MILL ROAD CORRIDOR STUDY

ASSESSMENT OF ECOLOGICAL EFFECTS
July 2008

Kessels & Associates Ltd
ECOLOGY AND ENVIRONMENTAL PLANNING

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Executive Summary

Background

Manukau City Council has commissioned Kessels & Associates Ltd to undertake an assessment of ecological effects (AEE) for Mill Road / Redoubt Road realignment options investigations. Of the originally twelve alignment options, seven have been discarded during the specialist evaluation workshop, which was held on 18th April 2008, leaving five options to be assessed in greater detail within this study.

This ecological assessment constitutes the results of a detailed investigation of the ecological values of the proposed corridor area and the ecological constraints of the overall project, including an evaluation of:

- The location, extent, type and significance of terrestrial and aquatic indigenous vegetation communities, existing protected natural areas and fauna habitats supported within the project area.
- Results of botanical, avifauna and aquatic biota surveys carried out between March and July 2008.
- The nature and magnitude of any potential adverse ecological effects arising from each proposed road alignment option on key ecological features.
- A broad outline of suitable avoidance, remediation and mitigation measures required to address any potential adverse ecological effects.
- An outline of the requirements of further ecological investigations and monitoring requirements.

Description of Existing Vegetation

All options largely traverse a pastoral and urban landscape with no indigenous plant or animal habitats remaining. However, within stream gullies, patches of native bush and small wetland and seepage zones still persist. Some of these are modified and subject to weed intrusion, but others, largely, thanks to the efforts of private landowners, contain intact indigenous vegetation communities, many of which are under-represented within the Auckland Region. Principally, these stands contain mature taraire and puriri forest with kahikatea and wetland species dominating the wet gully floors. Several seepage zones remain in the otherwise almost completely cleared gullies within Totara Park in the north-west of the subject area.

Avifauna

Birds consist of common exotic and native species, with reasonably abundant populations of tui and kereru evident within the bush remnants. North Island kaka are visiting the area occasionally.

Bats

New Zealand long-tailed bats have previously been found both within the Hunua Ecological District, where the proposed corridor area is situated. Though no surveys have been conducted in the corridor area, long-tailed bats may be present at this locality.

Aquatic Biota

Fish and aquatic macroinvertebrate habitats consist of species reflecting a reasonably modified semi-urban environment, which pollution tolerant species dominating the silty and mobile substrates.

Ecological Sensitivity Assessment

According to the threatened environments classification described by Walker *et al.* (2007) the main proportion of the proposed corridor area is situated within "Category 3 - At risk". However, the proposed alignment options C and D would directly affect indigenous vegetation within an area classed as "Category 1 - Acutely threatened" (refer to the map in Appendix IV). The

potentially affected indigenous vegetation remnants were also assessed against the Auckland Regional Council Regional Policy Statement criteria and two bush remnants are considered to be of regional significance.

Effects on Indigenous Ecosystems

Options J, I and K are situated within an ideal location from an ecological perspective. These options are largely situated within pasture/urban landscape, and largely follow existing roads, consequently do not dissect any significant natural features.

Options C and D would comprise the crossing and clearance of indigenous bush (yet to be quantified, but likely to be less than 1 ha) as well as significant tree trimming, causing habitat loss and disturbance to indigenous wildlife. The dissection of these forest remnants will also result in fragmentation and disruption of ecological corridor values. Substantial mitigation will be required should these options be pursued.

No endangered, rare, threatened or vulnerable plant species or plant communities would be directly affected by any of the proposed alignment options. However, kereru and North Island kaka are present in the area and longfin eel and koura are reported in the Freshwater Fish Database for both Puhinui Creek and Papakura Stream. Further surveys for NZ long-tailed bats and lizards are proposed to confirm with greater certainty that these threatened species are not utilising the site if either Option C or D become the preferred options.

No fish or aquatic macroinvertebrate habitats would be adversely affected provided appropriate sediment control measures are adopted. As all perennial stream crossings are proposed to be bridges, no specific fish passage provisions are required. At this stage water abstraction requirements are unknown. Provided that suitable storage and/or non-fully allocated water sources can be devised and found, water abstraction during construction should result in no more than minor adverse effects on in-stream biota.

The key aspects, which require further investigation, are:

- Assessment of the potential effects of the water abstraction requirements once exact hydrological needs are known.
- Further wildlife surveys should Option C or D be pursued.
- Development of a detailed Ecological Restoration & Monitoring Plan should Option C or D be pursued.

1 Introduction

1.1 Project Outline

Manukau City Council has commissioned Kessels & Associates Ltd to undertake an assessment of ecological effects (AEE) for the proposed Mill Road / Redoubt Road realignment. Mill Road and Redoubt Road provide an arterial road connection east of State Highway 1 between Papakura District and Manukau City (Figure 1). They connect the suburbs Flat Bush and Takanini, which are constantly growing. The occurrence of a significant number of accidents has even more increased the need to carry out a corridor study aiming to identify a more suitable route that can cope with this increased pressure.

Twelve alignment options have been assessed, seven of which have been discarded during a specialist evaluation workshop, which was held on 18th April 2008. Five remaining options, three for the main west-east connection (C, D, J) and two for the north-south connection to Murphy's Bush (K, I), have been assessed in greater detail within this study (Figure 2).

The details of each alignment option, i.e. location, earth-work requirements etc. were detailed by OPUS in July 2008 and are attached as Appendix I.

This study constitutes the results of a detailed assessment of the ecological (aquatic, terrestrial and avifauna) values of the site, including an evaluation of:

- The type and significance of terrestrial and aquatic values supported within the project area;
- Results of botanical, aquatic and fauna surveys carried out between March and July 2008;
- The sensitivity and significance of these ecological features within the local, regional and national context;
- The nature and magnitude of any ecological effects arising from the proposed alignment options; and
- An outline of possible avoidance, remediation, mitigation and monitoring measures required to address any potential adverse ecological effects.

While alignment option J mainly follows the existing Mill Road, the other options will cross pasture land as well as some remnants of indigenous forest and scrublands (Figure 2). There are also a number of small seepage zones and streams scattered within the site, which could be affected by the proposed road alignments. The nearest protected natural areas are Totara Reserve and Murphy's Bush Scenic Reserve.

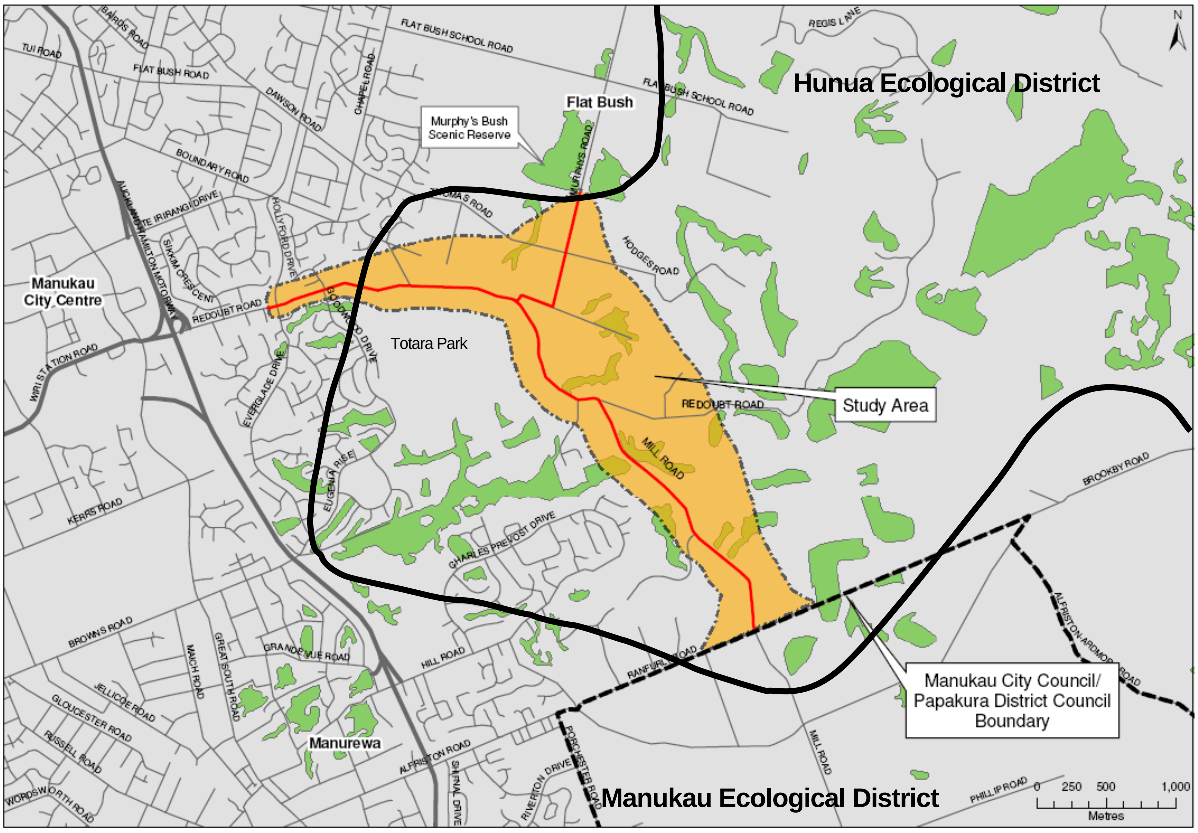

Figure 1 Location map including Ecological District Boundary

Figure 2 Overview of the five remaining alignment options assessed in this study

2 Methodology

This report is based on a general field survey of the study area conducted in March 2008, three other detailed site visits in early April, late May and late July 2008, a review of existing literature and databases, as well as the local knowledge of the authors. The key reference documents for this project are the detailed road alignment option descriptions provided by OPUS (July 2008), which are attached as Appendix I.

During the general field survey key ecological "hot spots" were identified, where potential adverse effects may be greatest. Intensive fieldwork studies were conducted in those "hot spots".

The following surveys were conducted:

- Detailed botanical surveys;
- Avifauna surveys;
- Weed and animal pest assessments;
- Vegetation typing; and
- Visual assessments of freshwater aquatic biota habitats.

All proposed alignment options were inspected and assessments made based on the site visits combined with an assessment of existing data and literature.

Further fauna surveys on long-tailed bats/pekapeka (*Chalinolobus tuberculatus*) should be scheduled for the upcoming summer (December 2008 to March 2009) if options C, D or I, which lead through bush areas, are considered to be taken further. An addendum report could be issued by May 2009 to report on this further monitoring.

2.1 Existing Literature Review

All existing databases and reports were reviewed to determine where the key significant natural areas and waterways are located and to ascertain their characteristics. Specifically the following documents and databases were reviewed:

- Manukau District Plan Maps;
- Hunua Ecological District Protected Natural Areas Programme (PNAP) report;
- Auckland Regional Plan;
- National Freshwater Fish Database; and
- Ornithological Society of New Zealand (OSNZ) national bird-distribution database.

2.2 Indigenous Vegetation Communities

Vegetation within the corridor area was visually assessed during the three site visits in April, May and July 2008. Broad indigenous vegetation communities were mapped on recent aerial photography and incorporated into the project's GIS database (Figure 3).

Where indigenous vegetation was potentially impacted by clearances required for any of the proposed alignment options, for project machinery or component transport, the species present were recorded, with particular attention paid to uncommon or unusual species.

Several wetlands and seepage zones were also visually assessed for dominant vegetation types and threatened or unusual plant species.

2.3 Avifauna

On site bird surveys in form of point records (opportunistic surveys), which involve counting all birds seen or heard within a 100 m radius of an observer, have provided an overview of the species present and an estimate of species abundance within the proposed corridor area. In addition, the review of the Ornithological Society of New Zealand (OSNZ) records provides an outline of the distribution of the rare and common avifauna within the study area.

2.4 Bats

No specific site surveys were conducted for bats at this stage. However, the long tailed bat (*Chalinolobus tuberculatus*) has been recorded in the Hunua Ecological District and surveys on long tailed bats are therefore recommended for the period December 2008 - January 2009 (see Appendix III for details) to detect if bats are present within the subject area. An addendum report could be issued in March 2009 to report on this further monitoring.

In New Zealand it is not necessary to capture bats for species census as the calls of the two occurring species are very distinct. Surveys can be conducted by teams of observers who slowly (approximately 3 km per hour) walk along a predetermined path, listening for the sound of bat echolocation calls with a heterodyne bat detector set to 40 kHz (O'Donnell & Sedgeley, 1999).

2.5 Aquatic Biota Habitats

Visual assessments of freshwater aquatic biota habitats were undertaken during the site visits and the National Freshwater Fish Database (FFDB) was reviewed. A brief inspection of the macroinvertebrate populations was undertaken during the site visit in July 2008.

2.6 Herpetofauna and Terrestrial Invertebrates

No specific surveys were conducted for herpetofauna or terrestrial invertebrates. However, data from the Hunua Ecological District Protected Natural Areas Programme (PNAP) survey was reviewed to give a general list of native lizard species expected in the region of the proposed corridor area.

2.7 Determination of Ecological Significance

Section 6.4.7 of the Auckland Regional Policy Statement (RPS) gives some guidance to the criteria used to evaluate Significant Natural Areas. It is summarised as follows:

1. *The significance of natural heritage resources in the Region, and the identification of the qualities and values which give rise to their significance, shall be determined using criteria including the following:*
   - *(i) the extent to which an area is representative or characteristic of the natural diversity in an ecological district or contains outstanding or rare indigenous community types;*
   - *(ii) the presence of a threatened species or uncommon, special or distinctive features;*
   - *(iii) the extent to which a natural area can maintain its ecological viability over time;*
   - *(iv) the extent to which an area is of sufficient size and shape to maintain its intrinsic values;*
   - *(v) the relationship a natural feature has with its surrounding landscape, including its role as an ecological corridor or riparian margin, and the extent of buffering or protection from external adverse effects;*
   - *(vi) the natural diversity of species of flora and fauna, biological communities and ecosystems, geological or edaphic features such as landforms and land processes, parent material, and records of past processes;*
   - *(vii) the diversity of ecological pattern, such as the change in species composition or communities along environmental gradients;*
   - *(viii) the extent to which an area is still reflective of its original natural character and quality;*
   - *(ix) the extent to which an area provides an important habitat for species at different stages of their life cycle, e.g., breeding, spawning, roosting, feeding, and haul-out areas for the New Zealand fur seal;*
   - *(x) the importance of an area to Tangata Whenua.*
2. *In assessing natural heritage resources, their contribution to the viability of the Region's ecosystems will be considered significant if they exhibit the following characteristics:*
   - *(i) the area provides a characteristic example of the ecology of the local area; and*
   - *(ii) the area is of good quality (e.g., for natural areas it has an intact understorey and is characterised by a low level of invasion from pest species); and*

(iii) the area contributes to the ecological viability of surrounding areas and biological communities; or

(iv) the area contains a Regionally threatened species or a unique or special feature; or

(v) the area contains an unprotected ecosystem type, or an ecosystem type under-represented within the protected area network of an ecological district; or

(vi) the area is a component of, adjoins or provides a buffer to, a significant natural resource, or a watercourse or coastal margin; or

(vii) the area has habitat values, or provides or contributes to a habitat corridor or connection facilitating the movement of fish or wildlife species in the local area; or

(viii) the area is in a landscape which is depleted of indigenous vegetation; or

(ix) the protection of the area adds significantly to the spatial characteristics of the protected area network (e.g., by improving connectivity or reducing distance to the next protected area); or

(x) the area is significant to Tangata Whenua; or

(Refer also to Chapter 3 - Matters of Significance to Iwi)

(xi) there is a community association with, or public appreciation of, the aesthetic values of the landform or feature.

