ECOLOGICAL ASSESSMENT OF A PROPOSED URBAN DEVELOPMENT AT 144-252 PARK ESTATE ROAD, HINGAIA

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ECOLOGICAL ASSESSMENT OF A PROPOSED URBAN DEVELOPMENT AT 144-252 PARK ESTATE ROAD, HINGAIA

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1. INTRODUCTION

Civil Plan Consultants Limited, on behalf of the Hugh Green Group (the client), is developing a master plan for a large urban development at 144-252 Park Estate Road, Hingaia. These properties contain significant areas of wetlands (particularly at 144 Park Estate Road) and a number of degraded watercourses, which the client is seeking to reshape through reclamation and enhancement works in order to allow residential subdivision. Most of the land is zoned as 'Residential - Mixed Housing Suburban Zone' under the Auckland Unitary Plan (AUP), with smaller areas zoned as 'Residential - Mixed Housing Urban Zone' and 'Business - Neighbourhood Centre Zone'.

Bulk earthworks will be undertaken in two Phases: Phase 1 comprises the northwestern part of the site, while Phase 2 comprises the remaining land between the Phase 1 parcel, the southern motorway, and coastal boundary. Civil Plan Consultants Limited has commissioned Wildland Consultants Ltd to prepare an ecological assessment of the proposed development within the Phase 1 earthworks area. The assessment includes the following:

- Assessment of the existing vegetation and ecosystems.
- Stream Ecological Valuation (SEV) of an affected watercourse.
- Assessment of the potential effects of the development.
- Recommendations to offset and mitigate potential adverse effects of the proposed development.

2. METHODS

2.1 Vegetation and habitats

A literature search was undertaken to identify relevant ecological information on the site, and existing information was collated and reviewed. Site visits were carried out on 19 March 2018 and 6 June 2018. During the first site visit, all wetlands and watercourses were mapped and broadly described (Figure 1). All vascular plant species observed at the site were recorded (Appendix 1) together with incidental observations of fauna species (Appendix 2). Representative photographs were taken in the field, and these are provided in Appendix 3. A search of the New Zealand Freshwater Fish Database (NIWA 2018) was undertaken to obtain local records of fish.

2.2 Stream ecological valuation

SEVs were carried out on the impact reach and the proposed compensation reach on 23 July 2018 (Figure 2). The SEV methodology is a comprehensive means of quantifying the value of aquatic ecosystems. This method was developed by a panel of experts (Rowe *et al*. 2006, Storey *et al*. 2011) for Auckland Regional Council, and is the recommended method for assessing streams in the Auckland and Wellington regions. It has also been applied successfully in other parts of New Zealand. In 2016, an additional SEV calculator was created that includes reference data for intermittent

streams (Neale *et al.* 2016). This allowed the use of the method to be expanded to the assessment of intermittent streams.

The SEV calculation uses a range of qualitative and quantitative variables to quantify the main ecological functions of streams. This data is manipulated using a series of formulae to produce an SEV score of between 0 (a stream with no ecological values) and 1 (a pristine stream with maximum ecological values). The method allows very different streams to be evaluated and compared.

Usually, fourteen key ecological functions of streams are assessed. These key functions are divided into four categories (Table 1) and all are weighted equally. The resulting SEV score is the mean function score (i.e. the sum of all function scores divided by 14). These function scores enable stream and catchment managers to understand the range of ecological services a stream provides.

Table 1: Summary of the 14 ecological functions used to calculate SEV scores.

Hydraulic Functions (Processes associated with water storage, movement and transport)	**Habitat Provision** (The types, amount and quality of habitats that the stream reach provides for flora and fauna)
1. Natural flow regime 2. Floodplain effectiveness 3. Connectivity for natural species migrations 4. Natural connectivity to groundwater	10. Fish spawning habitat 11. Habitat for aquatic fauna
Biogeochemical Functions (Relates to the processing of minerals, particulates and water chemistry)	**Biodiversity Functions** (The occurrence of diverse populations of indigenous native plants and animals that would normally be associated with the stream reach)
5. Water temperature control 6. Dissolved oxygen maintained 7. Organic matter input 8. In-stream particle retention 9. Decontamination of pollutants	12. Fish fauna intact (Note: excluded from this assessment) 13. Invertebrate fauna intact (Note: excluded from this assessment) 14. Riparian vegetation intact

When SEVs are calculated for impact and potential compensation reaches, the scores can be used to determine an Environmental Compensation Ratio (ECR). This value is used to calculate the total stream area that should be restored at the compensation reach to ensure "no net loss in ecological value".

When calculating an ECR the biotic functions relating to fish and invertebrate fauna are not included. This is because of the difficulty associated with predicting how fish and macroinvertebrate communities will respond to different impacts. For this reason, fish and invertebrate data was not collected at the study site. SEV data for the impact and compensation streams are presented in Appendix 2.

3. ECOLOGICAL CONTEXT

3.1 Manukau Ecological District

The study site is located in the Manukau Ecological District, which covers *c*.62,100 hectares of low altitude rolling hills and flats between the Manukau Harbour in the north and the Waikato River in the south. The underlying geology is predominantly Pliocene-Quaternary basalts, with smaller areas of Pliocene sediments bordering the harbour, and Holocene river sediments near the Waikato River.

Most of the district has fertile, well-drained soils derived from weathered volcanic ash. The fertile soils, in combination with reliable rainfall, mean that the district is well suited for agriculture and horticulture and consequently most of the district has been highly modified. The former forest cover, most often dominated by pūriri (*Vitex lucens*), taraire (*Beilschmiedia tarairi*), or kahikatea (*Dacrycarpus dacrydioides*), has been severely reduced in extent. Only 908 hectares (2%) of the original 42,462 hectares of podocarp/broadleaved species forest and kauri (*Agathis australis*) forest remains, and of these 908 hectares, only 103 hectares is protected. The loss of freshwater wetlands has been even greater, with 105 hectares (0.4%) remaining, of which only two hectares are protected (Lindsay *et al.* 2009). Estuarine vegetation, including seagrass (*Zostera muelleri* subsp. *novozelandica*) beds, mangroves (*Avicennia marina* subsp. *australica*), and saltmarsh are now the most extensive areas of indigenous vegetation remaining. In 2006, mangroves were estimated to cover *c*.1,100 hectares within Manukau Harbour (Kelly 2008).

3.2 Local context

The study site is located in rural land to the west of Papakura and Drury. It is bounded by Park Estate Road to the north and the southern motorway to the east, while the southern and eastern margins border the lower saline reaches of Drury Creek. Drury Creek includes two marine Significant Ecological Areas (SEA-M2-29w1 and SEA-M2-29a), which include a 'significant wading bird area'. Mangroves are abundant in this part of Drury Creek, while oioi (*Apodasmia similis*) salt meadow is locally common on the southern boundary of the study site, adjacent to the Drury Esplanade Reserve. Land to the west and south of the study site is largely characterised by farming and horticulture, although urban development has recently commenced in areas such as Karaka.

Approximately 70% of the study site is located on 'Acutely Threatened' land environments (<10% indigenous vegetation cover remaining) and 30% is on 'Critically Underprotected' land environments (>30% left and <10% protected) (Walker *et al*. 2007).

4. VEGETATION AND HABITATS

4.1 Overview

Eight broad terrestrial vegetation types were identified at the site during the surveys:

1. Soft rush-rank grass-creeping buttercup rushland
2. Soft rush-Mercer grass rushland
3. Water pepper herbfield
4. Mercer grass-soft rush grassland
5. Eucalyptus obliqua treeland
6. Exotic treeland and shelterbelts
7. Exotic coastal forest and scrub
8. Exotic grassland

Each of these vegetation types is described below. Aquatic habitats (permanent and intermittent streams) are described in Section 4.8, with particular focus on the 'impact' and proposed 'compensation' streams.

4.2 Soft rush-rank grass-creeping buttercup rushland (Vegetation Type 1)

This vegetation type is restricted to Wetland 1 in the northwestern corner of the Phase 1 works area (Figure 1). It is characterised by co-dominant soft rush (*Juncus effusus*), rank exotic grasses such as Mercer grass (*Paspalum distichum*) and Yorkshire fog (*Holcus lanatus*), and creeping buttercup (*Ranunculus repens*) with local willow weed (*Persicaria maculosa*) and water pepper (*P. hydropiper*), frequent lotus (*Lotus pedunculatus*), and scattered emergent gorse (*Ulex europeaus*) (Figure 1, Plate 1). The soil was very boggy throughout most of this vegetation type.

Plate 1: Exotic species such as soft rush, watercress, and rank exotic grasses characterise a small, boggy depression in Wetland 1. 19 March 2018.

4.3 Soft rush-Mercer grass rushland (Vegetation Type 2)

Wetlands 2 and 3 within the Phase 1 works area and larger wetlands to the east of the site are dominated by soft rush and Mercer grass with frequent exotic herbs including water pepper, willow weed, creeping buttercup, and lotus (Figure 1, Plates 2-4). Larger wetlands also support locally common rautahi (*Carex lessoniana*), one of the few indigenous wetland plant species at the site. The soil was very boggy throughout most of this vegetation type, and small pools of standing water were observed.

Plate 2: Grazed Mercer grass and discrete patches of soft rush on hill slope seeps within Wetland 2. 19 March 2018.

Plate 3: Soft rush surrounded by grazed pasture in Wetland 3. 19 March 2018.

Plate 4: View looking southwest across a large wetland characterised by soft rush and Mercer grass. 19 March 2018.

4.4 Water pepper herbfield (Vegetation Type 3)

A cluster of small, scattered ephemeral wetlands in the centre of the property are characterised by abundant water pepper with frequent to occasional soft rush (Figure 1, Plate 5). These wetlands are likely to become dry during summer, which may in turn result in a change in plants species composition.

Plate 5: Water pepper and soft rush characterise some of the smaller ephemeral wetlands at the site. 19 March 2018.

4.5 Mercer grass-soft rush grassland (Vegetation Type 4)

Vegetation Type 4 occurs on both sides of the central farm race (Figure 1) and is characterised by abundant Mercer grass and commonly occurring soft rush with frequent exotic herbs such as creeping buttercup and water pepper (Plate 6). A partially blocked culvert under the farm race has caused low-lying areas to become flooded on the eastern side of the farm race (Plate 7). Downstream (on the western side of the farm race), the water is brackish and plant species such as bachelor's button (*Cotula coronopifolia*) occur locally (Plate 8).

Plate 6: Clumps of Mercer grass and soft rush are emergent in open water adjacent to the central farm race. 6 June 2018.

Plate 7: Mercer grass, soft rush and creeping buttercup occur in flooded parts of Vegetation Type 4. 6 June 2018.

Plate 8: Brackish stream downstream and adjacent to Vegetation Type 4. The prostrate indigenous herb Batchelor's button is visible in the middle of photograph. 6 June 2018.

4.6 *Eucalyptus obliqua* Treeland (Vegetation Type 5)

Two planted copses of *Eucalyptus obliqua* (*c.*15-18 metres tall) occur near the southern boundary of the property (Figure 1). They were planted as a Watercare wastewater treatment development. The understorey is relatively open and largely comprises exotic grasses and herbs (Plate 9). Interpretation of historical aerial photography (Auckland Geomaps) shows that the plantation is at least thirty years old.

Plate 9: Understorey and ground tier vegetation in the *Eucalyptus obliqua* treeland. 6 June 2018.

4.7 Exotic treeland and shelterbelts (Vegetation Type 6)

Discrete areas of exotic treeland frequently occur in the western and northwestern areas of the study site. Stand alone trees and small groups of trees are typically characterised by eucalyptus (*Eucalyptus* spp.), English oak (*Quercus robur*), Lombardy poplar (*Populus nigra*), macrocarpa (*Cupressus macrocarpa*), and Monterey pine (*Pinus radiata*). Shelterbelts have been planted in an east-west orientation alongside some of the paddocks at the site, most of which comprise tree privet (*Ligustrum lucidum*) and to a lesser extent, crack willow (*Salix* x*fragilis*) and necklace poplar (*Populus deltoides*).

4.8 Exotic coastal forest and scrub (Vegetation Type 7)

Forest and scrub dominated by exotic plant species are largely restricted to the western margin of the property, adjacent to Drury Creek (Figure 1). Frequent canopy species include tree privet and black wattle (*Acacia mearnsii*), with scattered mature emergent pines (*Pinus radiata and P. pinaster*) (Plate 10). Other pest plant species such as pampas (*Cortaderia selloana*) and Japanese honeysuckle (*Lonicera japonica*) occur throughout this vegetation type (Freshwater Solutions Ltd 2015). Indigenous species, including tī kōuka (*Cordyline australis*), māpou (*Myrsine australis*), whekī (*Dicksonia squarrosa*) and bracken (*Pteridium esculentum*), occur occasionally (Freshwater Solutions Ltd 2015).

Plate 10: Tree privet and brush wattle form a canopy along the coastal margin of the site. Mature emergent pine trees are also visible. 19 March 2018.

Data Acknowledgment
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Figure 1. Vegetation and habitat types at Park Estate Road, Hingaia

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Scale: 1:4,500
Date: 7/08/2018
Cartographer: FM
Format: A3R

4.9 Exotic grassland (Vegetation Type 8)

Grazed and rough exotic grassland is the most abundant vegetation type at the site and comprises grass species such as kikuyu (*Cenchrus clandestinus*), cocksfoot (*Dactylis glomerata*), rye grass (*Lolium perenne*), and Yorkshire fog together with herbs such as white clover (*Trifolium repens*), clustered dock (*Rumex conglomeratus*), and narrow-leaved plantain (*Plantago lanceolata*).

4.10 Freshwater habitats

4.10.1 Overview

The site contains approximately seven intermittent streams and at least two permanent reaches (Figure 1), all of which have been adversely impacted by the removal of riparian buffering and trampling/pugging by stock. The stream channels often become diffuse where they flow through wetlands. The majority of intermittent stream channels support abundant exotic macrophytes such as water pepper and Mercer grass. Artificial drains occur at two locations on the property (Figure 1), and are most conspicuous on the margins of the *Eucalyptus obliqua* treeland.

4.10.2 Impact reach

The impact reach forms the headwaters of an intermittent stream (*c.*65 metres long), which drains into Wetland 3 (Figure 2). The watercourse is straight for much of its length with few notable features or habitat types apart from a narrow culvert in the upper reach (*c.*10 centimetres wide and *c.*1.5 metres long). The channel is up to *c.*0.4 metres wide, faintly incised in the upper- and mid-reaches, and largely free of terrestrial macrophytes. The channel is, however, heavily pugged by stock, particularly in the lower reaches where it is poorly defined and characterised by a boggy flood-plain (Plate 3). Bankside vegetation comprises entirely grazed exotic pasture and herbs with abundant rye grass and creeping bent (*Agrostis stolonifera*) with locally common creeping buttercup and occasional clustered dock. No water was present in the stream channel during the site visit on 19 March 2018; however, a discernible flow was present during the SEV fieldwork on 23 July 2018 (Plate 11).

4.10.3 Proposed compensation reach

The proposed compensation reach is part of the same watercourse as the impact reach, occurring downstream of Wetland 3 (Figure 2). The riparian vegetation is characterised by grazed exotic pasture grasses and herbs comprising rye grass and creeping bent with locally common creeping buttercup and white clover, and occasional cocksfoot, soft rush, narrow-leaved plantain, clustered dock and Yorkshire fog (Plate 12). Woody species are largely absent from the riparian margin apart from occasional exotic shrubs, primarily tree privet and barberry (*Berberis glaucocarpa*). The mid to lower parts of the watercourse are characterised by a low-lying boggy floodplain *c.*5 metres wide with commonly occurring soft rush. The stream is between one and three metres wide and up to eight centimetres deep over a bed of soft fine sediment and frequent patches of watercress (*Nasturtium officinale*).

Plate 11: Downstream view of the impact reach showing the straight, faintly-incised channel. 23 July 2018.

Plate 12: Proposed compensation reach. 23 July 2018.

The upper section of the proposed compensation reach is more steeply incised, with gently sloping banks on the true left and steeper banks on the true right (Plate 13). The floodplain is narrower than in the lower reach (up to two metres wide) and dominated by low-growing herbs, mainly creeping buttercup, immediately adjacent to the watercourse. The stream is *c*.0.5 metres wide and up to seven centimetres deep, with a bed of soft fine sediment. A necklace poplar shelter belt on the true left bank marks the upstream extent of this reach.

Plate 13: Defined channel in the proposed compensation reach.
23 July 2018.

Figure 2. Proposed options for wetland and stream offsetting for Stage 1 works at Park Estate Road, Hingaia

5. FLORA

Sixteen species of indigenous plants and 55 species of naturalised plants were recorded during the survey (Appendix 1), although an exhaustive search for plants was not undertaken during the surveys. No vascular plant species recorded are classified as nationally or regionally threatened as per de Lange *et al.* (2018) and Stanley *et al*. (2005), respectively.

6. FAUNA

6.1 Avifauna

Eight indigenous bird species were observed during the survey: poaka/pied stilt (*Himantopus himantopus leucocephalus*), pīwakawaka/fantail (*Rhipidura fuliginosa placabilis*), spur-winged plover (*Vanellus miles novaehollandiae*), pūkeko (*Porphyrio porphyrio melanotus*), kāhu (*Circus approximans*), welcome swallow (*Hirundo tahitica*), paradise shelduck (*Tadorna variegata*), and kōtare/kingfisher (*Todiramphus sanctus vagans*). None of these species is classified as 'Threatened' or 'At Risk' by Robertson *et al.* (2017).

Four exotic bird species were recorded: myna (*Acridotheres tristis*), common pheasant (*Phasianus colchicus*), skylark (*Alauda arvensis*), and feral pigeon (*Columba livia*).

6.2 Fish

A targeted fish survey was beyond the scope of the project. It is considered likely that indigenous fish species are present in the lower reaches of the permanent and intermittent watercourses, particularly eels (*Anguilla* spp.), banded kōkopu (*Galaxias fasciatus*), and inanga (*G. maculatus*). A search of the New Zealand Freshwater Fish Database (NIWA 2018) was undertaken on 25 July 2018 (Table 2). Records in the database indicate that the Pahurehure Inlet and its tributaries, including Drury Creek, support a wide range of indigenous fish and macroinvertebrate species, including several that are threatened. Table 1 lists the species found and their threat status as per Goodman *et al*. (2014) for fish and Grainger *et al*. (2014) for aquatic invertebrates.

Table 2: Fish species recorded from Pahurehure Inlet and tributaries (New Zealand Freshwater Fish Database).

Species Name	Common Name	Threat Classification
Fish		
Anguilla australis	Shortfin eel	Not Threatened
Anguilla dieffenbachii	Longfin eel	At Risk-Declining
Cyprinus carpio	Koi carp	Introduced and Naturalised
Galaxias fasciatus	Banded kōkopu	Not Threatened
Galaxias maculatus	Inanga	At Risk-Declining
Gambusia affinis	Mosquitofish	Introduced and Naturalised
Gobiomorphus cotidianus	Common bully	Not Threatened
Gobiomorphus gobioides	Giant bully	Not Threatened

Species Name	Common Name	Threat Classification
Invertebrates		
Echyridella menziesi	Freshwater mussel	At Risk-Declining
Paranephrops planifrons	Freshwater crayfish	Not Threatened
Paratya curvirostris	Freshwater shrimp	Not Threatened

6.3 Reptiles

A targeted survey for reptiles was beyond the scope of this report, although there is suitable habitat for indigenous skinks such as copper skink (*Oligosoma aeneum*) and ornate skink (*O. ornata*), including open bush margins and rank grass. The closest lizard record to the study site is for copper skink, approximately 2.8 kilometres to the northwest (Department of Conservation Herpetofauna Database). Habitat for indigenous arboreal geckos is generally not suitable at the study site, and it is considered highly unlikely that geckos are present.

6.4 Long-tailed bats

Long-tailed bats (*Chalinolobus tuberculatus*) occur in the Auckland Region within forests dominated by both indigenous and exotic trees. The species is classified as 'Threatened-Nationally Critical' by O'Donnell *et al*. (2018). The closest record of long-tailed bat is from Clevedon Scenic Reserve, approximately 14 kilometres to the northeast (Bioresearches Ltd 2013). Mature exotic trees (e.g. pine, macrocarpa, and oak) occur frequently along the western boundary of the site, and in the northwestern corner with the Phase 1 earthworks extent. These trees have the potential to support bats.

7. STREAM ECOLOGICAL VALUATION

7.1 Overview

The 12 functions measured in an SEV assessment are grouped into four categories - Hydraulic Functions, Biogeochemical Functions, Habitat Provision Functions and Biodiversity Functions. The impact and compensation reaches were separate reaches of the same watercourse and as such, were very similar in morphology and the scores achieved for each function were similar (Table 3).

Table 3: Summary of SEV scores for each SEV reach. Note: Biodiversity Functions relating to fish and aquatic macroinvertebrates are not calculated when an SEV is being undertaken to calculate the Environmental compensation Ratio.

Category	Impact reach	Compensation reach
Hydraulic Functions	0.40	0.63
Biogeochemical Functions	0.27	0.40
Habitat Provision Functions	0.00	0.29
Biodiversity Functions	0.10	0.11
Mean SEV score (excluding Biodiversity Functions)	0.279	0.425

7.2 Hydraulic functions

The impact reach obtained a 'moderate' mean score (0.40) for Hydraulic functions (Table 3) and the compensation reach obtained a 'good' mean score (0.63). Much of the compensation reach has a natural channel shape whereas the impact reach has predominantly been straightened which contributes to the lower score in the impact reach. Both reaches have an unnatural loading of fine sediment and damage caused to the banks and stream bed by livestock, and both have no piped inflows. There are no physical barriers to fish migration (e.g. perched culverts) in either reach.

7.3 Biogeochemical functions

The impact reach and compensation reach obtained 'poor' (0.27) and 'moderate' (0.40) scores respectively for Biogeochemical Functions (Table 3). The water surface of the impact reach has very little shading whereas the compensation reach has some areas of moderate shading; however, much of this shading is provided by aquatic macrophytes rather than woody riparian vegetation. Macrophytes can cause oxygen levels to drop at night, placing additional stress on aquatic fauna. They also trap organic matter, which in turn contributes to the formation of anaerobic sediment patches.

7.4 Habitat provision functions

Both reaches achieved 'poor' mean scores for the Habitat Provision Functions (0.15 and 0.22 for the impact and compensation reaches, respectively, Table 3). The compensation reach provides potential spawning habitat for galaxiids in the form of gently sloping banks that will become flooded during high rainfall events, but the lack of shade makes the habitat unsuitable for spawning. The lack of a significant amount of stable habitat such as large woody debris or cobbles/boulders means there is no suitable breeding habitat for bullies (*Gobiomorphus* spp.) within either reach.

7.5 Biodiversity functions

As the overall focus of the SEVs was to provide data for an ECR calculation, the Biodiversity Functions related to fish and aquatic macroinvertebrates (Functions 12 and 13, Table 1) were not calculated. Predicting how biodiversity values will respond to restoration is difficult and therefore these functions are not included in ECR calculations. However, the Riparian Vegetation Intactness variable was assessed and the reaches scored poorly (0.10 and 0.11 for the impact and compensation reaches respectively) due to the absence of woody riparian vegetation.

8. ECOLOGICAL FUNCTIONS

8.1 Terrestrial and wetland values

Woody terrestrial vegetation within the Phase 1 earthworks extent is largely limited to exotic treeland characterised by eucalyptus (*Eucalyptus* spp.) and macrocarpa (*Cupressus macrocarpa*). These trees will provide roosting and nesting habitat for birds and they could support long-tailed bats if sufficient habitat complexity is

present, e.g. cracks, fissures, holes, and large pieces of flaking bark. Suitable habitat for indigenous gecko species is absent from the site, and the fact that the woody vegetation is isolated from larger tracts of indigenous vegetation further precludes their presence. However, rank grass on the margins of woody vegetation provides potential habitat for indigenous skinks.

Wetlands present within the Phase 1 earthworks extent are small and have been highly modified by stock and are dominated by exotic plant species. Due to the lack of habitat complexity and fencing, they are highly unlikely to support indigenous fish and cryptic wetland bird species such as fernbird (*Bowdleria punctata vealeae*) and spotless crake (*Porzana tabuensis*). Wetlands, however, are one of the most nationally threatened and degraded ecosystem types in New Zealand (Ausseil *et al.* 2011) with less than 10% of the original extent remaining (Ausseil *et al*. 2008). This means that even small degraded wetlands have inherent value and potential for restoration and/or enhancement. Wetland vegetation also helps to filter and purify water before it drains into downstream receiving environments.

8.2 Aquatic values

The impact reach obtained a 'poor' SEV score (excluding Biodiversity Functions) of 0.279. The proposed compensation reach achieved a 'moderate' SEV score of 0.425. As with many rural watercourses, the absence of woody riparian vegetation and channel degradation by stock are key reasons for the low scores. A full breakdown of the SEV results is provided in Appendix 2. The impact reach dries out during summer (Plate 14) and does not have the potential to support indigenous fish, even in wetter parts of the year. The proposed compensation reach has connectivity to the brackish lower reaches of Drury Creek and it is likely that indigenous fish (e.g. inanga, shortfin eel, and banded kōkopu) and macroinvertebrates are present during autumn and winter.

Plate 14: Dry channel in the impact reach. 19 March 2018.

9. POTENTIAL ECOLOGICAL EFFECTS OF THE PROPOSED DEVELOPMENT

9.1 Overview

The potential effects (both negative and positive) of the proposed Phase 1 works can be summarised as:

- Loss of intermittent stream habitat.
- Loss of wetland habitat
- Loss of terrestrial bird habitat
- Loss of habitat for, and mortality of, indigenous lizards
- Loss of habitat for, and mortality of, long-tailed bats
- Effects of stormwater on aquatic and marine habitats
- Effects of domestic pets on wading birds
- Sedimentation of aquatic and marine habitats
- Removal of stock.

Each potential effect is addressed in more detail below.

9.2 Loss of intermittent stream habitat

Approximately 80 metres of intermittent stream habitat will be removed during Phase 1 earthworks (Figure 2). The SEV results indicate the watercourse has low ecological values; however, it is important to acknowledge that over 18 kilometres of stream length is lost on average each year in the Auckland Region (Rowe *et al*. 2011). Remaining open reaches therefore have intrinsic ecological and hydrological values despite their level of degradation.

9.3 Loss of wetland habitat

Approximately 5,388 m^2 of exotic vegetation within Wetlands 2 and 3 will be removed during Phase 1 earthworks. These wetlands have been highly degraded by stock and do not have sufficient habitat to support indigenous fish and cryptic wetland bird species such as fernbird and spotless crake. Common indigenous birds such as pūkeko are highly mobile and are more likely to roost and nest in larger, more intact wetlands in the east of the property. However, the values of small degraded wetlands dominated by exotic vegetation should be recognised given they can still provide important ecosystem functions such as flood attenuation and filtering sediments and nutrients from overland run-off.

