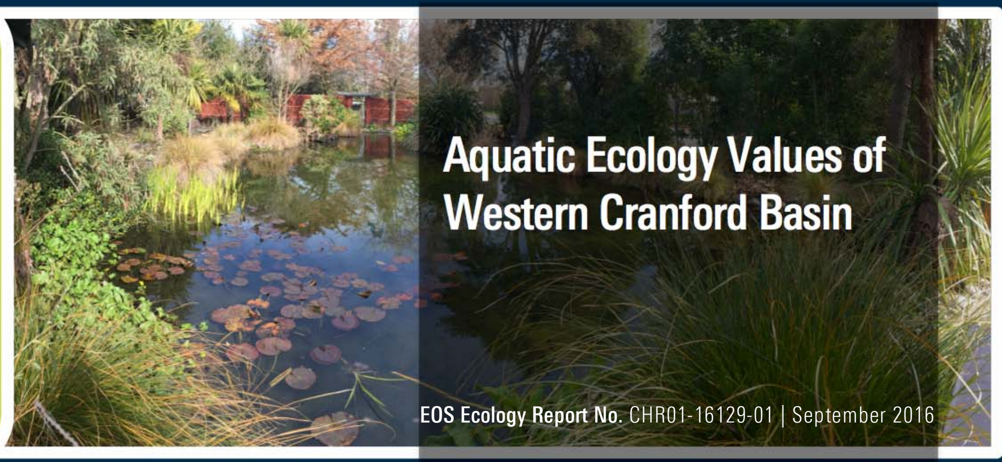
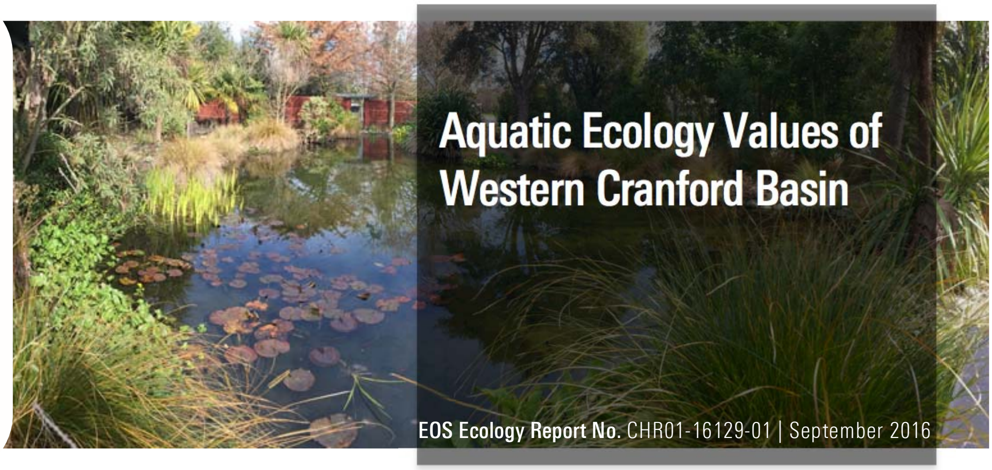


Aquatic Ecology Values of Western Cranford Basin

EOS Ecology Report No. CHR01-16129-01 | September 2016

AQUATIC SCIENCE & VISUAL COMMUNICATION



Aquatic Ecology Values of Western Cranford Basin

EOS Ecology Report No. CHR01-16129-01 | September 2016

Prepared for Christchurch City Council

Prepared by EOS Ecology

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Reviewed by Shelley McMurtrie

EXECUTIVE SUMMARY

The Christchurch City Council (CCC) is investigating the potential to bring the remaining rural area known as Cranford Basin inside the urban limits, and allowing urban development in areas outside of the designations for the Northern Arterial Extension and a large proposed stormwater treatment facility. EOS Ecology was engaged to undertake an aquatic ecological assessment of the western part of Cranford Basin where urban development is proposed. The waterways in this area form the upper part of the Tysons Drain catchment and ultimately discharge to the Styx River via Winters Road Drain and Horners Drain.

The waterways of the western Cranford Basin consist of artificially created drainage channels with mud/silt bottoms and some constructed ponds. Riparian vegetation is generally exotic grasses and trees (poplars) with the only significant native vegetation being planted relatively recently on the edges of a constructed pond. The area has numerous springheads, which provide reliable base flow of relatively high water quality to the waterways. This source of water provides great opportunity for waterway creation and enhancement to be a key component for any future urban development in the area.

Sampling of macroinvertebrates (four sites) and fish (six sites) indicated the waterways in the western Cranford Basin had the same biota as previous surveys in other parts of the Basin. The macroinvertebrate community was dominated by the endemic snail *Potamopyrgus*, with microcrustaceans (ostracods and copepods), midge larvae, and pea clams also being widespread and relatively common. This macroinvertebrate assemblage is typical of soft-bottomed, low gradient streams in urban and rural landscapes. Macroinvertebrate Community Index (MCI) scores ranged from 56.8 to 74.0 indicating poor habitat conditions at all four macroinvertebrate sampling sites.

Four species of fish were found, with short fin eel and upland bully being the most abundant and widespread. The other two species, longfin eel and inanga are of conservation concern as they are classified as "At Risk - Declining" by the latest freshwater fish threat classification (Goodman *et al.,* 2013). The finding of an inanga high up the Tysons Drain catchment is notable as it indicates this migratory species with relatively poor ability to negotiate instream structures can pass the weirs and culverts that lie between Tysons Drain and the Styx River.

It is recommended future urban development in the area includes the establishment of a network of green space reserves based on the springheads and their outflow channels. This could involve a combination of enhancing the existing channels and creating new channels, as well as incorporating riparian planting of native groundcover and shading trees, as well as public walkways. Ideally stormwater will be kept out of these springheads and enhanced waterways, and sustainable urban design principles be compulsory for all urban developments in the western Cranford Basin (e.g., capture and reuse of rainwater, minimisation of impervious surfaces, rain gardens, swales). If the waterways and springs are enhanced and protected appropriately then they could be suitable for future introduction of koura (freshwater crayfish)..

1 INTRODUCTION

The Christchurch City Council (CCC) is investigating the potential to bring the remaining rural area known as Cranford Basin inside the urban limits, and allowing urban development in areas outside of the designations for the Northern Arterial Extension and a large proposed stormwater treatment facility. Cranford Basin has numerous springheads (see PDP, 2013; and Beca, 2016), an extensive network of drainage channels, and some ponds. While these drainage channels and ponds are not natural features, they provide aquatic habitat for native and endemic aquatic flora and fauna in an area that has undergone drastic changes in land use over the last 150 years. Hence before further land development occurs it is important to determine the ecological values of these watercourses so any adverse effects can be avoided, remedied, or mitigated. Assessments of ecological values have already been completed for the northern and eastern parts of Cranford Basin (McMurtrie *et al.*, 2005; Opus, 2014). However for the western part where much of the residential development is proposed, there is no information on the ecological values of the drainage channels and ponds. EOS Ecology was engaged to undertake an aquatic ecological assessment of this particular part of Cranford Basin. This assessment included a site visit, macroinvertebrate and fish surveys, reporting on the state of the existing environment, and providing recommendations for the use/treatment of waterways in any future development of the area.

2 METHODS

2.1 Site Selection

A site visit was undertaken on 29 August 2016 to walk and map the waterways and choose locations for ecological surveys, for the area west of Cranford Street and within the future urban development area. The site walkover concentrated on mapping the waterways and pond network and as such did not include a walkover of the wider land area. We note that Beca, Christchurch undertook a comprehensive site walkover in subsequent days to map the springs in the area.

