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VOLUME 2

APPENDIX K

Ecological Assessment, Freshwater Solutions (2020)

report

February 2020

223 Kohimarama Road and 7 John Rymer Place Stream Ecological Assessment

Submitted to:
Ryman Healthcare Ltd

freshsolutions water
environmental consultants

Quality Assurance

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Executive Summary

Ryman Healthcare Ltd is proposing to construct and operate a comprehensive care retirement village ('Proposed Village') at 223 Kohimarama Road and 7 John Rymer Place, Auckland ('Site'). The Site is located in the Pourewa Creek catchment and the headwaters of a highly modified Pourewa Creek tributary and associated side-branches are located within the Site. The Proposed Village design consists of multi-level apartment blocks and a village centre building, which contains care rooms and communal facilities for residents. Wastewater will be connected to the local Allum Street network, while stormwater from the Site will connect to the existing stormwater infrastructure at the south-eastern boundary (and which ultimately discharges via an existing stormwater outlet at the end of John Rymer Place – Watercourse D).

The three watercourses (A, B and C) within the Site are highly modified intermittent streams with limited ecological values. Watercourse A has the highest ecological values of these streams including supporting moderate populations of banded kōkopu.

Watercourse D is a permanent stream fed by stormwater from the upstream catchment, which is reflected in the poor water quality and aquatic biota (macroinvertebrates and fish) observed during sampling. The MCI-sb index for the stream is 70, which indicates poor stream health. Water quality sampling revealed low dissolved oxygen levels coupled with elevated nutrients, microbial and metals, which are likely to be limiting aquatic biota. The SEV score for Watercourse D is 0.586 and indicative of moderate ecological function.

The Pourewa Creek is the ultimate receiving environment for stormwater discharges from the wider catchment. It is a large permanent slow flowing watercourse that is swampy in nature. The MCI-sb index for the stream is 71, which indicates poor stream health. Water quality sampling revealed low dissolved oxygen levels coupled with some elevated metals. Pourewa Creek drains a Significant Ecological Area ('SEA') and the coastal forest of Kepa Reserve before discharging to Hobson Bay.

The key potential effects of the Proposed Village with regard to freshwater ecology include the diversion and daylighting of Watercourse A and earthworks and construction effects (sedimentation and discharge).

The proposed realignment, daylighting and restoration of Watercourses A and C will increase the amount and quality of stream habitat within the Site. Enhancements will improve habitat for what is expected to remain a limited benthic invertebrate community but is expected to significantly enhance the amount and quality of habitat and potential spawning habitat for banded kōkopu. It is recommended a fish relocation plan is prepared and implemented prior to any streamworks in Watercourse A, B and C.

Provided all earthworks within the Site are completed in accordance with Auckland Council guidelines (i.e., GD05), then no adverse freshwater ecology effects on the downstream environment are anticipated. Overall, any potential adverse freshwater ecology effects of the Proposed Village will be negligible provided the recommendations set out in this report are implemented. The realignment, daylighting and restoration of Watercourses A and C will have a positive effect on the overall ecology within the Site and see an increase in the length of stream natural channel from 60 m to 165 m. A Stream Ecological Valuation (SEV) and Environmental Compensation Ratio (ECR) assessment determined the realignment and daylighting of Watercourse A and C will result in a net-gain in ecological values.

1.0 Introduction

1.1 Background

Ryman Healthcare Ltd is proposing to construct and operate a comprehensive care retirement village ('Proposed Village') at 223 Kohimarama Road and 7 John Rymer Place, Auckland ('Site') (Figure 1).

The Site is located in the Pourewa Creek catchment. The headwaters of a highly modified Pourewa Creek tributary and associated side-branches are located within the Site. Three watercourses have been identified within the Site and are hereafter referred to as Watercourses A, B and C. These watercourses within the Site drain into existing stormwater infrastructure that discharges into Watercourse D via a stormwater outlet at the end of John Rymer Place which then flows into Pourewa Creek.

The Proposed Village design consists of multi-level apartment blocks and a village centre building, which contains care rooms and communal facilities for residents. Wastewater will be connected to the local Allum Street network, while stormwater will be piped to the existing stormwater outlet at the end of John Rymer Place.

This report assesses the aquatic and riparian ecological values of watercourses impacted by the Proposed Village, and assesses the effects of the Proposed Village on those values.

2.0 Methodology

2.1 Desktop Review of Existing Information

A desktop review of existing information was undertaken. Historical aerial images between 1940 and 1977 were obtained from Retrolens. The images provided an insight into the history of the Site and assisted with determining whether watercourses were natural, modified or artificial features. Information including underground infrastructure, overland flow paths and Significant Ecological Areas ('SEAs') was obtained from Auckland Council Geomaps. Background information for the wider Pourewa Creek was obtained from the Watercourse Management Plan for the Hobson Bay catchment (Golder Associates 2014). Fish data for the Site and wider Pourewa Creek catchment was obtained from the New Zealand Freshwater Fish Database (NZFFD).

2.2 Site Visits

Site visits were carried out on 31 October 2018, 29 June 2019 (with Council staff), 5 August 2019 (with Council staff), 27 August 2019, 22 October 2019 and 21 November 2019 to classify and assess the ecological values of watercourses affected by the Proposed Village.

2.3 Stream Classification

The status of watercourses draining the Site, and those impacted by stormwater were assessed in accordance with criteria outlined in the Auckland Unitary Plan Operative in Part ('AUP') and within the June-October window recommended by Auckland Council. The AUP stream classification criteria are presented in Appendix A. A pre-application meeting was held on site with Auckland Council representative Christina Bloom (Specialist: Freshwater and Sediment) on 5 August 2019 to confirm stream classifications.

Figure 1: Location of Proposed Village at 223 Kohimarama Road.

2.4 Water Quality

Physico-chemistry was measured in the receiving environment (i.e., Watercourse D and Pourewa Creek) using calibrated YSI meters. Water samples were collected from Watercourse D and the Pourewa Creek on 21 November 2019 and 22 October 2019 respectively, for the analysis of turbidity, total suspended solids, total nitrogen, ammoniacal-N, nitrite-N, nitrate-N, total Kjeldahl nitrogen, dissolved reactive phosphorus, total phosphorus, $cBOD_5$ and *Enterococci*, along with a selection of metals.

2.5 Aquatic Habitat and Biological Communities

Aquatic and riparian habitat characteristics of Watercourses A, B, C, D and Pourewa Creek were described (e.g., width, depth, habitat type, streambed substrate, shade, erosion, flow velocity, aquatic plants and periphyton cover).

Macroinvertebrates were assessed in Watercourse A on 27 August 2019 using a kick-net (mesh 0.5 mm) and tray to identify the broad taxonomic groups to provide a general indication of the macroinvertebrate community present. Macroinvertebrate samples were collected from Watercourse D on 21 November 2019 and Pourewa Creek on 27 August 2019 using a kick-net (mesh 0.5 mm) and following the semi-quantitative Protocol C2 (Stark et al. 2001). Data was analysed to determine community composition, taxa number, abundance, EPT taxa and MCI-sb scores.

An electric fishing machine survey was carried out along Watercourse A on 27 August and on Watercourse D on 21 November 2019.

2.6 Stream Ecological Valuation

Stream Ecological Valuation (SEV) data was collected from Watercourse A on 27 August 2019 and Watercourse D on 21 November 2019 in accordance with the method outlined in Neale et al. (2016) to determine ecological values. SEV scores range between 0 (poor) and 1 (excellent) and are calculated from physical habitat, biological community (invertebrates and fish) and desktop data. The very short length of Watercourse B and the very limited amount of surface water present in Watercourse C meant SEV surveys were not carried out on these watercourses.

3.0 Description of Environment

3.1 Site and Surrounds

The Site is bound by Kohimarama Road to the north east, Selwyn College to the west and residential housing off John Rymer Place to the south-east.

