REPORT

Annual Aquatic Ecology Monitoring

Styx River, Cashmere Stream and Balguerie Stream

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Executive Summary

Christchurch City Council (CCC) engaged Tonkin & Taylor Ltd (T+T) to undertake the aquatic ecology monitoring at three sites on the Styx River and Cashmere Stream, and to analyse existing aquatic ecology monitoring data from the Balguerie Stream. This report describes the results from the 2020 round of annual aquatic ecology monitoring undertaken in relation to the Environment Canterbury (ECan) Comprehensive Stormwater Network Discharge Consent (CSNDC; CRC190445).

Results show that aquatic habitat and macroinvertebrate communities in 2020 were generally comparable to previous years at the Styx River and Balguerie Stream sites. The macroinvertebrate community included a number of pollution sensitive taxa at all sites and community composition was indicative of “fair” (Styx River and Cashmere Stream sites) through to “good” quality (Balguerie Stream).

Most of the monitored attributes complied with the CSNDC target levels. Except for fine sediment cover (<2 mm diameter) and dissolved oxygen (% saturation) levels at the Styx River and Cashmere Stream sites, and additionally total macrophyte cover at the Cashmere Stream sites.

There was no increasing or decreasing trends indicative of declining ecosystem health. While some statistically significant trends were detected across the sampled sites, these did not indicate a decline in ecosystem health that could be attributed to stormwater discharges.

The CSNDC consent outlines that trend analysis on available data is to be undertaken to determine whether habitat quality and ecological values are remaining stable, improving, or degrading. It is recommended that annual monitoring is continued over a longer period of time or is conducted on a more frequent basis (e.g. quarterly) as more robust and reliable trend analysis can be conducted on longer term more frequent data. Furthermore, alignment of monitoring methodologies between sites should be undertaken to ensure consistency with the CSNDC sampling methods. Currently, there are discrepancies between the ECan and the CSNDC sampling methods for fine sediment cover and total and emergent macrophytes attributes.

1 Introduction

Christchurch City Council (CCC) has resource consent to discharge stormwater from the existing and future reticulated stormwater network within Christchurch City and the settlements of Banks Peninsula. Historically, stormwater discharges were monitored under separate programmes but are now collectively monitored under the Comprehensive Stormwater Network Discharge Consent (CSNDC; CRC190445), which commenced on 20 December 2019.

As part of the CSNDC, a Stormwater Management Plan (SMP) has been developed for each sub-catchment within Christchurch City and the settlements of Banks Peninsula. CCC has engaged Tonkin & Taylor Ltd (T+T) to undertake site-specific monitoring and review of historical data for three of these sub-catchments (Pūharakekenui/Styx River, Ōpāwaho/Heathcote River, and Te Pātaka o Rākaihautū/Banks Peninsula) to assess if stormwater discharges have negatively affected the aquatic ecology of the waterways, and to determine if the surface water quality objectives of the consents are being met.

1.1 Report scope

The purpose of this report is to summarise and assess the latest results of the annual aquatic ecology monitoring at sites located on the Styx River, Cashmere Stream, and Balguerie Stream. This includes:

- Assessing each site against the most relevant indices and guidelines where available to determine habitat quality and ecological values.
- An assessment as to whether the Receiving Environment Objectives and Attribute Target Levels relating to aquatic ecology as specified the CSNDC are being met.
- A comparison of recent and historical data to determine whether habitat quality and ecological values are remaining stable, improving, or declining.
- A summary of the overall health of the sites, and potential reasons for any significant spatial or temporal trends. A discussion of likely reasons for any poor or declining habitat quality and ecological values is also provided.
- Advice on how to improve habitat quality at any particular site.

2 Methods

2.1 Monitoring sites

For the 2020 annual aquatic ecology monitoring round T+T sampled three wadable stream sites and analysed existing ecological data at one site (Table 2.1). Sampling was undertaken at the Styx River (Site 14; Figure 7-1) and two sites on Cashmere Stream (Heath 27 and Heath 28; Figure 7-2). Existing aquatic ecological data was analysed for the Balguerie Stream (SQ00170; Figure 7-3).

The monitoring site at the Styx River was historically sampled as part of the Styx Stormwater Management Plan (SSMP; CRC131249) and this is the first year that monitoring is being undertaken under the CSNDC. The two Cashmere Stream sites are new and are being monitored for the first time as part of the CSNDC.

