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BROOKBY QUARRY - STAGE 3
ECOLOGICAL ASSESSMENT OF EFFECTS

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Brookby Quarry: Stage 3
Ecological Assessment of Effects

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Authors:	**Treffery Barnett**, M.Sc. (Hons) **Chris Wedding**, M.Sc. (Hons) **Jennifer Shanks,** M.Sc. (Hons) JS Ecology
Approved for Release	**Chris Wedding** **Ecology Manager**

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COVER PHOTO: BROOKBY QUARRY STREAM AND VEGETATION

P O Box 2828, Shortland Street, Auckland 1140. Telephone: (09) 379-9417 Facsimile (09) 307-6409
Website: www.bioresearches.co.nz

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1. INTRODUCTION

1.1 BROOKBY QUARRY AND PROPOSED STAGE 3 EXPANSION

Bioresearches was commissioned by Brookby Quarries Limited to undertake an assessment of ecological effects of a proposed expansion into Stage 3 of the Brookby Quarry operation. The Stage 3 area (Project area) is zoned 'Special Purpose Zone: Quarry' (SPQZ) under the Auckland Unitary Plan – Operative in Part (AUP) and comprises some 30 ha of land which is almost entirely covered in indigenous vegetation (Figure 1).

This report describes the terrestrial and freshwater ecological values of the Project area, provides a stepwise assessment of the actual and potential ecological effects that would be expected to result from the expansion, and presents recommendations to avoid, remedy, mitigate, offset or compensate those effects as appropriate.

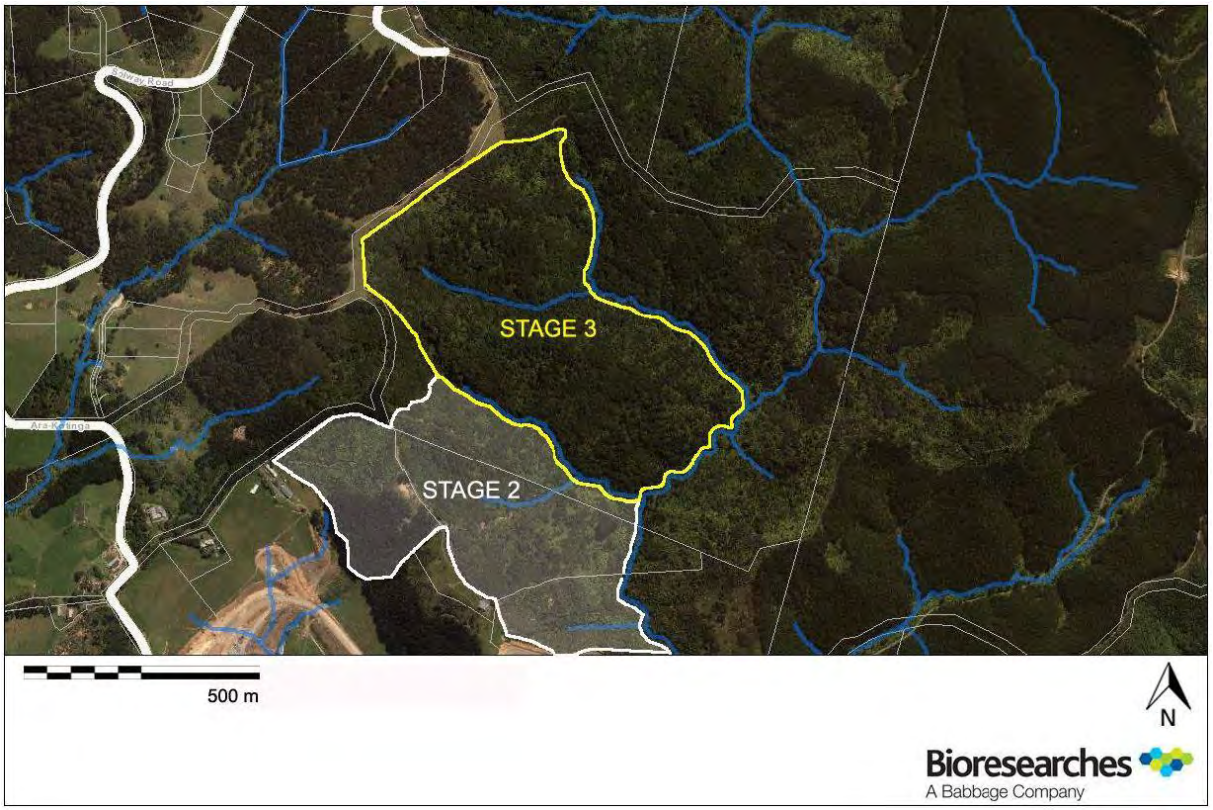

Figure 1. Brookby Quarry Stage 3 (Project Area)

1.2 BROOKBY QUARRY ECOLOGICAL CONTEXT AND SITE DESCRIPTION

1.2.1 Ecological context

Brookby Quarry lies within the Hunua Ecological District ('E.D.') which is part of the Auckland Ecological Region. The key area of native vegetation within the Hunua E.D. is the very large forest block of the Hunua Ranges comprising some 20,000ha of native forest, the bulk of which is tawa-podocarp forest with kauri-hard beech at lower elevations. A large number of small forest remnants exist in the low relief foothills of the ranges along with some larger blocks such as the Maraetai and Mataitai Forest, each several hundred hectares in size.

The Project area is surrounded by regenerating native bush at various stages of maturity within the Significant Ecological Area (SEA_T_5274) to the north and east. To the south is Brookby Quarry and to the west is the Solway subdivision which includes areas of plantation pines, recent native restoration planting and lifestyle dwellings.

Further areas of significant native vegetation occur nearby across the Brookby-Maraetai Hills area and a mosaic of native and exotic forest and scrub extends through to the coast at Umupuia Beach south of Maraetai. Substantial areas of taraire, tawa, podocarp forest (WF9) and 'kauri, podocarp, broadleaved, beech forest' (WF12) are found across these areas and on the Whitford hills to the west.

The 14,000 hectare Hunua Ranges Regional Park lies 10 km to the south east and is administered by the Auckland Council. It is predominantly native forest and hence the area of vegetation between Clevedon and Maraetai forms an important ecological link between the inner Hauraki Gulf Islands and the Hunua Ranges (Auckland Council, 2012).

1.2.2 The Project area

The Project area is almost entirely covered in indigenous vegetation within SEA_T_5274, which comprises a mosaic of different vegetation types including taraire forest and regenerating native forest types such as kānuka (*Kunzea robusta*) scrub/ forest and tānekaha-dominant conifer forest. The area is bounded by Papakura Stream to the east, and tributaries of Papakura Stream to the north and south (Figure 2).

The total area of SEA_T_5274 which partially overlies the Brookby SPQZ as measured on the Unitary Plan GIS website is approximately 142ha. The Project area comprises 30.73ha (21.6%) of this SEA. The majority of the SEA is mapped by the Auckland Council as 'kānuka scrub/forest' (VS2). There are also several patches of 'taraire, tawa, podocarp forest' (WF9), mapped within the Project area.

Information supplied by Auckland Council regarding the SEA indicates that the habitat meets two criteria from Schedule 3 of the Auckland Unitary Plan:

- **Criterion 2:** Threat status and Rarity (Criterion 2b), as a result of the presence of longfin eel (at-risk; declining) and
- **Criterion 4**: Stepping stones, migration pathways and buffers (Criterion 4c), presumably migration pathways for longfin eel.

The topography of the Project area is generally steep. A main ridge trends west-east rising between the south-western boundary of the site and Papakura Stream. Another ridge to the north is partly within the Project area and runs in a generally north-south direction, with watercourses to the south and east, which empty into a tributary of Papakura Stream. The tributary streams flowing to the Papakura stream are typically steeply incised between clay/silt banks.

The Stage 3 area has a 20 m set back from the Papakura Stream, and from the tributary that forms the north-eastern boundary to the area.

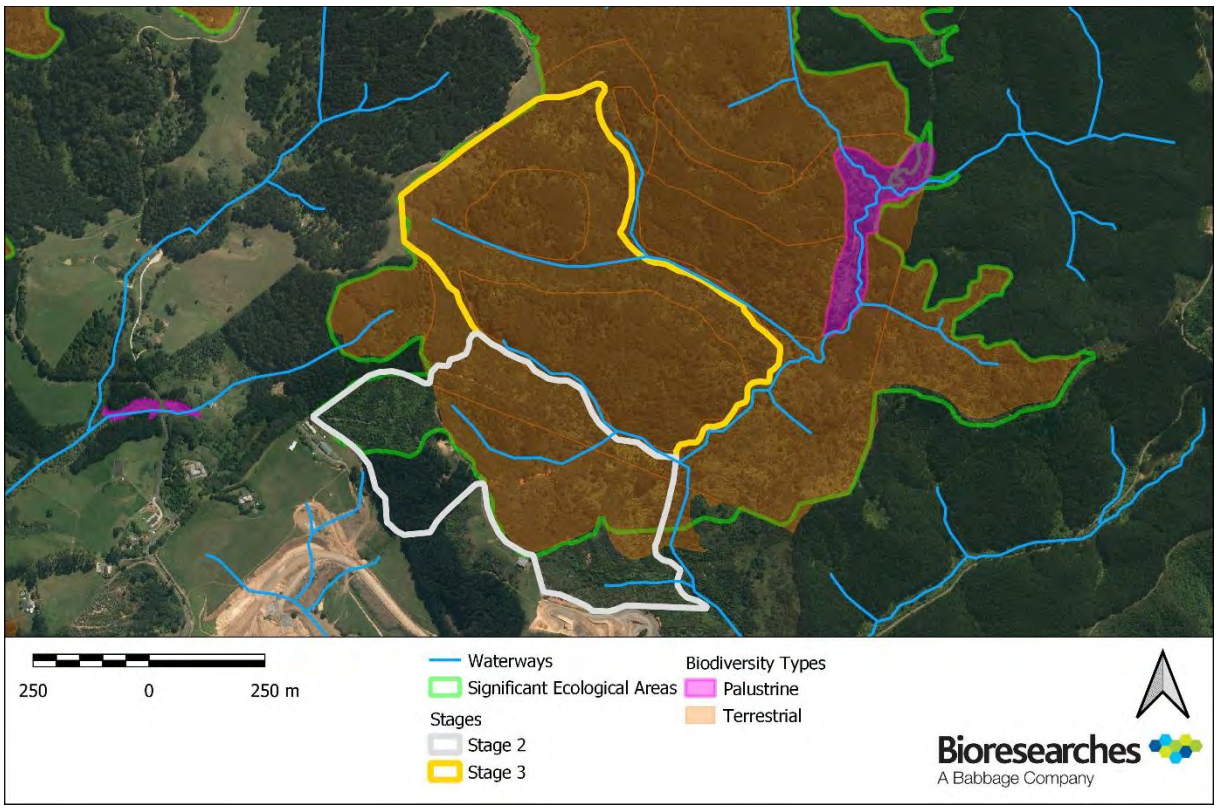

Figure 2. Stage 3 Expansion Area with AUP SEA and Biodiversity Overlays.

2. METHODOLOGY

2.1 ASSESSMENT STANDARDS

The assessment methods generally follow the Ecological Impact Assessment Guidelines (EcIAG), published by Environment Institute of Australia and New Zealand Inc. (EIANZ) (Roper-Lyndsay *et al*. 2018). The EcIAGs provide a standardised matrix framework that allows ecological effects assessments to be clear and transparent and consistent. The EcIAG framework is generally used in impact assessments in New Zealand as good practice.

Herein, we provide a description and assessment of terrestrial and freshwater ecological values, including ecosystem types, species and habitats, within the Stage 1B1 area.

The EcIAG (Roper-Lyndsay *et al*., 2018) provides a four-step process for undertaking terrestrial and freshwater assessments as follows:

Step 1: Assess the value of the area, taking into consideration species (Table 1) and other attributes of importance for vegetation or habitats (
Table 2) to assign an overall value (Table 3).

Step 2: Determine the magnitude of effect. This step also includes consideration of the timescale and permanence of the effect, whereby temporary (< 25 years) and long-term (substantial improvement after 25 years) effects are distinguished from permanent (beyond the span of a human generation) effects.

Step 3: Evaluate the severity of ecological effect using a matrix of the above criteria (Table 5).

Step 4: Impact Management, using the effects hierarchy of avoid, remedy, mitigate, offset, compensate.

Plant species of interest included all those potentially present with a national conservation rating as per de Lange *et al.* (2018), as well as species of regional conservation significance (Stanley *et al.* 2005). This assessment refers to ecosystem types identified for the Auckland Region (Singers *et al*.2017) and Holdaway *et al.* (2012). Refer Section 2.2 for a statement on assessment standards of myrtaceous species and myrtle rust.

Fauna considered in this report includes terrestrial invertebrates as well as all those that are protected by the Wildlife Act 1953 including, lizards, birds and long-tailed bats; and native fish, which are not legally protected. Particular consideration was given where species with a conservation status of nationally 'At Risk' or higher have the potential to be present.

Table 1. Factors to be considered in assigning value to species (Roper-Lyndsay et al. 2018)

Determining factors	Value
Nationally threatened species, found in the ZOI either permanently or seasonally	Very High
Species listed as 'At Risk' – declining, found in the ZOI, either permanently or seasonally	High
Species listed as any other category of 'At Risk' found in the ZOI (Zone of Interest) either permanently or seasonally	Moderate
Locally (ED) uncommon or distinctive species	Moderate
Nationally and locally common indigenous species	Low
Exotic species, including pests, species having recreational value	Negligible

Table 2. Attributes to be considered when assigning ecological value or importance to a site or area of vegetation / habitat / community (as per Table 4 of Roper-Lyndsay et al. 2018).

Matters	Attributes to be considered
Representativeness	*Criteria for representative vegetation and aquatic habitats:* • Typical structure and composition • Indigenous species dominate • Expected species and tiers are present • Thresholds may need to be lowered where all examples of a type are strongly modified. *Criteria for representative vegetation and aquatic habitats:* • Species assemblages that are typical of the habitat • Indigenous species that occur in most of the guilds expected for the habitat type
Rarity/ distinctiveness	*Criteria for rare/distinctive vegetation and habitats:* • Naturally uncommon or induced scarcity • Amount of habitat or vegetation remaining • Distinctive ecological features • National Priority for Protection *Criteria for rare/distinctive species of species assemblages:* • Habitat supporting nationally threatened or At-Risk species, or locally uncommon species • Regional or national distribution limits of species or communities • Unusual species or assemblages • Endemism
Diversity and Pattern	• Level of natural diversity, abundance and distribution • Biodiversity reflecting underlying diversity • Biogeographical considerations- pattern, complexity • Temporal considerations, considerations of lifecycles, daily or seasonal cycles of habitat availability and utilisation
Ecological context	• Site history and local environment conditions which have influenced the development of habitats and communities • The essential characteristics that determine an ecosystems integrity, form, functioning and resilience (from 'intrinsic value' as defined in RMA) • Size, shape and buffering • Condition and sensitivity to change • Contribution of the site to ecological networks, linkages, pathways and the protection and exchange of genetic material • Species role in ecosystem functioning - high level, key species identification, habitat as proxy

Table 3. Assigning value to areas (Roper-Lyndsay et al. 2018).

Value	Description
Very High	Area rates High for three or all of the four assessment matters listed in Table 2 Likely to be nationally important and recognised as such.
High	Area rates High for two of the assessment matters listed in Table 2, Moderate and Low for the remainder, or Area rates High for one of the assessment matters, Moderate for the remainder. Likely to be regionally important and recognised as such.
Moderate	Area rates High for one matter listed in Table 2, Moderate and Low for the remainder, or area rates Moderate for two or more assessment matters Low or Very Low for the remainder Likely to be important at the level of the Ecological District.
Low	Area rates Low or Very Low for majority of assessment matters and Moderate for one. Limited ecological value other than as local habitat for tolerant native species.
Negligible	Area rates Very Low for three matters and Moderate, Low or Very Low for remainder.

Table 4. Criteria matrix for describing magnitude of effects (Roper-Lyndsay et al. 2018).

Magnitude	Description
Very High	Total loss of, or very major alteration, to key elements/ features of the baseline conditions such that the post development character/ composition/ attributes will be fundamentally changed and may be lost from the site altogether; AND/OR Loss of a very high proportion of the known population or range of the element / feature.
High	Major loss or major alteration to key elements/ features of the existing baseline conditions such that the post-development character, composition and/or attributes will be fundamentally changed; AND/OR Loss of a high proportion of the known population or range of the element / feature.
Moderate	Loss or alteration to one or more key elements/features of the existing baseline conditions, such that post-development character, composition and/or attributes will be partially changed; AND/OR Loss of a moderate proportion of the known population or range of the element / feature.
Low	Minor shift away from baseline conditions. Change arising from the loss/alteration will be discernible, but underlying character, composition and/or attributes of the existing baseline condition will be similar to pre-development circumstances/patterns; AND/OR Having a minor effect on the known population or range of the element / feature.
Negligible	Very slight change from existing baseline condition. Change barely distinguishable, approximating to the 'no change' situation; AND/OR Having a negligible effect on the known population or range of the element / feature.

Table 5. Criteria matrix for describing level of effects (Roper-Lyndsay et al. 2018).

Ecological Value → Magnitude ↓	Very High	High	Moderate	Low	Negligible
Very High	Very High	Very High	High	Moderate	Low
High	Very High	Very High	Moderate	Low	Very Low
Moderate	High	High	Moderate	Low	Very Low
Low	Moderate	Low	Low	Very Low	Very Low
Negligible	Low	Very Low	Very Low	Very Low	Very Low
Positive	Net gain	Net gain	Net gain	Net gain	Net gain

2.2 Assessment Standards for Species Potentially Affected by Myrtle Rust

All native members of the Myrtaceae family currently have a national conservation status of 'Nationally Threatened- Vulnerable'. This is derived from the fact that members of the Myrtaceae are considered to be vulnerable to myrtle rust (*Austropuccinia psidii*), a serious plant disease thought to have recently arrived in New Zealand (2017). In response, all myrtaceous species were reclassified as 'Nationally Threatened Vulnerable' (or a higher threat classification), including pōhutukawa, all species of rātā, mānuka and kānuka (de Lange *et al.* 2018). Most of these species were previously considered 'Not Threatened' and the recent reclassification is a precautionary step since the effects of the disease on New Zealand native myrtle species are largely unknown (de Lange *et al.* 2018). There is currently no effective treatment for myrtle rust.

It is noted that none of the more common myrtaceous species designated as 'Threatened- nationally vulnerable' on the basis of myrtle rust threat meet any of the criteria for this threat category listed in de Lange *et al*. (2018). This is because the numbers of individuals and areas of occupancy are large and the predicted rate of decline is unknown.

The implications of this conservation status change is that widespread and common species, such as kānuka *(Kunzea robusta*) and mānuka (*Leptospermum scoparium*) (typically dominant components of regenerating ecosystems and planting mixes) and common epiphytic rātā species such as white rātā (*Metrosideros diffusa*), small white rātā (*M. perforātā*) and climbing rātā (*M. fulgens*) are attributed a very high value (e.g. EIANZ 2018) and their occurrence causes a technical 'significant' classification under most district or regional plans according to the Resource Management Act (e.g. AUP SEA criterion 2). This is not consistent with valuations of common, robust species.

Mānuka and kānuka in particular form extensive areas of regenerating native vegetation throughout the Auckland Region and are widely planted as part of landscape and ecological restoration planting.

Myrtle rust is widespread throughout most of the North Island and parts of the northern South Island. Most native myrtaceous species are known to be infected with myrtle rust (Toome-Heller *et al.* 2020) however there have been no reports of widespread serious effects on native Myrtaceae species, except for a species of *Lophomyrtus* which is known to be highly susceptible to the disease. Early results from a study of Myrtaceae species at one native forest site found that in white rātā (*Metrosideros diffusa*) and mānuka the severity of infection was less on these species than observed on *Lophomyrtus* (Sutherland *et al.* 2020). Mānuka and kānuka to date, have shown very low levels of myrtle rust infection, however, the rust is still in its early establishment phase. Australian experience suggests it may take 10 or more years to truly establish which New Zealand Myrtaceae will be most affected.

Approach to valuation and assessment of effects

Kānuka, mānuka, and the common epiphytic rātā species (mentioned above) that are widespread and abundant throughout their range are valued as part of the ecosystems in which they are found but will not trigger 'Very High' or elevated values under Table 1 or Table 2 of the EIANZ framework. For the purposes of achieving an objective and meaningful ecological impact assessment of these species under the framework they will be evaluated under their pre-myrtle rust conservation status.

Should widespread and serious effects of myrtle rust on these species and vegetation types begin to appear in New Zealand this approach may need to be re-visited. A significant research programme is under way, to investigate and develop potential solutions and new approaches to help control or lessen the impacts of myrtle rust in the future (Ministry for Primary Industries 2018).

2.3 Survey Methods

Field assessments were carried out during April and June 2015, September to November 2019, July and October 2020 and addressed terrestrial (vegetation and flora, reptiles, birds, bats) and freshwater ecology (streams and wetlands).

2.3.1 Vegetation and Flora

The vegetation at Brookby Quarry was surveyed between April and June 2015. Detailed methods and results are set out in 'Brookby Quarry Stage Three Expansion Area: Assessment of Ecological Values' (Bioresearches, 2018). A further short survey of the Project area was undertaken in October 2020 in response to information sought by the Environment Court regarding the potential presence of threatened plant species.