The Site contains the headwaters of Watercourse A, which is a highly modified first order tributary of Pourewa Creek. Watercourse B is a short side-branch that drains into Watercourse A and has formed below a stormwater pipe outlet. Watercourse C is a modified remnant of the original Watercourse A alignment that was formed when the Selwyn College sports field within the Site was created at some time between 1961 and 1968. Watercourse D originates as an open channel offsite at the end of John Rymer Place and is where stormwater from the Proposed Village will be directed into.

Vegetation within the Site comprises exotic grass and weeds and mostly exotic shrubs and mature trees. None of the vegetation within the Site has been identified as Significant Ecological Area (SEA).

The Pourewa Creek catchment has been highly modified through residential development, and little open channel (with the exception of that occurring in the Site and Watercourse D) remains. Historically Watercourse D drained a gully that extended up through the current alignment of John Rymer Place. Watercourse A formed one of the key tributaries that historically fed into Watercourse D as was another tributary in the current alignment of Ashwell Street. Watercourses A-C within the Site drain into a pipe network that originates on-site (Figure 2). The piped network ultimately discharges into what remains of Watercourse D located to the south of the Site immediately adjacent to 64 John Rymer Place (Figure 2). Watercourse D joins the Pourewa Creek some 80 m downstream.

Pourewa Creek is a permanent stream that drains coastal forest of Kepa Reserve, which is identified as a terrestrial SEA (SEA_T_5242) before discharging to Hobson Bay. The coastal forest SEA_T_5242 meets all five criteria outlined in Schedule 3 of the AUP for SEA qualification (e.g., a) representativeness, b) stepping stones, migration pathways and buffers, c) threat status and rarity, d) uniqueness or distinctiveness, e) diversity).

Pourewa Creek transitions into mangrove lined intertidal habitat identified as a marine SEA-M1-51c approximately 460 m downstream from the Watercourse D confluence. Schedule 4 of the AUP describes the Pourewa Creek SEA as '*containing some of the largest mangroves in the ecological district. The value of these mangroves is enhanced by the gradation from mangrove forest into the coastal forest of Pourewa Reserve. Pourewa Valley contains remnants of coastal forest and one of the finest examples of mangrove forest in the Auckland area with some trees up to 4m in height. Several patches of eelgrass, now a rather uncommon species in the Waitemata Harbour since its devastation by disease in the 1950s, are found on the tidal flats. There are some old kānuka, cabbage trees, kōwhai and pōhutukawa. The Council and community groups have undertaken the protection and enhancement of this area. Birds of the area include mallard ducks, pied stilts, kingfishers, blue reef herons, grey warblers, tūī and pūkeko'.*

Pourewa Creek flows for an additional 1.34 km downstream to the inlet/outlet of Ōrākei Basin. The lower reaches of Pourewa Creek have potential īnanga spawning habitat and supports one of the best examples of mangrove forest in the Auckland area with some trees up to 4 m in height (Golder Associates 2014).

3.2 Historical Information

Aerial photography from 1951 shows the Site was steep with a series of scarps in the western area of the Site formed by apparent slope movement towards the south-west. The Site was filled and the natural contour altered during the development of Selwyn College between 1961 and 1968. The 1951 aerial image shows a natural gully system that previously occurred within the Site. It is not possible to be certain, but it is likely the watercourse draining this gully (i.e., Watercourse A) was at least intermittent prior to modifications that have occurred within the Site since 1951 (Figure 3).

4.0 Stream Assessment

4.1 Introduction

Watercourses within the footprint of the Proposed Village and downstream environment are shown on Figure 4 along with their classifications in accordance with AUP criteria (refer to Appendix A for criteria). The watercourses within the Site are ephemeral, intermittent or artificial in nature as shown on Figure 4.

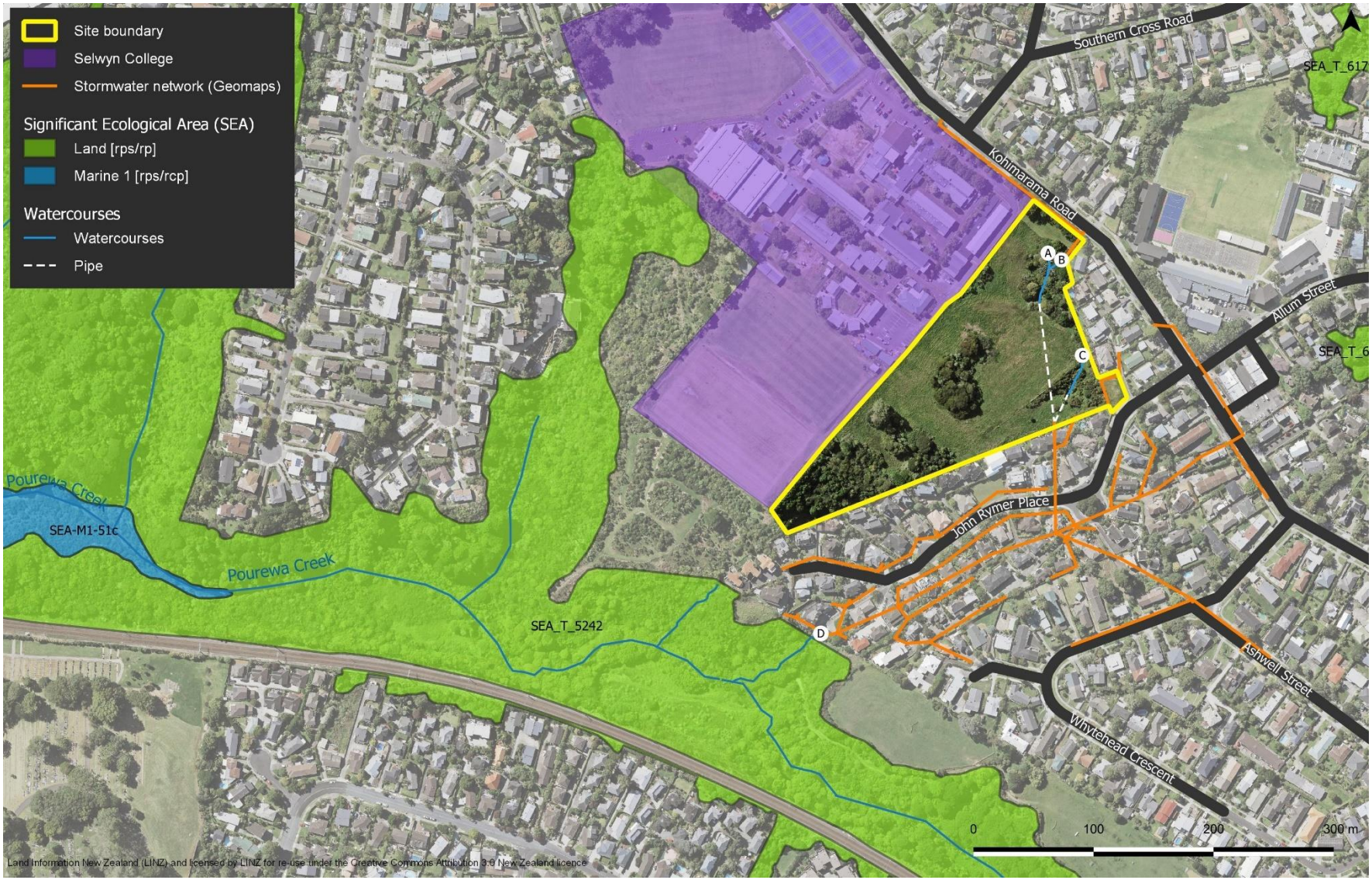

Figure 2: Downstream stormwater network, Pourewa Creek and nearby Significant Ecological Areas.

Figure 3: 1951 Aerial image of the Site.