9.4 Loss of terrestrial bird habitat

Any adverse effects on indigenous birds are likely to be no more than minor as the bird species present are all common and are able to produce extra clutches to compensate for failed breeding attempts.

9.5 Loss of habitat for, and mortality of, indigenous lizards

There is suitable habitat at the site to support indigenous skink species such as copper skink and ornate skink (At Risk-Declining), which means they may be adversely impacted by vegetation clearance associated with Phase 1 earthworks. Impacts may be both direct (e.g. mortality, habitat loss, displacement), and indirect (e.g. greater risk of predation, greater competition for resources). The presence of gecko species is considered highly unlikely.

9.6 Loss of habitat for, and mortality of, long-tailed bats

Mature exotic trees within the Phase 1 earthworks extent have the potential to support long-tailed bats. Tree-felling associated with Phase 1 earthworks therefore has the potentially to adversely affect bats.

9.7 Effects of domestic pets on wading birds

The close proximity of the proposed development to a 'significant wading bird area' within estuarine habitats of Drury Creek (SEA-m2-29w) means that resident and migratory birds are at risk of predation by cats and dogs. It is not unreasonable to assume that resident cats would enter the estuary, given their propensity to roam. Uncontrolled dogs also have the potential to disturb feeding birds and/or kill ground-nesting birds in saltmarsh and on sandflats within Drury Creek.

9.8 Effects of stormwater on aquatic and marine habitats

The proposed development will significantly increase the area of impermeable surfaces on the property. Surface run-off from impermeable ground can greatly increase the amount and rate of stormwater flow. After heavy rainfall events, large amounts of fast-moving water flows into streams, creating a scouring effect that is harmful to aquatic fauna and can result in streambank erosion and sedimentation. Roofs, roads, and driveways are the main contributors to surface run-off.

Stormwater can also transport a range of contaminants such as heavy metals, which accumulate in estuarine receiving environments. Heavy metals such as zinc (commonly used in roofing) can persist in the aquatic environment for considerable periods of time, particularly in sediment. As a consequence, metals can accumulate in the tissues of benthic organisms and their predators at higher trophic levels. Zinc is toxic to aquatic plants and animals (Widianarko *et al.* 2001). Zinc is one of the most common contaminants found in estuarine receiving and largely results from galvanised surfacing used in residential and industrial roofing. In residential areas, contamination can also occur through seemingly innocuous activities such as washing cars on impermeable surfaces, whereby cleaning chemicals and detergents are readily transported into drains and into aquatic and estuarine receiving environments.

9.9 Sedimentation of aquatic and marine habitats

Sediment-dwelling organisms are a major component of broader estuarine, harbour and coastal ecosystems, providing food for birds, fish, and humans, and affecting

water quality, nutrient cycling, and productivity. Increased siltation or sedimentation caused by earthworks can adversely affect these organisms and the animal communities that feed on them. Avifauna and aquatic fauna, for example, may be indirectly affected by more frequent deposition of silt in estuarine areas (Senior & Ramsay 2003). Given the close proximity to Drury Creek and the Manukau Harbour, sedimentation from exposed earth during construction poses a significant potential threat to both aquatic and marine biodiversity.

9.10 Removal of stock

All farming activities will cease if the proposed development proceeds. The removal of cattle will significantly benefit watercourses and wetlands at the site. Any grazing animals, including horses, that may remain will be excluded from all streams and natural areas if the development proceeds.

10. SUGGESTED MEASURES TO COMPENSATE OR MITIGATE POTENTIAL ECOLOGICAL EFFECTS

10.1 Restoration of wetland habitat

In order to compensate the loss of wetland habitat within Wetlands 2 and 3, it is proposed to restore *c*.8,480 m^2 of wetland vegetation within Wetlands 1, 3, and 7 (Figure 2). This will largely involve planting the wetland interior with appropriate indigenous plant species, including rautahi, pūrei (*Carex virgata*), harakeke, giant umbrella sedge (*Cyperus ustulatus*), and tī kōuka/cabbage tree. A five metre terrestrial buffer will also be planted on the margins of the wetlands once stock have been removed.

10.2 Compensation for the loss of intermittent stream habitat

The Environmental Compensation Ratio (ECR) is used to determine the length of stream that needs to be restored to achieve no net loss of ecological value relative to the length of stream to be degraded, taking into account the relative ecological quality of each stream. In situations where restoration is not possible, the ECR can also be used to determine the amount of financial compensation required (Rowe *et al*. 2006), although nowadays this option is rarely taken. In applying environmental compensation ratios, the length of stream to be restored should never be less than the length of stream to be degraded (Storey *et al.* 2011).

Where the impact reach is similar to the reach to be restored, and assuming that full restoration is possible over a short time frame, a theoretical ECR close to 1:1 may be warranted. However, where the stream to be restored has lower ecological value than the reach being degraded, the ratio needs to be set at a higher level to compensate for this. It may therefore be necessary to restore three to four times the length of stream to be degraded. In the Auckland Region, the average ECR is in the order of 1:3.

The ECR equation also takes into account the inherent time delay before the full benefits are realised at the compensation stream and the possible failings or inadequacies that may occur with restoration projects. The use of the ECR is

generally required to quantify that "no net loss or a net gain in the natural values" is achieved by offsetting activities following stream loss as per Rule (E3.3(4)) of the Auckland Unitary Plan (Operative in Part), which states:

> *"Restoration and enhancement actions, which may form part of an offsetting proposal, for a specific activity should:*
>
> *a) Be located as close as possible to the subject site*
> *b) Be 'like-for-like' in terms of the type of freshwater system affected*
> *c) Preferably achieve no net loss or a net gain in the natural values including ecological function of lakes, rivers, streams or wetlands; and*
> *d) Consider the use of biodiversity offsetting as outlined in Appendix 8: Biodiversity offsetting."*

The formula used to calculate the ECR is:

$$\textbf{ECR} = \frac{\textbf{Predicted loss of function}}{\textbf{Predicted gain after restoration}} \times \textbf{1.5 delay factor}$$

The predicted gain assumes best practices are used for restoration of the compensation stream. In this case, it is proposed to plant the riparian margin on both sides of the proposed compensation reach up to the property boundary east of the stream and the driveway west of the stream. Note that the ECR excludes biotic scores (function numbers 12 and 13) due to difficulties predicting how biodiversity values will respond to restoration.

Calculations

The existing and predicted SEV scores for the impact stream and the proposed compensation stream following restoration are listed in Table 4 below. Predicted SEV scores for the impact and compensations streams are based on calculations presented in Appendix 2. Assumptions relating to the predicted SEV score for the compensation reach are outlined in Appendix 3.

Table 4: Existing and predicted SEV scores for the impact stream and the potential compensation stream following restoration. Note that these scores have been calculated excluding Biotic Functions.

Site Name	Existing Function Score	Predicted Score Following Restoration	Predicted Score Following impact	Predicted Loss of Function	Predicted Gain Through Restoration
Impact reach	0.28	0.55	0	0.28	0.27
Compensation reach	0.43	0.71	n/a	n/a	0.28

Stream Areas

The areas of the two streams are included in Table 5 below.

Table 5: Areas of the impact and compensation reaches.

Site Name	Average Wetted Width (m)	Length (m)	Reach Area (m^2)
Impact reach	0.79	70	55
Compensation reach	1.2	210	n/a

Level of compensation

In order to compensate for the loss of the impact site:

ECR = (0.55 - 0)/(0.71 - 0.43) × 1.5 = 2.95

This indicates that 2.95 times the area of the impact stream needs to be restored in the compensation stream to result in no net loss of function.

The total area of stream habitat to be lost at the impact stream is 55 m^2. The total area required to be restored, using an ECR of 2.95, is 162 m^2, which equates to 135 metres of stream length to be restored (i.e. 162 m^2 divided by an average width of the compensation stream, which is 1.2 metres).

10.3 Lizard management

To determine potential effects on resident lizard populations, a preliminary survey for indigenous skinks would need to be undertaken. If lizards are present within any habitats that are to be cleared, a Lizard Management Plan (LMP) will need to be prepared. The LMP will include the following information outlining the measures that can be undertaken to mitigate the potential impacts of the proposed works on indigenous lizard populations:

- A description of methodology for survey, trapping and relocation of lizards rescued including, but not limited to, protocols regarding salvage, relocation, nocturnal and diurnal capture, supervised habitat clearance/transfer; post-vegetation clearance capture; artificial cover objects, and opportunistic relocation. Capture techniques should be determined by the consulting herpetologist and detailed within the LMP.
- Methodology for minimising lizard mortality resulting from construction works associated with the project.
- Mechanisms for enriching lizard habitats in restoration areas including provision of additional refugia, if required, e.g. depositing salvaged logs or debris for newly released skinks that have been rescued.
- Locations for the potential release of lizards, including details on any weed and pest management to ensure the relocation site is maintained as appropriate habitat.
- Selection of a recipient site that will remain in indigenous vegetation in the long term.

- Timing of activities. The LMP must be implemented outside of the winter months of June, July and August due to low lizard detectability during the colder months.

10.4 Bat management

To determine the presence of long-tailed bats at the site, acoustic bat monitoring devices should be deployed for a minimum of ten days during warm weather (>10 degrees Celsius at night). This could be carried out in conjunction with the preliminary lizard survey. If bats are detected, a Bat Management Plan (BMP) will need to be prepared and implemented, and approved by Auckland Council, prior to tree-felling.

10.5 Management of domestic pets

The adverse effects of dogs can be avoided as long as they are controlled on a leash when in close proximity to estuarine habitats. However, the hunting habits of domestic cats are difficult to curb, although they hunt less as they get older (King 2005). Providing extra food is unlikely to reduce hunting behaviour because prey capture, killing, and consumption are relatively independent of each other (Barrat 1998). Fitting house cats with bells might (Ruxton *et al.* 2002) or might not (Barrat 1998) reduce predation on wildlife. Night curfews for cats have been suggested, but may have little value. For example, in Canberra 70% of the birds and 90% of the reptiles caught by cats were brought in during the day (Barrat 1997), so a night curfew might reduce only the number of rodents and hedgehogs killed. Cat bans are becoming an increasingly common component of subdivision applications in New Zealand, particularly where ecologically sensitive environments are concerned[1,2]. Given the proximity of the proposed development to high value estuarine habitats, a cat ban should be considered for residential areas within the proposed development.

10.6 Riparian and wetland setbacks

As a minimum, all intermittent and permanent watercourses to be retained should have a ten-metre buffer on each side. All development and associated roads and tracks should be set back at least ten metres from restored wetlands, which will include five metres of terrestrial buffer planting (Figure 2).

10.7 Stormwater management

There is an opportunity to create infrastructure during the construction process that will significantly reduce the impacts of stormwater on aquatic and marine receiving environments; which is commonly referred to as 'Low Impact Design' (ARC 2000). Such an approach can be achieved by using various methods to minimise and control storm run-off water as close to its origin as possible, before it enters a watercourse.

[1] The Western Bay of Plenty District Council made a landmark decision in November 1996 to ban cats and dogs from the Five Jems subdivision at Waihi Beach.

[2] Harbourside Development took up Forest and Bird's suggestion of making their Kaiwharawhara (Wellington) subdivision wildlife-friendly by prohibiting cats to protect a bird corridor close to the 'mainland island' Karori Sanctuary.

A range of low impact design features could be included in the design of the proposed development, including:

- The use of water tanks to capture roof water for domestic use and to provide for the temporary storage and controlled release of roof runoff.
- The use of swales, filter strips and rain gardens to provide for treatment of stormwater runoff from impervious areas.
- The use of rain gardens, proprietary devices and/or wetlands for the treatment of stormwater runoff from reticulated areas.
- The discharge of captured runoff at appropriate locations incorporating energy dissipation and flow dispersion structures.

In addition, permeable surfaces should be maximised wherever possible, including the use of permeable material for pavements and driveways. In order to prevent zinc entering the local watercourses, galvanised paint should not be used in the proposed development.

10.8 Best practice sediment control during development

Auckland Council best practice guidelines for erosion and sediment control (TP90) should be followed at all times during development works to prevent excess sediment entering the impact watercourse and flowing downstream into the receiving environment.

10.9 Legal protection of restored stream and wetland habitat

Restored wetlands and watercourses will be protected through the use of statutory mechanisms such as protective covenants. Covenants are designed to protect ecologically significant parcels of land in perpetuity, and can include financial contributions towards fencing and ongoing pest control. Areas planted in indigenous species should also be protected in perpetuity, although such areas will most likely require a Council covenant rather than a QEII covenant.

10.10 Restoration of coastal habitats

In addition to the suggested mitigation measures outlined above, there is an opportunity to replace existing exotic coastal vegetation with suitable indigenous species, particularly along the western boundary of the site. This area includes some large pines, which should be felled or poisoned and left to break down in situ prior to development works commencing. It is anticipated that an Esplanade Reserve will extend along most of the coastal boundary, which will include a walking/cycling path.

11. SUMMARY AND CONCLUSIONS

Civil Plan Consultants Limited, on behalf of the Hugh Green Group (the client), is developing a master plan for a large urban development at 144-252 Park Estate

Road, Hingaia. These properties contain significant areas of wetlands (particularly at 144 Park Estate Road) and a number of degraded watercourses, which the client is seeking to reshape through reclamation and enhancement works in order to allow residential subdivision.

This report assessed potential ecological effects within the Phase 1 earthworks extent. The proposed works will result in the removal of *c.*5,388 m^2 of exotic vegetation within Wetlands 2 and 3, and *c.*70 metres of intermittent stream habitat.

Woody vegetation within the Phase 1 earthworks extent is largely limited to exotic trees and shelterbelts. Some of the larger trees have the potential to support long-tailed bat roosts, and it is possible the indigenous skinks are present in grassland and woody debris. Wetland and aquatic values within the Phase 1 earthworks extent are low given their level of degradation, absence of indigenous plant species, and lack of habitat to support indigenous fauna. No species of vascular plants classified as nationally or regionally threatened by de Lange *et al*. (2018) and Stanley *et al*. (2005), respectively, will be affected by the proposed works.

As well as the loss of wetland and intermittent stream habitat, the proposed development has the potential to adversely affect indigenous fauna such as long-tailed bats and copper skinks. Domestic pets – particularly cats – pose a threat to wading birds in estuarine habitats of Drury Creek, immediately adjacent to the site. Adverse effects on terrestrial birds are expected to be less than minor. Sedimentation from earthworks and stormwater run-off from constructed buildings and roads both have the potential to adversely affect aquatic and marine habitats.

The removal of Wetland 2 and partial removal of Wetland 3 will be compensated by restoring *c.*8,480 m^2 of wetland habitat elsewhere on the property. The loss of the stream habitat will be compensated for by restoring approximately 135 metres of intermittent stream habitat downstream of Wetland 3. The potential effects of stormwater and sedimentation on downstream receiving environments can be managed by implementing best practice at the design Phase, including low impact design features such as wetlands, rain gardens, and permeable surfaces.

In addition to the proposed offset restoration, there is the opportunity to restore coastal terrestrial habitats along the western boundary of the property.

A comprehensive Ecological Management Plan (EMP) will need to be prepared in order to guide ecological works at the site, and all planting areas should be legally protected in perpetuity under a covenant.

If the abovementioned measures are appropriately implemented, the potential adverse impacts of the proposed development will be no more than minor.

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VASCULAR PLANT SPECIES RECORDED FROM PARK ESTATE ROAD, HINGAIA

INDIGENOUS SPECIES

Gymnosperms

Podocarpus totara var. *totara*	tōtara

Dicot. trees and shrubs

Avicennia marina subsp. *australasica*	mānawa, mangrove
Myrsine australis	māpou
Plagianthus divaricatus	marsh ribbonwood mākaka

Ferns

Dicksonia squarrosa	whekī
Pteridium esculentum	bracken

Sedges

Carex lessoniana	toetoe-rautahi
Cyperus ustulatus	toetoe upoko-tangata

Rushes

Apodasmia similis	oioi
Juncus kraussii var. *australiensis*	wi, wīwī sea rush

Monocot. herbs (other than orchids, grasses, sedges, and rushes)

Lemna disperma	karearea
Phormium tenax	harakeke, flax
Typha orientalis	raupō

Composite herbs

Cotula coronopifolia	bachelor’s button
Senecio bipinnatisectus	Australian fireweed

Dicot. herbs (other than composites)

Geranium homeanum	pinakitere

NATURALISED AND EXOTIC SPECIES

Gymnosperms

Cupressus macrocarpa	macrocarpa
Pinus pinaster	maritime pine
Pinus radiata	radiata pine

Dicot. trees and shrubs

Acacia mearnsii	black wattle
Berberis glaucocarpa	barberry
Eucalyptus obliqua	messmate
Ligustrum lucidum	tree privet
Ligustrum sinense	Chinese privet
Paraserianthes lophantha	brush wattle
Populus deltoides	necklace poplar
Populus nigra	Lombardy poplar
Quercus robur	English oak
Rubus sp. (*R. fruticosus* agg.)	blackberry
Salix ×fragilis	crack willow
Solanum mauritianum	woolly nightshade
Syzygium smithii	lillypilly, monkey apple
Ulex europaeus	gorse

Dicot. lianes

Araujia hortorum	moth plant
Calystegia sepium × *C. silvatica*	
Lonicera japonica	Japanese honeysuckle

Grasses

Agrostis capillaris	browntop
Agrostis stolonifera	creeping bent
Cenchrus clandestinus	kikuyu grass
Cortaderia selloana	pampas
Dactylis glomerata	cocksfoot
Holcus lanatus	Yorkshire fog
Lolium perenne	rye grass
Paspalum dilatatum	paspalum
Paspalum distichum	Mercer grass
Schedonorus arundinaceus	tall fescue
Sporobolus africanus	ratstail

Rushes

Juncus articulatus	jointed rush
Juncus effusus var. *effusus*	soft rush, leafless rush
Juncus tenuis var. *tenuis*	track rush

Composite herbs

Anthemis cotula	stinking mayweed
Jacobaea vulgaris	ragwort

Dicot. herbs (other than composites)

Apium nodiflorum	water celery
Callitriche stagnalis	starwort
Linum bienne	pale flax
Lotus pedunculatus	lotus
Ludwigia palustris	water purslane
Modiola caroliniana	creeping mallow
Myosotis laxa subsp. *caespitosa*	water forget-me-not
Nasturtium officinale	watercress
Persicaria hydropiper	water pepper
Persicaria maculosa	willow weed
Plantago lanceolata	narrow-leaved plantain
Plantago major	broad-leaved plantain
Ranunculus repens	creeping buttercup
Ranunculus sceleratus	celery-leaved buttercup
Rumex conglomeratus	clustered dock
Rumex obtusifolius	broad-leaved dock
Solanum nigrum	black nightshade
Trifolium pratense	red clover
Trifolium repens	white clover

CURRENT SEV RESULTS

Function category	Function	Variable (code)	Impact Current	Compensation Current
		Vchann	0.28	0.43
		Vlining	0.80	0.80
		Vpipe	1.00	1.00
Hydraulic	**NFR**	**=**	**0.45**	**0.55**
		Vbank	1.00	1.00
		Vrough	0.20	0.20
Hydraulic	**FLE**	**=**	**0.20**	**0.20**
		Vbarr	0.30	1.00
Hydraulic	**CSM**	**=**	**0.30**	**1.00**
		Vchanshape	0.36	0.72
		Vlining	0.80	0.80
Hydraulic	**CGW**	**=**	**0.65**	**0.77**
Hydraulic function mean score			**0.40**	**0.63**
		Vshade	0.00	0.26
biogeochemical	**WTC**	**=**	**0.00**	**0.26**
		Vdod	0.60	0.75
biogeochemical	**DOM**	**=**	**0.60**	**0.75**
		Vripar	0.00	0.05
		Vdecid	1.00	1.00
biogeochemical	**OMI**	**=**	**0.00**	**0.05**
		Vmacro	0.88	0.50
		Vretain	0.36	0.36
biogeochemical	**IPR**	**=**	**0.36**	**0.36**
		Vsurf	0.55	1.00
		Vripfilt	0.20	0.20
biogeochemical	**DOP**	**=**	**0.37**	**0.60**
Biogeochemical function mean score			**0.27**	**0.40**
		Vgalspwn	0.00	1.00
		Vgalqual	0.00	0.00
		Vgobspwn	0.10	0.10
habitat provision	**FSH**	**=**	**0.05**	**0.05**
		Vphyshab	0.05	0.27
		Vwatqual	0.03	0.14
		Vimperv	0.90	0.90
habitat provision	**HAF**	**=**	**0.26**	**0.39**
Habitat provision function mean score			**0.15**	**0.22**
		Vripcond	0.10	0.11
		Vripconn	1.00	1.00
Biodiversity	**RVI**	**=**	**0.10**	**0.11**
Biodiversity function mean score			**0.10**	**0.11**
SEV score minus biodiversity functions 12 and 13			**0.279**	**0.425**

PREDICTED SEV RESULTS

Function category	Function	Variable (code)	Compensation potential	Impact (Piped)	Impact potential
		Vchann	0.51	0.00	0.28
		Vlining	0.80	0.00	0.80
		Vpipe	1.00	0.00	1.00
Hydraulic	**NFR**	**=**	**0.61**	**0.00**	**0.45**
		Vbank	1.00	0.00	1.00
		Vrough	0.90	0.00	0.90
Hydraulic	**FLE**	**=**	**0.90**	**0.00**	**0.90**
		Vbarr	1.00	0.00	0.30
Hydraulic	**CSM**	**=**	**1.00**	**0.00**	**0.30**
		Vchanshape	0.62	0.00	0.36
		Vlining	0.80	0.00	0.80
Hydraulic	**CGW**	**=**	**0.74**	**0.00**	**0.65**
Hydraulic function mean score			**0.81**	**0.00**	**0.58**
		Vshade	0.60	0.00	0.60
Biogeochemical	**WTC**	**=**	**0.60**	**0.00**	**0.60**
		Vdod	1.00	0.00	0.60
Biogeochemical	**DOM**	**=**	**1.00**	**0.00**	**0.60**
		Vripar	0.50	0.00	0.50
		Vdecid	1.00	0.00	1.00
Biogeochemical	**OMI**	**=**	**0.50**	**0.00**	**0.50**
		Vmacro	0.82	0.00	0.88
		Vretain	0.44	0.00	0.36
Biogeochemical	**IPR**	**=**	**0.44**	**0.00**	**0.36**
		Vsurf	1.00	0.00	0.65
		Vripfilt	0.60	0.00	0.60
Biogeochemical	**DOP**	**=**	**0.80**	**0.00**	**0.63**
Biogeochemical function mean score			**0.67**	**0.00**	**0.54**
		Vgalspwn	1.00	0.00	0.00
		Vgalqual	0.25	0.00	0.00
		Vgobspwn	1.00	0.10	1.00
Habitat Provision	**FSH**	**=**	**0.63**	**0.00**	**0.50**
		Vphyshab	0.65	0.00	0.39
		Vwatqual	0.35	0.00	0.21
		Vimperv	0.90	0.00	0.90
Habitat Provision	**HAF**	**=**	**0.64**	**0.00**	**0.47**
Habitat provision function mean score			**0.63**	**0.00**	**0.49**
		Vripcond	0.62	0.00	0.62
		Vripconn	1.00	1.00	1.00
Biodiversity	**RVI**	**=**	**0.62**	**0.00**	**0.62**
Biodiversity function mean score			**0.62**	**0.00**	**0.62**
SEV score minus biodiversity functions 12 and 13			**0.706**	**0.00**	**0.549**

APPENDIX 4

ASSUMPTIONS USED IN PREDICTING THE SEV SCORE FOR THE IMPACT STREAMS AT 144-252 PARK ESTATE ROAD, HINGAIA

Function Category	Variable	Assumption
Hydraulic	Vchann	Stream channel extensively modified. 100% “straightened and/or deepened”.
	Vlining	100% of banks and bed lined with impermeable artificial materials.
	Vpipe	Unchanged.
	Vbank	No hydrological connectivity with floodplain within the entire reach
	Vrough	No riparian area covered with artificial surfaces.
	Vbarr	Changed from no barriers to partial barriers for all impact streams.
	Vchanshape	Automatic calculation, no input from ecologist.
Biogeochemical	Vshade	No shading given there is no upstream habitat.
	Vdod	Unchanged.
	Vveloc	Velocity increased to reflect uniform nature of pipes.
	Vdepth	Depth standardised throughout reach.
	Vripar	No trees or bushes within riparian zone.
	Vdecid	Stream cover is not deciduous.
	Vmacro	No macrophytes within pipe.
	Vretain	Automatic calculation, no input from ecologist.
	Vsurft	All substrate artificial hard surface classified as ‘bedrock’.
	Vripfilt	No riparian filtering.
Habitat provision	Vgalspwn	No suitable spawning habitat.
	Vgalqual	No suitable spawning habitat.
	Vgobspwn	Automatic calculation, no input from ecologist.
	Vphyshab	No habitat given that there is no upstream connectivity.
	Vwatqual	Unchanged.
	Vimperv	Unchanged.
Biodiversity	Vfish	Not included in calculation.
	Vmci	Not included in calculation.
	Vept	Not included in calculation.
	Vripcond	Automatic calculation, no input from ecologist.
	Vripconn	No connectivity to riparian zone.

APPENDIX 5

ASSUMPTIONS USED IN PREDICTING THE POTENTIAL SEV SCORE FOR THE IMPACT STREAMS AT 144-252 PARK ESTATE ROAD, HINGAIA

Function Category	Variable	Assumption
Hydraulic	Vchann	Unchanged.
	Vlining	Unchanged.
	Vpipe	Unchanged.
	Vbank	Unchanged.
	Vrough	Improved due to a 10 metre wide riparian margin is restored on both sides of the streams.
	Vbarr	No change.
	Vchanshape	Automatic calculation, no input from ecologist.
Biogeochemical	Vshade	Increase in shading to high as a result of riparian restoration.
	Vdod	Slight improvement due to shade provided by riparian planting.
	Vveloc	Unchanged.
	Vdepth	Unchanged.
	Vripar	Improved due to planting 10 metre wide margin on each side of the streams.
	Vdecid	Unchanged.
	Vmacro	Reduced macrophytes due to increased shade from riparian planting.
	Vretain	Automatic calculation, no input from ecologist.
	Vsurft	Unchanged.
	Vripfilt	Riparian planting areas will provide moderate to high filtering activity.
Habitat provision	Vgalspwn	Unchanged.
	Vgalqual	Unchanged.
	Vgobspwn	Automatic calculation, no input from ecologist.
	Vphyshab	Habitat parameters improved.
	Vwatqual	Unchanged.
	Vimperv	Unchanged.
Biodiversity	Vfish	Not included in calculation.
	Vmci	Not included in calculation.
	Vept	Not included in calculation.
	Vripcond	Automatic calculation, no input from ecologist.
	Vripconn	Unchanged.