Vegetation mapping

The main ridge tracks were walked and the vegetation on either side was investigated by dropping down off the ridge at intervals to look for plant communities. The riparian margins within the Project area were investigated for specialist riparian species and the epiphyte community was scrutinised using binoculars. Vegetation mapping was done using vantage points and binoculars where possible

and mapping using a hand-held Garmin Dakota 20 GPS unit. High resolution aerial photography was also used to inform the mapping process (Google Earth and Auckland Council GIS).

Vegetation descriptions

The species composition and characteristics of the key vegetation types were recorded. Descriptions, with the approximate area (ha) of each vegetation type, derived from vegetation mapping are given in Section 3.1.3

Plant habitats investigated were:

- Taraire forest (Singers *et al.* 2017:WF9)
- Tānekaha-conifer-kānuka scrub/forest
- Kānuka scrub/forest (Singers *et al.* 2017: VS2)
- Tree fern scrub
- Riparian and stream bed habitats
- Tree canopy/ epiphytic habitats

Forest Plot measurements

Within representative forest types, forest plots were marked out and the species composition, density, diameter and basal area of the trees were recorded. These measurements were designed to provide information on the quality of the forest and to inform possible mitigation strategies. Detailed methods and results are found in the Appendices of this report.

Recent updates

The purpose of this work was to update the existing species list and ensure that any threatened species had been captured. Vegetation mapping was refined and updated as necessary using standard non-plot methods.

The survey involved re-investigation of all parts of the proposed Stage 3 quarry pit extension area making opportunistic and targeted searches for threatened species including small or cryptic species such as orchids. Species of interest potentially present and searched for were identified from national and regional lists of threatened or at risk plant species and the habitats present at Brookby Quarry.

For the threatened species survey, searches were undertaken by two botanists on 16th October 2020. Detailed methods and description of results are given in 'Brookby Quarry Ecological Valuations Report Prepared for the Environment Court for Areas Identified as both Significant Ecological Areas (SEA) and Special Purpose Quarry Zone (SPQZ) under the Auckland Unitary Plan' (JS Ecology & Bioresearches 2020)

2.3.2 Invertebrates

Most native invertebrates are not directly protected under the Wildlife Act (1953). Protected invertebrates are listed in Schedule 7 of the Act, and include various species, including the kauri snail, *Paryphanta busbyii* and wetapunga, *Deinacrida heteracantha*. Both of these species occur in the Auckland Region, although have restricted distributions that do not extend south of the Rodney District.

Other invertebrate species that are not listed as protected may also contribute to qualify habitats as significant by their presence. In particular, the rhytid snail, *Amborhytida dunniae*, a medium sized carnivorous land snail is classified as Nationally 'At Risk' (Mahlfeld *et al.,* 2012).

Peripatus (Phylum: Onychophora) is widely regarded as important from an evolutionary perspective, with characteristics of both worms and arthropods. They are poorly understood, and there is no formal clarification of their taxonomy and conservation status.

Rhytid snails and peripatus require cool, moist areas of leaf litter in native forest and scrub. They can be found in deep leaf litter and in association with rotten logs and fallen nīkau fronds.

Methods

Habitat searches were undertaken throughout the Stage 3 area. Habitat searches involved opportunistically lifting logs and nīkau fronds, and undertaking targeted searches of the forest floor within 1 m^2 quadrats.

Quadrat searches involved systematically removing all leaf litter from within the quadrat, so that invertebrates could be identified. Searchers wore a headlamp during all targeted and opportunistic habitat searches so that all search areas were fully illuminated.

2.3.3 Hochstetter's Frogs

Hochstetter's frog (*Leiopelma hochstetteri*) is a small, endemic frog that occurs in scattered, fragmented populations throughout the northern half of the North Island and on Great Barrier Island (Green & Tessier, 1990). It is listed as 'At Risk – Declining' by the Department of Conservation (Newman *et al.,* 2013) and is regarded as 'Vulnerable' on the IUCN Red List 2009 (Bell *et al*., 2010).

Frog populations in the Auckland Region form three genetically distinct groups, of which populations in the Waipu-Brynderwyn-Warkworth areas are considered most at risk by the Auckland Council, due to habitat fragmentation and land use changes (Boffa Miskell, 2012). The closest known frog populations to Brookby Quarry are in the Hunua Ranges and are among the most well studied of the species.

The frog is most commonly associated with shaded streambeds or seepages under mature native forest. However, it is capable of tolerating modified habitats, such as exotic forest (Douglas, 1999; Bell *et al.,* 2004; Stephenson & Stephenson, 1957). Hochstetter's frogs are sensitive and vulnerable to

environmental disturbances, such as floods and sedimentation (Najera-Hillman *et al.,* 2009) and because they tend to occur in small and localised populations (Newman, 1996).

Methods

Desktop investigations involved a review of the Department of Conservation's *Amphibian and Reptile Distribution Scheme* (ARDS) database (accessed March 2017), as well as an analysis of aerial and topographic imagery for the presence of first and second order streams, where potential habitat is most likely.

Streams where potential habitat was present were surveyed for frog presence. All frog habitat assessments and searches were undertaken by Chris Wedding (WA 37604-FAU, Appendix III).
All footwear and equipment was sanitised using Trigene prior to survey.

Stream searches were undertaken on 12 September 2017 to determine suitability of potential habitat and the presence of frogs. Suitable potential habitat for Hochstetter's frogs was considered to be first and second order stony stream banks under a mature forest canopy, with occasional small pools or waterfalls and a gently sloping bank. Such streams are less prone to flooding than larger streams and have plenty of searchable habitat.

Marginal potential habitats were also searched. Such areas were considered to provide some of the attributes of suitable potential habitat, although searchable areas were patchy along the watercourse.

Unsuitable habitats were viewed but not searched. Such watercourses were either dry or highly channelized, indicating potential for high flows to wash frogs downstream.

Searches were undertaken during the day, between 1000 and 1500 hours. Searches involved moving slowly upstream with a headlamp to increase visibility of search areas. All potential refuges were examined by carefully lifting stones, logs and leaf litter along both stream banks, up to one metre from the water's edge. Overhanging vegetation and rock crevices were also examined under torch light. All lifted substrates were replaced in their original position.

2.3.4 Lizards

New Zealand has two major groups of terrestrial reptiles: lizards (Order Squamata) and tuatara (Order Rhynchocephalia). Tuatara are not present on mainland New Zealand, outside wildlife sanctuaries, and therefore are not considered in this assessment. Nine species of native lizard have been recorded on the Auckland mainland and six of these are classified as Nationally 'At Risk' by the Department of Conservation (Hitchmough *et al.,* 2016).

One introduced species, the rainbow skink (*Lampropholis delicata*), is classified as an 'Unwanted Organism' by the Ministry of Agriculture and Fisheries (MAF) under the Biosecurity Act (1993) and is not considered in this assessment, other than noting where they were observed.

Table 6. Threat classification of native lizards from the Auckland Region. Threat category as per Hitchmough et al. (2016)

Species	Threat Category	Threat Status
Copper skink (*Oligosoma aeneum*)	Not Threatened	N/A
Ornate skink (*Oligosoma ornatum*)	At Risk	Declining
Moko skink (*Oligosoma moco*)	At Risk	Relict
Striped skink (*Oligosoma striatum*)	At Risk	Declining
Shore skink (*Oligosoma smithi*)*	At Risk	Relict
Forest gecko (*Mokopirirakau granulatus*)	At Risk	Declining
Pacific gecko (*Dactylocnemis pacificus*)	At Risk	Relict
Elegant (green) gecko (*Naultinus elegans*)	At Risk	Declining

*Strictly a coastal species

Methods

Specific survey methodologies were employed to target native lizard species within different habitat types. Those methodologies included the use of artificial lizard retreats (ARs), primarily for terrestrial species, and nocturnal visual encounter searches (VES), primarily for arboreal species. Manual habitat searches of logs and leaf litter were also undertaken in conjunction with invertebrate assessments

All lizard survey work was undertaken by at least two experienced DOC permitted herpetologists (WA 37604-FAU)

Artificial lizard retreats

Eleven artificial lizard refuge (AR) stations were installed on 16 March 2017. Each station consisted of four ARs (n = 36 ARs). ARs were left to settle in the environment for at least four weeks before they were checked. Lizard retreat checks were undertaken on three, non-consecutive days during calm and settled weather (20th, 26th April and 12th September 2017). Repeated checks are necessary as native lizards often use multiple retreat sites within their home ranges. All lizards observed were recorded with a hand-held GPS unit (Garmin 60CSx).

Sites where ARs were placed were typically within and alongside dense clusters of vegetation, logs, fallen trees and organic debris dams where potential lizard encounters were considered most likely.

ARs used by Bioresearches are 500 mm x 500 mm corrugated Onduline© sheets (distributed by GBS Group Ltd). Onduline© is an organic, bitumen-saturated material used in reptile surveys throughout New Zealand, due to its light weight and suitable thermal properties (Lettink & Cree, 2007; Wilson *et al.,* 2007).

Nocturnal Visual Encounter Surveys (VES)

Nocturnal VES were undertaken on 25 and 27 September 2017. Focused headlamps (*Fenix* ™ HP 11) aided by 8 x 42 Nikon *Monarch* binoculars were used to search for geckos on the ground, on tree branches and in foliage. Searches involved walking slowly along the track edges where a greater profile of the forest edge was more visible. Particular attention was placed on scanning kānuka trees and

epiphytes, where gecko encounters were considered most likely. A total of 10 person-search hours were conducted over 1.85 km of track edge.

Where any lizards were encountered, an encounter rate was calculated as *n / (h x s)*, where:
n = number of geckos encountered
h = number of hours spent searching
s = number of surveyors searching

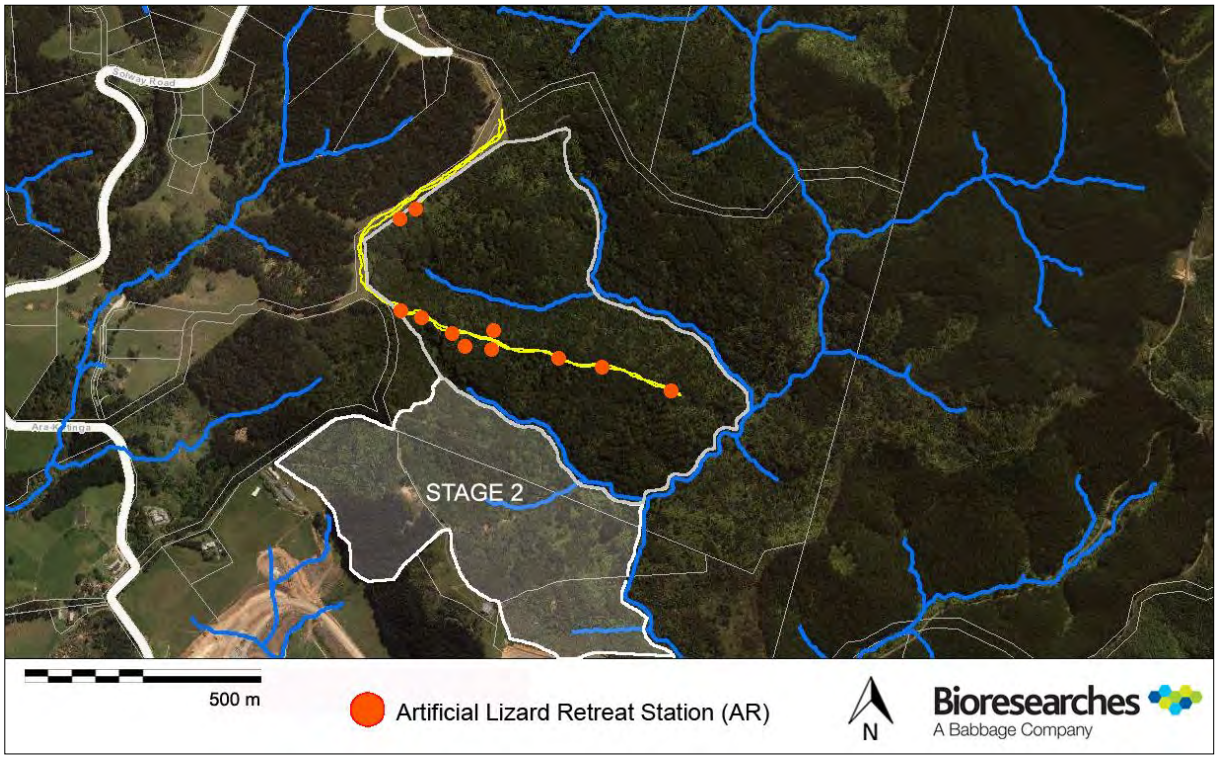

Figure 3. Artificial lizard retreat station (AR) and night search (VES) route (yellow line).

2.3.5 Birds

A desktop analysis involved a review of the New Zealand Bird Atlas data, inaturalist, and New Zealand eBird.

Habitat assessments of mature and regenerating native forest were also undertaken during site visits (day and night searches) in September, November and December 2020. Incidental visual and call observations were recorded for all forest birds seen and heard during numerous site visits.

Formal bird surveys for species using the Project area were recorded via replicate five-minute counts.

5-Minute bird counts

Replicated (n = 4) five-minute bird counts were undertaken at five stations (20 individual counts), and sampled the range of habitats present but focussed on the secondary native forest. The estimated audio-visual radius at each station was 50 m.

At each station the general weather conditions, any other noise and any wind effects on the vegetation were recorded. Counts were aided by 8 x 42 Nikon *Monarch* binoculars.

The five-minute count surveys were undertaken 16 March and 20th April 2017 between approximately 0900 and 1100 hours.

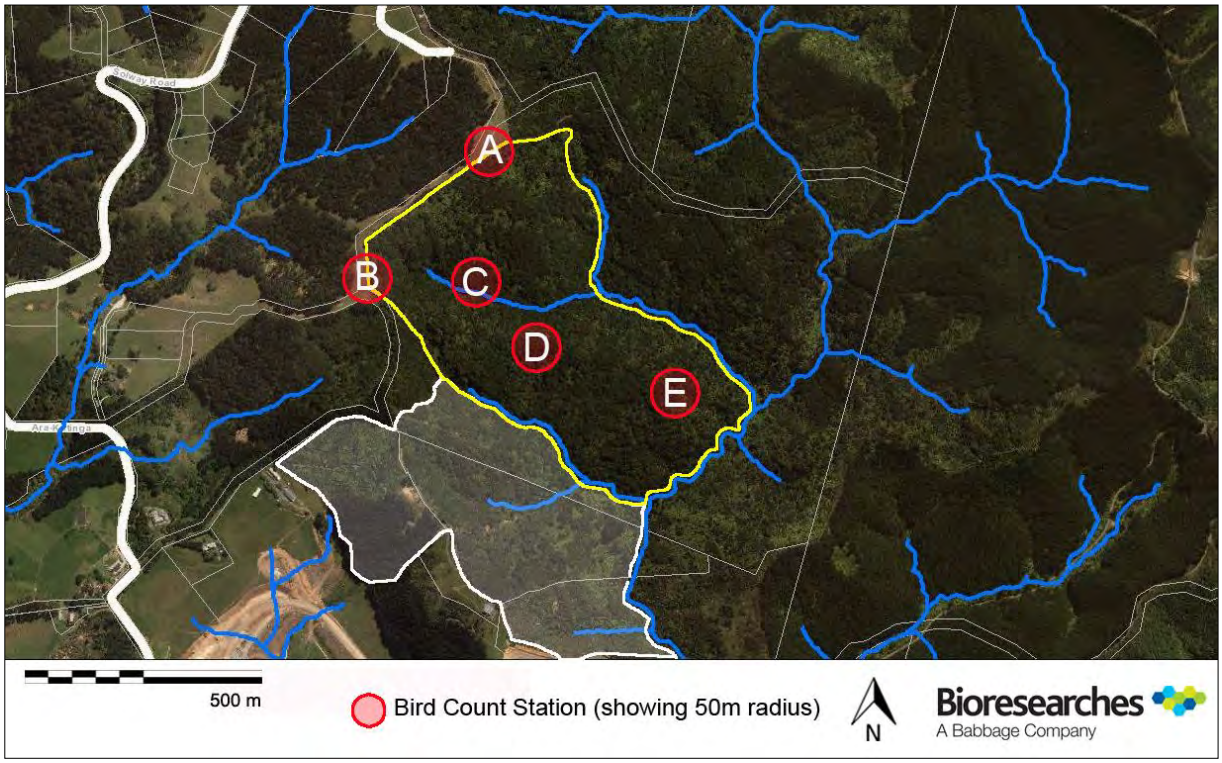

Figure 4. Locations of bird count stations with 50 m audio-visual radius, at Stage 3 of Brookby Quarry.

2.3.6 Bats

Long-tailed bats (LTBs; *Chalinolobus tuberculatus*) are classified as 'Nationally Critical' (O'Donnell *et al.,* 2018). This classification is given the qualifier 'Conservation Dependent' which indicates the taxon is likely to move to a higher threat category if current management ceases (Townsend *et al.,* 2008). LTBs are known to occur at several sites across the Auckland Region (e.g. Rodney District, Waitākere Ranges, Hunua Ranges). The Hunua Ranges is the closest known population to Brookby Quarry, however, individual bats have been recorded within 3 km of the site, at Clevedon Scenic Reserve.

Long-tailed bats typically use linear landscape features such as bush edges, gullies and water courses to transit between roosting and feeding sites (Borkin and Parsons 2009; Griffiths 1996). They also tend to forage in open areas, including clearings (Borkin and Parsons 2009; Griffiths 1996), along forest edges (Alexander 2001; O'Donnell and Sedgeley 1994), over wetlands, open water and along rivers and roadways (Borkin and Parsons 2009; Griffiths 1996). Long tailed bats may travel 20 km between roost sites and foraging areas.

Bats are dependent on roosting cavities with specific micro-climates, which are typically rare in landscapes. They require large trees (including exotic and standing dead trees) with cavities (e.g. knot holes, hollows), and from summer, communal roosts are dominated by females and young. However, individual bats may still refuge beneath other suitable features such as within epiphytes, loose bark hollow tree ferns or under tree fern skirts.

Short-tailed bats (*Mystacina uberculata*), New Zealand's other bat species, are associated with extensive areas of old-growth native forest (Lloyd 2001). Because of the absence of extensive areas of this habitat type in and around Brookby Quarry, and that there are no short-tailed bat records within 20 km of the Project area, we consider this species is unlikely to be present.

Methods

LTB surveys were undertaken using four fixed-location Automatic Bat Monitoring (ABM) detectors and hand-held recorders. All survey work, including analysis, was undertaken by Chris Wedding, DOC-certified bat ecologist for survey and analysis with 15 years' experience.

Automatic Bat Monitoring (ABM) detectors

ABMs were used to record ultrasonic echolocation calls that are produced by bats during their navigation and foraging behaviours (Sedgeley *et al.,* 2012). An ABM records the ultrasonic echolocation calls emitted by bats and converts them to frequencies that are audible to humans (Parsons & Szewczak, 2009).

An ABM is comprised of two ultrasound sensors and microphones, a sound-activated recording device, a timer to turn the system on and off each day, and a rain-noise detector that turns the system off in the event of heavy, persistent rainfall. ABMs record and store data passively and remotely, and have the capacity to record both long-tailed (40 kHz) and lesser short-tailed bat calls (28 kHz).

The ABMs were set to begin recording 30 minutes before sunset and turn off 30 minutes after sunrise, for 40 nights from 16 March to 26 April 2017.

Data Analysis

ABM data were downloaded and the waveforms analysed using Bat Box 1.0 software (Department of Conservation, 2008). The total number of 'usable nights' (UNs) was determined using climate data (CliFlo, New Zealand's National Climate Database; NIWA, 2017) and recording analysis (e.g. when the recorder log indicated a noise switch- pause for a period of more than half the night). Nights were considered 'useable' if the temperature remained above 5°C and more than half the night was free of rain or insect noise.

Each echolocation pass was time (hour/minute/second) and date stamped (year/month/day) providing timing information for activity.

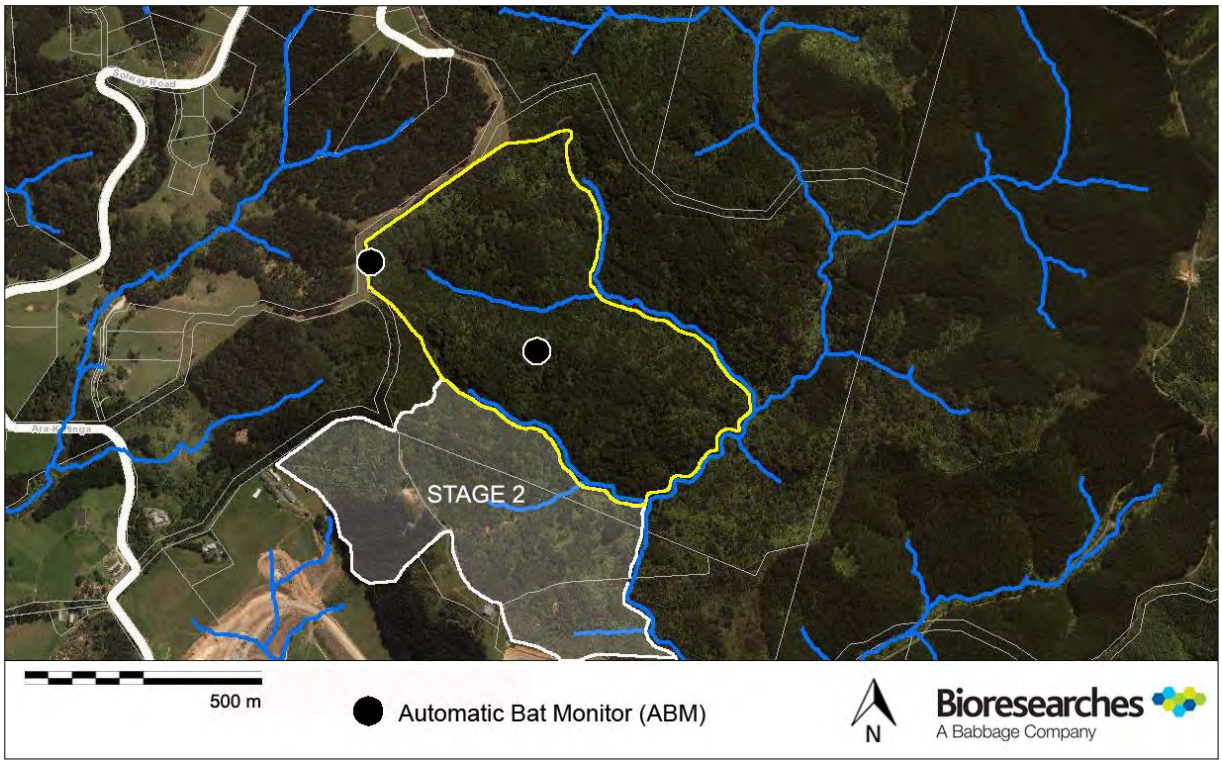

Figure 5. Locations of Automatic Bat Monitors at Stage 3, Brookby Quarry.

