. a tunnel and bridge) to minimise habitat loss and severance.
- Within the Project footprint, alignment optimisations through changes to design and construction methodologies that produce the best ecological outcomes (e.g. avoidance of wetlands).
- Intensive monitoring programmes that minimise the potential for vulnerable species being harmed during road construction (e.g. radio-tracking of kiwi).
- Salvaging and relocation of important biodiversity values (e.g. lizards, large felled trees).
- The establishment and operation of a long term pest mammal control programme to mitigate for residual adverse effects on indigenous biodiversity values.

1.4 Background to the ecological assessment of the Project

In 2016, through the earlier stages of the Project, consideration of options for the Project focused on land located to the west of SH3 known as Parininihi (Figure 1.2). As a consequence, habitat assessments for terrestrial invertebrate communities focused on assessing ecological values to the west of SH3 along the previously proposed ‘MC23’ alignment (Figure 1.2).

Nonetheless, information gained from the initial surveys is relevant to this assessment because both the MC23 alignment and the Project footprint pass through broadly similar forest types and the distance between the two routes is relatively small (<5km).

Where possible, within seasonal survey constraints, an additional habitat assessment was undertaken along the Project footprint during the 2017 autumn period to augment the earlier habitat assessment information obtained to the west, and to inform the assessment of the likely nature and scale of effects of the Project. Importantly, the detailed vegetation mapping that has been undertaken for the Project footprint (as set out in the Assessment of Effects – Vegetation (Technical Report 7a, Volume 3 of the AEE)) provides a robust baseline habitat assessment for predicting the fauna species that are likely to be present.

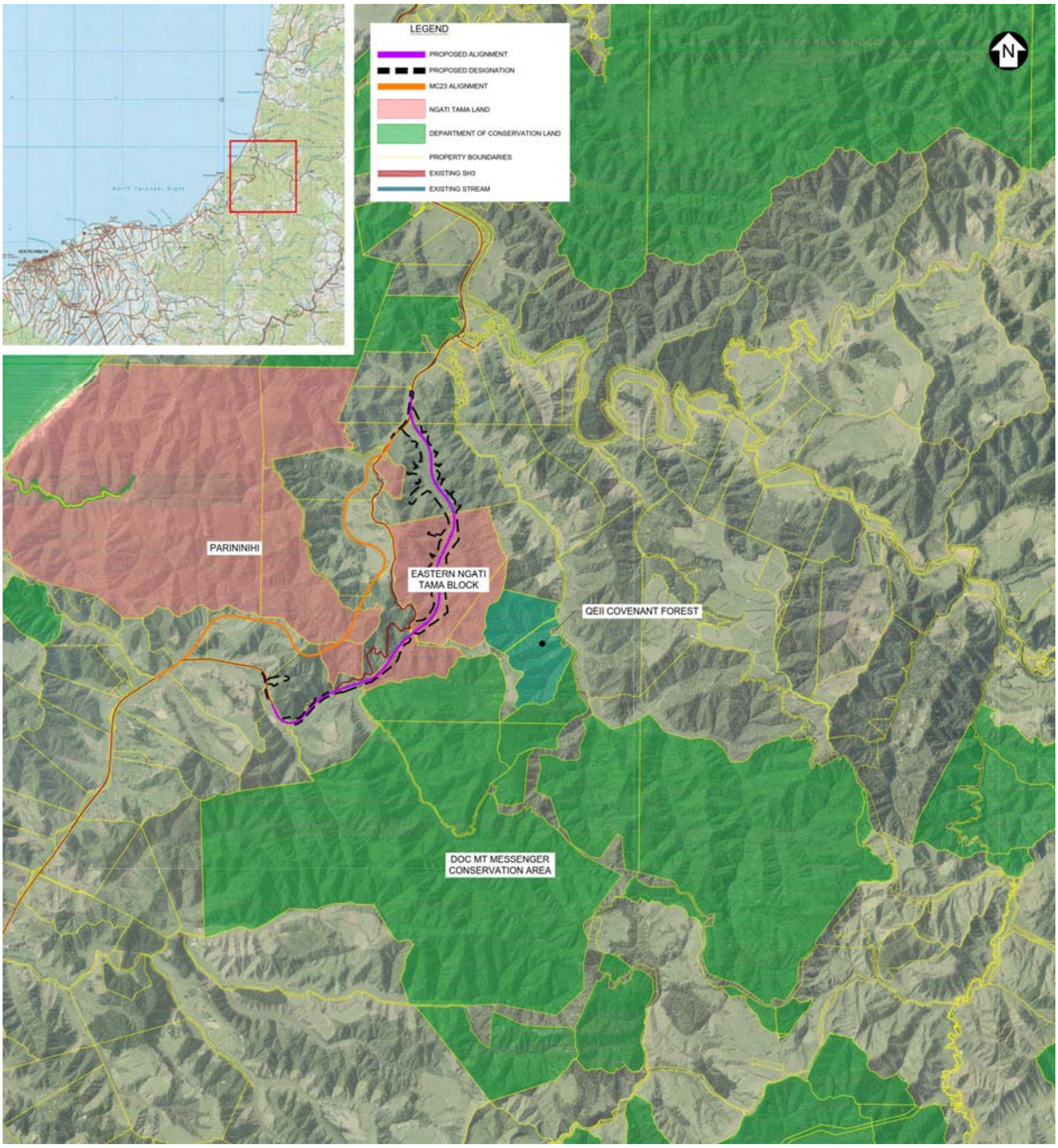

Figure 1.2 - The wider Project area, showing Parininihi and the previous MC23 alignment to the west of the existing SH3, and the Project footprint, Eastern Ngati Tama forest block to the east, with the Mimi River to the south and Mangapepeke Stream towards the north

Large parts of the Project footprint have been used for pastoral farming or have otherwise been subject to browsing and pugging impacts by unfenced stock, and feral goats and pigs. The land to the west of SH3, within Parininihi, has had the benefit of over 20 years of intensive pest management. Accordingly, the biodiversity values associated with Parininihi are recognised as being higher than those of the Project footprint.

In the absence of detailed baseline invertebrate community surveys undertaken during the optimal season within the Project footprint, it has been conservatively assumed that terrestrial invertebrate values within the Project footprint are comparable to values associated with Parininihi. While further survey work and invertebrate sampling surveys are proposed (Section 5.5), the information obtained from the habitat assessments obtained to date is appropriate for assessing the likely effects of the Project on invertebrate communities within and near the Project footprint.

1.5 The wider Project area

The Project is situated in the North Taranaki Ecological District[1] (Figure 3). The Ecological District includes a moderately diverse range of habitats, from stream flats and surrounding high productivity farmland to less developed steep hill country, through to high-diversity indigenous forest on hill country. The forest often occupies steep hillslopes with sparsely vegetated bluffs as well as a series densely vegetated interconnected ridge systems. Warm, humid summers and mild, wet winters create conditions suitable for dense broadleaved dominant forest with an abundance of lianes and epiphytic plants over mostly hill country land, and kahikatea, pukatea and swamp maire forest and associated wetlands in valley floor areas.

The wider Project area (Figure 1.2and Figure 1.4), within which the Project footprint is located, includes approximately 4,430ha of predominately indigenous forest, as well as farmland habitat. The indigenous forest includes:

- a contiguous area of 1,332ha of indigenous forest owned and managed by Ngāti Tama that is located to the immediate west of Mt Messenger known as Parininihi (see Section 1.5.1); and
- a contiguous forest (approximately 3,098ha in size) immediately adjacent to Mt Messenger and to the east of SH3 (see Section 1.5.2). This area is referred to as the Eastern Ngāti Tama forest block (but also includes public conservation land managed by the Department of Conservation (DOC) and private landowners).

[1] http://www.doc.govt.nz/Documents/science-and-technical/Ecoregions1.pdf

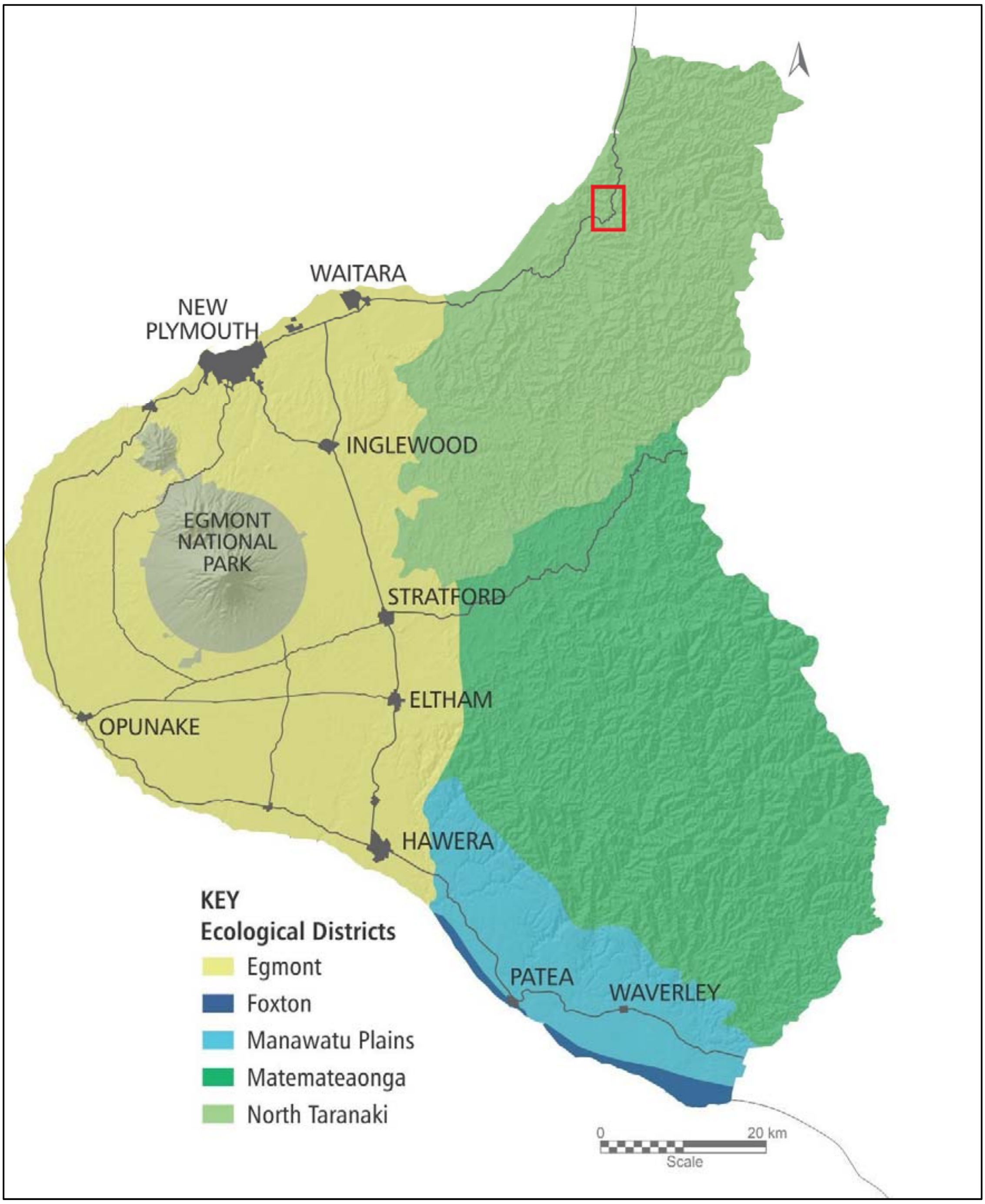

Figure 1.3 - Taranaki Ecological Districts (Taranaki Regional Council, 2017)