3. The heritage value of freshwater ecosystems shall be progressively identified and protected from the adverse effects of use and development."

The key natural features were also assessed against the "The Threatened Environment Classification" GIS map as described by Walker *et al.* (2007) (Appendix IV). The Threatened Environment Classification uses indigenous vegetation as a surrogate for indigenous biodiversity, which includes indigenous ecosystems, habitats and communities. Walker *et al*. (2007) state that the Threatened Environment Classification "is most appropriately applied to help identify places that are priorities for formal protection against clearance and/or incompatible land uses, and for ecological restoration to restore lost species, linkages and buffers". The classification identifies six threat categories as follows:

Category	Criteria	Category Name
1	< 10 % indigenous vegetation left	Acutely Threatened
2	10-20 % indigenous vegetation left	Chronically Threatened
3	20-30 % indigenous vegetation left	At Risk
4	>30 % left & 10 % protected	Critically Under-protected
5	>30 % left & 10-20 % protected	Under-protected
6	>30 % left & > 20 % protected	Less Reduced & Better Protected

3 Description of Existing Natural Features

3.1 Description of Ecological Districts

An Ecological District (ED) is a scientifically determined region, which reflects the underlying biophysical characteristics of a locality. Each ED has a number of unique or distinctive natural habitat features (usually botanical), which distinguish it from neighbouring Ecological Districts. The proposed corridor area is situated within the Hunua ED in the Auckland Ecological Region with the north-western end reaching into the Manukau ED.

Hunua Ecological District

The Hunua Ecological District still supports a relatively high proportion of native bush. In general, the early vegetation within this district would have been kauri-podocarp-broadleaved forests, with kauri particularly prominent on the ridges. In some places, where the soils have formed from volcanic rocks and ash, the fertility is higher and the species present reflect this. Puriri and taraire often dominate on these more fertile soils.

Because of their size and sometimes high levels of connection, the bush areas within the Hunua Ecological District are often important habitats. In general, these are considered to be good habitat on the basis of the populations of the more common bush birds they support. Some of the areas are important for kereru, which was once thought common, but is now considered to be gradually declining. However, while birds are often the focus, this is usually because they are more visible than other fauna. For example, geckos and even native bats, are likely to rely upon many of these habitats, but because they are harder to see, they are often not mentioned.

Manukau Ecological District

The Manukau Ecological District has been largely cleared of native vegetation and almost all of its wetlands have been drained. Only 1.6% of the entire Manukau Ecological District has native vegetation of any type remaining on it. Reduction to around 20% of former extent is usually considered to be significant. Reduction to below 5% is considered to be severe. The reductions in the Manukau Ecological District are well below these levels. The only significant area of natural landscape remaining is the Manukau Harbour itself. Any remaining examples of original forests or wetlands, or any regenerating native vegetation that is developing into vegetation that once clothed the district therefore need to be considered as significant.

The early vegetation of the Manukau Ecological District was a mix of conifer-broadleaved forests and wetlands in peaty areas. On the flat lands, the terrain is slightly undulating, with some areas being slightly raised and better drained and other areas being sunken and often saturated. The drier areas on flat lands would once have supported lowland conifer-broadleaved forest of a range of species including totara, kahikatea, taraire, puriri, pukatea, kohekohe and titoki. On wet soils in peaty depressions, kahikatea would have dominated with swamp maire and pukatea growing in and under the kahikatea canopy. On the most poorly drained soils there would have been sedgelands.

3.2 Underlying Geology & Soils

The Mill Road corridor area is situated on low lying to undulating foothills and flatlands.

The soils within the Hunua Ecological District are mainly hill and steepland clayey soils with impeded drainage (some podzolised) from strongly weathered sedimentary rocks. Small areas of clayey but friable, well drained loam soils are present on easier slopes from old, strongly weathered volcanic ash. Loamy, poorly drained and gleyed alluvial soils occur in the valleys. The soils on the hilly and steep slopes show complex patterns, which are reflected in the vegetation.

The Manukau ED is characterised by basalt lava and other deposits from Pliocene-Quaternary age volcanoes in the central region, fringed to the north and south by Pliocene to Holocene sediments. Pleistocene sediments form a large area in the north close to the study area.

Within Manukau ED, poorly drained, gleyed alluvial soils and peat deposits are the dominant soil types on the river flats and swamps, with small pockets of volcanic loam soils from basaltic lava and scoria scattered throughout the ecological district. Silty, generally well drained loam soils from old strongly- weathered volcanic ashes are dominant on the rolling and hilly land, while strongly leached and podzolised clayey soils, from strongly weathered sedimentary rocks, occur on the hilly and steep slopes (McEwen, 1987; Pohlen, 1965).

3.3 Indigenous Vegetation

Of the once widespread podocarp-broadleaved forests and the kahikatea swamp forests that were extensive in pre-human times throughout both ecological districts, only the occasional small forest remnant remains within the gullies of the study area. These remnants have a species composition of warm temperate forests and are often dominated by taraire and puriri with the occasional kauri. Kahikatea are dominant on the wet gully floors. The transition from taraire to tawa forest was obvious in the Tiffany Bush area. Several seepage zones remain in the otherwise almost completely cleared gullies within Totara Park in the north-west of the subject area.

Those natural areas that could be directly affected by one of the alignment options are described in detail below (refer to Figure 3 for the numbering). Area 4 contains mainly exotic ornamental tree species and is not described in further detail. Common names are used in the text; for a species list containing the botanical names refer to Appendix II.

Figure 3 Natural areas affected by the proposed alignment options

Bush block 1 - affected by Option D

The vegetation in this gully is largely weed infested especially around the margins and in the northern end adjacent to the Watercare area. Although mainly classified as exotic scrub, it shows influences of secondary semi-coastal podocarp-broadleaved forest (Photo 1).

Where the proposed option D crosses, the margins are dominated by pines, woolly nightshade and gorse with species such as Chinese privet, tree privet, Himalayan honeysuckle and pampas occurring throughout on the sideslopes. Exotic species of the groundcover include wandering Jew, creeping buttercup, Kikuyu grass, lotus, black nightshade, hedge woundwort as well as common pasture herbs and grasses. One moth plant specimen was noted on the gully floor as well.

Native species present at the proposed crossing include one large (20 m tall) puriri, the treeferns mamaku and ponga, as well as shrub species like kawakawa, hangehange, kanono and saplings of nikau and mapou. Juvenile kiekie and flowering NZ passionfruit were also observed. Native groundcover species included swards of *Carex geminata* and raupo, other *Carex* species, ferns like ring fern and water fern, shrubby haloragis and bamboo grass.

A small perennial stream is contained in this gully, which is further described in chapter 3.6.

Further south towards Mill Road, the canopy of this gully contains large specimens of kahikatea, taraire and rewarewa with the occasional young rimu, as well as cabbage tree, nikau and kanuka. Ponga and mamaku are present as well and kahakaha was noted in the crowns of the larger trees. Seedlings of mapou and pigeonwood are common. Additional weed species that occur around the margins of this area include blackberry, Japanese honeysuckle and montbretia.

Photo 1 Overview of bush block 1

Bush blocks 2 & 3 - affected by Options C & D

Bush block 3 has been fenced off from stock for more than twelve years. Both Bush blocks 2 and 3 are both understood to be legally protected as Council Covenants under the Reserves Act 1977, although verification is required.

These two bush blocks are rare examples of old growth semi-coastal podocarp-broadleaved forest with a canopy height of 20-25 m. The DBH (diameter breast height) of some specimens were measured as follows: kahikatea, kohekohe and taraire – 600 mm, puriri – 1240 mm, rimu – 370 mm and kanuka – 350 mm.

The canopy of this forest type contains a diverse mixture of conifer and broadleaved species, with taraire and puriri being dominant on the slopes and kahikatea being dominant on the gully floor (Photo 2). Rimu, tanekaha, the odd matai and pukatea emerge through the canopy and mahoe, tawa, karaka, pigeonwood, mapou, cabbage tree and nikau add to the diversity. Totara, kanuka, lancewood and titoki are present on the drier slopes and ponga, wheki and mamaku are common treeferns. NZ passionfruit and two climbing rata species are present lianes. Epiphytes include the ferns hound's tongue fern, fragrant fern, hanging spleenwort, sickle spleenwort, filmy fern, fork fern and leather-leaf fern as well as kahakaha.

The understorey supports species such as mapou, hangehange, young lancewood, karamu, kanono, putaputaweta and the occasional flax. *Coprosma spathulata* and mingimingi grow higher up the slopes. Lacebark, kauri, *Pittosporum*, korokia and five-finger species have been planted along the margins of the western gully (2).

An abundance of seedlings of various different species is present in the groundcover, namely karaka, mahoe, pigeonwood, taraire, mangeao and puriri. Ferns make up most of the groundcover with thread fern, sweet fern, *Lastreopsis microsora* and gully fern being the most dominant species. The groundcover also contains a variety of pasture herbs and grasses, as well as bamboo grass, nertera and hookgrass.

The orchid *Acianthus sinclairii* was noted on the lower slopes close to the stream and bamboo orchid grows epiphytic in the canopy.

A number of different fungi species was noted as well.

A large number of weed species was noted along the southern margins of these stands that are adjacent to Mill Road. Observed tree and shrub species are a macrocarpa, poplar, bamboo, wattle, woolly nightshade, gorse, Himalayan honeysuckle and Chinese privet. Exotic groundcover species are black nightshade, Arum lily, inkweed, elephant's ear, both ginger species, Agapanthus, garden nasturtium, wandering Jew, bindweed, montbretia, *Cyperus* sp., daisy, mint and ragwort. Periwinkle and gorse were the main weed species observed along the north-western margin of bush block 3.

Photo 2 Canopy of bush block 3; showing large taraire, puriri, kahikatea and rimu

Area 5 - affected by Options C & D

The small gullies in Totara Reserve contain small seepage zones in the gully heads, which for the most part, contain mostly pasture grasses and weeds with few native species (Photo 3). These gullies contain the headwaters of the Puhinui Stream, which is further described in chapter 3.6. *Juncus effusus*, water pepper and pasture grasses are the most common groundcover species on the gully floors. The slightly drier slopes are mainly cleared with only a few trees and shrubs remaining. The only native species present close to the gully heads are ponga, manuka and pigeonwood seedlings. Further down the gullies, a few tall (15 m) totara and kahikatea remain in conjunction with mahoe, wheki, mamaku, gully tree fern, hangehange, manuka, mingimingi and mapou. The climbing pohuehue was also present. Weed species present include tree privet, Chinese privet, barberry, woolly nightshade and gorse.

Most of the gullies contain streams with minimal flow or sometimes stagnant (in May 2008), which are mainly ephemeral and incised.

Photo 3 One of the seepage zones affected by Options C & D

3.4 Avifauna

Resident bird populations within the study area comprise mostly of common native and exotic species of open grasslands, including a variety of small, mostly exotic passerines like blackbird, song-thrush, sparrow, yellowhammer and finches, as well as Australasian harrier, kingfisher, pukeko, rosella, magpie, Indian myna and spur-winged plover. Tui, kereru, silvereye, fantail and grey warbler were heard in bush blocks 2 and 3 (refer to Figure 3) and North Island kaka and shining cuckoo have been reported to be visiting the area. Bellbird are recorded in the Hunua Ranges in increasing numbers and may be able to spread back into smaller forest remnants, such as the ones in the subject area, in the future.

3.5 Bats

There are two species of native bat in New Zealand – the lesser short-tailed bat (*Mystacina tuberculata*) and the long-tailed bat (*Chalinolobus tuberculatus*). Lesser short-tailed bats are currently thought to be restricted in their range to forest reserves in the central North Island and lower South Island (King, 2005). Although short tailed bats are forest specialists, they are not likely to be found within the study site. The long-tailed bat, however, has a wider distribution in the North Island of New Zealand. Conversely, long-tailed bats are often found in open areas foraging extensively over farmland (Griffiths, 1996; Borkin, 1999) and frequenting forest edges or low density regenerating kanuka (*Kunzea ericoides*) and manuka (*Leptospermum scoparium*) forests (O'Donnell, 2001b). New Zealand long-tailed bats have been found within the Hunua ED (in the Hunua Ranges).

Extensive surveys have not previously been conducted in the corridor area. However, it is not unlikely that long-tailed bats are present within this site. Long-tailed bats are dormant during periods of cold weather movement and therefore surveys have not been undertaken at this stage. The long-tailed bat has been classified as nationally vulnerable (Hitchmough *et al.*, 2007). Detailed monitoring of the site should therefore be conducted in the summer to determine absence or presence of this species, and to enable the assessment of possible disturbance of the New Zealand long-tail bat through the project (see Appendix III for details).

3.6 Freshwater Environments

The proposed Mill Road re-alignment will potentially affect two streams; the headwaters of the Puhinui Stream and Creek, and the mid-reach of the Papakura Stream.

The Puhinui Stream flows through Totara Park which is managed by Manukau City Council. The Puhinui Stream flows for approximately 12 km before discharging into the Manukau Harbour, encompassing a catchment of approximately 2220 m^2. Puhinui Stream is considered to be highly modified in parts and as a result a restoration concept plan has been created for the stream. The key ecological restoration goals for the stream include: reduction of flood and stream side erosion, enhance wildlife, restore historic and cultural resource, restore and improve water quality and habitat, and restore physical and biological functioning (Puhinui Stream Restoration Concept Plan, 2002).

One of the headwaters of the Puhinui Stream is present in bush block 1 in form of a small first order perennial stream (according to ARC Regional Plan guidelines). Where the proposed alignment option (D) crosses, its dry wetted width is 1 m and its wetted width is 700 mm (Photo 4). The run depth is 3-5 cm and some shallow pools are present of up to 10 cm depth. The substrate is soft silt with occasional gravel and small cobble.