2.4 FRESHWATER HABITATS

2.4.1 Introduction

Stream ecological assessments of the Stage 3 expansion area were carried out on 10th, 11th and 12th of March 2015, and 31st of July and 1st of August 2017. Prior to carrying out the fieldwork in July/August 2017 the indicative extent of the permanent and intermittent streams in the proposed expansion area was mapped from the Auckland Council GeoMaps, catchments and hydrology overlay, augmented by earlier field work carried out by the ecological teams. The extent of the proposed Stage 3 expansion area, with respect to the streams, was determined from the Survey Worxs 100 Year Plan Drawing No. 7-356-105-Des 24.04.15, and is illustrated on Figure 6.

2.4.2 Site Locations

Three un-named permanent streams and twelve un-named intermittent streams, all tributaries to the Papakura Stream, were assessed in the expansion area. The location and description of each stream site and the five representative sections of the streams where more detailed assessments were carried out are presented in Table 7 and Figure 6.

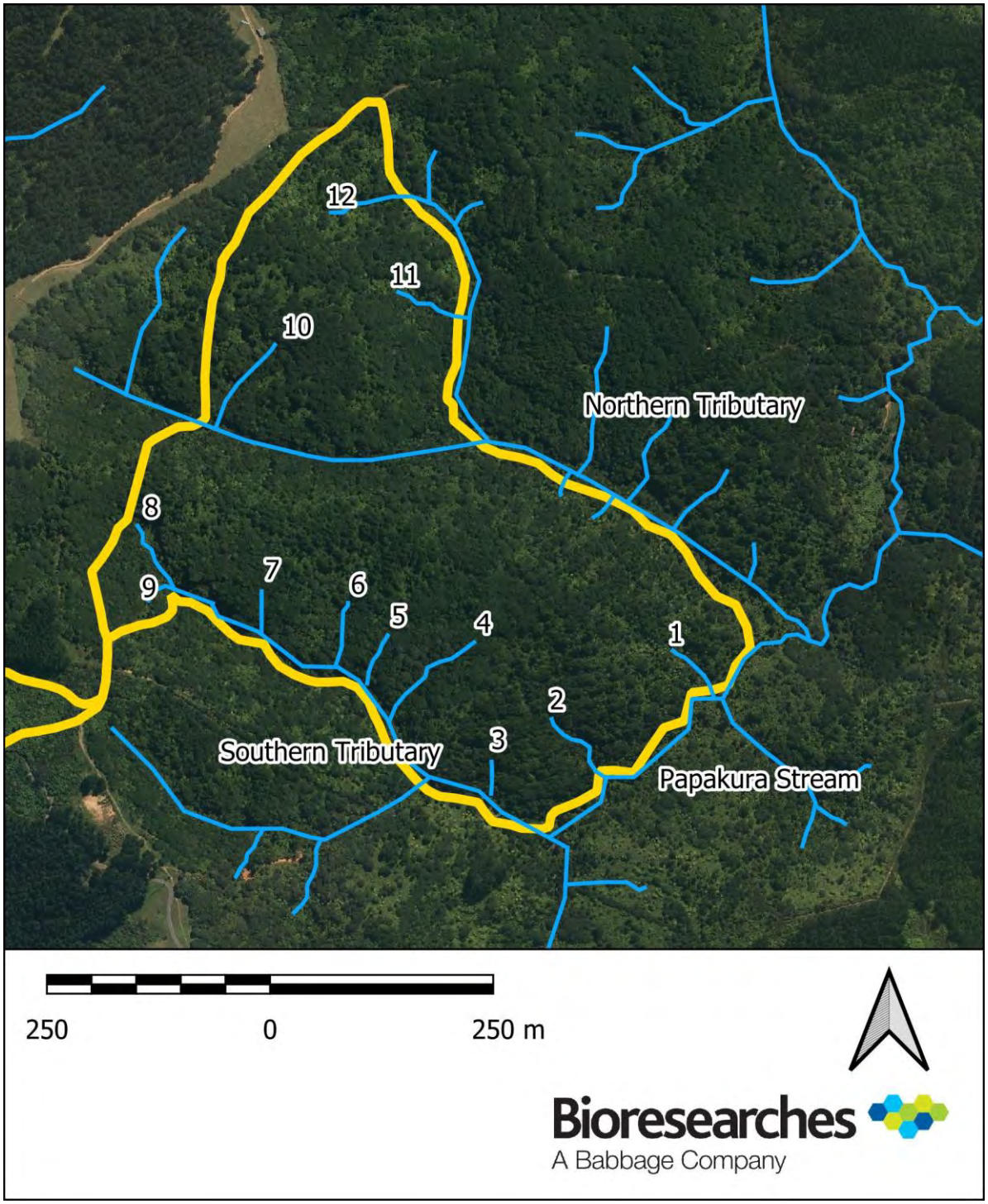

Figure 6. Stream Locations in Brookby Quarry Stage 3 Expansion Area. Source of Base Map: Auckland Council GeoMaps GIS viewer (September 2017); Stage 3 outline based on Survey Worxs 100 Year Plan Drawing No. 7-356-105-Des 24.04.15.

Table 7. Papakura Stream Tributaries - Site Locations

Site Name	Location	Map Reference NZTM*
N - ST	North Branch of Southern Tributary	E 1779475 N 5908263
ST	Southern Tributary (between to confluences)	E 1779672 N 5908106
W - NT	West Branch of Northern Tributary	E 1779496 N 5908505
WC 1 : PS	Intermittent tributary to Papakura Stream	E 1779906 N 5908264
WC 2 : PS	Intermittent tributary to Papakura Stream	E 1779784 N 5908159
WC 3 : ST	Intermittent tributary to the Southern Tributary	E 1779669 N 5908140
WC 4 : N-ST	Intermittent tributary to North Branch of Southern Tributary	E 1779594 N 5908254
WC 5 : N-ST	Intermittent tributary to North Branch of Southern Tributary	E 1779543 N 5908274
WC 6 : N-ST	Intermittent tributary to North Branch of Southern Tributary	E 1779502 N 5908296
WC 7 : N- ST	Intermittent tributary to North Branch of Southern Tributary	E 1779411 N 5908317
WC 8 : NH - ST	Northern headwater tributary to North Branch of Southern Tributary	E 1779295 N 5908384
WC 9 : SH - ST	Southern headwater tributary to North Branch of Southern Tributary	E 1779303 N 5908351
WC 10 : W-NT	Intermittent tributary to West Branch of Northern Tributary	E 1779391 N5908584
WC 11 : N-NT	Lower intermittent tributary of the North Branch of Northern Tributary	E 1779613 N 5908660
WC 12 : N-NT	Upper intermittent tributary of the North Branch of Northern Tributary	E 1779559 N 5908785

*to approximate mid-point of watercourse

2.4.3 Freshwater Methodology

All streams were assessed and described, width and depth measurements were collected over a representative area of the stream, the upper and lower extents of the watercourses assessed and marked with hand-held GPS units, and photographs collected. Habitat limiting factors, such as major slips, barriers to fish passage, or permanence of water flows were noted.

Detailed assessments of five representative reaches of the streams were undertaken using the Stream Ecological Valuation (SEV) methodology.

The SEV methodology (Storey *et al.*, 2011; Neal *et al.*, 2016) enables the overall function of the stream to be assessed and compared to the quality of other streams in the Auckland Region. The SEV procedure involves the collection of habitat data (e.g. stream depth, substrate type, riparian cover), and sampling of fish communities and macroinvertebrates (e.g. insect larvae, snails), the latter being

recognised indicators of habitat quality. SEV data are then entered into a SEV calculator to calculate a SEV value.

The SEV assessments were undertaken over a representative 100 m section of each of the watercourses in the Stage 3 expansion area. The SEV reach was marked at the upstream and downstream boundaries with a handheld GPS.

Macroinvertebrates were sampled from the instream habitats to obtain semi-quantitative data in accordance with the Ministry for the Environment's current 'Protocols for Sampling Macroinvertebrates in Wadeable Streams' (Stark *et al*., 2001). Sampling was undertaken along each SEV reach, using protocol 'C1: hard-bottomed, semi-quantitative' as the streams were hard bottomed. The macroinvertebrate sample was preserved in 70% ethyl alcohol (ethanol), returned to the laboratory and sorted (using protocol 'P3: full count with sub-sampling option', Stark *et al*., 2001). Macroinvertebrates were then identified to the lowest practicable level and counted to enable biotic indices to be calculated.

Three biotic indices were calculated, namely the number of taxa, the percentage of Ephemeroptera (mayflies); Plecoptera (stoneflies) and Trichoptera (caddisflies) recorded in a sample (%EPT) and the Macroinvertebrate Community Index (MCI). EPT are three orders of insects that are generally sensitive to organic or nutrient enrichment. The MCI is based on the average sensitivity score for individual taxa recorded within a sample. MCI scores of >120 are indicative of excellent habitat quality, 100 - 119 are indicative of good habitat quality, 80 – 99 are indicative of fair habitat quality and < 80 are indicative of poor habitat quality (Stark & Maxted, 2007b). Raw macroinvertebrate data are presented in Appendix IV.

Fish communities were comprehensively sampled in March 2015 using Gee's minnow traps and fyke nets, where there was sufficient water, and electric fishing was carried out using an EFM300 backpack electric fishing machine. The electric fishing machine temporarily stuns the fish, allowing them to be captured. An Index of Biotic Integrity (IBI) was calculated for the streams based on fish species present, altitude and distance inland (Joy & Henderson, 2004).

In situ spot measurements of basic water quality parameters (temperature, dissolved oxygen and conductivity) were undertaken within the SEV reach. Measurements were undertaken using a Yellow Springs Instruments (YSI) Professional Series combined dissolved oxygen/temperature/conductivity meter.

3. EXISTING ENVIRONMENT

3.1 VEGETATION AND FLORA

3.1.1 Original vegetation

The original forest in this area is likely to have been Taraire, tawa, podocarp forest (WF9) and Kauri, podocarp-broadleaved beech forest (WF12) as mapped on the Auckland Council Geomaps biodiversity layer for the potential extent of ecosystems. Kauri (*Agathis australis*), occasional tānekaha (*Phyllocladus trichomanoides*), tōtara (*Podocarpus totara*) and hard beech (*Fuscospora truncata*) would have generally occupied the well-drained ridges with taraire, rimu, miro (*Prumnopitys ferrugine*a), northern rātā (*Metrosideros robusta*), tawa (*Beilschmiedia tawa*), rewarewa *(Knightia excelsa*) and locally abundant pūriri (*Vitex lucens*) in gullies and on shallow hillslopes. Pukatea (*Laurelia novae-zelandiae*) and kahikatea (*Dacrycarpus dacrydioides*) would have been common in gullies (Singers & Rogers, 2014; Singers *et al.,* 2017). The forest has been logged and much of it has probably been burned; in some parts more than once. Current vegetation types are described below.

3.1.2 Current vegetation types

The composition of the vegetation varies considerably across the site according to its maturity and site-specific factors such as aspect and topography. It forms a mosaic of forest types that is indicative of multiple past disturbances. Key vegetation types are listed in

Table 8 and mapped in Figure 9

Table 8. Vegetation type value and quantity within Brookby Stage 3

Vegetation type	Threat status	Quantity (ha)	Botanical value
Regenerating kānuka scrub / forest with patches of tree fern dominant forest	Not Threatened	6.3	Moderate
Taraire dominant broadleaved forest.	Endangered	10.75	High
Tānekaha dominant forest on the northern side of the central ridge.	Not Threatened	9.5	Moderate
Small pockets of podocarp forest dominated by rimu and tōtara along the central ridge	Not Threatened	1.4	Moderate
Total		**27.95**	

A species list of native plants found within the Stage 3 quarry expansion area can be found in Appendix I, which also lists the forest type (s) each species was recorded in.

Kānuka scrub / forest

The regenerating kānuka scrub (c. 6.3ha) within the Project area is typical of successional vegetation following clearance of the original podocarp-broadleaved forest that would have formerly occupied the site.

As a result of past management practices and site-specific features such as aspect and slope its successional stage varies across the site. There are some quite extensive patches of damp tree fern forest of low diversity where a thick layer of fallen fern fronds appears to be suppressing regeneration of other forest pioneer species such as broadleaved shrubs. The dominant species are silver fern (*Cyathea dealbata*) on dryer slopes with black ponga / mamaku (*Cyathea medullaris*) and rough tree fern (Dicksonia squarrosa) in damper and shadier areas. Seedlings of rangiora (*Brachyglottis repanda*), hangehange (*Geniostoma ligustrifolium*), lancewood (*Pseudopanax crassifolius*) and other common shrub species in more open areas indicate that this vegetation will transition to scrub forest with time. The kānuka forest is of varying age, although much of it is at a mature stage and contains occasional good-sized specimens of rewarewa, rimu, tānekaha and tōtara.

Common amongst the kānuka are mature lancewood, silver tree fern, tall māhoe (*Melicytus ramiflorus*) and scattered tall nīkau. Hangehange, kawakawa (*Piper excelsum*) and twiggy coprosma (*Coprosma rhamnoides*) are common understorey plants. Ground cover plants include cutty grass (*Gahnia setifolia*), crown fern (*Blechnum discolour*) and native sedges (*Carex lambertiana* & *C. uncinata*) in various habitats amongst which are seedlings of kahikatea, taraire and other future canopy species. Rough tree fern, mamaku native fuchsia (*Fuchsia excorticata*), patē and wineberry (*Aristotelia serrātā*) are found as streamside plants. Vines include native passion vine (*Passiflora tetrandra*) and bush lawyer (*Rubus cissoides*). Tī ngahere; cabbage tree (*Cordyline banksii*) is occasional, particularly along track edges.

The mature kānuka forest generally has moderate botanical values as it has a good diversity of native species which are typical of this vegetation type. The kānuka trees are of good size and the presence of numerous tānekaha poles and scattered young rewarewa, rimu, tānekaha and tōtara indicates that the vegetation is transitioning towards the broadleaf-podocarp vegetation that once occupied the site. Areas of younger kānuka and tree fern forest are of moderately low botanical value as the plant community is of lower diversity and is made up of common pioneer species.

This forest type is generally common throughout the Auckland Region since it has colonised many areas that were formerly occupied by tall forest that were burnt last century. It corresponds to 'Kānuka scrub/forest' a regenerating ecosystem with an IUCN classification for the Auckland Region of 'Least Concern' indicating it is not threatened.

Taraire forest

Taraire-dominant forest (c. 10.76ha) generally occupies the southern faces of the ridges and are probably remnants of the original forest which appear to have been logged and podocarps removed early last century. Due to this past modification, the canopy is heavily dominated by taraire with tawa as a secondary species and rewarewa, tōtara, rimu and kahikatea occasional. Scattered larger pūriri

are also a feature of this forest type. This forest type corresponds to 'Taraire, tawa podocarp forest' (WF9) as classified by Singers *et al.* (2017)

Tall nīkau are common and kohekohe (*Dysoxylem spectabile*) form the subcanopy of the forest with a deep layer of sclerophyllous taraire leaf litter underneath and a sparse ground layer.

As is typical of this forest type there are numerous epiphytes and climbers such as kahakaha (*Astelia hastata*), perching lily (*Astelia solandri*), kiekie (*Freycinetia banksii*) and supplejack (*Ripogonum scandens).* Three species of climbing rātā and numerous epiphytic ferns are also found on tree trunks and high in the canopy.

Native shrubs and understorey plants are most numerous along the forest edges and in light gaps. They include hangehange, coprosma species (*C. spathulata, C. grandifolia, C. lucida*), pigeonwood (*Hedycarya arborea*) heketara (*Olearia rani*), māhoe, and silver tree ferns. Patē is common along streamsides. The understorey is often very sparse under closed canopy forest however, with few broadleaved species present.

In the ground layer are found seedlings of the canopy, sub canopy and shrub species as well as ground ferns such as hairy fern (*Lastreopsis hispida*), hen and chicken fern (*Asplenium bulbiferum*) and the related *Asplenium lamprophyllum*. In damp, dark parts of the forest crape fern (*Leptopteris hymenophylloides*) and native begonia (*Elatostema rugosa*) are found. Groundcover is often comprised mainly of a deep sclerophyllous layer of fallen taraire leaves however.

The botanical values of this vegetation are high despite historic modification through selective logging. The canopy is heavily dominated by one tree species (taraire); other canopy species such as rimu, kahikatea, tawa and pūriri are found in much lower numbers than would be expected. Other species that could be expected to be present such as pukatea and miro are nearly absent. Overall, diversity of other suites of plants such as groundcover plants and epiphytes is good although browsing by goats has reduced the occurrence and density of palatable species. Generally, the vegetation is representative of its type despite the relative proportions of different canopy species being atypical of natural unmodified forest.

Taraire forest has an IUCN classification for the Auckland Region of 'Endangered'.

Transitional forest of tānekaha, old kānuka and young podocarps

Transitional forest containing mature kānuka with abundant tānekaha and good numbers of other young podocarps such as rimu and tōtara, (c. 9.5 ha) represents a successional stage between kānuka scrub and podocarp-broadleaved forest. Tānekaha poles and some larger trees are dominant with scattered tōtara, rimu, rewarewa, large old kānuka and occasional miro. Understorey plants include heketara, *Coprosma spathulata*, silver tree fern, tōtara and rewarewa seedlings, twiggy coprosma, hangehange, māpou, and nīkau. This vegetation type is generally of somewhat lesser diversity than either the taraire forest or the mature kānuka forest. It occupies the northern face of the central ridge and the north eastern end of the northern ridge which is likely to be a drier environment than the habitat occupied by the taraire forest on the southern ridge faces. It may also have suffered more

intense effects from historic fires than the southern faces of the ridges and hence it is recovering along a different successional pathway. The botanical values of this vegetation are **moderate**. It is classified as an advanced successional stage of 'Kānuka scrub/forest' a regenerating ecosystem with an IUCN classification for the Auckland Region of 'Least Concern' indicating it is not threatened.

Podocarp-dominant forest

Small pockets of rimu-dominant forest and tōtara-dominant forest occur along the crest of the central ridge and comprise 1.4 ha approximately in total. The tōtara-dominant forest is found at the eastern end of the central ridge. There are some large tōtara trees here with scattered taraire and rewarewa. The understorey is relatively open. The rimu dominant patch of forest is approximately half way down the central ridge on the southern side. There is a significant component of tānekaha and a scattering of miro. The rather sparse understorey is composed mainly of silver fern, twiggy coprosma and mingimingi (*Leucopogon fasciculatus*). For both these vegetation types the canopy contains a significant component of tānekaha. They represent a later successional stage than the tānekaha dominant forest.

The botanical values of this vegetation are moderate. It is a variation of the transitional tānekaha dominant forest classified as an advanced successional stage of 'Kānuka scrub/forest' a regenerating ecosystem with an IUCN classification for the Auckland Region of 'Least Concern' indicating it is not threatened.

Regenerating broadleaved scrub

Cutover pine forest in the south west corner of the Stage 3 area (Figure 9) has regenerated into mixed native and exotic scrub which is very dense. Māhoe and silver tree fern are the dominant native shrubs with hangehange, karamu and māpou also common. Woolly nightshade (*Solanum mauritianum*), gorse (*Ulex europaeus*), pampas (*Cortaderia selloana*) and blackberry (*Rubus fruticosus*) infest the site and it is typical of the vegetation seen on such sites throughout the warm, humid Auckland Region. Other weeds such as wild ginger (*Hedychium gardnerianum*) and inkweed (*Phytolacca octandra*) are also common. The botanical values of this vegetation are low due to a significant component of invasive pest plants and the low diversity of native plants which are all common pioneer species. Regenerating broadleaved scrub /forest has an IUCN classification for the Auckland Region of 'Least Concern'.

Threatened and Regionally Rare Plants

One species with a national and regional threat ranking, carmine rātā (*Metrosideros carminea*) was recorded growing on a silty bank above a small tributary of the Papakura Stream.