APPENDIX 6

ASSUMPTIONS USED IN PREDICTING THE POTENTIAL SEV SCORES FOR THE COMPENSATION STREAM AT 144-252 PARK ESTATE ROAD, HINGAIA

Function Category	Variable	Assumption
Hydraulic	Vchann	Unchanged.
	Vlining	Unchanged.
	Vpipe	Unchanged.
	Vbank	Unchanged.
	Vrough	Improved due to a 10 metre wide riparian margin is restored on both sides of the stream.
	Vbarr	All barriers will be remediated, i.e. retrofitting perched culverts.
	Vchanshape	Automatic calculation, no input from ecologist.
Biogeochemical	Vshade	Riparian planting will provide high shading to the streams.
	Vdod	Slight improvement due to shade provided by riparian planting.
	Vveloc	Unchanged.
	Vdepth	Unchanged.
	Vripar	Improved due to planting 10 metre wide margin on each side of the stream.
	Vdecid	Unchanged.
	Vmacro	Unchanged due to very low amount of macrophytes currently present.
	Vretain	Automatic calculation, no input from ecologist.
	Vsurft	Unchanged.
	Vripfilt	Riparian planting areas will provide moderate to high filtering activity.
Habitat provision	Vgalspwn	Unchanged.
	Vgalqual	Banks slope and riparian planting will improve quality of galaxid spawning habitat.
	Vgobspwn	Automatic calculation, no input from ecologist.
	Vphyshab	Habitat parameters improved.
	Vwatqual	Unchanged.
	Vimperv	Unchanged.
Biodiversity	Vfish	Not included in calculation.
	Vmci	Not included in calculation.
	Vept	Not included in calculation.
	Vripcond	Automatic calculation, no input from ecologist.
	Vripconn	Connectivity to the riparian zone will not be impeded.

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ECOLOGICAL MANAGEMENT PLAN FOR 144-252 PARK ESTATE ROAD, HINGAIA: PHASE I

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ECOLOGICAL MANAGEMENT PLAN FOR 144-252 PARK ESTATE ROAD, HINGAIA: PHASE I

Mid reaches of an intermittent stream proposed for restoration.

Contract Report No. 4760

November 2018

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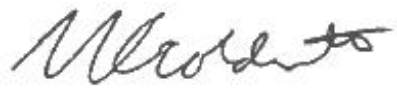

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Nick Goldwater
Principal Ecologist
Wildland Consultants Ltd

1. INTRODUCTION

Civil Plan Consultants Limited, on behalf of the Hugh Green Limited (the client), is developing a master plan for a large urban development at 144-252 Park Estate Road, Hingaia. These properties contain large areas of wetlands (particularly at 144 Park Estate Road) and a number of degraded watercourses, which the client is seeking to reshape through reclamation and enhancement works in order to allow residential subdivision. Most of the land is zoned as 'Residential - Mixed Housing Suburban Zone' under the Auckland Unitary Plan (AUP), with smaller areas zoned as 'Residential - Mixed Housing Urban Zone' and 'Business - Neighbourhood Centre Zone'.

Bulk earthworks will be undertaken in two Phases: Phase 1 comprises the northwestern part of the site, while Phase 2 comprises the remaining land between the Phase 1 parcel, the southern motorway, and coastal boundary. In August 2018, Wildland Consultants Ltd prepared an ecological assessment of the proposed subdivision (Wildland Consultants 2018). The ecological assessment identified two wetlands and one intermittent stream that would be impacted by the proposed bulk earthworks in Phase 1. A Stream Ecological Valuation (SEV, Wildland Consultants 2018) identified a suitable intermittent stream that could serve as mitigation for the proposed stream loss, and a site survey identified three wetlands that could be restored to compensate for the loss of wetland habitat. All restoration works are to be guided by an Ecological Management Plan (EMP).

Civil Plan Consultants Ltd commissioned Wildland Consultants Ltd to develop an EMP for the Phase 1 works. This plan provides recommendations for the ecological restoration of one intermittent stream and three wetlands on the property, together with recommendations for the management of indigenous skinks and long-tailed bats (*Chalinolobus tuberculatus*). Restoration will be achieved through stock exclusion, and revegetation and enhancement planting. Recommendations for revegetation planting include plant schedules with details of the species, grades, and numbers of plants to be planted along with maps of the recommended planting areas.

2. SITE DESCRIPTION AND CONTEXT

The study site is located in in the Manukau Ecological District in a landscape comprising rural land to the west of Papakura and Drury. It is bounded by Park Estate Road to the north and the southern motorway to the east, while the southern and eastern margins border the lower saline reaches of Drury Creek. Drury Creek includes two marine Significant Ecological Areas (SEA-M2-29w1 and SEA-M2-29a), which include a 'significant wading bird area'. Mangroves (*Avicennia marina* subsp. *australasica*) are abundant in this part of Drury Creek, while oioi (*Apodasmia similis*) salt meadow is locally common on the southern boundary of the study site, adjacent to the Drury Esplanade Reserve. Land to the west and south of the study site is largely characterised by farming and horticulture, although urban development has recently commenced in areas such as Karaka.

Vegetation at the site is characterised by pasture, wetlands dominated by exotic plant species, shelterbelts, mixed exotic-indigenous coastal forest and scrub, and exotic treeland.

Approximately 70% of the study site is located on 'Acutely Threatened' land environments (<10% indigenous vegetation cover remaining) and 30% is on 'Critically Underprotected' land environments (>30% left and <10% protected) (Walker *et al*. 2007).

3. PROJECT OBJECTIVES

The objectives of the EMP are:

(i) to mitigate for the loss of wetland and intermittent stream habitats at the site by revegetating the riparian margins of an intermittent stream and buffer zones of three wetlands, together with enhancement planting within three wetlands; and

(ii) to minimise or avoid potential adverse impacts on indigenous skinks and long-tailed bats.

Revegetation and enhancement planting will improve the ecological values of the site through the restoration of riparian habitat, promoting natural regeneration of the wetlands, and improving habitat values for indigenous flora and fauna.

4. METHODS

Field surveys were undertaken on 19 March 2018 and 6 June 2018 during which sites were identified that could be restored to compensate for the loss of the wetlands. In addition, an SEV was undertaken on 23 August 2018 to assess a watercourse proposed to compensate for the loss of intermittent stream habitat. All potential sites recommended for restoration were mapped in the field onto hard copy prints of digital aerial photographs. The maps were then digitised using ArcGIS 10.4 (GIS programme).

Detailed planting plans then were developed for each area, taking into consideration environmental conditions of the site and the objectives of the planting. Planting plans include plant schedules, pre-treatment requirements, and ongoing maintenance of the planting areas to ensure ongoing survival and success.

5. PEST PLANTS

Pest plants within the planting areas are largely restricted to occasional gorse (*Ulex europeaus*), barberry (*Berberis glaucocarpa*), and tree privet (*Ligustrum lucidum*). In addition, several Chinese privet (*Ligustrum sinense*) shelter belts occur in close proximity to the planting areas. The Chinese privet shelter belts are a seed source for the rest of the property and birds may disperse seeds into the planting areas. Pest

plants within the planting areas will compete with indigenous species and compromise revegetation efforts.

All of the abovementioned plant species are classified as Surveillance Pest Plants under the Auckland Regional Pest Management Strategy 2007-2012 (ARPMS, ARC 2007) and should be controlled. Surveillance Pest Plants include species that have been identified as having significant impacts on biodiversity across the entire Auckland Region. The Auckland Council seeks to prevent their establishment or spread by prohibiting their sale, propagation, distribution, and exhibition (ARC 2007).

It is recommended that all Surveillance Pest Plant species observed within the planting areas and the shelter belts be controlled. Recommended control methods are presented in Appendix 3

6. PLANTING

6.1 Revegetation planting

6.1.1 Overview

Seven planting areas have been identified at the site:

- Three of the planting areas are the buffer zone of wetlands.
- Three are wetland land interiors where enrichment planting is recommended.
- One planting area is located within the riparian margin of an intermittent stream.

The locations of the planting areas are shown in Figure 1. All planting work within these areas should follow the plant schedules provided below (Tables 1-7) and the timeline presented in Section 8.

6.1.2 Planting Areas A, B and C: Wetland buffers

There are three planting areas (Planting Areas A-C) that include five metre buffers around the two freshwater wetlands and one brackish wetland proposed for restoration. Planting in these areas will enhance filtering of overland flow entering the wetlands, provide nesting and foraging habitat for indigenous fauna, and act as a visual screen and reduce disturbance to fauna using the wetland habitat. This will be achieved by using a combination of low-growing species and taller woody indigenous species tolerant of wet soils and periodic flooding. The vegetation in the buffer zones is currently characterised by grazed exotic grassland with occasional gorse. The exotic grassland includes kikuyu (*Cenchrus clandestinus*), which is an aggressive grass that will smother seedlings. Therefore, these planting areas will require site preparation to control the exotic grasses and to reduce competition following planting. Plant spacings are designed to result in canopy closure within three to five years and to reduce the chance of pest plant invasion. The plant schedules for these areas are provided in Tables 1-3.

Table 1: Planting schedule for Planting Area A (*c*.890 m^2)

Species	Common Name	Grade	Spacing (m)	Number
Carex virgata[1]	pūrei	1.5L	0.75	80
Coprosma robusta	kahikatea	1.5L	1.4	45
Cordyline australis[1]	tī kōuka, cabbage tree	1.5L	1.4	45
Dacrycarpus dacrydioides	kahikatea	PB5	5	5
Kunzea robusta	kānuka	1.5L	3	85
Leptospermum scoparium	mānuka	1.5L	1.4	70
Melicytus ramiflorus	māhoe	1.5L	3	30
Phormium tenax	harakeke	1.5L	1.4	45
Veronica stricta	koromiko, hebe	1.5L	1.4	45
Total				**450**

1. Plant on the wetter margins of the wetland

Table 2: Planting schedule for Planting Area B (*c*.1,593 m^2)

Species	Common Name	Grade	Spacing (m)	Number
Carex virgata[1]	pūrei	1.5L	0.75	140
Coprosma robusta	kahikatea	1.5L	1.4	80
Cordyline australis[1]	tī kōuka, cabbage tree	1.5L	1.4	80
Dacrycarpus dacrydioides	kahikatea	PB5	5	5
Kunzea robusta	kānuka	1.5L	3	120
Leptospermum scoparium	mānuka	1.5L	1.4	120
Melicytus ramiflorus	māhoe	1.5L	3	40
Phormium tenax	harakeke	1.5L	1.4	80
Veronica stricta	koromiko, hebe	1.5L	1.4	80
Total				**745**

1. Plant on the wetter margins of the wetland

Table 3: Planting schedule for Planting Area C (*c*.653 m^2)

Species	Common Name	Grade	Spacing (m)	Number
Carex virgata[1]	pūrei	1.5L	0.75	60
Coprosma robusta	kahikatea	1.5L	1.4	35
Cordyline australis[1]	tī kōuka, cabbage tree	1.5L	1.4	35
Dacrycarpus dacrydioides	kahikatea	PB5	5	5
Kunzea robusta	kānuka	1.5L	3	85
Leptospermum scoparium	mānuka	1.5L	1.4	50
Melicytus ramiflorus	māhoe	1.5L	3	35
Phormium tenax	harakeke	1.5L	1.4	35
Veronica stricta	koromiko, hebe	1.5L	1.4	35
Total				**375**

1. Plant on the wetter margins of the wetland

6.1.3 Planting Areas 1 and 2: Freshwater wetlands

The wetlands at the site are currently degraded and comprise exotic rushland and grassland characterised by Mercer grass (*Paspalum distichum*) with emergent soft rush (*Juncus effusus*) and frequent exotic herbs such as water pepper (*Persicaria hydropiper*), willow weed (*P. maculosa*), and creeping buttercup (*Ranunculus repens*) (Appendix 1: Plates 1 & 2). These wetland habitats have the potential to be restored to indigenous sedgeland habitat.

The plant schedules include species that can tolerate waterlogged conditions such as tī kōuka (*Cordyline australis*) and indigenous sedges (e.g. rautahi/*Carex lessoniana*). These areas do not require dense planting; instead, the aim is to create 'clusters' of indigenous vegetation that will establish throughout the wetlands over time. Site preparation is minimal, although spot spraying of Mercer grass with grass-specific herbicide will improve the chances of plant survival. The schedules for Planting Areas 1 and 2 are provided in Table 4 and 5. (Note that plant numbers in the schedules are estimated on a per 'cluster' basis).

Table 4: Planting schedule for Planting Area 1 (*c*.1,180 m^2)*

Species	Common Name	Grade	Spacing (m)	Number
Carex secta		1.5L	1	20
Carex lessoniana	rautahi	1.5L	1	25
Carex virgata	pūrei	1.5L	1	25
Cordyline australis	tī kōuka, cabbage tree	1.5L	3	10
Cyperus ustulatus	giant umbrella sedge	1.5L	1.4	20
Phormium tenax	harakeke	1.5L	3	25
Total				**125**

* Three clusters required for this area, i.e. total of 375 plants.

Table 5: Planting schedule for Planting Area 2 (*c*.3,795 m^2)

Species	Common Name	Grade	Spacing (m)	Number
Carex secta		1.5L	1	65
Carex lessoniana	rautahi	1.5L	1	85
Carex virgata	pūrei	1.5L	1	85
Cordyline australis	tī kōuka, cabbage tree	1.5L	3	25
Cyperus ustulatus	giant umbrella sedge	1.5L	1.4	65
Phormium tenax	harakeke	1.5L	3	85
Total				**410**

* Four clusters required for this area, i.e. total of 1,640 plants.

6.1.4 Planting Area 3: Saline wetland

Planting Area 3 comprises a degraded wetland/floodplain adjacent to the brackish reaches of a permanent stream (Appendix 1: Plate 3). The vegetation is characterised by abundant Mercer grass and common soft rush with exotic herbs (e.g. creeping buttercup) occurring frequently. The downstream extent of this wetland has some saline influence and supports brackish tolerant species such as bachelor's button (*Cotula coronopifolia*). This planting area should be planted more intensively (i.e. average spacing of 1.4 metres across the site) in order to suppress the growth of rank grasses. The planting schedule for Planting Area 3 is presented in Table 6.

Table 6: Planting schedule for Planting Area 3 (*c*. 3,056 m^2)

Species	Common Name	Grade	Spacing (m)	Number
Carex lessoniana	rautahi	1.5L	0.5	1300
Cordyline australis	tī kōuka, cabbage tree	1.5L	1.4	220
Cyperus ustulatus	giant umbrella sedge	1.5L	1.4	800
Leptospermum scoparium	mānuka	1.5L	1.4	190
Olearia solandri	coastal tree daisy	1.5L	1.4	80
Phormium tenax	harakeke	1.5L	1.4	445

Species	Common Name	Grade	Spacing (m)	Number
Plagianthus divaricatus	saltmarsh ribbonwood	1.5L	1.4	330
Total				**3,365**

6.1.5 Planting Area 4: Compensation stream riparian margin

Planting Area 4 comprises the ten-metre riparian margin of the proposed compensation watercourse downstream of Wetland 3. The area is currently characterised by grazed exotic grassland on the upper banks with soft rush and exotic herbs on the lower banks and floodplain. Revegetating the riparian margin will enhance the ecological values of the stream by stabilising the banks and providing shade. The species selected for this area include early successional species (e.g. kānuka and karamū) which are recommended for planting on the upper banks, together with species that characteristically occur close to watercourses and are able to tolerate waterlogged conditions (e.g. pūrei). Canopy cover is expected to be reached within three to five years, and the shade created will naturally control many of the light-demanding exotic grasses, shrubs, and herbs. The planting schedule for this area is provided in Table 7.

Table 7: Plant schedule for Planting Area 4 (*c*.3,159 m^2)

Species	Common Name	Grade	Spacing (m)	Total No.
Carex virgata[1]	pūrei	1.5L	0.5	280
Carpodetus serratus[2]	putaputawētā	1.5L	1.4	120
Cordyline australis[3]	tī kōuka	1.5L	1.4	160
Dacrycarpus dacrydioides[3]	kahikatea	1.5L	5	10
Kunzea robusta[4]	kānuka	1.5L	3	200
Leptospermum scoparium[1]	mānuka	1.5L	1.4	240
Melicytus ramiflorus[4]	māhoe	1.5L	3	100
Phormium tenax[3]	harakeke	1.5L	1.4	120
Pittosporum tenuifolium[4]	kōhūhū	1.5L	1.4	80
Veronica stricta[1]	koromiko	1.5L	1.4	170
Total				**1,480**

1. Plant on stream edge
2. Plant on toe-slope and floodplain
3. Plant throughout
4. Plant in well-drained areas (mid to upper slopes)

Figure 1: Proposed planting areas for Park Estate subdivision: Stage 1

6.2 Site preparation

Appropriate site preparation is essential to the success of indigenous revegetation plantings. All environmental pest plants should be controlled within the planting areas. Pest plants are rare in the planting areas and comprise occasional gorse on the wetland margins and barberry and tree privet in the stream riparian margin. All non-invasive exotic grasses and herbaceous plants within the wetland buffers and stream riparian margin should be blanket sprayed with a Glyphosate-based herbicide before planting work is carried out.

6.3 Agrichemical use, record keeping and reporting

All herbicide application operations should be undertaken by "Growsafe" certified operators, in line with the Agrichemical Users' Code of Practice (NZS 8409 2004: The Management of Agrichemicals) and industry best practice. This includes recording and maintaining records of all agrichemical usage on appropriate spray record sheets.

Reports summarising the herbicide application work undertaken during each year of the programme should be presented to Auckland Council on an annual basis. This report should include, but is not limited to:

- The timing of pest plant control rounds.
- Weather conditions during control rounds.
- Pest plant species controlled.
- The results/effectiveness of the control.
- Recommendations for pest plant control priorities for the following year.

6.4 Plant stock and availability

All plants should be sourced from the Manukau Ecological District, in line with Auckland Council's eco-sourcing Code of Practice. To ensure availability, the plant stock should be ordered as far in advance as possible, especially for slower-growing species required in larger grades (e.g. kahikatea).

6.5 Plant layout and spacing

In general, most shrub and smaller tree species should be planted at 1.4 to 3 metre centres. Larger growing species (e.g. kahikatea) should be planted further apart at approximately five metre centres, while maintaining an overall coverage of 1.4 metre spacing between all plants. Within wetland areas, sedges and rushes should be planted at 0.5-0.75 metre centres (3-4 plants/m^2).

6.6 Maintenance

Planted areas should be inspected at least three times during the first two years following planting. During these visits, plants should be released from exotic vegetation to ensure they are able to receive sufficient sunlight to thrive. As the plants become established they will begin to out-compete other exotic species and the

frequency of releasing will decrease. After five years no releasing should be necessary.

Limited infill planting[1] may be required during the next planting season depending on plant survival over the first summer. Infill plants should be of the same grade as those used in the initial planting. The number and species of infill plants should be identified in February or March prior to the planting season.

6.7 Pūkeko control

Pūkeko (*Porphyrio melanotus melanotus*) control should be undertaken if they are observed in high numbers near the planting areas prior to planting, or if suspected damage to the new plantings is detected. Shooting is the most effective control method for pūkeko. If shooting is to be undertaken during the game bird season, it can be carried out under a game bird hunting licence from Fish and Game NZ. Any pūkeko control that takes place outside of the game bird season requires a special permit, which can also be provided by Fish and Game NZ.

6.8 Record keeping and reporting

Records of all pest animal control operations should be maintained in line with industry best practice. A summary of the pest animal control work undertaken during each year of the programme should be presented to Auckland Council on an annual basis. This includes, but is not limited to:

- A plan showing the approximate locations of bait stations, traps, and signage;
- Timing of control rounds;
- Weather conditions during control rounds;
- Number of bait stations used, and amount of bait take;
- Number of traps installed, and number and species of animals caught; and
- A record of correspondence (if any) regarding the pest animal control operation.

6.9 Legal protection of restored stream and wetland habitat

Restored wetlands and watercourses will be protected through the use of statutory mechanisms such as protective covenants. Covenants are designed to protect ecologically significant parcels of land in perpetuity, and can include financial contributions towards fencing and ongoing pest control. Areas planted in indigenous species should also be protected in perpetuity, although such areas will most likely require a Council covenant rather than a Queen Elizabeth II Open Space covenant. Once the construction of the subdivision has been completed no stock will be present at the site. It is therefore not considered necessary to fence the protected areas.

[1] Infill planting is required on sites where there are gaps in the planting because of plant mortality or where initial stocking rates were too low.

7. MANAGEMENT OF INDIGENOUS FAUNA

7.1 Overview

Habitats were identified in the ecological assessment as having the potential to support indigenous skink species and long-tailed bat, the latter of which is classified as 'Threatened-Nationally Critical' by O'Donnell *et al*. (2018). Prior to the commencement of vegetation removal and earthworks, preliminary surveys for skinks and bats should be undertaken. If these species are detected, appropriate management plans will need to be prepared and implemented.

7.2 Lizard management

To determine potential effects on resident lizard populations, a preliminary survey for indigenous skinks would need to be undertaken, which typically involves deploying devices such as Artificial Cover Objects in likely skink habitat for a minimum of four to six weeks. Herpetologists would also undertake a thorough search for indigenous skinks, targeting objects such as logs and woody debris on the margins of scrub and shrubland.

If lizards are found to be within any habitats that are to be cleared, a Lizard Management Plan (LMP) will need to be prepared. The LMP will include the following information outlining the measures that can be undertaken to mitigate the potential impacts of the proposed works on indigenous lizard populations:

- A description of methodology for survey, trapping and relocation of lizards rescued including, but not limited to, protocols regarding salvage, relocation, nocturnal and diurnal capture, supervised habitat clearance/transfer; post-vegetation clearance capture; artificial cover objects, and opportunistic relocation. Capture techniques should be determined by the consulting herpetologist and detailed within the LMP.
- Methodology for minimising lizard mortality resulting from construction works associated with the project.
- Mechanisms for enriching lizard habitats in restoration areas including provision of additional refugia, if required, e.g. depositing salvaged logs or debris for newly released skinks that have been rescued.
- Locations for the potential release of lizards, including details on any weed and pest management to ensure the relocation site is maintained as appropriate habitat.
- Selection of a recipient site that will remain in indigenous vegetation in the long term.
- Timing of activities. The LMP must be implemented outside of the winter months of June, July and August due to low lizard detectability during the colder months.

7.3 Bat management

To determine the presence of long-tailed bats at the site, acoustic bat monitoring devices should be deployed for a minimum of ten nights during warm weather (>10 degrees Celsius at night). This could be carried out in conjunction with the preliminary lizard survey. If bats are detected, a Bat Management Plan will need to be prepared and implemented, and approved by Auckland Council, prior to tree-felling.

8. WORK PROGRAMME, RESOURCES, AND TIMELINE

The recommended work programmes for pest plant control, pest animal control and planting work is provided below. Timing is based on the Auckland Council financial year of 1 July to 30 June.

Year 1

Task	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Order plants												
Site preparation (Planting Areas 3, 4 & 6)												
Site preparation (Planting Areas 1, 2, 5 & 7); pūkeko control (if deemed necessary)												
Planting (Planting Areas 3, 4 & 6)												

Year 2

Task	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Planting (Planting Areas 1, 2, 5 & 7); pūkeko control (if deemed necessary)												
Infill planting (Planting Areas 3, 4 & 6 if required)												
Monitoring of planting and releasing where necessary												

Year 3

Task	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Infill planting (Planting Areas 1, 2, 5 & 7 if required)												
Monitoring of planting and releasing where necessary												

Year 4

Task	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Monitoring of planting and releasing where necessary												

Year 5

Task	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Monitoring of planting and releasing where necessary												

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REFERENCES

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APPENDIX 1

SITE PHOTOGRAPHS

Plate 1: Exotic species such as soft rush, watercress, and rank exotic grasses characterise a small, boggy depression in Planting Area 1. 19 March 2018.

Plate 2: Soft rush surrounded by grazed pasture in Planting Area 2 (wetland) and Planting Area B (buffer). 19 March 2018.

Plate 3: Brackish stream downstream and adjacent to Planting Area 3 (right side). The saline indigenous herb bachelor's button is visible in the middle of photograph. 6 June 2018.

Plate 4: Grazed exotic grassland characterises the banks of the stream in Planting Area 4. 23 July 2018.

RECOMMENDED HERBICIDE TREATMENTS

Pest Plant	Control Method(s)	Chemical(s)	Application Rate	Timing	Remarks
Barberry (*Berberis glaucocarpa*)	Hand pull seedlings/small plants			Year round	
	Cut and treat stumps	Triclopyr	60ml/1 litre water	October-April	
	Drill and inject	Metsulfuron	5g/1 litre water, plus 2 ml surfactant	October-April	
	Cut and treat stump	Triclopyr	60ml/1 litre water	October-March	
Chinese privet (*Ligustrum sinense*)	Hand pull seedlings/small plants			Year round	
	Cut and treat stumps	Triclopyr	60ml/1 litre water	October-April	
	Drill and inject	Metsulfuron	5g/1 litre water, plus 2 ml surfactant	October-April	
Gorse (*Ulex europaeus*)	Knapsack – foliar spray	Metsulfuron	5g/10 litres water plus 10ml Pulse	November-March	
	Cut and treat stumps	Triclopyr	60ml/1 litre water	October-March	
Mercer grass (*Paspalum distichum*)	Knapsack – foliar spray	Glyphosate 360	100ml/10 litres water	Year round	
	Knapsack – foliar spray	Haloxyfop	70ml/10 litres water	Year round	Useful for releasing around indigenous plantings to minimise non-target damage. Not to be used over water.
Tree privet (*Ligustrum lucidum*)	Cut and treat stumps	Triclopyr	60ml/1 litre water	November-March	
	Drill and inject	Metsulfuron	20g/litre water, plus 2ml surfactant	November-March	

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ASSESSMENT OF ECOLOGICAL EFFECTS OF A PROPOSED URBAN DEVELOPMENT AT 144-252 PARK ESTATE ROAD, HINGAIA (PHASE 2 WORKS)

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ASSESSMENT OF ECOLOGICAL EFFECTS OF A PROPOSED URBAN DEVELOPMENT AT 144-252 PARK ESTATE ROAD, HINGAIA (PHASE 2 WORKS)

Overview of wetland and an intermittent stream at 144-252 Park Estate Road.

Contract Report No. 4969

May 2019

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CONTENTS

Reviewed and approved for release by:

_____

Nick Goldwater
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1. INTRODUCTION

Civil Plan Consultants Limited, on behalf of Hugh Green Limited (the client), is developing a master plan for a large urban development at 144-252 Park Estate Road, Hingaia. These properties contain significant areas of wetlands (particularly at 144 Park Estate Road) and a number of degraded watercourses, which the client is seeking to reshape through reclamation and enhancement works in order to allow residential subdivision.

Most of the land is zoned as 'Residential - Mixed Housing Suburban Zone' under the Auckland Unitary Plan (AUP), with smaller areas zoned as 'Residential - Mixed Housing Urban Zone' and 'Business - Neighbourhood Centre Zone'.

Bulk earthworks have been proposed in two Phases. Phase 1 comprises the northwestern part of the site, and was consented in 2018 (BUN60325204). Phase 2 generally comprises the remaining land between the Phase 1 parcel, the southern motorway, and coastal boundary.