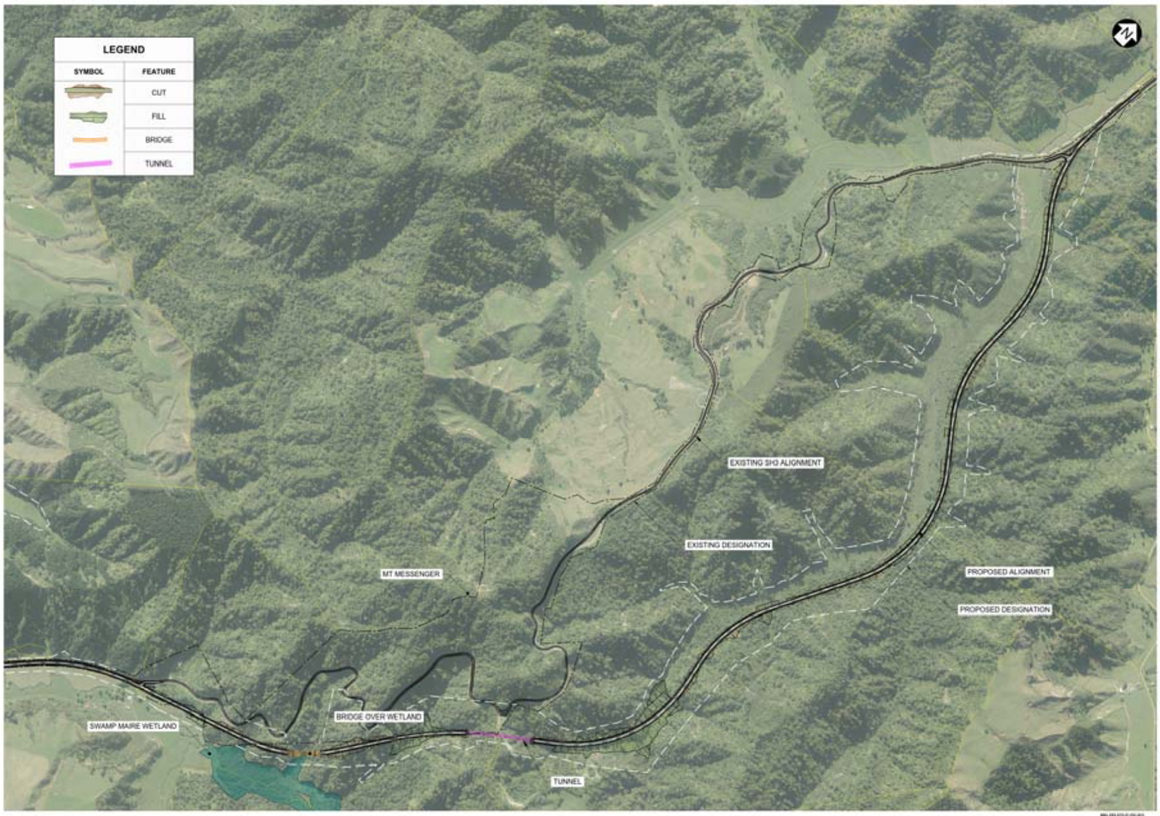

Figure 1.4 - The Project footprint, designation area and existing SH3

1.5.1 Parininihi

Parininihi, previously known as "Whitecliffs Conservation Area" is a large tract (1,332ha) of mainly primary forest centred on the Waipingao Stream catchment (Figure 1.2 and Figure 1.4). This area is classified as "Rimu tawa forest" within the New Zealand Forest Service class map (NZFSMS6). The area encompasses a rare continuous forest sequence through coastal, semi-coastal and lowland bioclimatic zones. As such, the area is regarded as being ecologically significant, and has been described as "the best example of primary coastal hardwood-podocarp forest on the west coast of the North Island" by eminent forest ecologist John Nicholls (Bayfield et al. 1991).

Ecological management of Parininihi was started in the early 1990s by the Department of Conservation, and involved possum and goat pest control activities. Since the return of this land to Ngāti Tama in 2003, management of these pests has continued, and control of rodents, mustelids and feral cats has also occurred. Consequently, the health and ecological integrity of the area is now improving, as evidenced by the regeneration of browse-sensitive plants. This is considered to have a corresponding positive habitat impact for invertebrates.

Parininihi (and all land to the west of the existing SH3) is being avoided by the Project footprint, following the route selection process carried out in 2017.

1.5.2 Eastern Ngāti Tama forest block

The Ngāti Tama forest Ngati Tama land to the east of the existing SH3 (Figure 1.2and Figure 1.4) primarily comprises forest, with some pasture farmland. The dominant forest to the east of the existing SH3 corridor is approximately 3,098ha (Figure 2) and would have originally been very similar forest type to the western part of Parininihi; however, it has not had consistent pest control. Consequently, the ecological condition of this area is poorer, with fewer palatable canopy trees remaining, such as thin-barked totara and northern rata.

Within the Mangapepeke Stream catchment (Figure 1.2) to the east of existing SH3, vegetation communities are more modified and have been affected by stock grazing, fire and logging. Of greatest ecological significance in this area is the hydrologically intact swamp forest (Figure 1.4) and non-forest wetland areas in the valley floor of the northern Mimi River catchment (Figure 1.4), which offers potential habitat for various terrestrial invertebrates. The valley floor sequence within the northern tributary of the Mimi River represents a full range of swamp forest, scrub and non-forest wetland communities.

2 Assessment methods

Terrestrial invertebrate community values within the wider Project area were assessed by reviewing existing information and data, and by undertaking field surveys along and near to the previously proposed MC23 alignment (Figure 1.2).

This report broadly follows Environmental Impact Assessment (EcIA) guidelines developed by the Environment Institute of Australia and New Zealand (EIANZ 2015). As described in Section 2.3, entomological professional judgement and expertise have also been applied in the assessment process to reflect good practice.

2.1 Desktop review

A desktop assessment was undertaken to review available information and data relating to the ecology of the Project footprint and the wider Project area. These included:

- Electronic databases of New Zealand entomological collections and all likely New Zealand sources of published accounts containing records of invertebrates found within the wider Project area at Mt Messenger were searched using the term “Mt Messenger”, “Mt Messenger” or “Messenger”. These databases included:
  - ‘BUGZ’ – A literature database of 16,080 articles on the terrestrial invertebrates of New Zealand, published since 1775;
  - Fauna of New Zealand Series (Appendix B);
  - New Zealand Arthropod Collection, Landcare Research, Auckland;
  - Auckland War Memorial Museum Entomology Collection, Auckland;
  - Museum of New Zealand Te Papa Tongarewa Entomology Collection, Wellington;
  - NatureWatch – an online tool to record biological observations throughout New Zealand; and
  - Hemideina (tree weta) species distributions, Landcare Research, Hamilton.
- Identifying areas within and surrounding the wider Project area that are listed as having significant ecological values including:
  - Parininihi; and
  - Mt Messenger Conservation Area
- Review of New Plymouth District Plan Appendix 21: Criteria for Significant Natural Areas.
- Consultation with specialist invertebrate taxonomists including:
  - Dr Richard Leschen, Landcare Research (Coleoptera);
  - Dr Marie-Claude Larivière, Landcare Research (Hemiptera and Carabidae);
  - Dr Robert Hoare, Landcare Research (Lepidoptera);
  - Dr Gary Barker, Landcare Research (Mollusca);
  - Dr Thomas Buckley, Landcare Research (Phasmatodea);
  - Mr Scott Bartlam, Landcare Research (Earthworms);

- Dr Phil Sirvid, Museum of New Zealand Te Papa Tongarewa (Araneae);
- Dr Richard Toft, Entecol Ltd, Nelson (Diptera);
- Dr Jo Berry, Consultant (Hymenoptera); and
- Mr Stephen Thorpe, Consultant (General invertebrates).

2.2 Field assessment methods

As described in section 1.4, baseline invertebrate community surveys along the Project footprint have not yet been undertaken due to seasonal constraints. Although many native New Zealand invertebrate taxa are active throughout the year, a number of studies have reported a higher diversity and abundance of invertebrates captured in summer and autumn than in winter and spring (Moeed & Meads 1984, 1985, 1987a, b). The optimal time for sampling invertebrate communities is between late November and February. Further surveys are therefore recommended, as discussed in detail in Section 5.5.

A site walkover of the Project footprint was undertaken on 26 July 2017 to assess habitat quality for invertebrates. This assessment, conducted by an invertebrate ecologist and senior ecologist, involved assessing habitat visually and documenting vegetation assessment values and vegetation types as described in the Assessment of Ecological Effects – Vegetation (Technical Report 7a, Volume 3 of the AEE). This approach was considered appropriate given the limitations involved in surveying invertebrates in winter. While traversing the Project footprint, invertebrates were searched for by turning over logs, but very few were found.

In addition, the previously proposed MC23 route, west of the current SH3 across the Waipingao Valley (Figure 1.2) was visited in February 2017 during the peak of invertebrate activity. While traversing the MC23 alignment, invertebrates were searched for by hand, by turning over logs, and by digging soil pits (30cm in depth). All invertebrates found were preserved in 70% ethanol, and where possible, given species-level identifications.

2.3 Assessment of effects methodology

The assessment of ecological effects broadly follows the EcIA guidelines (EIANZ, 2015), with some adaptation, including to allow for the expert opinion of entomological specialists to be applied within the context of the EIANZ framework.[2]

The EIANZ framework is useful in it enables effects to be assessed in a systematic and transparent way. EIANZ is currently undertaking a review of existing guidelines.

[2] In terms of the EIANZ process steps, Step 4, which provides for the overall level of effects to be translated to an "RMA effect" has been omitted. The rationale for this includes that it is considered more appropriate / straightforward for ecological effects to be expressed in the high / moderate / low terms used in the other EIANZ steps.

2.3.1 Assessment of Ecological Values (Step 1)

Ecological values were assigned a level on a scale of ‘Low’, ‘Moderate’, ‘High’ or ‘Very High’ based on assessing the values of species, communities, and habitats identified against criteria set out in the EcIA guidelines (Table 2.1).

Table 2.1 – Assignment of values within the wider Project area to species, vegetation and habitats (adapted from EIANZ, 2015). Note that the ecological value assigned to each species was based on criteria set out in the column ‘Species Value requirements’ only.

Value	Species value requirements	Vegetation/habitat value requirements
Very High	Nationally ‘Threatened’ species occur or expected to occur within the Project footprint	Meets most of all of the ecological significance criterion as set out in relevant statutory policies and plans.
High	Nationally ‘At Risk’ species occur or expected to occur	Meets one of some of the ecological significance criterion as set out in relevant statutory policies and plans
Moderate	No Nationally Threatened or At Risk species occur, but locally uncommon or rare species, or keystone species (that are considered important for ecological integrity and function) present	Habitat type does not meet ecological significance criteria as set out in the relevant statutory policies and plans but does provide locally important ecosystem services (e.g. erosion and sediment control, and landscape connectivity)
Low	No species present that are Nationally Threatened, At Risk, locally uncommon or rare, or considered keystone species	Nationally or locally common habitat and that does not provide locally important ecosystem services

2.3.2 Magnitude of unmitigated Effect assessment (Step 2)

Step 2 of the EcIA guidelines requires an evaluation of the unmitigated magnitude of effects on local ecological values based on footprint size, intensity and duration. The unmitigated ‘Magnitude of the Effect’ that the Project is expected to have on species found in the Project footprint is evaluated as being either ‘No Effect’, ‘Negligible’, ‘Low’, ‘Moderate’, ‘High’ or ‘Very High’ (see Table 2.2).

The unmitigated ‘Magnitude of Effect’ is a function of:

- The scale of unmitigated effect per se (i.e. the areal extent of the Project footprint);
- The proportion of habitat loss versus local availability (e.g. the proportion of habitat loss relative to the contiguous habitat that remains);
- The duration of effect (e.g. permanent versus temporary); and
- The intensity of the unmitigated effect (i.e. the extent to which habitat loss within the Project footprint was complete or partial).