Ecological survey sites were selected such that they provided good coverage of the area, had sufficient water for sampling fish and macroinvertebrates, could be safely accessed, and were able to be surveyed with the time available. Figure 1 shows the whole Cranford Basin and surrounds while Figure 2 shows the location of photo points and survey sites in the western part of project area.

Figure 1 Cranford Basin and surrounds showing designations, waterways, and areas for proposed future urban development. The thick blue waterway lines in the western Cranford Basin are those mapped by EOS Ecology in the current study.

Figure 2 Location of sites sampled for aquatic macroinvertebrates and fish in western Cranford Basin by EOS Ecology on 31 August and 1 September 2016. The thick blue waterway lines in the western Cranford Basin area are those mapped by EOS Ecology from site walkovers (the upstream end of channels shown on the map is where water was first seen in the channel invert). Letters refer to photographs presented in Figure 3-5. Photographs of surveyed sites are provided in the Appendices (Section 9.1). Note alignment of downstream end of channel discharging into Tysons Drain Branch No 2 has not yet been confirmed.

2.2 Surveys

EOS Ecology undertook habitat and fish surveys at six monitoring sites on 31 August and 1 September 2016 (Figure 2). Aquatic invertebrate surveys were undertaken at four sites (Sites 1–4) and fish surveys at six sites (Sites 1–6) (see Appendix 9.1 for site photos). At each site, aspects of the instream habitat and riparian condition were visually assessed on a site-wide basis. For waterway sites (i.e., Sites 1, 2, 3, and 5) channel attributes were quantified at transects located at the upstream, middle, and downstream ends of each sampled reach). Transect measures were not taken at the two pond sites (Sites 4 and 6).

2.2.1 Habitat Sampling

A visual qualitative assessment of a number of habitat parameters was carried out over the entire surveyed site (i.e. site-wide assessments). The parameters measured at the site-scale included the following:

» Habitat type (percentage riffle/run/pool).

» Substrate composition. The percentage cover of the following particle size categories: mud/silt/clay: <0.06 mm; sand: 0.06–2 mm; gravel: 2–16 mm; pebble: 16–64 mm; small cobble: 64–128 mm; large cobble: 128–256 mm; boulder: >256mm; bedrock/manmade concrete, as per the CREAS criteria.

» Aquatic plant and organic matter coverage and composition. Macrophytes were identified to the lowest practicable level (either to genus or species).

» Fish cover. The percentage of wetted bed area in which cover for fish was provided by the following attributes: substrate, macrophytes/filamentous algae, debris, overhanging vegetation, undercut banks, overhead shade.

The riparian zone condition was assessed within a 5 m band on either side of the bank within the fish sites. The percentage cover of five different vegetation types (grass, scrub/gorse, exotic trees, native vegetation, gravel/earth) was estimated.

At the waterway sites (Sites 1, 2, 3, and 5), quantitative measurements were made of the channel at three transects (upstream end, middle, and downstream end of the fish site). These measures included bank undercuts and vegetation overhang on both banks, as well as thalweg measures of floating vegetation, free water depth, macrophyte depth, and sediment depth. Transect measures were not taken at Sites 4 and 6, as these were ponds rather than channels.

2.2.2 Invertebrate Sampling

Aquatic benthic invertebrate were collected within Sites 1-4. At ten representative locations within each site, invertebrates were collected by disturbing the substrate within a $0.1m^2$ area upstream of a conventional kick net (500 µm mesh size). The replicates were then combined for each site, resulting in a total sample area of 1 m^2, covering the range of habitats. The full range of habitat types were surveyed within each site, including mid-channel and margin areas, inorganic substrate (e.g. the streambed), and macrophytes (aquatic plants). Each invertebrate sample was kept in a separate container (one sample per site), preserved in 70% isopropyl alcohol, and taken to the laboratory for identification. The samples were processed according to the “Protocol P2 – 200 Individual Fixed Count with Scan for Rare Taxa” procedure of Stark *et al.* (2001). All invertebrates were counted and identified to the lowest practical level using a binocular microscope and several identification keys (Winterbourn *et al*., 2006; Winterbourn, 1973; Chapman *et al*., 2011).

2.2.3 Fish Sampling

At the four flowing waterway sites (Sites 1, 2, 3, and 5) fish surveys were undertaken using a single pass electrofishing method via a backpack operated Kainga EFM 300 electrofishing machine. Electrofishing passes a low amperage electric current through the water to temporarily stun the fish, and allowing them to be caught in a handheld net. The fish were transferred to buckets of water for identification and measurement, and were then returned live to the stream, at a suitable location within the reach from which they were caught.

Site 4 consisted of an artificial pond with small riffle channels flowing into and out of the pond. Due to the depth of the pond (in excess of 1 meter in the centre), a combination of netting, trapping and electrofishing were used to survey all available habitats. Three baited fyke nets and four baited gee minnow traps were set in the large pond on the afternoon of 31 August and removed the following morning so as to capture fish during peak night time activity. Fish captured were removed to buckets of water to be held until electrofishing was complete. Electrofishing was then carried out, focusing on the small riffle channels upstream and downstream of the pond, as well as the pond edges. Following electrofishing all fish were identified and measured, and were then returned live to a suitable location within the reach from which they were caught.

Site 6 consisted of a shallow, silt-bottomed pond. The pond was surveyed by electrofishing, targeting areas within the pond most likely to provide fish habitat. Fish were removed to buckets of water for identification and measurement before being returned live to the pond from which they were caught.

2.3 Data Analysis

Invertebrate data were summarised by taxa richness, total abundance, and abundance of the five most common taxa. Biotic indices calculated were the number of Ephemeroptera-Plecoptera-Trichoptera taxa (EPT taxa richness), %EPT abundance, the Macroinvertebrate Community Index (MCI), Urban Community Index (UCI), and their quantitative equivalents (QMCI and QUCI, respectively). The points below provide brief clarification of these metrics:

» Taxa richness is the number of different taxa identified in each sample. Taxa is generally a term for taxonomic groups, and in this case refers to the lowest level of classification that was obtained during the study. Taxa richness can be used as an indication of stream health or habitat type, where sites with greater taxa richness are usually healthier and/or have a more diverse habitat.

» EPT refers to three Orders of invertebrates that are generally regarded as 'cleanwater' taxa. These Orders are Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies); forming the acronym EPT. These taxa are relatively intolerant of organic enrichment or other pollutants and habitat degradation. The exception to this is the hydroptilid caddisflies (e.g. Trichoptera: Hydroptilidae: *Oxyethira, Paroxyethira*), which are algal piercers and often found in high numbers in nutrient enriched waters with high algal content. For this reason, EPT metrics are presented excluding Hydroptilidae. EPT taxa richness and %EPT abundance can provide a good indication as to the health of a particular site. The disappearance and reappearance of EPT taxa also provides evidence of whether a site is impacted or recovering from a disturbance. EPT taxa are generally diverse in non-impacted, non-urbanised stream systems, although there is a small set of EPT taxa that are also found in urbanised waterways.