The Papakura Stream crosses the boundary between Manukau City and Papakura District Councils and has a catchment area of 56 km^2. The Papakura Stream catchment is primarily rural and discharges to the Pahurehure Inlet of the Manukau Harbour. A flood management plan was prepared by Beca Carter Hollings and Ferner Ltd. in June 1993 for the stream. The report was prepared as a result of the flooding in the catchment, particularly surface flooding upstream of Mill Road, which attenuates peak flows downstream (Beca Carter Hollings and Ferner Ltd, 1993).

Photo 4 Stream present in bush block 1

3.6.1 Water Quality

The Auckland Regional Council routinely monitors several of the streams, estuaries and lakes within the Auckland Region. Included in the routine surveys are the Papakura and Puhinui Streams. The survey site for the Papakura Stream is located at Porchester Road (Map Reference R11: 814 620), the catchment landuse is primarily pastoral 85% with a small amount of urban landuse 0.7%. The survey site for the Puhinui Stream is located at ford (Map Reference R11: 768 660), the catchment landuse is 52.3% pastoral and 39.8% urban.

The results of a 10 year monitoring program (from 1992 to 2002) for these streams have been adapted from the Auckland Regional Council Technical Publication 207 (2003), and are presented in Table 1.

Both streams have similar seasonal temperature values for the 10 year period (1992 to 2002). However, the values were slightly higher in the Puhinui Stream particularly in summer; this may be the result of heated surface water runoff from impermeable surfaces.

The dissolved oxygen levels were higher in the Puhinui Stream. Dissolved oxygen is a measure of the oxygen levels within the water and can be affected by a number of processes including, water flow (riffle habitat), aquatic plants and oxygen consumption by micro-organisms. The consumption of oxygen by micro-organisms is referred to as the biological oxygen demand (BOD). The median BOD levels are low at 1 mg/L, which is below the ANZECC (2000) physiochemical stressor guideline for protection of aquatic species at 5 mg/L.

Water transparency, turbidity and suspended sediment loads have been measured for the streams. The Papakura Stream has a higher transparency and less suspended solids, but interestingly has a higher turbidity than the Puhinui Stream.

Presumptive and faecal coliform levels are greater in the Puhinui Stream than the Papakura Stream. The Papakura Stream has a greater catchment area and is dominated by pastoral land use, which can impact faecal levels in a stream.

In general the Papakura Stream has a larger catchment dominated by pastoral land use, which has impacts on the water quality of the stream. This stream has a lower dissolved oxygen level and higher presumptive and faecal coliform levels than the Puhinui Stream. The Puhinui Stream has a mixed pasture and urban landuse, which has impacted the water quality resulting in higher summer temperatures, lower transparency and higher suspended sediment levels, all of which are likely to be the result of increased surface runoff.

Table 1 Median water quality results for 2002 from monthly recordings at Papakura and Puhinui Streams

Water Quality Parameters	Papakura Stream	Puhinui Stream
Temperature (°C)	14.2	14.5
Dissolved Oxygen (%)	71.7	96.8
Biological Oxygen Demand (mg/L)	1	1
Black Disk Transparency (m)	0.62	0.45
Turbidity (NTU)	6	1.5
Suspended solids (mg/L)	3.7	6.9
Presumptive coliforms (MPN/100mL)	4000	3650
Faecal coliforms (MPN/100mL)	3000	1000

3.6.2 Fish

No specific fish surveys have been undertaken for this study. However, common bullies have been observed during the May site visit in the Puhinui tributary situated in the gully crossed by alignment option D.

The Papakura Stream and Puhinui Creek and tributary have been fished previously with the results on the freshwater fish database (FFDB) displayed in Table 2.

Six fish species have been captured in the Papakura Stream, while five fish species and freshwater crayfish were recorded in the Puhinui Creek and tributary. The streams have four species in common, with longfin eel and inanga recorded in Papakura Stream and not in Puhinui Creek and koura in Puhinui Creek but not Papakura Stream.

The presence of longfin eel and koura at these sites is of importance as these species are considered to be threatened and in gradual decline (Hitchmough *et al*., 2007). Both species are also important culturally as food sources. Longfin eels are often upland species and prefer to reside in headwater streams with abundant cover in the form of overhead shade and undercut banks. Large eels are top predators in freshwater environments feeding on smaller fish and koura. Koura seek refuge and habitat in undercut banks.

All of the fish species recorded, except mosquito fish, are native and diadromous species, requiring part of their life stage to be spent in the ocean as well as freshwater. These fish enter the freshwater environment through the Manukau Harbour, where the streams discharge. The presence of these fish indicates that access to these sites is sufficient (i.e. there are no barriers to migration).

Mosquito fish are small fish that have been described as aggressive and are able to tolerate adverse ecological conditions such as high temperatures and salinities. In ideal conditions these pest fish can reproduce rapidly (within weeks) giving birth to numerous live young. They can therefore dominate and possibly out-compete native fish in ideal conditions. However, these fish are often found in high numbers where conditions are not suitable for native fish species (i.e. stagnant pools and drains).

Inanga make up a significant component of the whitebait run, migrating into streams in late spring, early summer. Another whitebait species that is common in Auckland urban streams is the banded kokopu, while this species was not recorded on the FFDB records, it could occur within these streams.

Table 2 FFDB results for the Papakura Stream and Puhinui Creek and tributary extracted 15/07/2008

Stream	Fish species		Year	Abundance	Minimum length (mm)	Maximum length (mm)
Papakura Stream	Longfin eel	*Anguilla dieffenbachii*	2000, 2001	common	150	400
	Common bully	*Gobiomorphus cotidianus*	2000, 2001	rare	50	60
	Shortfin eel	*Anguilla australis*	2000, 2001	common	200	
	Redfin bully	*Gobiomorphus huttoni*	2000, 2001	rare	60	70
	Inanga	*Galaxias maculatus*	2001	common		
	Mosquito fish	*Gambusia affinis*	2001	occasional		
Puhinui Creek and tributary	Koura	*Paranephrops*	1997	rare		
	Common bully	*Gobiomorphus cotidianus*	1997	common	30	40
	Shortfin eel	*Anguilla australis*	1997, 1998	abundant	100	700
	Mosquito fish	*Gambusia affinis*	1998	abundant	20	40
	Redfin bully	*Gobiomorphus huttoni*	1997	common		

3.6.3 Invertebrates

No macroinvertebrate samples were taken from the streams for this preliminary survey. However, a brief inspection of the macroinvertebrate population has been undertaken during the July site visit, and the results indicate that the predominant macroinvertebrate species assemblages are dominated by small crustaceans (*Paracalliope* & *Paraleptemphobus*), freshwater snails (*Potamopyrgus*) and true fly larvae (mostly *Austrosimulium* & *Orthocladiinae*). All of these species are pollution tolerant and typical of intensively managed pastoral catchments, as well as being of small, first order upper stream systems.

3.7 Other Indigenous Fauna

3.7.1 Reptiles

Although not recorded in this survey, the forest areas in within the subject corridor are likely to provide habitat for several geckos and skinks. Six lizard species (forest, Pacific grey and Auckland green geckos and copper, ornate and shore skinks) have been recorded in the Hunua Ecological District. Three of these species are considered to be in gradual decline and of national conservation concern - the Auckland green gecko, the Pacific grey gecko and the ornate skink. Although there are numerous secure island populations of the ornate skink, there is concern about the level of mainland decline in this species. Forest gecko and green gecko are likely to be found in the forests and scrublands within and adjacent to the study area. The ornate skink is found in lowland areas throughout the North Island.

3.7.2 Native Frogs

Native frogs (*Leiopelma* spp.) have not been observed or reported in the region of the proposed Mill Road / Redoubt Road corridor (PNAP Report, 1999).

However the seepage areas and gullies are likely to provide habitat for two exotic frog species: *Litoria aurea* and *Litoria raniformis*.

3.7.3 Terrestrial Invertebrates

Hundreds of different indigenous insect species may be found within the study area. However, few areas in this region have been seriously sampled for their invertebrates. Insufficient data is available of the molluscan faunas in the subject area; however, more than 100 landsnails have been identified within the Hunua ED (PNAP Report, 1999).

Glow-worms (*Arachnocampa luminosa*) are present along the stream within bush area 3.

3.8 Introduced Mammals

Feral animals are found throughout the study area. Rabbits, possums, hares and hedgehogs are widespread. Feral cats, ferrets and stoats are likely to be present.

4 Ecological Significance Assessment and Threatened Species

4.1 Significant Natural Areas within the Corridor Area

Virtually all remaining natural areas in the Hunua and especially the Manukau ED are considered to be important natural features because of their scarcity.

While 23% of the Hunua ED is covered by natural areas under some form of protective tenure for conservation (PNAP Report, 1999), only 1.6 % of the Manukau ED total land area remains under native vegetation cover. Forest types with taraire dominant canopy now only cover 0.8% of the land area in Manukau Ecological District.

According to the threatened environments classification described by Walker *et al.* (2007) the main proportion of the proposed corridor area is situated within Category 3 - At risk. However, the southern end of the corridor area, which includes Bush Areas 2 & 3, is classed as Category 1 - Acutely Threatened (refer to the map in Appendix IV). In effect this indicates that any indigenous vegetation within this criteria zone is nationally under-represented (less than 10%) and also under-protected nationally.

No wetlands of regional ecological importance are located within the corridor area. However, the seepage zones within Totara Park can be considered as ecologically significant given the degree of modification wetlands have suffered regionally and nationally.

4.2 Ecological Significance Assessment using ARC Criteria

The following table includes the ecological significance assessment using the ARC criteria for bush areas 1, 2 and 3, as well as for the seepage zones (area 5) in Totara Park.

Table 3 Ecological Significance Assessment using ARC criteria

Summary of ARC Criteria	Bush block 1	Bush block 2	Bush block 3	Area 5 - seepage zones
1. the natural area is representative or characteristic of the natural diversity in the ecological district or containing outstanding or rare indigenous community types	NO	YES - the area contains elements of semi-coastal forest	YES - the area contains elements of semi-coastal forest	NO
2. the area is of good quality (e.g., for natural areas it has an intact understorey and is characterised by a low level of invasion from pest species	NO - the vegetation is largely weed infested, native species only remain on the lower slopes and the gully floor	YES - both canopy and understorey are well developed and weed species are uncommon	YES - both canopy and understorey are well developed and weed species are uncommon	NO - exotic species are dominant
3. the area contains an unprotected ecosystem type, or an ecosystem type under-represented within the protected area network of an ecological district	NO	YES - the vegetation type is underrepresented in Manukau ED, but not in Hunua ED	YES - the vegetation type is underrepresented in Manukau ED, but not in Hunua ED	NO
4. the area is in a landscape which is depleted of indigenous vegetation	YES - the area is situated within a "Category 1 - Acutely threatened" area according to the Threatened Environments Classification	YES - the area is situated within a "Category 1 - Acutely threatened" area according to the Threatened Environments Classification	YES - the area is situated within a "Category 1 - Acutely threatened" area according to the Threatened Environments Classification	YES - the area is situated within a "Category 1 - Acutely threatened" area according to the Threatened Environments Classification
5. presence of a threatened species or uncommon, special or distinctive features	YES - kereru and North Island kaka are present in the area and utilize the bush area	YES - kereru and North Island kaka are present in the area and utilize the bush area	YES - kereru and North Island kaka are present in the area and utilize the bush area	NO
6. the natural area can maintain its ecological viability over time	NO - not possible unless major weed control measures are carried out	YES	YES	NO - threatened by stock intrusion and weed species
7. the natural area is of sufficient size and shape to maintain its intrinsic values	YES - if weed control measures were carried out	YES	YES	NO - not unless fenced and planted up with suitable native species
8. relationship the natural feature has with its surrounding landscape, including its role as an ecological corridor or riparian margin, and the extent of buffering or protection from external adverse effects	YES - the bush area - although weed infested - forms an ecological corridor and is a buffer for a perennial stream	YES - the bush area forms an ecological corridor and is a buffer for a perennial stream	YES - the bush area forms an ecological corridor and is a buffer for a perennial stream	YES - although heavily depleted gully systems as such form important ecological corridors

9. contains a good natural diversity of species of flora and fauna, of ecological patterns, such as the change in species composition or communities along environmental gradients, or of geological or edaphic features such as landforms and land processes, parent material, and records of past processes	NO - although the area combines forest and stream ecosystems the diversity of indigenous flora and fauna is only moderate	YES - the bush comprises a good diversity of indigenous flora and fauna species and combines forest and stream ecosystems which follow environmental gradients	YES - the bush comprises a good diversity of indigenous flora and fauna species and combines forest and stream ecosystems which follow environmental gradients	NO
10. the area is still reflective of its original natural character and quality	NO	YES	YES	NO
11. the area provides an important habitat for species at different stages of their life cycle, e.g., breeding, spawning, roosting or feeding	YES - the stream contained in the gully may provide important habitat for native fish species	YES - both the canopy trees as well as the stream contained in the gully provide important habitat for indigenous fauna	YES - both the canopy trees as well as the stream contained in the gully provide important habitat for indigenous fauna	NO
12. the protection of the area adds significantly to the spatial characteristics of the protected area network (e.g., by improving connectivity or reducing distance to the next protected area)	YES	YES	YES	YES
13. importance of the area to Tangata Whenua	unknown	unknown	unknown	unknown
14. there is a community association with, or public appreciation of, the aesthetic values of the landform or feature	NO	YES - the bush area is of interest to a local landcare group	YES - the bush area is of interest to a local landcare group	YES - the seepage zones are situated within Totara Park which is the largest public reserve within the Manukau District

4.3 Threatened Flora and Fauna

This survey did not collect detailed information on threatened species, and further survey work would be necessary to do this. However, the nationally threatened king fern (*Marattia salicina*) (listed by Hitchmough *et al.*, 2007 as being in the threat category of 'serious decline') was observed at the site and the regionally uncommon swamp maire (*Syzygium maire*) was found in association with a few very large (1.5 m tall) and uncommon *Carex secta* specimens. All of these species were present in the Tiffany Bush area, which is situated within the corridor area, but will not be affected by any of the proposed alignment options.

Kereru (Gradual Decline – bush and scrublands) were observed within bush areas 2 and 3 and North Island kaka (Critical – native bush) have been reported to be visiting the area occasionally.

There are another six known nationally threatened fauna species, which may be found in a variety of habitats within the study area (Hitchmough *et al.*, 2007). These are:

- Longfin eel – Gradual Decline – upper catchment streams, wetlands and rivers.
- Koura – Gradual Decline – most streams within the study area.
- North Island long-tailed bat – Nationally vulnerable – bush and scrub.
- Auckland green gecko – Gradual Decline – bush and scrublands.
- Pacific grey gecko – Gradual Decline – bush and scrublands.
- Ornate skink – Gradual Decline – bush and scrublands.