The ‘Project footprint’ is the principal spatial zone, where the direct effects of the Project on ecology were considered to occur (see detailed plans in Volume 2 of the AEE). The Project footprint includes:

- the road footprint (i.e. the road and its anticipated batters and cuts, spoil disposal sites, haul roads and stormwater ponds);
- an Additional Works Area (AWA), accounting for additional habitat loss for construction access, laydown areas and temporary stormwater drains (see more detail in Volume 2: Drawing Set); and
- a 5m edge effects parcel.

Note that the AWA is smaller in habitats with ‘High’ ‘Ecological Values’ because temporary work activities will be focused on the road footprint and immediately adjacent areas, and more precautions will be taken in managing construction effects, in order to mitigate potential adverse effects on the surrounding habitat. These measures will be set out in the Construction and Environmental Management Plan (Volume 5 of the AEE), which will include the Ecology and Landscape Management Plan.

The inclusion of the 5m edge effects parcel in the Project footprint accounts for the degradation of habitat suitability in close proximity to the direct effects footprint through edge effects. The creation of new edges where existing vegetation is removed is known to alter micro-climatic conditions (e.g. through increased exposure to temperature extremes, desiccation, and wind) with potential adverse effects on both habitat suitability and availability for a number of species (Young & Mitchell 1994; Davis-Colley *et al.* 2000). Moreover, a variety of other factors, including invasion of weeds and occupancy of mammalian predators and browsers are generally considered to be higher in edge habitats (Murcia 1995; Lahti 2009) though evidence for higher predation rates is mixed (Ruffell *et al.* 2014). While edge effects are do not result in the direct clearance of vegetation for the purposes of calculating offset the 5m edge has been included in the calculation as though it were a direct total loss.

Table 2.2 – Summary of the criteria for describing the magnitude of unmitigated effect as adapted from EcIA guidelines (EIANZ, 2015).

Magnitude of effect	Description
Very High	Total loss or major alteration of the existing baseline conditions; Total loss or loss of a very high proportion of the known population or range
High	Considerable loss or alteration of existing baseline conditions; Loss of high proportion of the known population or range
Moderate	Moderate loss or alteration to existing baseline conditions; Loss of a moderate proportion of the known population or range
Low	Minor shift away from existing baseline conditions;

Magnitude of effect	Description
	Minor effect on the known population or range
Negligible	Very slight change from the existing baseline conditions; Negligible effect on the known population or range

2.3.3 Level of effects assessment in the absence of mitigation (Step 3)

Step 3 of the EcIA guidelines requires the overall level of effect to be determined using a matrix that is based on the ecological values and the magnitude of effects on these values **in the absence of any efforts to avoid, remedy or mitigate for potential effects.** Level of effect categories include 'No Ecological Effect', 'Very Low', 'Low', 'Moderate', 'High' and 'Very High'. Table 2.3 shows the EcIA matrix outlining criteria to describe the overall level of ecological effects. Entomological professional judgement and expertise have also been applied in the assessment process to reflect good practice.

Table 2.3 – Criteria for describing overall levels of unmitigated ecological effects as adapted from EcIA guidelines (EIANZ, 2015).

Magnitude of effect	Ecological Value			
	Very High	High	Moderate	Low
Very High	Very High	Very High	High	Moderate
High	Very High	High	Moderate	Low
Moderate	High	High	Moderate	Low
Low	Moderate	Low	Low	Very Low
Negligible	Low	Very Low	Very Low	Very Low
No effect	No ecological effect	No ecological effect	No ecological effect	No ecological effect

3 Desktop survey and habitat assessment results

3.1 Terrestrial invertebrate desktop review results

As with many parts of New Zealand, there is a paucity of entomological knowledge around the wider Project area and the Mt Messenger area. In addition, the taxonomic knowledge of New Zealand terrestrial invertebrates is very uneven across major groups. Large-bodied invertebrate groups (e.g. weta) are better known than small and cryptic species. Moreover, only a small proportion of the records from New Zealand's entomological collections are electronically databased and therefore readily accessible.

The Mt Messenger area has, however, been suggested as a 'transitional zone' for invertebrate species, lying at both the northern limit of southern population ranges, and at the southern limit of northern population ranges. The area consequently supports a diverse invertebrate fauna. The area is distinctive in that it is one of the few North Island localities where a number of taxa that have predominately northern South Island distributions are also present (Taranaki Regional Council 2006; Marske et. al. 2012; Leschen & Buckley 2015).

3.1.1 Invertebrate database searches (NZ insect collections) and published literature

A search of databases and published literature found a total of 179 invertebrate taxa recorded in the vicinity of Mt Messenger (Appendix B). While the exact location of these recorded taxa is unknown (in terms of whether they originate from within the Mt Messenger Conservation Area or the wider Project area), the precise locality of each specimen record is noted as "Mt Messenger". It is therefore assumed that these species are likely to be present in the wider Project area, and potentially within the Project footprint.

No records were found of invertebrate community surveys being carried out within the Mt Messenger area, and all specimen records found were from taxonomists surveying for particular invertebrate groups.

Ten taxa recorded at Mt Messenger were 'holotypes' (a single specimen upon which the description and name of a new species is based) in either the New Zealand Arthropod Collection, Auckland War Memorial Museum Entomology Collection or Museum of New Zealand Te Papa Tongarewa Entomology Collection.

The presence of taxa recorded in Appendix B is discussed further in relation to taxonomic groups in Section 3.1.2 below.

3.1.2 Information obtained from specialist taxonomists

Feedback from specialist taxonomists regarding each faunal group investigated is discussed below.

3.1.2.1 Earthworms

Only one species of the native earthworm, *Rhododrilus benhami,* has been recorded at Mt Messenger during one survey in 1950 (Lee, 1959). This taxon is classified as 'Not Threatened' (Buckley 2015).

3.1.2.2 Araneae (spiders)

Five species of spiders have been recorded at Mt Messenger (Appendix B). There are no threatened species recorded from the area but only limited surveys have been conducted in this location (Sirvid et al. 2012; Sirvid, pers. comm., 2017).

3.1.2.3 Coleoptera (beetles)

A total of 51 beetle taxa have been recorded from Mt Messenger (Appendix B). This fauna is typical of the beetle community from native tawa-rewarewa-kamahi forests (Leschen, pers. comm., 2017). There are a number of beetle species (e.g. *Syrphetodes marginatus, Epistranus lawsoni, Pristoderus bakewelli, Brachynopus scutellaris,* and *Hisperonia hystrix*) collected from Mt Messenger that have widespread North Island and northern South Island distributions (Marske et al. 2012; Leschen & Buckley 2015).

Twelve species of ground beetles (Carabidae) have been found at Mt Messenger (Appendix B), with 11 being endemic taxa with widespread distributions in New Zealand. Two taxa (*Parabaris lesagei* and *Selenochilus omalleyi*) are only known from eight populations in the North Island (Larochelle & Larivière 2005, 2013). Therefore, Mt Messenger is a significant site for these species (Larivière, pers. comm., 2017).

None of the species known from Mt Messenger are classified as threatened (Leschen et al. 2012). Mt Messenger is the type locality of three species of staphylinids, including two species of deadwood osoriines in the genus *Paratrochus*, which are common in deadwood (McColl 1982), and *Stenosogala ramsayi*, a leaf litter pselaphine (Leschen, pers. comm., 2017). All of these species have populations either widespread in the southern North Island and northern South Island or with populations elsewhere in the Taranaki and/or Waikato Regions.

3.1.2.4 Diptera (flies)

Little is known regarding the fly communities at Mt Messenger but there are currently no threatened species known from that location (Toft, pers. comm., 2017).

3.1.2.5 Hemiptera (plant bugs)

A total of 20 Hemipteran taxa from Mt Messenger have been recorded in the databased entomological collections (Appendix B). The majority (85%) of species are endemic taxa but their distribution is considered widespread. A species to note is Cyrtorhinus cumberi, an endemic Hemipteran only known from a few populations. This suggests Mt Messenger is an important site for this species (Larivière, pers. comm., 2017). Another species to note is Mniovelia kuscheli. This endemic monotypic genus also has Mt Messenger as the type locality. Mesoveliidae plant bugs are mostly aquatic insects living on the surface of water but Mniovelia is one among few genera of terrestrial mesoveliids that live on terrestrial substrates saturated with water (Larivière, pers. comm., 2017).

3.1.2.6 Hymenoptera (social insects)

Nineteen species of Hymenoptera are known from databased entomological collections in New Zealand (Appendix B). A number of type specimens for their species were collected from Mt Messenger including *Archaeoteleia karere, Rotoita basalis*, and *Parabetyla tahi*. These are all endemic wasps found in the northern North Island.

3.1.2.7 Lepidoptera (butterflies and moths)

A total of 46 Lepidoptera are known from Mt Messenger (Appendix B). All are macro-moths collected by J.S. Dugdale in the late 1960s, and there have been no recent surveys. The lack of records of many abundant and ubiquitous forest species, eg *Rhapsa scotosialis* (Erebidae), indicates that the survey was very incomplete and unlikely to have included sufficient sampling effort to reveal rarer species (Hoare, pers. comm., 2017). Despite this, the Lepidopteran fauna appears to be dominated by endemic species that are typical of lowland North Island forest.

The forest ringlet (*Dodonidia helmsii*), one of New Zealand's rarest butterflies, has been recorded at Waitaanga (approximately 17km northwest of Mt Messenger) and at Uruti (approximately 6km south of Mt Messenger) in the 1990's (Wheatley 2017; Museum of New Zealand Te Papa Tongarewa Entomology Online Collection).

3.1.2.8 Mollusca (snails and slugs)

Twenty-five snail taxa have been recorded from Mt Messenger, all of which are in the Museum of New Zealand Te Papa Tongarewa Entomology Collection database (Appendix B). The snail fauna recorded from Mt Messenger is typical of communities found in native forests of the North Island. There are no known threatened species associated with Mt Messenger, although the area has not been thoroughly surveyed (Barker, pers. comm., 2017).

3.1.2.9 Orthoptera (weta and grasshoppers)

Hemideina thoracica (Auckland tree weta) has been recorded from Mt Messenger (Appendix B). This tree weta is common in northern North Island forests. While no records exist for cave and ground weta from Mt Messenger, they are likely to occur there because of their wide distribution.

3.1.2.10 Phasmatodea (stick insects)

The common stick insect (*Clitarchus hookeri*) has been found at Mt Messenger. This is a frequent species in native forest found throughout New Zealand. Another species of native stick insect known from Mt Messenger is *Asteliaphasma jucundum*. This record is noteworthy as Mt Messenger is the most southern location in which this taxon has been found (Buckley, pers. comm., 2017).

3.1.2.11 Phthiraptera (lice)

One species of chewing louse (*Apterygon mirum*) is known from Mt Messenger (Appendix B). This endemic species of louse has only been recorded from the feathers of the North Island brown kiwi (*Apteryx mantelli;* Palma et al. 2004).

3.1.2.12 Onychophora (peripatus)

Currently no species of peripatus are known from Mt Messenger. Should they exist at Mt Messenger, the most likely species of peripatus at Mount Messenger would be *Peripatoides novaezealandiae*. This ovoviviparous (producing young by means of eggs which are hatched within the body of the parent) taxa is widely distributed throughout New Zealand. However, it appears that *P. novaezealandiae* is actually a species complex, which is currently under revision.

3.2 Terrestrial invertebrate habitat assessment results

3.2.1 MC23 site walkover

On 22 February 2017, two transects were walked by Dr Corinne Watts and Dr Liz Deakin near or on the preliminary 'MC23' route (Figure 3.1) in Parininihi and the Waipingao catchment. A total of 17 invertebrate taxa were observed while walking these transects (Appendix C). The taxa observed were either already known from the Mt Messenger area or expected to be found there. One exception was the spiny longhorn beetle (*Blosyropus spinosus*). This species is considered rare but is probably seldom encountered, rather than threatened (McGuinness 1998).