Carmine rātā is a myrtaceous species that has a long-standing conservation status of 'Regionally at risk-sparse' for the Auckland Region (Stanley *et al.* 2005). Taxa in this category occur in typically small and widely scattered populations for largely unknown reasons. Although their distribution appears wholly natural and is not considered the result of past or recent anthropogenic disturbance they are naturally susceptible to extirpation within parts of their range (Stanley *et al* 2005). The regional threat status means that the national threat status (Nationally Threatened- Vulnerable) assigned due to the arrival

of myrtle rust may be more significant for carmine rātā than for other common species of rātā in the Auckland Region. This is because small and scattered populations have a greater risk of local extinction than widespread and abundant populations.

Carmine rātā is a species endemic to New Zealand, occurring in the North Island from Te Paki south to Taranaki in the west and Mahia Peninsula in the east. The species is a woody, long-climbing vine of closed forest and forest margins, often along water ways and on ridge lines, especially on rock outcrops and cliff faces. Only mature plants are reproductive and these are often overlooked unless flowering as they occur high in the tree canopy. Carmine rātā flowers from late winter to mid-spring, and has vibrant displays of bright red flowers in groups at the ends of the stems. Flowering can be sporadic from season to season however (C. Kilgour pers. comm.)

Not all potential habitat for carmine rātā was able to be investigated during the survey. Other occurrences of the species are highly likely within the general area at Brookby. Often the plant exists only in the juvenile phase and is more rarely found as an adult. Similar vegetation types and plant habitats also occur in areas outside the proposed expansion area at Brookby on the north eastern side of the proposed expansion area and along the Papakura Stream which may provide habitat for the plant. Other adjacent areas of forest outside the Brookby site are also likely to provide habitat for the species.

Figure 7. Carmine rātā within the Stage 3 quarry expansion area at Brookby

Figure 8. Carmine rātā habitat at Brookby within the Stage 3 quarry expansion area

3.1.3 Vegetation mapping

Vegetation mapping for the Project area is shown in Figure 9. The vegetation was initially mapped in 2015 and then refined in 2020.

The mapped vegetation (Figure 9) differs considerably from Auckland Council's Geomaps due to refinements achieved following the current investigations in line with the updated quarry design. Of note, are that:

- The taraire forest is not as extensive as officially mapped although it is still a significant component of the forest at the site.
- Tānekaha-dominant forest comprises a significant area across the Brookby site on the drier north-facing central ridge face.

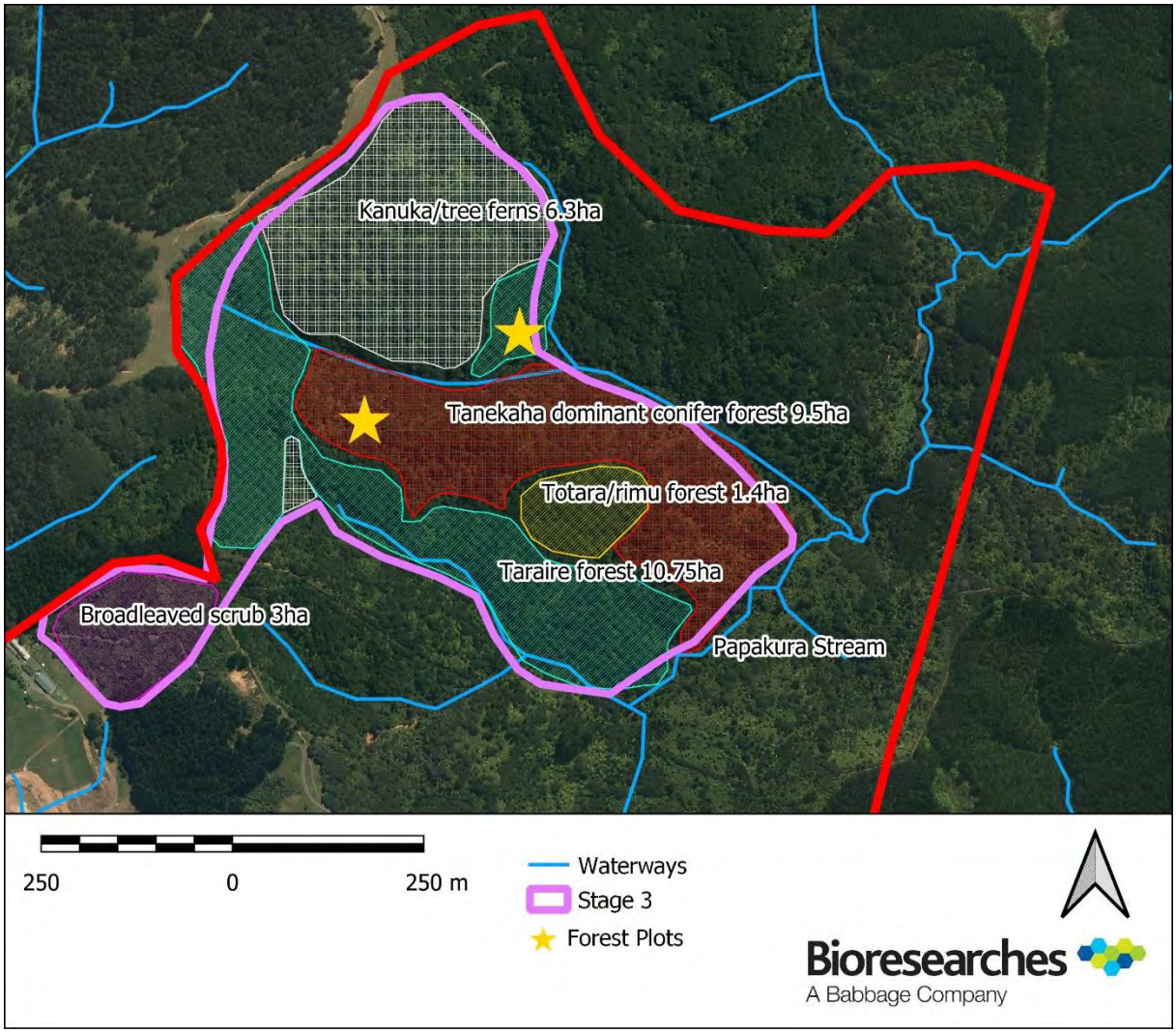

Figure 9. Mapped vegetation types within Brookby Quarry Stage 3 expansion area as established by the Bioresearches ecological survey. Pink line: indicative of Stage 3 and the location of forest plots shown by yellow stars.

3.1.4 Summary Vegetation and Flora Values

One 'threatened' (and Regionally 'At Risk') plant, carmine rātā, was found in one location at Brookby Quarry within the Project area. Other myrtaceous species were present (as discussed below, but refer section 2.2).

Other Myrtaceae species

White rātā, small white rātā and climbing rātā were all recorded at Brookby, most commonly amongst taraire forest. All three species were relatively abundant as they typically are throughout the Auckland Region.

The Project area contains approximately 10.75ha of taraire forest (WF9), a type listed as 'Endangered' by the Auckland Council (Singers *et al.* 2017). The taraire forest does appear to have been modified by past logging of podocarps. Past landuse practices including burning and grazing have resulted in the mosaic of different vegetation types observed at the site today. Feral animals including goats, pigs and possums continue to pose a threat to the current ecosystem types.

The following vegetation types were mapped within the Stage 3 quarry expansion area:

- Regenerating kānuka scrub / forest with patches of tree fern dominant forest (6.3ha). Not Threatened.[1]
- Taraire dominant broadleaved forest. (10.75ha). Threatened: Endangered.
- Tānekaha dominant forest on the northern side of the central ridge (9.5ha). Not Threatened.
- Regenerating broadleaved scrub (3ha). Not Threatened
- Small pockets of podocarp forest dominated by rimu and tōtara along the central ridge (1.4ha). Not Threatened.

3.2 FAUNA INVERTEBRATES

A total of 95 quadrat searches were undertaken within four broad forested areas (Figure 8) of Stage 3 (Table 9). Habitat searches did not reveal any peripatus, *Amborhytida dunniae* snails or other invertebrate taxa with conservation ratings other than 'Not Threatened'. The carnivorous land snail, *Rhytida greenwoodi* (Not Threatened) was found occasionally within areas C and D.

Table 9. Summary of forest floor targeted search effort.

Date	Area searched	Number of plots	Major leaf litter type	Weather conditions
20-Apr	B	22	taraire / tānekaha/nīkau	Fine, calm
20-Apr	C	23	taraire	
26-Apr	A	26	tree fern / nīkau / kānuka	Fine, calm
25-May	D	24	taraire / tānekaha/nīkau	cloudy, calm

Quadrat searches identified millipedes (Class: Diplopoda), including pill millipedes (Order Sphaerotheriida) and landhoppers (Amphipoda) as among the most common invertebrates recorded, as well as other small (>10 mm diameter) land snails. Opportunistic searches revealed other invertebrate species, particularly species not always associated with leaf litter, including slaters

[1] threat classifications as set out in Singers *et al.* (2017)

(Isopoda); cockroaches (Blattodea) and ground wētā (Anostostomatidae). Large banded tunnel web spiders (*Hexathele hochstetteri*) were observed occasionally during litter searches and nocturnal searches. The giant centipede (*Cormocephalus rubriceps*) was recorded from within Stage 2.

Most of the species observed were native, although none had a national threat classification of nationally 'At-Risk' or greater.

3.2.1 Discussion and Assessment

The invertebrate searches did not identify any threatened or 'At Risk' species and it was noted that the forest floor supported only a few logs that could be searched (around and under). For this reason, the project area is not considered to be important habitat for either the rhytid snail, peripatus or other invertebrate species of interest. Both *Rhytida greenwood*: (common) and peripatus were recorded in the southern taraire-dominated block in 2000 (Bioresearches, 2000).

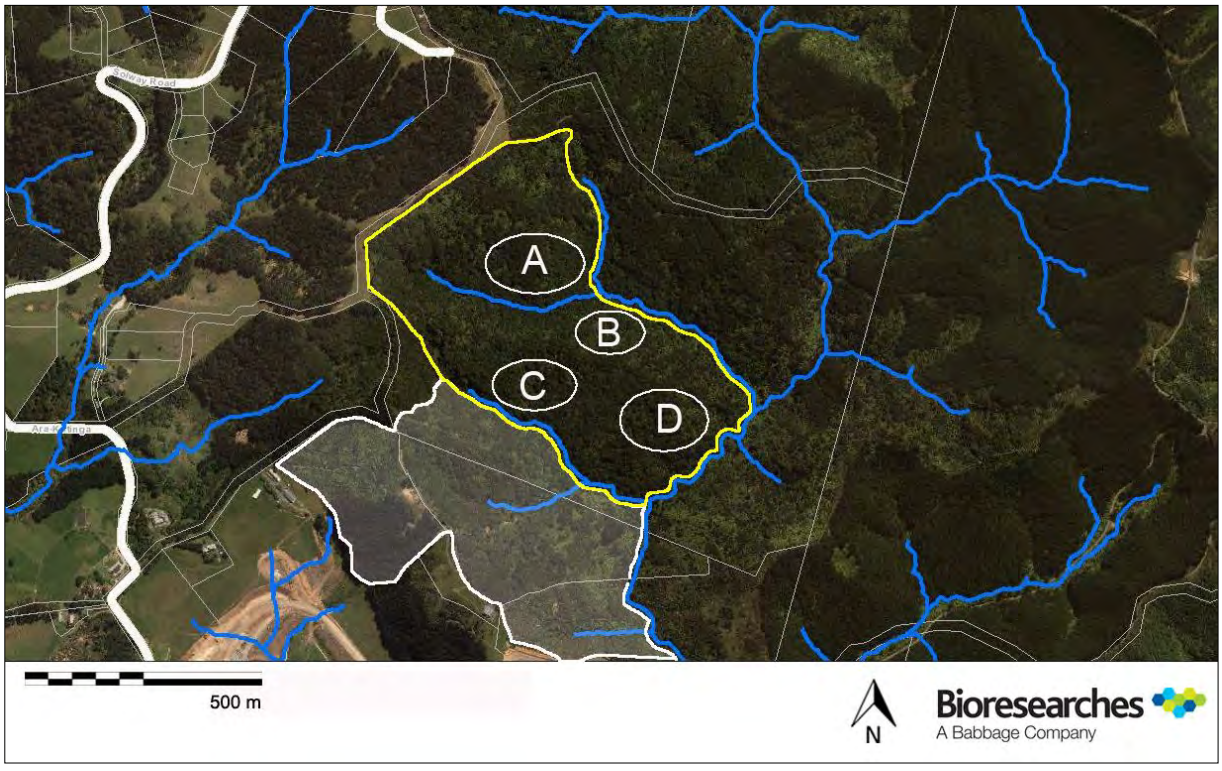

Figure 10. Indicative quadrat search areas for forest floor invertebrates.

3.3 HOCHSTETTER'S FROGS

No native frogs were observed and no watercourses were considered suitable to provide habitat for a population of Hochstetter's frogs within the Stage 3 area in the long term. It was noted however, that small, isolated pockets of potential habitat were observed in the form of small waterfalls (Figure 11 and Figure 12). Despite no frogs being observed within the vicinity of these, native frogs have been found in similarly small and isolated waterfalls with crevice retreats elsewhere beyond Brookby.

Figure 11. Small waterfall within the Brookby Stage 3 area. Note the silty water, typical of the observed streams where frog habitat was marginal

Figure 12. Small waterfall within the Brookby Stage 3 area.

3.4 LIZARDS

No lizards were recorded from 176 AR inspections.

Two forest geckos were recorded from nocturnal VES. One gecko was recorded from along the north western bush edge and one at the western end of the ridge track (Figure 13). An average encounter rate of 0.2 forest geckos/hour was achieved from the two searches. Introduced rainbow skinks were observed at the western edge and under ARs associated with that edge.

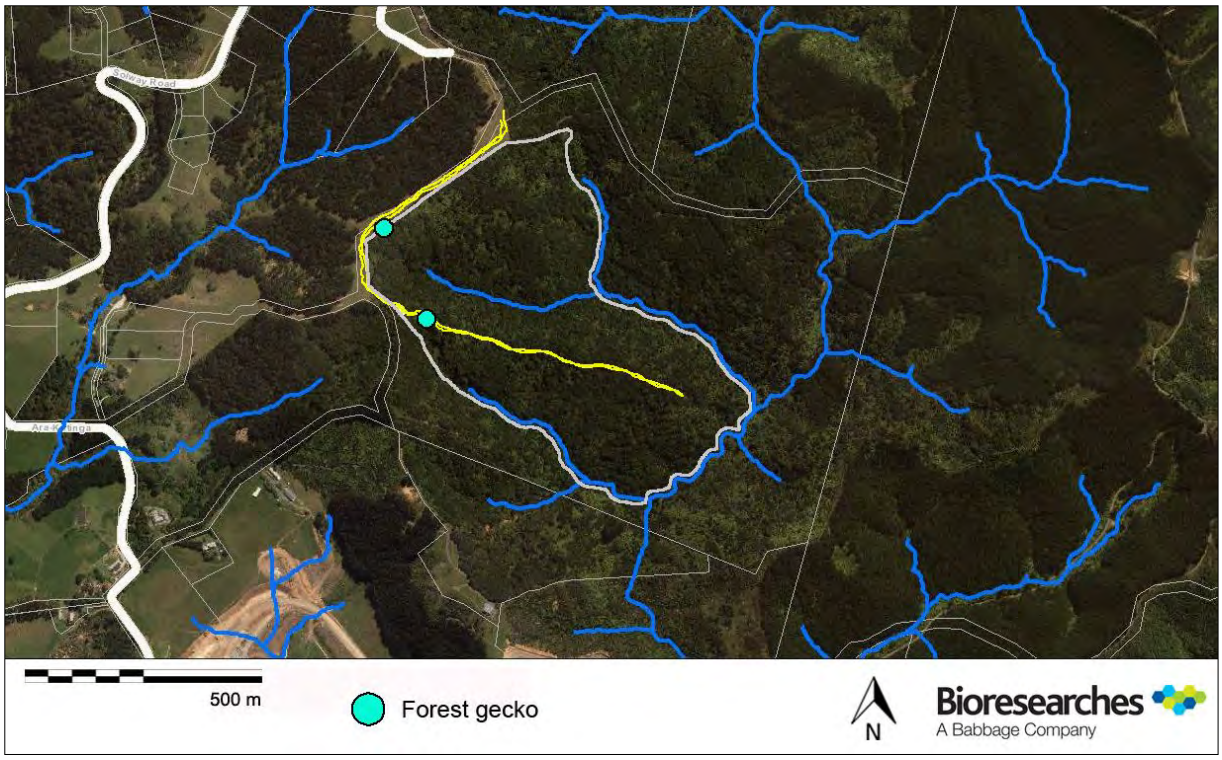

Figure 13. Forest gecko locations and search route (yellow line) at Stage 3, Brookby Quarry.

3.4.1 Discussion and assessment

Although no native skinks were observed, copper skinks are likely to be present, at least at low densities. The non-detection of native skinks does not imply their absence; however, low numbers and lack of detection may be an indication of poor habitat quality, potentially due to few logs and few interstitial spaces (small gaps) to provide sufficient refuge from predators, particularly introduced pest species. It is further noted that no native skinks have been detected from the Stage 2 area, either from the baseline survey or any lizard management to date.

Native skinks refuging in leaf litter, without cover from logs, rocks or other retreats, are likely to be easy prey for mammalian predators, including rats (*Rattus* spp.), mice (*Mus musculus*), hedgehogs (*Erinaceus europaeus*), possums (*Trichosurus vulpecula*), pigs (*Sus scrofa*), mustelids (*Mustela* spp.) and feral cats (*Felis catus*).

Two forest geckos were recorded from northern and western parts of the property. Forest geckos are strongly arboreal, though are habitat generalists and occur in both seral and mature indigenous

vegetation. They are classified as Nationally 'At Risk' and the species is likely to be present throughout the site in both mature forest and seral scrub.

The overall encounter rate of 0.2 geckos/hour is slightly lower than the Stage 2 area, but comparable with eleven other locations where forest geckos have been detected throughout the Auckland Region between 2008-2015 (average 0.34 geckos/hour). It is noted that this species was not detected from a further 26 locations surveyed by the author with comparable potential habitat over the same period, and this supports their conservation status.

It is possible that some additional lizard species (e.g. Table 6) occur at very low, undetectable levels in parts of the site, however, most of these species have widespread distributions in the North Island and are not classified as greater than 'At Risk'.

3.5 BIRDS

A review of various databases (DOC fauna, inaturalist, New Zealand eBird, accessed 7 December 2020) indicates presence of a suite of common native birds throughout the project area.

Three 'At Risk- recovering' species have been recorded in the surrounding landscape, and two of these have a strong association with the Hunua Ranges (North Island kokako (*Callaeas wilsoni*) and North Island kākā (*Nestor meridionalis*)). The third, NZ dabchick (*Poliocephalus rufopectus*), inhabits freshwater lakes and ponds, including on farmland. All of these species, if present within the investigation area, would have 'Moderate Value' in accordance with Table 3 (Section 2).

The native avifauna recorded from five-minute counts in the Project area consisted of eight common species that also occur throughout the Auckland Region areas (Table 10). Introduced species were not recorded. Other non-threatened native species that were recorded from site visits, include morepork (*Ninox novaeseelandiae*) and shining cuckoo (*Chrysococcyx lucidus*). Tomtit (*Petroica macrocephala toitoi*) and North Island kākā (*Nestor meridionalis septentrionalis*) may visit intermittently due to the proximity of the Hunua Ranges where these species are resident.

Of these species, only North Island kākā have a conservation rating of 'At Risk' (Recovering; Robertson *et al.,* 2017). The presence of kereru (*Hemiphaga novaeseelandiae*) is notable but it no longer has a conservation rating and is described as abundant (Scofield & Stephenson, 2013).

Table 10. Bird species counted at five stations from four counts per station

Common Name	Species Name	STATION						
		A	**B**	**C**	**D**	**E**	**TOTAL**	**MEAN**
fantail	*Rhipidura fuliginosa*	6	9	6	6	7	34	8.5
grey warbler	*Gerygone igata*	6	7	5	6	6	30	7.5
NZ kingfisher	*Todiramphus sanctus*	5	6	2	5	4	22	5.5
NZ pigeon	*Hemiphaga novaeseelandiae*	3	4	3	4	5	19	4.75
silvereye	*Zosterops lateralis*	13	8	7	4	9	41	10.25
swamp harrier	*Circus approximans*	0	1	0	0	0	1	0.25

tui	*Prosthemadera novaeseelandiae*	6	5	6	9	9	35	8.75
welcome swallow	*Hirundo neoxena*	5	4	0	0	0	9	2.25

3.6 BATS

The Department of Conservation's National bat database identifies multiple bat records at the Hunua Ranges, which supports one of the best-known populations of long-tailed bats in the Auckland Region. Nearer to Brookby Quarry, there is one bat record at Clevedon, 4 km from the Investigation Area. This record was submitted by Bioresearches (2013) and represents 4 'passes' from 54 useable nights of recording.

No long-tailed bats (LTB's) were recorded from fixed automatic recorders in the current study.

Some of the larger trees such as taraire (*Beilschmiedia tarairi*) and rimu (*Dacrydium cupressinum*) support suitable cavities for LTB communal roosting. Epiphytes, such as *Astelia hastatum*, and *Astelia solandri*, may also be used occasionally by bats as solitary roosts, particularly in taraire and podocarp-dominated areas.

Despite the presence of potential roosting habitat, LTBs were not recorded at the site from edge and forest track locations over a 40-night period. However, because the species has been recorded from contiguous vegetation, (Clevedon Scenic Reserve, around 4 km from the Project area) and that LTBs have very large home ranges of LTBs (up to 5629 ha; O'Donnell, 2001) the lack of detection from this survey only indicates that the site did not support important habitat to the species at the time of survey. This may change over time and space in the surrounding landscape.