The Balguerie Stream site is located within the Banks Peninsula township of Akaroa. Monitoring is currently undertaken by ECan as part of their long-term State of the Environment (SoE) aquatic ecological health monitoring programme. This is the first time this site will be assessed as part of any CCC stormwater monitoring programme.

All monitoring sites were chosen by CCC to assess if stormwater discharges are negatively affecting the aquatic ecology of the waterway and to determine if the aquatic ecology objectives and attribute targets of the consent are being met.

Table 2.1: Monitoring sites

Stream name	Site name	Co-ordinates (NZMG)	Field survey undertaken	Historic site	Sampled by	Date first sampled
Styx River	STYX 14	E2478252 N5749370	Yes	Yes	CCC/ T+T	2013
Cashmere Stream	Heath 27	E2477452 N5736476	Yes	No	CCC/ T+T	2020
Cashmere Stream	Heath 28	E2477361 N5736392	Yes	No	CCC/ T+T	2020
Balguerie Stream	SQ00170	E2807759 N5711175	No*	Yes	ECan	2000

*Note: Desktop assessment of existing monitoring data undertaken.

2.2 CSNDC sampling methodology

Monitoring was undertaken on 30 April 2020 under baseflow conditions. This was outside of the prescribed monitoring period outlined in the CSNDC due to the New Zealand COVID-19 lockdown. To ensure no confounding effects on ecological surveys, checks were undertaken ahead of sampling to ensure channel maintenance had not been undertaken or recently completed at each site.

Sampling methodology at the Styx River and Cashmere Stream sites is identical to that undertaken in previous years under the SSMP. Monitoring included measurements of water quality, habitat, macrophyte and periphyton cover, and sampling of benthic macroinvertebrates.

Each sampling site comprised a 20 m long sampling reach. Sampling was undertaken either at the reach scale, transect scale (0 m, 10 m, and 20 m) or at five observations delineated at each of the three transects (sub-transect scale). A summary of the parameters and sampling/ monitoring methods is outlined in Table 2.2.

Water quality sampling included measurements of dissolved oxygen (DO, measured as % saturation), temperature (°C), pH and conductivity (µS/cm) using a calibrated YSI professional plus water quality meter. Water velocity measurements were taken using a calibrated Global Water FP111 Flow Prob.

Macroinvertebrate sampling entailed collection of a single kick net sample at each site, covering a total area of approximately 1.5 m² and sampling all representative habitats. Samples were collected using semi-quantitative protocols C1 (hard-bottomed) and C2 (soft bottomed) from Stark *et al* (2001). Collected macroinvertebrates were preserved in denatured ethanol and sent to Stark Environmental Ltd for processing and identification. Samples were processed using the 200 fixed count, plus scan for rare taxa method (Protocol P2 from Stark *et al* 2001).

At each site, photographs were taken upstream and downstream, and photographs of any other important site features (such as instream habitat and/or macrophyte cover) were taken.

Table 2.2: Monitoring scale and parameters sampled and measured

Reach scale	Transect scale	Sub-transect scale
Flow habitat composition (riffle, run, pool)	Velocity	In-stream habitat
Wetted width	Bank and riparian characteristics	Wetted width
Water permanence	Surrounding land use	Fine sediment depth and cover
Water quality	Bank material, height, erosion and slope	Embeddedness
Macroinvertebrate samples	Riparian vegetation	Substrate composition
Upstream/downstream photographs		Instream habitat features photographs

2.3 Data analysis

2.3.1 Data management

The 2020 monitoring data collected from the Styx River and Cashmere Stream were added to Microsoft Excel spreadsheets. The spreadsheet are available from CCC on request.

2.3.2 Water quality and instream habitat data

The latest water quality and instream habitat data were summarised (where necessary), plotted and compared with the relevant CSNDC water quality and instream attribute targets.

Water quality and instream habitat attribute targets adopted in the CSNDC are provided in Table 2.3 and Table 2.4. The water quality attribute targets (Table 2.3) are derived from the Canterbury Land and Water Regional Plan (LWRP), which details minimum water quality objectives for spring-fed – plains and urban, and Banks Peninsula waterways. The instream habitat attribute targets (Table 2.4) were chosen because they can all impact macroinvertebrate communities and all have associated LWRP outcomes.