The leaf litter throughout was deep (> 5cm) with an abundance of deadwood, covered with a range of ground cover plants (Figure 3.2). The forest had a diverse understorey plant community with a varied emergent tree layer including a number of epiphyte species. This diversity of vegetation was noted to indicate a diverse invertebrate taxa.

3.2.2 Project footprint walkover

On 26 July 2017, the Project footprint was walked for approximately five hours by Dr Corinne Watts and Dr Liz Deakin near or on the Project footprint (Figure 3.3). Leaf litter along the Project footprint appeared patchy with the presence of pig rooting and cattle in the lower reaches of the valley along the Mangapepeke Stream (Figure 3.4). It was noted that there was an abundance of deadwood within the forest. There was a low diversity of ground cover plants and a sparse understorey plant community (Figure 3.5). The forest had a varied emergent tree layer including a number of epiphyte species (Assessment of Ecological Effects – Vegetation (Technical Report 7a, Volume 3 of the AEE)).

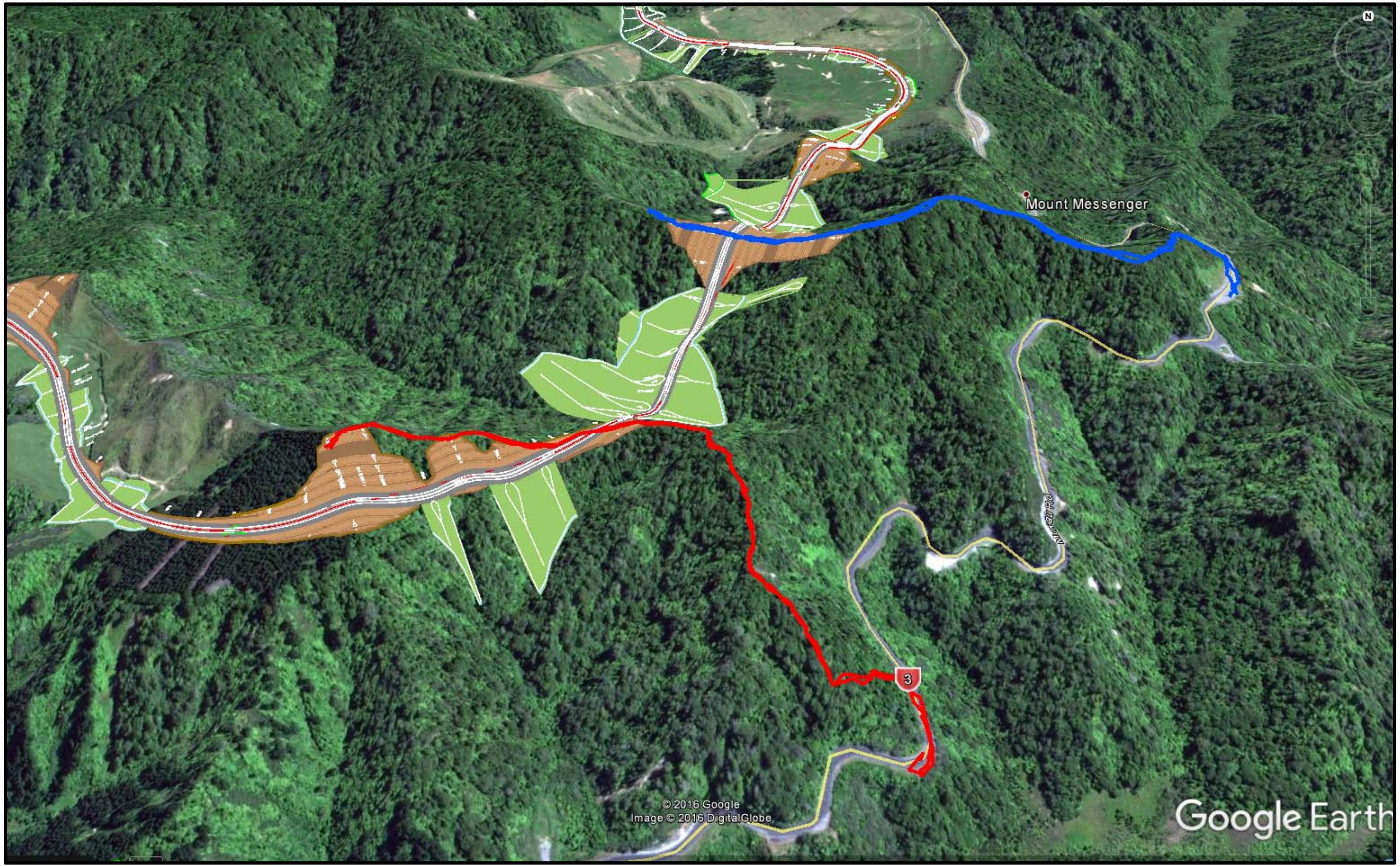

Figure 3.1 – Location of transect 1 (red line) and transect 2 (blue line) walked by Corinne Watts and Liz Deakin in relation to the preliminary alignment 'MC23', west of the Project footprint

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Figure 3.2 – Photo showing a deep leaf litter layer with an abundance of deadwood covered with a diverse ground cover on a ridgeline in the Parininihi (outside of the Project footprint).

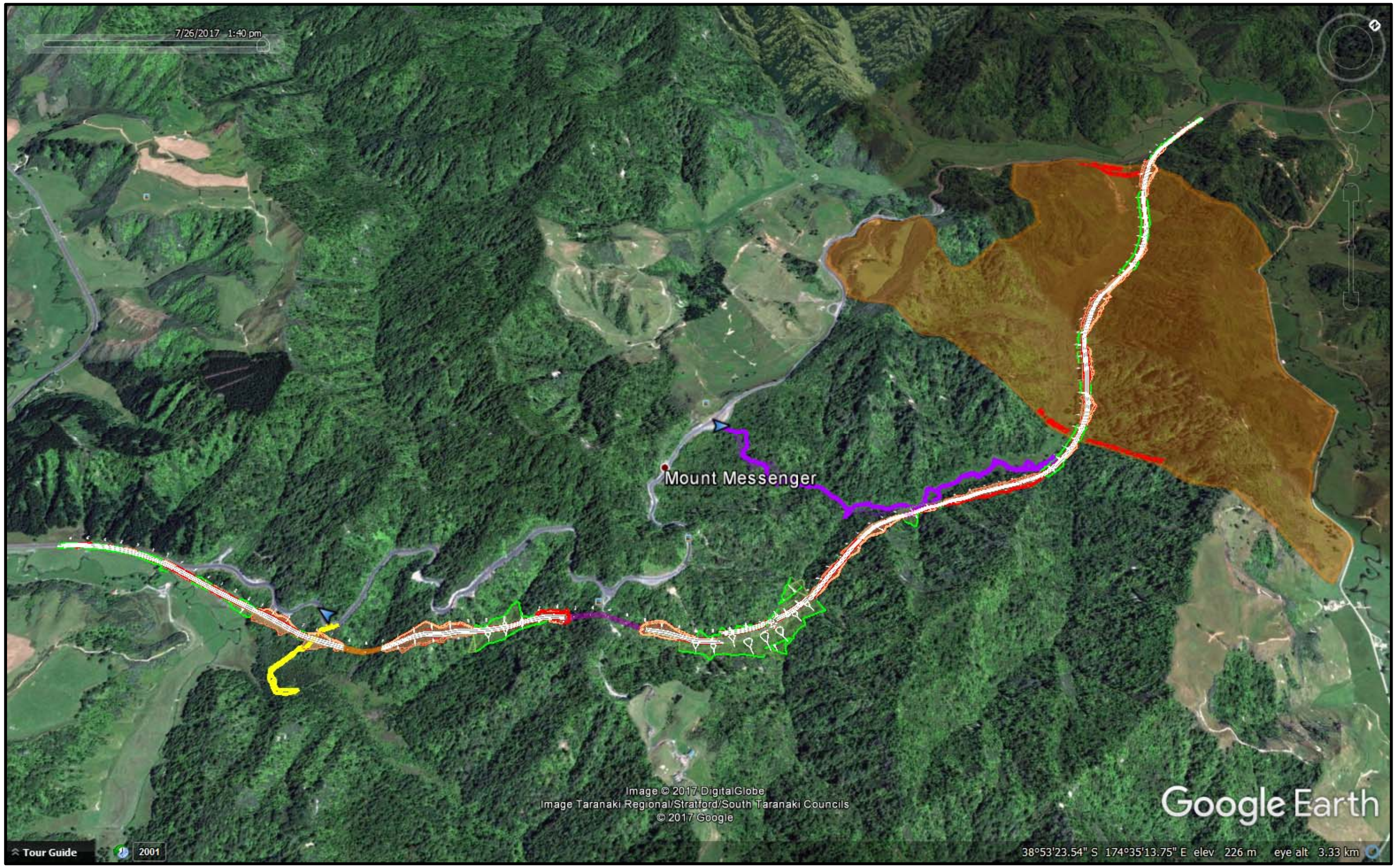

Figure 3.3 – Location of routes walked (highlighted with purple and yellow lines) by Corinne Watts and Liz Deakin in relation to the Project

Figure 3.4 – Photo showing evidence of pugging from stock and pest animals, Mangapepeke Valley

Figure 3.5 – Photo showing low diversity of ground cover plants and a sparse understorey plant community in the Mangapepeke Valley. This is due to browsing by stock and pests

4 Assessment of unmitigated effects on terrestrial invertebrate values

This assessment is broadly based on the EcIA guidelines produced by EIANZ (2015), adapted based on expert opinion as described in Section 2.3 to determine the overall unmitigated 'level of effect' of the Project on terrestrial invertebrate communities.

4.1 Terrestrial invertebrate values

The ecological value of native terrestrial invertebrates affected by the Project was determined using Step 1, Table 2.1 (Section 2.3). However, the limitations associated with a desktop investigation, limited habitat assessment of parts of the proposed route, and a field inspection and incomplete invertebrate sampling of parts of an alternative route option, are acknowledged. No species found in the wider Project area are on the Threatened Species List. However, this absence may be due, at least in part, to limited studies. It is possible that invertebrate species that are of conservation value would be present within the Project footprint. However, the likelihood of this occurring is small and the amount of forest habitat loss (less than 1%) within the wider Project area is likely to have a minimal effect on any local population (see the discussion on effects below).

Terrestrial invertebrate community values within the wider Project area have been assessed as 'High'.

While this assessment of "High" does not follow the methodology in Table 1 (as no 'threatened' or 'at risk' species are known or expected to occur) this is a precautionary, conservative approach given limited surveys to date (see above), noting that:

- Neither desktop studies nor field observations (carried out either to the west of SH3, or along the Project footprint) confirm the presence of any nationally 'at risk' species (the normal threshold for assigning a 'High' value).
- The invertebrate fauna is 'typical' of communities inhabiting native forests of southern North Island and northern South Island.
- The ecological condition of the forest within the proposed route is considered poorer, with fewer palatable plant species, compared to the nearby Parininihi. This is due to the absence of consistent animal pest control, lack of fencing, and the presence of grazing stock (particularly in the Mangapepeke Valley, as noted in the Assessment of Ecological Effects – Vegetation (Technical Report 7a, Volume 3 of the AEE)).
- It is likely that the taxa expected to be most affected by mammals are already extinct in the Mt Messenger area.