- In the mid-1980s the MCI was developed as an index of community integrity for use in stony riffles in New Zealand streams and rivers, and can be used to determine the level of organic enrichment for these types of streams (Stark, 1985). Although developed to assess nutrient enrichment, the MCI will respond to any disturbance that alters macroinvertebrate community composition (Boothroyd & Stark, 2000), and as such is used widely to evaluate the general health of waterways in New Zealand. Recently a variant for use in streams with a streambed of sand/silt/mud (i.e. soft-bottomed) was developed by Stark & Maxted (2007a) and is referred to as the MCI-sb. Both the hard-bottomed (MCI-hb) and soft-bottomed (MCI-sb) versions calculate an overall score for each sample, which is based on pollution-tolerance values for each invertebrate taxon that range from 1 (very pollution tolerant) to 10 (pollution-sensitive). MCI-hb and MCI-sb are calculated using presence/absence data and a quantitative version has been developed that incorporates abundance data and so gives a more accurate result by differentiating rare taxa from abundant taxa (QMCI-hb, QMCI-sb). MCI (QMCI) scores of ≥120 (≥6.00) are interpreted as 'excellent', 100–119 (5.00–5.99) as 'good', 80–99 (4.00–4.99) as 'fair', and <80 (<4.00) as 'poor' (Stark & Maxted, 2007b). As mud/silt was the dominant substrate size at Sites 1–3 only the soft-bottomed variants (MCI-sb and QMCI-sb) were used at this site. The hard-bottomed variants were used at Site 4 where invertebrate samples were collected from constructed stony channels.
- The UCI/QUCI score can be used to determine the health of urban and peri-urban streams by combining tolerance values for invertebrates with presence/absence or abundance invertebrate data (Suren *et al.*, 1998). This biotic index is indicative of habitat relationships, and to some degree incorporates urban impacts. Negative scores are indicative of invertebrate communities tolerant of slow-flowing water conditions associated with soft-bottomed streams (and often with a high biomass of macrophytes), whereas positive scores are indicative of communities present in fast-flowing streams with coarse substrates (Suren *et al.*, 1998).

3 RESULTS

3.1 Habitat

3.1.1 General Overview of Waterbodies

The site walkover identified a reasonable number of waterway channels and permanent ponds within the project area (Figure 2 - 5). Some of these ponds and channels differ from the information provided on the CCC waterways map layer, which appears to be a result of their realignment by landowners over the years. In particular the ponded network and channel flowing into the upper reaches of Tysons Drain Branch No 1 (i.e., Figure 4a-e) is a realignment of an old drainage channel to the west; while the network of drainage channels around Tysons Drain Branch No 3 (i.e., Figure 4m-t) appear to have been dug out to drain wet areas and facilitate infilling. Similarly part of the unnamed channel to the southwest (Figure 5) appears to have been recently dug as a result of filling within a boggy area (i.e., with high groundwater/a large spring network).

The waterways within the Tysons Drain network are connected via an open channel to Styx River via Winters Road Drain and Horners Drain. In contrast, Godfreys Drain enters a piped network after 240m, where it flows into the Christchurch Accommodation Top 10 Holiday Park and then into Tysons Drain downstream of Cranford Street. The unnamed drain that flows into Tysons Drain Branch No 2 is linked to two separate catchments via Tysons Drain Branch No 2 - via a short pipe to the Dudley Creek diversion, which flows through a 2km piped section and discharges into Horseshoe Lake and the Avon River; as well as an open channel connection to Tysons Drain that ultimately flows into the Styx River.

In general all waterways were straight soft-bottomed channels with steep-sided earth banks typical of channels excavated for drainage. Riparian vegetation was dominated by exotic herbs and pasture grasses, and provided little in the way of overhanging cover for aquatic biota. Shading of channels was mainly provided by adjacent exotic shelterbelts, or were otherwise unshaded. A significant area of native trees (mainly *Pittosporum* species) were found along the west branch flowing into Tysons Drain branch No 1 South (Figure 4i). The channel substrate was usually a fine sediment of variable depth, with the exception of the channel feeding into and out of the downstream pond west of Tysons Drain Branch No 1 West (i.e., Site 4), which consisted of small cobbles (Figure 4c).

Most channels appeared to have permanent flow, with the exception of Godfreys Drain (Figure 3) and the headwaters of various branch channels feeding into Tysons Drain. Godfreys Drain receives stormwater from Shearer Ave and as well from Grassmere Street, and becomes piped where it enters the Christchurch Accommodation Top 10 Holiday Park (Figure 2). The main source of flow for other waterways appear to be from groundwater seepage and piped water from field tile drains or springheads, with the start of the lines in Figure 2 indicating where water was first seen in the channels during our site visits. The network of drains at the upstream end of Tysons Drain include occluded channels that have been dug out without any connection to other surface waterways, or which have been dug to have a connection at both ends (i.e., Tysons Drain Branch No 3). Similarly Tysons Drain Branch No 2 appears to flow both ways, with a piped connection to the Dudley Creek diversion (which connects to Horseshoe Lake and the Avon River via a 2km pipe) and a clear channel connection with Tysons Drain (which connects to the Styx River).

Five significant ponded areas were noted; an isolated pond east of Godfreys Drain (Figure 4u) which has no inflow or outflow channels but is presumably springfed; a network of four ponds west of Tysons Drain Branch No 1 West (Figure 4a-d) which were created by the realignment of a drainage channel fed by springs; a pond adjacent to Tysons Drain Branch No 1 (Figure 4g); and a large ponded area (albeit heavily silted) to the west of Tysons Drain Branch No 3 (Figure 4r). With the exception of the latter, these ponds appear to have been excavated to create a feature of the spring inputs. The habitat values were greatest for the upstream pond in the four-pond network immediately to the west of Tysons Drain Branch No 1 West. This pond had extensive plantings of vegetation (native sedges and other plants) around its margins and was reasonably well shaded by trees, with the flow supplemented by bore water. The second (middle) pond was substantially larger, but with little cover provided around the edge or within the pond itself. The shallower nature may make it more susceptible to turbid water by ducks disturbing settled sediment. Water for this pond and the downstream one was sourced from a spring source piped under the most upstream pond (Figure 2). The third pond was deeper and had a good overhanging cover provided by large *Carex secta* sedges, but there was little shade. The fourth pond no longer had a spring flow input so was occluded and held only stagnating rainwater and garden rubbish.

A reasonable number of areas of standing water were observed within the project area, but were not considered as key ecological aquatic habitat due to the fact that they were not thought to be permanently wet (due to variation in groundwater levels and modification by tilling and land drainage activities) or were generally not connected via surface flow to waterway channels. These were however, mapped in detail by Beca (2016) and form part of the wider spring network described in that report.

A: Godfreys Drain, looking upstream.

B: Godfreys Drain near to where it enters the piped section, looking upstream.

Figure 3 Photos of the Godfreys Drain, as visited by EOS Ecology on 29 August and 8 September 2016.

A: Upstream pond, looking upstream.

B: Middle pond, looking upstream.

C: Cobble-lined channel flowing into the downstream pond, looking downstream.

D: Downstream west pond, looking downstream. Lack of spring input means this only holds stagnating rainwater

E: Realigned outlet from pond network, looking upstream.

F: Tysons Drain Branch No 1, looking downstream.

G: Pond (fed from a spring source) flowing into Tysons Drain Branch No 1.

H: Tysons Drain Branch No 1 South, looking downstream.

I: Tysons Drain Branch No 1 West, looking downstream.

J: Tysons Drain Branch No 1 West, looking upstream.

K: Confluence of Tysons Drain Branch No 1 (left) with Tysons Drain (centre and left), looking upstream into Tysons Drain.

L: Tysons Drain, looking downstream at faster flowing section and adjacent spring inputs.

M: Looking up stream at a cross intersection of Tysons Drain (centre) with Tysons Drain Branch No 3 (left) and a south-east side branch. Recent fill is visible on the left.

N: Looking upstream along Tysons Drain, with the confluence for the south loop of Tysons Drain Branch No 3 on the right.

O: Looking upstream (north-west) at the north loop of Tysons Drain Branch No 3.

P: The south loop of Tysons Drain Branch No 3, looking towards Tysons Drain, with recent infilling on the right.

Q: Occluded channel to the south of the south loop of Tysons Drain Branch No 3, looking south towards Grassmere St.

R: Looking south (towards Grassmere Street) at the springfed standing water west of Tysons Drain No 3.

S: Looking upstream at the south-east branch off Tysons Drain. Recent fill is visible on the right.

T: Looking upstream at the confluence of a south-west branch with the south-east branch off Tysons Drain.