Were necessary further assessment against relevant regional and National indices and guidelines was undertaken to determine habitat quality and ecological values and condition.

Table 2.3: CSNDC water quality attribute target levels for waterways

Waterway (Site name)	pH	DO (% saturation)	Temperature (°C)	Conductivity (µS/cm)[1]
Styx River (STYX 14)	6.5 – 8.5	≥70%	≤20	n/a
Cashmere Stream (Heath 27 Heath 28) Balguerie Stream (SQ00170)	6.5 – 8.5	90%	≤20	n/a

Note:

1) Default guideline values for conductivity are available for various River Environment Classifications (REC) in New Zealand (Australian and New Zealand Guidelines for Fresh and Marine Water Quality); these are not currently included in the CSNDC.

Table 2.4: CSNDC instream habitat attribute target levels for waterways

Waterway (Site name)	Minimum Quantitative Macroinvertebrate Community Index (QMCI)	Maximum Fine sediment (< 2 mm diameter)	Maximum Total Macrophyte Cover of Streambed	Maximum Filamentous algae (>20 mm length) cover
Styx River (STYX 14)	5	20%	50%	30%
Cashmere Stream (Heath 27 Heath 28) Balguerie Stream (SQ00170)	5	20%	30%	20%

2.3.3 Macroinvertebrate analyses

The latest macroinvertebrate data from each site was summarised (where necessary), plotted (where appropriate) and compared with the relevant CSNDC instream attribute targets (Table 2.4).

The following biological indices were calculated from the raw macroinvertebrate data to provide additional indication of stream ecological value and condition:

- **Taxa Richness**: The number of different invertebrate taxa (families, genera, species) at a site. Richness may be reduced at impacted sites but is not a strong indicator of pollution.
- **%EPT**: The percentage of all individuals collected made up of pollution-sensitive Ephemeroptera (mayfly), Plecoptera (stonefly), and Trichoptera (caddisfly) taxa (EPT). %EPT is typically reduced at polluted sites and is particularly sensitive to sedimentation. This metric is calculated without pollution-tolerant hydroptilid caddisflies, which can skew %EPT results at sites where they are abundant.
- **EPT Taxa Richness**: The number of different EPT taxa at a site. It is reduced at polluted sites. Calculated with the pollution-tolerant hydroptilid caddisflies excluded.
- **MCI and QMCI**: The Macroinvertebrate Community Index (MCI) and the Quantitative MCI (QMCI) (Stark 1985). Invertebrate taxa are assigned scores from 1 to 10 based on their tolerance to organic pollution. Highest scoring taxa (e.g., many EPT taxa) are the least tolerant to organic pollution.

The MCI is based on presence-absence data, where scores are summed for each taxon in a sample, divided by the total number of taxa collected, then multiplied by a scaling factor of 20.

The QMCI requires abundance data where MCI scores are multiplied by abundance for each taxon, summed for each sample, then divided by total invertebrate abundance for each sample. We calculated site MCI and QMCI scores using the tolerance scores for hard bottomed streams, to reflect the dominant substrate present (Stark & Maxted, 2007).

MCI and QMCI scores can be interpreted as per the quality classes of Stark & Maxted (2007), as summarised in Table 2.5.

Table 2.5: Interpretation of MCI and QMCI scores (from Stark & Maxted 2007)

Quality Class	MCI	QMCI
Excellent	>119	>5.99
Good	100-119	5.00-5.90
Fair	80-99	4.00-4.99
Poor	<80	<4.00

2.3.4 Trend assessment of habitat quality and ecological values

The latest results from the Styx River and Balguerie Stream were compared to historical data to determine whether habitat quality and ecological values are remaining stable, improving, or degrading. No trend analysis was undertaken on the Cashmere Stream 2020 annual monitoring due to only one data point being available. Statistical analyses to assess trends over time were conducted on the following parameters:

- Fine sediment cover (<2 mm diameter).
- Emergent and total macrophyte cover.
- Cover of long filamentous algae (>2 cm long).
- Macroinvertebrate indices (including taxa richness, EPT taxa richness and percent abundance, and QMCI).

Trends were examined statistically using the Mann-Kendall trend test on annual median data for each site in Time Trends statistical software (version 6.30. build 11). The CSNDC outlines that the statistical level of significance for trend analysis is set to 5% (i.e. $P<0.05$).