The presence of diverse forest vegetation communities (see Assessment of Ecological Effects – Vegetation (Technical Report 7a, Volume 3 of the AEE)) along the Project footprint in the Mangapepeke Valley indicates the likelihood of a diverse invertebrate community. Numerous studies have shown the strong correlation between invertebrate assemblages and habitat structure. Several studies have found that invertebrate distributions are closely linked to vegetation (e.g. composition, structure and health) and leaf litter depth, biomass and presence of deadwood (see Watts et al. 2008 and references within). Therefore, and following a conservative / precautionary approach, ranking the invertebrate values as 'High' follows the recommendation for vegetation values within the Project footprint (see Assessment of Ecological Effects – Vegetation (Technical Report 7a, Volume 3 of the AEE)).

One of the relatively few thorough studies of an invertebrate group in New Zealand (the study of detritivorous osoriine staphylinids by McColl, 1982), found that Mt Messenger has the highest diversity of this group of anywhere in New Zealand. If similar studies were carried out on other invertebrate groups, they may support a high assessment of the Mt Messenger forest based on biodiversity values because there is no obvious reason why osoriine staphylinids alone would be disproportionately represented there.

From searching the databased entomological collections and reviewing input from specialist taxonomists, it appears that only a small proportion of taxa known from Mt Messenger are introduced species. For example, of the 20 Hemipteran (plant bug) taxa recorded in entomological collection databases from Mt Messenger, only 3 (15%) species were introduced (Larivière, pers. comm., 2017). This suggests the indigenous invertebrate communities of Mt Messenger have a high resistance to invasion. From a conservation perspective, this result is encouraging, considering these native forest and scrub remnants are surrounded by highly modified habitats dominated by exotic species. Harris and Burns (2000) found the beetle communities within fragments of kahikatea surrounded by pasture in the Waikato Basin were also dominated by indigenous beetle species, with only a few introduced species present. This suggests that remnants of native forest can sustain a diverse invertebrate fauna compared with the surrounding agricultural landscape. Over the long-term these invertebrate communities may be dependent on functional connections to other nearby native vegetation in the landscape.

Some noteworthy invertebrate records found in our investigations were endemic taxa known only from a few locations, including in the vicinity of the wider Project area, for example, the endemic ground beetle, *Parabaris lesagei,* which is only known from eight populations in the North Island (Larochelle & Larivière 2005). The endemic plant bug, *Cyrtorhinus cumberi,* is also only known from a few populations. Mt Messenger is therefore a significant site for these insects (Larivière, pers. comm., 2017).

It is noteworthy (from a scientific viewpoint) that 10 taxa recorded from Mt Messenger in the entomological collections were designated as 'holotypes' for their species' description. These specimens were chosen as the best examples, and sometimes the first and only, of the species. Our current understanding of the species' characteristics and ecology is therefore based largely on the Mt Messenger collections.

Some threatened invertebrate taxa of conservation interest have been found near Mt Messenger. For example, the forest ringlet has been observed within 6km of Mt Messenger at Uruti (Museum of New Zealand Te Papa Tongarewa Entomology Online Collection). Since the 1990's, no surveys for the forest ringlet have occurred at Uruti. Larvae of the forest ringlet are known to feed on *Gahnia* and *Chionochloa* species on the edges of forest clearings (Wheatley 2017). *Gahnia pauciflora* and *G. setifolia* have been occasionally observed within the Project footprint (see Assessment of Ecological Effects – Vegetation (Technical Report 7a, Volume 3 of the AEE)), so it is possible the forest ringlet could be present within the wider Project area (and Project footprint).

This butterfly has, or once had, a distribution as far south as Greymouth in the South Island, but has become increasingly rare over the past 50 years and is classified by Department of Conservation as At Risk: Relict, Serious Decline (Stringer et al. 2012). The cause of decline is unknown but habitat loss, predation by introduced wasps, birds and rodents, as well as impacts of feral pigs on host plant abundance have been suggested as contributing factors.

4.2 Potential adverse effects on terrestrial invertebrates

In general terms, new roads have the potential to create a range of ecological effects on terrestrial invertebrate communities, both during construction (resulting from direct physical disturbance) and on an ongoing basis from road operation and maintenance.

In relation to terrestrial invertebrates, potential adverse construction effects of new roads generally include:

- Direct removal of habitat;
- Direct mortality;
- The creation of habitat edge effects, altering the composition and habitat value of adjacent vegetation; and
- Habitat fragmentation and isolation.

Potential ongoing adverse effects of roads (in general) on terrestrial invertebrates, without mitigation, include:

- Decreased landscape and habitat connectivity through fragmentation;
- The increased presence of people and introduced species in previously less accessible areas; and
- Lost opportunities for creating wildlife corridors.

4.3 Magnitude of unmitigated effects on terrestrial invertebrates

The magnitude of unmitigated effects of the Project on native terrestrial invertebrates was determined using the methodology set out in Section 2.3.2 combined with professional entomological judgement. A conservative approach has been taken due to the paucity of entomological surveys identifying invertebrate species that could be ‘threatened’, ‘at risk’, and/or declining.

The magnitude of unmitigated effects on the terrestrial invertebrate community within the Project footprint has been assessed as being ‘Low’ to ‘Moderate’. While the range of potential effects described in Section 4.2 above have been considered where relevant, the two main effects on terrestrial invertebrates associated with Project construction and operation that have informed the magnitude of effects rating are:

- Habitat loss and habitat degradation through edge effects; and,

- Habitat severance/fragmentation, i.e. loss of ecological connectivity.

4.3.1 Habitat loss and degradation

It is expected that up to approximately 44.4ha of indigenous dominant or mixed exotic/indigenous habitat will be affected by the Project. Within this area, 19.466ha of primary vegetation communities are present, and 13.826ha and 11.117ha of secondary scrub/forest and rushland/sedgeland mosaic respectively.

Previous studies have found that beetle communities are strongly linked to vegetation types, suggesting that any removal of vegetation will impact on the community present (Crisp et al. 1998; Watts & Gibbs 2002; Watts et al. 2015). However, the amount of native forest habitat loss as a result of this Project (ca 33ha) constitutes less than 1% of the available forest habitat within the wider Project area (ca 4,430ha; Figure 1.2). This amount is unlikely to compromise the sustainability of terrestrial invertebrate populations in the forest after construction.

4.3.2 Habitat fragmentation

Fragmentation of existing habitat is a potential adverse effect of the Project on the invertebrate community. The loss of species from forest systems and alteration of ecosystem function due to loss of microhabitats and changes in physical and chemical environment has been linked to forest fragmentation (Harris & Burns 2000). The effects of forest fragmentation on invertebrates are not always obvious and not all species are affected equally (Didham et al. 1998; Ewers & Didham 2008).

However, as the native vegetation within the Project footprint has already been fragmented, the effects of small areas of additional fragmentation are likely to be insignificant. Related to fragmentation, there is a vast literature debating the magnitude and extent of edge effects for many invertebrate taxa (e.g. Didham 1997; Ewers & Didham 2008), and generalisations are available derived from trait and guild features of the invertebrates. It is likely that edge effects are already having pronounced effects on invertebrate communities along existing road margins.

4.4 Overall level of effects on terrestrial invertebrates

A 'value' assessment of 'High' combined with an unmitigated 'magnitude of effects' assessment of ‘Low’ to 'Moderate' correlates to an overall level of unmitigated effects of 'High', when applying Step 3 of the EcIA guidelines.

For the reasons set out in section 4.1 above, describing the likely overall effects of the Project on terrestrial invertebrates as 'High' is a conservative, precautionary assessment. It is based on potential presence of high value species in the Project footprint, rather than any knowledge or expectation that such species are present. It also requires a conservative approach to what constitutes a 'moderate' loss or alteration of baseline conditions, and a conservative assessment of the possibility that there will be a 'moderate' loss of known populations and ranges of relevant species (noting that approximately 1% of the available habitat in the wider Project area will be affected by the Project).

In practice, it is likely, based on professional judgement, that the true overall level of unmitigated effects on terrestrial invertebrates will be 'Low' to 'Moderate'. In any event, a range of mitigation measures that will benefit invertebrates are proposed in respect of the Project. These are discussed in Section 5, as is my conclusion that together these measures will appropriately address any potential effects on invertebrates (notwithstanding the uncertainty as to what species are currently present).

5 Proposed measures for addressing potential adverse effects

Extensive and ongoing effort has been made to avoid, remedy, mitigate or offset potential ecological effects of the Project on flora and fauna groups, including terrestrial invertebrate communities. The ecologists engaged to advise on the Project, and provide expert assessments of the potential effects of the Project on ecological values, have been closely involved in these efforts.

Through the process of selecting the alignment, the inclusion of structures (a tunnel and bridge), and design and construction methods for the Project, ecological effects on terrestrial invertebrates have been either avoided or reduced in magnitude. To mitigate for residual effects that cannot be avoided, the Project will include restoration planting and habitat enhancement, and most importantly, a large scale pest control programme.

Through these efforts, it is expected that there will ultimately be no net loss (and most likely a net benefit) for terrestrial invertebrates affected by the Project.

Measures that will avoid, remedy, mitigate or offset potential adverse effects on terrestrial invertebrates (or otherwise benefit terrestrial invertebrates) are set out below. These measures will be detailed and actioned through the development and implementation of an Ecology and Landscape Management Plan (ELMP) that will include a section that sets out terrestrial invertebrate management and monitoring requirements and provides further detail on all measures discussed below.

5.1 Project measures to avoid or minimise effects

A number of adverse ecological effects on terrestrial invertebrates (and other ecological values) have been avoided through the selection of the proposed Project alignment, which (unlike many other options) completely avoids the ecologically important value land to the west of the existing SH3.

5.1.1 Avoidance through the options assessment process

The options considered for the Project included alignments to the west of SH3 which traversed areas with significant biodiversity values, including the Waipingao catchment and adjacent Parininihi land. Potential adverse effects identified for options to west of SH3 are described in the options assessment reports. These effects include loss of significant habitats, severance of a nationally important vegetation sequence and effects on associated regionally and nationally significant flora. Moreover, half of these options excluded the use of structures (bridges and tunnels) and had large cuts and fills, which would have resulted in considerably more significant ecological effects through both habitat loss and potential effects on native fauna.

Overall, the selection of the current Project footprint has meant effects on invertebrates within the higher quality Parininihi forest have been avoided.

5.1.2 Avoidance or mitigation of effects through optimisation of the Project footprint

The Project footprint traverses areas of significant habitat and vegetation types to the east of Mt Messenger. All vegetation types and significant trees (see Assessment of Ecological Effects – Vegetation (Technical Report 7a, Volume 3 of the AEE)) have been mapped and delineated to identify the most ecologically significant areas in the wider Project area. Project ecologists have worked closely with design and construction engineers to avoid or minimise ecological effects on these significant habitat types. Such efforts include:

- Inclusion of a 235m long tunnel through the ridge dividing the Mangapepeke and Mimi catchments. The tunnel has greatly reduced the size of the cut and fill area that would otherwise have been required.
- Incorporation of a 120m bridge across a tributary valley to the Mimi River on the south side of the route. This bridge sits very close to the ecologically significant wetland area and has substantially reduced the effect that a cut and fill approach would have had on the wetland and will preserve east-west ecological connectivity.
- Introduction of construction techniques to minimise ecological impact. The bridge mentioned above has been designed in a way that will allow it to be constructed from each side rather than the valley bottom. This will reduce the amount of ground and vegetation disturbance compared to a more conventional approach of building the bridge from the valley bottom and it will also reduce the risk of sediment erosion down into the wetland.
- Minor adjustments to the route to reduce the number of significant trees to be felled. The number of trees potentially needing to be felled has been reduced from more than 20 to 15 by this means.
- Avoidance or mitigation of effects on significant ecological values (i.e. significant vegetation/habitat types and trees through):
    - Realignment of the corridor, including shifting part of the corridor further from the ecologically significant wetland area.
    - Location of construction yards, laydown areas, construction access tracks and haul roads away from ecologically sensitive/significant areas to minimise the extent of disturbance and vegetation clearance.
    - Use of retaining walls to avoid loss of significant trees where possible.
    - Undertaking vegetation/habitat clearance in accordance with the Construction Environmental Management Plan (CEMP) and the ELMP to further reduce effects on significant habitat. The CEMP is supported by a suite of sub-plans, which outline the management of specific construction effects such as construction-related ecological effects in more detail.
    - Physical delineation (such as fencing or flagging tape) will be used to clearly mark the extent of vegetation clearance to be undertaken, along with vegetation to be protected.