5 Assessment of Ecological Effects

5.1 Summary of Potential Ecological Effects

The proposed Mill Road / Redoubt Road alignment options largely follow existing roads or are crossing extensively farmed pasture land. However, options C and D will cross ecologically significant indigenous forest remnants containing streams and could also affect a few seepage zones within Totara Park.

Potential impacts of the proposed road alignments on indigenous vegetation, streams and wildlife can be divided into two groups – direct impacts and indirect impacts. These are summarised as Table 4. The potential ecological factors presented to fauna by the construction of new roads can be characterised into three broad classes of hazard factors. These comprise of:

1) a behavioural element, caused by fauna avoiding the vicinity of the turbines as a behavioural response to a visual stimulus and/or sound stimulus;
2) a physical habitat element, where fauna respond to destruction, modification or creation of habitat associated with infrastructure construction; and
3) a direct demographic element, resulting from mortality arising from physical collisions with traffic.

More specifically, direct impacts could include:

- habitat loss and damage and destruction of plants and other wildlife, in the course of road construction; and
- sediment run-off from road construction affecting water quality and aquatic biota habitat quality.

Indirect impacts could include:

- loss, damage, modification or fragmentation of existing plant communities and wildlife habitat;
- disturbance from traffic and associated activities (noise, visual);
- reduced breeding success of individual birds or other wildlife nesting in close proximity to the road;

- new weeds being introduced into indigenous plant communities by machinery etc; and
- increased predation and scavenger pressure in adjoining fauna habitats, as the new alignment may remove critical habitat for certain species, reducing overall habitat quality.

These effects can largely be avoided, remedied or mitigated for by the implementation of suitable construction and restoration measures. In particular, it is recommended that the main tool for giving effect to these requirements should be detailed in a Construction Environment Management Plan (CMEP) and if an option is chosen, which traverses a significant indigenous vegetation remnant, a detailed Ecological Restoration & Monitoring Plan.

5.2 General Adverse Ecological Effects for all Options

5.2.1 Threatened species

No nationally threatened plant species were found in the vegetation surveys within the corridor area, which would be removed as part of the road construction.

However, kereru and North Island kaka are present in the bush areas and longfin eel and koura are listed in the Freshwater Fish database for Papakura Stream and Puhinui Creek.

In addition, if either Options C or D are selected, further bat and lizard surveys are recommended to ensure none of these species potentially utilise the road corridor.

5.2.2 Weeds

The corridor area is already highly weed infested. Nonetheless, vehicles and other material brought in to the site can quickly introduce new weeds and/or spread existing ones. Measures to minimise the effects and introduction of new weed species are required.

Fresh earth exposed during clearance and construction will provide ideal conditions for the further spread of weeds already existing within the area. Furthermore, machinery and aggregate brought in from other areas increases the risk of new weed species establishing within the existing natural areas. Therefore, it is critical that all machinery and aggregate is thoroughly cleaned, or otherwise guaranteed free of attached seed or plant matter before it is brought on site.

Provided due care and initial weed control is carried out as and when required, it is expected that the indigenous species will quickly gain a foot-hold and dominate vegetative cover along access road batters and cuts.

Mitigation Requirements

Measures to minimise effects of the introduction of weeds include:

- As far as possible, confining vehicle movements to formed accessways;
- Ensuring construction vehicles are cleaned between jobs (to avoid introducing soil from other sites on tyres, etc);
- As far as possible, ensuring aggregate sources are free of weeds;
- Undertaking routine monitoring of site works to ensure new infestations are detected and removed before they have an opportunity to spread;
- Scrape off existing topsoil and plant matter for each turbine site within nature features, stockpile and use to re-sow exposed areas as required; and
- Re-sow and/or replant all turbine sites within indigenous forest areas with locally-sourced native grasses and low-growing shrubs within or adjacent to existing indigenous vegetation remnants.

The detailed measures required to achieve the aforementioned measures should be incorporated into a Construction Environmental Management Plan (CEMP).

5.2.3 Aquatic Biota

Construction Effects

Adverse ecological effects associated with sediment runoff are well documented for New Zealand freshwater ecosystems (e.g. Ryan, 1991; Boubee *et al*., 1997). Potential adverse effects associated with sediment runoff from exposed excavations and works directly within the stream bed may cause significant and pro-longed sediment discharges if not adequately controlled.

Particular care needs to be taken to ensure sediment runoff does not affect the stream ecosystems downstream during construction and during preloading of any abutments and embankments. Streams and rivers within the catchment of the site provide good habitat for a range of fish and invertebrate species which are sensitive to modification and high silt loadings. Provided that robust silt control measures are employed, construction effects are likely to be no more than minor.

A number of seepage zones are found within the study area. It will be important to consider the placement of excavation material in order to reduce sedimentation of these areas. Excavation material should not be placed in seepage zones or in steep areas. Provided robust silt control measures are employed during construction seepage zones should not be adversely affected by the construction.

Construction of the fill embankments should be undertaken in the dry season, so as to minimise work within the water. It is important to ensure no spillage when pouring any concrete when working with concretes over the waterway.

Concrete can be particularly toxic to aquatic life. During construction care will be needed to avoid silt and concrete from directly discharging into the waterway.

If any of the options entail the removal of stream and riparian margin vegetation, this direct impact would need some form of replacement or enhancement of similar stream habitat elsewhere within the catchment.

Because no culverts, and only bridges, are proposed over all perennial waterways, no specific measures for maintaining fish or invertebrate passage are required.

Operational Effect

Motor vehicles emit a range of substances which deposit onto the road surface and surrounding areas. The substances most likely to adversely affect the surrounding ecosystems are zinc, copper and aromatic hydrocarbons. Pollutants and sediments carried by water runoff and aerial dispersal from the completed road may have some impact on receiving waters.

Moreover, the risk of accidental spills discharging into the adjacent waterways could cause significant adverse effects and stormwater runoff could be diverted to discharge to ground soakage if feasible to avoid this risk.

Dilution rates may not be sufficient to reduce contaminant loading to below guideline concentrations (ANZACC, 2000). A precautionary approach in stormwater drain design should be adopted in this situation as vehicle per day movements are likely to be over 20,000. Wherever practical, stormwater drains should be designed to run over grass swales and should also be fitted with sediment sumps. This would be expected to reduce contaminant loadings to acceptable levels.

Mitigation Requirements

A Sediment Management Plan would address adverse ecological effects associated with silt run-off and ensure implementation of appropriate control measures during construction. There are a number of best practicable options for silt control, many of which are detailed in Auckland Regional Council's "*Erosion and Sediment Control Guidelines for Land Disturbing Activities – TP90*".

Monitoring during construction will ensure that any potential erosion problem areas are identified at an early stage. Appropriate contingency measures can then be undertaken quickly.

Where possible, temporary silt ponds should be retained as permanent features, replanted with appropriate wetland plants, in order to attenuate flood flows and treat contaminants from road run-off discharges, in addition to the use of grass swale drains and sediment sumps.

5.3 Effects on Avifauna

Resident bird populations within the study area comprise mostly of common native and exotic species of open grasslands, including a variety of small, mostly exotic passerines like blackbird, song-thrush, sparrow, yellowhammer and finches, as well as Australasian harrier, kingfisher, pukeko, rosella, magpie, Indian myna and spur-winged plover. Tui, kereru, silvereye, fantail and grey warbler were heard in bush blocks 2 and 3 (refer to Figure 3) and North Island kaka and shining cuckoo have been reported to be visiting the area.

Local disturbance to these populations is likely to occur during construction works, but as the overall proportion of habitat loss is very small and short-term for these species, the existing bird populations are likely to readily re-establish following completion of works if they do indeed become displaced in the first instance. From a regional perspective the loss of indigenous bird habitat is considered to be minor, as only a relatively small area of vegetation that is immediately available will be lost. Moreover, as farmland already cuts through the forest remnants, adverse effects on bird species with large home ranges is likely to be minor.

However, tui, bellbird and kereru move on a daily and seasonal basis between remnants for food, roosting and breeding requirements and seed dispersal functions (Robertson, 1988; Pierce & Graham, 1995). Tui and kereru tend to fly between forest remnants during the day and on “a line of sight” basis, travelling over 50 km to reach suitable food sources (Robertson, 1988). Thus, in the short-term, the loss of even less than 1 ha may reduce overall food supplies for these species. Replanting of indigenous species on cut and fill batters and enhancement of the ecological health and condition of nearby fragments would reduce these effects.

There is no research in New Zealand to assess how these particular species cope with obstructions such as roads. The behaviour of each particular species may be different, but ecologically important birds such as bellbird, tui and to a lesser extent, kereru appear to adapt to noise and light associated with roads and urban environments (personal observations). The ability of these key indicator species to adapt to the new alignment and become accustomed to associated noise and movement should not be underestimated. The birds would easily be able to fly over the road. On the other hand, further fragmentation of habitat may allow greater influxes of predators, such as stoats and feral cats. Although, as the stands are small now, predators are likely to have unimpeded access at present. Nonetheless, these indigenous birds are under pressure at the moment and any small decline in habitat quality or quantity may cause additional stresses, which would adversely affect diversity and abundance.

Summary

Overall, in consideration of the habitat available and densities of birds present the impact on birds is likely to be low from a regional perspective, but more severe with Options C and D. Mitigation is required. This could be implemented through the proposed Ecological Restoration & Monitoring Plan.

5.3.1 Fragmentation

Fragmentation of the landscape produces a series of fragmented patches surrounded by a matrix of differing vegetation types or land use (Saunders *et al*., 1987). The formation of a fragmented landscape can have considerable consequences on the species utilising the area as it may increase the isolation of a patch, reducing species dispersal from one patch to another and create barriers to normal dispersal and colonisation processes. Fragmentation effects could thus potentially lead to the extinction of species if fragmentation is extensive enough. The magnitude of fragmentation effects will largely be dependent on the shape and size of the patches, which are formed, the distance between patches and the composition of the surrounding matrix (Murcia, 1995). The composition of the surrounding matrix may completely prevent, reduce or increase movement between patches.

In New Zealand forests edge effects result in the propagation of shade intolerant species. The creation of an edge can negatively affect specific life cycle stages of some plants while favouring others. For instance changes in solar radiation affecting seedling germination and survival of species, such as kohekohe, but favours ponga, totara and mapou (Young & Mitchell, 1994). These changes will ultimately lead to changes in community composition on the edge and in the interior. Edge effects also result in a reduction of canopy height from the forest interior towards the edge, causing merging of forest canopy and subcanopy layers at the edge (Oosterhoorn and Kappelle, 2000).

For Options C and D fragmentation effects could be significant and suitable mitigation and restoration measures will be required.

Mitigation Requirements

A number of options are available for mitigation of forest edges. Three major issues need to be addressed (1) replacement/restoration planting on exposed soil and (2) sealing the newly created edge and (3) reducing overall fragmentation of bush in the area by increasing patch size. Specifically the following recommendations for addressing potential edge effect effects are:

1. Planting newly exposed, open ground with suitable, locally sourced (where possible) native species would help reduce colonisation and establishment of weedy exotic species.

2. Planting the new forest edge with a dense band of fast growing native species to help reduce weed incursion into the forest.

3. Targeted additional planting of native bush with fencing against stock to improve the over all patch size and there by reduce the effects of fragmentation.

5.4 Effects on Bats

New Zealand bats are non-migratory; they show a high fidelity for their natal home ranges (O'Donnell, 2000). This suggests that long-tailed bats do not undertake long, non-echolocation flights and thus may be able to detect and avoid new structures such as bridges.

For many aerial hawking bats, including long-tailed bats, insect activity is the best predictor for bat activity (O'Donnell, 2001a). If the road lights would be shielded from the ground (to minimise visual impacts for local residents), the risk of insects being attracted to them and thereby the risk of bat strike is considered to be minimal.

Conclusions

To assess any potential conflict between bats and the proposed Mill Road / Redoubt Road alignment options, it first needs to be established with a high degree of certainty whether there are any bats within the area. Further surveys within the breeding season are therefore recommended should either Options C or D be chosen (refer to Appendix III). If bats are identified in the area, monitoring of bat movement is recommended to assess how much they use the area and to establish risk and options for mitigation.

Mitigation Requirements

It is possible that the effects of the proposed road alignments will be more than minor on the local long-tailed bat populations if bats are found within or adjacent to any of the proposed alignment options. Further monitoring is required before construction to ascertain if there will be any potential adverse effects on bats at this locality. In addition, at each of the proposed bush clearance sites, specific pre-clearance surveys are required to ascertain if bat roosting sites would be directly removed.

5.5 Effects on other Fauna

Because there is no major vegetation clearance proposed, the geckos and skinks are unlikely to be affected by any of the road alignments.

It is also unlikely that native terrestrial molluscs are reliant on the habitats which are to be disturbed as part of this proposal.

No other indigenous fauna species, such as insects (including flying insects), are expected to be adversely affected by any of the road alignment options. The main potential effects on terrestrial invertebrates are:

- Displacement due to disturbance;
- Habitat change and loss; and
- Disruption to flight paths/dance of flying insects.

Disturbance during construction is unlikely to lead to the displacement of indigenous invertebrates or their habitats where the options follow existing roads. However, wherever an alignment option does not follow an existing road the new structure will form a wide permanent barrier to insect movement. The mating dance of some taxa may be influenced by disruptions to airflows, but as most insects are localised and reproductive dance activity occurs in calmer conditions any effects are expected to be negligible or no more than minor.

Mitigation Recommendations

Little information is available about the condition and make up of lizard populations and no detailed studies have been conducted within the proposed corridor area. However, many locally found indigenous lizard species are threatened species or consent of localised populations in gradual decline. Therefore, the potential exists for any new environmental pressure to have consequences for local populations.

If either Options C or D becomes the preferred option, monitoring is recommended to determine if lizards are indeed utilising this area and if mitigation is required.