To this end, Civil Plan Consultants Limited has requested that Wildland Consultants Ltd prepare an assessment of ecological effects for the proposed development within the Phase 2 earthworks area. The assessment includes the following:

(i) Mapping and descriptions of the existing vegetation, habitats and ecosystems present;

(ii) Ecological values of vegetation and habitats, including Stream Ecological Valuations (SEVs) of potentially affected watercourses;

(iii) Potential ecological effects of the proposed earthworks and development; and

(iv) Recommendations to avoid, mitigate, offset and compensate potential adverse ecological effects.

2. ECOLOGICAL CONTEXT

2.1 Overview

144-252 Park Estate Road is located in the suburb of Hingaia within the Manukau Ecological District. The Manukau Ecological District covers *c*.62,100 hectares of low altitude rolling hills and flats between the Manukau Harbour in the north and the Waikato River in the south. The underlying geology is predominantly Pliocene-Quaternary basalts, with smaller areas of Pliocene sediments bordering the harbour, and Holocene river sediments near the Waikato River.

Most of the district has fertile, well-drained soils derived from weathered volcanic ash. The fertile soils, in combination with reliable rainfall, mean that the district is well suited for agriculture and horticulture and consequently most of the district has been highly modified. The former forest cover, most often dominated by pūriri (*Vitex lucens*), taraire (*Beilschmiedia tarairi*), or kahikatea (*Dacrycarpus dacrydioides*), has been severely reduced in extent. Only 908 hectares (2%) of the original

42,462 hectares of podocarp/broadleaved species forest and kauri (*Agathis australis*) forest remains, and of these 908 hectares, only 103 hectares is protected. The loss of freshwater wetlands has been even greater, with 105 hectares (0.4%) remaining, of which only two hectares are protected (Lindsay *et al.* 2009). Estuarine vegetation, including seagrass (*Zostera muelleri* subsp. *novozelandica*) beds, mangroves (*Avicennia marina* subsp. *australica*), and saltmarsh are now the most extensive areas of indigenous vegetation remaining. In 2006, mangroves were estimated to cover *c*.1,100 hectares within Manukau Harbour (Kelly 2008).

2.2 Local context

The study site is located in rural land to the west of Papakura and Drury. It is bounded by Park Estate Road to the north and the southern motorway to the east, while the southern and eastern margins border the lower saline reaches of Drury Creek. Drury Creek includes two marine Significant Ecological Areas (SEA-M2-29w1 and SEA-M2-29a), which include a 'significant wading bird area'. Mangroves are abundant in this part of Drury Creek, while oioi (*Apodasmia similis*) salt meadow is locally common on the southern boundary of the study site, adjacent to the Drury Esplanade Reserve. Land to the west and south of the study site is largely characterised by farming and horticulture, although urban development has recently commenced in areas such as Karaka.

Approximately 70% of the study site is located on 'Acutely Threatened' land environments (<10% indigenous vegetation cover remaining) and 30% is on 'Critically Underprotected' land environments (>30% left and <10% protected) (Walker *et al*. 2007).

2.3 Site description

The property occupies an area of land approximately 96.6 hectares in size, most of which is grazed. The land is predominately gently sloping with a southerly aspect, although there are some steeper sections of land towards the north of the site, and some flat land in the south bordering the estuary. The eastern side of the property is characterised by several large adjoining wetland systems and associated intermittent streams and drains. A smaller wetland system and stream are also present in the western part of the site. All streams and wetlands drain into the Drury Creek to the south.

In terms of the existing development (prior to Phase 1 earthworks), the land is largely undeveloped with only a few dwellings in the north of the site accessed off Park Estate Road. Access roads occur on the property, which were previously used by the farm manager and Watercare. The majority of woody vegetation on the property are located adjacent to Drury Creek.

3. METHODS

3.1 Vegetation and habitat survey

A literature search was undertaken to identify relevant ecological information on the site, and existing information was collated and reviewed. This desktop review included a search of the New Zealand Freshwater Fish Database (NIWA 2018) to obtain local records of fish.

Site visits were carried out on 19 March 2018, 6 June 2018, and 19 March 2019. The 2018 surveys focussed on a broad scale site overview and vegetation characterisation, and the areas included in Phase 1 of the development earthworks. The 2019 site visit focussed on further characterising the vegetation and habitats within the Phase 2 development earthworks, being the subject of the current report.

During the site visits, all wetlands and watercourses were mapped and broadly described (Figure 1). All vascular plant species observed at the site were recorded (Appendix 1). Representative photographs were taken in the field, and these are provided throughout this report.

Vegetation and habitat types were digitised onto aerial imagery using ArcGis10.1.

3.2 Fauna survey

The suitability of the vegetation at the site to provide habitat for species such as pekapeka (long-tailed bait; *Chalinolobus tuberculatus*), forest gecko (*Mokopirirakau granulatus*), elegant gecko (*Naultinus elegans elegans*), copper skink (*Oligosoma aeneum*), and ornate skink (*O. ornatum*) was assessed during the initial 2018 site visits.

A lizard survey was carried out on the property in spring 2018 as part of the Phase 1 consent works. Twenty-seven lizard funnel traps were baited with canned pear and checked on three consecutive mornings. The traps were set in three clusters of five and two clusters of six within vegetation near the pasture margins within the Phase 1 works area.

Hand-searching for lizards was also carried out in both spring 2018 within the Phase 1 works area and March 2019 within the Phase 2 works area. Hand-searching targeted logs, low-lying vegetation, and other woody debris. Based on the Phase 1 results whereby only plague skinks (*Lampropholis delicata*) were found (see Section 6.4), it was considered unlikely that installing funnel traps in the Phase 2 area would detect any indigenous skinks.

Targeted surveys for avifauna and fish species were outside of the scope of this study. For bird species, incidental observations were carried out during all site visits. No targeted fish surveys were carried out due to the general absence of water within the affected stream reaches at the time of survey.

3.3 Stream Ecological Valuation (SEV)

SEVs were carried out on the impact and proposed offset reaches on 19 March 2019 (Figure 2). The SEV methodology is a comprehensive means of quantifying the value of aquatic ecosystems. This method was developed by a panel of experts (Rowe *et al*. 2006, Storey *et al*. 2011) for Auckland Regional Council, and is the recommended method for assessing streams in the Auckland and Wellington regions. It has also been applied successfully in other parts of New Zealand. In 2016, an additional SEV calculator was created that includes reference data for intermittent streams (Neale *et al.* 2016). This allowed the use of the method to be expanded to the assessment of intermittent streams.

The SEV calculation uses a range of qualitative and quantitative variables to quantify the main ecological functions of streams. This data is manipulated using a series of formulae to produce an SEV score of between 0 (a stream with no ecological values) and 1 (a pristine stream with maximum ecological values). The method allows very different streams to be evaluated and compared.

Usually, fourteen key ecological functions of streams are assessed. These key functions are divided into four categories (Table 1) and all are weighted equally. The resulting SEV score is the mean function score (i.e. the sum of all function scores divided by 14). These function scores enable stream and catchment managers to understand the range of ecological services a stream provides.

Table 1: Summary of the 14 ecological functions used to calculate SEV scores.

Hydraulic Functions (Processes associated with water storage, movement and transport)	**Habitat Provision** (The types, amount and quality of habitats that the stream reach provides for flora and fauna)
1. Natural flow regime 2. Floodplain effectiveness 3. Connectivity for natural species migrations 4. Natural connectivity to groundwater	10. Fish spawning habitat 11. Habitat for aquatic fauna
Biogeochemical Functions (Relates to the processing of minerals, particulates and water chemistry)	**Biodiversity Functions** (The occurrence of diverse populations of indigenous native plants and animals that would normally be associated with the stream reach)
5. Water temperature control 6. Dissolved oxygen maintained 7. Organic matter input 8. In-stream particle retention 9. Decontamination of pollutants	12. Fish fauna intact (Note: excluded from this assessment) 13. Invertebrate fauna intact (Note: excluded from this assessment) 14. Riparian vegetation intact

When SEVs are calculated for impact and potential offset reaches, the scores can be used to determine an Environmental Compensation Ratio (ECR). This value is used to calculate the total stream area that should be restored at the offset reach to ensure "no net loss in ecological value".

When calculating an ECR the biotic functions relating to fish and invertebrate fauna are not included. This is because of the difficulty associated with predicting how fish

and macroinvertebrate communities will respond to different impacts. For this reason, in conjunction with low water levels in the streams assessed, fish and invertebrate data was not collected at the study site. SEV data for the impact and compensation streams are presented in Appendix 2.

3.3.1 SEV and ECR methodology constraints

It is recognised (e.g. in Neale *et al.* 2016) that SEVs for intermittent streams should take place when flowing water is present in the stream to allow for more accurate measurements of SEV functions dependent on water presence, including dissolved oxygen, macrophyte presence, and depth and width measurements. However, due to time limitations on consent lodgement, it was not an option in this case to wait until the winter months to carry out these assessments.

At the time of assessment, most of the streams had no surface water present, and the streams that did had insufficient flow to undertake velocity measurements. Proxy measurements have therefore been assigned for functions dependent on water presence, based on the assumptions outlined in Appendices 4 and 5 and the assessor's experience undertaking SEVs in similar environments.

As all the streams outlined in this report and used in the ECR calculations have been undertaken in the same conditions, it is considered the SEV scores are relative to each other and therefore will provide a reasonably accurate representation of the offsetting extents proposed.

4. VEGETATION AND HABITATS

4.1 Overview

Eight broad terrestrial vegetation types were identified at the site during the surveys:

1. Soft rush-rank grass-creeping buttercup rushland
2. Soft rush-Mercer grass rushland
3. Water pepper herbfield
4. Mercer grass-soft rush grassland
5. Eucalyptus obliqua treeland
6. Exotic treeland and shelterbelts
7. Exotic coastal forest and scrub
8. Exotic grassland

Each of these vegetation types is described below, with Figure 1 displaying the distribution of the types.

Aquatic habitats (permanent and intermittent streams) are described in Section 4.3, with particular focus on the 'impact' and proposed 'compensation' streams.

4.2 Terrestrial habitats

4.2.1 Soft rush-rank grass-creeping buttercup rushland (Vegetation Type 1)

This vegetation type is primarily restricted to a small wetland in the northwest of the Phase 2 works area, along with pockets in the southeast. It is characterised by co-dominant soft rush (*Juncus effusus*), rank exotic grasses such as Mercer grass (*Paspalum distichum*) and Yorkshire fog (*Holcus lanatus*), and creeping buttercup (*Ranunculus repens*) with local willow weed (*Persicaria maculosa*) and water pepper (*P. hydropiper*), frequent lotus (*Lotus pedunculatus*), and scattered emergent gorse (*Ulex europeaus*) (Figure 1, Plate 1). The soil was very boggy throughout most of this vegetation type.

Plate 1: Exotic species such as soft rush, watercress, and rank exotic grasses characterise a small, boggy depression in Wetland 1. 19 March 2018.

4.2.2 Soft rush-Mercer grass rushland (Vegetation Type 2)

The larger wetlands in the east of the site are dominated by soft rush and Mercer grass with frequent exotic herbs including water pepper, willow weed, creeping buttercup, and lotus (Figure 1, Plates 2-4). These wetlands also support locally common rautahi (*Carex lessoniana*), one of the few indigenous wetland plant species at the site. The soil was very boggy throughout most of this vegetation type, and small pools of standing water were observed.

Plate 2: Grazed Mercer grass and discrete patches of soft rush on hillslope seeps within Wetland 2. 19 March 2018.

Plate 3: Soft rush surrounded by grazed pasture in Wetland 3. 19 March 2018.

Plate 4: View looking southwest across a large wetland characterised by soft rush and Mercer grass. 19 March 2018.

4.2.3 Water pepper herbfield (Vegetation Type 3)

A cluster of small, scattered ephemeral wetlands in the centre of the property are characterised by abundant water pepper with frequent to occasional soft rush (Figure 1, Plate 5). These wetlands are likely to become dry during summer, which may in turn result in a change in plants species composition.

Plate 5: Water pepper and soft rush characterise some of the smaller ephemeral wetlands at the site. 19 March 2018.

4.2.4 Mercer grass-soft rush grassland (Vegetation Type 4)

Vegetation Type 4 occurs on both sides of the central farm race (Figure 1) and is characterised by abundant Mercer grass and commonly occurring soft rush with frequent exotic herbs such as creeping buttercup and water pepper (Plate 6). A partially blocked culvert under the farm race has caused low-lying areas to become flooded on the eastern side of the farm race (Plate 7). Downstream (on the western side of the farm race), the water is brackish and plant species such as bachelor's button (*Cotula coronopifolia*) occur locally (Plate 8).

Plate 6: Clumps of Mercer grass and soft rush are emergent in open water adjacent to the central farm race. 6 June 2018.

Plate 7: Mercer grass, soft rush and creeping buttercup occur in flooded parts of Vegetation Type 4. 6 June 2018.

Plate 8: Brackish stream downstream and adjacent to Vegetation Type 4. The prostrate indigenous herb Bachelor's button is visible in the middle of photograph. 6 June 2018.

4.2.5 *Eucalyptus obliqua* treeland (Vegetation Type 5)

Two planted copses of *Eucalyptus obliqua* (*c.*15-18 metres tall) occur near the southern boundary of the property (Figure 1). They were planted as a Watercare wastewater treatment development. The understorey is relatively open and largely comprises exotic grasses and herbs (Plate 9). Interpretation of historical aerial photography (Auckland Geomaps) shows that the plantation is at least thirty years old.

This vegetation is scheduled for removal prior to lodgement of the consent application.

Plate 9: Understorey and ground tier vegetation in the *Eucalyptus obliqua* treeland. 6 June 2018.

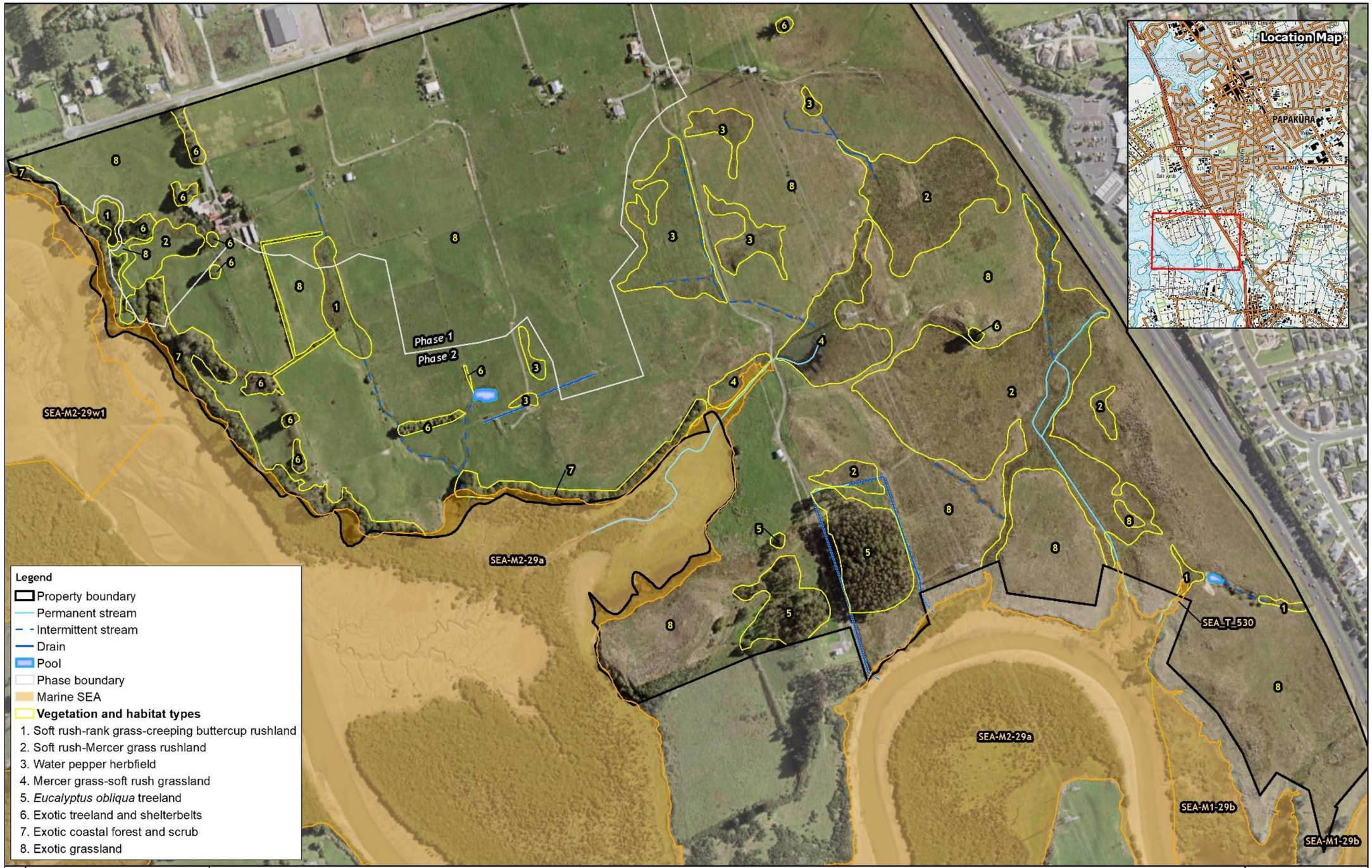
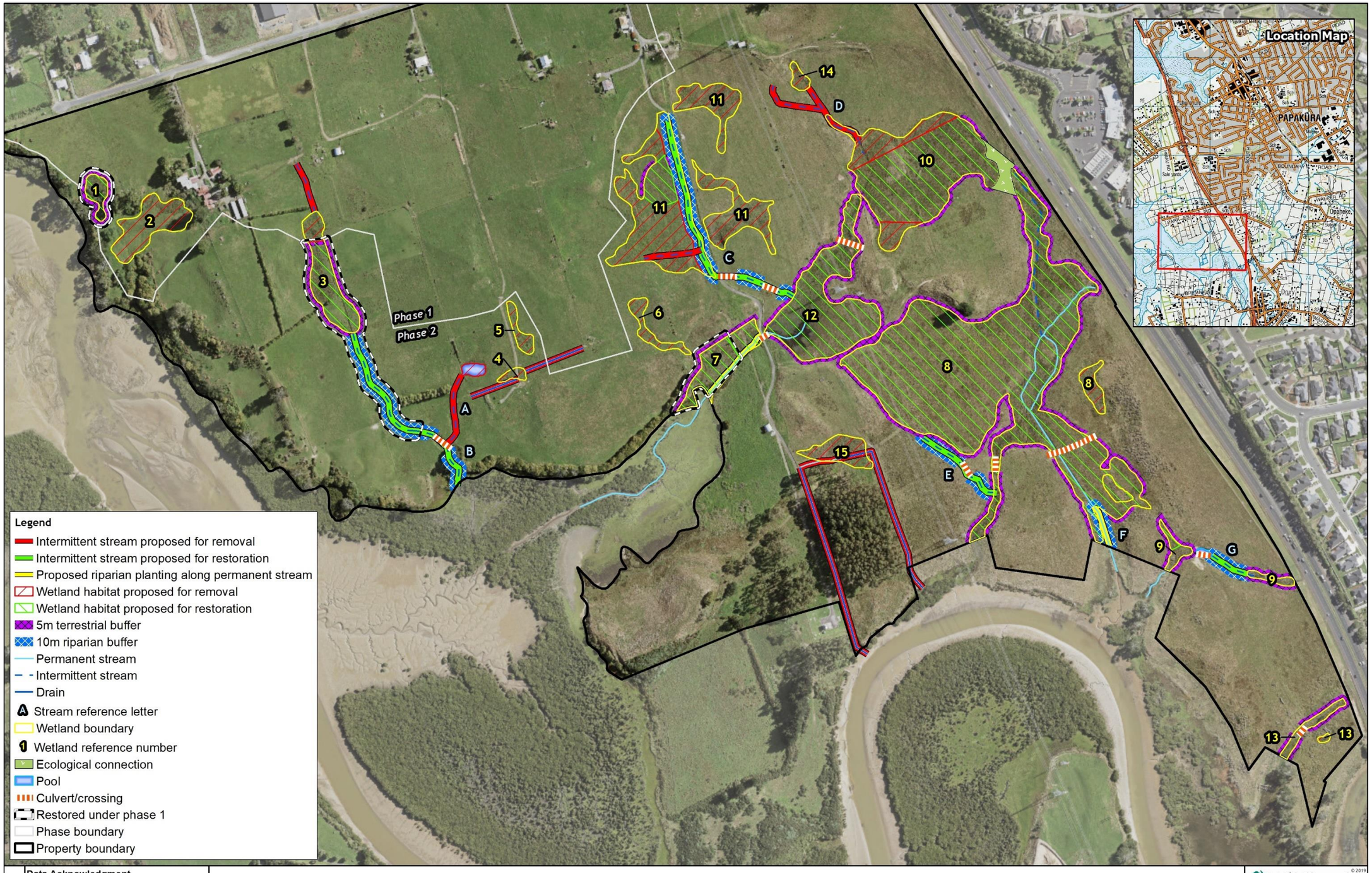


Figure 1. Vegetation and habitat types at Park Estate Road, Hingaia



Data Acknowledgment
Map contains data sourced from LINZ
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Figure 2. Proposed options for wetland and stream compensation for Phase 2 works at Park Estate Road, Hingaia

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4.2.1 Exotic treeland and shelterbelts (Vegetation Type 6)

Discrete areas of exotic treeland frequently occur in the western areas of the study site. Stand-alone trees and small groups of trees are typically characterised by eucalyptus (*Eucalyptus* spp.), English oak (*Quercus robur*), Lombardy poplar (*Populus nigra*), macrocarpa (*Cupressus macrocarpa*), and Monterey pine (*Pinus radiata*). Shelterbelts have been planted in an east-west orientation alongside some of the paddocks at the site, most of which comprise tree privet (*Ligustrum lucidum*) and to a lesser extent, crack willow (*Salix fragilis*) and necklace poplar (*Populus deltoides*).

4.2.2 Exotic coastal forest and scrub (Vegetation Type 7)

Forest and scrub dominated by exotic plant species are largely restricted to the western margin of the property, adjacent to Drury Creek (Figure 1). Frequent canopy species include tree privet and black wattle (*Acacia mearnsii*), with scattered mature emergent pines (*Pinus radiata and P. pinaster*) (Plate 10). Other pest plant species such as pampas (*Cortaderia selloana*) and Japanese honeysuckle (*Lonicera japonica*) occur throughout this vegetation type (Freshwater Solutions Ltd 2015). Indigenous species, including tī kōuka (*Cordyline australis*), māpou (*Myrsine australis*), whekī (*Dicksonia squarrosa*) and bracken (*Pteridium esculentum*), occur occasionally (Freshwater Solutions Ltd 2015).

Plate 10: Tree privet and brush wattle form a canopy along the coastal margin of the site. Mature emergent pine trees are also visible. 19 March 2018.

4.2.3 Exotic grassland (Vegetation Type 8)

Grazed and rough exotic grassland is the most abundant vegetation type at the site and comprises grass species such as kikuyu (*Cenchrus clandestinus*), cocksfoot (*Dactylis glomerata*), rye grass (*Lolium perenne*), and Yorkshire fog together with herbs such as white clover (*Trifolium repens*), clustered dock (*Rumex conglomeratus*), and narrow-leaved plantain (*Plantago lanceolata*).

4.3 Freshwater habitats

4.3.1 Overview

The Phase 2 earthworks extent contains approximately seven intermittent streams and at least two permanent reaches (Figure 1), all of which have been adversely impacted by the removal of riparian buffering and trampling/pugging by stock. The stream channels often become diffuse where they flow through wetlands. The majority of intermittent stream channels support abundant exotic macrophytes such as water pepper and Mercer grass. Artificial drains occur at two locations on the property (Figure 1), and are most conspicuous on the margins of the *Eucalyptus obliqua* treeland.

The Phase 2 earthworks extent includes streams proposed to be piped, culverted, or reclaimed, and streams proposed to be restored (Figure 2). The locations of these streams as described below are mapped in Figure 2.

4.3.2 Impact Reach A

This impact reach forms the headwaters of an intermittent stream (*c.*100 metres long), adjoining another intermittent stream at its downstream end (Reach B). The stream headwaters are sourced from a small pond. Both the pond and stream were dry at the time of the March 2019 site assessment (Plate 11), however, water presence was observed at the lower end. The adjoining Reach B has been partially approved for restoration as part of the Phase 1 development works. The remaining downstream portion of the adjoining stream will be restored in association with the current works (as per Section 4.3.4).

The watercourse has evidence of a defined channel being present throughout the winter months, with macrophytes still occurring in wetter parts of the channel, including water pepper, Mercer grass and soft rush. The remaining vegetation largely comprises terrestrial pasture species such as clustered dock, white clover, creeping buttercup, and narrow-leaved plantain. Evidence of stock grazing the channel is present and has resulted in poorly defined channel boundaries in sections (Plate 12). Woody species are absent from the riparian margins.

Plate 11: Dry pond at upstream end of impact reach. 19 March 2019.

Plate 12: Pasture vegetation and pugging within stream channel. 19 March 2019.

4.3.3 Impact Reach D

This reach forms two adjoining watercourses between a small upstream wetland area and larger downstream wetland area (see Figures 1 and 2). No flowing water was present in either watercourse at the time of the site assessment, although defined banks and channels covered in aquatic macrophytes were discernible in most cases (Plate 13). Macrophytes most commonly observed include water pepper, Mercer

grass, and soft rush. Scattered gorse is present in the riparian margins, otherwise these are dominated by exotic pasture grasses and herbs.

Plate 13: Western arm of impact reach with water pepper in channel, looking downstream. 19 March 2019.

4.3.4 Proposed Offset Reach B

The riparian vegetation of this proposed offsetting reach is characterised by grazed exotic pasture grasses and herbs comprising rye grass and creeping bent (*Agrostis stolonifera*) along with locally common creeping buttercup and white clover. Woody species are largely absent from the riparian margins, aside from occasional exotic shrubs including tree privet and barberry (*Berberis glaucocarpa*). One mature pine tree (*Pinus radiata*) is present at the downstream end of the watercourse near the property boundary.

The upper reaches of the current offset reach are low-lying and boggy with soft fine sediment forming the bed of the stream, while the lower reaches have a more defined channel within a vegetated canopy (Plate 14).

4.3.1 Proposed Offset Reach C

This reach is characterised by narrow channels which appear to have been deepened and straightened in the past, perhaps to allow more suitable grazing of the surrounding wetland areas. The main channel extent runs to the immediate west of the main farm race (Plate 15), with channel definition being affected by cattle presence. Water was present intermittently in pools at the time of the site assessment, primarily in heavily grazed sections and likely as a result of recent rain. The surrounding wetland was largely dry, but becomes inundated over the winter months as observed on previous site visits.

Plate 14: Downstream extent of offset Reach B beneath mature pine. 19 March 2019.