U: Isolated springfed pond to the east of Godfreys Drain.

Figure 4 **Photos of streams and ponds in the Tysons Drain network west of Cranford Basin, as visited by EOS Ecology on 29 August and 8 September 2016.**

A: Looking upstream at a channel recently excavated around the base of recent fill, draining a springhead.

B: Looking downstream from the same location as photo 5A.

C: looking further downstream from photo U, where it flows into Tysons Drain Branch No 2. Photo provided by Beca.

Figure 5 Photos of the unnamed drainage area in the south-east corner of the project area west of Cranford Basin, as visited by EOS Ecology on 29 August and 8 September 2016.

3.1.2 Habitat Description of Surveyed Sites

Sites 1, 2, 3, and 5 were all located in drainage channels. Site 4 included an artificial pond and its inlet and outlet channels, while Site 6 was an artificial pond with no apparent inlet or outlet (see Figure 2 and Appendix 9.1 for site photos). All sites surveyed had mud/silt bottoms, with the exception of constructed stony inlet and outlet channels from the pond at Site 4. Instream habitat in drainage channels tended to be mostly low gradient runs with faster flowing shallow riffle habitat being relatively rare (Table 1). Water depths were low to moderate while the depth of fine sediment was high (Table 1). Filamentous algae were present at four of the six sites and particularly abundant at Site 3. Macrophytes were not particularly prominent at any of the sites and this could have been related to both management (spraying/removal of macrophytes) and the time of year (macrophytes tend to reach maximum coverage over summer and sampling was done in late winter/early spring) (Table 1).

Riparian vegetation was dominated by unmanaged grass at all sites with large poplars also growing along the waterways at Site 1 and Site 2. The only significant native riparian vegetation encountered was at Site 4, where it had been planted around the constructed pond with *Carex secta* sedges (Table 1, Appendix 9.1).

Table 1 Habitat parameters measured at six sites in the western Cranford Basin by EOS Ecology on 31 August and 1 September 2016.

Parameter	Site 1	Site 2	Site 3	Site 4*	Site 5	Site 6#
Bed substrate	99.8% mud/silt 0.1% gravel 0.1% small cobbles	100% mud/silt	99% mud/silt 1% gravel	95% mud/silt 2% gravel 3% small cobble	99% mud/silt 1% gravel	100% mud/silt
Habitat type (%riffle/run/pool)	5/95/0	0/90/10	0/100/0	5/10/85	0/100/0	0/0/100
Water depth (cm)	Mean: 14.3 Range: 8–19	Mean: 20.3 Range: 14–32	Mean: 12.3 Range: 9–18	Not measured	Mean: 29 Range: 15–41	Not measured
Fine sediment depth (cm)	Mean: 29.7 Range: 1–80	Mean: 70.7 Range: 47–97	Mean: 73.6 Range: 41–123	Not measured	Mean: 63.7 Range: 2–109	Not measured
Channel width (cm)	Mean: 78.3 Range: 44–102	Mean: 150.7 Range: 142–160	Mean: 79 Range: 58–112	Not measured	Mean: 177.3 Range: 94–248	Not measured
Organic matter composition	10% filamentous algae 0.01% watercress	2% *Lemna* 30% woody debris	78% filamentous algae 20% watercress 2% *Lemna*	5% terrestrial roots/vegetation 2% leaf litter 1% woody debris	5% filamentous algae 40% watercress 5% *Lemna* 3% woody debris	40% filamentous algae 10% water lily
Riparian vegetation	TLB: 100% grass	TLB: 45% grass 5% scrub gorse 50% poplar trees	TLB: 80% grass 30% native	TLB: 10% grass 20% exotic 70% native	TLB: 90% grass 10% scrub/grass	TLB: 90% grass 8% exotic trees 2% native
	TRB: 19% grass 1% scrub/gorse 80% poplar trees	TRB: 80% grass 20% poplar trees	TRB: 99% grass 1% exotic trees	TRB: 80% grass 10% native 10% gravel/earth	TRB: 90% grass 9% scrub/grass 1% exotic trees	TRB: 95% grass 2% exotic trees 3% native
Fish cover (% of wetted bed area)	1% substrate 10% macrophytes/algae 1% debris 40% undercut banks	30% debris 30% overhanging vegetation 5% undercut banks	78% macrophytes/algae 2% debris 20% undercut banks	2% substrate 1% debris 5% overhanging vegetation	40% macrophytes/algae 3% debris	40% macrophytes/algae 1% debris 1% overhanging vegetation
Channel shading	95% overhead shade	75% overhead shade	30% overhead shade	No shading	2% overhead shade	20% overhead shade
Biota survey	Fish Macroinvertebrates	Fish Macroinvertebrates	Fish Macroinvertebrates	Fish Macroinvertebrates	Fish	Fish

*Site 4 included artificially created ponds with mud/silt bottoms joined by stony-bottomed channels; #Site 6 was a small isolated pond.

3.1.3 Overview of Spring Habitats

Beca (2016) undertook a comprehensive survey of springs in the area, where they found a large number of shallow ponded and occluded water that would likely vary (and potentially dry up) throughout the year, as well as permanent spring sources of water (Figure 6). In general spring activity and high groundwater was most evident in the western half of the project area.