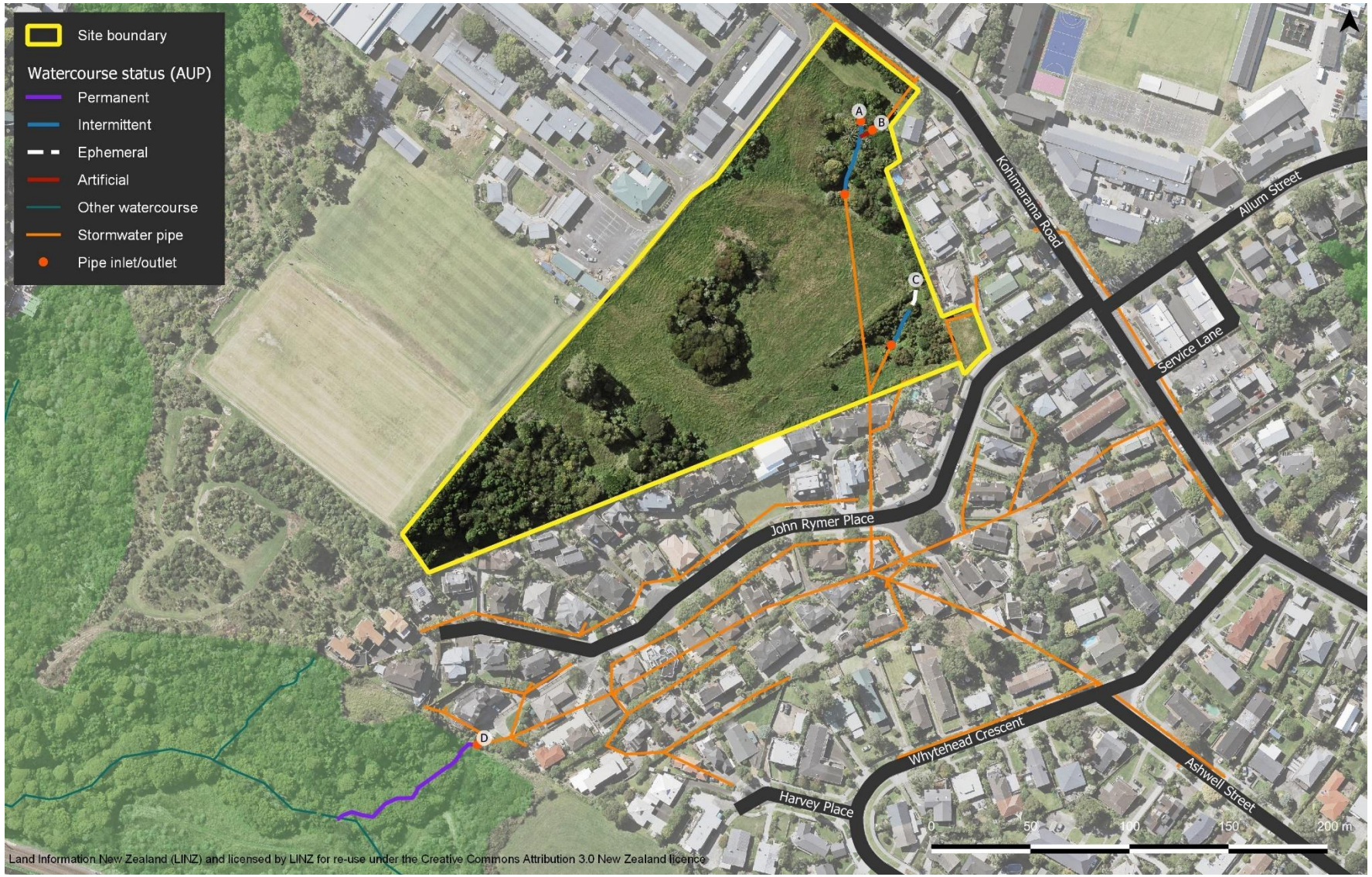

Figure 4: Current stream alignment and status.

4.2 Watercourse A and B

Watercourses A and B enter the Site via two stormwater pipes in an area of dense vegetation near the northern boundary. Stormwater from these pipes has scoured two short stream channels (Watercourse A = 52 m and Watercourse B = 15 m in length) that converge and drain downstream in a poorly defined channel that becomes more defined until it opens out into a wide pooled area surrounded by dense vegetation above a pipe inlet (Figure 5 and Figure 6). The bed of Watercourse A and B comprises weathered clay and silt with habitat dominated by run and occasional disconnected pools of stable water.

Figure 5: Disconnected pool in upper intermittent section of Watercourse A.

Figure 6: Wide pooled area on Watercourse A above pipe inlet.

The upper section of Watercourse A downstream from the stormwater pipes and within the area of dense vegetation is located in the position of the gully that is shown on the 1940 aerial and meets the Auckland Council definition of an intermittent watercourse.

The short section of Watercourse B below the stormwater outlet is considered an artificial channel as it has only formed due to stormwater flow from the pipe. Watercourse B has very low ecological values given it is artificial and does not flow during baseflow conditions.

There is no channel or surface water to the immediate south of the area of dense vegetation in the alignment of this upper stream section. The inlet of the stormwater pipe in this vicinity was not seen during the survey due to the dense nature of the vegetation.

The SEV score for Watercourse A was 0.532, which is indicative of moderate ecological function. Watercourse A scored well for natural connectivity to groundwater, dissolved oxygen levels maintained, organic matter input, instream particle retention and fish spawning habitat functions. Watercourse A scored low for natural flow regime, connectivity for natural species migrations and riparian vegetation intact functions.

4.3 Watercourse C

Watercourse C is a modified overland flow path that has formed along the eastern boundary of the Site. Watercourse C was dry at the time of the survey, lacked a defined channel and had terrestrial vegetation growth along its base. This part of Watercourse C is classed as ephemeral. Watercourse C then drains into a densely vegetated gully with moderate gradient that has a short section located above an earth bund that would be classed as intermittent due to the presence of a defined channel and small amount of shallow surface water at the time of the survey (Figure 7). This portion of the gully appears to be in the location of a section of the original gully shown on the 1940 aerial image. The earth bund across the gully represents the lowermost extent of open watercourse within the Site.

The very limited amount of surface water in this section of intermittent stream indicates it is not connected with the upper section of intermittent stream in the northern vegetated area within the Site. It is assumed Watercourse C drains into the stormwater network.

Figure 7: Shallow non-flowing water in intermittent section of Watercourse C.

4.4 Watercourse D

Watercourse D was classified as a permanent stream in accordance with AUP criteria as it had deep stable pools and continuous flow at the time of the survey (Figure 8).

Watercourse D forms the lowermost section of the original gully catchment that historically extended up the present-day alignment of John Rymer Place. Watercourse D presently originates as an open channel below the stormwater pipe at the end of John Rymer Place and drains approximately 80 m down to its confluence with Pourewa Creek.

The channel has a low gradient and meanders through an area of mostly exotic vegetation and regenerating native scrub that provides moderate shade. Flow is constrained in places by debris dams, dense willow (*Salix* sp.) and arum lily *(Zantedeschia aethiopica)* resulting in blockages, sub-surface flow and the formation of a small side channel on the true-right side where water spills from the mainstem onto the floodplain.

The main channel ranges in width between 0.2–1.8 m (mean = 1.07 m) with depths between 0.02–0.42 m (mean = 0.17 m). The bed comprises silt, fine gravels and weathered clay. Instream habitat comprised medium-large pools, runs and occasional chutes formed over willow tree roots. Habitat also included occasional woody debris with overhanging vegetation providing good bankside cover. There was no evidence of accelerated bank erosion and the stream had good connectivity with the surrounding low-lying floodplain.

The SEV score for Watercourse D was 0.586, which is indicative of moderate ecological function. Watercourse D scored well for hydraulic function (i.e., natural channel, moderate riparian vegetation and good floodplain connectivity) and biogeochemical functions (i.e., velocity, depth, shading, riparian vegetation and filtering). Watercourse D is located within a Significant Ecological Area (SEA_T_5242) and is zoned ‘Open Space – Informal Recreation Zone’ in the AUP.

Figure 8: Section of stream channel along Watercourse D.