3.7 SUMMARY OF FAUNA

Terrestrial fauna assessed at Brookby Quarry through targeted surveys within the Project area included invertebrates, Hochstetter's frogs (*Leiopelma hochstetteri*), lizards (skinks and geckos), birds and bats. Surveys were undertaken during appropriate times of the year for targeting fauna that are both cryptic and / or seasonal in optimum activity patterns (September, March & April).

Overall, the fauna recorded within the Project area consisted of common native invertebrates and birds, with the exception of two forest geckos (*Mokoprirakau granulatus*) recorded from kānuka scrub which have conservation status of 'At Risk', (Hitchmough *et al.* 2016).

No threatened species were recorded from fauna surveys for invertebrates, frogs, lizards, birds or long-tailed bats. North Island kākā ('At Risk') and long-tailed bats ('Nationally Critical', O'Donnell *et al*. 2017) may be intermittent visitors to the site and therefore not identified during the survey period.

Hochstetter's frog is very unlikely to be present at the site because stream habitat is unsuitable throughout the area. It is possible that some lizard species occur at very low, undetectable levels in parts of the site. None of these possible species have a conservation status higher than 'At Risk' however.

'At Risk' forest geckos are habitat generalists and occur in both seral and mature indigenous vegetation (including exotic trees). Two were recorded in edge kānuka scrub, representing a relatively low encounter rate for this species. However, they are likely to be present, at low to moderate density throughout the Stage 3 area.

4. FRESHWATER HABITATS

4.1 STREAM SITES

All aquatic habitats within the Stage 3 expansion area were assessed. These comprised three un-named permanent streams and twelve un-named intermittent streams, all tributaries to the Papakura Stream, within the expansion area. The location and description of each stream site and the five representative sections of the streams where more detailed assessments were carried out are presented in Table 7 and Figure 6.

No wetlands were located within the Stage 3 expansion area, and none were expected due to the steep rocky topography.

The results of the detailed stream assessments and site characteristics are summarised in Table 11 and described below, with raw macroinvertebrate data presented in Appendix IV and the summary SEV data presented in Appendix V.

Table 11. Brookby Quarry Stage 3 Stream Characteristics

	Site 1 Southern Tributary	Site 2 North Branch Southern Tributary	Site 3 Intermittent Stream WC 4 to N Branch Southern Trib.	Site 4 West Branch to Northern Tributary	Site 5 Papakura Stream
Habitat Features					
Average width (m)	0.73	0.61	0.45	0.63	1.96
Average depth (m)	0.05	0.02	0.03	0.05	0.15
Dominant substrates	Gravel and bedrock	Mud and gravel	Bedrock and gravel	Bedrock and gravel	Cobble, gravel and bedrock
Macrophyte abundance	None	None	None	None	None
Riparian vegetation	Regenerating native bush Dominated by nikau and ponga	Regenerating native scrub dominated by supplejack	Regenerating native bush with bare ground	Regenerating native scrub	Regenerating native bush
Water Quality					
Date	11/03/2015	11/03/2015	31/7/2017	1/08/2017	12/3/2015
Time	14:00	14:30	11:30	11:00	15:30
Temperature (°C)	15.3	15.0	-	-	16.3
Oxygen saturation (%)	86.9	99.6	-	-	103.6
Dissolved oxygen (g/m³)	8.68	10.01	-	-	10.16
Conductivity (µS/cm)	85	154	-	-	154
Clarity (m)	0.4	0.4	-	-	0.58
Macroinvertebrates					
Sampling protocol	Hard bottom	Hard bottom	Hard bottom	Hard bottom	Hard bottom
No. of taxa	22	20	16	20	24
Dominant taxon	amphipod	amphipod	amphipod	*Orthopsyche species*	freshwater snail
EPT	13	10	9	9	15
%EPT*	36	28	26	55	41
MCI	145 excellent	140 excellent	133 Excellent	133 Excellent	128 excellent
SQMCI	6.8 excellent	6.5 excellent	5.99 good/excellent	7.25 excellent	6.5 excellent
Fish					
Species recorded	Banded kōkopu, Unidentified eel	Banded kōkopu	-	-	Banded kōkopu, Longfin eel Crans bully
Number of fish	12	5	-		84
Fish IBI Score	48	36	[36]*	[36]*	48
Rating	Very Good	Good	Good*	Good*	Very Good
Stream Ecological Value					
SEV Score	0.85	0.72	0.78	0.77	0.88

*predicted minimum assuming banded kōkopu immediately downstream would inhabit the watercourse.

4.2 PHYSICAL HABITATS

4.2.1 Site 1 Southern Tributary (ST)

The Southern Tributary from the confluence with Papakura Stream to the junction of the first upstream fork was about 150 m long.

The stream formed a natural channel at the base of a steep gully, with some channel incision.

The channel ranged between 0.3 wide to over 1.5 m wide in the pools. The water flow was slow with a good range of hydrologic conditions (runs, pools, and cascades) and the substrate dominated by gravel with bedrock and some wood providing good habitat for macroinvertebrates. There was some loading of fine sediment in the channel which was easily suspended when disturbed. Shading on the channel was very high, >90%, provided by the steep banks, undercuts and a heavy cover of ferns and palms (Figure 14).

The riparian vegetation on the steep banks and adjacent to the stream was dominated by nīkau and ponga, with kiekie, parātāniwha, hangehange and rewarewa and there was a dense layer of leaf litter and organic material on the banks providing filtering and organic input for the stream.

One intermittent stream (Watercourse 3, Figure 6) drained to this lower section of the Southern Tributary.

Figure 14. Site 1 Southern Tributary

4.2.2 Site 2 North Branch of Southern Tributary (N-ST)

The Southern Tributary forked upstream of Papakura Creek, diverting south-east to the Stage 2 area (South Branch) and north-east (North Branch) as part of the Stage 3 area (refer Figure 6).

The North Branch of the Southern Tributary drained a very steep gully system for approximately 380 m before joining the confluence with the Southern Tributary and ultimately draining to the Papakura Creek. The headwaters of the North Branch formed two intermittent streams (Watercourses 8 and 9, Figure 6) and four intermittent watercourses drained to the North Branch from the centre of the Stage 3 area (Watercourses 4 to 7, Figure 6).

Thick supplejack formed an impenetrable barrier over much of the watercourse, and up and over the banks. The gully was very steep and mobile, with a medium to low density cover of kohekohe, nīkau, taraire, parātāniwha, karamu and kawakawa. (Figure 15).

The substrate was dominated by gravel with some clay or silt and wood with leaf litter present in the watercourse.

The channel was narrow and shallow with some incision from flood flows and very steep banks. The channel ranged between 0.4 and 1 m wide, and averaged 0.02 m deep with a slow trickle flow of water. There were no significant pools within the SEV reach and the watercourse was too shallow for fyke nets or gee minnow traps to be set.

The steep topography and riparian vegetation combined to provide high shade on the channel.

The northern branch of the southern tributary provided moderate quality aquatic habitat with a limited variety of hydrologic conditions, no deep pools and low flow.

A 2 m vertical drop over bedrock was present above the junction with the southern branch, below the SEV reach.

Figure 15. Site 2 North Branch of Southern Tributary

4.2.3 Intermittent Streams (WC1 to WC12) and SEV Site 3 Intermittent Stream (WC4)

Twelve intermittent streams varying in length from 25 to 115 m were present in the Stage 3 expansion area (Figure 16 to Figure 26). Although two additional potential intermittent streams were indicated on the Auckland Council GeoMap overland flow path overlay, draining to the Northern Tributary, the streams were not present.

The intermittent streams were small, on average 0.18 m to 0.45 m wide and shallow, often forming a trickle flow between small pools.

Watercourse 4 (WC4) was the longest of the intermittent watercourses and was chosen as representative of the intermittent watercourses in the Stage 3 area.

The watercourse was very steep and incised with pools and drops. The channel ranged between 0.12 and 0.94 m wide (averaging 0.45 m), with small pools reaching a maximum depth of 0.17 m. The substrate was dominated by bedrock and gravel with a moderate contribution of small wood (<50 mm in width) providing good habitat for macroinvertebrates. The intermittent stream had very high shading throughout, provided for by the steep banks, and the riparian zone, comprised of regenerating native bush, provided complete shading cover over the stream.

The riparian vegetation on the steep banks of the stream comprised tawa and taraire, ponga, kohekohe, parātāniwha, nīkau and māhoe. Bare ground was common.

The habitat at this site was indicative of the aquatic habitats in the majority of the intermittent streams in this catchment; narrow, steep, incised, shallow but with occasional pools, a mix of hydrologic conditions and well shaded by regenerating native scrub or bush.

Figure 16. Intermittent Stream WC2 (and indicative of WC1)

Figure 17. Intermittent Stream WC3

Figure 18. Intermittent Stream WC4

Figure 19. Intermittent Stream WC5

Figure 20. Intermittent Stream WC6

Figure 21. Intermittent Stream WC7

Figure 22. Intermittent Stream WC8

Figure 23. Intermittent Stream WC9

Figure 24. Intermittent Stream WC10

Figure 25. Intermittent Watercourse WC11

Figure 26. Intermittent Watercourse 12

4.2.4 Site 4. West Branch of Northern Tributary (W-NT)

The West Branch of the Northern Tributary cut east to west through the upper section of the Stage 3 area. The stream varied in width from 0.1 m to 1.2 m wide (averaging 0.63 m), with a good flow and variety of hydrologic conditions. Several steep vertical or near vertical drops, 5 m and 3 m, were present which would have provided a barrier to most migratory freshwater fish. The channel was incised and the substrate was dominated by bedrock with medium and large gravel and very little wood. The banks had slipped in several places, taking trees into the watercourse and opening up the canopy, and there was more soft sediment within this tributary than in many of the others in the Stage 3 area.

The riparian vegetation was less well established than in the southern sector and comprised mainly of small trees and shrubs dominated by māhoe, supplejack, whēki-ponga, nīkau, kawakawa and hangehange.

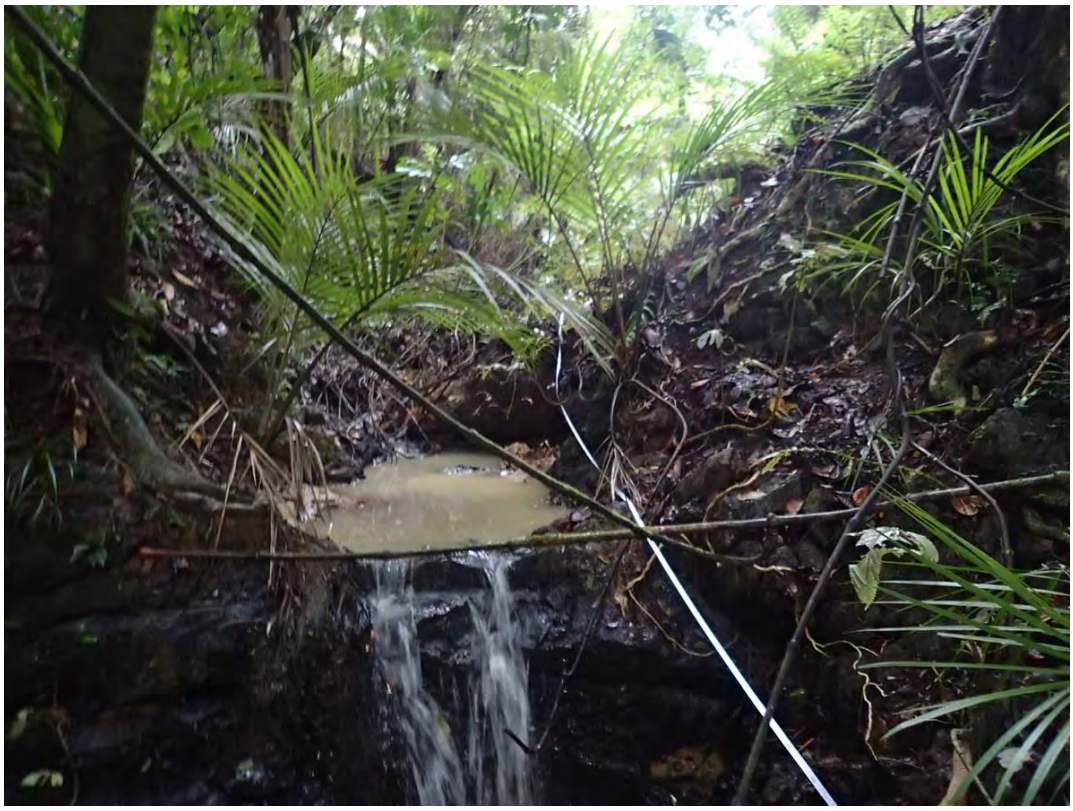

Figure 27. Site 4 West Branch to Northern Tributary

4.2.5 Site 5 Papakura Stream

The Papakura Stream traverses the eastern side of the proposed expansion area and collects water from the northern and southern tributaries.

The stream was wider than the western tributaries, averaging 2 m wide and 0.2 m in the runs, and had a good mixture of hydrological conditions with a variety of pools and runs with occasional riffles and cascades. There was a wide variety of favourable aquatic habitat types present including woody

debris, riffles, undercut banks, root mats, and stable habitat. The substrate was dominated by bedrock and cobble with some fine gravel and only a small portion of soft substrate. The banks of the stream were very steep and vertical in places and in other areas widened out with shallow areas suitable for fish spawning.

No aquatic macrophytes were present and the stream had high shading provided by the steep banks and riparian vegetation. The riparian vegetation was dominated by parātānewha, immediately adjacent to the stream and ponga, *Asplenium*, nīkau, mānuka and kānuka on the banks. There was a thick organic litter layer under the canopy.

Figure 28. Site 5 Papakura Stream

4.3 WATER QUALITY

Three spot samples were collected to provide basic water quality measurements, one at each of the representative SEV sites (Sites 1, 2 and 5). The water temperatures ranged between 15.0 and 16.3°C. The lowest temperatures were in the smaller, well shaded upper tributaries (Table 11). Oxygen saturation was moderate to high (87 – 104 %). The temperatures and dissolved oxygen concentrations were well within the range that is considered suitable for most benthic invertebrates (Biggs *et al*., 2002; Davis-Colley *et al.,* 2013).

Conductivity levels were moderate to low showing minimal signs of nutrient enrichment from the catchment. Clarity measurements were lower in the upper tributaries, probably as a result of a higher proportion of soft substrate, and slightly higher in the Papakura Stream.

4.4 MACROINVERTEBRATES

Amphipods (*Paraleptamphopus subterraneus*) were numerically dominant at the three southern watercourses within the Stage 3 area, with a species of net building caddis fly (*Orthopsyche*) dominant in the north of the area (Site 4). Newly hatched freshwater snails, *Potamopyrgus*, were numerically dominant at the Papakura Stream site, comprising 50% of the individuals, with the mayfly *Coloburiscus* subdominant (20%). There was a good variety of macroinvertebrates at every site ranging from 16 taxa at Site 3 (the representative intermittent tributary) to 24 taxa at the Papakura Stream site.

Site 1, the Southern Tributary, had nine sensitive taxa (with individual MCI scores of 8 or greater) and a MCI score of 145 or 'excellent' habitat quality (Stark & Maxted, 2007a). There were thirteen species of EPT taxa which comprised 36% of the sample.

At Site 2, North Branch of the Southern Tributary, the MCI score was 140, rated as 'excellent' and seven of the taxa had individual MCI scores of 8 or greater. The %EPT score was 28%.

Site 3, the representative intermittent watercourse, showed similar results with an 'excellent' MCI score (133) and more than a quarter of the sample comprised sensitive EPT taxa.

Site 4, the northern-most site, had nine sensitive taxa and more than half of the sample was comprised of EPT taxa (55%). This resulted in a MCI score of 133, excellent.

Site 5, Papakura Stream site, had the highest number of taxa present (24 taxa) and a high %EPT (41%). Although the MCI score was lower at this site (128) it was still above the threshold for 'excellent' habitat quality.

The SQMCI index, which also takes into account the abundance of the macroinvertebrates was indicative of 'excellent' habitat quality at all of the sites.

4.5 NATIVE FISH

Fish were surveyed at Sites 1, 2 and 5 in 2015 and from Papakura Stream in 2016 and 2017. Banded kōkopu (*Galaxias fasciatus*) and kōura (*Paranephrops planifrons*) were found throughout the streams surveyed. Adult and juvenile banded kōkopu were found at Sites 1 and 5; only juveniles (52 mm or less) were observed at Site 2. Site 2 provided little good habitat for fish with only shallow water (average 10 mm deep) and no pools to provide habitat when flows were lower. In addition, eels (*Anguilla* species) were found at Sites 1 and 5 and Crans bullies (*Gobiomorphus basalis*) were common at Site 5. The habitat at Site 3, the representative intermittent tributary, was suitable for fish when water levels are high, and the strong climbing species, banded kōkopu and eels, are expected to be present in all the intermittent streams on occasions.

Longfin eel, ranging in size from 170 to 790 mm in length, were present in Papakura Stream. The abundance of fish in the streams increased with the size of the watercourse with six fish caught in each of the upper tributary sites (Sites 1 and 2), twelve in the Southern Tributary (Site 1) and over 70 caught in the Papakura Stream (Site 5). The Crans bullies ranged in size from juvenile to adult with

the male Crans bullies in full breeding colours in March (darker with an orange stripe along the dorsal fin).

Both adult and juvenile kōura were present at all the sites, except for the intermittent stream site, and ranged in size from 25 – 75 mm in length.

The Fish IBI scores were 48 in the larger watercourses, Sites 1 and 5, indicative of 'Very Good' species diversity in comparison to other Auckland streams, given the altitude and distance from the sea (Joy & Henderson, 2004), and 36, indicative of 'Good', in the smaller steeper watercourse at Site 2. Working with the assumption that banded kōkopu and native eels would utilise the other small volume, steep watercourses, (i.e. the upper northern watercourse (Site 4) and the intermittent streams when water levels are sufficient) the fish IBI for these sites would also be 'Good'.

Longfin eels are listed as 'at risk; declining' on the threatened species list (Dunn *et al.*, 2018) with the qualifiers of conservation dependent and data poor. Their presence elevates the value of the lower tributaries as habitat for aquatic biota.

New Zealand Freshwater Fish Database Search

A search of the New Zealand freshwater fish database returned fish records from 23 sites within the upper Papakura Stream catchment where shortfin eels, longfin eels, banded kōkopu, common bullies, Crans bullies, redfin bully and kōura were recorded.

4.6 Stream Ecological Valuation

The SEV scores (Appendix V) of the tributaries with the Stage 3 area were high, ranging between 0.72 and 0.88, indicating that the functional and ecological values of the streams have been only slightly affected by land use changes. The SEV score at Site 2, was lower than the adjacent sites primarily because of the very steep sided channel impeding access to the flood plain, providing limited connection between the stream channel and riparian zone, and providing no habitat suitable for fish spawning. The riparian vegetation intactness score was also lower than the adjacent sites due to the limited understory on the steep mobile slopes away from the stream channel.

4.7 Extent of Aquatic Habitat

Table 12 and Table 13 present a summary of the extent of the aquatic habitats within the Stage 3 Areas as illustrated in Figure 6.

Three sections of permanent watercourse, the Southern Tributary, the North Branch of the Southern Tributary and the West Branch of the Northern Tributary; and 12 intermittent watercourses are present within the Stage 3 area. The combined stream length was assessed to be approximately 1700 metres (un-surveyed) with approximately 810 m^2 of aquatic bed habitat.

Table 12. Stage 3 Area - Stream Length Measurements

Stream Code	Location	Approximate Length (m)
W - NT	West Branch of Northern Tributary	295
ST	Southern Tributary (from Papakura Stream to confluence with north and south branches)	150
N - ST	North Branch of Southern Tributary	380
WC 1 : PS	Intermittent tributary to Papakura Stream	70
WC 2 : PS	Intermittent tributary to Papakura Stream	65
WC 3 : ST	Intermittent tributary to the Southern Tributary	60
WC 4 : N-ST	Intermittent tributary to North Branch of Southern Tributary	120
WC 5 : N-ST	Intermittent tributary to North Branch of Southern Tributary	60
WC 6 : N-ST	Intermittent tributary to North Branch of Southern Tributary	80
WC 7 : N- ST	Intermittent tributary to North Branch of Southern Tributary	45
WC 8 : NH - ST	Northern headwater tributary to North Branch of Southern Tributary	80
WC 9 : SH - ST	Southern headwater tributary to North Branch of Southern Tributary	25
WC 10 : W-NT	Intermittent tributary to West Branch of Northern Tributary	115
WC 11 : N-NT	Lower intermittent tributary of the North Branch of Northern Tributary	70
WC 12 : N-NT	Upper intermittent tributary of the North Branch of Northern Tributary	85
Total length of permanent and intermittent streams (m)		**1700**

Table 13. Stage 3 Area Streams - Estimated Extent of Bed Area of Aquatic Habitat

Stream Code	Approximate Length (m)	Average Width	Bed Area (m^2)
W - NT	295	0.63	185
ST	150	0.73	110
N - ST	380	0.61	232
WC 1 : PS	70	0.18	13
WC 2 : PS	65	0.22	14
WC 3 : ST	60	0.43	26
WC 4 : N-ST	120	0.45	54
WC 5 : N-ST	60	0.40	24
WC 6 : N-ST	80	0.41	32
WC 7 : N- ST	45	0.29	13
WC 8 : NH - ST	80	0.22	18
WC 9 : SH - ST	25	0.15	4
WC 10 : W-NT	115	0.36	41
WC 11 : N-NT	70	0.29	20
WC 12 : N-NT	85	0.28	24
Total stream length (m)	1700		
Total bed area (m^2)			**810**

5. THREATENED AND AT RISK TAXA AND ECOSYSTEMS PRESENT AT BROOKBY

5.1 SUMMARY OF RESULTS

One threatened plant, carmine rātā ('Nationally threatened- Vulnerable' and 'Regionally at risk- sparse') was found in one location at Brookby Quarry within the Stage 3 proposed quarry expansion area during the recent botanical survey. Carmine rātā is considered to be threatened on the basis of its sparse distribution in the Auckland Regions and its national threat status. Other species of Myrtaceae found at Brookby have a National threat status of 'Nationally threatened –vulnerable' but are not considered to be actually threatened currently (see Section 2). The Stage 3 area also contains approximately 10.75ha of taraire forest (WF9), a type listed as 'Endangered' by the Auckland Council (Singers *et al.* 2017). As set out in the Bioresearches 2018 report the taraire forest does appear to have been modified by past logging of podocarps.