Plate 15: Looking upstream of watercourse alongside farm race. 19 March 2019.

The lower reaches of the watercourse, downstream of the farm race, feature a deeper defined channel with some barberry and blackberry (*Rubus fruticosus* agg.) present in the riparian margins. The remaining in-stream and riparian vegetation features a mixture of aquatic macrophytes and terrestrial pasture species, most notably Mercer

grass, paspalum (*Paspalum dilatatum*), creeping bent, cocksfoot, soft rush, willow weed, and kikuyu.

4.3.2 Proposed Offset Reach E

The reach is set within a wider wetland-like environment with vegetation including water pepper, soft rush, creeping buttercup, Yorkshire fog, lotus, and clustered dock. No surface water was present at the time of the current site assessment; however, channel width has been able to be estimated based on presence of aquatic macrophytes (Plate 16) and previous site visits when water has been present.

Plate 16: Intermittent stream channel within wet pasture, dominated by water pepper. 19 March 2019.

4.3.3 Proposed Offset Reach F

This reach forms the downstream extent of a permanent stream up to one metre wide in sections, located adjacent to Wetland 8. The surrounding vegetation includes both wetland (soft rush-Mercer grass rushland) species as described in Section 4.2.2, together with exotic dominant pasture vegetation on the true left bank.

This channel appears to have been straightened and deepened in an attempt to drain the surrounding wetland, although it has retained a sufficient volume of water and flow. The reach is in close proximity to Drury Creek and may be tidally influenced during spring tides.

4.3.4 Proposed Offset Reach G

This watercourse is located at the easternmost side of the property, bounding the State Highway 1 motorway. The watercourse occurs between two crossings, both currently

in disrepair. Impounded water upstream of the eastern crossing has formed a wetland upstream, while the western crossing has formed a pond (Plate 17). The pond is to be dewatered and culverted as part of the development, while the remaining watercourse is proposed to be restored. At present stagnant water is present throughout the stream, intermixed with woody debris from rotting trees in the riparian margins and regenerating crack willow (Plate 18), and dense mats of aquatic macrophytes such as willow weed and Mercer grass. Additional aquatic macrophytes observed within the channel include grass-leaved rush (*Juncus planifolius*), water forget-me-not (*Myosotis laxa* subsp. *caespitosa*), rautahi, water purslane (*Ludwigia palustris*), water plantain (*Alisma plantago-aquatica*), and soft rush.

Plate 17: Pond at downstream end of watercourse, looking toward damaged crossing. 19 March 2019.

Plate 18: Crack willow regenerating within stream channel. 19 March 2019.

5. FLORA

Seventeen species of indigenous plants and 57 species of naturalised plants were recorded during the site surveys (Appendix 1), although an exhaustive search for plants was not undertaken during the surveys. No vascular plant species recorded are classified as nationally or regionally threatened as per de Lange *et al.* (2018) and Stanley *et al*. (2005), respectively.

6. FAUNA

6.1 Avifauna

Nine indigenous bird species were observed during the surveys: poaka/pied stilt (*Himantopus himantopus leucocephalus*), pīwakawaka/fantail (*Rhipidura fuliginosa placabilis*), spur-winged plover (*Vanellus miles novaehollandiae*), pūkeko (*Porphyrio porphyrio melanotus*), kāhu (*Circus approximans*), welcome swallow (*Hirundo tahitica*), paradise shelduck (*Tadorna variegata*), piropiro/grey warbler (*Gerygone igata*) and kōtare/kingfisher (*Todiramphus sanctus vagans*). None of these species is classified as 'Threatened' or 'At Risk' by Robertson *et al.* (2017).

Four exotic bird species were recorded: myna (*Acridotheres tristis*), common pheasant (*Phasianus colchicus*), skylark (*Alauda arvensis*), and feral pigeon (*Columba livia*).

6.2 Aquatic fauna

A targeted fish survey was beyond the scope of the project. It is, however, considered likely that indigenous fish species are present in the lower reaches of the permanent and intermittent watercourses, particularly eels (*Anguilla* spp.), banded kōkopu (*Galaxias fasciatus*), and inanga (*G. maculatus*).

A search of the New Zealand Freshwater Fish Database (NIWA 2018) was undertaken on 25 July 2018 (Table 2). Records in the database indicate that the Pahurehure Inlet and its tributaries, including Drury Creek, support a wide range of indigenous fish and macroinvertebrate species, including several that are threatened. Table 2 lists the species found and their threat status as per Dunn *et al*. (2017) for fish and Grainger *et al*. (2014) for aquatic invertebrates.

Table 2: Fish species recorded from Pahurehure Inlet and tributaries (New Zealand Freshwater Fish Database).

Species Name	Common Name	Threat Classification
Fish		
Anguilla australis	Shortfin eel	Not Threatened
Anguilla dieffenbachii	Longfin eel	At Risk-Declining
Cyprinus carpio	Koi carp	Introduced and Naturalised
Galaxias fasciatus	Banded kōkopu	Not Threatened
Galaxias maculatus	Inanga	At Risk-Declining
Gambusia affinis	Mosquitofish	Introduced and Naturalised
Gobiomorphus cotidianus	Common bully	Not Threatened
Gobiomorphus gobioides	Giant bully	Not Threatened

Species Name	Common Name	Threat Classification
Invertebrates		
Echyridella menziesi	Freshwater mussel	At Risk-Declining
Paranephrops planifrons	Freshwater crayfish	Not Threatened
Paratya curvirostris	Freshwater shrimp	Not Threatened

6.3 Long-tailed bats

Long-tailed bats (*Chalinolobus tuberculatus*) occur in the Auckland Region within forests dominated by both indigenous and exotic trees. The species is classified as 'Threatened-Nationally Critical' by O'Donnell *et al*. (2018). The species is threatened by habitat loss, primarily the loss of roost trees, and by predation by introduced mammals.

The closest record of long-tailed bat is from Clevedon Scenic Reserve, approximately 14 kilometres to the northeast (Bioresearches Ltd 2013). With removal of the mature *Eucalytpus obliqua* trees in the south of the property, potential bat habitat within the Phase 2 earthworks area is considered unlikely to be present.

6.4 Herpetofauna

The closest lizard record to the study site is for copper skink, approximately 2.8 kilometres to the northwest (Department of Conservation Herpetofauna Database). Habitat for indigenous arboreal geckos is generally not suitable at the study site, and it is considered highly unlikely that geckos are present.

The previous lizard survey on the property undertaken in spring 2019 found no indigenous skinks within the trapping period. Eight plague skinks (*Lampropholis delicata*) were caught in the traps, and several more plague skinks were observed whilst searching through vegetation. Plague skinks are classified as an 'Unwanted Organism' under the Biosecurity Act 1993.

If indigenous skinks are present at the site, they are currently at levels below detectability. It is therefore considered the current phase of works could continue without specialist lizard management being undertaken.

6.5 Introduced pest mammals

Pest animals likely to be present at the site include brush-tailed possums (*Trichosurus vulpecula*), ship rats (*Rattus rattus*), Norway rats (*R. norvegicus*), mice (*Mus musculus*), and hedgehogs (*Erinaceus europaeus*). Mustelids (stoats, *Mustela erminea*; ferrets, *M. furo*; and weasels, *M. nivalis vulgaris*) and feral and domestic cats (*Felis catus*) may also utilise the site occasionally.

7. STREAM ECOLOGICAL VALUATION

7.1 Impact reaches

7.1.1 Overview

The 12 functions measured in an SEV assessment are grouped into four categories: Hydraulic Functions, Biogeochemical Functions, Habitat Provision Functions and Biodiversity Functions. Both impact streams (see Figure 2) are intermittent streams near the top of the catchment, with only a pond/wetland upstream, and therefore have similar scores. A summary of the scores is provided in Table 3, and scores separated out by category are included in Appendix 2.

Table 3: Summary of SEV scores for each SEV impact reach. Note: Biodiversity Functions relating to fish and aquatic macroinvertebrates are not calculated when an SEV is being undertaken to calculate the Environmental Compensation Ratio.

Category	Impact Reach A	Impact Reach D
Hydraulic Functions	0.54	0.68
Biogeochemical Functions	0.35	0.34
Habitat Provision Functions	0.18	0.20
Biodiversity Functions	0.10	0.10
Mean SEV score (excluding Biodiversity Functions)	**0.29**	**0.33**

7.1.2 Hydraulic functions

Both impact reaches obtained a moderate to good score for Hydraulic functions (Table 3). Both streams have a predominately natural bed, however, the channel has been impacted by apparent straightening and excessive macrophyte growth. Both reaches have damage caused to the banks and stream bed from stock grazing. Impact Reach D has no physical barrier to fish migration (e.g. perched culverts) present, although impact Reach A has a crossing in the upstream area nearby the pond, which has contributed to a slightly lower score under this category.

7.1.3 Biogeochemical functions

Both impact reaches obtained poor scores for Biogeochemical functions (Table 3), largely reflective of very poor shading from woody vegetation in the riparian margins, with this generally being absent. Small amounts of shade would be provided to the water surface by aquatic macrophytes, however, dense macrophyte growth as observed here is representative of poorer water quality resulting from high nutrient levels. Macrophytes can cause oxygen levels to drop at night, placing additional stress on aquatic fauna. They also trap organic matter, which in turn contributes to the formation of anaerobic sediment patches.

7.1.4 Habitat provision functions

Both impact reaches achieved poor mean scores for the Habitat Provision Functions (Table 3). Both reaches have some gently sloping banks present that will become

flooded during high rainfall events, but the lack of shade makes these reaches unsuitable for galaxid spawning. The lack of a significant amount of stable habitat such as large woody debris or cobbles/boulders means there is no suitable breeding habitat for bullies (*Gobiomorphus* spp.) within either reach. Physical habitat variation within the streams is limited, and stable habitat for macroinvertebrates is provided only in the form of in-stream macrophyte presence.

7.1.5 Biodiversity functions

As the overall focus of the SEVs was to provide data for an ECR calculation, the Biodiversity Functions related to fish and aquatic macroinvertebrates (Functions 12 and 13, Table 1) were not calculated. Predicting how biodiversity values will respond to restoration is difficult and therefore these functions are not included in ECR calculations. However, the Riparian Vegetation Intactness variable was assessed and the reaches scored poorly (both achieving a score of only 0.10) due to the absence of woody riparian vegetation.

7.2 Offset reaches

7.2.1 Overview

A summary of the scores of the intermittent offset reaches (see Figure 2) is provided in Table 4, and scores separated out by category are included in Appendix 2. An SEV assessment was not undertaken for the permanent offset stream (Reach F, Figure 2) due to this being incomparable in ECR calculations.

Table 4: Summary of SEV scores for each SEV offset reach. Note: Biodiversity Functions relating to fish and aquatic macroinvertebrates are not calculated when an SEV is being undertaken to calculate the Environmental Compensation Ratio.

Category	Offset Reach B	Offset Reach C	Offset Reach E	Offset Reach G
Hydraulic Functions	0.63	0.42	0.68	0.40
Biogeochemical Functions	0.40	0.23	0.28	0.40
Habitat Provision Functions	0.22	0.21	0.18	0.40
Biodiversity Functions	0.11	0.10	0.12	0.18
Mean SEV score (excluding Biodiversity Functions)	**0.43**	**0.24**	**0.32**	**0.35**

7.2.2 Hydraulic functions

Two of the offset reaches (Reaches C and G, Table 4) obtained moderate scores for Hydraulic functions, while the others obtained good scores (Reaches B and E, Table 4). The main differences between the offset reaches relate to whether barrier to fish migration are present, with no barriers occurring in Reach B or E, but a partial barrier occurring in Reach C in the form of an undersized culvert, and a complete barrier occurring in Reach G in the form of a removed culvert. The reaches also have

varying degrees of channel modification including excessive macrophyte growth and unnatural loadings of sediment. Reach C appears to be almost completely deepened and straightened as a result of trying to drain the adjacent wetland area.

7.2.3 Biogeochemical functions

Reaches C and E obtained poor scores for Biogeochemical function, while Reaches B and G obtain moderate scores (Table 4). The poor scores are largely attributable to an almost complete lack of woody riparian vegetation. Small amounts of shade would be provided to the water surface by aquatic macrophytes, however, dense macrophyte growth as observed here is representative of poorer water quality resulting from high nutrient levels. Macrophytes can cause oxygen levels to drop at night, placing additional stress on aquatic fauna. They also trap organic matter, which in turn contributes to the formation of anaerobic sediment patches. Reaches B and G obtained higher scores due to some woody vegetation presence and more variation in in-stream substrate, including leaf litter and woody debris.

7.2.4 Habitat provision functions

Most offset reaches achieved poor mean scores for the Habitat Provision Functions, aside from Reach G which achieved a moderate score (Table 4). Reach G was the only reach which had some suitable galaxid spawning habitat, although all reaches except Reach E have some gently sloping banks present that will become flooded during high rainfall events. The lack of a significant amount of stable habitat such as large woody debris or cobbles/boulders means there is very little suitable breeding habitat for bullies (*Gobiomorphus* spp.) within the reaches. Physical habitat variation within the streams is limited, and stable habitat for macroinvertebrates is provided only in the form of in-stream macrophyte presence, with the exception of Reach G which also had some woody debris within the stream.

7.2.5 Biodiversity functions

As the overall focus of the SEVs was to provide data for an ECR calculation, the Biodiversity Functions related to fish and aquatic macroinvertebrates (Functions 12 and 13, Table 1) were not calculated. Predicting how biodiversity values will respond to restoration is difficult and therefore these functions are not included in ECR calculations. However, the Riparian Vegetation Intactness variable was assessed and the reaches scored poorly (achieving scores of 0.10 - 0.18, Table 4) due to the general absence of woody riparian vegetation.

8. ECOLOGICAL VALUES

8.1 Terrestrial vegetation values

Woody terrestrial vegetation within the Phase 2 earthworks extent is largely limited to scattered exotic trees including tree privet, crack willow, and radiata pine. These trees will provide roosting and nesting habitat for birds, but are unlikely to support long-tailed bats due to lack of size and sufficient habitat complexity. Suitable habitat for indigenous gecko species is absent from the site, and the fact that the woody

vegetation is isolated from larger tracts of indigenous vegetation further precludes their presence. Rank grass on the margins of woody vegetation provides potential habitat for indigenous skinks, however, none have been discovered on the site in past surveys.

The value of terrestrial vegetation is considered to be very low.

8.2 Wetland values

Wetlands present within the Phase 2 earthworks extent include a mixture of small fragmented wetland patches, along with larger areas of wetland in the central east of the property. All wetlands have been highly modified by stock and are dominated by exotic plant species, although there are some localised patches of rautahi sedgeland in the larger wetlands. Due to the lack of habitat complexity and fencing, they are highly unlikely to support indigenous fish and cryptic wetland bird species such as fernbird (*Bowdleria punctata vealeae*) and spotless crake (*Porzana tabuensis*).

Wetlands, however, are one of the most nationally threatened and degraded ecosystem types in New Zealand (Ausseil *et al.* 2011) with less than 10% of the original extent remaining (Ausseil *et al*. 2008). This means that even small degraded wetlands have inherent value and potential for restoration and/or enhancement. Wetland vegetation also helps to filter and purify water before it drains into downstream receiving environments, with this being particularly important at the project area due to its proximity to the coast and marine Significant Ecological Areas.

The value of the most of the wetlands (i.e. Wetlands 4, 5, 6, 11, 13 and 14) present is considered to be low, with the larger wetlands (i.e. Wetlands 8, 10 and 12) have low to moderate ecological values.

8.3 Freshwater values

The stream reaches assessed obtained poor to moderate SEV scores (excluding Biodiversity Functions), ranging from between 0.24 (offset Reach C) to 0.43 (offset Reach B). As with many rural watercourses, the absence of woody riparian vegetation and channel degradation by stock are key reasons for the low scores. A full breakdown of the SEV results is provided in Appendix 2.

All of the reaches assessed by SEV are intermittent in nature and dry out to varying degrees over the summer months, with four of the six reaches having little or no surface water present at the time of the site assessment. These reaches are considered to have no or only low value habitat to support indigenous fish species, even in wetter parts of the year. The remaining reaches (offset reaches B and G) had some water present in the downstream cross sections at the time of the site visits, and are immediately connected or in close proximity to Drury Creek downstream. Offset Reach B is likely to support indigenous fish (e.g. inanga, shortfin eel, and banded kōkopu) and macroinvertebrates present during autumn and winter, and Reach G has the potential to support indigenous fish with remediation of downstream migration barriers.

The ecological values of the freshwater habitats present are considered to be low to moderate.

8.4 Values throughout the remainder of the property

The vegetation present outside of the habitats described above is dominated by exotic pasture species (Vegetation Type 8; Exotic Grassland). The ecological values of these areas are considered to be very low.

9. POTENTIAL ECOLOGICAL EFFECTS

9.1 Overview

The potential effects (both negative and positive) of the proposed Phase 2 works can be summarised as:

- Loss of intermittent stream habitat
- Loss of wetland habitat
- Loss of exotic terrestrial vegetation
- Loss of terrestrial bird habitat
- Loss of habitat for, and mortality of, indigenous lizards
- Loss of habitat for, and mortality of, long-tailed bats
- Effects of stormwater on aquatic and marine habitats
- Effects of domestic pets on wading birds
- Sedimentation of aquatic and marine habitats
- Removal of stock

Each of these potential effects is addressed in more detail below.

9.2 Loss of intermittent stream habitat

Approximately 275 metres of intermittent stream habitat will be reclaimed during the Phase 2 earthworks (Figure 2). The SEV results indicate the affected watercourses have low ecological values; however, it is important to acknowledge that over 18 kilometres of stream length is lost on average each year in the Auckland Region (Rowe *et al*. 2011). Remaining open reaches therefore have intrinsic ecological and hydrological values despite their level of degradation.

An additional 92 metres of intermittent stream habitat will be piped within culverts to facilitate road crossings and construction for the future development. Depending on culvert design, the impact will be to a lesser degree than stream reclamation, but will still permanently alter the stream habitat present. Only culverts requiring consent (i.e. culverts that are not a permitted activity) are addressed in this assessment.

9.3 Loss of wetland habitat

Approximately 29,280 m^2 of exotic vegetation within various wetlands (see Figure 2) will be removed during the Phase 2 earthworks, with the wetland systems being

reclaimed, and within the footprint of crossings to be constructed. The affected wetlands have been highly degraded by stock and do not have sufficient habitat to support indigenous fish and cryptic wetland bird species such as fernbird and spotless crake. Common indigenous birds such as pūkeko are highly mobile and are more likely to roost and nest in the larger, more intact wetlands that are to be retained and restored.

In saying that, however, the values of small degraded wetlands dominated by exotic vegetation should be recognised given they can still provide important ecosystem functions such as flood attenuation and filtering sediments and nutrients from overland run-off.

9.4 Loss of terrestrial vegetation

The exotic trees present at the site are scattered and are of limited ecological value, with the larger tree stands having previously been removed. The potential ecological effects of removing the remaining exotic terrestrial vegetation are no more than minor.

9.5 Loss of terrestrial bird habitat

Any adverse effects on indigenous birds are likely to be no more than minor as the bird species present are all common and would be able to produce extra clutches to compensate for failed breeding attempts.

9.6 Loss of habitat for, and mortality of, indigenous lizards

The presence of gecko species is considered highly unlikely. While there is suitable habitat at the site to support indigenous skink species such as copper skink and ornate skink (At Risk-Declining), previous surveys have only discovered the exotic plague skink.

If there are skinks present, impacts may be both direct (e.g. mortality, habitat loss, displacement), and indirect (e.g. greater risk of predation, greater competition for resources). Previous surveys for indigenous skinks undertaken on the property have not detected any populations, and it is therefore considered potential effects on skinks would be less than minor.

9.7 Loss of habitat for, and mortality of, long-tailed bats

All mature exotic trees present within the proposed Phase 2 earthworks footprint that could have supported bat habitat have already been removed as a Permitted activity. It is therefore considered potential effects on long-tailed bats would be less than minor.

9.8 Effects of domestic pets on wading birds

The close proximity of the proposed development to a ‘significant wading bird area’ within estuarine habitats of Drury Creek (SEA-m2-29w) means that resident and migratory birds are at risk of predation by cats and dogs. It is not unreasonable to assume that resident cats would enter the estuary, given their propensity to roam.

Uncontrolled dogs also have the potential to disturb feeding birds and/or kill ground-nesting birds in saltmarsh and on sand flats within Drury Creek.

9.9 Effects of stormwater on aquatic and marine habitats

The proposed development will significantly increase the area of impermeable surfaces on the property. Surface run-off from impermeable ground can greatly increase the amount and rate of stormwater flow. After heavy rainfall events, large amounts of fast-moving water flows into streams, creating a scouring effect that is harmful to aquatic fauna and can result in streambank erosion and sedimentation. Roofs, roads, and driveways are the main contributors to surface run-off, and the intent is to develop these on the site in the future.

Stormwater can also transport a range of contaminants such as heavy metals, which accumulate in estuarine receiving environments, such as Drury Creek to the south of the subject site. Heavy metals such as zinc (commonly used in roofing) can persist in the aquatic environment for considerable periods of time, particularly in sediment. As a consequence, metals can accumulate in the tissues of benthic organisms and their predators at higher trophic levels. Zinc is toxic to aquatic plants and animals (Widianarko *et al*. 2001). Zinc is one of the most common contaminants found in estuarine receiving environments and largely results from galvanized surfacing used in residential and industrial roofing.

In residential areas, contamination can also occur through seemingly innocuous activities such as washing cars on impermeable surfaces, whereby cleaning chemicals and detergents are readily transported into drains and into aquatic and estuarine receiving environments.

9.10 Sedimentation of aquatic and marine habitats

Sediment-dwelling organisms are a major component of broader estuarine, harbour and coastal ecosystems, providing food for birds, fish, and humans, and affecting water quality, nutrient cycling, and productivity. Increased siltation or sedimentation caused by earthworks can adversely affect these organisms and the communities that feed on them. Avifauna and aquatic fauna, for example, may be indirectly affected by more frequent deposition of silt in estuarine areas (Senior & Ramsay 2003). Given the close proximity to Drury Creek and the Manukau Harbour, sedimentation from exposed earth during construction poses a significant potential threat to both aquatic and marine biodiversity.

9.11 Removal of stock

All farming activities will cease if the proposed development proceeds. The removal of cattle will significantly benefit watercourses and wetlands at the site. Any grazing animals, including horses, that may remain will be excluded from all streams and natural areas if the development proceeds.

10. SUGGESTED MEASURES TO MANAGE POTENTIAL ADVERSE ECOLOGICAL EFFECTS

10.1 Overview

Opportunities to avoid, remedy, mitigate, or compensate for actual or potential ecological effects resulting from the proposed development have been considered in the project design and proposal as outlined below. The ecological assessment and management have been framed around allowing the site to be developed for residential purposes in line with the new zoning under the Auckland Unitary Plan.

10.2 Alternatives to the reclamation of wetland and watercourses

From an ecological perspective, the best option would have been to avoid existing wetland areas and watercourses in the project design. However, this was considered impossible in order to allow for residential development of the site at the density anticipated in the Auckland Unitary Plan. Therefore, to ensure the highest value ecological areas were retained, the initial ecological assessment in 2018 assigned values to each wetland. The larger, higher value wetlands will be retained in the proposal, and restored to compensate for the smaller degraded wetland areas that will be reclaimed.

In terms of watercourses, all permanent streams on the property have been avoided in the project design, while some intermittent and ephemeral watercourses will be reclaimed or piped. Stream crossings will be retained in their current locations, where possible. The Environmental Compensation Ratio (ECR) has been used to determine the extent of stream restoration to offset the residual effects of the proposed piping and reclamation, as outlined in Section 10.3.

10.3 Restoration of wetland habitat

In order to compensate for the loss of wetland habitat within the wetlands identified as 4, 5, 6, , 10, 11, 13, 14 and 15 (total area 27,950 m^2), and in the footprints of new crossings (total area *c.*1,330 m^2), it is proposed to restore *c.*87,890 m^2 of wetland habitat within the wetlands identified as 7, 8, 9, 10, 11, 12 and 13 (for wetland references see Figure 2). This will largely involve planting the wetland interior with appropriate indigenous plant species, including rautahi, pūrei (*Carex virgata*), harakeke, giant umbrella sedge (*Cyperus ustulatus*), and tī kōuka/cabbage tree. A five metre terrestrial buffer will also be planted on the margins of the wetlands once stock have been removed.

The proposed compensation amount for wetlands has largely been determined based on the extent of existing wetlands on the property. The initial site assessment determined the existing quality of the wetland areas, with the majority of smaller wetlands found to be intermittently wet with a low diversity of vegetation. The larger wetlands have a similar vegetation composition, but have greater restoration potential due to larger size and more consistent hydrological inputs. The proposal therefore aims to retain the higher quality wetlands, where possible, and assumes the post-development hydrological inputs will remain similar to allow the wetlands to develop a dominant plant cover of indigenous wetland species following restoration.

In terms of compensation, it is recognised there is no set ratio for compensating wetland loss in New Zealand (*c.f.* ECR for streams), however, a ratio of 1:3 is a recognised starting point for degraded wetlands. This ratio would assume the wetlands to be restored for compensation are similarly degraded, as wetlands already dominated by indigenous vegetation have less potential to be improved by restoration. In the case of this application, all wetlands on the property are similarly degraded, and the wetlands to be restored will be significantly improved by restoration including pest plant control, planting appropriate indigenous species in the wetland, and buffer planting around the wetland. The proposal provides a ratio of 1:3 for wetland restoration, which is considered sufficient for providing a suitable level of compensation for the loss of the smaller, lower quality intermittent wetlands.

10.4 Offsetting the loss of intermittent stream habitat

10.4.1 Background

The Environmental Compensation Ratio (ECR) is used to determine the length of stream that needs to be restored to achieve no net loss of ecological value relative to the length of stream to be degraded, taking into account the relative ecological quality of each stream. In situations where restoration is not possible, the ECR can also be used to determine the amount of financial compensation required (Rowe *et al*. 2006), although nowadays this option is rarely taken. In applying environmental compensation ratios, the length of stream to be restored should never be less than the length of stream to be degraded (Storey *et al.* 2011).

Where the impact reach is similar to the reach to be restored, and assuming that full restoration is possible over a short time frame, a theoretical ECR close to 1:1 may be warranted. However, where the stream to be restored has lower ecological value than the reach being degraded, the ratio needs to be set at a higher level to offset this. It may therefore be necessary to restore three to four times the length of stream to be degraded. In the Auckland Region, the average ECR is in the order of 1:3.