Table 4 Ecological Effect Risk Assessment Matrix

	SIGNIFICANT POTENTIAL DIRECT ADVERSE ECOLOGICAL EFFECTS	POTENTIAL INDIRECT ADVERSE ECOLOGICAL EFFECTS	AVOIDANCE, REMEDIATION, MITIGATION REQUIREMENTS	MONITORING REQUIREMENTS
Forests	Yes – clearance necessary for Options C and D	Loss of habitat, edge effects, native birds, weeds.	Weed control, suitable CEMP & mitigation measures	Regular monitoring for weeds
Wetlands	No – provide that fill disposal sites are not placed within identified wetlands and seepage zones	Sediment discharges during construction	Weed control, suitable CEMP & mitigation measures	
Threatened Plants	None affected			
Terrestrial Fauna				
Insect	Minor – insect strike with attraction to lights	Minor	Shield lights to reduce risk of insect aggradation	Pre & post site surveys
Herpetofauna	Minor	Minor		
Avifauna	Minor - bird strike	Minor		
Aquatic Biota	Yes - stream crossings for roads construction Yes- abstraction of water during construction	Yes – silt runoff and fish/invertebrate migration impediments through culverts	Yes – silt management good practice measures and fish friendly culverts Fencing off of stream margins & replanting with native plants	Yes – water quality during construction
Key Threatened Fauna Species				
NZ pigeon (kereru)	Minor - potential strike – moderate risk & low localised potential effect only			
North Island kaka	Minor - potential strike – moderate risk & low localised potential effect only			
Long-fin eel & koura	Minor – if suitable silt control measures undertaken			
Long tailed bat	None to minor – but further survey required if Options C or D chosen			Further bat and ornate skink survey proposed pre-construction to confirm low risk/ no presence assumptions
Lizards	None to minor – but further survey required if Options C or D chosen			

5.6 Option C

The main ecological impact of this option is the crossing of bush blocks 2 and 3 (Photo 5). Although the two gullies will be crossed with bridges and batters will be kept to a minimum, a small area of ecologically significant semi-coastal podocarp broadleaved forest will need to be cleared or the crowns trimmed. Given the density of the stand and the amount of large trees present, it is likely that up to ten large trees would be removed.

Provided that silt control measures are carried out, the effects on the streams in these gullies are considered to be minor and should only occur during the construction phase.

Noise and visual effects may disturb present birds.

This option may also have potentially significant adverse effects on the seepage zones in the gully heads in Totara Park (Photo 6). Two of the present gully heads will be filled in and some – mainly exotic – vegetation removed. This option is therefore associated with the disturbance of upper catchment habitat for indigenous fish species and the discharge of sediments into the catchment during construction.

For the most part the seepage areas found in Totara Park contain mainly pasture grasses and weeds with few native species. However, Collier & Smith (2005) note the high and largely unknown biodiversity and wider ecosystem function values of seep areas. Given the high ecological values of seepage zones, all overburden sites should therefore avoid direct impact into the seepage wetlands wherever possible.

If Option C is chosen, strict sediment and post-construction rehabilitation measures will need to be undertaken.

The construction of a pond for the treatment of stormwater runoff from the road is not considered to cause major adverse effects. In fact, the construction of this pond may create a valuable habitat, especially if combined with appropriate restoration measures of the gully system.

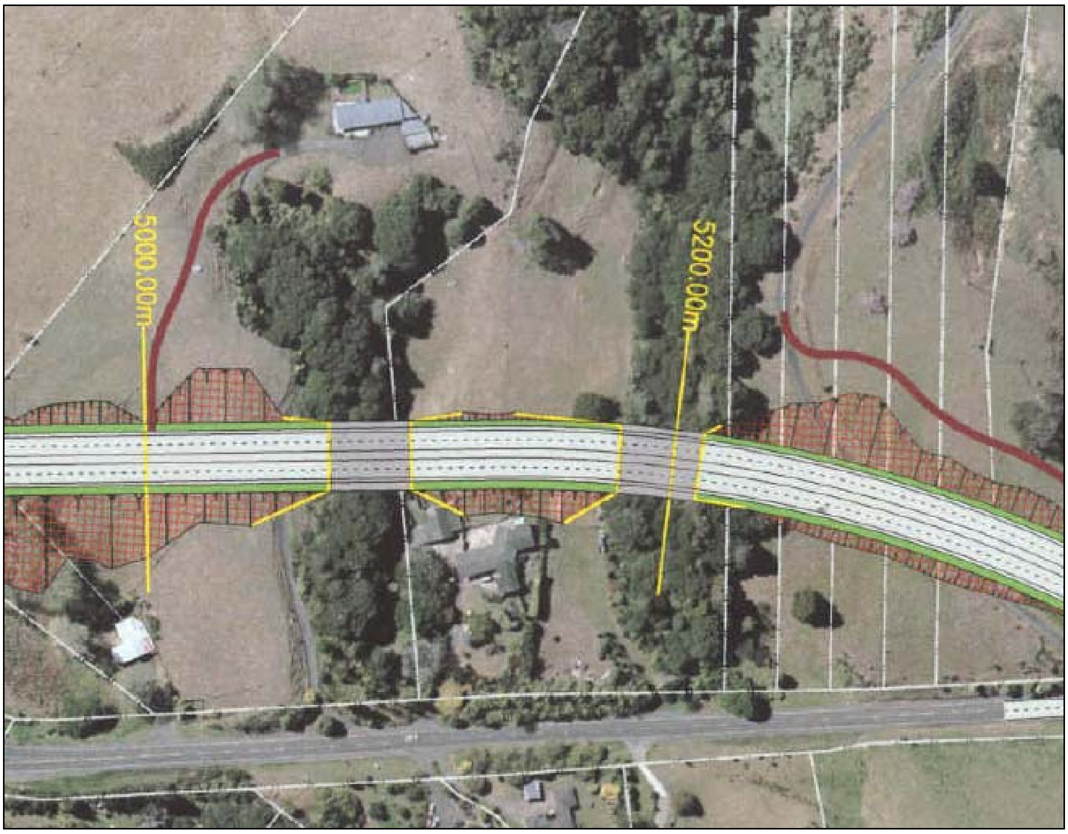

Photo 5 Aerial view of the proposed crossing of Option C through bush blocks 2 & 3

Photo 6 Proposed realignment of Options C & D at Totara Park, showing infill of gully heads and proposed stormwater storage pond

5.7 Option D

Option D causes the same ecological effects as Option C within Totara Park (see above for details).

This option also includes the crossing of two bush areas (1 and 3) and the associated loss of mature trees and habitat (Photo 7).

Bush block 1 (on the left) will be crossed via a 180 m span bridge. The construction of this bridge will include the removal of some large pine trees on the top of the gully slopes and possibly some exotic shrubs. Any remaining native vegetation in this area is contained on the lower slopes and on the gully floor and will therefore not be effected through clearance.

The crossing of bush area 3 will include the construction of a 50 m span bridge. Bush clearance will be reduced to a minimum, but one large taraire would be removed and some trimming may be necessary.

Photo 7 Crossing of Option D through bush block 1 (left) and 3 (right)

5.8 Option J

Option J largely follows the existing Mill Road alignment with only a small intrusion into Totara Park (Photo 8). The rest of the road works for this alignment includes cuts, which will cause the removal of weed infested roadside vegetation. The amount of habitat loss through this option is insignificant compared to the other options.

The overall ecological effects of Option J are considered to be negligible. This option therefore is the preferred alignment from an ecological point of view.

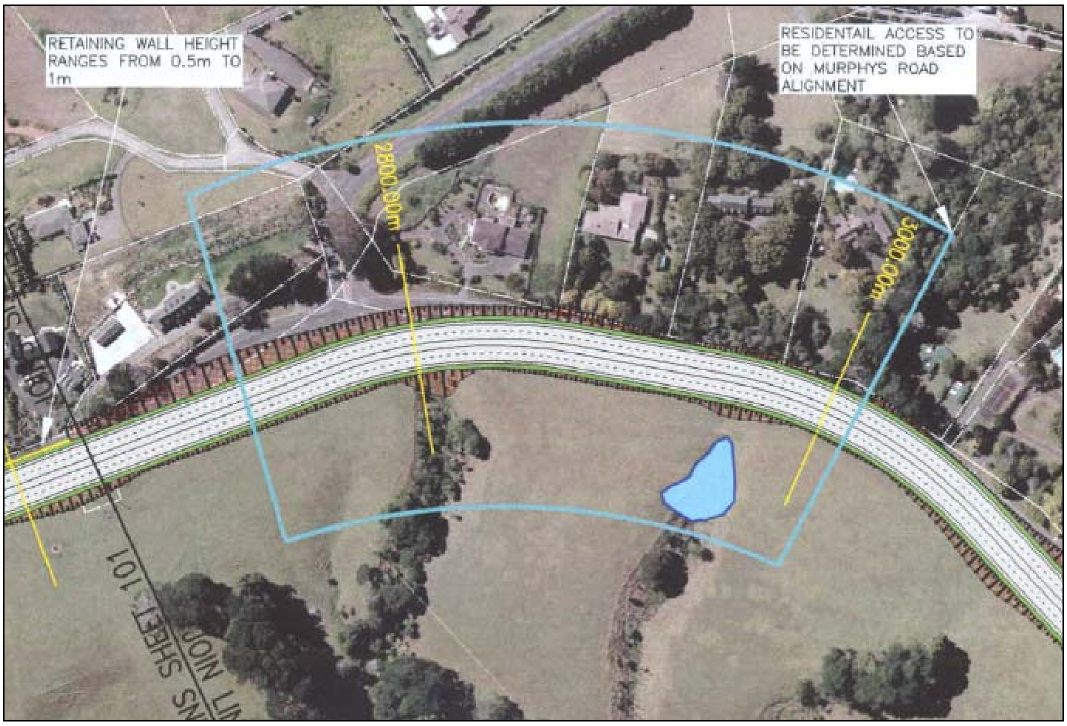

Photo 8 Alignment of Option J in Totara Park

5.9 Option I

Option I largely follows the existing Murphy's Road alignment and only includes the removal of some large exotic ornamental trees at the intersection with Mill Road.

The effects of this option are considered to be less than minor.

5.10 Option K

Option K will cut through pasture land over the entire length, which is of minimal value from a biodiversity perspective, and no vegetation clearance or stream crossings will be involved. As this option is situated on a ridgeline, the streams on either side may be affected if no appropriate silt control measures are carried out.

The effects of this option are considered to be negligible.

6 Conclusions & Recommendations

6.1 Summary of Potential Ecological Effects

Options J, I and K are situated within an ideal location from an ecological perspective. These options are largely situated within pasture/urban landscape, and largely follow existing roads, consequently do not dissect any significant natural features.

Options C and D would comprise the crossing and clearance of indigenous bush (yet to be quantified, but likely to be less than 1 ha) as well as significant tree trimming, causing habitat loss and disturbance to indigenous wildlife. The impacted vegetation type is not classified as nationally threatened; however, the forest remnants are situated within an area classed as acutely threatened according to the Threatened Environment Classification by Walker *et al.* (2007) and is considered to be regionally significant. The dissection of these forest remnants will also result in fragmentation and disruption of ecological corridor values. Substantial mitigation will be required should these options be pursued.

No endangered, rare, threatened or vulnerable plant species or plant communities would be directly affected by any of the proposed alignment options. However, kereru and North Island kaka are present in the area and longfin eel and koura are reported in the Freshwater Fish Database for Puhinui Creek and Papakura Stream. Further surveys for NZ long-tailed bats and lizards are proposed to confirm with greater certainty that these threatened species are not utilising the site if either Option C or D become the preferred options.

No fish or aquatic macroinvertebrate habitats would be adversely affected provided appropriate sediment control measures are adopted. As all perennial stream crossings are proposed to be bridges no specific fish passage provisions are required. At this stage water abstraction requirements are unknown. Provided that suitable storage and/or non-fully allocated water sources can be devised and found, water abstraction during construction should result in no more than minor adverse effects on in-stream biota.

The key aspects, which require further investigation, are:

- Assessment of the potential effects of the water abstraction requirements once exact hydrological needs are known.
- Further wildlife surveys should Option C or D be pursued.
- Development of a detailed Ecological Restoration & Monitoring Plan should Option C or D be pursued.

6.2 Recommendations for further Pre-Construction Monitoring

Bats

Little information is available about the condition and make up of long-tailed bat populations and no detailed studies have been conducted on the bat population in the proposed area. Currently it is not possible to predict population effects resulting from any wind power-related mortality. However, bats tend to be long lived but slow to reproduce; female long-tailed bats produce only one pup per year (King, 2005). Therefore, the potential exists for any new environmental pressure, no matter how slight, to have consequences for local populations of long-tailed bat.

Monitoring is recommended to determine if bats are utilising this area and if mitigation is required should Options C or D be chosen. Monitoring should take place in the summer months as during winter bats will reduce movement and go into torpor.

Reptiles

Little information is available about the condition and make up of lizard populations and no detailed studies have been conducted within the proposed corridor area. Monitoring is recommended should Options C or D be chosen.

6.3 Avoidance, Remediation & Mitigation Recommendations

OPUS has ensured minimisation of potential adverse effects on significant natural areas during the design process. Considerable effort has been made to minimise impacts on indigenous vegetation by:

- Highlighting significant natural areas as a result of the scoping assessments, preliminary site inspections and discussions with local residents; and
- The design of alignment routes to minimise effects on existing natural features and protected areas.

It is recommended that measures be taken to avoid, remedy or mitigate the adverse effects of the project (inclusive of the wind turbines, access roads and the transmission lines) on these key natural features and habitats, which include:

1. The preparation and implementation of a Construction Environmental Management Plan (CEMP) to ensure that all aspects of the construction and operation of the road are carried out in such a way to minimise any potential adverse effects associated with sensitive flora and fauna habitat disturbance, sediment runoff, water abstraction and stream crossings;
2. Ongoing monitoring of re-vegetated areas to ensure that the risks associated with the operation of the wind farm are low and provision of risk minimisation contingencies if required.
3. Preparation and implementation of an Ecological Restoration & Monitoring Plan should Option C or D be pursued.

6.4 Environmental Management Plan & Post-Monitoring Requirements

As part of the resource consent application, it is recommended that Manukau City Council prepare and implement a Construction Environmental Management Plan (CEMP) to ensure that all aspects of the construction and operation of the new road alignment are carried out in such a way as to minimise any potential adverse effects, including any ecological effects. It is recommended that the Ecological Management Plan should incorporate the following measures:

- All areas are to be taped off to clearly delineate the maximum extent of the clearance zones within each key natural feature directly adjacent to construction activities. Any breach of these zones should result in substantial financial penalties for the offending contractor.
- All machinery and material brought on site are to be completely weed free.
- All dangerous goods and fuel/oil storage and filling stations are to be situated outside of key natural features.
- Equipment and training to deal with emergency spills is to be established on site.
- Suitable fire prevention and fire fighting equipment are to be established on site.
- Stormwater control and sediment management designs and practices during construction should comply with ARC's erosion and sediment control guidelines.

If Options C or D are chosen:

- Threatened fauna species directly affected should be transferred off-site before works begin.
- Within indigenous vegetation areas, soil and seedling transfer should be conducted before construction works begin. Stock piling and rapid translocation and spreading of topsoil from each site within indigenous vegetation areas before construction to facilitate rapid re-colonisation of seeds, leaf litter, humus and soil invertebrate populations to new sites.
- All re-sowing and re-planting of cleared indigenous vegetation areas and along road batters and cuts is to comprise of locally sourced indigenous grass and shrub species only.