Nationally and Regionally 'Threatened' and 'At-Risk' ecosystems, flora and fauna species detected within the Project area are:

- forest gecko (*Mokopirirakau granulatus*): Nationally 'At Risk-Declining'
- longfin eel (*Anguilla dieffenbachii*): Nationally 'At Risk – Declining'
- taraire forest: Regionally 'Endangered'
- carmine rātā: 'Nationally threatened – Vulnerable' and 'Regionally at risk- sparse'

5.2 POTENTIAL FOR OTHER 'THREATENED' OR 'AT RISK' TAXA TO BE PRESENT

5.2.1 Native orchids

Taraire orchid (*Danhatchia australis*) was not observed. This is the only species of ground orchid with a national or regional conservation status of 'Threatened' or 'At Risk' and considered potentially present on the basis of the habitat types that occur at the site. The lack of observations does not rule out its presence as it is a small and cryptic species which does not flower every year (de Lange 2020).

Species of ground orchid listed as Nationally Threatened (Critical, Endangered and Vulnerable) are either not recorded for the Auckland Region or their habitats are not found at Brookby. Most of these species are found in low nutrient bogs and swamps or in gumland.

With the exception of taraire orchid and the tiny tree orchid *Bulbophyllum tuberculatum*, habitats do not exist for any Nationally 'At Risk' species (Declining, Relict, Naturally uncommon) at Brookby or the species are not found in the Auckland region. There is only one recent record for the tree orchid for Auckland (Waitakere) and it has very specific habitat requirements, only being found in association with particular species of grey foliose lichens on tree trunks. Tree trunks at Brookby are not particularly licheniferous as most potential host trees are relatively young.

5.2.2 Other flora species

Species listed in Table 2 which were identified from relevant publications as potentially being present within the Stage 3 area at Brookby were particularly searched for. None except carmine rātā were recorded.

Table 14. Plant species with regional or national threat rankings considered potentially present within the Brookby Stage 3 quarry expansion area.

Common name	Botanical name	National threat status	Regional threat status
Pokākā	*Elaeocarpus hookerianaus*	Not threatened	Regionally critical
Taraire orchid	*Danhatchia australis*	Naturally uncommon	Regionally critical
Swamp maire	*Syzygium maire*	Threatened- nationally critical	Chronically threatened- serious decline
Leafless rush	*Juncus pauciflorus*	Threatened – nationally vulnerable	Regionally endangered
Small kiokio	*Parablechnum procerum*	Not threatened	Regionally at risk- Range restricted
Green mistletoe	*Ileostylis micranthus*	Not threatened	Regionally critical
Carmine rātā	*Metrosideros carminea*	Threatened- nationally vulnerable	Regionally at risk- sparse

5.2.3 Invertebrates

The project area is not considered to be important habitat for the 'At Risk' rhytid snail, or other invertebrate species of interest. However, this species may still be present within leaf litter of older growth taraire forest, where it is most likely to occur if at all.

5.2.4 Lizards

It is possible that some additional lizard species (e.g. Table 6) occur at very low, undetectable levels in parts of the site, however, most of these species have widespread distributions in the North Island and are not classified as greater than 'At Risk'. That is, no 'Threatened' species are likely to be present within the Project area.

5.2.5 Bats

Despite the presence of potential roosting habitat, particularly large trees, long tailed bats were not recorded at the site from edge vegetation (potential flight paths) over a 40-night period. However, the species has been recorded from contiguous vegetation, around 4 km from the site, at Clevedon Scenic Reserve. The large home ranges of long tailed bats (up to 5629 ha; O'Donnell, 2001) however, indicate that there is some potential for the species to pass through or use the site intermittently, though the lack of detection from this survey suggests that the site did not support important habitat to the species at the time of survey. This may change over time and space in the landscape.

5.2.6 Freshwater fauna

A search of the New Zealand freshwater fish database returned fish records from 23 sites within the upper Papakura Stream catchment where shortfin eels, longfin eels, banded kōkopu, common bullies, Crans bullies, redfin bully and kōura were recorded. Except for longfin eel, all of these species have a conservation status of 'Not Threatened' (Dunn *et al*. 2018)

6. SUMMARY OF ECOLOGICAL VALUES

6.1 VEGETATION AND FLORA

6.1.1 General comments

The composition of the vegetation within the project area varies considerably according to its age and site-specific factors such as aspect. It forms a mosaic of forest types that is indicative of multiple past disturbances including fire, grazing and logging.

The **botanical values of the site as a whole are moderate**; however, areas of more mature **taraire forest have high value**s even though the canopy is strongly dominated by one species (taraire) and it lacks diversity in the understorey. **Areas of young kānuka and tree fern forest have moderately low value**s due to their lack of maturity and lower overall species diversity.

All of the forest types described for the site are common across the Auckland Region although taraire forest is much reduced from its former extent and is classified by the Auckland Council as 'Endangered' (Singers *et al.* 2017). Perceived threats to taraire forest include mainly animal pests such as possums, goats, pigs and rats which have the potential to cause mortality and regeneration failure in palatable species.

Kānuka scrub / forest and the later successional tānekaha-dominant forest types are regenerating native vegetation types which are generally not considered threatened (except by potential effects of myrtle rust). They have probably increased in abundance since pre-human times following clearance of the original podocarp-broadleaved forest that would have formerly occupied many sites (Singers *et al.* 2017). The recent arrival of myrtle rust into New Zealand poses a potential threat to the kānuka-dominant forest and scrub types, although not to the tānekaha dominant forest which contains only a small component of kānuka.

6.1.2 Species values

Species values for Brookby Quarry were assessed according to Table 3 (Section 2) and are presented in Table 14 below. Carmine rātā triggers a 'Very high' valuation on the basis of both its national threat rating and its Regionally 'At Risk' status. While other myrtle species present within Brookby are not assigned 'High Value' status, as explained in 2.2 carmine rātā is considered an exception on the basis of its regionally sparse distribution in light of the disease threat facing other myrtaceous species. The eventual effects of this disease on native myrtaceous species are currently unknown. Carmine rātā is therefore rated 'Very High'. Without the threat of myrtle rust carmine rātā would trigger a valuation of moderate under the criteria in Table 1.

Table 14. Species attributes for flora within the Brookby Quarry Stage 3 Project area

Determining factors	Value	Species
Nationally threatened species, found in the ZOI either permanently or seasonally	Very High	Carmine rātā
Species listed as 'At Risk' – declining, found in the ZOI, either permanently or seasonally	High	
Species listed as any other category of 'At Risk' found in the ZOI either permanently or seasonally	Moderate	
Locally (ED) uncommon or distinctive species	Moderate	

6.1.3 Ecosystem values for terrestrial vegetation

This section reviews the overall ecological values for terrestrial vegetation in accordance with the matters and attributes listed in Table 2 Section 2.1, using the results of botanical surveys and desktop research.

Representativeness

Two key vegetation types are present within the Project area: taraire forest and kānuka scrub/forest (VS2). Some of the kānuka scrub is at an advanced stage of the successional process and contains abundant podocarps. The vegetation has been modified in the past through logging, burning and grazing, however the vegetation types present are typical in structure and composition for their types and contain the expected range of species and tiers. The area rates as **high** for representativeness.

Rarity / Distinctiveness

Carmine rātā, a nationally threatened species was found within the Project area, including within the approximately 10.75 ha of regionally endangered taraire forest. These factors give the area a rating of **high** for rarity and distinctiveness.

Diversity and Pattern

The area of investigation is a mosaic of vegetation types that chiefly reflect past land use. The regenerating vegetation is of different age in different parts of the site, however edaphic factors have influenced the type of regeneration according to aspect, drainage etc. All vegetation types are forest types. Diversity and pattern is **moderate**.

Ecological context

Although the area is currently surrounded by native vegetation on two sides, it is vulnerable to the effects of quarrying activities occurring along its southern edge in the Stage 2 quarry area and there is also some vulnerability to the effects of plantation forestry clear fell logging on the neighbouring property to the east. A lifestyle subdivision lies on the west, however it is well connected to the rest of the SEA to the north. The SEA functions as stepping stone habitat in the landscape. In ecological context it rates as **moderate**.

Conclusion

The Stage 3 quarry expansion area rates as high for two attributes and moderate for the other two attributes giving it an overall rating of **high**.

Table 15. Summary table of terrestrial vegetation and flora values of the Brookby Quarry Stage 3 Project area.

Determining matters	Brookby Stage 3 vegetation
Representativeness	High
Rarity/distinctiveness	High
Diversity and pattern	Moderate
Ecological context	Moderate
Overall rating	**High**

6.2 TERRESTRIAL FAUNA

Overall, the fauna recorded within the Project area consisted of common native invertebrates and birds, with the exception of a moderate-low density of 'At Risk' forest geckos.

No threatened species were recorded from fauna surveys for invertebrates, frogs, lizards, birds or long-tailed bats. North Island kākā (At Risk- recovering) and long-tailed bats (Nationally Critical) may be intermittent visitors to the site and therefore were not identified during the survey period.

There is very low potential for Hochstetter's frog to be present at the site due to the unsuitability of stream habitat throughout the area. It is possible that some lizard species occur at very low, undetectable levels in parts of the site.

This section reviews the overall ecological values for terrestrial vegetation in accordance with the matters and attributes listed in Table 2, Section 2.1, using the results of botanical surveys and desktop research.

Representativeness

The Project area supported a very patchy potential habitat quality, with deeper leaf-litter that has potential to support a greater diversity of ground-based fauna than was recorded, such as rhytid snails, skinks and geckos, generally associated with the areas of taraire forest. Occasional rock outcrops and crevices, large native trees and log fall in this area do provide good potential habitat for invertebrates, lizards, birds and bats, however no such species were recorded from searches and the survey results were generally consistent with Stage 2, in that some expected native lizards, birds and bats were not recorded, despite apparent habitat suitability. While forest gecko was recorded from the Project area, at least four other native lizard species could be expected from these potential habitats, including copper skink, ornate skink, green gecko and pacific gecko. Copper skink, in particular, is a relatively common robust species that is widespread in the Auckland region and North Island.

A typical suite of common avifauna was recorded, and a few other species may also intermittently use the site, including 'Not Threatened' tomtit and 'recovering' (moderate value) kākā.

Overall, given expected species 'tiers' including a range of common native avifauna, reptiles and potential for long tailed bats (based on presence nearby), the fauna representativeness is considered **Moderate**.

Rarity / Distinctiveness

Forest gecko ('High' value) was the only species recorded with a conservation rating beyond 'Not Threatened'. Forest geckos have a status of 'At Risk- declining' on the basis of having a total area occupancy of >10,000 ha and a predicted decline of 10-70% (Hitchmough *et al.* 2017). No other rare or distinct species were recorded, although it is considered that basing part of an assessment on presence of rare or cryptic fauna is problematic. The Project area has some potential for intermittent presence of kākā (moderate value) and long tailed bats (very high) despite these highly mobile species not being detected from surveys and over repeated site visits. While kānuka forest would not be of particularly high value to these two latter species, areas of taraire forest could support roosting habitat. The Project area has conservatively **high** rarity value.

Diversity and Pattern

As per the vegetation, the Project area of investigation is a mosaic of habitat types that chiefly reflect past land use. Diversity, as recorded, is lower than expected given that the Project area is large itself, and that its habitats are buffered by a much larger area of surrounding habitats. The only noteworthy species recorded (forest gecko) was not abundant. Some 'Not Threatened' species that could be expected for a large area of vegetation, such as copper skink and tomtit, were apparently absent. Diversity and pattern for fauna is considered **Low**.

Ecological context

The Project area sits within a larger area of SEA and has a relatively large area to edge ratio compared to long or narrow shaped fragments. Therefore, it's habitats should be relatively resilient to land use changes occurring in the surrounding landscape, including quarrying (stage 2), lifestyle residential Solway subdivision blocks), plantation forestry) and such large and resilient habitats tend to have greater natural biodiversity and carrying capacity than smaller areas.

However, while the relatively low biodiversity and low abundances of some fauna, as observed from the studies, may be partly due to a history of disturbance, many of the taxa not recorded could still have been expected to be recorded from this site, such as other reptile species (many of which often occur in disturbed environments such as edge habitats and urban environments in the Auckland Region) and mobile avifauna (e.g. tomtit).

It is likely that the wider fragment functions as stepping stone habitat in the landscape for mobile species, some of which may use the habitats intermittently but were not recorded from surveys or observations. However, there are also likely to be other factors limiting biodiversity, such as pest predator abundance. Feral pigs, possums and rats have all been recorded within the fragment previously and a long history of high pest animals are likely to have limited biodiversity and carrying capacity. Given the relatively large area of habitat, the Project area has **moderate** ecological context.

Conclusion

The Stage 3 quarry expansion area rates as high for one attribute, moderate for two and low for one. Overall, the ecological value of the fragment to fauna is therefore **moderate**.

6.3 FRESHWATER HABITATS

Three sections of permanent watercourse and 12 intermittent streams are present within the Stage 3 area. All the permanent tributaries and the most of the intermittent tributaries investigated had high freshwater values. The riparian vegetation cover was good to excellent along many of the stream reaches and the location of the tributaries in steep gullies helped to provide high shading to the aquatic habitats.

The streams were dominantly rocky habitat, which is uncommon in the Auckland area, and all showed a high degree of hydraulic variation with shoots, runs, waterfalls, riffles and pools. There was evidence of slipping and erosion throughout the catchment, including a major hillside slip into the Papakura Stream, causing a partial dam and ponding above the slip, and slips causing large trees and sediment to affect the movement of water in areas of the upper tributaries.

Figure 29. Papakura Stream slip.

Macroinvertebrate communities in all the tributaries were found to be dominated by taxa indicative of high habitat quality. A moderate to diverse range of taxa was recorded (16 to 24 taxa), including

25 EPT taxa and 11 taxa with individual MCI scores >8, which are typically sensitive to reduced water quality. The overall MCI scores indicated 'excellent' instream habitat quality and SQMCI scores indicated 'good' and 'very good' quality.

The upper tributaries provided habitat for banded kōkopu and kōura, and the lower tributaries also provided habitat for eels and bullies. Overall, the fish IBI indicated that these habitats had a 'good' (upper tributaries) and 'very good' (lower tributaries) diversity of fish in comparison to other Auckland streams (Joy & Henderson, 2004). The presence of longfin eel (rated as 'at risk; declining') elevated the value of the lower tributaries as habitat for aquatic biota.

Water quality parameters showed temperatures and dissolved oxygen concentrations were well within the range that is considered suitable for most benthic invertebrates and conductivity levels were moderate to low, showing minimal signs of nutrient enrichment.

The SEV scores for the entire site were high, with the highest value (0.88) attributed to the larger watercourse forming the upper reaches of Papakura Stream (Site 5) and the lowest score (0.72) to the smaller tributary watercourse at the base of a very steep gully system in the north-west of the catchment (Site 2). The mixture of hard substrate, good riparian cover and steep banks throughout the proposed expansion area provided high shading to support sensitive invertebrate taxa and has resulted in largely unmodified high-quality streams.

The aquatic habitat within the Stage 3 area comprises an estimated 1700 linear metres of high value streams (permanent and intermittent), resulting in 810 m^2 of aquatic bed area.

6.4 Summary of Overall Ecological Values

Table 9. Summary table of ecological valuations of the Project area at Brookby Quarry

Vegetation Value	Fauna Value	Freshwater Value	Overall Value
High	Moderate	High	High

7. ASSESSMENT OF EFFECTS AND RECOMMENDATONS

7.1 AVOIDANCE

Stage 3 has been specifically designed to provide a 20 m set back from the Papakura Stream and the southern side of its western tributary at its northern boundary. This would effectively avoid loss of these high value watercourses and ensures a riparian buffer during construction and operation of the Stage 3 proposal. However, beyond these riparian buffer zones, terrestrial and freshwater values could not be avoided to extract the rock resource.

7.2 DIRECT EFFECTS

The effects of quarry expansion Stage 3 on the terrestrial ecology values within the proposed Stage 3 expansion would require the removal of approximately 28 ha of high value indigenous vegetation and habitats (Table 16). In addition, habitats of the following high value species would also be removed:

- Carmine rātā (*Metrosideros carminea*), found amongst taraire forest, which is 'Nationally threatened –Vulnerable' and 'Regionally at risk- sparse'.
- Forest gecko (*Mokoprirrakau granulatus*), probably widespread, but particularly in kānuka forest.
- Longfin eel (*Anguilla dieffenbachii*), within 20m length of affected watercourses

Table 16. Ecosystem types value and quantity within Brookby Stage 3

Ecosystem type	Threat status	Ecological value	Area affected (ha)
Regenerating kānuka scrub / forest with patches of tree fern dominant forest	Not Threatened	Moderate	6.3
Taraire dominant broadleaved forest.	Endangered	High	10.75
Tānekaha dominant forest on the northern side of the central ridge.	Not Threatened	Moderate	9.5
Small pockets of podocarp forest dominated by rimu and tōtara along the central ridge	Not Threatened	Moderate	1.4
Total		**High**	**27.95**
Ecosystem type		**Ecological Value**	**Length affected (m)**
Intermittent and permanent streams	**Not Threatened**	**High**	**1700**

The removal of moderate to high value vegetation would probably result in mortality to fauna, including invertebrates, lizards and flightless birds (such as unfledged chicks). Critically Endangered long-tailed bats are not expected to be affected by the proposal, however this should be confirmed by resurvey and appropriate management and compensation, where necessary.

Vegetation removal activities may also result in direct mortality, injury and / or displacement of native fauna, of which lizards and birds are protected (Wildlife Act 1953).

Removal of moderate value foraging, roosting and nesting habitat could result in displacement of fauna into the surrounding environment. Displaced fauna have a lower likelihood of survival where the carrying capacity of adjacent habitats is stressed through increased competition for fewer resources. Displaced animals have a higher probability of risk of predation by both exotic and native predators. For 'At Risk' and 'Threatened' species, this effect can be significantly greater, and greater still during important seasonal periods such as breeding.

7.3 Magnitude and Level of Effects

The magnitude of ecological effects and overall impact are assessed using Tables 4 & 5 (Section 2).

The proposed use of the Stage 3 area for the quarrying of aggregate will result in the total loss of all vegetation and habitats within the Stage 3 area. Although the Project area sits within a larger area of SEA_T_5274, vegetation and habitats, much of the surrounding vegetation is not within an SEA overlay. Within the wider landscape, the magnitude of ecological effects is considered **'High'**, on the basis that a high proportion of the known population or range of this vegetation and habitat would be lost.

For endangered taraire forest, this magnitude would be **'Very High'**, given its greater rarity in the surrounding landscape.

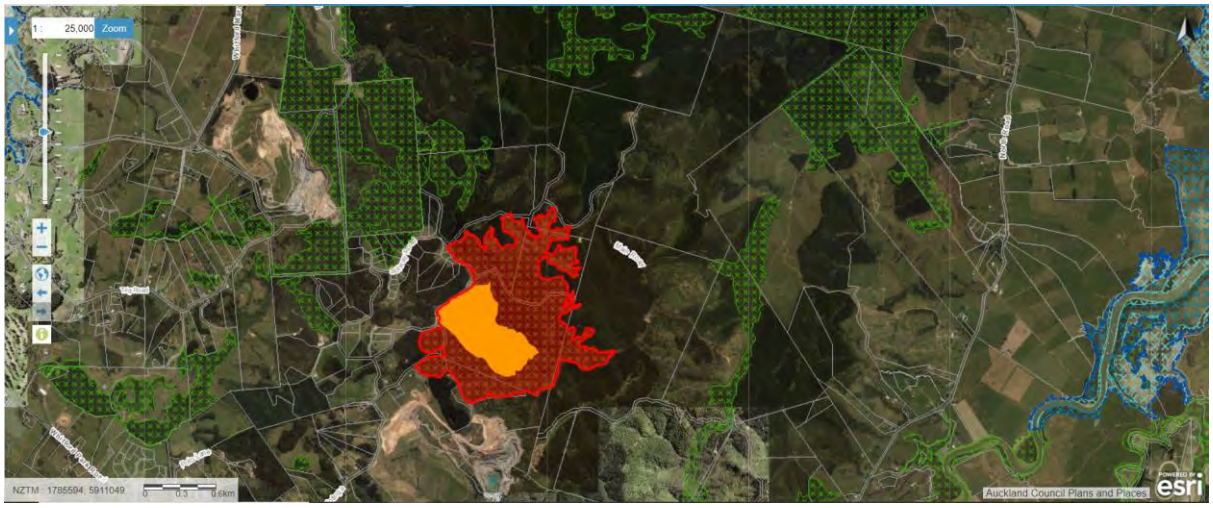

Figure 30. Approximate area of Brookby Stage 3 (Gold) within SEA_T_5274 (red). Note that SEA vegetation south of the Project area are within Stage 2 of the Quarry.