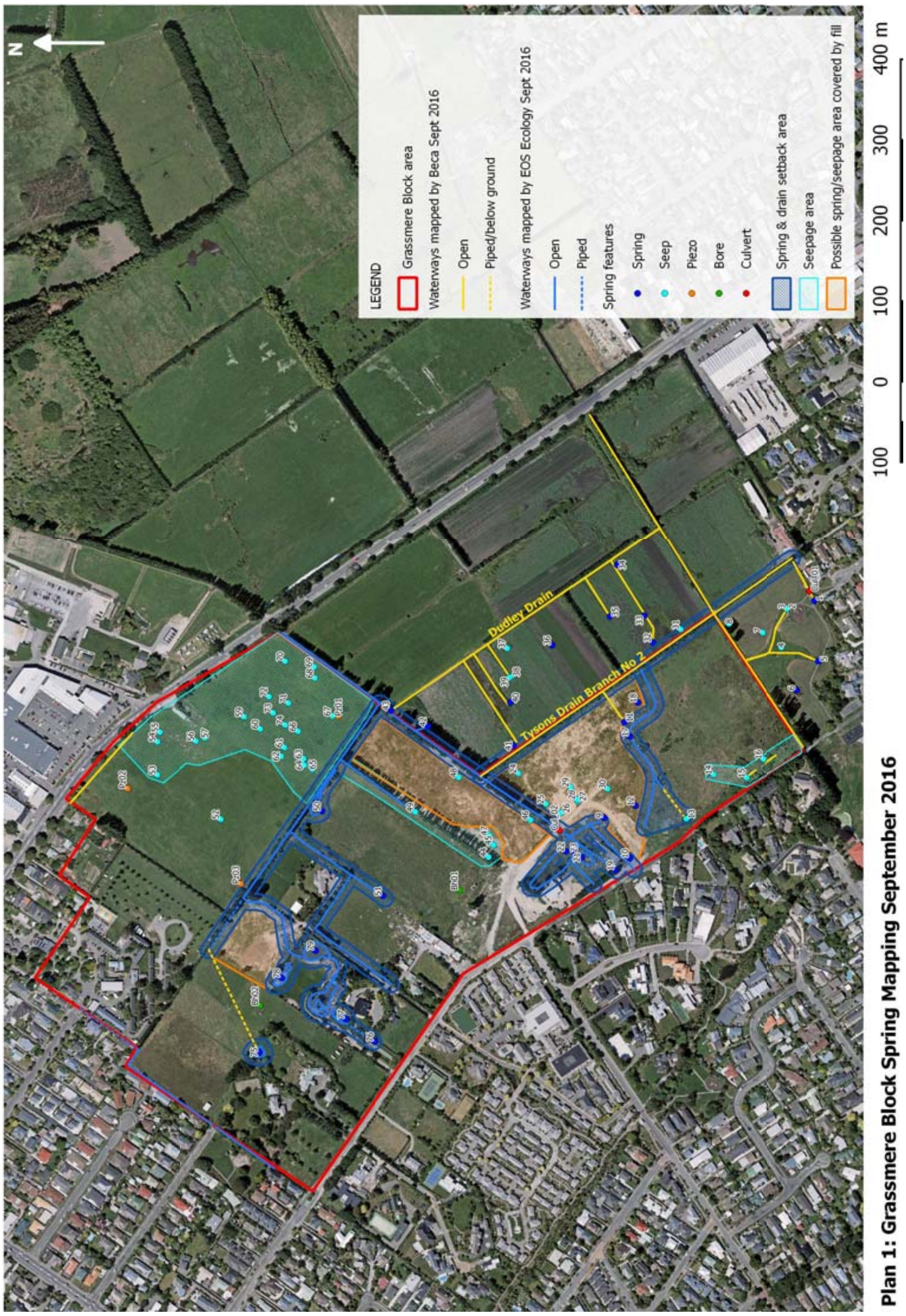

Figure 6 Location of springheads identified by Beca (2016). Map supplied by Beca, Christchurch on the 28 September 2016.

3.2 Invertebrates

3.2.1 Overview

A total of 27 invertebrate taxa were recorded from the four sites where macroinvertebrates were sampled (Sites 1–4). The most diverse groups were the two-winged flies (Diptera: nine taxa), molluscs (Mollusca: four taxa), and crustaceans (Crustacea: four taxa), followed by hemiptera (true bugs: two taxa) and caddisflies (Trichoptera: two taxa). Groups represented by one taxon included nematode worms (Nematoda), oligochaete worms (Oligochaeta), damselflies (Odonata), leeches (Hirudinea), proboscis worms (Nemertea), and mites (Arachnida: Acari).

Overall the freshwater snail *Potamopyrgus* (Figure 7) accounted for 83.6% of all invertebrates captured, dominated the community and was found at all four sites. The only other taxa with overall relative abundances greater than 1% were ostracod microcrustaceans (4.1%, found at all sites), Sphaeriidae pea clams (3.2%, found at Sites 1–3), orthoclad midge larvae (3.2%, found at Sites 1, 2, and 4), oligochaete worms (1.2%, found at all sites), and copepod microcrustaceans (1.2%, found at Sites 1 and 3) (Figure 7). The cleanwater EPT (Ephemera-Plecoptera-Trichoptera) group was represented by caddisflies (order Trichoptera), with both the mayfly (Ephemeroptera) and stonefly (Plecoptera) orders absent. Caddisflies accounted for only 0.5% of total invertebrate abundance, with only two taxa recorded. The most abundant of these was the more pollution-tolerant hydroptillid caddisfly *Oxyethira* (0.4%, found only at Sites 1 and 4), while *Hudsonema* was more uncommon (0.1%, found only at Site 1).

Considering the five most abundant taxa at each site, Sites 1–3 were all similar in being strongly dominated by the snail *Potamopyrgus* and including ostracod microcrustaceans and Sphaeriidae pea clams in the top five most abundant taxa (Figure 7). Site 4 differed in that *Potamopyrgus* did not dominate the community, with orthoclad midge larvae and ostracod microcrustaceans having higher relative abundances (Figure 7).

3.2.2 Biotic Indices

Biotic indices at all four sites sampled for macroinvertebrates (Sites 1–4) were similar overall (Table 2). EPT were rare or absent, MCI/QMCI were in the poor "quality class" of Stark & Maxted (2007b), and UCI/QUCI scores were all negative; indicating invertebrate communities tolerant of slow-flowing water conditions often associated with soft-bottomed streams (Table 2). It is notable Site 4 had the highest number of taxa as this was the only hard-bottomed site sampled, however the taxa found there were still generally those tolerant of degraded conditions, hence MCI/QMCI and UCI/QUCI scores were similar to the other three sites (Table 2).

3.3 Fish

Four fish species were found across the six sites that were sampled for fish (Sites 1–6). In order of abundance for all sites combined, these were upland bully (*Gobiomorphus breviceps*), shortfin eel (*Anguilla australis*), longfin eel (*A. dieffenbachii*), and inanga (*Galaxias maculatus*) (Figure 8). Shortfin eel and upland bully were the most widespread species found, with shortfin eel being at all sites and upland bully at five of the six sites sampled (Figure 8). Sites 1 and 5 had the greatest fish diversity with three species captured at each (Table 3). Of the drainage channel sites that were electrofished (Sites 1, 2, 3, and 5) the

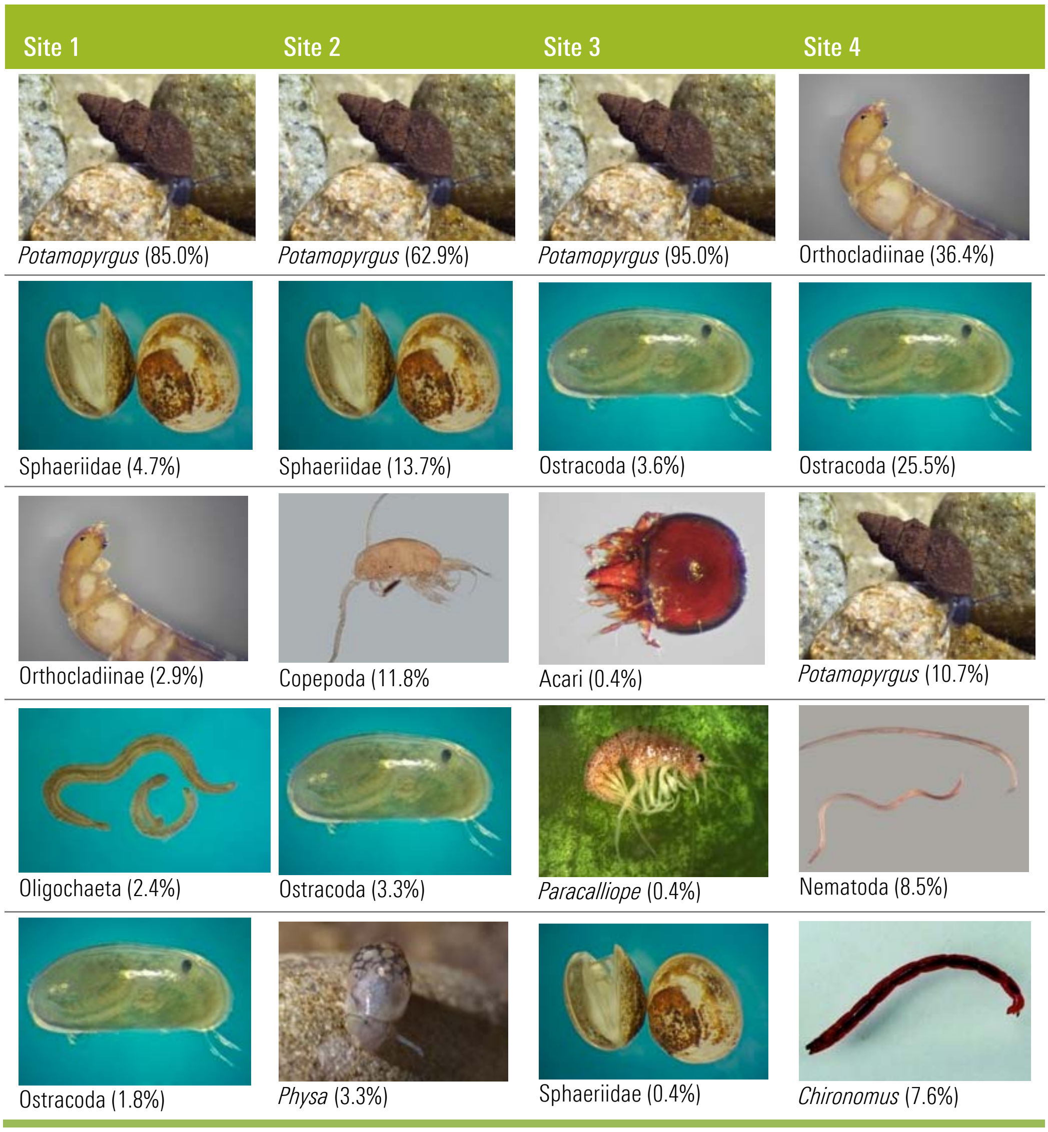

Figure 7 The five most abundant macroinvertebrate taxa at four western Cranford Basin sites sampled by EOS Ecology on 31 August 2016. The relative abundance of each taxon is given in parentheses. Photos © EOS Ecology.