The ECR equation also takes into account the inherent time delay before the full benefits are realised at the offset stream and the possible failings or inadequacies that may occur with restoration projects. The use of the ECR is generally required to quantify that "no net loss or a net gain in the natural values" is achieved by offsetting activities following stream loss as per Rule (E3.3(4)) of the Auckland Unitary Plan (Operative in Part), which states:

> *"Restoration and enhancement actions, which may form part of an offsetting proposal, for a specific activity should:*
>
> *a) Be located as close as possible to the subject site*
> *b) Be 'like-for-like' in terms of the type of freshwater system affected*
> *c) Preferably achieve no net loss or a net gain in the natural values including ecological function of lakes, rivers, streams or wetlands; and*
> *d) Consider the use of biodiversity offsetting as outlined in Appendix 8: Biodiversity offsetting."*

The formula used to calculate the ECR is:

$$\text{ECR} = \frac{\textbf{Predicted loss of function}}{\textbf{Predicted gain after restoration}} \times \textbf{1.5 delay factor}$$

The predicted gain assumes best practices are used for restoration of the compensation stream. In this case, it is proposed to plant the riparian margin on both sides of the proposed offset reaches to a distance of 10 metres. The land beyond this is to be earthworked and it is assumed best practice erosion and sediment control measures will be utilised.

Note that the ECR excludes biotic scores (function numbers 12 and 13) due to difficulties predicting how biodiversity values will respond to restoration.

10.4.2 Calculations - intermittent streams

The existing and predicted SEV scores for the impact streams and the proposed compensation streams (as shown in Figure 2) following restoration are listed in Table 5 below. Predicted SEV scores for the impact and offset reaches are based on calculations presented in Appendix 3. Assumptions relating to the predicted SEV scores for the impact and offset reaches are outlined in Appendix 4 and 5.

Table 5: Existing and predicted SEV scores for the impact reaches and the potential offset reaches following restoration. Note that these scores have been calculated excluding Biotic Functions.

Site Name	Existing Function Score	Predicted Score Following Restoration	Predicted Score Following impact	Predicted Loss of Function	Predicted Gain Through Restoration
Impact Reach A	0.29	0.45	0	0.29	0.16
Impact Reach D	0.33	0.49	0	0.33	0.16
Offset Reach B	0.43	0.71	-	-	0.28
Offset Reach C	0.24	0.56	-	-	0.32
Offset Reach E	0.32	0.58	-	-	0.26
Offset Reach G	0.35	0.61	-	-	0.26

In terms of areas, due to the absence of water in some of the streams, it was not possible to measure the wetted width, and consequently calculate the area. Therefore, the areas available for compensation have been estimated, and the calculations undertaken in reverse to determine the maximum wetted width for the impact reaches to allow their reclamation to be compensated. These calculations are outlined for each impact stream reach below. The areas of the offset reaches are summarised in Table 6.

Table 6: Areas of the intermittent offset stream reaches.

Site Name	Average Wetted Width (m)	Length (m)	Reach Area (m^2)
Offset Reach B	1.2	67	80.4
Offset Reach C	1.5	259	388.5
Offset Reach E	1.5	103	154.5
Offset Reach G	1.6	80	128

[1] Length of reach assumes culverts have already been constructed and are unavailable for offsetting.
[2] Wetted width estimated based on intermittent water presence, aquatic vegetation, and previous site surveys.

Reaches B and G have been used in calculations to compensate for the loss of Impact Reach A using the following ECRs:

ECR (Reach B) = (0.45-0) / (0.71-0.43) × 1.5 = 2.4

ECR (Reach G) = (0.45-0) / (0.61-0.35) × 1.5 = 2.6

This indicates that 2.4 times the area of Impact Reach A would need to be restored in offset Reach B to result in no net loss of function, and 2.6 times the area in offset Reach G. Working in reverse, therefore, the area to be restored in Reach B would offset an area of 33.5 m^2 in Impact Reach A, and the area to be restored in Reach G will offset an area of 49.2 m^2.

The total area of Impact Reach A offset by these two reaches is 82.7 m^2. The length of Reach A is 100 metres. The loss of Reach A will therefore be offset if the wetted width does not exceed 0.83 metres.

To offset the loss of Impact Reach D, the longer stream reaches C and E have been used in calculations using the following ECRs:

ECR (Reach C) = (0.49-0) / (0.56-0.24) × 1.5 = 2.3

ECR (Reach E) = (0.49-0) / (0.58-0.32) × 1.5 = 2.8

This indicates that 2.3 times the area of Impact Reach D would need to be restored in offset Reach C to result in no net loss of function, and 2.8 times the area in offset Reach E. Working in reverse, therefore, the area to be restored in Reach C would offset an area of 168.9 m^2 in Impact Reach D, and the area to be restored in Reach E will compensate an area of 55.2 m^2.

The total area of Impact Reach D offset by these two reaches is 224.1 m^2. The length of Reach D is 175 metres. The loss of Reach D will therefore be offset if the wetted width does not exceed 1.28 metres.

It is considered the impact reaches are unlikely to exceed the calculated widths due to their small catchment areas. However, it is recommended the impact reaches are revisited during the months of water presence (likely winter) to ensure the wetted widths are within the calculated offset levels.

10.4.3 Additional offset stream reaches

One further intermittent stream reach within wetland 11 (see Figure 2) will be lost under the proposal; however, as this stream is located entirely within a wetland system it was not considered appropriate to use SEV and ECR methodology. It is noted that much longer reaches of both comparable intermittent and permanent streams within wetland systems are to be restored as part of the proposal, most notably the streams

within wetland 8 (see Figure 2). It is considered the restoration of the wetland systems will also restore the streams present, effectively also providing an offset for the wetland 11 channel that will be lost.

Additionally, a permanent stream outside of wetland systems is to be restored, referenced as Reach F in Figure 2. This permanent reach is approximately 60 metres long and links wetland 8 with the downstream Drury Creek. While not required for offsetting the loss of streams elsewhere on the property, it is considered the restoration of this stream reach provides an offset for the second culvert to be placed within Reach C, that cannot be constructed as a permitted activity.

10.5 Riparian setbacks and restoration

As a minimum, all intermittent and permanent watercourses to be retained should have a ten-metre buffer on each side. All development and associated roads and tracks should be set back at least ten metres from restored wetlands, which will include five metres of terrestrial buffer planting (Figure 2).

As outlined in the previous section, approximately 509 metres of intermittent stream and 60 metres of permanent stream are to be restored in association with the proposal. Restoration will largely involve planting of the riparian margins of these streams to an extent of 10 metres either side where possible. Riparian planting will follow best-practice methods for the Auckland Region with plants to be sourced from the Manukau Ecological District. The proposed planting is to be outlined in the project Ecological Management Plan (EMP).

As well as improving the quality and ecological value of the watercourses, it is anticipated the proposed riparian planting (and wetland buffer planting) will also benefit indigenous terrestrial fauna utilising the habitat, including birds and potentially skink species.

10.6 Fish management

A Fish Management Plan (FMP) will need to be prepared, approved by Auckland Council, and implemented before any works take place within the watercourses. This could be produced as part of an EMP for the project.

The FMP will detail methods for capturing indigenous fish species and identify a suitable release site for indigenous fish beyond the extent of works. It will also need to detail methods of capture and euthanasia for pest fish species (gambusia) to ensure that they are not inadvertently introduced to neighbouring watercourses or catchments. If the FMP is properly implemented, the effects on indigenous fish are likely to be no more than minor.

10.7 Management of domestic pets

The adverse effects of dogs can be avoided as long as they are controlled on a leash when in close proximity to estuarine habitats. However, the hunting habits of domestic cats are difficult to curb, although they hunt less as they get older (King 2005). Providing extra food is unlikely to reduce hunting behaviour because prey capture,

killing, and consumption are relatively independent of each other (Barrat 1998). Fitting house cats with bells might (Ruxton *et al.* 2002) or might not (Barrat 1998) reduce predation on wildlife. Night curfews for cats have been suggested, but may have little value. For example, in Canberra 70% of the birds and 90% of the reptiles caught by cats were brought in during the day (Barrat 1997), so a night curfew might reduce only the number of rodents and hedgehogs killed. Cat bans are becoming an increasingly common component of subdivision applications in New Zealand, particularly where ecologically sensitive environments are concerned[1,2]. Given the proximity of the proposed development to high value estuarine habitats, a cat ban should be considered for residential areas within the proposed development.

10.8 Management of cultivated pest plants

In order to control the spread of pest plants from domestic gardens, no plant species listed in the National Plant Pest Accord (NPPA) or the Auckland Regional Pest Management Strategy (ARC 2007), in any category, should be permitted to be planted or cultivated, either in the ground or in pots. This should be a condition of consent, although it is acknowledged that it will be difficult to enforce. Many species not listed in the NPPA or RPMS can also establish from dumped garden refuse, for example fruit salad plant (*Monstera deliciosa*) and hydrangea (*Hydrangea macrophylla*). Natural areas, especially along lot boundaries and wetland edges, should be surveyed annually for new pest plant incursions. Exotic plants within natural areas should be controlled when they are first recorded in order to increase the likelihood and efficiency of achieving total control.

10.9 Stormwater management

There is an opportunity to create infrastructure during the construction process that will significantly reduce the impacts of stormwater on aquatic and marine receiving environments; which is commonly referred to as 'Low Impact Design' (ARC 2000). Such an approach can be achieved by using various methods to minimise and control storm run-off water as close to its origin as possible, before it enters a watercourse. A range of low impact design features could be included in the design of the proposed development, including:

- The use of water tanks to capture roof water for domestic use and to provide for the temporary storage and controlled release of roof runoff.
- The use of swales, filter strips and rain gardens to provide for treatment of stormwater runoff from impervious areas.
- The use of rain gardens, proprietary devices and/or wetlands for the treatment of stormwater runoff from reticulated areas.
- The discharge of captured runoff at appropriate locations incorporating energy dissipation and flow dispersion structures.

[1] The Western Bay of Plenty District Council made a landmark decision in November 1996 to ban cats and dogs from the Five Jems subdivision at Waihi Beach.

[2] Harbourside Development took up Forest and Bird's suggestion of making their Kaiwharawhara (Wellington) subdivision wildlife-friendly by prohibiting cats to protect a bird corridor close to the 'mainland island' Karori Sanctuary.

In addition, permeable surfaces should be maximised wherever possible, including the use of permeable material for pavements and driveways. In order to prevent zinc entering the local watercourses, galvanised paint should not be used in the proposed development.

10.10 Best practice sediment control during development

Auckland Council best practice guidelines for erosion and sediment control (GD05) should be followed at all times during development works to prevent excess sediment entering the impact watercourse and flowing downstream into the receiving environment.

10.11 Legal protection of restored stream and wetland habitat

Restored wetlands and watercourses will be protected through the use of statutory mechanisms such as protective covenants. Covenants are designed to protect ecologically significant parcels of land in perpetuity, and can include financial contributions towards fencing and ongoing pest control. Areas planted in indigenous species should also be protected in perpetuity, although such areas will most likely require a Council covenant rather than a QEII covenant.

10.12 Restoration of coastal habitats

In addition to the suggested mitigation measures outlined above, there is an opportunity to replace existing exotic coastal vegetation with suitable indigenous species, particularly along the western boundary of the site. This area includes some large pines, which should be felled or poisoned and left to break down in situ prior to development works commencing. It is anticipated that an Esplanade Reserve will extend along most of the coastal boundary, which will include a walking/cycling path.

11. CONCLUSIONS

Civil Plan Consultants Limited, on behalf of Hugh Green Limited (the client), is developing a master plan for a large urban development at 144-252 Park Estate Road, Hingaia. These properties contain significant areas of wetlands (particularly at 144 Park Estate Road) and a number of degraded watercourses, which the client is seeking to reshape through reclamation and enhancement works in order to allow residential subdivision.

This report assessed potential ecological effects within the Phase 2 earthworks extent. The proposed works will result in the removal of *c.*29,280 m^2 of exotic wetland habitat, and *c.*275 metres of intermittent stream habitat.

Wetland and aquatic values within the Phase 2 earthworks extent are low given their level of degradation, absence of indigenous plant species, and lack of habitat to support indigenous fauna. Larger wetlands which contain some indigenous vegetation and provide buffering to permanent streams are considered to have the highest values at the site. No species of vascular plants classified as nationally or regionally

threatened by de Lange *et al*. (2018) and Stanley *et al*. (2005), respectively, will be affected by the proposed works.

As well as the loss of wetland and intermittent stream habitat, the proposed development has the potential to adversely affect indigenous fauna. Domestic pets - particularly cats - pose a threat to indigenous wading birds in estuarine habitats of Drury Creek, immediately adjacent to the site. Adverse effects on terrestrial birds and herpetofauna are expected to be less than minor. Sedimentation from earthworks and stormwater run-off from constructed buildings and roads both have the potential to adversely affect aquatic and marine habitats.

The whole and partial removal of wetlands within Phase 2 will be compensated by restoring *c*.87,890 m^2 of wetland habitat elsewhere on the property. The loss of the stream habitat will be compensated for by restoring approximately 509 metres of intermittent stream habitat. The potential effects of stormwater and sedimentation on downstream receiving environments can be managed by implementing best practice at the design phase, including low impact design features such as wetlands, rain gardens, and permeable surfaces.

In addition to the proposed compensation restoration, there is the opportunity to restore coastal terrestrial habitats along the western boundary of the property.

A comprehensive Ecological Management Plan (EMP) has been prepared in order to guide ecological works at the site. All planting areas should be legally protected in perpetuity under a covenant.

If the abovementioned measures are appropriately implemented, the potential adverse impacts of the proposed development will be no more than minor.

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VASCULAR PLANT SPECIES RECORDED AT PARK ESTATE ROAD, HINGAIA

INDIGENOUS SPECIES

Gymnosperms

Podocarpus totara var. *totara*	tōtara

Dicot. trees and shrubs

Avicennia marina subsp. *australasica*	mānawa, mangrove
Myrsine australis	māpou
Plagianthus divaricatus	marsh ribbonwood mākaka

Ferns

Dicksonia squarrosa	whekī
Pteridium esculentum	bracken

Sedges

Carex lessoniana	toetoe-rautahi
Cyperus ustulatus	toetoe upoko-tangata

Rushes

Apodasmia similis	oioi
Juncus kraussii var. *australiensis*	wi, wīwī sea rush
Juncus planifolius	grass-leaved rush

Monocot. herbs (other than orchids, grasses, sedges, and rushes)

Lemna disperma	karearea
Phormium tenax	harakeke, flax
Typha orientalis	raupō

Composite herbs

Cotula coronopifolia	bachelor’s button
Senecio bipinnatisectus	Australian fireweed

Dicot. herbs (other than composites)

Geranium homeanum	pinakitere

NATURALISED AND EXOTIC SPECIES

Gymnosperms

Cupressus macrocarpa	macrocarpa
Pinus pinaster	maritime pine
Pinus radiata	radiata pine

Dicot. trees and shrubs

Acacia mearnsii	black wattle
Berberis glaucocarpa	barberry
Eucalyptus obliqua	messmate
Ligustrum lucidum	tree privet
Ligustrum sinense	Chinese privet
Paraserianthes lophantha	brush wattle
Populus deltoides	necklace poplar
Populus nigra	Lombardy poplar
Quercus robur	English oak
Rubus sp. (*R. fruticosus* agg.)	blackberry
Salix ×fragilis	crack willow
Solanum mauritianum	woolly nightshade
Syzygium smithii	lillypilly, monkey apple
Ulex europaeus	gorse

Dicot. lianes

Araujia hortorum	moth plant
Calystegia sepium × *C. silvatica*	bindweed
Lonicera japonica	Japanese honeysuckle

Sedges

Cyperus eragrostis	umbrella sedge

Grasses

Agrostis capillaris	browntop
Agrostis stolonifera	creeping bent
Cenchrus clandestinus	kikuyu grass
Cortaderia selloana	pampas
Dactylis glomerata	cocksfoot
Holcus lanatus	Yorkshire fog
Lolium perenne	rye grass
Paspalum dilatatum	paspalum
Paspalum distichum	Mercer grass
Schedonorus arundinaceus	tall fescue
Sporobolus africanus	ratstail

Rushes

Juncus articulatus	jointed rush
Juncus effusus var. *effusus*	soft rush, leafless rush
Juncus tenuis var. *tenuis*	track rush

Composite herbs

Anthemis cotula	stinking mayweed
Jacobaea vulgaris	ragwort

Dicot. herbs (other than composites)

Alisma plantago-aquatica	water plantain
Apium nodiflorum	water celery
Callitriche stagnalis	starwort
Linum bienne	pale flax
Lotus pedunculatus	lotus
Ludwigia palustris	water purslane
Modiola caroliniana	creeping mallow
Myosotis laxa subsp. *caespitosa*	water forget-me-not
Nasturtium officinale	watercress
Persicaria hydropiper	water pepper
Persicaria maculosa	willow weed
Plantago lanceolata	narrow-leaved plantain
Plantago major	broad-leaved plantain
Ranunculus repens	creeping buttercup
Ranunculus sceleratus	celery-leaved buttercup
Rumex conglomeratus	clustered dock
Rumex obtusifolius	broad-leaved dock
Solanum nigrum	black nightshade
Trifolium pratense	red clover
Trifolium repens	white clover

APPENDIX 2

CURRENT SEV RESULTS - IMPACT STREAMS

Function Category	Function	Variable (code)	STREAM A	STREAM D
		Vchann	0.58	0.46
		Vlining	1.00	1.00
		Vpipe	1.00	1.00
Hydraulic	**NFR**	**=**	**0.72**	**0.64**
		Vbank	1.00	1.00
		Vrough	0.20	0.20
Hydraulic	**FLE**	**=**	**0.20**	**0.20**
		Vbarr	0.30	1.00
Hydraulic	**CSM**	**=**	**0.30**	**1.00**
		Vchanshape	0.76	0.61
		Vlining	1.00	1.00
Hydraulic	**CGW**	**=**	**0.92**	**0.87**
Hydraulic function mean score			**0.54**	**0.68**
		Vshade	0.08	0.06
biogeochemical	**WTC**	**=**	**0.08**	**0.06**
		Vdod*	0.75	0.75
biogeochemical	**DOM**	**=**	**0.75**	**0.75**
		Vripar	0.00	0.00
		Vdecid	0.90	1.00
biogeochemical	**OMI**	**=**	**0.00**	**0.00**
		Vmacro	0.48	0.32
		Vretain	0.40	0.32
biogeochemical	**IPR**	**=**	**0.40**	**0.32**
		Vsurf	0.88	0.94
		Vripfilt	0.20	0.20
biogeochemical	**DOP**	**=**	**0.54**	**0.57**
Biogeochemical function mean score			**0.35**	**0.34**
		Vgalspwn	0.85	0.68
		Vgalqual	0.00	0.00
		Vgobspwn	0.10	0.10
habitat provision	**FSH**	**=**	**0.05**	**0.05**
		Vphyshab	0.14	0.14
		Vwatqual	0.07	0.06
		Vimperv	0.90	1.00
habitat provision	**HAF**	**=**	**0.31**	**0.34**
Habitat provision function mean score			**0.18**	**0.20**
		Vripcond	0.10	0.10
		Vripconn	1.00	1.00
Biodiversity	**RVI**	**=**	**0.10**	**0.10**
Biodiversity function mean score			**0.10**	**0.10**
SEV score minus biodiversity functions 12 and 13			**0.29**	**0.33**

* The correction factor for Vdod was unable to be calculated due to lack of depth and velocity measurements; the initial Vdod value has been used for all streams

CURRENT SEV RESULTS - OFFSET STREAMS

Function Category	Function	Variable (code)	Stream B	Stream C	Stream E	Stream G
		Vchann	0.43	0.16	0.42	0.36
		Vlining	0.80	1.00	0.96	0.96
		Vpipe	1.00	1.00	1.00	1.00
Hydraulic	**NFR**	**=**	**0.55**	**0.44**	**0.60**	**0.56**
		Vbank	1.00	0.92	1.00	0.44
		Vrough	0.20	0.16	0.20	0.31
Hydraulic	**FLE**	**=**	**0.20**	**0.15**	**0.20**	**0.14**
		Vbarr	1.00	0.30	1.00	0.00
Hydraulic	**CSM**	**=**	**1.00**	**0.30**	**1.00**	**0.00**
		Vchanshape	0.72	0.34	0.84	0.84
		Vlining	0.80	1.00	0.96	0.96
Hydraulic	**CGW**	**=**	**0.77**	**0.78**	**0.92**	**0.92**
Hydraulic function mean score			**0.63**	**0.42**	**0.68**	**0.40**
		Vshade	0.26	0.08	0.00	0.50
biogeochemical	**WTC**	**=**	**0.26**	**0.08**	**0.00**	**0.50**
		Vdod*	0.75	0.50	0.75	0.50
biogeochemical	**DOM**	**=**	**0.75**	**0.50**	**0.75**	**0.50**
		Vripar	0.05	0.00	0.00	0.05
		Vdecid	1.00	1.00	1.00	0.57
biogeochemical	**OMI**	**=**	**0.05**	**0.00**	**0.00**	**0.04**
		Vmacro	0.50	0.54	0.54	0.48
		Vretain	0.36	0.20	0.28	0.28
biogeochemical	**IPR**	**=**	**0.36**	**0.20**	**0.28**	**0.28**
		Vsurf	1.00	0.58	0.57	0.99
		Vripfilt	0.20	0.18	0.20	0.40
biogeochemical	**DOP**	**=**	**0.60**	**0.38**	**0.39**	**0.70**
Biogeochemical function mean score			**0.40**	**0.23**	**0.28**	**0.40**
		Vgalspwn	1.00	0.59	0.00	0.81
		Vgalqual	0.00	0.00	0.00	0.25
		Vgobspwn	0.10	0.10	0.10	0.20
habitat provision	**FSH**	**=**	**0.05**	**0.05**	**0.05**	**0.20**
		Vphyshab	0.27	0.26	0.09	0.65
		Vwatqual	0.14	0.05	0.04	0.15
		Vimperv	0.90	0.90	1.00	0.90
habitat provision	**HAF**	**=**	**0.39**	**0.37**	**0.31**	**0.59**
Habitat provision function mean score			**0.22**	**0.21**	**0.18**	**0.40**
		Vripcond	0.11	0.11	0.12	0.18
		Vripconn	1.00	0.90	1.00	1.00
Biodiversity	**RVI**	**=**	**0.11**	**0.10**	**0.12**	**0.18**
Biodiversity function mean score			**0.11**	**0.10**	**0.12**	**0.18**
SEV score minus biodiversity functions 12 and 13			**0.43**	**0.24**	**0.32**	**0.35**

* The correction factor for Vdod was unable to be calculated due to lack of depth and velocity measurements; the initial Vdod value has been used for all streams.

POTENTIAL SEV RESULTS - IMPACT STREAMS

Function Category	Function	Variable (code)	STREAM A	STREAM D
		Vchann	0.58	0.46
		Vlining	1.00	1.00
		Vpipe	1.00	1.00
Hydraulic	**NFR**	**=**	**0.72**	**0.64**
		Vbank	1.00	1.00
		Vrough	0.52	0.52
Hydraulic	**FLE**	**=**	**0.52**	**0.52**
		Vbarr	0.30	1.00
Hydraulic	**CSM**	**=**	**0.30**	**1.00**
		Vchanshape	0.76	0.61
		Vlining	1.00	1.00
Hydraulic	**CGW**	**=**	**0.92**	**0.87**
Hydraulic function mean score			**0.62**	**0.76**
		Vshade	0.60	0.60
biogeochemical	**WTC**	**=**	**0.60**	**0.60**
		Vdod	0.75	0.75
biogeochemical	**DOM**	**=**	**0.75**	**0.75**
		Vripar	0.50	0.50
		Vdecid	1.00	1.00
biogeochemical	**OMI**	**=**	**0.50**	**0.50**
		Vmacro	0.67	0.62
		Vretain	0.40	0.32
biogeochemical	**IPR**	**=**	**0.40**	**0.32**
		Vsurf	0.80	0.88
		Vripfilt	0.60	0.60
biogeochemical	**DOP**	**=**	**0.70**	**0.74**
Biogeochemical function mean score			**0.59**	**0.58**
		Vgalspwn	0.85	0.68
		Vgalqual	0.00	0.00
		Vgobspwn	0.10	0.10
habitat provision	**FSH**	**=**	**0.05**	**0.05**
		Vphyshab	0.39	0.39
		Vwatqual	0.26	0.26
		Vimperv	0.90	1.00
habitat provision	**HAF**	**=**	**0.49**	**0.51**
Habitat provision function mean score			**0.27**	**0.28**
		Vripcond	0.33	0.33
		Vripconn	1.00	1.00
Biodiversity	**RVI**	**=**	**0.33**	**0.33**
Biodiversity function mean score			**0.33**	**0.33**
SEV score minus biodiversity functions 12 and 13			**0.45**	**0.49**

POTENTIAL SEV RESULTS - OFFSET STREAMS

Function Category	Function	Variable (code)	Stream B	Stream C	Stream E	Stream G
		Vchann	0.51	0.16	0.42	0.36
		Vlining	0.80	1.00	0.96	0.96
		Vpipe	1.00	1.00	1.00	1.00
Hydraulic	**NFR**	**=**	**0.61**	**0.44**	**0.60**	**0.56**
		Vbank	1.00	0.92	1.00	0.44
		Vrough	0.90	0.90	0.90	0.90
Hydraulic	**FLE**	**=**	**0.90**	**0.83**	**0.90**	**0.40**
		Vbarr	1.00	1.00	1.00	1.00
Hydraulic	**CSM**	**=**	**1.00**	**1.00**	**1.00**	**1.00**
		Vchanshape	0.62	0.34	0.84	0.84
		Vlining	0.80	1.00	0.96	0.96
Hydraulic	**CGW**	**=**	**0.74**	**0.78**	**0.92**	**0.92**
Hydraulic function mean score			**0.81**	**0.76**	**0.86**	**0.72**
		Vshade	0.60	0.60	0.60	0.60
biogeochemical	**WTC**	**=**	**0.60**	**0.60**	**0.60**	**0.60**
		Vdod	1.00	0.75	0.75	0.75
biogeochemical	**DOM**	**=**	**1.00**	**0.75**	**0.75**	**0.75**
		Vripar	0.50	0.50	0.50	0.50
		Vdecid	1.00	1.00	1.00	1.00
biogeochemical	**OMI**	**=**	**0.50**	**0.50**	**0.50**	**0.50**
		Vmacro	0.82	0.74	0.74	0.70
		Vretain	0.44	0.20	0.28	0.28
biogeochemical	**IPR**	**=**	**0.44**	**0.20**	**0.28**	**0.28**
		Vsurf	1.00	0.70	0.69	0.83
		Vripfilt	0.60	0.60	0.60	0.60
biogeochemical	**DOP**	**=**	**0.80**	**0.65**	**0.65**	**0.72**
Biogeochemical function mean score			**0.67**	**0.54**	**0.56**	**0.57**
		Vgalspwn	1.00	0.59	0.00	0.81
		Vgalqual	0.25	0.00	0.00	0.75
		Vgobspwn	1.00	0.10	0.10	0.20
habitat provision	**FSH**	**=**	**0.63**	**0.05**	**0.05**	**0.40**
		Vphyshab	0.65	0.54	0.39	0.75
		Vwatqual	0.35	0.26	0.26	0.26
		Vimperv	0.90	0.90	1.00	0.90
habitat provision	**HAF**	**=**	**0.64**	**0.56**	**0.51**	**0.67**
Habitat provision function mean score			**0.63**	**0.31**	**0.28**	**0.54**
		Vripcond	0.62	0.62	0.62	0.62
		Vripconn	1.00	1.00	1.00	1.00
Biodiversity	**RVI**	**=**	**0.62**	**0.62**	**0.62**	**0.62**
Biodiversity function mean score			**0.62**	**0.62**	**0.62**	**0.62**
SEV score minus biodiversity functions 12 and 13			**0.71**	**0.56**	**0.58**	**0.61**

APPENDIX 4

ASSUMPTIONS USED IN PREDICTING THE POTENTIAL SEV SCORE FOR IMPACT STREAMS AT 144-252 PARK ESTATE ROAD, HINGAIA

Function Category	Variable	Assumption
Hydraulic	Vchann	Unchanged.
	Vlining	Unchanged.
	Vpipe	Unchanged.
	Vbank	Unchanged.
	Vrough	Improved due to a 10 metre wide riparian margin restored with native planting on both sides of the streams. Assumes outer 10 metres margins remain in pasture.
	Vbarr	No change.
	Vchanshape	Automatic calculation, no input from ecologist.
Biogeochemical	Vshade	Increase in shading to high as a result of riparian restoration.
	Vdod	Slight improvement due to shade provided by riparian planting.
	Vveloc	Cannot predict due to not being measured at time of assessment (no water present).
	Vdepth	Cannot predict due to not being measured at time of assessment (no water present).
	Vripar	Improved due to planting 10 metre wide margin on each side of the streams. Assumes outer 10 metre margins remain in pasture.
	Vdecid	Slight improvement due to willows (Stream A) being replaced by indigenous evergreen shading.
	Vmacro	Reduced macrophytes due to increased shade from riparian planting.
	Vretain	Automatic calculation, no input from ecologist.
	Vsurft	Substrate unchanged, but reduced macrophytes and increased leaf litter due to increased shade from riparian planting.
	Vripfilt	Riparian planting areas will provide moderate to high filtering activity.
Habitat Provision	Vgalspwn	Unchanged.
	Vgalqual	Unchanged.
	Vgobspwn	Automatic calculation, no input from ecologist.
	Vphyshab	Habitat parameters improved.
	Vwatqual	Unchanged.
	Vimperv	Unchanged.
Biodiversity	Vfish	Not included in calculation.
	Vmci	Not included in calculation.
	Vept	Not included in calculation.
	Vripcond	Automatic calculation, no input from ecologist.
	Vripconn	Unchanged.