2.3.5 Desktop assessment of Balguerie Stream

The CSNDC requires that the Balguerie Stream is monitored annually. Currently, ECan have been undertaking SoE monitoring at Balguerie Stream (site SQ00170) annually from 2000 through to 2019 during the summer season (i.e. October through to February). Monitoring for 2020 is yet to be completed but will occur over the 2020/2021 summer.

For the purposes of this report, we have used monitoring data from the 2019/2020 summer season to assess against the relevant CSNDC water quality and instream attribute targets. Assessments were undertaken on habitat, macroinvertebrate, macrophyte and periphyton data only. No water quality data were available.

Similarly, to the Styx River and Cashmere Stream sites, the Balguerie Stream data were summarised (where appropriate) and compared to CSNDC instream habitat attribute targets. Trends over time were analysed statistically using the Mann-Kendall trend test.

The ECan data are collected as part of its SoE aquatic ecosystem health monitoring programme and has not been developed to solely assess impacts of stormwater discharges. Therefore, there are differences in how the ECan data are collected and analysed when compared to the annual aquatic ecology monitoring data collected as part of the CSNDC. ECan habitat data are collected using rapid habitat assessment (RHA) protocols that provide a habitat 'score'. It does not solely rely on transect based percent coverage that the CSNDC annual aquatic ecology monitoring utilises.

Where there is similarity in sampling methodology (i.e. macroinvertebrates and periphyton) results can be interpreted as such. However, were habitat 'scores' have been used instead of percent cover (i.e. fine sediment cover and total and emergent macrophytes), we have adjusted the habitat 'scores' to reflect (an as close as possible) the percent cover scale described in the RHA Appendix B.

3 Results and Discussion

3.1 General site descriptions

3.1.1 Styx River – STYX 14

This sampling site is located within the Styx River Recreational Reserve and is bordered by a mix of native grasses, and mid-succession native shrubs and trees, as well as some exotic weed species (e.g. blackberry and convolvulus and willows). A moderate amount of shading is provided to the river by this mixed canopy cover. Overhanging vegetation and stable bank undercuts provide reasonable fish cover, and the predominantly stony stream bed is good habitat for pollution-sensitive invertebrates. Representative site and specific habitat photographs from 2020 are attached in Appendix C.

3.1.2 Cashmere Stream – Heath 27 and Heath 28

The two Cashmere Stream sites are located behind a residential neighbourhood and are bordered by rural farmland. The streams riparian zone is dominated by heavily grazed pasture grasses on the true left-hand side and a mix of mid-succession native and late-succession exotic canopy and sub canopy species on the true right-hand side. There is some evidence of stock access to the waterways in some locations at each site. The mixed canopy included native grasses and flaxes, and exotic weed species (such as willow, broom, ivory and gorse), which provided partial shading of the stream. The true left-hand bank was unstable, with active erosion and bank slumping evident. While the true right-hand side bank was dominated by man-made bank protection structures (e.g. timber and concrete flood protection/deflection structures). Adequate fish and macroinvertebrate cover was generally limited and when present was unstable and of low quality.

3.1.3 Banks Peninsula – Balguerie Stream

The Balguerie Stream site is located within the Banks Peninsula township of Akaroa. A site visit was not undertaken during the 2020 monitoring round. However, a general site description from the available ECan data is provided below.

The stream is typical of those encountered within urban areas of Bank Peninsula and is moderately impacted by the immediate residential land use bordering the stream. Introduced trees dominate the riparian area, however, a mixed (native and introduced) understory is present as well as regenerating sub canopy and canopy native species. The stream is a mix of pool, run and riffle-chute type habitat in the upper areas and the streambed is dominated by boulder and cobble substrate.

3.2 Water quality

Water temperatures were cool, dissolved oxygen saturation levels were moderate and pH levels were circum-neutral across all monitored sites (Table 3.1). All water quality parameters measured were at typical levels for urban Canterbury streams and generally at an adequate level for sustaining aquatic life.

DO (% saturation levels) recorded at the time of the site visit did not meet the CSNDC attribute targets for both the Styx River and Cashmere stream (Table 3.1). While pH levels were within the specified CSNDC ranges and water temperature met the CSNDC attribute target level (Table 3.1).