- Measures to minimise effects of the introduction of weeds into key natural features include: As far as possible, confining vehicle movements to formed accessways; ensuring construction vehicles are cleaned between jobs (to avoid introducing soil from other sites on tyres etc.); ensuring aggregate sources are free of weeds; undertaking routine monitoring of site works to ensure new infestations are detected and removed before they have an opportunity to spread; and post-construction weed control (e.g. targeted herbicide spraying) should be carried out where necessary.

The key aspects for the development of a detailed monitoring and contingency programme for long-tailed bats and lizards are:

- At each proposed bush clearance site pre-clearance surveys are required to ascertain if bat roosting sites or lizards would be directly removed and suitable contingencies developed to avoid or remedy impacts on roosting sites (such as timing of works or translocation).
- If bats and/or lizards are present, and are shown to have home ranges within any of the proposed road alignment corridors, development of a monitoring and mitigation package to ensure impacts on local populations are no more than minor.

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Appendix I
Road Alignment Option Details

Provided by OPUS, July 2008

Option C


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GOODWOOD DRIVE
TOTARA PARK
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JOIN LINE
JOINS SHEET
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MILL ROAD – REDOUBT ROAD
CORRIDOR STUDY
OPTION C
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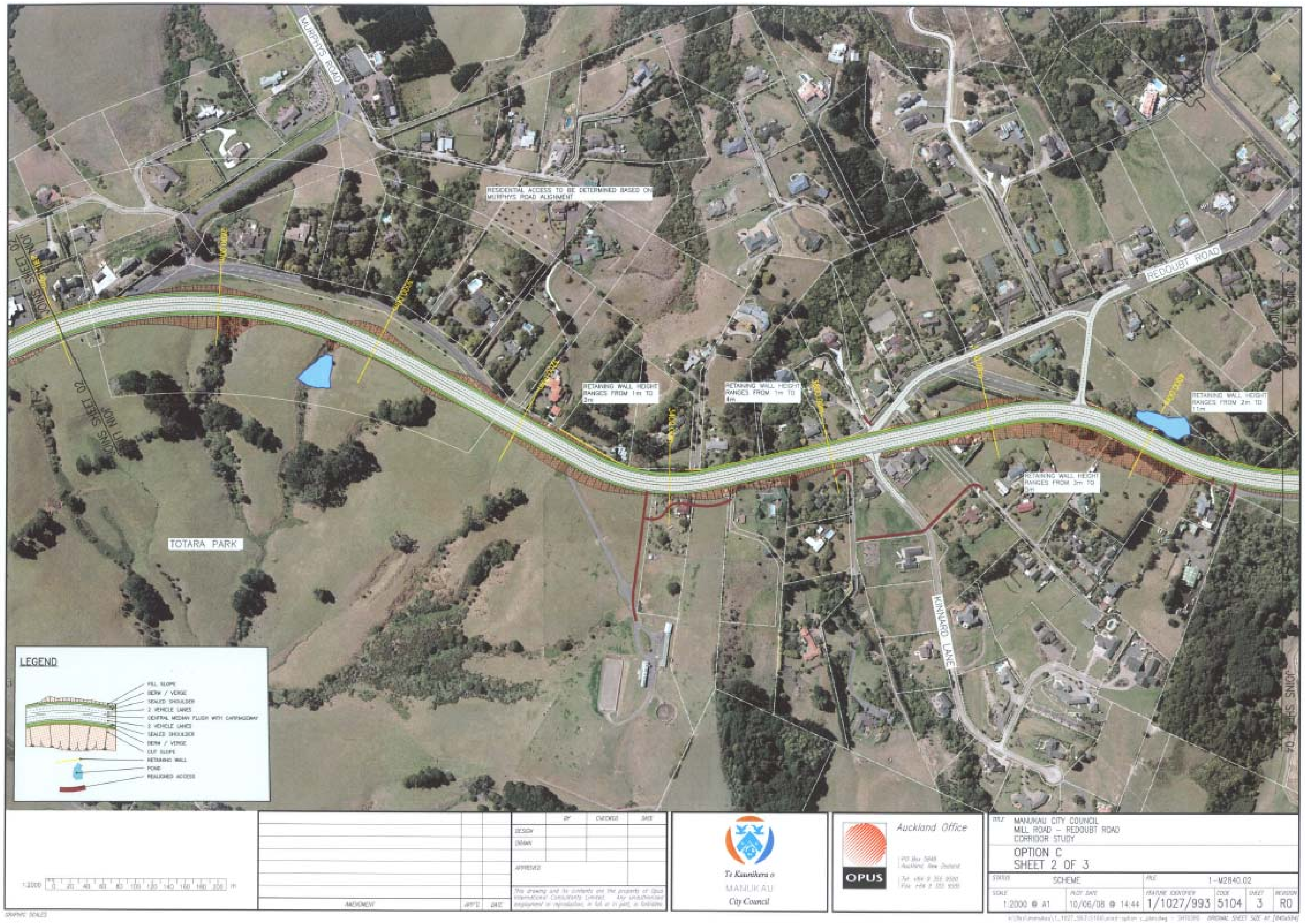
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KINNARD LANE
LEGEND
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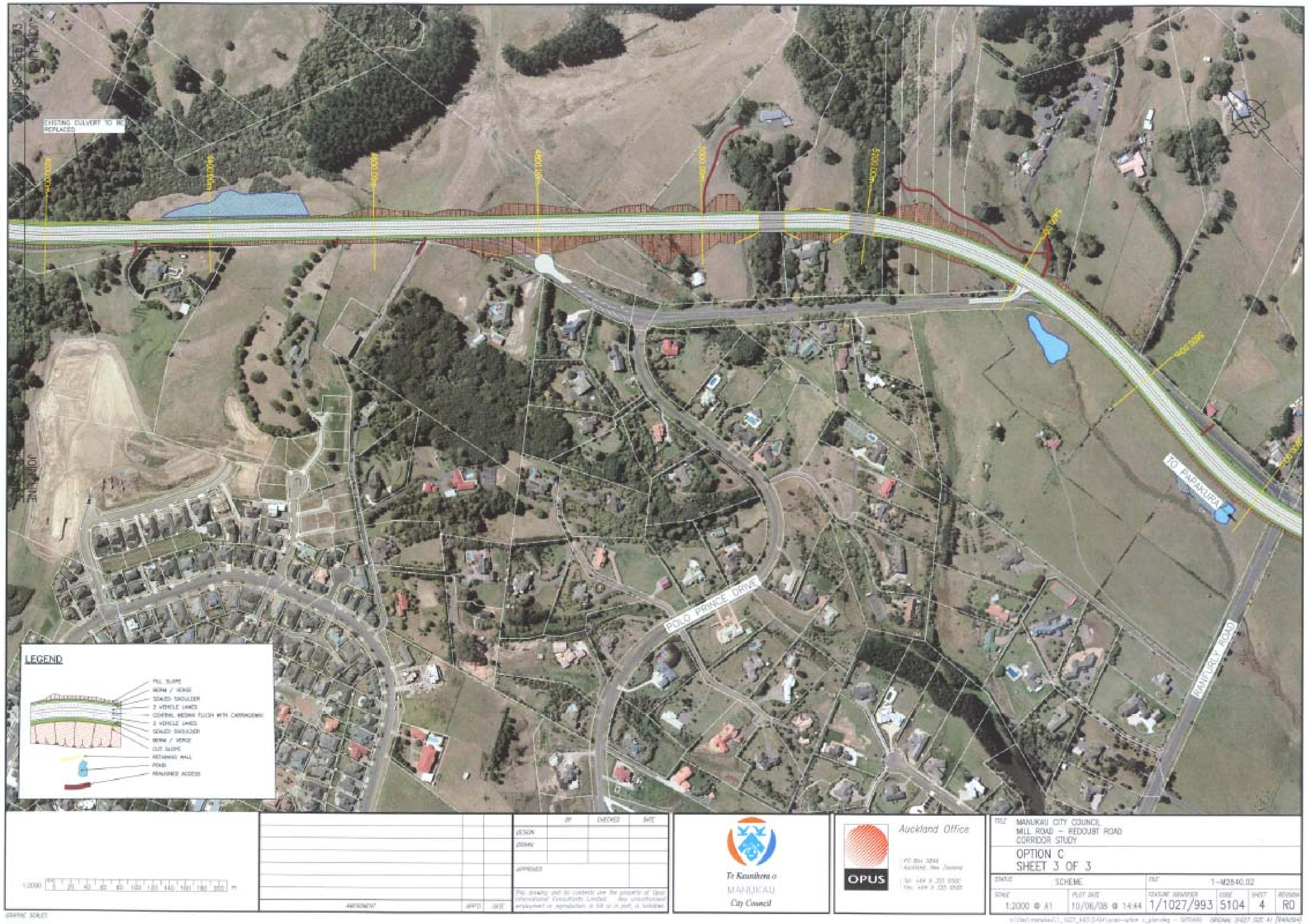
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Option D