Table 2 Macroinvertebrate community indices from four western Cranford Basin sites sampled by EOS Ecology on 31 August 2016. EPT taxa and %EPT are given excluding hydroptilidae caddisflies.

	Biotic Indices						
Site	Taxa	EPT	% EPT	MCI*	QMCI*	UCI	QUCI
1	15	1	0.3	74.0	2.3	-1.7	-0.02
2	11	0	0	71.3	2.3	-4.7	-0.13
3	8	0	0	56.8	2.1	-2.2	-0.001
4	19	0	0	65.3	2.6	-1.6	-0.04

* Soft-bottomed MCI/QMCI values (MCI-sb) are given for Sites 1–3. At Site 4 macroinvertebrates were sampled from a constructed stony-bottomed channel so hard-bottomed MCI/QMCI values (MCI-hb) are presented here.

greatest total CPUE was at Site 5 and the least at Site 3 (Table 3). All fish captured were native (shortfin eel and inanga) or endemic (upland bully and longfin eel). Longfin eel and inanga are of conservation concern as they are classified as "At Risk - Declining" by the latest freshwater fish threat classification (Goodman *et al.,* 2013).

There were a number of fish passage barriers observed during the site walkover (Figure 9), which may help explain the limited fish communities at some of the surveyed sites. Site 6 was an occluded pond with no surface water connections and supported only shortfin eel. Shortfin eels are able to move overland during rain events, which might explain their ability to colonise the pond. The pond habitat of Site 4 was located in an area upstream of several fish passage barriers (Figure 9), and presumably no fish rescue and relocation operations were undertaken that the time that these ponds were created. Only eels (shortfin and longfin) were found here as they would be better able to negotiate the fish passage barriers. Upland bullies are non-diadromous (they do not require access to the sea for part of their lifecycle) and so their presence in the rest of the stream network would be a historic one. The adult inanga found at Site 5 is the first record of this species this far upstream in this catchment, but it is probable that numbers would be limited due to some passage barriers further downstream.

Upland bully; found at five of six sites; not threatened.

Shortfin eel; found at all six sites; not threatened.

Longfin eel; found at two of six sites; declining.

Inanga; found at one of six sites; declining.

Figure 8 The fish species captured during sampling of six sites in western Cranford Basin by EOS Ecology on 31 August and 1 September 2016. Also shown are the number of sites they were found at and the latest conservation status of each species. Photos © EOS Ecology.

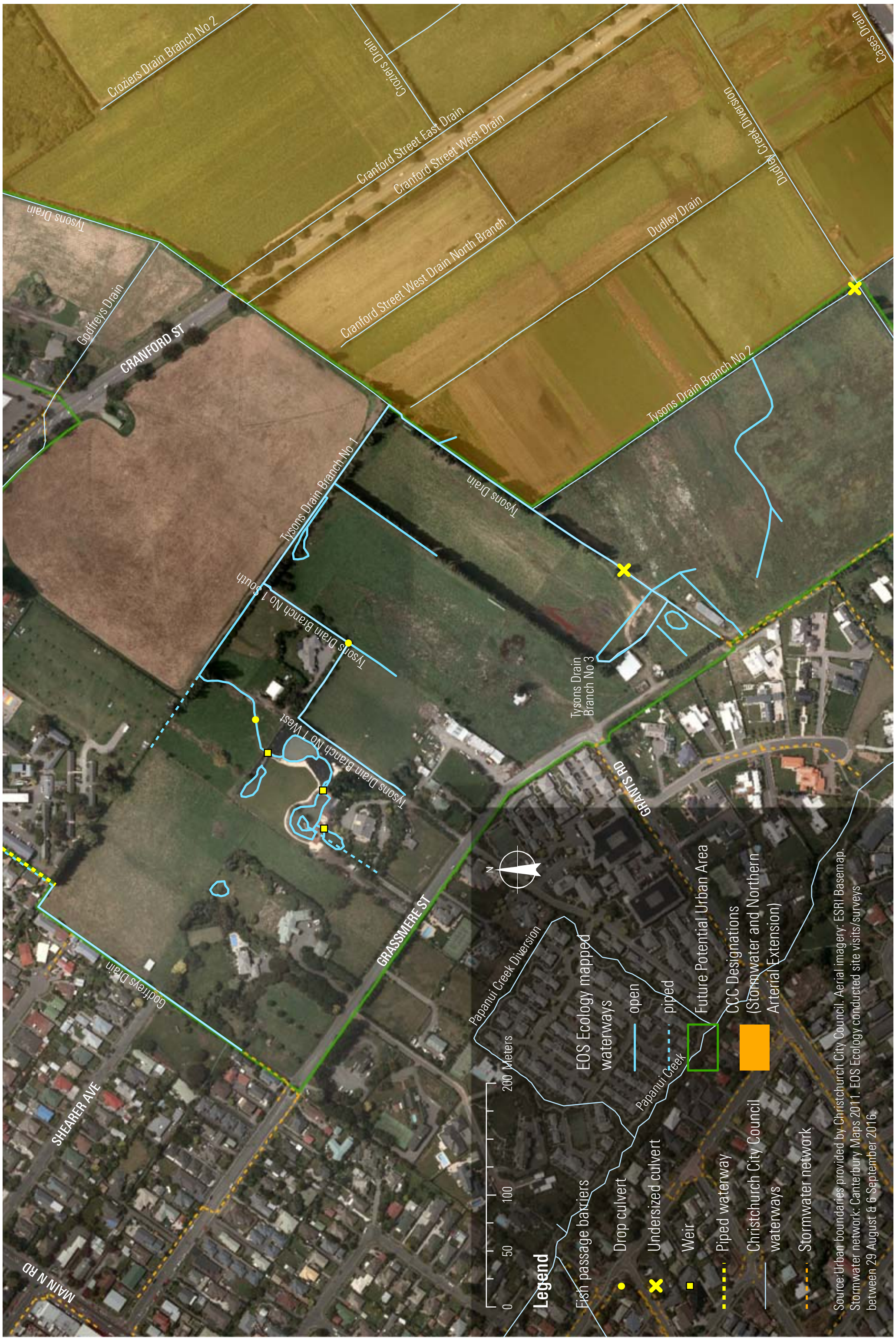

Figure 9 Fish passage barriers identified during the site walkover in September 2016.

Table 3 Summary of fish sampling from six western Cranford Basin sites sampled by EOS Ecology on 31 August and 1 September 2016. "Raw" indicates actual numbers caught; CPUE = catch per unit effort expressed as per area fished from electrofishing and fish/net/night for fyke nets. No fish were captured in Gee minnow traps. Electrofishing CPUE could not be calculated for Site 4 (pond edge and channels were fished so no area could be sensibly calculated) or Site 6 (spot fishing of small pond).