Table 3.1: Water quality data for the Styx River and Cashmere Stream sites

Site	Time and date sampled	Parameter	Value	Water quality target
STYX 14	30/04/2020 at 0815	Dissolved oxygen (%)	67	≥70
		Temperature (°C)	12.0	≤20
		pH	6.67	Lower: 6.5; Upper: 8.5
		Conductivity (µS/cm)	89.4	-
Heath 27	30/04/2020 at 1128	Dissolved oxygen (%)	69	90
		Temperature (°C)	13	≤20
		pH	6.8	Lower: 6.5; Upper: 8.5
		Conductivity (µS/cm)	177	-
Heath 28	30/04/2020 at 1257	Dissolved oxygen (%)	69	90
		Temperature (°C)	13.7	≤20
		pH	7.2	Lower: 6.5; Upper: 8.5
		Conductivity (µS/cm)	181	-

Note: Underlined values do not meet the respective water quality target.

Water quality results from the Styx River were similar to those found in previous years (Instream, 2018 and 2019). However, DO (% saturation) was markedly lower in 2020 (67%) when compared with 2019 (86%). Likewise, this result was lower than the 2018 median value of 78.5% recorded at the Styx River Main North Road site located approximately 1 km downstream (Noakes & Marshall 2019). More detailed water quality data for the Styx River can be found in the annual water quality monitoring report of Noakes & Marshall (2019), which summarises results of monthly sampling at multiple locations throughout the Styx River catchment.

No water quality data are available for the Balguerie Stream site.

3.3 Habitat

The 2020 monitoring results for instream habitat, and cover of both macrophytes and periphyton are summarised below. Site images for the Styx River and Cashmere Stream sites are attached in Appendix C.

3.3.1 Styx River – STYX 14

The sampling site was of moderate water depth (average depth of 65 cm), with a silt/sand/gravel bed and moderate water velocity (average of 0.3 m/s). The site mainly comprised run habitat (80%), with some small pools and backwaters present (10% of the reach respectively).

Regarding the CSNDC attribute targets, the results show that:

- Fine sediment cover(<2 mm diameter) was 49% in 2020, which exceeds the CSNDC waterway attribute target of 20% (Table 3.2 and Figure 3-1)
- No long filamentous algae (>2 cm) was recorded in 2020 (Table 3.2 and Figure 3-10
- Total macrophyte cover was 28%, which meets the CSNDC waterway attribute target of 50% (Table 3.2 and Figure 3-2).

Overall periphyton cover was marginal (ranging from an average cover of 5-11% across each transect) and was predominantly thin mat forming algae (≤ 0.5 mm thick). Organic matter cover was variable (ranging from an average cover of 8 - 20% across each transect) and included a mix of leaf litter, coarse woody debris, and larger stick debris. Average emergent macrophyte cover was 7%, which complied with the LWRP freshwater outcome of 30% cover (Figure 3-2). Macrophyte cover was dominated by water buttercup (*Ranunculus Linnaeus*), and less cover by species including Elodea, creeping bent (*Agrostis stolonifera*) and grass.

No significant increasing or decreasing trend was detected for three of the habitat variables tested (P>0.050; Appendix D, Table 1). A weak increasing trend was detected for fine sediment cover (P=0.054). This trend was likely influenced by two low values (i.e. in 2014 and 2018) that are followed by a return to substantially higher values and the considerable variation in the data generally. This result does not suggest a meaningful pattern through time and does not indicate a decline in ecosystem health that could be attributed to stormwater discharges (Figure 3-1).

3.3.2 Cashmere Stream – Heath 27 and Heath 28

The Heath 27 and Heath 28 sampling sites were of moderately shallow water depth (average depth of 36 cm and 35 cm, respectively). Substrate comprised of a silt/sand and gravel bed for Heath 27 and a silt/sand bed with sporadic patches of gravel and pebbles at Heath 28. Water velocity within these sites was moderate to low (average of 0.4 m/s for Heath 27 and 0.2 m/s for Heath 28). Both sites mainly comprised of run habitat (90-95%), with some small pool and backwater habitats (5% and 10% of the reach respectively).

Regarding the CSNDC attribute targets, the results show that:

- Fine sediment cover (<2 mm diameter) was 45% for Heath 27 and 95% for Heath 28 in 2020, exceeding the CSNDC waterway attribute target of 20% (Table 3.2).
- Bed cover of long filamentous algae (>2 cm long) was 9.5% for Heath 27, while no cover was evident for Heath 28, which meets the CSNDC waterway attribute target of 30% (Table 3.2).
- Total macrophyte cover was 36 and 35% for Heath 27 and Heath 28 respectively, which exceeds the CSNDC waterway attribute target of 30% (Table 3.2).