4.5 Pourewa Creek

The Pourewa Creek is a large slow flowing watercourse that is swampy in nature and often flowing in multiple channels (Figure 9). Willow (*Salix* sp.) is common within the channel forming debris jams (and thus large pools) as well as pool-ramp sequences caused by their fibrous root mats. The soft bottomed channel is approximately 5–8 m wide, 0.4–0.6 m deep but occasionally deeper in places (>1.0 m). Water is slightly turbid and iron floc was common in the sluggish environment. The Pourewa Creek is moderate-poorly shaded by willow and Chinese privet. Macrophytes are abundant and included watercress *(Nasturtium officinale),* water celery *(Apium nodiflorum),* and water starwort *(Callitriche stagnalis).* Woody debris and leaf litter are abundant.

Figure 9: Typical Characteristics of the Pourewa Creek downstream of the Site.

5.0 Water Quality

5.1 Water Physiochemistry

Water physiochemistry was measured in Pourewa Creek on 22 October 2019 and in Watercourse D on 21 November 2019 with data summarised in Table 1. Water quality was measured in these watercourses as they represent the downstream environment that will receive stormwater generated from the Proposed Village.

Water temperature was slightly lower in the Pourewa Creek (14.5°C) than Watercourse D (16.9°C), however, this was likely a reflection of the month elapsed between sampling incidences. Water temperatures in the Pourewa Creek were categorised as 'excellent' by NIWA guidelines (i.e., within 10–14.9°C), while those in Watercourse D were categorised as 'good'. Dissolved oxygen in both the Pourewa Creek (60% and 6.2 g/m^3) and

Watercourse D (55% and 5.3 g/m^3) was low and likely to be limiting to aquatic biota at the time of the survey. Both sites were below recommended ANZECC (2000) guidelines and within Attribute State B of Appendix 2 of the National Policy Statement for Freshwater Management 2014.

Conductivity ranged between 269 µS/cm in Pourewa Creek and 349 µS/cm in Watercourse D indicating moderately enriched waters. Stream pH was circum-neutral in Pourewa Creek (7.2) and slightly acidic in Watercourse D (5.8) and outside the recommended ANZECC (2000) guidelines.

5.2 Water Quality

A summary of water quality results for the Pourewa Creek on 22 October 2019 and Watercourse D on 21 November 2019 is presented in Table 1 and described in the following sections. Laboratory results are presented in Appendix B.

Table 1: Water quality results for the Pourewa Creek and Watercourse D.

Parameter	Pourewa	Watercourse D	Guidelines and standards
Temperature (°C)	14.7	16.9	-
Dissolved oxygen (g/m³)	6.2	5.3	NPS: State A ≥7.5 (1-day min.), State B ≥5.0 and <7.5 (1-day min.), State C ≥4.0 and <5.0 (1-day min.)
Dissolved oxygen (%)	60	55	98 – 105% (ANZECC 2000)
pH	7.2	5.8	7.2 – 7.8 (ANZECC 2000)
Conductivity (µS/cm)	269	349	-
TSS (g/m³)	<3	5	-
Total Nitrogen (g/m³)	0.44	1.01	<0.614 (ANZECC 2000)
Ammoniacal-N (g/m³)	0.015	0.27	National Bottom Line = 1.3; NPS Attribute state B = >1.0 and ≤2.4; <0.021 (ANZECC 2000)
Nitrate-N (g/m³)	0.176	0.42	<0.444 (lowland site median) (ANZECC 2000); NPS State B >1.0 and ≤ 2.4 (annual median)
Total Kjeldahl Nitrogen (g/m³)	0.26	0.58	-
DRP (g/m³)	0.008	<0.004	<0.010 (ANZECC 2000)
Total Phosphorus (g/m³)	0.029	0.057	<0.033 (ANZECC 2000)
$cBOD_5$ (g O_2/m³)	<2	2	<5 (ANZECC 2000), <2 (MfE (1992) guideline for the prevention of sewage fungus).
Enterococci (cfu/ 100 ml)	460	600	<61–151/100 mL (single sample) (Department of Health 1992), <35/100 mL (bathing season median) (ANZECC 2000)
Total Arsenic (g/m³)	<0.0011	<0.0011	
Total Cadmium (g/m³)	<0.000053	<0.000053	<0.0002 (95% protection, ANZECC 2000)
Total Chromium (g/m³)	<0.00053	0.00061	
Total Copper (g/m³)	0.0039	0.0035	<0.0014 (95% protection, ANZECC 2000)
Total Lead (g/m³)	0.00025	0.00028	<0.0034 (95% protection, ANZECC 2000)
Total Nickel (g/m³)	0.00124	0.0037	<0.0011 (95% protection, ANZECC 2000)
Total Zinc (g/m³)	0.0138	0.024	<0.008 (95% protection, ANZECC 2000)

Nutrients

Dissolved nitrogen and phosphorus can cause nuisance algal growths in some rivers (MFE 2000) while total phosphorus and total nitrogen can result in eutrophication effects such as nuisance macrophyte and macroalgal growths in the lower reaches of rivers and in estuaries (NIWA 2007, NIWA 2012).

Total nitrogen, ammoniacal-N, nitrate-N, TKN, TP, DRP and $cBOD_5$ concentrations in the Pourewa Creek were below the relevant guidelines (identified in Table 1) at the time of the survey (Table 1).

Both nitrogen and phosphorous were elevated in the sample of Watercourse D. Total nitrogen, ammoniacal-N, and total phosphorous concentrations all exceeded the relevant guidelines (identified in Table 1) while the Nitrate-N concentration was high, just within the exceedance level. The concentration of $cBOD_5$ just met the exceedance criteria. The sample indicated a source of nitrogen and phosphorous at the time of the survey.

Microbial

Enterococci concentrations in both the Pourewa Creek and Watercourse D were above the recommended guidelines for a single sample (Department of Health) and greater than the bathing season median (ANZECC 2000).

Heavy Metals

Total copper, zinc and lead were all elevated (exceeding ANZECC guidelines) in both the Pourewa Creek and Watercourse D, which is not unusual for streams receiving stormwater inputs.

6.0 Aquatic Biota

6.1 Benthic Invertebrates

Raw invertebrate data is presented in Appendix C. Watercourse D supported an invertebrate community with low taxa richness (10 taxa) and high abundance (5167 individuals/m^2) due to very high numbers of the snail *Potamopyrgus*. The community comprised mainly Mollusca (snails), Crustacea (amphipods), and Oligochaeta (worms). No water and habitat quality sensitive EPT taxa were recorded. The MCI-sb score for the Watercourse D community was 70 and indicative of poor stream health.

The Pourewa Creek supported an invertebrate community with low taxa richness (11 taxa) and high abundance (1,247 individuals/m^2). The community was dominated by Crustacea (amphipods) (80%), with fewer numbers of Mollusca (snails) and Diptera (true flies). The most common genus was the Crustacea *Paracalliope* which are abundant in lowland, slow-flowing weedy streams. Water and habitat sensitive EPT taxa were absent. The MCI-sb score was 71 and indicative of poor stream health.

The invertebrate community recorded from Watercourse A was dominated by habitat and water quality tolerant taxa including *Potamopyrgus* (snails), Amphipods, Ostracods, chironomids (midges) and worms with no water or habitat sensitive taxa identified. The invertebrate community recorded from Watercourse A was a reflection of habitat (i.e., soft-bottomed, water short intermittent habitat, trickle flow) and water quality (i.e., stormwater influence) with the taxonomic groups recorded being commonly found in small, slow flowing soft-bottomed streams draining urban catchments.

6.2 Freshwater Fish

An electric fishing survey on 27 August 2019 within Watercourse A site recorded 11 banded kōkopu ranging in length between 80 and 150 mm from pool habitat. The presence of banded kōkopu in the headwater fragment of Watercourse A upstream of a long-piped section demonstrates the very strong climbing ability of this diadromous species. It is expected that a small number of banded kōkopu will continue to be able to negotiate the stormwater pipe between the downstream boundary of the Site and the Pourewa Creek and this has been taken into account in the restoration of the stream onsite.

The electric fishing survey of Watercourse D on 21 November 2019 revealed moderate numbers of shortfin eel (13 individuals) ranging in size between 100–800 mm. Freshwater Solutions observed banded kōkopu in Watercourse D on a previous site visit.