Site	Method	Effort (minutes or traps set)	Fishing details	Shortfin eel	Longfin eel	Inanga	Upland bully	Total
1	Electrofishing	27 mins	~118 m² fished	Raw: 26 CPUE: 0.22/m²	Raw: 3 CPUE: 0.03/m²	0	Raw: 22 CPUE: 0.19/m²	Raw: 51 CPUE: 0.43/m²
2	Electrofishing	10 mins	~75 m² fished	Raw: 5 CPUE: 0.07/m²	0	0	Raw: 18 CPUE: 0.24/m²	Raw: 23 CPUE: 0.31/m²
3	Electrofishing	13 mins	~95 m² fished	Raw: 18 CPUE: 0.19/m²	0	0	Raw: 1 CPUE: 0.01/m²	Raw: 19 CPUE: 0.20/m²
4*	Electrofishing	5 mins	Fishing along edges of pond and inflow and outflow channels; Traps set in pond	Raw: 7	0	0	0	Raw: 7
	Trapping	4 Gee minnow traps 3 Fyke nets		Raw: 1 Fyke CPUE: 0.33/net /night	Raw: 1 Fyke CPUE: 0.33/net /night	0	0	Raw: 2 Fyke CPUE: 0.66/net/ night
5	Electrofishing	15 mins	~89 m² fished	Raw: 9 CPUE: 0.10/m²	0	Raw: 1 CPUE: 0.01/m²	Raw: 34 CPUE: 0.38/m²	Raw: 44 CPUE: 0.49/m²
6#	Electrofishing	2 mins	Spot fishing through small pond	Raw: 1	0	0	Raw: 1	Raw: 2

*Site 4 involved fishing in an artificial pond and its inlet/outlet channels; #Site 6 was an isolated pond.

4 ECOLOGICAL SIGNIFICANCE

An assessment of the ecological value of the drainage channels and ponds in western Cranford Basin following the criteria developed for the Proposed Canterbury Regional Policy Statement (Wildlands, 2013) generally indicate a low ranking that does not meet the threshold for ecological significance (Table 4). However they do have a high rarity value in that they provide habitat for species with an "At Risk – Declining" conservation status (long fin eel and inanga), and a moderate habitat value as they provide habitat for numerous native and endemic species in a heavily modified environment (Table 4).

Table 4 Assessment of ecological significance of the western Cranford Basin watercourses sampled by EOS Ecology on 31 August and 1 September 2016. This assessment follows the criteria of Wildlands (2013). Red text indicates low significance where the threshold for that criterion is not met, blue text where there is moderate significance, and green text where there is high significance.

Criteria	Ranking
Representativeness	
1. Indigenous vegetation or habitat of indigenous fauna that is representative, typical or characteristic of the natural diversity of the relevant ecological district. This can include degraded examples where they are some of the best remaining examples of their type, or represent all that remains of indigenous biodiversity in some areas.	**Low representative value (does not meet threshold):** freshwater habitats in the area are artificially created drainage channels or ponds.
2. Indigenous vegetation or habitat of indigenous fauna that is a relatively large example of its type within the relevant ecological district.	**Low (does not meet threshold):** freshwater habitats in the area are relatively small examples of artificially created drainage channels or ponds.
Rarity/Distinctiveness	
3. Indigenous vegetation or habitat of indigenous fauna that has been reduced to less than 20% of its former extent in the Region, or relevant land environment, ecological district, or freshwater environment.	**Does not meet threshold**: freshwater habitats in the area are artificially created drainage channels or ponds so have no "former extent".
4. Indigenous vegetation or habitat of indigenous fauna that supports an indigenous species that is threatened, at risk or uncommon, nationally or within the relevant ecological district.	**High rarity value (meets threshold):** species with "At Risk – Declining" conservations status present (long fin eel and inanga).
5. The site contains indigenous vegetation or an indigenous species at its distribution limit within Canterbury Region or nationally.	**Does not meet threshold**: no such species known to be present.
6. Indigenous vegetation or an association of indigenous species that is distinctive, of restricted occurrence, occurs within an originally rare ecosystem, or has developed as a result of an unusual environmental factor or combination of factors.	**Low distinctive value (does not meet threshold):** such artificially created freshwater habitats and associated biota assemblage are widespread.
Diversity and Pattern	
7. Indigenous vegetation or habitat of indigenous fauna that contains a high diversity of indigenous ecosystem or habitat types, indigenous taxa, or has changes in species composition reflecting the existence of diverse natural features or ecological gradients.	**Low (does not meet threshold):** freshwater habitats in the area are artificially created drainage channels or ponds thus not representative of any indigenous ecosystem or habitat type.
Ecological Context	
8. Vegetation or habitat of indigenous fauna that provides or contributes to an important ecological linkage or network, or provides an important buffering function.	**Low ecological context value (does not meet threshold):** freshwater habitats in the area are artificially created drainage channels or ponds near top of catchment.
9. A wetland which plays an important hydrological, biological or ecological role in the natural functioning of a river or coastal system.	**Low wetland functionality (unlikely to meet threshold):** former wetland functionality lost through drainage and conversion to agriculture/horticulture.
10. Indigenous vegetation or habitat of indigenous fauna that provides important habitat (including refuges from predation, or key habitat for feeding, breeding, or resting) for indigenous species, either seasonally or permanently.	**Moderate habitat value (meets threshold):** provides remnant freshwater habitat for numerous native or endemic species in a highly modified environment.

5 DISCUSSION

5.1 Habitats

All the waterways and ponds sampled in the western Cranford Basin are artificially constructed habitats in the upper Tysons Drain catchment, which are directly linked to the Styx River via Winters Road Drain and Horners Drain. They are in a highly modified environment that was formerly wetland. The Christchurch "black maps" which indicate waterways, swamps, and vegetation as of 1856 show the general Cranford Basin area described as "swamp" with raupo, tussocks, toi toi, and flax (CCC, 2006). The channels were generally created for land drainage purposes while the ponds were constructed for landscape/aesthetic purposes. The channels were generally low gradient, soft-bottomed, slow water velocity environments with minimal instream habitat variability. Numerous springheads have been identified in the area and these provide reliable base flows to the drainage channels and may form thermal refuges for some species during hot summer months. These springs mean there is great potential for the creation of small waterways with reliable flows of relatively high quality water.

Despite being artificially constructed aquatic environments, these channels and ponds are the only remaining surface water habitats in an area that was once wetland and is now surrounded by urban land use where all wetlands have been drained and most small waterways piped. Hence they provide valuable habitat for many native and endemic freshwater species as well as a water source for numerous terrestrial animals (e.g., birds, small mammals, insects including bees).

5.2 Biota

The aquatic macroinvertebrate community of the western Cranford Basin was the same as that found in the greater Cranford Basin area by previous studies. McMurtrie *et al.* (2005) undertook a 15-site investigation of the aquatic ecology of the Mairehau-Cranford area that included seven sites within Cranford Basin area (located within the CCC land identified in Figure 1). Overall they found *Potamopyrgus* snails, oligochaete worms, Sphaeriidae pea clams, ostracod microcrustaceans, and chironomids (includes Orthocladiinae and *Chironomus*) were the most abundant macroinvertebrate taxa, which is essentially the same as what this current survey found in the western Cranford Basin area. Similarly the recent survey by Opus of the area of Cranford Basin to be affected by construction of the Northern Arterial Extension and proposed stormwater treatment facility (located within the CCC land identified in Figure 1) found *Potamopyrgus* snails, oligochaete worms, Sphaeriidae pea clams, ostracod microcrustaceans, and Orthocladiinae chironomids to be the most abundant taxa (Opus, 2014). Hence all the drainage channels of Cranford Basin generally have very similar macroinvertebrate communities with a core group of taxa that are typical of low-gradient, soft-bottomed watercourses throughout New Zealand. This was of no surprise given the majority of sampling sites across the three studies have very similar instream habitat, being generally a soft-bottomed mud/silt bed with slow water velocities and all were artificial channels constructed to drain what was predominantly wetland when European settlers arrived. Additionally these drainage channels have been subjected to runoff from urban and horticultural land use and all the contaminants that this brings.