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TOTARA PARK
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RETAINING WALL HEIGHT RANGES FROM 1m TO 3m
JOIN LINE
JOIN SHEET
LEGEND
Auckland Office
OPUS
Te Kaunihera o
MANUKAU
City Council
MANUKAU CITY COUNCIL
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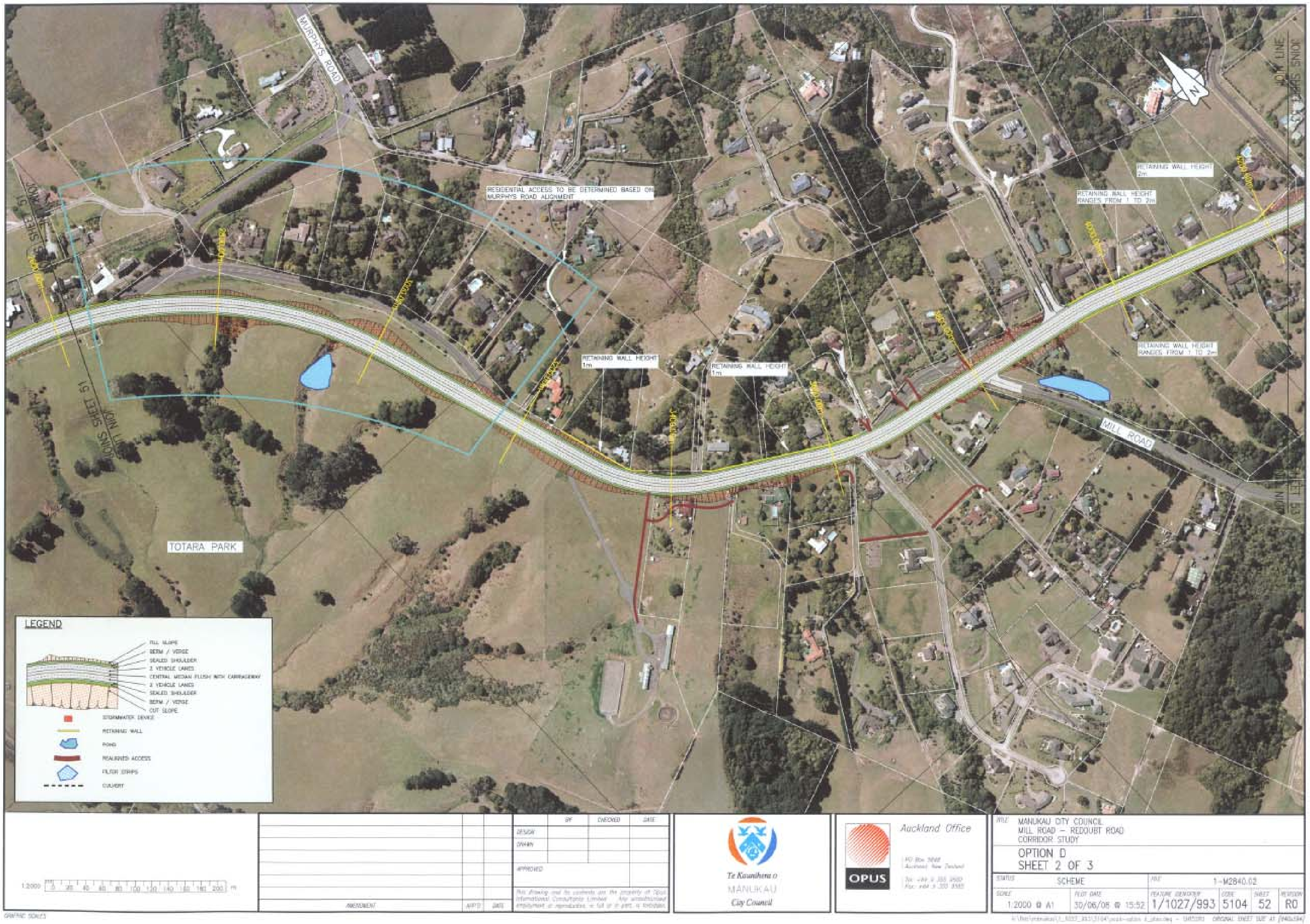
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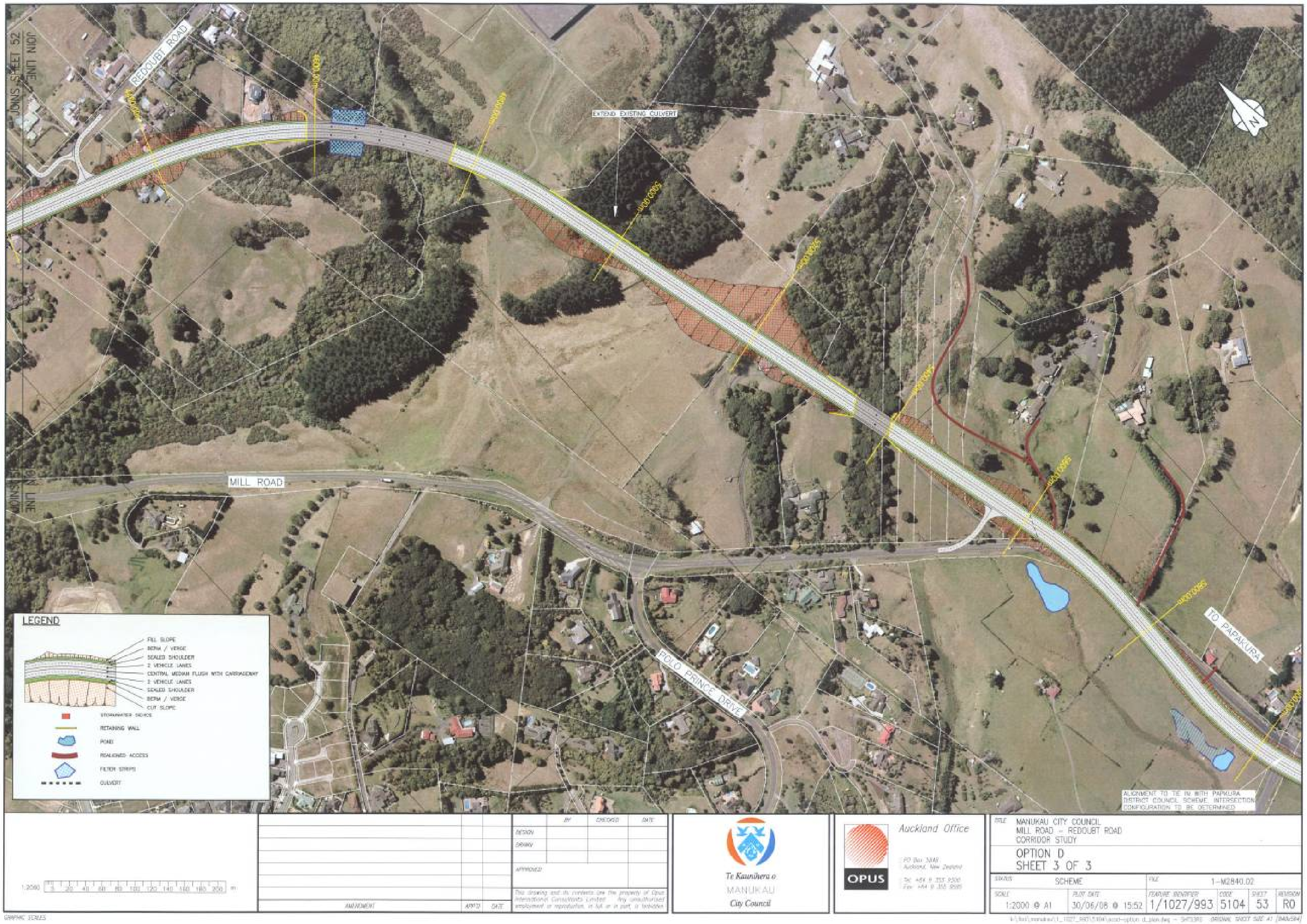
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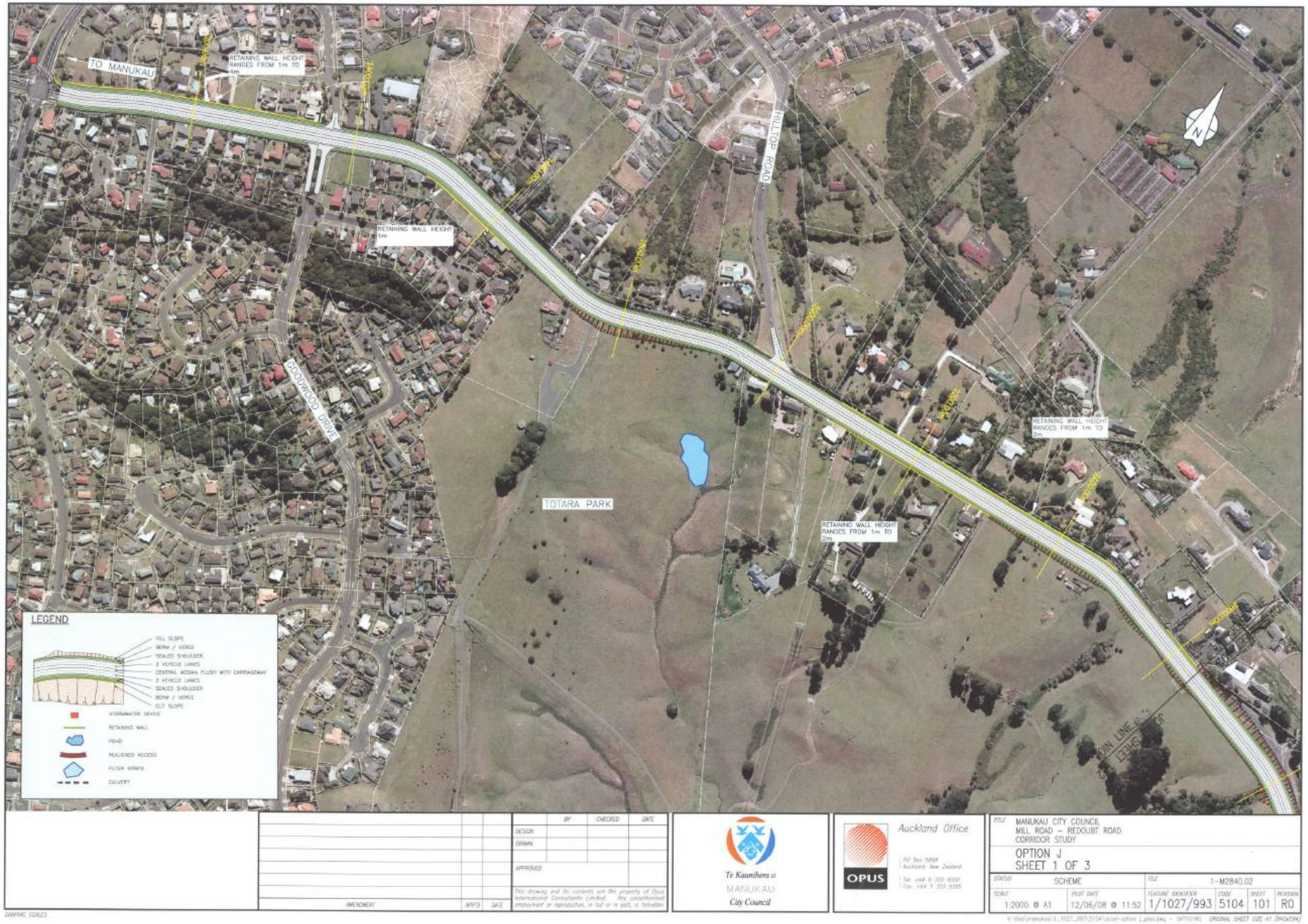
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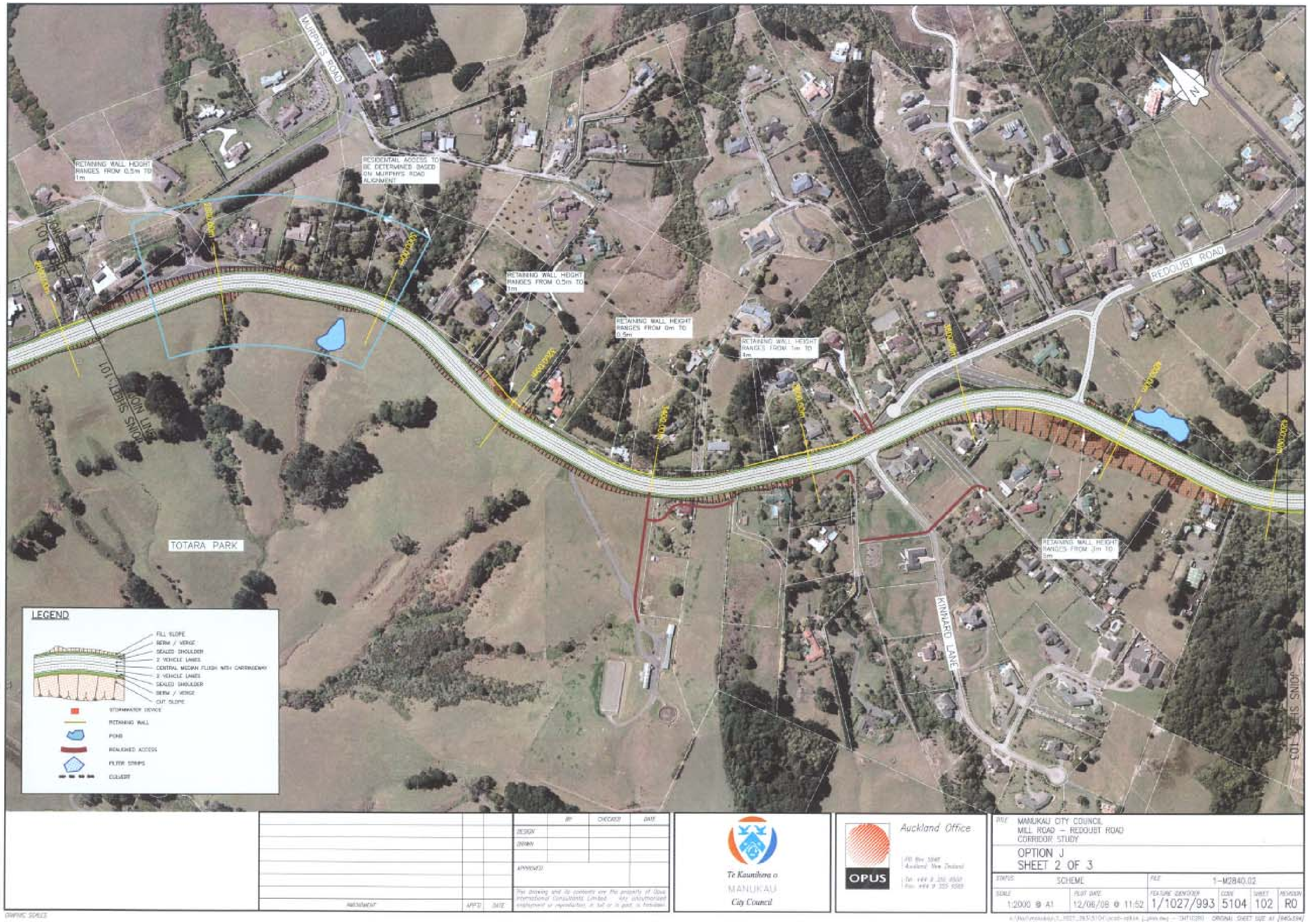
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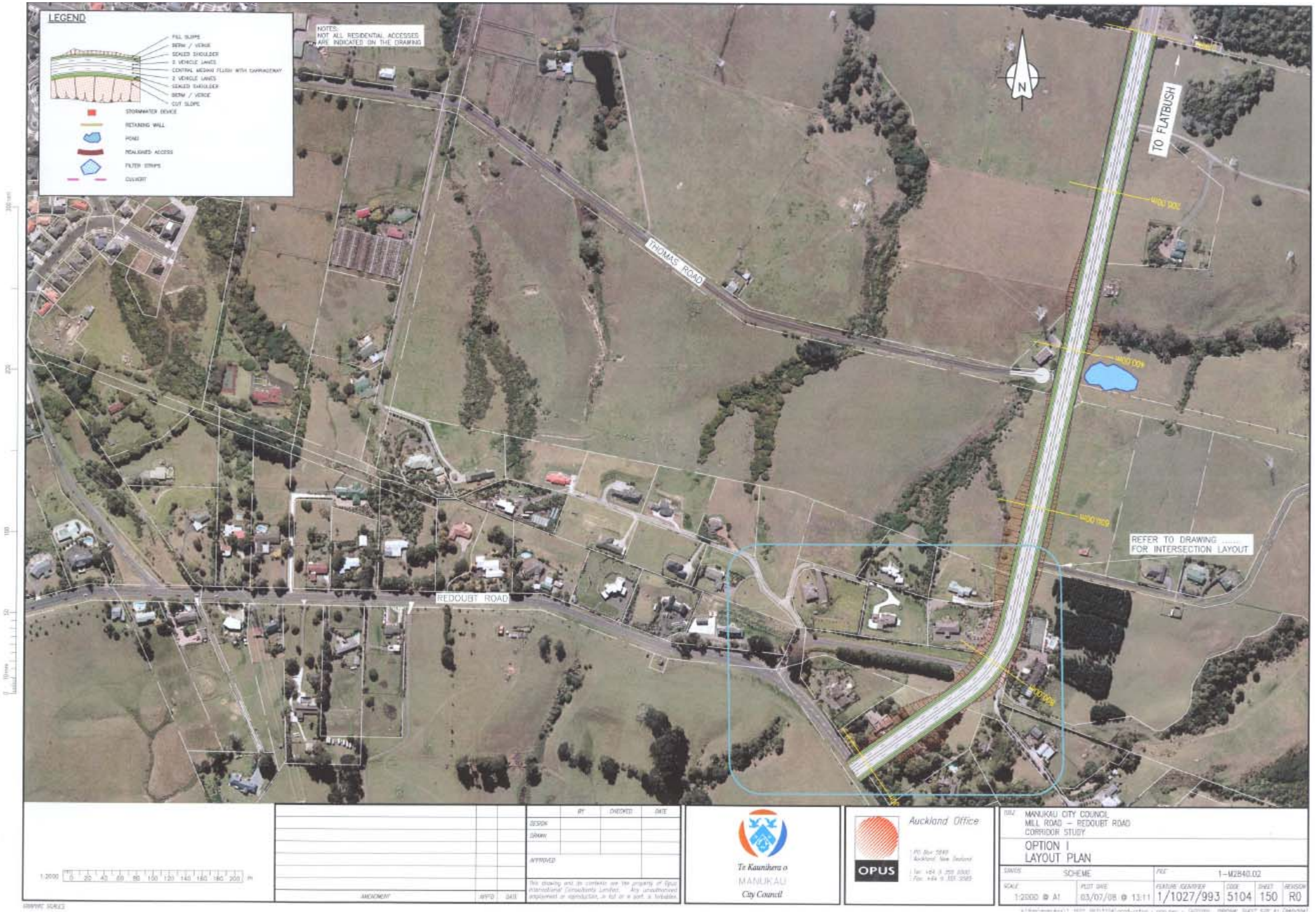
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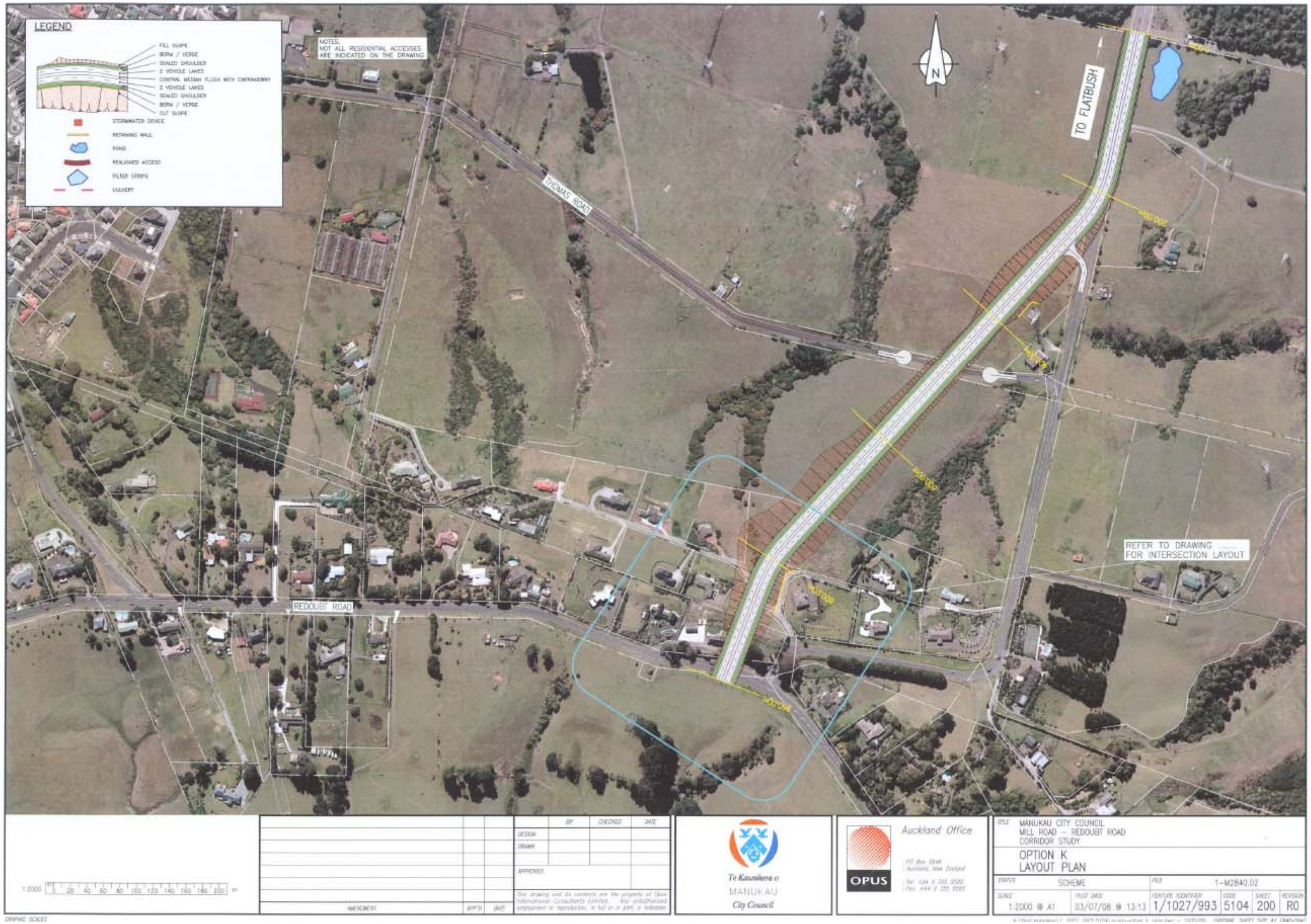
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Appendix II
Flora Species List