The Kepa Road Reserve forms part of the Pourewa Creek catchment and indigenous fish have been recorded from streams within the reserve including banded kōkopu and eels. According to the NZFFD, īnanga, common bully, shortfin eel, longfin eel and banded kōkopu have been identified in tributaries immediately to the south of the Site and John Rymer Place. Shortfin eel, longfin eel and banded kōkopu have also been identified in Pourewa Creek in close proximity to the Site.

Habitat in Watercourse D is suitable for all species listed in the NZFFD from Pourewa Creek despite only shortfin eel and banded kōkopu being recorded during the present surveys. However, water quality (i.e., particularly dissolved oxygen) observed at the time of the survey may be limiting a species like īnanga (refer to Section 5.0 for water quality assessment).

6.3 Freshwater Ecological Values

Watercourses within the Site are modified remnants of the upper gully catchment. The entire catchment below the Site down to Pourewa Creek, with the exception of ~80 m of Watercourse D, is piped and forms the stormwater network.

Watercourses A and C are modified intermittent streams with moderate to poor ecological values, respectively. Watercourse A has the highest ecological values of streams within the Site as it had an SEV score of 0.532 and supports a population of banded kōkopu in occasional stable pools. Watercourse B is an artificial channel that has formed below a stormwater outlet and has low ecological values.

Watercourse D is permanent and fed predominantly by stormwater, which is reflected in water quality and aquatic biota (macroinvertebrates and fish) observed during sampling. The MCI-sb index for the stream was 70 and indicative of poor stream health. Water quality sampling revealed low dissolved oxygen levels coupled with elevated nutrients, microbial and metals which may be limiting water quality sensitive invertebrates (e.g., mayflies, stoneflies, caddisflies). The SEV score for Watercourse D was 0.586 and indicative of moderate ecological function. Shortfin eel was recorded from Watercourse D during the electric fishing survey but banded kōkopu have been observed. Overall, Watercourse D in the downstream receiving environment below the Site has moderate ecological value.

The Pourewa Creek is a large permanent slow flowing watercourse that is swampy in nature. The MCI-sb index for the stream was 71 and indicative of poor stream health, while water quality sampling revealed low dissolved oxygen levels coupled with some elevated metals concentrations. Pourewa Creek flows through a terrestrial SEA comprising the coastal forest associated with Kepa Reserve into a marine SEA comprising mangroves before discharging to Hobson Bay.

7.0 Assessment of Ecological Effects

7.1 Proposed Village Interface with Watercourses

Wastewater from the Proposed Village will be piped to the existing local network at Allum Road (Beca 2020) and no effects on freshwater ecology are anticipated.

A stormwater reticulation network will be constructed to capture and convey runoff from all hard areas (Beca 2020). The post site development peak flows (both into the piped stormwater network and overland) will be limited to pre development (with attenuation) levels (Beca 2020). Stormwater from the Proposed Village will connect to the existing stormwater network near the south-eastern boundary of the Site, which ultimately discharges to Watercourse D via an outlet structure and which is authorised by Councils Regional Network Discharge Consent (RNDC) held by Healthy Water (Beca 2020).

In order to enable the Proposed Village, modified existing watercourses within the Site (Watercourse A and C) will be realigned to drain along the Site's eastern boundary. The realignment will also involve daylighting existing piped sections within the Site.

Key aspects of the Proposed Village of relevance to the ecological assessment are:

- The diversion and daylighting of Watercourse A and C.
- Earthworks and construction effects (sedimentation and discharge).
- Construction of retaining walls within riparian yard.

7.2 Stream Diversion, Daylighting and Riparian Planting

Development of the Proposed Village will involve realigning Watercourses A and C into a new stream alignment along the eastern boundary of the Site, daylighting piped sections and riparian planting along the new stream channel. The proposed realignment and restoration of Watercourse A and C will increase the amount and quality of aquatic habitat within the Site. Drawing 044-RCT_401_C0-021 prepared by Beca (2020) shows the proposed grading and drainage plan for the Site and the new alignment. Drawing 044-RCT_401_C3-061 prepared by Beca (2020) shows a long section of the proposed new stream channel. Drawings 044-RCT_401_C3-086 and 044-RCT_401_C3-087 prepared by Beca (2020) show cross sections of the proposed new stream.

The proposed new stream will be constructed to have variable widths, depths, habitat types (e.g., run, riffle, pool) and will flow within a wider floodplain. The bed will comprise coarse substrate (e.g., boulder, cobble, gravel) and weathered clay. The steep topography of the Site requires the construction of retaining walls (see Section 7.5) along some sections of the stream within the floodplain for stability reasons (Figure 10). The current design shows four drops in stream channel along its length within the Site given the steep topography. The drops in channel will be steeper, lined with appropriate substrate to prevent scour and erosion (e.g., boulder, cobble) and will allow passage for the fish species likely to be found in headwater reaches that have excellent climbing ability (e.g., eels, banded kōkopu).

The proposed new stream alignment will meander along the boundary of the proposed buildings and structures (Figure 10). The proposed conceptual planting will include low stature species along the stream edge and floodplain and adjacent to the proposed buildings (Figure 11). A detailed planting plan has not been finalised but species may include native sedges and rushes with flax *(Phormium tenax),* toetoe *(Austroderia fulvida)* and small shrubs such as hebe *(Veronica stricta)*. Slope sections (mainly on the true-left bank) may be planted with a greater variety of small trees and shrubs and may include species such as mānuka *(Leptospermum scoparium)*, karamū *(Coprosma robusta),* karo and kōhūhū (*Pittosporum* spp.) and cabbage tree *(Cordyline australis).*

Figure 10: Proposed stream alignment and planting (plan from Design Squared).