The level of overall impact is calculated from a matrix (Table 5) that considers the magnitude of effect ('High' and 'Very High') and the ecological value of the site ('High'). Therefore the overall level of the impact is assessed as '**Very High**' for both High and Very High magnitude effects, according to the EIANZ impact assessment methods.

8. RECOMMENDATIONS FOR BIODIVERSITY MANAGEMENT, MITIGATION, OFFSETTING

Biodiversity offsetting is a process that seeks to counter-balance the unavoidable impacts of development activities on biodiversity by enhancing the state of biodiversity elsewhere. It is a widely accepted approach to impact management which is underpinned by a set of principles whereby 'no net loss' of biodiversity can be demonstrated through a transparent process. Measurable conservation gains must be achieved to counter significant residual biodiversity losses that cannot be avoided, minimised or remediated.

It is not possible to directly replace mature taraire forest or any other forest type except the kānuka forest within any reasonable timescale. Mitigation and biodiversity offsetting will therefore need to comprise a package of conservation actions of which restoration planting will be one component. The proposed biodiversity offset package given below is based on information and examples given in Maseyk *et al.* 2015: A Biodiversity Offsets Accounting Model for New Zealand.

There are 30.73 ha of native vegetation within the SEA in the Stage 3 expansion area. Approximately 32 ha of SEA vegetation will remain outside the Stage 3 area at Brookby, most of which is kānuka/tree fern forest, tānekaha dominant conifer forest and some taraire forest.

8.1 Minimise / Mitigation Actions

Actions to minimise the effects of removal of vegetation and habitats would provide for enhancement buffer planting along all newly created vegetation edges, and fauna management, including but not limited to capture and relocation (e.g. habitat replacement and enhancement) to minimize potential effects of habitat removal on indigenous fish, lizards, birds and, potentially long-tailed bats.

Because opportunities to avoid and minimise the very high level of effects of the proposal are limited, biodiversity offsetting or compensation actions would be required to counterbalance loss of watercourses, vegetation and habitats.

8.2 Biodiversity Offsetting Options To Counterbalance Loss Of Vegetation And Flora

8.2.1 Enhance and protect similar but degraded forest

Identify nearby areas of degraded native vegetation similar to that being lost and enhance this through weed and pest control, enhancement planting with missing species, buffer planting and fencing off from livestock. The nearest areas of taraire forest of any size are the Maraetai hills forest, or the Hunua foothills –Mataitai forest and the Otau Mountain Road Reserve. There are also pockets of this forest type on private land north of the Hunua Ranges. There may also be opportunities for significant biodiversity gains through providing additional long term predator control within or adjacent to the Hunua Ranges, where an existing 1150 ha area of intensive management (kōkako Management Area) protects high fauna values in kōkako, kākā, North Island robin, tomtit, Hochstetter's frog and a wide range of vegetation and ecosystem types.

Arrangements would need to be made with DOC or the Auckland Council if the land is publicly owned or with owners if the land is privately owned to ensure the proposed biodiversity enhancement work can be undertaken on an ongoing basis for the period of the resource consents. The area enhanced would be a multiplier of the area lost at Brookby arrived at by comparing detailed data on the biodiversity values of the forest at Brookby with detailed data on the biodiversity values of the forest at the offset site. Suitable land may potentially need to be purchased.

8.2.2 Restoration planting

Possible sites at 96 Kimptons Road and/or cutover forestry land to the west would provide good opportunities for restoration planting that Brookby is currently investigating. To ensure there is no net loss of biodiversity as well as extent of native vegetation, a multiplier based on the area and detailed biodiversity values of the affected vegetation would probably be required, at least for taraire vegetation, and depending on the extent of long-term protection and enhancement of other vegetation types provided for in an overall package. Restoration planting should preferably be contiguous with other areas of native vegetation and contribute to ecological connectivity in the landscape.

8.2.3 Covenant all remaining SEA at Brookby Quarry

Ideally, ongoing control of goats, pigs, possums, mustelids and rats should be controlled outside the SPQZ, across the Brookby quarry site and preferably the entire SEA if permissions allow. More detailed information on the values of this vegetation would be needed to demonstrate exactly what biodiversity values are being protected. The general values of the vegetation types are known however.

8.2.4 Threatened plants

The presence of the threatened plant - carmine rātā can be addressed through a threatened species management plan. While it has been classified as regionally 'At Risk-Sparse' for the Auckland Region since 2005, the species was considered 'Not Threatened' at the national level until the arrival of myrtle rust in New Zealand in mid-2017. The scale of conservation effort required to offset the loss of carmine rātā from Stage 3 expansion area is likely to be dependent on how susceptible rātā species are to myrtle rust.

Elements of the threatened plant management plan could include:

- Locating adult plants within the Stage 3 area and areas of forest outside the Stage 3 area that will remain. This is only possible when plants are flowering.
- Monitor and protect (intensive possum control) adult plants that will remain outside the Stage 3 area. Follow any available protocols for protecting plants from myrtle rust.
- Collecting seed/ cuttings from adult plants at Brookby
- Growing plants from the collected seed in a nursery
- Including the nursery-grown plants in restoration planting areas at Brookby.

The plant is readily propagated from seed and from cuttings and rooted pieces. It will grow in the open as well as closed forest and therefore these measures are feasible. Since the normal growth habit of the plant is a vine it may not be possible to translocate any actual plants from the Stage 3 area.

Similarly, although other species of rātā present at Brookby are currently widespread and abundant in the Auckland Region the need for managing these species may arise if myrtle rust is found to be significantly affecting their survival.

8.2.5 Biodiversity Offset Calculation

A summary of a potential biodiversity offset package is given in Section 8.5 Table 17. If this option is progressed, the final biodiversity offset package would be derived from a number of factors, some of which are currently unknown. The characteristics of offset sites are not yet known and detailed numerical data on biodiversity values at the offset and impact sites are yet to be collected (Brookby currently has forest plot data for the impact site). These data will largely be collected from a series of 20m x 20m vegetation plots within representative vegetation types in accordance with the RECCE method. Types of data collected are likely to include:

- Species diversity of native vascular plants
- Number, basal area and crown cover of emergent trees
- Subcanopy height and cover
- Understorey cover
- Ground layer cover and species diversity

Other potential data types could include elements of biodiversity of particular note at Brookby such as epiphyte abundance and diversity.

Elements of biodiversity for native fauna would be measured and required offsets for these calculated (Section 9.4). Offsets for fauna (including birds, lizards, potentially bats) would be integrated with offsets for loss of vegetation to provide maximum biodiversity gains. Similarly stream mitigation and offsetting would be integrated with vegetation offsets where possible.

Each biodiversity offset is site-specific because the biodiversity attributes of each site are unique. The publication 'A Biodiversity Offsets Accounting Model for New Zealand' (Maseyk *et al.* 2015) provides some guidance and examples. This model (and any later versions) would be used to inform and calculate the Brookby biodiversity offset for the Stage 3 area.

8.3 Potential Biodiversity Offset Package for Loss of Vegetation

A summary of a potential biodiversity offset package is presented in Table 17 under two scenarios:

Scenario 1: To offset loss of high value taraire forest (10.75ha) and tānekaha dominant forest (11ha).

- Identify areas of degraded taraire and tānekaha forest in the local landscape to protect and enhance with fencing, pest and weed control, buffer planting etc.
- Total area of degraded forest required is estimated at 300 – 500ha depending on the availability and quality of the offset areas. Offset the loss of extent of native vegetation within the SEA and the lower value kānuka/ tree fern forest with approximately 30ha of new planting (6:1 ratio) of kānuka.
- Threatened plant management plan for carmine rātā and protection of the remaining SEA outside the SPQZ (approximately 32ha).

Scenario 2: If insufficient or no suitable existing areas of native forest available to protect, undertake large-scale replanting of native vegetation in advance of vegetation loss.

- Planting ratios for taraire forest will be high (perhaps 10:1 = 107ha) and for tānekaha forest perhaps 6:1 (66ha) and 3:1 for kānuka forest (18.9ha) if planting is undertaken well in advance of vegetation removal at the quarry. Total planting would be in the order of 191.9ha. Threatened plant management plan for carmine rātā and protection of the remaining SEA outside the SPQZ (c. 32ha).

Table 17 gives approximate figures for the potential size of offset areas which are based on examples given in the Biodiversity Offsets Accounting Model for New Zealand User Manual (Maseyk *et al.* 2015) and several other publications. Column 2 gives a likely range, while column 4 suggests a possible range if areas of degraded vegetation are enhanced.

Actual New Zealand examples of biodiversity offsets that have been successfully implemented and demonstrated to deliver 'no net loss' are very difficult to find in the literature. This is partly because the concept and practice has only started to come into general use in the past 5 years. There are no agreed ratios for how much new planting needs to be undertaken for every hectare of a particular forest type that is lost. Neither is there any guidance as to the scale of protection and restoration of degraded habitats that might be required to offset the loss a hectare of particular forest types. Much depends on how degraded any potential offset site may be and how much improvement in biodiversity values the offset is expected to deliver over what time period.

The quality of the proposed offset is also important including long term management, monitoring, reporting and planting in advance of vegetation removal for restoration planting. These processes must be transparent with clear and measurable biodiversity outcomes.

8.4 TERRESTRIAL FAUNA

No threatened fauna species have been recorded at Brookby Quarry, however there is potential for intermittent presence of long-tailed bats (*Chalinolobus tuberculatus*), a highly mobile, Nationally critical species. Pre-surveys for bats would need to be undertaken prior to removal of high risk trees-primarily in the taraire and tōtara / rimu forest areas. Where bats are detected from pre-surveys, 'high risk' trees would be subject to Department of Conservation's tree-felling protocols. Further, additional

habitat enhancement should be provided through installation and monitoring of artificial bat roost boxes at appropriate locations.

Forest geckos (*Mokopirirrakau granulatus*) are 'At Risk' and would be managed in accordance with a Wildlife Authority and an approved lizard management plan. The plan would outline methods to capture and relocate geckos, and enhance relocation site habitats (legal protection and predator control). Monitoring of current release site for Stage 2 would provide insight to benefits of existing predator control intensity and use of installed tree shelters as habitat enhancement measures. Note this monitoring has not yet commenced but is planned for the current summer-autumn season.

No 'At Risk' or 'Threatened' native birds were recorded or are expected. However, as part of the overall mitigation and offset package, avifauna abundance and diversity would be targeted for measurable improvements through the overarching mitigation and offset package, including provision of legal protection and predator control and buffer enhancement, where required, of existing retained and habitats that can be identified as supporting the same species and can be legally protected ('like for like' habitats).

Like for like habitats, in accordance with best-practice biodiversity offset principles, should be as close as possible to the area of impact, where biodiversity values, including fauna, are the same or similar to those that would be lost. Such habitats should also be demonstrably additional to what would otherwise occur, including that they are additional to any avoidance, remediation or mitigation undertaken in relation to the adverse effects of the activity.

8.4.1 Fauna values that would require measuring to assist offset calculation of strategy

Resurveys would be required for bats, geckos and avifauna.

1. Bats: surveys within the Stage 3 area over November-February would target critical breeding period, when roost tree selection is highly specific.

   Rationale: identify any potential habitat constraints early and plan for potential enhancement measures.

2. Geckos: surveys at the Stage 2 release site and ideally also other potential offset areas, including night searches and tree cover checks.

   Rationale: determine use of artificial shelters, an encounter rate and capacity to provide additional shelters and support additional geckos. Information would be used to provide quantifiable measures against which existing habitat enhancement measures are performing (at release site), and other capacity to increase those measures within the context of an offset outcome. Information would also be used to gain measureable improvements from offset actions at other sites that would be protected and enhanced (e.g. provided predator control).

3. Birds: five-minute bird counts revisited at footprint as well as existing revegetation areas and future offset areas (i.e. other sites that would be protected and enhanced).

Rationale: This information would also be used to gain measureable improvements / targets from offset actions at other sites that would be protected and enhanced (e.g. provided predator control). In particular, offset actions would aim to measurably improve native bird abundance and diversity

8.5 SUMMARY OF POTENTIAL BIODIVERSITY OFFSET PACKAGE FOR LOSS OF VEGETATION AND FLORA

A summary of potential biodiversity offset package for loss of vegetation and flora and habitats within Brookby Stage 3 Expansion Area is presented as Table 17.

Table 17. Summary of potential biodiversity offsetting for vegetation and habitat loss within Stage 3 Expansion area

Biodiversity type or element lost	Proposed offset	Additional vegetation information required to determine scale of offset	Potential size of offset Scenario 1	Potential size of offset Scenario 2
10.76 ha taraire forest	Protection and enhancement of other areas of taraire forest in the Hunua Ecological District that are degraded and/or threatened by pests, weeds or grazing. Possible area required 80 - 110ha[2]	1. Confer with Auckland Council and Department of conservation to locate suitable areas available to enhance. 2. Undertake collection of detailed numerical biodiversity data (vegetation & fauna) at both the Brookby site and the offset site to allow calculation of area (ha) of offset required.	Based on the 'Endangered' status of taraire forest this could be 200 - 300 hundred hectares of degraded or threatened taraire forest to protect and enhance.	Restoration planting in advance of vegetation removal with long term management and maintenance over the lifetime of the resource consents. Assume a ratio of 10:1 = 107ha
11ha tānekaha /conifer forest	Protection and enhancement of other areas of this forest type in the Hunua Ecological District that are degraded and/or threatened by pests, weeds or grazing. Possible area required: 50 -110ha	As for taraire forest	This type of forest is not classified as threatened, however it is quite mature with some big trees and might require 100 – 200ha of degraded forest protected.	Restoration planting in advance of vegetation removal with long term management and maintenance over the lifetime of the resource consents. Assume a ratio of 6:1 = 66ha
6.3ha kānuka /tree fern	Restoration planting. Likely area required 30ha to ensure no loss of extent of native vegetation. Protection and enhancement of other areas of this forest type in the Hunua Ecological District that support like for like fauna values and are degraded and/or threatened by pests.	1. Undertake collection of detailed numerical biodiversity data for the kānuka/ tree fern forest at the Brookby site to determine area and composition of planting required.	At least 30ha (6:1) restoration planting of kanuka forest to maintain extent of native bush cover in the landscape.	Restoration planting in advance of vegetation removal with long term management and maintenance over the lifetime of the resource consents. Assume a ratio of 3:1= 18.9ha

[2] Possible areas given in Table 1 are based on examples given in Maseyk,F; Maron, M.;Seaton, R., and Dutson, G.2015: A Biodiversity Offsets Accounting Model for New Zealand. User Manual. Actual areas cannot be calculated without detailed biodiversity data on both the impact and the offset sites.

		2. Undertake collection of detailed numerical biodiversity data (geckos & birds)) at both the Brookby site and the offset site to allow calculation of area (ha) of offset required.		
Carmine rātā	Threatened plant management plan	Locate adult plants within and outside the Stage 3 area at Brookby to determine losses and to locate plants to be protected.	Carmine rātā management plan	Carmine rātā management plan
Loss of extent of SEA_T_5274	Protection of remaining area of SEA at Brookby[3]	More detailed information on values of remaining vegetation to be protected (general values are known).	C. 32 ha of SEA will remain outside the SPQZ. Whether this can all be protected will depend on quarry design	Protect remaining SEA outside SPQZ at Brookby
Totals			1. 300 – 500ha of protection and enhancement of degraded forest 2. 30ha of new planting in advance 3. Threatened plant management for carmine rātā 4. 32ha Protection of remaining SEA at Brookby	1. 191.9ha of new planting in advance of vegetation removal with long term management and maintenance. 2. Threatened plant management for carmine rātā 3. 32ha Protection of remaining SEA at Brookby

[3] May be overlap with proposed offsetting for loss of fauna values.

8.6 FRESHWATER HABITATS

Three un-named permanent streams and twelve un-named intermittent streams, all tributaries to the Papakura Stream, were assessed within in the Stage 3 expansion area. No wetlands were recorded or expected due to the steep, very rock terrain. The proposed use of the Stage 3 area for quarrying aggregate will result in the total loss of the tributary streams. There will be no loss of freshwater habitats in the Papakura Stream, and both the Papakura Stream and the Northern Tributary will be separated from the quarrying activity by a 20 m riparian buffer.

8.6.1 Stream Environmental Compensation Procedure

Auckland Unitary Plan Operative in Part (AUP)

Under Section E3 Lakes, rivers streams and wetlands of the AUP, E3.2. Objectives [rp] (3) states:

Significant residual adverse effects on lakes, rivers, streams or wetlands that cannot be avoided, remedied or mitigated are offset where this will promote the purpose of the Resource Management Act 1991.

Guidance on good practice biodiversity offsetting is provided in the AUP and in the Ministry for the Environment *et al.* (2014) document. In summary the offsetting restoration and enhancement documents recommend:

a) The site be located as close as possible to the subject site;
b) Be 'like-for-like';
c) Preferably achieve no net loss;
d) Consideration of the use of biodiversity offsetting; and
e) The use of Storey *et al*. (2011), Appendix 8 (AUP Operative in part, 2016) and Ministry for the Environment *et al.* (2014) for guidance.

The loss of the 1700 m (810m²) of aquatic habitat in the Stage 3 expansion area is considered a significant residual adverse effect under the AUP and would require offset environmental compensation.

Environmental Compensation Ratio (ECR)

For permanent and intermittent streams, SEV scores are used to calculate environmental compensation for loss of natural stream habitat by using the Environmental Compensation Ratio (ECR; Storey *et al.*, 2011). The ECR takes into account the SEV values of both the affected or impacted stream/s and the proposed restoration site stream/s, and determines any differential between the scores to provide a ratio for compensation which will result in 'no net loss of area weighted stream function' (Storey *et al*., 2011).

The ECR equation is calculated as follows:

$$ECR = [(SEVi\text{-}P – SEVi\text{-}I) / (SEVm\text{-}P – SEVm\text{-}C)] \times 1.5$$

Where:

- SEVi-P and SEVi-I are the potential SEV value and SEV value after impact, respectively, for the site to be impacted.
- SEVm-C and SEVm-P are the current and potential SEV values, respectively, for the site where the environmental compensation (mitigation) works are to be applied.
- 1.5 is a multiplier that allows for the delay in achieving compensation benefits.

The ECR calculations are, unavoidably, carried out using a number of assumptions. The 'Potential' SEV scores are calculated by altering parameter scores assuming best practice riparian restoration of the stream has taken place and is well established to a level providing at least 70% shade to the stream bed. As the streams within the Stage 3 expansion area have full riparian cover, no additional 'potential' will be added to the SEV score. Calculation of the 'Potential' score for a restoration site will assumed native riparian restoration of a 20m margin (10m either side of the watercourse). Calculation of the 'Impact' SEV scores would assume an outcome as proposed, with the full length of the stream being lost.

Following calculation of the ECR, the area of stream impacted (based on length and width of the stream) is multiplied by this value to determine the stream area required for remediation works.

A detailed Restoration Planting Plan and Weed Management Plan would be prepared for the stream riparian site by a qualified plant ecologist to ensure good quality native habitat is created. A minimum of a five-year defects and maintenance contract would be required for the restoration planting to ensure cover is achieved, weed control is maintained and to ensure the proposed compensation is achieved over the medium term.

8.6.2 Potential Restoration Sites

When assessing a site for restoration, under the ECR model, the most advantageous sites are those that can provide the largest change from their current value to their 'potential' value. For example sites with

- No or minimal riparian cover;
- Riparian cover comprised of exotic pest plants that can be legally removed prior to the baseline SEV being carried out;
- Fish barriers e.g. hanging culverts, fords;
- Piped inputs to the stream that can be removed;
- Bare ground;
- Wide streams or
- A piped stream that can be daylighted.

Streams that have no riparian vegetation within pasture, with a poorly performing culvert (or two) provide the best uplift and can provide a change from a SEV score of 0.35 to 0.65/0.7, i.e. a difference of 0.3 or 0.35. Daylighting culverts provides the best uplift (from 0.2 to 0.7) but proves to be ten times more expensive than just riparian planting.

Sites should be selected to provide an uplift of at least 0.3, and preferably be slightly wider than the section of impact stream that is being compensated for.

Table 18 provides an estimate of the potential length of stream required to offset the loss of the streams in the Stage 3 expansion area.

The following assumptions have been made for each of the restoration site scenarios, the results of which are summarised in Table 19:

A. Farm streams, with an uplift of 0.35. Width of the stream the same as the Impact site streams.
B. Farm streams, with an uplift of 0.35. Width of the stream 1.5 times the width of the impact streams.
C. Farm stream, with an uplift of 0.35. Width of the stream 2 times the width of the impact streams.
D. Farm stream, with some existing riparian vegetation, with an uplift of 0.25. Width the same as the impact streams.

Scenario D is the most likely scenario, with parts that could come under the Scenarios A – C.

At all sites SEVs would be required to be carried out (without the fish and biota components) to allow calculation of the ECR.