APPENDIX 5

ASSUMPTIONS USED IN PREDICTING THE POTENTIAL SEV SCORES FOR THE OFFSET STREAMS AT 144-252 PARK ESTATE ROAD, HINGAIA

Function Category	Variable	Assumption
Hydraulic	Vchann	Unchanged.
	Vlining	Unchanged.
	Vpipe	Unchanged.
	Vbank	Unchanged.
	Vrough	Improved due to a 10 metre wide riparian margin restored on both sides of the stream.
	Vbarr	All barriers will be remediated to ensure fish passage is possible.
	Vchanshape	Automatic calculation, no input from ecologist.
Biogeochemical	Vshade	Riparian planting will provide high shading to the streams.
	Vdod	Slight improvement due to shade provided by riparian planting and stock exclusion.
	Vveloc	Unchanged.
	Vdepth	Unchanged.
	Vripar	Improved due to planting 10 metre wide margin on each side of the stream.
	Vdecid	Unchanged.
	Vmacro	Reduced macrophytes due to increased shade from riparian planting.
	Vretain	Automatic calculation, no input from ecologist.
	Vsurft	Substrate unchanged, but reduced macrophytes and increased leaf litter due to increased shade from riparian planting.
	Vripfilt	Riparian planting areas will provide moderate to high filtering activity.
Habitat Provision	Vgalspwn	Unchanged.
	Vgalqual	Banks slope and riparian planting will improve quality of galaxid spawning habitat.
	Vgobspwn	Automatic calculation, no input from ecologist.
	Vphyshab	Habitat parameters improved.
	Vwatqual	Unchanged.
	Vimperv	Unchanged.
Biodiversity	Vfish	Not included in calculation.
	Vmci	Not included in calculation.
	Vept	Not included in calculation.
	Vripcond	Automatic calculation, no input from ecologist.
	Vripconn	Connectivity to the riparian zone will not be impeded.

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ECOLOGICAL MANAGEMENT PLAN
FOR 144-252 PARK ESTATE ROAD, HINGAIA: PHASE 2

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R4970

ECOLOGICAL MANAGEMENT PLAN FOR 144-252 PARK ESTATE ROAD, HINGAIA: PHASE 2

Stream proposed for weed control and planting. 19 March 2019.

Contract Report No. 4970

May 2019

Project Team:
Jessica Reaburn - Field survey, report author
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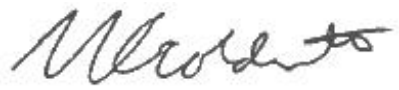

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Nick Goldwater
Principal Ecologist
Wildland Consultants Ltd

1. INTRODUCTION

Civil Plan Consultants Limited, on behalf of Hugh Green Limited (the client), is developing a master plan for a large urban development at 144-252 Park Estate Road, Hingaia. These properties contain large areas of wetlands (particularly at 144 Park Estate Road) and a number of degraded watercourses, which the client is seeking to reshape through reclamation and enhancement works in order to allow residential subdivision. Most of the land is zoned as 'Residential - Mixed Housing Suburban Zone' under the Auckland Unitary Plan (AUP), with smaller areas zoned as 'Residential - Mixed Housing Urban Zone' and 'Business - Neighbourhood Centre Zone'.

Bulk earthworks have been proposed in two Phases: Phase 1 comprises the northwestern part of the site, while Phase 2 generally comprises the remaining land between the Phase 1 parcel, the southern motorway, and coastal boundary. The Phase 1 earthworks were consented in 2018 and are underway. In April 2019, Wildland Consultants Ltd prepared an ecological assessment of the Phase 2 earthworks (Wildland Consultants 2019).

The ecological assessment identified eight wetlands and two intermittent streams that would be impacted by the proposed bulk earthworks in Phase 2. Stream Ecological Valuations (SEVs, Wildland Consultants 2019) identified suitable intermittent streams that could serve as mitigation for the proposed stream loss, and a site survey identified six wetlands that could be restored to compensate for the loss of wetland habitat. All restoration works are to be guided by an Ecological Management Plan (EMP).

To this end, Civil Plan Consultants Ltd commissioned Wildland Consultants Ltd to develop an EMP for the Phase 2 works. This plan provides recommendations for the ecological restoration of four intermittent streams, one permanent stream, and six wetlands on the property, together with recommendations for the management of indigenous freshwater fish. Restoration will be achieved through stock exclusion, and revegetation and enhancement planting. Recommendations for revegetation planting include plant schedules with details of the species, grades, and numbers of plants to be planted along with maps of the recommended planting areas.

2. SITE DESCRIPTION AND CONTEXT

The study site is located in the Manukau Ecological District in a landscape comprising rural land to the west of Papakura and Drury. It is bounded by Park Estate Road to the north and the southern motorway to the east, while the southern and eastern margins border the lower saline reaches of Drury Creek. Drury Creek includes two marine Significant Ecological Areas (SEA-M2-29w1 and SEA-M2-29a), which include a 'significant wading bird area'. Mangroves (*Avicennia marina* subsp. *australasica*) are abundant in this part of Drury Creek, while oioi (*Apodasmia similis*) salt meadow is locally common on the southern boundary of the study site, adjacent to the Drury Esplanade Reserve. Land to the west and south of the study site is largely characterised by farming and horticulture, although urban development has recently commenced in areas such as Karaka.

Vegetation at the site is characterised by pasture, wetlands dominated by exotic plant species, shelterbelts, mixed exotic-indigenous coastal forest and scrub, and exotic treeland.

Approximately 70% of the study site is located on 'Acutely Threatened' land environments (<10% indigenous vegetation cover remaining) and 30% is on 'Critically Underprotected' land environments (>30% left and <10% protected) (Walker *et al*. 2007).

3. PROJECT OBJECTIVES

The objectives of the EMP are:

(i) to compensate for and offset the loss of wetland and intermittent stream habitats respectively at the site by revegetating the riparian margins of intermittent streams and buffer zones of six wetlands, together with enhancement planting within six wetlands; and

(ii) to minimise or avoid potential adverse impacts on indigenous freshwater fish.

Revegetation and enhancement planting will improve the ecological values of the site through the restoration of riparian habitat, promoting natural regeneration of the wetlands, and improving habitat values for indigenous flora and fauna.

4. METHODS

4.1 Terrestrial ecological management

Field surveys were undertaken on 19 March 2018, 6 June 2018 and 19 March 2019 during which sites were identified that could be restored to compensate for the loss of the wetlands. In addition, SEVs were undertaken on 19 March 2019 to assess watercourses proposed to compensate for the loss of intermittent stream habitat, as well as a survey identifying weed populations within the Phase 2 development area.

All potential sites recommended for restoration were mapped in the field onto hard copy prints of digital aerial photographs. The maps were then digitised using ArcGIS 10.4 (GIS programme).

Detailed planting plans then were developed for each area, taking into consideration environmental conditions of the site and the objectives of the planting. Planting plans include plant schedules, pre-treatment requirements, and ongoing maintenance of the planting areas to ensure ongoing survival and success.

4.2 Freshwater ecological management

A targeted fish survey was beyond the scope of the March 2019 assessment; however, several fish species have previously been recorded near the property (Wildland

Consultants 2019). It is therefore recommended that fish capture and relocation be undertaken in association with the proposed works, if deemed necessary by a suitably qualified and experienced freshwater ecologist at the time of works.

5. PEST PLANTS

5.1 Overview

Pest plants within the planting areas include occasional gorse (*Ulex europeaus*), barberry (*Berberis glaucocarpa*), blackberry (*Rubus fruticosus* agg.), crack willow (*Salix fragilis*), woolly nightshade (*Solanum mauritianum*), and tree privet (*Ligustrum lucidum*).

In addition, several Chinese privet (*Ligustrum sinense*) shelter belts occur in close proximity to the planting areas. The Chinese privet shelter belts are a seed source for the rest of the property and birds may disperse seeds into the terrestrial planting areas. Pest plants within the planting areas will compete with indigenous species and compromise revegetation efforts.

5.2 Pest plant categories

Most of the abovementioned plant species are classified as Surveillance Pest Plants under the Auckland Regional Pest Management Strategy 2007-2012 (ARPMS, ARC 2007) and should be controlled. Surveillance Pest Plants include species that have been identified as having significant impacts on biodiversity across the entire Auckland Region. The Auckland Council seeks to prevent their establishment or spread by prohibiting their sale, propagation, distribution, and exhibition (ARC 2007).

Woolly nightshade is the exception to this, with this species being classified as a Containment pest plant under the ARPMS (ARC 2007). Containment pest plants are abundant in certain habitats or areas in the Auckland Region and landowners and/or tenants are obliged to control these plants in accordance with ARPMS requirements. Woolly nightshade is specified complete removal in the Waitakere Ranges Weed Control Zone and Great Barrier Island only, with ‘Boundary Control’ (20 metres from boundary) to be undertaken in the remainder of Auckland. However, although the ARPMS only requires boundary control of this species, it is recommended in this case for control across all restoration areas to prevent any remaining individual plants acting as a seed source and allowing reinvasion.

5.3 Recommended control methodologies

It is recommended that all Containment and Surveillance pest plant species observed within the planting areas and the shelter belts be controlled. Recommended control methods are presented in Appendix 2.

5.4 Disposal of material

All environmental pest plant infestations can be dealt with *in situ*, removing the need for disposal. The seedlings of many pest plant species (e.g. gorse) can be controlled by hand-pulling and may be left to rot on site.

It is essential that plant seeds, tubers, and fragments are not dispersed from the current infestation areas as some species can easily be spread by seed or fragments (e.g. blackberry). Where cut vegetation is to be left on site, seed heads should be removed wherever possible and disposed of responsibly to avoid new infestations establishing.

5.5 Pest plant control outcomes

No mature, flowering or fruiting pest plants should remain in planting areas prior to planting being carried out. After planting, ongoing maintenance should be carried out in order to keep the areas in a pest plant-free state, particularly while the plants are establishing. All newly established plants, regrowth of unsuccessfully controlled pest plants, and plants that are hindering the growth of indigenous plantings, should be controlled during regular maintenance site visits. See Section 8 for the recommended frequency and timing of maintenance work.

5.6 Agrichemical use, record keeping and reporting

All herbicide application operations should be undertaken by "Growsafe" certified operators, in line with the Agrichemical Users' Code of Practice (NZS 8409 2004: The Management of Agrichemicals) and industry best practice. This includes recording and maintaining records of all agrichemical usage on appropriate spray record sheets.

Reports summarising the herbicide application work undertaken during each year of the programme should be presented to Auckland Council on an annual basis. This report should include, but is not limited to:

- The timing of pest plant control rounds.
- Weather conditions during control rounds.
- Pest plant species controlled.
- The results/effectiveness of the control.
- Recommendations for pest plant control priorities for the following year.

5.7 Banned flora

Potentially invasive exotic species should not be planted on the site in future, as it continues to be developed for residential land use. This includes any species listed in the Regional Pest Management Strategy for Auckland, in the National Pest Plant Accord, or on the weedbusters.org.nz website.

6. PLANTING

6.1 Revegetation planting

6.1.1 Overview

Thirty-five planting areas have been identified at the site:

- Fifteen of the planting areas are the terrestrial buffer zone of wetlands.
- Ten are wetland interiors where enrichment planting is recommended.
- Nine planting areas are located within the riparian margin of intermittent or permanent streams.
- One planting area is located on a hill slope connecting two wetland buffer zones.

The locations of the planting areas are shown in Figure 1. All planting work within these areas should follow the plant schedules provided below (Tables 1-21) and the timeline presented in Section 8.

6.1.2 Planting Areas A-F and H-P: Wetland buffers

There are fifteen planting areas (Planting Areas A-F and H-P) that include five metre buffers around the freshwater wetlands proposed for restoration. Planting in these areas will enhance filtering of overland flow entering the wetlands, provide nesting and foraging habitat for indigenous fauna, and act as a visual screen and reduce disturbance to fauna using the wetland habitat. This will be achieved by using a combination of low-growing species and taller woody indigenous species tolerant of wet soils and periodic flooding.

The vegetation in the buffer zones is currently characterised by grazed exotic grassland with occasional gorse. The exotic grassland includes kikuyu (*Cenchrus clandestinus*), which is an aggressive grass that will smother seedlings. Therefore, these planting areas will require site preparation to control the exotic grasses and to reduce competition following planting. The suggested plant spacings will result in canopy closure within three to five years as well as reduce the chance of pest plant invasion. The plant schedules for these areas are provided in Tables 1-7, with areas combined where they are located in close proximity around the same wetland system.

Table 1: Planting schedule for Planting Area A (*c*.643 m^2).

Species	Common Name	Grade	Spacing (m)	Number
Carex virgata[1]	pūrei	1.5L	0.75	60
Coprosma robusta	karamu	1.5L	1.4	30
Cordyline australis[1]	tī kōuka, cabbage tree	1.5L	1.4	30
Dacrycarpus dacrydioides	kahikatea	PB5	5	5
Kunzea robusta	kānuka	1.5L	3	65
Leptospermum scoparium	mānuka	1.5L	1.4	55
Melicytus ramiflorus	māhoe	1.5L	3	25
Phormium tenax	harakeke	1.5L	1.4	25
Veronica stricta	koromiko, hebe	1.5L	1.4	25
Total				**320**

1. Plant on the wetter margins of the wetland.

Table 2: Planting schedule for Planting Areas B, D, and F (*c*.3,650 m^2).

Species	Common Name	Grade	Spacing (m)	Number
Carex virgata[1]	pūrei	1.5L	0.75	300
Coprosma robusta	karamu	1.5L	1.4	190
Cordyline australis[1]	tī kōuka, cabbage tree	1.5L	1.4	190
Dacrycarpus dacrydioides	kahikatea	PB5	5	15
Kunzea robusta	kānuka	1.5L	3	315
Leptospermum scoparium	mānuka	1.5L	1.4	290
Melicytus ramiflorus	māhoe	1.5L	3	100
Phormium tenax	harakeke	1.5L	1.4	220
Veronica stricta	koromiko, hebe	1.5L	1.4	200
Total				**1,820**

1. Plant on the wetter margins of the wetland

Table 3: Planting schedule for Planting Areas C and H-K (*c*.9,960 m^2).

Species	Common Name	Grade	Spacing (m)	Number
Carex virgata[1]	pūrei	1.5L	0.75	800
Coprosma robusta	karamu	1.5L	1.4	500
Cordyline australis[1]	tī kōuka, cabbage tree	1.5L	1.4	500
Dacrycarpus dacrydioides	kahikatea	PB5	5	50
Kunzea robusta	kānuka	1.5L	3	1,020
Leptospermum scoparium	mānuka	1.5L	1.4	1,000
Melicytus ramiflorus	māhoe	1.5L	3	370
Phormium tenax	harakeke	1.5L	1.4	370
Veronica stricta	koromiko, hebe	1.5L	1.4	370
Total				**4,980**

1. Plant on the wetter margins of the wetland

Table 4: Planting schedule for Planting Area E (*c*.2,300 m^2).

Species	Common Name	Grade	Spacing (m)	Number
Carex virgata[1]	pūrei	1.5L	0.75	180
Coprosma robusta	karamu	1.5L	1.4	110
Cordyline australis[1]	tī kōuka, cabbage tree	1.5L	1.4	110
Dacrycarpus dacrydioides	kahikatea	PB5	5	15
Kunzea robusta	kānuka	1.5L	3	230
Leptospermum scoparium	mānuka	1.5L	1.4	220
Melicytus ramiflorus	māhoe	1.5L	3	100
Phormium tenax	harakeke	1.5L	1.4	95
Veronica stricta	koromiko, hebe	1.5L	1.4	90
Total				**1,150**

1. Plant on the wetter margins of the wetland

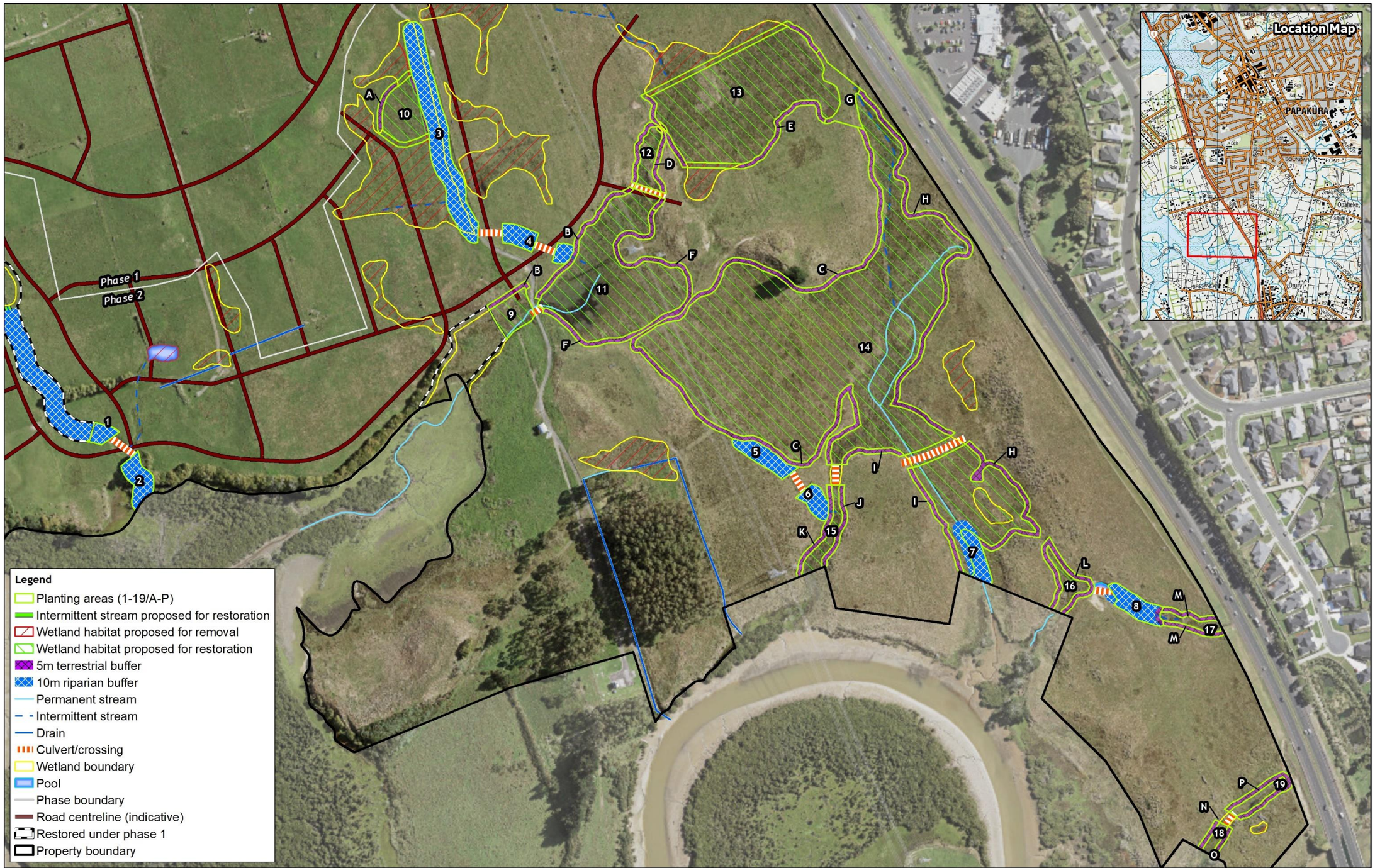

Figure 1: Proposed planting areas for Park Estate subdivision: Phase 2

Table 5: Planting schedule for Planting Area L (*c*.900 m^2).

Species	Common Name	Grade	Spacing (m)	Number
Carex virgata[1]	pūrei	1.5L	0.75	50
Coprosma robusta	karamu	1.5L	1.4	50
Cordyline australis[1]	tī kōuka, cabbage tree	1.5L	1.4	50
Dacrycarpus dacrydioides	kahikatea	PB5	5	10
Kunzea robusta	kānuka	1.5L	3	100
Leptospermum scoparium	mānuka	1.5L	1.4	100
Melicytus ramiflorus	māhoe	1.5L	3	30
Phormium tenax	harakeke	1.5L	1.4	30
Veronica stricta	koromiko, hebe	1.5L	1.4	30
Total				**450**

1. Plant on the wetter margins of the wetland.

Table 6: Planting schedule for Planting Area M (*c*.623 m^2).

Species	Common Name	Grade	Spacing (m)	Number
Carex virgata[1]	pūrei	1.5L	0.75	60
Coprosma robusta	karamu	1.5L	1.4	30
Cordyline australis[1]	tī kōuka, cabbage tree	1.5L	1.4	30
Dacrycarpus dacrydioides	kahikatea	PB5	5	5
Kunzea robusta	kānuka	1.5L	3	60
Leptospermum scoparium	mānuka	1.5L	1.4	55
Melicytus ramiflorus	māhoe	1.5L	3	20
Phormium tenax	harakeke	1.5L	1.4	25
Veronica stricta	koromiko, hebe	1.5L	1.4	25
Total				**310**

1. Plant on the wetter margins of the wetland.

Table 7: Planting schedule for Planting Areas N, O and P (*c*.2,000 m^2).

Species	Common Name	Grade	Spacing (m)	Number
Carex virgata[1]	pūrei	1.5L	0.75	165
Coprosma robusta	karamu	1.5L	1.4	100
Cordyline australis[1]	tī kōuka, cabbage tree	1.5L	1.4	100
Dacrycarpus dacrydioides	kahikatea	PB5	5	10
Kunzea robusta	kānuka	1.5L	3	190
Leptospermum scoparium	mānuka	1.5L	1.4	175
Melicytus ramiflorus	māhoe	1.5L	3	60
Phormium tenax	harakeke	1.5L	1.4	100
Veronica stricta	koromiko, hebe	1.5L	1.4	100
Total				**1,000**

1. Plant on the wetter margins of the wetland.

6.1.3 Planting Areas 9-19: Freshwater wetlands

The wetlands at the site are currently degraded and comprise exotic rushland and grassland characterised by Mercer grass (*Paspalum distichum*) with emergent soft rush (*Juncus effusus*) and frequent exotic herbs such as water pepper (*Persicaria hydropiper*), willow weed (*P. maculosa*), and creeping buttercup (*Ranunculus repens*) (see Appendix 1 photographs). The larger wetlands also support locally common rautahi (*Carex lessoniana*), one of the few indigenous wetland plant species at the site. These wetland habitats have the potential to be restored to indigenous shrubland and sedgeland habitats.

The plant schedules include species that can tolerate waterlogged conditions such as tī kōuka (*Cordyline australis*) and indigenous sedges (e.g. rautahi/*Carex lessoniana*). These areas do not require dense planting; instead, the aim is to create 'clusters' of indigenous vegetation that will establish throughout the wetlands over time. Open water wetland species will be included for Planting Area 11 to be planted within the western ponds.

Site preparation is minimal, although spot spraying of Mercer grass with grass-specific herbicide will improve the chances of plant survival. The schedules for Planting Areas 9-19 are provided in Tables 8-15. (Note that plant numbers in the schedules are estimated on a per 'cluster' basis).

Table 8: Planting schedule for Planting Area 16 (*c*.550 m^2)*.

Species	Common Name	Grade	Spacing (m)	Number
Carex secta		1.5L	0.75	10
Carex lessoniana	rautahi	1.5L	0.75	20
Carex virgata	pūrei	1.5L	0.75	15
Cordyline australis	tī kōuka, cabbage tree	1.5L	3	10
Cyperus ustulatus	giant umbrella sedge	1.5L	1	20
Leptospermum scoparium	mānuka	1.5L	1.4	5
Phormium tenax	harakeke	1.5L	1.4	20
Total				**100**

* Two clusters required for this area, i.e. total of 200 plants.

Table 9: Planting schedule for Planting Area 10 (*c*.2,132 m^2)*

Species	Common Name	Grade	Spacing (m)	Number
Carex secta		1.5L	0.75	25
Carex lessoniana	rautahi	1.5L	0.75	30
Carex virgata	pūrei	1.5L	0.75	30
Cordyline australis	tī kōuka, cabbage tree	1.5L	3	10
Cyperus ustulatus	giant umbrella sedge	1.5L	1	20
Leptospermum scoparium	mānuka	1.5L	1.4	10
Phormium tenax	harakeke	1.5L	1.4	25
Total				**150**

* Three clusters required for this area, i.e. total of 450 plants.

Table 10: Planting schedule for Planting Areas 11 and 12 (*c*.13,356 m^2)*.