- o Vegetation clearance will be staged so that vegetation is only cleared immediately prior to construction works at a given site only prior to construction works beginning in the Project footprint in order to reduce habitat effects and reduce the potential for erosion and sediment generation.
- o Installing an effective waste management system to minimise the chances of attracting pest mammals.
- o Having an ecologist on site to advise the construction teams when vegetation is being cleared near wetlands.

Taken together, these measures will be beneficial for invertebrates, particularly because (as described above) there is a strong link between the quality of vegetation, and the health of invertebrate communities.

5.2 Specific measures to avoid or minimise potential direct adverse effects on terrestrial invertebrates

Potential adverse effects of the Project on the terrestrial invertebrate communities are most likely to occur during the construction phase, including direct mortality of invertebrates during vegetation clearance and/or earthworks, habitat loss (from earthworks and vegetation clearance), habitat modification and disturbance, and habitat fragmentation (open areas created within relatively contiguous areas of habitat).

Introduction of new invertebrate taxa, possible exotic, not currently known from the Mt Messenger area, could occur during the construction phase, especially when vehicles are coming onto the site for the first time. For example, an overseas study suggests that the probability of introduced earthworm invasions is significantly increased with the occurrence of road construction (Cameron et al. 2007).

The risk of pest introductions will be managed by measures outlined in the ELMP. These measures may include confining vehicle movements to tracks and ensuring construction vehicles are cleaned between jobs as far as practicable. There is also a risk of pest invertebrates being introduced to the site via nursery planting stock used for habitat enhancement, therefore measures to minimise this risk are required.

5.3 Offsetting proposed for the Project

Details of the Transport Agency's measures to mitigate for residual effects on ecological values are set in detail in the Ecological Mitigation and Offset Report (Technical report 7h, Volume 3 of the AEE). The amount / area of restoration planting and pest management to be undertaken as offsetting has been determined through utilisation of the Biodiversity Offsets Accounting Model (see the Ecological Mitigation and Offset Report (Technical report 7h, Volume 3 of the AEE)). The extent of stream and riparian restoration to be undertaken has been determined by using the Stream Ecological Valuation method as described in the Ecological Effects Assessment: Freshwater Ecology (Technical report 7b, Volume 3 of the AEE) (Hamill 2017).

The key measures that are expected to contribute to mitigating for potential adverse effects on terrestrial invertebrates are summarised below. The measures include a comprehensive pest management programme to control introduced animals as the major focus of mitigation, coupled with restoration planting and habitat enhancement.

This mitigation package will ensure that any residual effects on terrestrial invertebrates are adequately addressed, and / or will benefit the general health of terrestrial invertebrate communities.

5.3.1 Pest management benefits for invertebrates

The proposed pest management programme is detailed in the Ecological Mitigation and Offset Report (Technical report 7h, Volume 3 of the AEE). That programme will in general terms be beneficial for terrestrial invertebrates, as predation of New Zealand's native invertebrate fauna by introduced mammals has been widely recognised as a major conservation concern (Buckley et al. 2012; Leschen et al. 2012; Mahlfeld et al. 2012; Sirvid et al. 2012; Stringer et al. 2012; Trewick et al. 2012). However, as detailed below, the precise level of benefit likely to accrue is difficult to quantify.

Although invertebrates are frequently reported in the diet of invasive mammals, few papers have quantified the impact of introduced mammals on native invertebrate populations or communities. In New Zealand, the majority of evidence regarding how mammals may affect invertebrate populations is derived from invertebrate response to island rodent eradications (Green 2002; Rufaut & Gibbs 2003; Sinclair et al. 2005), and to mainland rat control (Spurr 1996; Hunt et al. 1998; King 2007; Ruscoe et al. 2013). Eradication of mammals (particularly rodents) has usually resulted in altered invertebrate abundance (Green 2002; Watts et al. 2011, 2014), species richness (Sinclair et al. 2005), and behaviour (Rufaut & Gibbs 2003; Watts et al. 2011). Some invertebrates, however, have shown no response to rodent control (Craddock 1997; Van Aarde et al. 2004; Sinclair et al. 2005; Rate 2009).

These studies illustrate that the interactions between reducing mammal densities and resident invertebrate populations can be complicated and complex to predict. For example, the removal of mammal pests is likely to increase insectivorous bird species, resulting in varied responses of invertebrate populations (Sinclair et al. 2005; Watts et al. 2011). It is likely that the taxa most affected by mammals, and which would contribute most to community-level changes following mammal control, are already extinct in the Mt Messenger area, and on mainland New Zealand generally.

In addition to the complexity of food-web dynamics, a lack of studies examining the impacts of mammal control or eradication on invertebrate populations in New Zealand hampers predictive scenarios for many invertebrate taxa. Watts et al. (2014) suggested that significant increases in the abundance of invertebrates should not always be expected after mammalian predator control, although populations of large-bodied invertebrates may increase.

Recently, analysis of ground-based control by TBfree New Zealand and conservation agencies found that the only widespread species that has been shown to increase after mainland pest control is *H. thoracica*, probably because it is a favoured prey of ship rats (Byrom et al. 2016).

Nevertheless, the extensive pest management programme proposed for the Project is welcomed. As noted earlier in this report, there is a clear link between the health of vegetation communities, and the health of invertebrate communities. The pest management programme will lead to significant enhancement of the health of the vegetation communities in the area subject to management. That is expected, in turn, to lead to benefits for invertebrate communities.

5.3.2 Restoration plantings and habitat enhancement benefits for invertebrates

Overall, the proposed restoration planting and habitat enhancement programme summarised below and detailed in the Assessment of Ecological Effects – Ecological Mitigation and Offset (Technical Report 7h, Volume 3 of the AEE) will have beneficial and positive effects on invertebrates. Restoration planting and habitat enhancement will either occur within the wider Project area or nearby, and will consist of both mitigation and offset measures, as follows.

5.3.2.1 Mitigation:

- Planted riparian margins of 10m each side of the channel will be created;
- Restoration planting of all secondary scrub areas along the footprint plus temporary access tracks and storage areas that retain soil, hydrology and growing conditions suitable for reinstatement (up to 9ha); and
- Deployment of felled logs within mitigation sites to improve biodiversity values for a number of plants and animals.

5.3.2.2 Offsets:

- Restoration planting of up to 8ha of swamp forest;
- Planting of 200 seedlings of the same species for every significant tree that has to be felled; and
- Protection (fencing) and riparian planting of approximately 9km of existing stream.
- 560ha of pest management (benefiting the vegetation within that area and by association the invertebrates).

In time, restoration planting and habitat enhancement creates habitat, will improve ecological connectivity and reduce edge effects on existing vegetation, all of which are likely to benefit the terrestrial invertebrate community affected by the Project.

There will be value to the invertebrate community in replanting cuts, fills, and other disturbed areas with native plants along the Project footprint to reduce edge effects, especially to restore forest floor litter communities. The recovery of native invertebrate communities in restored sites is considerably accelerated, and will eventually become similar to mature forests when areas are actively replanted with native plants (Reay & Norton 1999).

Compelling evidence from studies in Australia that have examined forest rehabilitation after mining shows that 'recycling' habitat elements such as logs as forests are cleared, assists the recovery of invertebrate populations (Brennan et al. 2005). These logs represent important habitat for invertebrates and could be placed into existing forest or into roadside areas that are being replanted after construction.

Direct transfer of habitat, the salvage and replacement of intact 'sods' of vegetation together with underlying soil, minimises soil disturbance, and allows the transfer of reasonably intact ecological communities. Unfortunately, there is a paucity of published data on how invertebrates may benefit from transferring habitat. However, research conducted on the Stockton mine showed rapid recovery of above-ground and below-ground invertebrates with species richness and abundance non-significantly different from undisturbed areas after six months (Simcock et al. 1999; Boyer et al 2011). A critical component for fast rehabilitation of invertebrates is the salvage and immediate reuse of living profiles with intact plant/soil sods, as this can conserve plants, poorly-dispersing invertebrates and complex mycorrhizal interactions (Watts et al. 2008; Simcock and Ross 2017).

Restoration actions for individual taxa of conservation interest that are potentially within the Project footprint should be considered. For example, the forest ringlet has been recorded within 6km of Mt Messenger at Uruti in 1998 (Museum of New Zealand Te Papa Tongarewa Entomology Online Collection). *Gahnia pauciflora* and *G. setifolia,* host species of the forest ringlet, have been occasionally observed within the Project footprint (as stated in the Ecological Effects Assessment: Vegetation (Technical report 7a, Volume 3 of AEE) so it is possible the forest ringlet could be present. It is recommended that restoration actions for this butterfly, if present, include planting areas on the edge of the forest with *G. pauciflora* and *G. setifolia,* particularly when rehabilitating the new road margins.

5.4 Post-construction mitigation monitoring and reporting requirements for invertebrates

Interpreting changes in the invertebrate community after management manipulation is difficult, as both the abiotic and biotic factors affecting the fauna are complex, and such interactions within ecosystems are poorly understood (Watts et al. 2014).

It is therefore recommended that invertebrates do not need to be monitored in the mitigation and biodiversity offset site(s). Any such monitoring would likely be of little real benefit. It is appropriate and reasonable to assume that the general level of benefits for invertebrates addressed in section 5.3.2 (above) will accrue from the proposed pest management programme, restoration planting, and habitat enhancement.

5.5 Further invertebrate field surveys

Due to the seasonal constraints of sampling for invertebrates, no substantial empirical data was collected from the Project footprint for the purpose of this report. The ability to carry out invertebrate surveys in the spring/summer would provide more information on the invertebrate community within the Project footprint and increase certainty of conclusions and recommendations.

It is anticipated that terrestrial invertebrate community sampling will take place during late spring/summer 2017/2018, after the resource consent application is lodged. A robust sampling strategy will provide a clearer ‘snap-shot’ of the invertebrate fauna present along the Project footprint. It is important to note that the assessment of effects on invertebrate species set out in this report is conservative, and precautionary. It is very unlikely that further surveys will lead to a greater level of overall effects being anticipated than what has already been conservatively assumed.

There are numerous techniques available for sampling invertebrate communities which guarantee rapid acquisition of considerable collections and provide researchers with specimens. These methods include pitfall traps, malaise traps, visual searching, suction traps, insecticide fogging, sticky traps, light traps, and sweep-netting.

In the proposed study, pitfall traps will be used to sample the ground-dwelling invertebrate fauna and malaise traps will be used to collect the flying insect fauna inhabiting foliage. Both these types of traps are passive, easily transported and installed in the field, and can be left unattended for several weeks.

The number and type of vegetation to be sampled for invertebrates is yet to be advised. However, within each vegetation type it is recommended that at least 2-3 plots are used as replicates. At each plot (10 × 10m), one malaise trap will be centred with one pitfall trap placed approximately 5m away towards the corner of each plot. Traps will be set for one month over summer 2017/2018. Captured invertebrates will be sorted and counted at Order level. Beetles will be sorted and counted on the basis of external morphology to morphospecies or recognised taxonomic units (RTUs) and then, where possible, given generic and species-level identifications.