Table 18. Brookby Stage 3 Streams summary impact data

	Average Width	Total Bed area	Total Length	SEV Current	SEV Impact	Loss
Intermittent Stream	0.31	283	875	0.78	0.0	0.78
Permanent Stream	0.66	527	825	0.78	0.0	0.78

Table 19. Stream lengths required for riparian planting for four potential offset stream types

			Scenario			
	SEV Loss	Length loss	A +0.3 same width	B +0.3 width x 1.5	C +0.3 width x 2	D +0.25 same width
Intermittent	0.78	875	3400	2350	1700	4100
Permanent	0.78	825	3200	2100	1600	3850
Total Stream length required (m)			6600	4450	3300	8950
						most likely scenario

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10. APPENDICES

10.1 APPENDIX I. NATIVE PLANT SPECIES FOUND AT BROOKBY STAGE 3

K = Kānuka forest, T = Taraire forest, Tk = Tānekaha dominant forest, P = Podocarp dominant forest

Botanical name	Common name	Forest type[4]
Gymnosperms		
Dacrydium cupressinum	Rimu	T ,Tk,P
Dacrycarpus dacrydioides	Kahikatea	K, T, Tk, P
Podocarpus totara	Tōtara	K, Tk, P
Phyllocladus trichomanoides	Tānekaha	Tk, P
Prumnopitys ferrugineus	Miro	T, Tk, P
Dicot trees and shrubs		
Alseuosmia quercifolia	Oak leaved toropapa	TK
Aristotelia serrātā	Wineberry/makomako	K
Beilschmiedia tarairi	Taraire	T
Beilschmiedia tawa	tawa	T
Brachyglottis repanda	Rangiora	K
Carpodetus serratus	Putaputaweta/ marble leaf	Tk
Coprosma areolata	Thin leaved coprosma	K, Tk
Coprosma autumnalis	Kanono	T
Coprosma lucida	Shining karamu	K
Coprosma rhamnoides	Twiggy coprosma	K ,Tk, P
Coprosma robusta	karamu	K
Coprosma spathulata		K ,Tk, P
Dysoxylem spectabile	Kohekohe	T
Elaeocarpus dentatus	Hinau	T
Fuchsia excorticata	Tree fuchsia	K,T
Geniostoma ligustrifolium var. *ligustrifolium*	Hangehange	K, T, Tk
Hedycarya arborea	Pigeonwood	K,T
Knightia excelsa	Rewarewa	K,T,TK,P
Kunzea robusta	Kānuka	K,TK
Laurelia novaezelandiae	Pukatea	T
Leptocophylla juniperina	Prickly mingimingi	TK
Leptospermum scoparium	Mānuka	K
Leucopogon fasciculatus	Mingimingi	K ,Tk, P
Melicytus ramiflorus	Mahoe	T,TK
Metrosideros carminea	Carmine rātā	T
Metrosideros diffusa	White rātā	T
Metrosideros fulgens	Rātā	T,TK
Metrosideros perforātā	Small white rātā	T
Myrsine australis	Māpou/ matipo	K ,Tk, P
Nestegis lanceolata	White maire	T,TK
Olearia rani	Heketara	K,T,TK
Olearia furfuracea	Akepiro	TK

[4] K = kānuka forest, T = Taraire forest, Tk = Tānekaha dominant forest, P = Podocarp dominant forest

Passiflora tetrandra	Kohia vine/ NZ passion vine	K,T
Piper excelsum	Kawakawa	K
Pseudopanax crassifolius	Lancewood	K, TK
Rubus cissoides	Bush lawyer	K
Schefflera digitata	Pate	K
Solanum laciniatum	poroporo	K
Vitex lucens	Puriri	T,TK
Dicot herbs		
Acaena anserinifoloia	Piripiri	K
Callitriche muellerii	Mueller's starwort	Clay track
Centella uniflora	Centella	K
Elatostema rugosum	Parātāniwha/NZ begonia	T
Haloragis erecta	Shrubby haloragis	K
Hydrocotyle dissecta		Clay track
Hydrocotyle moschata	Hairy pennywort	Clay track
Hypericum pusillum	Swamp hypericum	Clay track
Lobelia anceps	Lobelia	K
Nertera depressa	Nertera	K,TK
Nertera dichondrifolia	Nertera	K,TK
Veronica plebeia		Clay track
Wahlenbergia violacea	Harebell	K
Monocots		
Astelia solandri	Perching lily	T
Astelia hastata	Tank lily	T
Bulbophyllum pygmaeum	Pygmy tree orchid	T
Cordyline australis	ti/ cabbage tree	K
Cordyline banksii	Te ngahere	K, TK
Cordyline pumilio	Dwarf cabbage tree	TK
Corybas trilobus	Spider orchid	T
Dianella nigra	NZ blueberry	K, TK
Earina mucronata	Bamboo orchid	K
Freycinetia banksii	Kiekie	K,T
Phormium tenax	Harakeke/ flax	K
Pterostylis alobula	Greenhood orchid	TK
Pterostylis banksii	Greenhood orchid	T
Rhopalostylis sapida	Nikau palm	K,T,TK
Ripogonum scandens	Supplejack	T
Ferns & Fern allies		
Asplenium bulbiferum	Hen & chickens fern	T
Asplenium flaccidum	Hanging spleenwort	K,T
Asplenium lamprophyllum		T
Asplenium oblongifolium	Shining spleenwort	T
Asplenium polyodon	Sickle spleenwort	T
Austroblechnum lanceolatum	Lance fern	K, T
Austroblechnum membranaceum		T
Cyathea dealbata	Silver fern	K,T,TK,P
Cyathea medullaris	Black ponga	K,T,TK
Dendroconche scandens	Fragrant fern/mokimoki	K,T
Dicksonia squarrosa	Wheki ponga	K,T,TK
Diploblechnum fraseri		K.TK
Doodia australis	Rasp fern	K

Histiopteris incisa	Water fern	K
Hymenophyllum ferrugineum	Rusty filmy fern	K
Icarus filiformis	Thread fern/ nini	T
Lastreopsis glabella	Smooth shield fern	T
Lastreopsis hispida	Hairy fern	K
Leptopteris hymenophylloides	Crape fern/heruheru	T
Lomaria discolor	Crown fern	K, T
Lygodium articulatum	Mangemange	K,T
Paesia scaberula	Ring fern	K
Parablechnum novae-zelandiae	Kiokio	K
Phlegmariurus varius	Clubmoss	T
Pneumatopteris pennigera	Gully fern	K
Pteridium esculentum	Bracken	K
Rumohra adiantiformis	Leathery shield fern	TK
Tmesipteris elongata	Fork fern	K, TK
Tmesipteris lanceolata	Fork fern	T
Trichomanes elongatum	Bristle fern	T
Trichomanes venosum	Veined bristle fern	T
Zealandia pustulatum	Hound's tongue fern	T
Sedges, rushes and grasses		
Carex uncinata	Hook sedge	K,T,TK,P
Carex banksiana	Fine leaved hook sedge	T,TK
Carex dissita	Forest sedge	T,K
Carex lambertiana	Forest sedge	K
Gahnia lacera	Cutty grass	TK
Gahnia pauciflora	Cutting sedge	TK
Gahnia setifolia	Razor sedge	K,
Juncus usitatus	Rush	Clay track
Microlaena avenacea	Bush rice grass	K,T
Oplismenus hirtellus subsp. *imbecilis*	Basket grass	K,T,
Schoenus maschalinus	Dwarf bog rush	Clay track
Schoenus tendo	Kauri grass	K,TK

10.2 APPENDIX II. FOREST PLOT MEASUREMENTS

Forest Plot Measurement Method

Within representative forest types forest plots were marked out and the species composition, density, diameter and basal area of the trees were recorded. These measurements were designed to provide information on the quality of the forest and to inform possible mitigation strategies.

The taraire-dominant forest found along the southern face of the main ridge represents the oldest and most mature forest type, while tanekaha dominant forest with scattered rimu forms a transitional forest type along the northern face of the ridge. One plot was located within each of these forest types (Figure 2). Measurements within three taraire forest plots have previously been carried out within the adjacent Stage 2 area for the Brookby Quarry Stage 2 baseline report (Bioresearches 2015) and the results of these can be found in that report. Measurements were carried out as follows.

1. Plots were located in areas of the forest that were considered representative of the forest type.

2. Each plot was circular, having a radius of 11.28m measured from one central tree. From this point the plot was marked out with flagging tape. The area of each plot was equivalent in area to 400m2 or 0.04ha.

3. The species was identified and the 'diameter at breast height' or **dbh** of all trees > 10cm dbh was recorded using a standard diameter tape measure. The standard height at which trees are measured is 1.4m above the ground, taking the upper side of the tree if the ground is sloping.

4. Tree diameter was used to calculate the basal area of each tree within the plot from which a mean basal area of each species per hectare could be calculated.

5. Tree ferns and nikau palms were not included as part of the measurements, however the number of tall nikau palms in the taraire forest plot was recorded because these formed a significant subcanopy to the forest and they provide additional information about forest composition.

FOREST PLOT RESULTS

Plot 1: Taraire forest

Species	Dbh measurements/ cm	Calculated basal areas m^2/0.04ha	Basal area m^2/ha	Mean diameter/cm	Stems/ha	% of basal area
Beilschmiedia tarairi	50.0, 35.4, 33.0, 37.5, 61.8	0.791	19.78	44.9	125	72
Olearia rani	18.8, 27.0, 24.1	0.130	3.26	23.5	75	11.5
Hedycarya arborea	14.0, 19.8, 14.0, (19.5 + 7.0), (12.0 + 9.9)	0.129	3.24	18.1	125	11.5
Knightia excelsa	19.1, 11.5, 15.4,	0.058	1.44	15.7	75	5
Totals		1.12	27.72		400	100
Tall nīkau	17				425	

Plot 2: Podocarp dominant forest

Species	Dbh measurements/ cm	Calculated basal areas m^2/0.04ha	Basal area m^2/ha	Mean diameter/cm	Stems/ha	% of basal area
Dacrydium cupressinum	36.5, 31.0, 31.5, 36.6, 29.1, 46.3, 35.2, 18.0	0.787	19.68	35.4	200	35
Phyllocladus trichomanoides	28.2, 34.0, 27.7, 29.9, 37.0, 23.0, 25.0, 34.0, 18.0, 15.4, 24.1, 22.3, 35.2, 25.0, 24.0, 25.0, 25.1, 29.8, 28.8, 40.4, 23.6, 24.0, 26.6,	1.4	35	27.8	575	62
Pseuodopanax crassifolius	17.5, 18.0	0.049	1.24	17.7	50	2
Knightia excelsa	18.3	0.026	0.65	18.3	25	1
Totals		2.262	56.57		850	100

Forest plot measurements

Two temporary circular forest plots were established as described in Appendix. One of these was within damp taraire forest near the northern stream tributary that forms the boundary to the Stage 3 area. The other plot was established within tānekaha dominant conifer forest along the central ridge.

See Appendix 2 for forest plot data. The key findings are as follows:

Plot 1: Taraire forest plot

The taraire forest plot was dominated by taraire (72% of basal area) and this species formed almost 100% of canopy trees. This finding is consistent with other taraire forest plots in the Stage 2 area, however the total basal area of all trees was much lower (27.2m^2 / ha compared with 47 – 67m^2 / ha in Stage 2) and the density of trees was also lower than in the Stage 2 plots. The mean diameter of individual trees was significantly higher in this plot than in the earlier Stage 2 plots. These differences may be attributable to the differing aspects and topography of the sites or they may reflect differing ages of the trees across the Brookby Quarry site.

As in other taraire plots the number of tall nīkau palms was similar to the total number of canopy trees and this species comprises the main understorey/subcanopy species. The understorey itself is sparse with few species other than nikau and at very low density.

Plot 2: Tānekaha dominant conifer forest plot

This plot was dominated by a few sizeable rimu trees with a large number of medium sized tānekaha amongst them. The total basal area of the plot was high at 56.57 m^2 / ha and 850 trees per hectare. Tānekaha accounted for 62% of the basal area of the plot with rimu making up 34%. These results indicate a dense transitional forest where intense competition will result in self- thinning over time and eventual transition towards podocarp-broadleaved forest.

10.3 APPENDIX III. WILDLIFE AUTHORITY 37604-FAU SPECIAL CONDITIONS.

SCHEDULE 3

SPECIAL CONDITIONS.

Relocation and habitat enhancement

1. The Authority Holder is only permitted to release lizards:
   a. That are classified as Not Threatened or At Risk species under the current threat classification system, and
   b. Into release site(s) that support habitat that is assessed by a qualified herpetologist as being of similar or better habitat compared to the source location, and being capable of supporting that lizard species, and,
   c. Into release site(s) that are within five hundred (500) metres of the development footprint or with consultation and agreement with the relevant DOC Services Manager), and
   d. Into release site(s) where habitat for that species of lizard is enhanced using accepted techniques such as provision of extra refuges suitable for the species or long-term predator control, and that this enhancement is undertaken and approved prior to the relocation taking place, and
   e. Into release site(s) where the site has long-term security from development or modification, for example Council or DOC- managed Reserves, legal protection through covenanting or legal protection through District Plan rule provisions).

2. The Services Manager(s) are to be contacted immediately for further advice if lizard species classified as Threatened are located within the footprint of the proposed development or within the proposed release site. This permit does not permit movement of Threatened species. A separate application to translocate Threatened species may be required.

3. The Services Manager(s) are to be contacted immediately for further advice if any of the conditions outlined in 1) above are not able to be met.

4. Where Threatened lizards are found within the footprint of the site during lizard salvage operations during construction, the Authority Holder shall contact the Services Manager(s) and transfer the lizard(s) to an approved lizard holding facility until a suitable release site is identified by DOC.

5. The Authority Holder must engage with the relevant tangata whenua prior to any relocation of lizards taking place in their rohe. Advice on engagement with tangata whenua should be sought from the Department of Conservation, Services Manager(s).

6. Any salvage operation for lizards shall be accompanied by a Lizard Management Plan that outlines, as a minimum, capture and handling techniques to be applied, the proposed relocation release site, management of the release site including provision for protection of relocated lizards, provision of post-release monitoring, and actions that will be followed in the event that Threatened lizard species are found within the development footprint.

7. Subject to holding an appropriate captive permit, the Authority Holder may hold any of the removed lizards in captivity for up to twelve (12) months then release them within five hundred (500) metres of the site where they were originally found once a Lizard Management Plan has been prepared and approved by DOC. The relevant DOC Services Manager must be notified within 48 hours if any lizards are placed into captivity.

8. Any offspring born in captivity must be released, together with the original animals collected, in accordance with the requirements of 1) above.

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Lizard capture and handling

9. Lizards must only be handled by people who are appropriately trained and experienced in lizard capture and handling, or under direct supervision of someone who is. Only non-destructive search methods may be used unless the Area is to be impacted and is the subject of a consented or permitted activity under the Resource Management Act 1991 or Conservation Act 1987.

10. Capture and handling of lizards must use techniques that minimise the risk of infection or injury to the animal.

11. If traps are used they must be covered to protect lizards from exposure and minimise stress. A small amount of damp leaf litter, or similar material, should be placed in the bottom to provide hiding places and reduce the risk of desiccation. Traps should be secured onto a secure surface to avoid disturbance from predators. Traps may be baited. All traps **must** be checked at least every 24 hours.

12. Lizard capture, handling and relocation should be undertaken at a suitable time of year when lizards are active, as advised by an experienced herpetologist

Reporting

13. A report is to be submitted in writing to the Director-General of Conservation, Services Manager, Auckland District Office as well as the Warkworth District Office, by 01 July each year for the life of this permit, summarising outcomes in accordance with the Lizard Management Plan. Each report must:
    a. include the species and number of any animals collected and released, and the GPS location (or a detailed map) of the collection point(s) and release point(s).

    b. include completed Amphibian and Reptile Distribution System (ARDS) cards (http://www.doc.govt.nz/conservation/native-animals/reptiles-and-frogs/species-information/herpetofauna-data-collection/ards-card/) to Herpetofauna, Department of Conservation, National Office, PO Box 10420 Wellington 6143 or herpetofauna@doc.govt.nz for all herpetofauna sightings and captures.

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10.4 APPENDIX IV. RAW MACROINVERTEBRATE DATA

PHYLUM	CLASS: Order	Family	Taxa	Taxa MCI hb	Taxa MCI sb	Site 1 Southern Tributary	Site 2 NW Branch Southern Tributary	Site 3 Intermittent NW Branch Southern Tributary	Site 4 West Branch Northern Tributary	Site 5 Papakura Stream
MOLLUSCA	**GASTROPODA**	Hydrobiidae	*Potamopyrgus antipodarum*	4	2.1	12	36	3	1	400
		Latiidae	*Latia neritoides*	3	6.1					1
ARTHROPODA	**CRUSTACEA: Amphipoda**		*Paraleptamphopus subterraneus*	5	5.5	328	336	280	9	66
			Paracalliope fluviatilis	5	5.5				1	
	Decapoda		*Paranephrops planifrons*	5	8.4	2	2		11	4
	INSECTA: Megaloptera	Corydalidae	*Archichauliodes diversus*	7	7.3	52	18			11
	Ephemeroptera	Ephemeridae	*Ichthybotus hudsoni*	8	9.2	8	8			
			Rallidens mcfarlanei							1
		Oligoneuriidae	*Coloburiscus humeralis*	9	8.1	62	32	1	2	175
		Leptophlebiidae	*Deleatidium* spp	8	5.6	6			1	40
			Acanthophlebia cruentata	7	9.6	2				
			Austroclima sepia	9	6.5	4				26
			Zephlebia spp	7	8.8	74	8	65	3	17
			Neozephlebia scita	7	7.6					2
	Plecoptera	Gripopterygidae	*Megaleptoperla diminuta*	9	7.3			1		
			Zelandoperla sp.	10	8.9				1	
		Eustheniidae	*Stenoperla prasina*	10	9.1	8	10		3	
		Austroperlidae	*Austroperla cyrene*	9	8.4	4	14	7	7	2
		Notonemouridae	*Spaniocercoides* sp.	8	*			2		
	Trichoptera	Hydropsychidae	*Aoteapsyche colonica*	4	6			1		49
			Orthopsyche fimbriata	9	7.5	16	34		14	2
			Orthopsyche (early instar)	9	*	22	44	24	23	
		Hydrobiosidae	Hydrobiosidae (early instar)	5	6.7			1		
			Hydrobiosis parumbripennis	5	6.7					2
			H. clavigera	5	6.7					1
			Psilochorema sp.	8	7.8	2	4			2
			Costachorema sp.	7	7.2					2
			Hydrochorema crassicaudatum	9	*		2			
		Polycentropodidae	*Polyplectropus puerilis*	8	8.1	2			1	
		Philopotamidae	*Hydrobiosella mixta*	9	7.6	20	8	1		15
			Triplectides obsoleta	5	5.7					1
	Neuroptera	Osmylidae	*Kempynus* sp.	5	*				1	
	Coleoptera	Elmidae	Elmidae	6	7.2					3
		Ptilodactylidae	Ptilodactylidae	8	7.1	12		2	4	
		Hydraenidae	Hydraenidae	8	6.7		4			
		Dytiscidae	*Homeodytes hookeri*	5	0.4				1	
	Diptera	Diptera	Diptera (early instar)	3	2.9			1		
		Tipulidae	*Limonia* sp.	6	6.3		2		1	1
			Aphrophilia neozelandica	5	5.6					2
		Hexatomini	*Paralimnophila skusei*	6	7.4	4	10	3	2	
			Eriopterini	9	7.5	2				
		Chironomidae	Chironomidae (t)	*	2	2	2			7
			Tanypodinae	5	6.5			3		
			Harrisius	6	4.7			1		
			Polypedilum	3	8				13	
			Orthcladiinae (not *Corynoneura*)	2	3.2				1	
		Dixidae	*Paradixa* sp.	4	8.5	2	2			
	Collembola	Collembola .	Collembola	6	5.3		2			
		TOTALS:	**NO. TAXA**			22	20	16	20	24
			NO. EPT TAXA			13	10	9	9	15
			NO. INDIVIDUALS			646	578	396	100	832
			* = unknown (t) = undifferentiated							

10.5 APPENDIX V. SEV SUMMARY TABLE

Function category	Report section	Function	Site 1 Sth Trib	Site 2 Nth Branch Sth Trib	Site 3 Int WC 4	Site 4 West Branch Nth Trib	Site 5 Papakura Stream
Hydraulic	**4.1**	**NFR**	0.93	0.85	1.00	0.98	0.99
Hydraulic	**4.2**	**FLE**	0.71	0.16	0.72	0.82	0.84
Hydraulic	**4.3**	**CSM**	1.00	1.00	1.00	1.00	1.00
Hydraulic	**4.4**	**CGW**	0.96	0.92	1.00	0.96	0.99
biogeochemical	**4.5**	**WTC**	0.98	0.84	1.00	1.00	0.86
biogeochemical	**4.6**	**DOM**	1.00	1.00	1.00	1.00	1.00
biogeochemical	**4.7**	**OMI**	1.00	1.00	1.00	1.00	1.00
biogeochemical	**4.8**	**IPR**	0.96	0.92	1.00	1.00	0.99
biogeochemical	**4.9**	**DOP**	0.86	0.95	0.50	0.41	0.79
habitat provision	**4.10**	**FSH**	0.50	0.05	0.05	0.05	0.61
habitat provision	**4.11**	**HAF**	1.00	0.90	0.96	1.00	0.98
Biodiversity	**4.12**	**FFI**	0.80	0.60	0.75	0.60	0.80
Biodiversity	**4.13**	**IFI**	0.79	0.70	0.62	0.66	0.85
Biodiversity	**4.14**	**RVI**	0.38	0.13	0.34	0.26	0.64
Overall mean SEV score (maximum value 1)			**0.85**	**0.72**	**0.78**	**0.77**	**0.88**