Species	Common Name	Grade	Spacing (m)	Number
Carex secta[1]		1.5L	0.75	50
Carex lessoniana	rautahi	1.5L	0.75	85
Carex virgata	pūrei	1.5L	0.75	85
Cordyline australis	tī kōuka, cabbage tree	1.5L	3	25
Cyperus ustulatus	giant umbrella sedge	1.5L	1	85
Leptospermum scoparium	mānuka	1.5L	1.4	15
Phormium tenax	harakeke	1.5L	1.4	55
Schoenoplectus tabernaemontani[1]	kāpūngāwhā	1.5L	0.75	50
Typha orientalis[1]	raupō	1.5L	0.75	50
Total				**500**

* Five clusters required for this area, i.e. **total of 2,500 plants.**

1. Plant in open water; numbers can be increased in western clusters.

Table 11: Planting schedule for Planting Area 13 (*c*.15,918 m^2)*.

Species	Common Name	Grade	Spacing (m)	Number
Carex secta		1.5L	0.75	55
Carex lessoniana	rautahi	1.5L	0.75	85
Carex virgata	pūrei	1.5L	0.75	65
Cordyline australis	tī kōuka, cabbage tree	1.5L	3	25
Cyperus ustulatus	giant umbrella sedge	1.5L	1	70
Leptospermum scoparium	mānuka	1.5L	1.4	15
Phormium tenax	harakeke	1.5L	1.4	85
Total				**400**

* Seven clusters required for this area, i.e. **total of 2,800 plants**.

Table 12: Planting schedule for Planting Areas 14 and 15 (*c*.56,848 m^2)*.

Species	Common Name	Grade	Spacing (m)	Number
Carex secta		1.5L	0.75	80
Carex lessoniana	rautahi	1.5L	0.75	105
Carex virgata	pūrei	1.5L	0.75	85
Cordyline australis	tī kōuka, cabbage tree	1.5L	3	35
Cyperus ustulatus	giant umbrella sedge	1.5L	1	90
Leptospermum scoparium	mānuka	1.5L	1.4	25
Phormium tenax	harakeke	1.5L	1.4	85
Total				**500**

* Fifteen clusters required for this area, i.e. **total of 7,500 plants**.

Table 13: Planting schedule for Planting Area 16 (*c*.841 m^2)*.

Species	Common Name	Grade	Spacing (m)	Number
Carex secta		1.5L	0.75	10
Carex lessoniana	rautahi	1.5L	0.75	20
Carex virgata	pūrei	1.5L	0.75	15
Cordyline australis	tī kōuka, cabbage tree	1.5L	3	10
Cyperus ustulatus	giant umbrella sedge	1.5L	1	20
Leptospermum scoparium	mānuka	1.5L	1.4	5
Phormium tenax	harakeke	1.5L	1.4	20
Total				**100**

* Three clusters required for this area, i.e. **total of 300 plants**.

Table 14: Planting schedule for Planting Area 17 (*c*.547 m^2)*.

Species	Common Name	Grade	Spacing (m)	Number
Carex secta		1.5L	0.75	10
Carex lessoniana	rautahi	1.5L	0.75	20
Carex virgata	pūrei	1.5L	0.75	15
Cordyline australis	tī kōuka, cabbage tree	1.5L	3	10
Cyperus ustulatus	giant umbrella sedge	1.5L	1	20
Leptospermum scoparium	mānuka	1.5L	1.4	5
Phormium tenax	harakeke	1.5L	1.4	20
Total				**100**

* Two clusters required for this area, i.e. **total of 200 plants**.

Table 15: Planting schedule for Planting Areas 18 and 19 (*c*.1,077 m^2)*.

Species	Common Name	Grade	Spacing (m)	Number
Carex secta		1.5L	0.75	20
Carex lessoniana	rautahi	1.5L	0.75	25
Carex virgata	pūrei	1.5L	0.75	20
Cordyline australis	tī kōuka, cabbage tree	1.5L	3	10
Cyperus ustulatus	giant umbrella sedge	1.5L	1	20
Leptospermum scoparium	mānuka	1.5L	1.4	10
Phormium tenax	harakeke	1.5L	1.4	20
Total				**125**

* Three clusters required for this area, i.e. **total of 375 plants**.

6.1.4 Planting Areas 1 and 2-9: Offset stream riparian margins

Planting Areas 1 and 2-9 comprise the ten-metre riparian margins of the proposed offset watercourses as shown in Figure 1, which include both intermittent and permanent watercourses. The areas are currently characterised by grazed exotic grassland on the upper banks with soft rush and exotic herbs on the lower banks and floodplains. Revegetating the riparian margins will enhance the ecological values of the streams by stabilising the banks and providing shade. The species selected for these areas include early successional species (e.g. kānuka and karamū) which are recommended for planting on the upper banks, together with species that characteristically occur close to watercourses and are able to tolerate waterlogged conditions (e.g. pūrei). Canopy cover is expected to be reached within three to five years, and the shade created will naturally control many of the light-demanding exotic grasses, shrubs, and herbs. The planting schedules for these areas are provided in Table 16-21.

Table 16: Plant schedule for Planting Areas 1 and 2 (*c*.1,720 m^2).

Species	Common Name	Grade	Spacing (m)	Total No.
Carex virgata[1]	pūrei	1.5L	0.5	90
Carpodetus serratus[2]	putaputawētā	1.5L	1.4	50
Coprosma robusta[3]	karamū	1.5L	1.4	90
Cordyline australis[3]	tī kōuka	1.5L	1.4	90
Dacrycarpus dacrydioides[3]	kahikatea	PB5	5	10
Kunzea robusta[4]	kānuka	1.5L	3	140
Leptospermum scoparium[2]	mānuka	1.5L	1.4	150
Melicytus ramiflorus[4]	māhoe	1.5L	3	45
Phormium tenax[3]	harakeke	1.5L	1.4	90
Pittosporum tenuifolium[4]	kōhūhū	1.5L	1.4	45
Veronica stricta[4]	koromiko	1.5L	1.4	50
Vitex lucens[4]	puriri	PB5	5	10
Total				**860**

1. Plant on stream edge
2. Plant on toe-slope and floodplain
3. Plant throughout
4. Plant on upper bank

Table 17: Plant schedule for Planting Area 3 (*c*.4,585 m^2).

Species	Common Name	Grade	Spacing (m)	Total No.
Carex virgata[1]	pūrei	1.5L	0.5	300
Carpodetus serratus[2]	putaputawētā	1.5L	1.4	120
Coprosma robusta[3]	karamū	1.5L	1.4	220
Cordyline australis[3]	tī kōuka	1.5L	1.4	220
Dacrycarpus dacrydioides[3]	kahikatea	PB5	5	20
Kunzea robusta[4]	kānuka	1.5L	3	340
Leptospermum scoparium[2]	mānuka	1.5L	1.4	340
Melicytus ramiflorus[4]	māhoe	1.5L	3	170
Phormium tenax[3]	harakeke	1.5L	1.4	220
Pittosporum tenuifolium[4]	kōhūhū	1.5L	1.4	120
Veronica stricta[4]	koromiko	1.5L	1.4	200
Vitex lucens[4]	puriri	PB5	5	20
Total				**2,290**

1. Plant on stream edge
2. Plant on toe-slope and floodplain
3. Plant throughout
4. Plant on drier outer edges

Table 18: Plant schedule for Planting Area 4 (*c*.1,479 m^2)

Species	Common Name	Grade	Spacing (m)	Total No.
Carex virgata[1]	pūrei	1.5L	0.5	140
Carpodetus serratus[2]	putaputawētā	1.5L	1.4	50
Coprosma robusta[3]	karamū	1.5L	1.4	70
Cordyline australis[3]	tī kōuka	1.5L	1.4	70
Dacrycarpus dacrydioides[3]	kahikatea	PB5	5	10
Kunzea robusta[4]	kānuka	1.5L	3	100
Leptospermum scoparium[2]	mānuka	1.5L	1.4	110
Melicytus ramiflorus[4]	māhoe	1.5L	3	40
Phormium tenax[3]	harakeke	1.5L	1.4	60
Pittosporum tenuifolium[4]	kōhūhū	1.5L	1.4	40
Veronica stricta[4]	koromiko	1.5L	1.4	40
Vitex lucens[4]	puriri	PB5	5	10
Total				**740**

1. Plant on stream edge
2. Plant on toe-slope and floodplain
3. Plant throughout
4. Plant on drier outer edges

Table 19: Plant schedule for Planting Areas 5 and 6 (*c*.2,188 m^2)

Species	Common Name	Grade	Spacing (m)	Total No.
Carex virgata[1]	pūrei	1.5L	0.5	180
Carpodetus serratus[2]	putaputawētā	1.5L	1.4	80
Coprosma robusta[3]	karamū	1.5L	1.4	80
Cordyline australis[3]	tī kōuka	1.5L	1.4	80
Dacrycarpus dacrydioides[3]	kahikatea	PB5	5	10
Kunzea robusta[4]	kānuka	1.5L	3	170
Leptospermum scoparium[2]	mānuka	1.5L	1.4	190
Melicytus ramiflorus[4]	māhoe	1.5L	3	80

Species	Common Name	Grade	Spacing (m)	Total No.
Phormium tenax[3]	harakeke	1.5L	1.4	80
Pittosporum tenuifolium[4]	kōhūhū	1.5L	1.4	50
Veronica stricta[4]	koromiko	1.5L	1.4	80
Vitex lucens[4]	puriri	PB5	5	10
Total				**1,090**

1. Plant on stream edge
2. Plant on toe-slope and floodplain
3. Plant throughout
4. Plant on drier outer edges

Table 20: Plant schedule for Planting Area 7 (*c*.1,276 m^2)

Species	Common Name	Grade	Spacing (m)	Total No.
Carex virgata[1]	pūrei	1.5L	0.5	92
Carpodetus serratus[2]	putaputawētā	1.5L	1.4	50
Coprosma robusta[3]	karamū	1.5L	1.4	50
Cordyline australis[3]	tī kōuka	1.5L	1.4	50
Dacrycarpus dacrydioides[3]	kahikatea	PB5	5	8
Kunzea robusta[4]	kānuka	1.5L	3	90
Leptospermum scoparium[2]	mānuka	1.5L	1.4	100
Melicytus ramiflorus[4]	māhoe	1.5L	3	40
Phormium tenax[3]	harakeke	1.5L	1.4	60
Pittosporum tenuifolium[4]	kōhūhū	1.5L	1.4	40
Veronica stricta[4]	koromiko	1.5L	1.4	50
Vitex lucens[4]	puriri	PB5	5	8
Total				**638**

1. Plant on stream edge
2. Plant on toe-slope and floodplain
3. Plant throughout
4. Plant on drier outer edges

Table 21: Plant schedule for Planting Area 8 (*c*.1,119 m^2)

Species	Common Name	Grade	Spacing (m)	Total No.
Carex virgata[1]	pūrei	1.5L	0.5	50
Carpodetus serratus[2]	putaputawētā	1.5L	1.4	50
Coprosma robusta[3]	karamū	1.5L	1.4	50
Cordyline australis[3]	tī kōuka	1.5L	1.4	50
Dacrycarpus dacrydioides[3]	kahikatea	PB5	5	5
Kunzea robusta[4]	kānuka	1.5L	3	85
Leptospermum scoparium[2]	mānuka	1.5L	1.4	95
Melicytus ramiflorus[4]	māhoe	1.5L	3	40
Phormium tenax[3]	harakeke	1.5L	1.4	50
Pittosporum tenuifolium[4]	kōhūhū	1.5L	1.4	40
Veronica stricta[4]	koromiko	1.5L	1.4	40
Vitex lucens[4]	puriri	PB5	5	5
Total				**560**

1. Plant on stream edge
2. Plant on toe-slope and floodplain
3. Plant throughout
4. Plant on drier outer edges

6.1.5 Planting Area G: Ecological connection hill slope planting

Planting Area G comprises the hill slope and toe between the two larger wetlands (8 and 10) in the northeast of the property. This planting will link the wetland buffer planting of these wetlands and contribute to creating an ecological corridor in the east of the property. The area is currently characterised by grazed exotic grassland.

The species selected for this area include early successional species (e.g. kānuka and karamū) which are recommended for planting on the upper banks, together with species that characteristically occur close to watercourses and are able to tolerate waterlogged conditions (e.g. harakeke). Canopy cover is expected to be reached within three to five years, and the shade created will naturally control many of the light-demanding exotic grasses, shrubs, and herbs. The planting schedules for these areas are provided in Table 26.

Table 26: Plant schedule for Planting Area G (*c*.1,371 m^2)

Species	Common Name	Grade	Spacing (m)	Total No.
Coprosma robusta[1]	karamū	1.5L	1.4	80
Cordyline australis[2]	tī kōuka	1.5L	1.4	80
Dacrycarpus dacrydioides[2]	kahikatea	PB5	5	10
Kunzea robusta[1]	kānuka	1.5L	3	135
Leptospermum scoparium[2]	mānuka	1.5L	1.4	130
Melicytus ramiflorus[1]	māhoe	1.5L	3	50
Phormium tenax[2]	harakeke	1.5L	1.4	70
Pittosporum tenuifolium[1]	kōhūhū	1.5L	1.4	40
Podocarpus totara[1]	tōtara	1.5L	8	10
Veronica stricta[1]	koromiko	1.5L	1.4	70
Vitex lucens[1]	pūriri	PB5	5	20
Total				**695**

1. Plant on drier outer edges
2. Plant throughout

6.2 Site preparation

Appropriate site preparation is essential to the success of indigenous revegetation plantings. All environmental pest plants should be controlled within the planting areas. Pest plants are rare in the planting areas and largely restricted to occasional gorse on the wetland margins and barberry and tree privet in the stream riparian margins. All non-invasive exotic grasses and herbaceous plants within the wetland buffers and stream riparian margins should be blanket sprayed with a Glyphosate-based herbicide before planting work is carried out.

As rank kikuyu is present within the planting area/areas, spraying should be undertaken at least 12 weeks prior to planting, to allow time for the vegetation to break down.

6.3 Plant stock and availability

All plants should be sourced from the Manukau Ecological District in line with Auckland Council's eco-sourcing Code of Practice. To ensure availability, the plant

stock should be ordered as far in advance as possible, especially for slower-growing species required in larger grades (e.g. kahikatea).

6.4 Plant layout and spacing

In general, most shrub and smaller tree species should be planted at 1.4 to three metre centres. Larger growing species (e.g. kahikatea) should be planted further apart at approximately five metre centres, while maintaining an overall coverage of 1.4 metre spacing between all plants. Within wetland areas, sedges and rushes should be planted at 0.5-0.75 metre centres (3-4 plants/2 m^2).

6.5 Maintenance

Planted areas should be inspected at least three times during the first two years following planting. During these visits, plants should be released from exotic vegetation to ensure they are able to receive sufficient sunlight to thrive. As the plants become established, they will begin to out-compete other exotic species and the frequency of releasing will decrease. After five years no releasing should be necessary.

Limited infill planting[1] may be required during the next planting season depending on plant survival over the first summer. Infill plants should be of the same grade as those used in the initial planting. The number and species of infill plants should be identified in February or March prior to the planting season.

6.6 Pūkeko control

Pūkeko (*Porphyrio melanotus melanotus*) control should be undertaken if they are observed in high numbers near the planting areas prior to planting, or if suspected damage to the new plantings is detected. Shooting is the most effective control method for pūkeko. If shooting is to be undertaken during the game bird season, it can be carried out under a game bird hunting licence from Fish and Game NZ. Any pūkeko control that takes place outside of the game bird season requires a special permit, which can also be provided by Fish and Game NZ.

6.7 Possum control

Timms traps are recommended for the control of possums should these be found browsing on planted vegetation. Timms traps are a kill trap and should be spaced at approximately 100 metre intervals within control areas.

Timms traps should be activated for a period of four weeks at least once per year. A second trapping period may also be considered if pest numbers are high and there is consistent trapping success during the first period. During each period of activation, the traps should be baited with half a cut apple and/or a cinnamon lure and should be cleared and rebaited at least weekly.

[1] Infill planting is required on sites where there are gaps in the planting because of plant mortality or where initial stocking rates were too low.

6.8 Rabbit control

Rabbits can be controlled using Pindone bait pellets. If the person carrying out the control work holds a Controlled Substance License (CSL), broadcasting of bait pellets or carrots laced with liquid Pindone is the most effective way of controlling rabbits. However, if someone with a CSL is not available multi feeder bait stations should be used to contain bait pellets.

The recommend rate of Pindone application is between 2-3 kgs in each bait station. This should provide enough bait to last 2 days, which should allow all potential rabbits within the treatment area to feed from the station. After 10-15 days re check for signs of rabbits and if necessary, re treat the area. Bait stations should be spread throughout the area where rabbit sign is evident.

6.9 Record keeping and reporting

Records of all pest animal control operations should be maintained in line with industry best practice. A summary of the pest animal control work undertaken during each year of the programme should be presented to Auckland Council on an annual basis. This includes, but is not limited to:

- A plan showing the approximate locations of bait stations, traps, and signage;
- Timing of control rounds;
- Weather conditions during control rounds;
- Number of bait stations used, and amount of bait take;
- Number of traps installed, and number and species of animals caught; and
- A record of correspondence (if any) regarding the pest animal control operation.

6.10 Legal protection of restored stream and wetland habitat

Restored wetlands and watercourses will be protected through the use of statutory mechanisms such as protective covenants. Covenants are designed to protect ecologically significant parcels of land in perpetuity, and can include financial contributions towards fencing and ongoing pest control. Areas planted in indigenous species should also be protected in perpetuity, although such areas will most likely require a Council covenant rather than a Queen Elizabeth II Open Space covenant. Once the construction of the subdivision has been completed no stock will be present at the site. It is therefore not considered necessary to fence the protected areas.

7. MANAGEMENT OF INDIGENOUS FRESHWATER FAUNA

7.1 Overview

A suitably qualified and experienced ecologist will be required to carry out the freshwater fauna capture and relocation work. This work is to be undertaken in all streams and ponds to be reclaimed or piped (including drains), if it is determined necessary at the time of works. If it is not determined necessary, a memorandum should be produced and submitted to Auckland Council outlining the reasons as to why fish capture and relocation will not be undertaken (e.g. dry streams).

For works requiring management of indigenous freshwater fauna, individuals will be removed from the impact reaches using one or all of the following methods:

- Trapping
- Electric fishing
- Sediment removal

It is preferable (although not always possible) to undertake the fish relocation works during a period of settled weather. Fishing will not occur within 48 hours of a heavy rainfall event. In the larger channels and ponds it may be necessary to drop the water levels to maximise the efficiency of the fauna capture techniques.

7.2 Channel dewatering

Some of the larger channels and ponds may need to be partially dewatered before the capture of freshwater fauna can proceed. Once earth bunds are in place to isolate a section of channel, water can then be pumped out. The pump inlet must be screened using three to five millimetre mesh to reduce the likelihood of fish being drawn into the pump. The pump discharge water is to be directed onto nearby land, well away from other waterways and waterbodies. Discharged water will be regularly checked at the discharge point for the presence of freshwater fauna that may have been drawn into the pump. Any indigenous fauna that are healthy/uninjured will be relocated with the other capture individuals. Badly injured fish will be euthanised and disposed of on site.

7.3 Capture methods

7.3.1 Trapping

Baited Gee minnow traps and fyke nets will be deployed in areas of suitable habitat in each impact watercourse. The number and type of fish traps used for each reach will depend on the length and size of the channels, and will be determined on-site prior to trap deployment. If the water levels are not high enough to use traps, this step will not be carried out.

The traps and nets will be set, anchored in place, and left overnight for a minimum of two consecutive nights. They will be set in the mid to late afternoon and then lifted early the following morning to remove any captured fauna. Most traps and nets will be placed near the surface of the water so that they retain an air gap, but deep enough to ensure that they do not become stranded overnight by changing water levels. Some traps will be placed on the bottom to target crustaceans (e.g. kōura). If large numbers of indigenous fauna are still being caught after two days, fishing will continue until the catch rate declines substantially.

7.3.2 Electric fishing

Where practicable, a backpack electric fishing machine will be used to disturb and capture fish in smaller channels using best practice (David *et al*. 2010). Particular attention will be given to areas where undercut banks and/or overhanging vegetation

may provide shelter to indigenous fish. At least two sweeps of each impact waterway will be carried out. If fish are detected, but not caught, a third sweep will be carried out.

Limitations to electric fishing at the site include the depth and width of watercourses, deep sediment, conductivity of the water, water flow, turbidity, and the weather.

7.3.3 Sediment removal

Fauna can remain hidden in deep sediment and not move into traps, or be captured through electric fishing methods (particularly eels and kōura). Where required, an excavator bucket will be used to carefully extract sediment and deposit it onto dry land. This will enable the sediment to be thoroughly searched for remaining indigenous fauna. A suitably qualified and experienced ecologist will need to be present through this process. This method has proven to be effective at recovering aquatic species from ponds and watercourses that contain deep sediments.

7.4 Transport and relocation

Captured indigenous freshwater fauna will be removed from the nets and traps and placed into chilly bins. The chilly bins will hold a minimum of 20 centimetres of water that has been collected from the impacted watercourses so as to minimise stress to the captured animals. The bins will be placed in a shaded area and a battery-powered air aerator will be used to keep the water well-oxygenated. The bins will have securely fitted lids to prevent fauna escaping. Large fish (particularly eels) will be kept separate from smaller individuals in order to reduce the risk of stress, injury, or predation. All indigenous freshwater fauna will be shifted to the relocation site as soon as possible following the clearance of the nets and traps.

The condition of all capture fauna will be visually assessed before being released. They will be removed from the bins by hand nets and placed carefully into the water at the release site. Water in the bins will be discharged onto land well away from the release site, to reduce the risk of spreading pest organisms.

7.5 Release sites

All indigenous freshwater fauna captured during the operation will be relocated to streams along the southern edge of the property that are to be restored in association with the development (see Figure 1). These are considered suitable habitat to support the known freshwater species, and they have good connectivity with the rest of the project site and Drury Creek.

7.6 Pest aquatic species

The presence of introduced fish within this project site means that dewatering water from the channels must be discharged onto land to prevent the spread of unwanted species (including fish eggs, plants, plant fragments, seeds, algae, and invertebrates) to other waterways.

7.7 Authorities required

The following authorisations are held by Wildland Consultants to enable staff to carry out various works in freshwater ecosystems, including the capture and relocation of freshwater fauna:

- A special permit under the Fisheries Act 1996 (MPI Special Permit Number 633).
- An electric fishing authority under the Conservation Act 1987 (Department of Conservation National Authorisation Number 52260-FAU).

7.8 Reporting

A short report in the form of a letter will be produced following the completion of the aquatic fauna capture and relocation works. This will contain an inventory of the fauna captured and relocated, together with representative photographs. Capture results will also be entered into the New Zealand Freshwater Fish Database, reporting to MPI, and/or reported to the Department of Conservation, as per the authorities held by Wildland Consultants.

8. WORK PROGRAMME, RESOURCES, AND TIMELINE

The recommended work programmes for pest plant control, pest animal control and planting work is provided below.

Year 1

Task	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Order plants												
Site preparation (Planting Areas 10-19)												
Site preparation (Planting Areas 1, 2-9 and A-P); pūkeko and rabbit/hare control (if deemed necessary)												
Planting (Planting Areas 10-19)												

Year 2

Task	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Planting (Planting Areas 1, 2-9 and A-P); pūkeko and rabbit/hare control (if deemed necessary)												
Infill planting (Planting Areas 10-19 if required)												
Monitoring of planting and releasing where necessary												

Year 3

Task	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Infill planting (Planting Areas 1, 2-9 and A-P if required)												
Monitoring of planting and releasing where necessary												

Year 4

Task	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Monitoring of planting and releasing where necessary												

Year 5

Task	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Monitoring of planting and releasing where necessary												

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APPENDIX 1

SITE PHOTOGRAPHS

Plate 1: Ponded open water in western Planting Area 11. 6 June 2018.

Plate 2: Typical wetland planting environment characterised by grazed pasture and soft rush. 19 March 2018.

Plate 3: Pugged stream channel and surrounding grazed pasture to be restored with indigenous vegetation, Planting Area 3. 19 March 2019.

Plate 4: Grazed exotic wetland and buffer area of Planting Area 17, to be restored adjacent State Highway 1. 19 March 2019.

RECOMMENDED HERBICIDE TREATMENTS

Pest Plant	Control Method(s)	Chemical(s)	Application Rate	Timing	Remarks
Barberry (*Berberis glaucocarpa*)	Hand pull seedlings/small plants			Year round	
	Cut and treat stumps	Triclopyr	60ml/1 litre water	October-April	
	Drill and inject	Metsulfuron	5g/1 litre water, plus 2 ml surfactant	October-April	
	Cut and treat stump	Triclopyr	60ml/1 litre water	October-March	
Blackberry (*Rubus fruticosus*)	Cut and treat stumps	Glyphosate gel 120g/KG	Paste with glyphosate gel	December-April	
	Knapsack - foliar spray	Triclopyr 600g/L	60ml triclopyr/10L water	December-April	Preferred choice close to water.
Chinese privet (*Ligustrum sinense*)	Hand pull seedlings/small plants			Year round	
	Cut and treat stumps	Triclopyr	60ml/1 litre water	October-April	
	Drill and inject	Metsulfuron	5g/1 litre water, plus 2 ml surfactant	October-April	
Crack willow (*Salix fragilis*)	Cut and treat stumps	Metsulfuron 600g/KG	5g metsulfuron + 2ml organosilicone/1L water	October-April	
	Drill and inject/Bore and spray	Metsulfuron 600g/KG	5g metsulfuron + 2ml organosilicone/1L water	October-April	Preferred option as leaving the tree standing avoids broken twigs/branches resprouting on ground.
		Glyphosate 510g/L	250ml glyphosate/1L water (25% glyphosate)	October-April	
	Basal bark application	Triclopyr 600g/L	2L triclopyr + 8L Syntol oil	October-April	ONLY on trees with base diameter <30cm
Gorse (*Ulex europaeus*)	Knapsack - foliar spray	Metsulfuron	5g/10 litres water plus 10ml Pulse	November-March	
	Cut and treat stumps	Triclopyr	60ml/1 litre water	October-March	
Mercer grass (*Paspalum distichum*)	Knapsack - foliar spray	Glyphosate 360	100ml/10 litres water	Year round	
	Knapsack - foliar spray	Haloxyfop	70ml/10 litres water	Year round	Useful for releasing around indigenous plantings to minimise non-target damage. Not to be used over water.
Tree privet (*Ligustrum lucidum*)	Cut and treat stumps	Triclopyr	60ml/1 litre water	November-March	
	Drill and inject	Metsulfuron	20g/litre water, plus 2ml surfactant	November-March	

Pest Plant	Control Method(s)	Chemical(s)	Application Rate	Timing	Remarks
Woolly nightshade (*Solanum mauritianum*)	Hand pull seedlings/small plants	-	-	Year round	
	Saplings - cut and treat stump	Glyphosate gel 120g/KG	Paste with glyphosate gel	Year round	

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