The fish community of the western Cranford Basin was comprised of the species that had been found in previous surveys. Opus (2014) sampled fish from four sites (located within the CCC land identified in

Figure 1, which ultimately flows into Horseshoe Lake via a piped section), and only caught low numbers of shortfin eel and upland bully at one site (upper Dudley Creek Diversion channel). The Mairehau-Cranford area investigation by McMurtrie *et al.* (2005) found the same four species (upland bully, shortfin eel, longfin eel, inanga) as the current study plus a small number of common bullies. McMurtrie *et al.* (2005) only found inanga in the lower parts of Horners Drain near the Styx River (all the sites in the current study ultimately flow to the Styx River via Horners Drain). They did however note that adult inanga were seen further upstream in Tysons Drain between Winters Rd and Cranford St (their Site 14). The current study confirms inanga penetrate far up the drainage network despite the presence of various barriers between the western Cranford Basin and the Styx River (McMurtrie *et al.,* 2005) and the relatively poor ability of inanga to negotiate instream structures (i.e. weirs and perched culverts).

Both the current study and McMurtrie *et al.* (2005) found upland bully and shortfin eel to be the most widespread and abundant fish species. The ability of these species to inhabit artificial waterways in high abundance is partially responsible for their "not threatened" conservation status. However, both surveys also found longfin eel and inanga are present, both of which have an "At Risk - Declining" conservation status (Goodman *et al.,* 2013). While these species were in relatively low abundances and at limited locations, their presence does indicate that any future changes to the drainage channel network could look to improve or augment the habitats these species prefer. Overall, the fish species present are typical of low-gradient Canterbury waterways near the coast.

Riparian vegetation primarily consisted of exotic grasses and trees (mostly poplars). The only significant area of native vegetation was relatively recent plantings around the pond at Site 4, and *Pittosporum* trees along a short section of channel flowing into Tysons Drain Branch No 1 South. Macrophytes were not particularly abundant or diverse, with exotic watercress or the ubiquitous native "duckweed" *Lemna* being present at some sites.

5.3 Ecological Significance

Given all surveyed watercourses in the western Cranford Basin were artificially created to drain wetland (drainage channels) or for landscape/aesthetic reasons (ponds) they have low ecological significance overall, despite providing habitat for numerous native and endemic species including two species with an "At Risk – Declining" conservation status. However, given the numerous springheads providing a reliable source of relatively high quality water these waterways all have great restoration/naturalisation potential. The proposed land use change provides the opportunity to require enhancement of the waterway network and protection of spring flows. If done correctly this would greatly increase ecological and aesthetic values, as well as enhancing the recreational and landscape values of any new urban development.

6 RECOMMENDATIONS

The proposed urban development in the western Cranford Basin has the potential to adversely affect the existing freshwater environments. With modern urban development plans usually seeking to maximise the number of residential lots there is often pressure to pipe minor waterways, especially if they are artificially constructed drainage channels. We recommend the following with respect to the use and treatment of the waterways of the western Cranford Basin in any future development in the area:

- Avoid any net loss in freshwater habitat area to ensure the same area of remnant aquatic habitat is retained.
- Concentrate restoration/naturalisation in the area where spring flows are greatest, meaning east/southeast from the network of four ponds in the headwaters of Tysons Drain Branch No 1. Godfreys Drain itself does not represent a channel with high restoration potential given the lack of base flow, existing untreated stormwater inputs, and the piped section downstream. However, this channel would be suitable to take treated stormwater from part of the development area, to ensure stormwater is kept out of the other springfed streams which have higher restoration potential.
- Seek to create a neighbourhood with a network of greenspace reserves based on key springheads areas and their outflow channels, and any looped or occluded channels reformed to a more natural channel network. This would involve construction of new waterways or enhancement of current waterways, and would incorporate as much freshwater habitat variability as possible given the low gradient of the area. This could include deeper zones aimed at providing inanga habitat and features such as small logs and constructed undercuts to provide cover for eels during the day. The reserves would allow for full riparian planting and pedestrian walkways. Any design of such waterways should follow the CCC's "Waterways, Wetlands, and Drainage Guide" (CCC, 2003).
- Ensure all waterways, springhead areas, and larger ponded areas are well shaded with native canopy trees, and have abundant overhanging bank vegetation. Exotic trees should not be located anywhere near the waterway network or where they can enter the stormwater network as the autumnal leaf fall could impact on dissolved oxygen levels in such small, slow flowing waterways. Such planting will require a reasonable margin of protected riparian zone on either side of the waterway channel to help reduce any shading issues created for adjacent residential properties.
- Ideally suitably trained and qualified ecologists (terrestrial/botanists and freshwater ecologist) should be involved in the design of waterway channels and springhead networks to maximise the ecological values of the network.
- Seek to keep stormwater out of the spring sources and newly created waterways as far as practical. At a minimum there should be no stormwater directed into the springheads and the upper sections of the waterways flowing from these springhead areas. Ideally all stormwater from any new urban development would be routed to the proposed stormwater treatment facility in Cranford Basin, or to a treatment system that discharges into Godfreys Drain .
- Provide a wide protected riparian and flood zone area where stormwater inputs may increase flood flows. A wider floodplain should allow for flood flow capacity whilst having larger plantings along the stream edge that may otherwise impinge on flood capacity in a more constricted area. Note however, that all low flow channels should be narrow to maximise water depth during drier months and to provide some level of resilience should groundwater inputs reduce following development.
- Investigate the possibility of reintroduction of native species such as koura (native freshwater crayfish) following enhancement. Isolated spring fed ponds could also be potential habitat for Canterbury mudfish reintroductions. Note however that such introductions will only be possible upstream of any stormwater inputs, which increases the importance of having headwater areas sequestered from the stormwater network. Waterways and ponds would also need to be designed to provide the habitat and hydraulic attributes that these specialist species require (refer to McMurtrie (2008) for information on creating habitat for koura), and as such would require specialist input in the design process.
- Maintain the surface water connection with the Styx River (i.e., do not divert upper Tysons Drain to the neighbouring Avon River catchment, which has a substantial piped section that represents a significant

migration barrier).

- Ensure all instream structures between the Styx River and upper Tysons Drain allow the free upstream and downstream passage of inanga. This will also require removal or modification of any weirs or perched culverts within the project area.
- Any construction that requires the diverting or filling in of existing drainage channels must incorporate fish relocations.
- Integrate any waterway creation in the western Cranford Basin with what is occurring in the rest of Cranford Basin, in particular the CCC stormwater treatment facility.
- Require all urban development in the western Cranford Basin to incorporate sustainable urban design features with respect to stormwater runoff. For example:
    - Rainwater capture and reuse;
    - Minimising impervious cover (e.g., using permeable paving);
    - The use of rain gardens and swales rather than standard curb and channel.
    - Avoiding use of building materials known to generate contaminants (e.g., copper guttering and roofing).

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9 APPENDICES

9.1 Site Photographs

Site 1 (looking downstream from top of site)

Site 2 (looking downstream from middle of site)

Site 3 (looking upstream from bottom of site)

Site 4 (looking across pond)

Site 4 (stony outlet stream from pond looking downstream)

Site 5 (looking downstream from middle of site)

Site 6 (looking across pond)

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