Due to the lack of taxonomic knowledge of a number of invertebrate groups in New Zealand, the research will focus on identifying beetle species, and their abundance, collected in the pitfall and malaise traps. Watts et al. (2008) noted that beetles are routinely selected as ‘bio-indicators’ for study in New Zealand as they:

- represent a large component of the invertebrate biodiversity;
- account for approximately 65% of the known New Zealand insect fauna;
- have representatives in all trophic groups; and
- have a wide range of habitat preferences.

The potential adverse effects of the Project on the terrestrial invertebrate communities are most likely to occur during the construction phase. It is recommended, therefore, that in addition to the sampling suggested above, surveys are conducted for below-ground (e.g. earthworms) and leaf-litter invertebrates (e.g. micro-snails).

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Appendices

Appendix A: A monograph series presenting New Zealand's unique terrestrial invertebrate fauna

Each publication introduces a taxonomic group including a checklist, descriptions and illustrations of taxa.

Volume	Year	Title
FNZ 01	1982	Terebrantia (Insecta: Thysanoptera)
FNZ 02	1982	Osoriinae (Insecta: Coleoptera: Staphylinidae)
FNZ 03	1982	Anthribidae (Insecta: Coleoptera)
FNZ 04	1984	Eriophyoidea except Eriophyinae (Arachnida: Acari)
FNZ 05	1984	Eriophyinae (Arachnida: Acari: Eriophyoidea)
FNZ 06	1984	Hydraenidae (Insecta: Coleoptera)
FNZ 07	1985	Cryptostigmata (Arachnida: Acari) - a concise review
FNZ 08	1986	Calliphoridae (Insecta: Diptera)
FNZ 09	1986	Protura (Insecta)
FNZ 10	1986	Tubulifera (Insecta: Thysanoptera)
FNZ 11	1987	Pseudococcidae (Insecta: Hemiptera)
FNZ 12	1987	Pompilidae (Insecta: Hymenoptera)
FNZ 13	1988	Encyrtidae (Insecta: Hymenoptera)
FNZ 14	1988	Lepidoptera - annotated catalogue, and keys to family-group taxa
FNZ 15	1988	Ambositrinae (Insecta: Hymenoptera: Diapriidae)
FNZ 16	1989	Nepticulidae (Insecta: Lepidoptera)
FNZ 17	1989	Mymaridae (Insecta: Hymenoptera)
FNZ 18	1989	Chalcidoidea (Insecta: Hymenoptera) - introduction, and review of smaller families
FNZ 19	1990	Mantodea (Insecta), with a review of aspects of functional morphology and biology
FNZ 20	1990	Bibionidae (Insecta: Diptera)
FNZ 21	1991	Margarodidae (Insecta: Hemiptera)
FNZ 22	1991	Notonemouridae (Insecta: Plecoptera)
FNZ 23	1992	Sciapodinae, Medeterinae (Insecta: Diptera) with a generic review of the Dolichopodidae
FNZ 24	1992	Therevidae (Insecta: Diptera)
FNZ 25	1992	Cercopidae (Insecta: Homoptera)
FNZ 26	1992	Tenebrionidae (Insecta: Coleoptera): catalogue of types and keys to taxa
FNZ 27	1993	Antarctoperlinae (Insecta: Plecoptera)
FNZ 28	1993	Larvae of Curculionoidea (Insecta: Coleoptera): a systematic overview
FNZ 29	1993	Cryptorhynchinae (Insecta: Coleoptera: Curculionidae)
FNZ 30	1994	Hepialidae (Insecta: Lepidoptera)

Volume	Year	Title
FNZ 31	1994	Terrestrial Talitridae (Crustacea: Amphipoda)
FNZ 32	1994	Sphecidae (Insecta: Hymenoptera)
FNZ 33	1995	Moranilini (Insecta: Hymenoptera)
FNZ 34	1995	Anthicidae (Insecta: Coleoptera)
FNZ 35	1995	Cydnidae, Acanthosomatidae, and Pentatomidae (Insecta: Heteroptera): systematics, geographical distribution, and bioecology
FNZ 36	1996	Leptophlebiidae (Insecta: Ephemeroptera)
FNZ 37	1997	Coleoptera: family-group review and keys to identification
FNZ 38	1999	Naturalised terrestrial Stylommatophora (Mollusca: Gastropoda)
FNZ 39	1999	Molytini (Insecta: Coleoptera: Curculionidae: Molytinae)
FNZ 40	1999	Cixiidae (Insecta: Hemiptera: Auchenorrhyncha)
FNZ 41	2000	Coccidae (Insecta: Hemiptera: Coccoidea)
FNZ 42	2001	Aphodiinae (Insecta: Coleoptera: Scarabaeidae)
FNZ 43	2001	Carabidae (Insecta: Coleoptera): catalogue
FNZ 44	2002	Lycosidae (Arachnida: Araneae)
FNZ 45	2003	Nemonychidae, Belidae, Brentidae (Insecta: Coleoptera: Curculionoidea)"
FNZ 46	2003	Nesameletidae (Insecta: Ephemeroptera)
FNZ 47	2003	Erotylidae (Insecta: Coleoptera: Cucujoidea): phylogeny and review
FNZ 48	2003	Scaphidiinae (Insecta: Coleoptera: Staphylinidae)
FNZ 49	2004	Lithinini (Insecta: Lepidoptera: Geometridae: Ennominae)
FNZ 50	2004	Heteroptera (Insecta: Hemiptera): catalogue
FNZ 51	2004	Coccidae (Insecta: Hemiptera: Coccoidea): adult males, pupae and prepupae of indigenous species
FNZ 52	2005	Raphignathoidea (Acari: Prostigmata)
FNZ 53	2005	Harpalini (Insecta: Coleoptera: Carabidae: Harpalinae)
FNZ 54	2005	Hierodoris (Insecta: Lepidoptera: Gelechoidea: Oecophoridae), and overview of Oecophoridae
FNZ 55	2006	Criconematina (Nematoda: Tylenchida)
FNZ 56	2007	Tyrophagus (Acari: Astigmata: Acaridae)
FNZ 57	2007	Apoidea (Insecta: Hymenoptera)
FNZ 58	2007	Alysiinae (Insecta: Hymenoptera: Braconidae)
FNZ 59	2007	Erotylinae (Insecta: Coleoptera: Cucujoidea: Erotylidae): taxonomy and biogeography
FNZ 60	2007	Carabidae (Insecta: Coleoptera): synopsis of supraspecific taxa
FNZ 61	2007	Lucanidae (Insecta: Coleoptera)
FNZ 62	2010	Trechini (Insecta: Coleoptera: Carabidae: Trechinae)
FNZ 63	2010	Auchenorrhyncha (Insecta: Hemiptera): catalogue
FNZ 64	2010	Pisauridae (Arachnida: Araneae)
FNZ 65	2010	Izatha (Insecta: Lepidoptera: Gelechioidea: Oecophoridae)
FNZ 66	2011	Diaspididae (Insecta: Hemiptera: Coccoidea)
FNZ 67	2011	Peloridiidae (Insecta: Hemiptera: Coleorrhyncha)
FNZ 68	2012	Simuliidae (Insecta: Diptera)

Volume	Year	Title
FNZ 69	2013	Carabidae (Insecta: Coleoptera): synopsis of species, Cicindelinae to Trechinae (in part)
FNZ 70	2013	Periegopidae (Arachnida: Araneae)
FNZ 71	2014	Fanniidae (Insecta: Diptera)
FNZ 72	2014	Micropterigidae (Insecta: Lepidoptera)

Appendix B: Invertebrate taxa known at Mt Messenger

Records were found by searching databases and the published literature. In total, 179 taxa were recorded in 476 individual records.

Source of record	Order	Family	Species
NatureWatch	Acari		*Allotanaupodus winksi*
Fauna of New Zealand Series	Araneae	Lycosidae	*Anoteropsis adumbrata*
Fauna of New Zealand Series	Araneae	Lycosidae	*Artoria separata*
Te Papa	Araneae		*Clubiona cada*
BUGZ database	Araneae		*Nonocambridgea gracilipes*
Te Papa	Araneae		*Paramamoea incertoides*
Auckland Museum	Coleoptera	Aderidae	*Xylophilus coloratus*
Auckland Museum	Coleoptera	Anobiidae	species 1
Fauna of New Zealand Series	Coleoptera	Anthicidae	*Macratria aotearoa*
Auckland Museum	Coleoptera	Carabidae	*Allocinopus smithi*
Auckland Museum	Coleoptera	Carabidae	*Demetrida lineella*
NZAC	Coleoptera	Carabidae	*Demetrida nasuta*
Fauna of New Zealand Series	Coleoptera	Carabidae	*Duvaliominus pseudistyx*
Auckland Museum	Coleoptera	Carabidae	*Gaioxenus pilipalpis*
NZAC	Coleoptera	Carabidae	*Molopsida seriatoporus*
NZAC	Coleoptera	Carabidae	*Nesamblyops oreobius*
Auckland Museum	Coleoptera	Carabidae	*Nesamblyops subcaecus*
Auckland Museum; Fauna of New Zealand Series	Coleoptera	Carabidae	*Parabaris lesagei*
NZAC	Coleoptera	Carabidae	*Plocamostethus planiusculus*
Fauna of New Zealand Series	Coleoptera	Carabidae	*Selenochilus omalleyi*
NZAC	Coleoptera	Carabidae	*Syllectus anomalus*
Auckland Museum	Coleoptera	Cerambycidae	species 1
Auckland Museum	Coleoptera	Cerylonidae	*Philothermus*
BUGZ database	Coleoptera	Clambidae	*Clambus saturnus annulus*
Auckland Museum	Coleoptera	Curculionidae	*Hoplocneme squamosa*
Auckland Museum	Coleoptera	Curculionidae	*Phrynixus*
Auckland Museum	Coleoptera	Curculionidae	*Scelodolichus*
NZAC	Coleoptera	Hydrophilidae	*Cyloma guttulatus/lineatus*
Auckland Museum	Coleoptera	Hydrophilidae	*Tormissus linsi*
Auckland Museum	Coleoptera	Leiodidae	*Inocatops*
Auckland Museum	Coleoptera	Leiodidae	species 1
NZAC	Coleoptera	Nitidulidae	*Hisperonia hystrix*
Auckland Museum	Coleoptera	Ptiliidae	*Cissidium foveolatum*