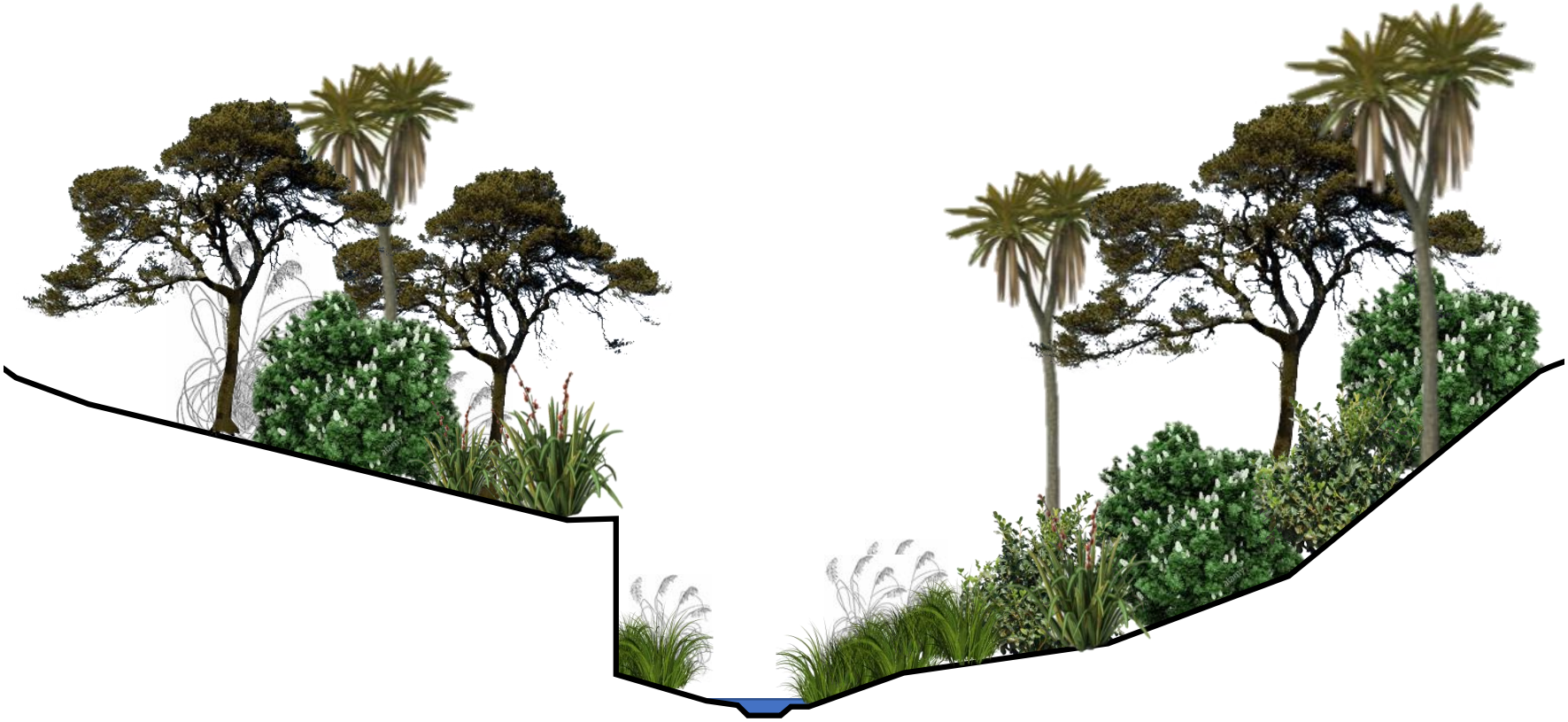

Figure 11: Cross section showing indicative planting along new stream (note: example of retaining wall on left bank).

Proposed enhancements will have a significant positive effect on overall stream ecology within the Site by improving benthic invertebrate habitat, increasing the amount and quality of habitat for banded kōkopu, enhancing potential spawning habitat for banded kōkopu, increasing shade, organic matter inputs and increasing the total length of natural stream within the Site (i.e., from 60 m to 165 m length of stream). The proposed new stream alignment will result in the diversion of 60 m of existing stream and creation of 165 m of new stream channel. The following presents a transparent assessment showing that the proposed new stream will have a positive effect and is based on SEV scores and the Environmental Compensation Ratio (ECR) approach outlined in Storey et al. (2011).

Predicted potential SEV scores for the impact stream sections (Watercourses A and C) and the proposed new stream channel used to calculate an ECR value are summarised in Table 2. An ECR value of 1.71 was calculated. The potential SEVi-P score for the existing Watercourses A and C were determined based on best practice riparian planting and combined for the purposes of the assessment (i.e., single SEVi-P score used). The SEVm-P score for the new stream channel was determined based on engineering plans provided by Beca and landscape plan provided by Design Squared. Factors taken into consideration when scoring potential SEVi-P and SEVm-P scores included the proximity of retaining walls to the proposed stream, width of riparian planting (i.e., <10 m in places) and proposed planting based on landscape plans. Refer to Appendix D for detailed SEV data.

Table 2: Predicted SEV scores and calculated ECR value.

Impact	Impact scores		Restore	Restoration scores		ECR value
	SEVi-P	SEVi-I		SEVm-P	SEVm-C	
A and C	0.646	0.000	New stream channel	0.568	0.000	1.71

Table 3 presents results of the assessment and shows a total minimum length of 114.3 m would need to be created and enhanced to ensure 'no net loss' of ecological values and function. A total length of 165 m of new stream channel will be created with the additional 50.7 m length (i.e., 165 m – 114.3 m = 50.7 m) representing a net gain and confirming a positive effect. The re-alignment of the stream will more than double the length of open stream channel (from 60 m to 165 m) and streambed area (from 42.9 to 105.6 m^2).

Table 3: Stream offset calculations for the proposed new stream diversion.

Impact reach				ECR		Restoration / realigned reach					(b) Length to restore (m)
Stream	Length (m)	Width (m)	(a) Area (m^2)	ECR	ECR x Area	Stream	Length (m)	Width (m)	Area (m^2)	length required to be restored (m)	
A and C	60	0.64	42.9	1.71	73.1	New stream channel	165.0	0.64	105.6	114.3	114.3

Notes: (a) = Streambed area impacted based on channel widths at 10 SEV cross sections;
(b) = Length of channel to restore and create and calculated by ('ECR x Area' / 'Stream Width'). The length to create defaults to 1:1 length if shorter than that impacted.

7.3 Fish Relocations

It is recommended that a Native Fish Relocation Plan be prepared and implemented in Watercourses A, B and C prior to and streamworks using an electric fishing machine. Fish captured should be relocated to Watercourse D or Pourewa Creek

7.4 Earthworks

Earthworks associated with the Proposed Village have the potential to result in sediment runoff to the watercourse. Provided all earthworks within the Site are completed in accordance with the approach outlined in Beca (2020) and meeting Auckland Council guidelines (i.e., GD05) then adverse effects on the receiving environment will be avoided.

7.5 Construction within Riparian Yard

The permitted riparian yard setback is 10 m from the edge of intermittent streams with the objective being to maintain water quality and provide protection from natural hazards. Some of the Proposed Village buildings and retaining walls will be located within the 10 m riparian yard of the new stream channel so will not meet this standard.

The existing Watercourse A is located in the headwaters of the catchment and naturally has a narrow channel and holding limited surface water under base flow conditions. The realigned stream will also have a narrow 'base flow' channel when it reaches an equilibrium state. The proposed narrow width of the base flow channel and steep V-sided gully will mean the new channel will become shaded by riparian vegetation that will include native sedges, shrubs and trees that will be <10 m wide in places. Narrower riparian widths in places will partially be offset by wider than 10 m wide riparian widths in other places along the stream. Lastly, the benefits of increasing the length of stream channel through proposed daylighting will result in an increase in the overall length of riparian habitat and habitat connectivity.

8.0 Recommendations and Conclusion

In summary, the potential adverse freshwater ecology effects of the Proposed Village will be negligible, and the realignment, daylighting and restoration of Watercourses A and C will have positive ecology effects subject to the following recommendations:

- The proposed new stream will be designed to have variable widths, depths, diverse habitat types (e.g., run, riffle, pool) and substrate (e.g., boulder, cobble, gravel).
- Any steeper sections proposed along the new stream will be designed to allow passage for species with climbing ability and migrate into headwater streams (e.g., eels and banded kōkopu).
- Prior to the realignment works commencing, a Native Fish Relocation Plan is to be prepared and implemented.
- The stormwater system for the Site will ensure that post development peak flows (both into the piped stormwater network and overland) will be limited to pre-development (with attenuation) levels (Beca 2020).
- Earthworks within the Site will meet Auckland Council's GD05 guidelines.

9.0 References

ANZECC 2000. Australia and New Zealand Guidelines for Fresh and Marine Water Quality.

Auckland Regional Council 1999. Auckland Regional Policy Statement. Operative 31 August 1999.

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Neale, M. W., Storey, R. G., and Quinn, J.M. 2016. Stream Ecological Valuation (SEV): Application to Intermittent Streams. Auckland Council Technical Report 2016/023.

NIWA 2007. Limiting nutrients for controlling undesirable periphyton growth. NIWA client report: HAM2007-006. February 2007.

NIWA 2012. Review of the New Zealand instream plant and nutrient guidelines and development of an extended decision making framework: Phases 1 and 2 final report. Report prepared for the Ministry of Science and Innovation Envirolink Fund. August 2012.

Storey, R. G., Neale, M. W., Rowe, D. K., Collier, K. J., Hatton, C., Joy, M. K., Maxted, J. R., Moore, S., Parkyn, S. M., Phillips, N. and Quinn, J.M. 2011. Stream Ecological Valuation (SEV): a method for assessing the ecological function of Auckland streams. Auckland Council Technical Report 2011/009.

Stark, J. D., Boothroyd, I. K. G., Harding, J. S., Maxted, J. R., Scarsbrook, M. R. 2001: Protocols for sampling macroinvertebrates in wadeable streams. Prepared for the Ministry for the Environment. November 2001.