Flora Species List

Compiled by Britta Deichmann & Gerry Kessels 14 July 2008

Indigenous species:

Acianthus sinclairii	heart-leaved orchid
Agathis australis	kauri
Alectryon excelsa	titoki
Asplenium flaccidum	hanging spleenwort
Asplenium oblongifolium	shining spleenwort
Asplenium polyodon	sickle spleenwort
Beilschmiedia taraire	taraire
Beilschmiedia tawa	tawa
Blechnum filiforme	thread fern
Blechnum novae-zelandiae	kiokio
Brachyglottis repanda	rangiora
Carex geminata	
Carex secta	pukio
Carex sp.	
Carpodetus serratus	putaputaweta
Collospermum hastatum	kahakaha
Coprosma grandifolia	kanono
Coprosma rhamnoides	twiggy coprosma
Coprosma robusta	karamu
Coprosma spathulata	coprosma
Cordyline australis	cabbage tree
cf. Corokia cotoneaster	korokio
Cortaderia fulvida	toetoe
Corynocarpus laevigatus	karaka
Cyathea cunninghamii	gully tree fern
Cyathea dealbata	ponga
Cyathea medullaris	mamaku
Dacrydium cupressinum	rimu
Dacrydium dacrydioides	kahikatea
Dicksonia squarrosa	wheki
Doodia media	rasp fern
Dysoxylum spectabile	kohekohe
Earina mucronata	bamboo orchid
Freycinetia banksii	kiekie
Geniostoma rupestre var. *ligustrifolium*	hangehange
Haloragis erecta	shrubby haloragis
Hedycarya arborea	pigeonwood
Histiopteris incisa	water fern

Hoheria sextylosa	lacebark
Hymenophyllum sp.	filmy fern
Knightia excelsa	rewarewa
Kunzea ericoides	kanuka
Lastreopsis microsora	
Laurelia novaezelandiae	pukatea
Leptospermum scoparium	manuka
Leucopogon fasciculatus	mingimingi
Litsea calicaris	mangeao
Macropiper excelsa	kawakawa
Melicytus ramiflorus	mahoe
Metrosideros diffusa	climbing rata
Metrosideros fulgens	climbing rata
Metrosideros perforata	white rata
Microsorum pustulatum	hound's tongue fern
Microsorum scandens	fragrant fern
Muehlenbeckia australis	pohuehue
Myrsine australis	mapou
Nertera villosa	nertera
Oplismenus hirtellus	bamboo grass
Paesia scaberula	ring fern
Passiflora tetrandra	NZ passionfruit
Parsonsia heterophylla	New Zealand jasmine
Phormium tenax	flax
Phyllocladus trichomanoides	tanekaha
Pittosporum ssp.	pittosporum
Pneumatopteris pennigera	gully fern
Podocarpus totara	totara
Pratia angulata	pratia
Prumnopitys taxifolia	matai
Pseudopanax arboreus	five-finger
Pseudopanax crassifolius	lancewood
Pteris macilenta	sweet fern
Pyrrosia eleagnifolia	leather-leaf fern
Rhopalostylis sapida	nikau
Schefflera digitata	pate
Tsmesipteris lanceolata	fork fern
Typha orientalis	raupo
Uncinia uncinata	hookgrass
Vitex lucens	puriri

Adventive species:

Acacia sp.	wattle
Agapanthus praecox subsp. orientalis	agapanthus
Alocasia brisbanensis	elephant's ear
Anthoxanthum odoratum	sweet vernal
Araujia sericifera	moth plant
Aster novi-belgii	Michelmas daisy
Bellis perennis	bellis daisy
Berberis glaucocarpa	barberry
Calystegia silvatica subsp. disjuncta	great bindweed
Cirsium arvense	Californian thistle
Cirsium vulgare	Scotch thistle
Cortaderia selloana	pampas
Crocosmia x crocosmiiflora	montbretia
Cupressus macrocarpa	macrocarpa
Cyperus sp.	
Dactylis glomerata	cocksfoot
Hedychium flavescens	yellow ginger
Hedychium gardnerianum	wild ginger
Holcus lanatus	Yorkshire fog
Juncus effusus	leafless rush
Leycesteria formosa	Himalayan honeysuckle
Ligustrum lucidum	tree privet
Ligustrum sinense	Chinese privet
Lonicera japonica	Japanese honeysuckle
Lotus pedunculatus	lotus
Mentha sp.	mint
Pennisetum clandestinum	Kikuyu grass
Persicaria hydropiper	water pepper
Phytolacca octandra	inkweed
Pinus radiata	radiata pine
Plantago lanceolata	narrow-leaved plantain
Plantago major	broad-leaved plantain
Populus sp.	poplar
Ranunculus repens	creeping buttercup
Rubus fruticosus agg.	blackberry
Senecio jacobaea	ragwort
Solanum mauritianum	woolly nightshade
Solanum nigrum	black nightshade
Stachys sylvatica	hedge woundwort
Stellaria media	chickweed

Taraxacum officinale	dandelion
Tradescantia fluminensis	wandering Jew
Trifolium repens	white clover
Tropaeolum majus	garden nasturtium
Ulex europaeus	gorse
Vinca major	periwinkle
Zantedeschia aethiopica	Arum lily

Appendix III
Bat Monitoring Methodology

Bat Monitoring Methodology

Prepared by Kessels & Associates Ltd

Survey of the proposed Mill Road / Redoubt Road corridor area for the presence and distribution of bats, their use of the area and where possible locate roost trees using ultrasound monitoring to establish baseline bat activity.

Bat Presence and Distribution Survey Methods

Presence and an estimation of the distribution of bats throughout the proposed Mill Road / Redoubt Road corridor can be assessed using ultrasound detection methods. Such methods can provide baseline information about bat activity in an area of interest, although the information is non-quantitative and cannot be related to population size or be used to accurately determine foraging or roosting sites. However, it can provide the basis for more detailed monitoring methods by identifying areas of concentrated bat activity, which can be used as capture sites. Further, ultrasound monitoring is a useful tool for determining natural seasonal fluctuations in bat activity.

As bats have been recorded to use forest edges as flyways (Law & Chidel, 2002), a transect will be designated along the edge of each of the forest patches and for any other significant habitats. Each transect will follow paths or corridors along the entire length of each forest edge nearest to the proposed corridor area or circumnavigating any forest patch that is entirely within the corridor. The exact path of each transect will be determined by experienced bat researchers to allow for easy access to and passage along transects, while also maximizing the potential to detect bats.

A team of two observers should conduct the transect surveys by walking slowly (approximately 3 km per hour) along transects and listening for the sound of bat echolocation calls with a heterodyne bat detector set to 40 kHz (O'Donnell & Sedgeley, 1999). Observers should use standard map and recording sheets on which to record the location of any bat passes (a series of sequential echolocation calls separated by a period of silence), the number of bat passes, the time of each bat pass and the number of any bats detected visually. In addition, observers should record cloud cover, temperature, relative wind, and a subjective assessment of insect activity (recorded on a scale from zero to five). To maximise the likelihood of detecting bats, surveys should be conducted during the bats' most active period, the first two hours after sunset (O'Donnell & Sedgeley, 1999). Because rain or very strong winds may greatly reduce the likelihood of detection (O'Donnell & Sedgeley, 1999), surveys should be conducted on clear nights with little or no wind.

In the first instance, 5 nights of ultrasound monitoring at each transect should be conducted between peak activities (usually between December – January). This will provide a baseline for activity and highlight areas where bats may be trapped in sufficient numbers.

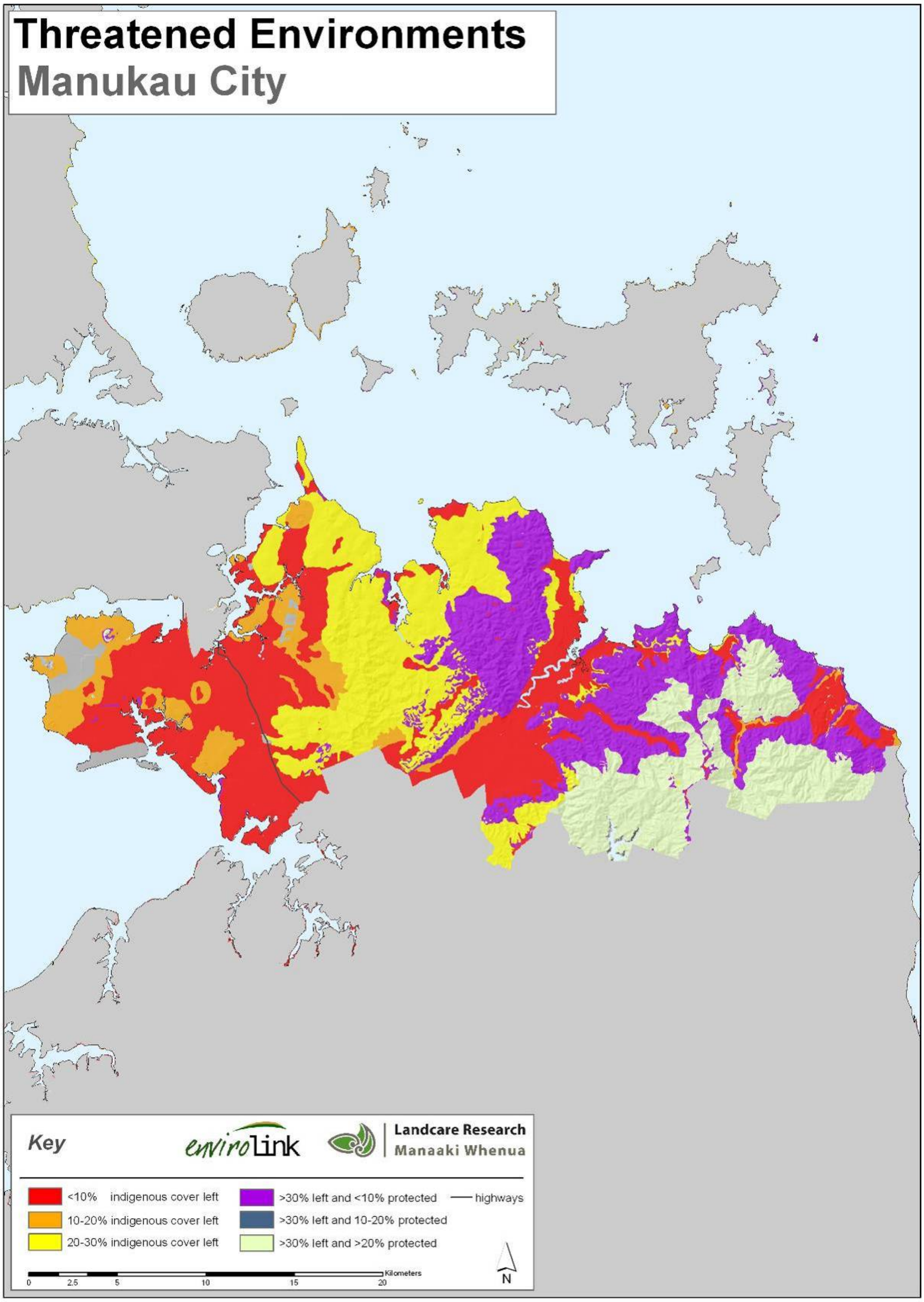
References

Law, B. S. & Chidel, M. 2006. Eucalypt plantings on farms: Use by insectivorous bats in south-eastern Australia. *Biological Conservation*. 133(2) pp. 236-249

O'Donnell, C.F.J. & Sedgeley, J.A. 1999. Use of roosts by the long-tailed bat, *Chalinolobus tuberculatus*, in temperate rainforest in New Zealand. *Journal of Mammalogy*, 80, pp. 913-923

Appendix IV
Threatened Environments Classification Map
Manukau City

As described by Walker *et al*. (2007)



Threatened Environments
Manukau City
Key
envirolink
Landcare Research
Manaaki Whenua
<10% indigenous cover left
10-20% indigenous cover left
20-30% indigenous cover left
>30% left and <10% protected
>30% left and 10-20% protected
>30% left and >20% protected
highways
Kilometers
0 2.5 5 10 15 20
N