Source of record	Order	Family	Species
Auckland Museum	Coleoptera	Scarabaeidae	*Saphobius squamulosus*
NatureWatch	Coleoptera	Staphylinidae	*Agnosthaetus brouni*
Auckland Museum	Coleoptera	Staphylinidae	*Agnosthaetus* sp. 1
Fauna of New Zealand Series	Coleoptera	Staphylinidae	*Brachynopus latus*
NZAC	Coleoptera	Staphylinidae	*Brachynopus scutellaris*
NZAC	Coleoptera	Staphylinidae	*Holotrochus tricarinus*
NZAC	Coleoptera	Staphylinidae	*Holotrochus tubifer*
NatureWatch	Coleoptera	Staphylinidae	*Hyperomma montanum*
NatureWatch	Coleoptera	Staphylinidae	*Hyperomma sanguineum*
Fauna of New Zealand Series	Coleoptera	Staphylinidae	*Paratrochus curvistis*
Fauna of New Zealand Series	Coleoptera	Staphylinidae	*Paratrochus hermes*
Fauna of New Zealand Series	Coleoptera	Staphylinidae	*Paratrochus microphthalmus*
Fauna of New Zealand Series	Coleoptera	Staphylinidae	*Paratrochus scapulifer*
NZAC; Fauna of New Zealand Series	Coleoptera	Staphylinidae	*Paratrochus tricarinatus*
NZAC; Fauna of New Zealand Series	Coleoptera	Staphylinidae	*Paratrochus tubifer*
Fauna of New Zealand Series	Coleoptera	Staphylinidae	*Paratrochus vagepunctus*
NatureWatch	Coleoptera	Staphylinidae	*Sagola boonei*
NatureWatch	Coleoptera	Staphylinidae	*Sagola egmontensis*
NZAC; NatureWatch	Coleoptera	Staphylinidae	*Stenosagola ramsayi*
Auckland Museum	Coleoptera	Tenebrionidae	*Stenadelium striatum*
NZAC	Coleoptera	Ulodidae	*Syrphetodes marginatus*
Auckland Museum	Coleoptera	Zopheridae	*Chorasus* sp. 1
NZAC	Coleoptera	Zopheridae	*Epistranus lawsoni*
NZAC	Coleoptera	Zopheridae	*Pristoderus bakewelli*
Auckland Museum	Diptera	Empididae	*Oropezella tanycera*
NZAC	Hemiptera	Acanthosomatidae	*Oncacontias vittatus*
NZAC	Hemiptera	Aradidae	*Acaraptera myersi*
NZAC	Hemiptera	Aradidae	*Neadenocoris sp.*
NZAC	Hemiptera	Ceratocombidae	*Ceratocombus aotearoae*
Auckland Museum	Hemiptera	Cercopidae	*Philaenus spumarius*
NZAC	Hemiptera	Cymidae	*Cymus novaezelandiae*
Fauna of New Zealand Series	Hemiptera	Diaspididae	*Serenaspis minima*
NZAC; Fauna of New Zealand Series	Hemiptera	Mesoveliidae	*Mniovelia kuscheli*
Auckland Museum	Hemiptera	Miridae	*Cyrtorhinus cumberi*
NZAC	Hemiptera	Miridae	*Stenotus binotatus*
NZAC	Hemiptera	Miridae	*Xiphoides myersi*
NZAC	Hemiptera	Pentatomidae	*Glaucias amyoti*
NZAC	Hemiptera	Rhyparochromidae	*Metagerra obscura*
NZAC	Hemiptera	Rhyparochromidae	*Regatarma forsteri*

Source of record	Order	Family	Species
NZAC	Hemiptera	Rhyparochromidae	*Targarema electa*
NZAC	Hemiptera	Rhyparochromidae	*Targarema stali*
NZAC	Hemiptera	Rhyparochromidae	*Truncala hirsuta*
Te Papa	Hemiptera		*Amphipsalta zealandica*
Te Papa	Hemiptera		*Kikihia muta*
Te Papa	Hemiptera		*Kikihia scutellaris*
Auckland Museum	Hymenoptera	Braconidae	species 1
Auckland Museum	Hymenoptera	Diapriidae	*Betyla* sp P81
Auckland Museum	Hymenoptera	Diapriidae	Genus D
Auckland Museum	Hymenoptera	Diapriidae	Genus D species 1
Auckland Museum	Hymenoptera	Diapriidae	Genus D species 2
Auckland Museum	Hymenoptera	Diapriidae	*Idiotypa* E77
Auckland Museum	Hymenoptera	Diapriidae	*Idiotypa* E88
Fauna of New Zealand Series	Hymenoptera	Diapriidae	*Parabetyla tahi*
Auckland Museum	Hymenoptera	Diapriidae	*Parabetyla tika*
Auckland Museum	Hymenoptera	Diapriidae	*Spilomicrus* E87
Auckland Museum	Hymenoptera	Embolemidae	*Embolemus zealandicus*
Auckland Museum	Hymenoptera	Formicidae	*Huberia brounii*
Auckland Museum	Hymenoptera	Formicidae	*Ochetellus glaber*
Auckland Museum	Hymenoptera	Ichneumonidae	species 1
Auckland Museum	Hymenoptera	Ichneumonidae	species 2
Auckland Museum	Hymenoptera	Platygastridae	*Archaeoteleia karere*
Auckland Museum	Hymenoptera	Platygastridae	*Mirobaeus* species 1
Auckland Museum	Hymenoptera	Pteromalidae	species 1
NatureWatch	Hymenoptera	Rotoitidae	*Rotoita basalis*
NZAC	Lepidoptera	Geometridae	*Austrocidaria bipartita*
NZAC	Lepidoptera	Geometridae	*Chalastra pellurgata*
NZAC	Lepidoptera	Geometridae	*Cleora scriptaria*
NZAC	Lepidoptera	Geometridae	*Declana floccosa*
NZAC	Lepidoptera	Geometridae	*Declana hermione*
NZAC	Lepidoptera	Geometridae	*Elvia glaucata*
NZAC	Lepidoptera	Geometridae	*Epiphryne undosata*
NZAC	Lepidoptera	Geometridae	*Epyaxa venipunctata*
NZAC; Te Papa; Fauna of New Zealand Series	Lepidoptera	Geometridae	*Ischalis nelsonaria*
NZAC; Fauna of New Zealand Series	Lepidoptera	Geometridae	*Ischalis variabilis*
NZAC	Lepidoptera	Geometridae	*Pasiphila inductata*
NZAC	Lepidoptera	Geometridae	*Pasiphila plinthina*
NZAC	Lepidoptera	Geometridae	*Pasiphila sphragitis*
NZAC	Lepidoptera	Geometridae	*Pasiphila testulata*
NZAC	Lepidoptera	Geometridae	*Poecilasthena pulchraria*

Source of record	Order	Family	Species
NZAC	Lepidoptera	Geometridae	*Pseudocoremia rudisata*
NZAC	Lepidoptera	Geometridae	*Pseudocoremia suavis*
BUGZ database	Lepidoptera	Geometridae	*Selidosema flava*
NZAC	Lepidoptera	Geometridae	*Sestra flexata*
NZAC	Lepidoptera	Hepialidae	*Aenetus virescens*
NZAC	Lepidoptera	Hepialidae	*Wiseana signata*
NZAC	Lepidoptera	Hepialidae	*Wiseana umbraculata*
Fauna of New Zealand Series	Lepidoptera	Micropterigidae	*Zealandopterix zonodoxa*
NZAC	Lepidoptera	Noctuidae	*'Graphania' sequens*
NZAC	Lepidoptera	Noctuidae	*Agrotis infusa*
NZAC	Lepidoptera	Noctuidae	*Agrotis ipsilon*
NZAC	Lepidoptera	Noctuidae	*Agrotis munda*
NZAC	Lepidoptera	Noctuidae	*Bityla defigurata*
NZAC	Lepidoptera	Noctuidae	*Chrysodeixis argentifera*
NZAC	Lepidoptera	Noctuidae	*Feredayia graminosa*
NZAC	Lepidoptera	Noctuidae	*Graphania chlorodonta*
NZAC	Lepidoptera	Noctuidae	*Graphania lignana*
NZAC	Lepidoptera	Noctuidae	*Graphania mutans*
NZAC	Lepidoptera	Noctuidae	*Graphania plena*
NZAC	Lepidoptera	Noctuidae	*Helicoverpa punctigera*
NZAC	Lepidoptera	Noctuidae	*Meterana alcyone*
NZAC	Lepidoptera	Noctuidae	*Meterana ochthistis*
NZAC	Lepidoptera	Noctuidae	*Meterana vitiosa*
NZAC	Lepidoptera	Noctuidae	*Persectania aversa*
NZAC	Lepidoptera	Noctuidae	*Proteuxoa sp. A*
NZAC	Lepidoptera	Noctuidae	*Tmetolophota arotis*
NZAC	Lepidoptera	Noctuidae	*Tmetolophota semivittata*
NZAC	Lepidoptera	Noctuidae	*Tmetolophota steropastis*
Fauna of New Zealand Series	Lepidoptera	Oecophoridae	*Izatha austera*
Fauna of New Zealand Series	Lepidoptera	Oecophoridae	*Izatha churtoni*
Fauna of New Zealand Series	Lepidoptera	Oecophoridae	*Izatha peroneanella*
Te Papa	Mollusca		*Allodiscus urquharti*
Te Papa	Mollusca		*Athoracophorus bitentaculatus*
Te Papa	Mollusca		*Cavellia irregularis*
Te Papa	Mollusca		*Charopa coma*
Te Papa	Mollusca		*Cytora fasciata*
Te Papa	Mollusca		*Flammulina perdita*
Te Papa	Mollusca		*Georissa purchasi*
Te Papa	Mollusca		*Huonodon hectori*
Te Papa	Mollusca		*Huonodon pseudoleiodon*
Te Papa	Mollusca		*Laoma mariae*

Source of record	Order	Family	Species
Te Papa	Mollusca		*Laoma nerissa*
Te Papa	Mollusca		*Mocella eta*
Te Papa	Mollusca		*Oxychilus* sp.
Te Papa	Mollusca		*Paralaoma lateumbilicata*
Te Papa	Mollusca		*Phrixgnathus erigone*
Te Papa	Mollusca		*Potamopyrgus antipodarum*
Te Papa	Mollusca		Punctidae sp. 190
Te Papa	Mollusca		Punctidae sp. 86
Te Papa	Mollusca		*Rhytida greenwoodi*
Te Papa	Mollusca		*Schizoglossa novoseelandica*
Te Papa	Mollusca		*Serpho kivi*
Te Papa	Mollusca		*Sororipyrgus kutukutu*
Te Papa	Mollusca		*Therasiella celinde*
Te Papa	Mollusca		*Therasiella neozelanica*
Te Papa	Mollusca		*Therasiella* sp. 1
NZAC; Fauna of New Zealand Series	Nematoda	Criconematidae	*Criconema magnum*
NZAC	Nematoda	Mononchidae	*Mononchus mesadenus*
Fauna of New Zealand Series	Nematoda		*Hemicriconemoides cocophillus*
Auckland Museum	Neuroptera	Hemerobiidae	*Micromus tasmaniae*
Auckland Museum	Opiliones	Monoscutidae	*Pantopsalis cheliferoides*
Hemideina (tree weta) species distributions	Orthoptera	Anostostomatidae	*Hemidenia thoracica*
NZAC	Phasmatodea	Phasmatidae	*Argosarchus horridus*
Te Papa	Phthiraptera		*Apterygon mirum*
NZAC	Thysanoptera	Thripidae	*Thrips obscuratus*
Fauna of New Zealand Series	Thysanoptera	Tubulifera	*Deplorothrips bassus*
Fauna of New Zealand Series	Thysanoptera	Tubulifera	*Psalidathrips tane*

Appendix C: Invertebrate taxa found by Dr Corinne Watts during the MC23 alignment walkover, February 2017

Transect	Order	Species	Comment
1	Annelida	*Rhododrilus benhami*	Common larger native earthworm
1	Annelida	*Maoridrilus* sp. 1	Native earthworm; undescribed species
1	Coleoptera	*Blosyropus spinosus*	Seldom seen; large flightless beetle
1	Coleoptera	*Triphyluus* sp.	Fungus beetle; common in leaf litter throughout NZ
1	Diptera	*Melanostoma fasciatum*	On mānuka flowers
1	Hymenoptera	*Leioproctus fulvescens*	On mānuka flowers
1	Lepidoptera	*Sestra flexata*	Common throughout NZ; larvae feed on bracken
1	Lepidoptera	*Ischalis variabilis*	Common throughout NZ; larvae feed on fronds of native ferns
2	Coleoptera	*Neocicndela tuberculata*	Tiger beetle; common in open native forest throughout NZ
2	Diptera	*Eristalis tenax*	Drone fly; Feeding on rata flowers
2	Hymenoptera	Hymenoptera sp.	Small native black wasp
2	Lepidoptera	Gymnobathra flavidella	A common dead-wood feeding forest species
2	Orthoptera	*Phaulacridium marginale*	Common native New Zealand grasshopper
Both	Hemiptera	*Amphipsalta zealandica*	Chorus cicada; common
Both	Hemiptera	*Amphipsalta cingulata*	Clapping cicada; common
Both	Hymenoptera	*Apis mellifera*	Seen on rata and mānuka flowers
Both	Hymenoptera	*Vespula germanica*	Nest seen on track; seen on mānuka flowers