No emergent macrophyte cover was evident for Heath 27, while for Heath 28 cover was 15%, complying with the LWRP freshwater outcome of 30% cover (Table 3.2).

Curly-leaf pondweed (*Potamogeton crispus*), and Elodea were dominant macrophyte species within the reach, though water buttercup (*Ranunculus Linnaeus*), creeping bent (*Agrostis stolonifera)*, and grass were also present.

Overall periphyton cover was low across both sites and ranged from an average transect cover of 4 - 11% at Heath 27, and 0 - 2% at Heath 28. Periphyton cover was predominantly thin and medium mat forming algae (0.5 – 3.00 mm thick). Organic matter cover was variable and ranged from an average transect cover of 14 – 36% at Heath 27 and 16 - 24% at Heath 28. Organic matter included a mix of macrophyte root, leaf litter, coarse woody debris and larger sticks and branches.

Table 3.2: 2020 instream habitat monitoring results - Styx River and Cashmere Stream sites

	Site name	Maximum Fine sediment (< 2 mm diameter)	Maximum Total Macrophyte Cover of Streambed	Emergent macrophyte cover (LWRP freshwater outcome)	Maximum Filamentous algae (>2 cm long)
Consent target	Styx River	20%	50%	30%	30%
2020 Result	STYX 14	49%	28%	7%	0%
Consent target	Cashmere Stream	20%	30%	30%	20%
2020 Result	Heath 27	45%	36%	0%	9.5%
	Heath 28	95%	35%	15%	0%

Note: Underlined values do not meet the respective CSNDC attribute target.

3.3.3 Balguerie Stream – SQ00170

The ECan data from 2000-2019 shows that the Balguerie Stream site is relatively shallow, ranging in depth from 0.015-0.24 m, with a substrate composed of a mix of boulders, cobbles, gravels and pebbles. The site had a range of water velocity types, including riffles, runs, chutes and small rock drops, pools and backwaters.

Regarding the CSNDC attribute targets, the results show that:

- Fine sediment cover (<2 mm diameter) was 10% in 2019/2020, which meets the CSNDC waterway attribute target of 20% (Figure 3-3**,** Table 3.3).
- No long filamentous algae (>2 cm long), emergent and total macrophytes were recorded during the 2019/2020 monitoring round (Table 3.3**,** Figure 3-4).

Fine sediment cover has varied through time and in the last five years scoring of this habitat parameter has remained less than the CSNDC water quality attribute target (Figure 3-3). Over the length of the monitoring record, fine sediment cover has historically exceeded the CSNDC waterway attribute target on multiple occasions (Figure 3-3). However, no statistically significant trend was evident for fine sediment cover at this site overtime (Table 2, P>0.05).

A statistically significant decrease in emergent and total macrophyte cover was detected (Appendix D, Table 2, P<0.05) for Balguerie Stream. However, it should be noted that the time series data shows that macrophyte cover (both emergent and total) has consistently been at 0% from 2008 onwards, therefore, the identified trend is being skewed by historical results that showed some variability and sporadic increases in macrophyte cover (Figure 3-4). This statistically significant result does not suggest a meaningful pattern through time and does not indicate a decline in ecosystem health that could be attributed to stormwater discharges.

No significant increasing or decreasing trends were detected for the remaining habitat variables tested at Balguerie Stream (Table 2, P>0.05).

Table 3.3: 2019/2020 instream habitat monitoring results for the Balguerie Stream

	Site name	Maximum Fine sediment (< 2 mm diameter)	Maximum Total Macrophyte Cover of Streambed	Emergent macrophyte cover (LWRP freshwater outcome)	Maximum Filamentous algae
Consent target	Balguerie Stream	20%	30%	30%	20%
	SQ00170	7.5%	0%	0%	0%

Note: Underlined values do not meet the respective CSNDC attribute target.