APPENDIX A

Stream Classification Criteria (AUP)

Auckland Unitary Plan Operative in Part

River or stream

A continually or intermittently flowing body of fresh water, excluding ephemeral streams, and includes a stream or modified watercourse; but does not include any artificial watercourse (including an irrigation canal, water supply race, canal for the supply of water for electricity power generation, and farm drainage canal except where it is a modified element of a natural drainage system).

Permanent river or stream

The continually flowing reaches of any river or stream.

Intermittent stream

Stream reaches that cease to flow for periods of the year because the bed is periodically above the water table. This category is defined by those stream reaches that do not meet the definition of permanent river or stream and meet at least three of the following criteria:

a) it has natural pools;
b) it has a well-defined channel, such that the bed and banks can be distinguished;
c) it contains surface water more than 48 hours after a rain event which results in stream flow;
d) rooted terrestrial vegetation is not established across the entire cross-sectional width of the channel;
e) organic debris resulting from flood can be seen on the floodplain; or
f) there is evidence of substrate sorting process, including scour and deposition.

Ephemeral stream

Stream reaches with a bed above the water table at all times, with water only flowing during and shortly after rain events. This category is defined as those stream reaches that do not meet the definition of permanent river or stream or intermittent stream.

Artificial watercourse

Constructed watercourses that contain no natural portions from their confluence with a river or stream to their headwaters.

Includes:

- canals that supply water to electricity power generation plants;
- farm drainage canals;
- irrigation canals; and
- water supply races.

Excludes: naturally occurring watercourses

APPENDIX B

Hill Laboratory Water Quality Results

Hill Laboratories
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Certificate of Analysis

Client:	Freshwater Solutions Limited	**Lab No:**	2262968	SPv1
Contact:	Nick Carter	**Date Received:**	23-Oct-2019	
	C/- Freshwater Solutions Limited	**Date Reported:**	29-Oct-2019	
	666 Great South Road	**Quote No:**	102105	
	Ellerslie	**Order No:**		
	Auckland 1051	**Client Reference:**		
		Submitted By:	Nick Carter	

Sample Type: Aqueous

Sample Name:		Pourewa 22-Oct-2019 2:40 pm				
Lab Number:		2262968.1				
Individual Tests						
pH	pH Units	7.2	-	-	-	-
Total Suspended Solids	g/m³	< 3	-	-	-	-
Total Nitrogen	g/m³	0.44	-	-	-	-
Total Kjeldahl Nitrogen (TKN)	g/m³	0.26	-	-	-	-
Total Phosphorus	g/m³	0.029	-	-	-	-
Carbonaceous Biochemical Oxygen Demand ($cBOD_5$)	g O_2/m³	< 2	-	-	-	-
Escherichia coli	cfu / 100mL	460	-	-	-	-
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn						
Total Arsenic	g/m³	< 0.0011	-	-	-	-
Total Cadmium	g/m³	< 0.000053	-	-	-	-
Total Chromium	g/m³	< 0.00053	-	-	-	-
Total Copper	g/m³	0.0039	-	-	-	-
Total Lead	g/m³	0.00025	-	-	-	-
Total Nickel	g/m³	0.00124	-	-	-	-
Total Zinc	g/m³	0.0138	-	-	-	-
Nutrient Profile						
Total Ammoniacal-N	g/m³	0.015	-	-	-	-
Nitrite-N	g/m³	0.003	-	-	-	-
Nitrate-N	g/m³	0.176	-	-	-	-
Nitrate-N + Nitrite-N	g/m³	0.180	-	-	-	-
Dissolved Reactive Phosphorus	g/m³	0.008	-	-	-	-

Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.
Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017 / US EPA 200.8	0.000053 - 0.0011 g/m³	1
Nutrient Profile		0.0010 - 0.010 g/m³	1
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1
Total Digestion	Nitric acid digestion. APHA 3030 E (modified) 23rd ed. 2017.	-	1

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
pH	pH meter. APHA 4500-H^+ B 23rd ed. 2017. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field. Samples and Standards are analysed at an equivalent laboratory temperature (typically 18 to 22 °C). Temperature compensation is used.	0.1 pH Units	1
Total Suspended Solids	Filtration using Whatman 934 AH, Advantec GC-50 or equivalent filters (nominal pore size 1.2 - 1.5µm), gravimetric determination. APHA 2540 D (modified) 23rd ed. 2017.	3 g/m^3	1
Total Nitrogen	Calculation: TKN + Nitrate-N + Nitrite-N. Please note: The Default Detection Limit of 0.05 g/m^3 is only attainable when the TKN has been determined using a trace method utilising duplicate analyses. In cases where the Detection Limit for TKN is 0.10 g/m^3, the Default Detection Limit for Total Nitrogen will be 0.11 g/m^3.	0.05 g/m^3	1
Total Ammoniacal-N	Phenol/hypochlorite colourimetry. Flow injection analyser. (NH_4-N = NH_4^+-N + NH_3-N). APHA 4500-NH_3 H (modified) 23rd ed. 2017.	0.010 g/m^3	1
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I (modified) 23rd ed. 2017.	0.002 g/m^3	1
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m^3	1
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I (modified) 23rd ed. 2017.	0.002 g/m^3	1
Total Kjeldahl Nitrogen (TKN)	Total Kjeldahl digestion, phenol/hypochlorite colorimetry. Discrete Analyser. APHA 4500-N_{org} D (modified) 4500 NH_3 F (modified) 23rd ed. 2017.	0.10 g/m^3	1
Dissolved Reactive Phosphorus	Filtered sample. Molybdenum blue colourimetry. Flow injection analyser. APHA 4500-P G (modified) 23rd ed. 2017.	0.004 g/m^3	1
Total Phosphorus	Total phosphorus digestion, ascorbic acid colorimetry. Discrete Analyser. APHA 4500-P B & E (modified from manual analysis and also modified to include a reductant to reduce interference from any arsenic present in the sample) 23rd ed. 2017. NWASCO, Water & soil Miscellaneous Publication No. 38, 1982.	0.004 g/m^3	1
Carbonaceous Biochemical Oxygen Demand ($cBOD_5$)	Incubation 5 days, DO meter, nitrification inhibitor added, dilutions, seeded. APHA 5210 B (modified) 23rd ed. 2017.	2 g O_2/m^3	1
Escherichia coli	Membrane filtration, Count on mFC agar, Incubated at 44.5°C for 22 hours, MUG Confirmation. APHA 9222 G 23rd ed. 2017.	1 cfu / 100mL	1

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

Kim Harrison MSc
Client Services Manager - Environmental

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Certificate of Analysis

Client:	Freshwater Solutions Limited	**Lab No:**	2279530 SPv1
Contact:	Nick Carter C/- Freshwater Solutions Limited 666 Great South Road Ellerslie Auckland 1051	**Date Received:**	22-Nov-2019
		Date Reported:	28-Nov-2019
		Quote No:	102105
		Order No:	
		Client Reference:	
		Submitted By:	Nick Carter

Sample Type: Aqueous

Sample Name:		TRIB F 21-Nov-2019 1:30 pm				
Lab Number:		2279530.1				
Individual Tests						
pH	pH Units	6.7	-	-	-	-
Total Suspended Solids	g/m³	5	-	-	-	-
Total Nitrogen	g/m³	1.01	-	-	-	-
Total Kjeldahl Nitrogen (TKN)	g/m³	0.58	-	-	-	-
Total Phosphorus	g/m³	0.057	-	-	-	-
Carbonaceous Biochemical Oxygen Demand ($cBOD_5$)	g O_2/m³	2	-	-	-	-
Escherichia coli	cfu / 100mL	600 #1	-	-	-	-
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn						
Total Arsenic	g/m³	< 0.0011	-	-	-	-
Total Cadmium	g/m³	< 0.000053	-	-	-	-
Total Chromium	g/m³	0.00061	-	-	-	-
Total Copper	g/m³	0.0035	-	-	-	-
Total Lead	g/m³	0.00028	-	-	-	-
Total Nickel	g/m³	0.0037	-	-	-	-
Total Zinc	g/m³	0.024	-	-	-	-
Nutrient Profile						
Total Ammoniacal-N	g/m³	0.27	-	-	-	-
Nitrite-N	g/m³	0.012	-	-	-	-
Nitrate-N	g/m³	0.42	-	-	-	-
Nitrate-N + Nitrite-N	g/m³	0.43	-	-	-	-
Dissolved Reactive Phosphorus	g/m³	< 0.004	-	-	-	-

Analyst's Comments

#1 Statistically estimated count based on the theoretical countable range for the stated method.

Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.
Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 23rd ed. 2017 / US EPA 200.8	0.000053 - 0.0011 g/m³	1
Nutrient Profile		0.0010 - 0.010 g/m³	1
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1
Total Digestion	Nitric acid digestion. APHA 3030 E (modified) 23rd ed. 2017.	-	1

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
pH	pH meter. APHA 4500-H^+ B 23rd ed. 2017. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field. Samples and Standards are analysed at an equivalent laboratory temperature (typically 18 to 22 °C). Temperature compensation is used.	0.1 pH Units	1
Total Suspended Solids	Filtration using Whatman 934 AH, Advantec GC-50 or equivalent filters (nominal pore size 1.2 - 1.5µm), gravimetric determination. APHA 2540 D (modified) 23rd ed. 2017.	3 g/m^3	1
Total Nitrogen	Calculation: TKN + Nitrate-N + Nitrite-N. Please note: The Default Detection Limit of 0.05 g/m^3 is only attainable when the TKN has been determined using a trace method utilising duplicate analyses. In cases where the Detection Limit for TKN is 0.10 g/m^3, the Default Detection Limit for Total Nitrogen will be 0.11 g/m^3.	0.05 g/m^3	1
Total Ammoniacal-N	Phenol/hypochlorite colourimetry. Flow injection analyser. (NH_4-N = NH_4^+-N + NH_3-N). APHA 4500-NH_3 H (modified) 23rd ed. 2017.	0.010 g/m^3	1
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I (modified) 23rd ed. 2017.	0.002 g/m^3	1
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m^3	1
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I (modified) 23rd ed. 2017.	0.002 g/m^3	1
Total Kjeldahl Nitrogen (TKN)	Total Kjeldahl digestion, phenol/hypochlorite colorimetry. Discrete Analyser. APHA 4500-N_{org} D (modified) 4500 NH_3 F (modified) 23rd ed. 2017.	0.10 g/m^3	1
Dissolved Reactive Phosphorus	Filtered sample. Molybdenum blue colourimetry. Flow injection analyser. APHA 4500-P G (modified) 23rd ed. 2017.	0.004 g/m^3	1
Total Phosphorus	Total phosphorus digestion, ascorbic acid colorimetry. Discrete Analyser. APHA 4500-P B & E (modified from manual analysis and also modified to include a reductant to reduce interference from any arsenic present in the sample) 23rd ed. 2017. NWASCO, Water & soil Miscellaneous Publication No. 38, 1982.	0.004 g/m^3	1
Carbonaceous Biochemical Oxygen Demand ($cBOD_5$)	Incubation 5 days, DO meter, nitrification inhibitor added, dilutions, seeded. APHA 5210 B (modified) 23rd ed. 2017.	2 g O_2/m^3	1
Escherichia coli	Membrane filtration, Count on mFC agar, Incubated at 44.5°C for 22 hours, MUG Confirmation. APHA 9222 G 23rd ed. 2017.	1 cfu / 100mL	1

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

Ara Heron BSc (Tech)
Client Services Manager - Environmental

APPENDIX C

Raw Macroinvertebrate Data

	MCI-sb	Watercourse D	Pourewa
Trichoptera			
Oxyethira	1.2	8	4
Diptera			
Austrosimulium	3.9	-	1
Chironomus	3.4	2	-
Orthocladiinae	3.2	-	48
Polypedilum	8.0	1	6
Collembolla	5.3	2	2
Crustacea			
Copepoda	2.4	-	1
Isopoda	4.5	1	-
Ostracoda	1.9	-	11
Paracalliope	5.5	1040	992
Acarina	5.2	-	2
Mollusca			
Physella (Physa)	0.1	48	20
Potamopyrgus	2.1	4000	160
Oligochaeta	3.8	64	-
Platyhelminthes	0.9	1	-
Taxa number		10	11
Abundance		5167	1247
MCI-sb		69.6	70.5

APPENDIX D

SEV Data

Function category	Function	Variable	Impact A and C SEVi-C	Impact A and C SEVi-I	Impact A and C SEVi-P	Restoration New stream SEVm-C	Restoration New stream SEVm-P	Downstream D SEV
		Vchann	0.730	0.000	0.910	0.000	0.910	0.890
		Vlining	0.880	0.000	0.920	0.000	0.820	0.960
		Vpipe	0.300	0.000	0.300	0.000	0.300	0.300
	NFR	=	0.234	0.000	0.274	0.000	0.264	0.274
		Vbank	0.920	0.000	0.920	0.000	0.520	1.000
		Vrough	0.560	0.000	0.860	0.000	0.560	0.720
Hydraulic	FLE	=	0.515	0.000	0.791	0.000	0.291	0.720
		Vbarr	0.300	0.000	0.300	0.000	0.300	1.000
	CSM	=	0.300	0.000	0.300	0.000	0.300	1.000
		Vchanshape	0.970	0.000	0.990	0.000	0.920	0.950
		Vlining	0.880	0.000	0.920	0.000	0.820	0.960
	CGW	=	0.910	0.000	0.943	0.000	0.853	0.957
Hydraulic function mean score			0.490	0.000	0.577	0.000	0.427	0.738
		Vshade	0.480	0.000	0.660	0.000	0.620	0.540
	WTC	=	0.480	0.000	0.660	0.000	0.620	0.540
		Vdod	0.600	0.000	0.600	0.000	0.600	0.600
	DOM	=	0.600	0.000	0.600	0.000	0.600	0.600
		Vripar	0.700	0.000	1.000	0.000	0.650	0.900
		Vdecid	1.000	0.000	1.000	0.000	1.000	0.270
biogeochemical	OMI	=	0.700	0.000	1.000	0.000	0.650	0.572
		Vmacro	1.000	0.000	1.000	0.000	1.000	0.960
		Vretain	0.760	0.000	0.920	0.000	0.920	0.900
	IPR	=	0.760	0.000	0.920	0.000	0.920	0.900
		Vsurf	0.573	0.000	0.629	0.000	0.901	0.720
		Vripfilt	0.360	0.000	0.620	0.000	0.520	0.520
	DOP	=	0.467	0.000	0.624	0.000	0.710	0.620
Biogeochemical function mean score			0.601	0.000	0.761	0.000	0.700	0.646
		Vgalspwn	1.000	0.000	1.000	0.000	1.000	1.000
		Vgalqual	0.750	0.000	0.750	0.000	0.750	0.750
		Vgobspwn	0.800	0.000	0.800	0.000	1.000	0.100
habitat provision	FSH	=	0.775	0.000	0.775	0.000	0.875	0.425
		Vphyshab	0.595	0.000	0.747	0.000	0.712	0.741
		Vwatqual	0.444	0.000	0.498	0.000	0.486	0.162
		Vimperv	0.200	0.000	0.200	0.000	0.300	0.200
	HAF	=	0.459	0.000	0.548	0.000	0.552	0.461
Habitat provision function mean score			0.617	0.000	0.661	0.000	0.714	0.443
		Vfish						0.500
	FFI	=						0.500
		Vmci						0.318
		Vept						0.167
Biodiversity		Vinvert						0.233
	IFI	=						0.239
		Vripcond	0.310	0.000	0.540	0.000	0.310	0.610
		Vripconn	0.585	0.000	0.585	0.000	0.585	0.650
	RVI	=	0.181	0.000	0.316	0.000	0.181	0.397
Biodiversity function mean score			0.181	0.000	0.316	0.000	0.181	0.397
SEV score			**0.532**	**0.000**	**0.646**	**0.000**	**0.568**	**0.586**