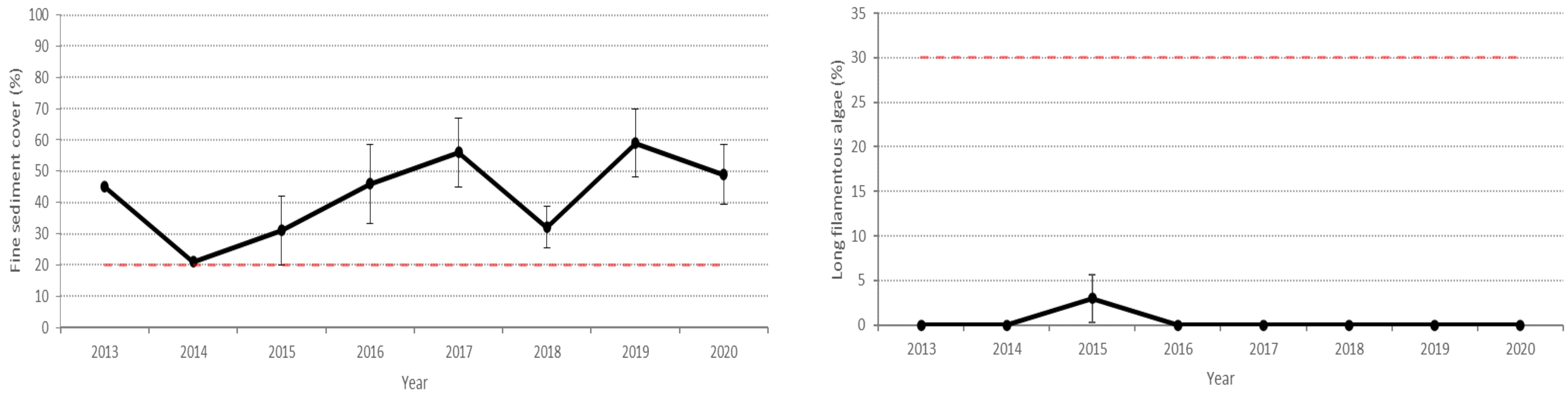

Figure 3-1: Styx River, STYX 14. Average bed cover with fine sediment (left) and average long filamentous algae (right). Dashed red lines indicate the CSNDC attribute target of 20% fine sediment cover and 30% long filamentous algae cover.

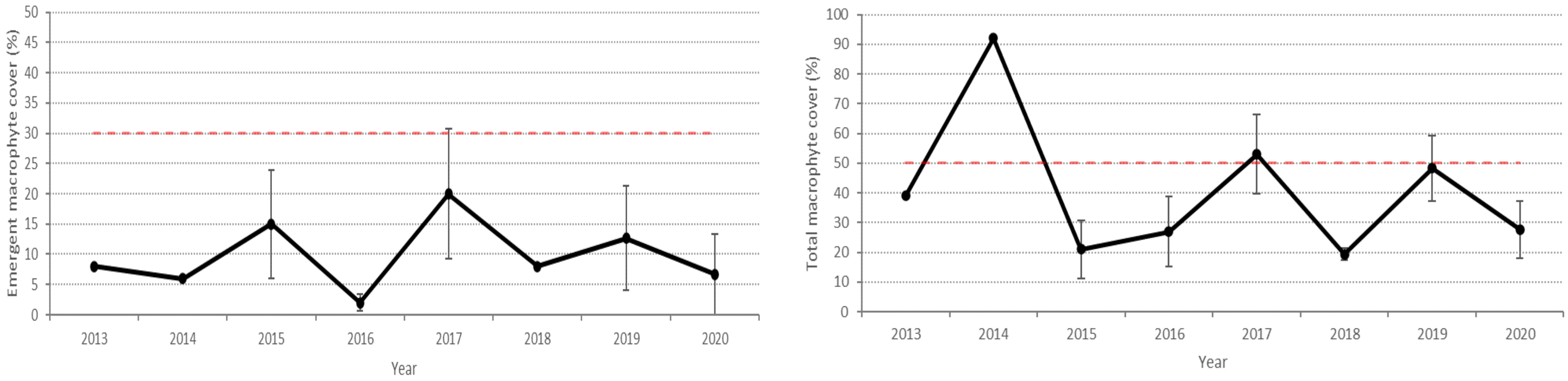

Figure 3-2: Styx River, STYX 14. Average bed cover with emergent macrophytes (left) and total macrophytes (right). Dashed lines indicate the LWRP outcome of 30% cover for emergent macrophytes and the CSNDC attribute target of 50% cover for total macrophytes. Note that the 2013 and 2014 data points are represented by a single reach observation and not the average of transect observations.

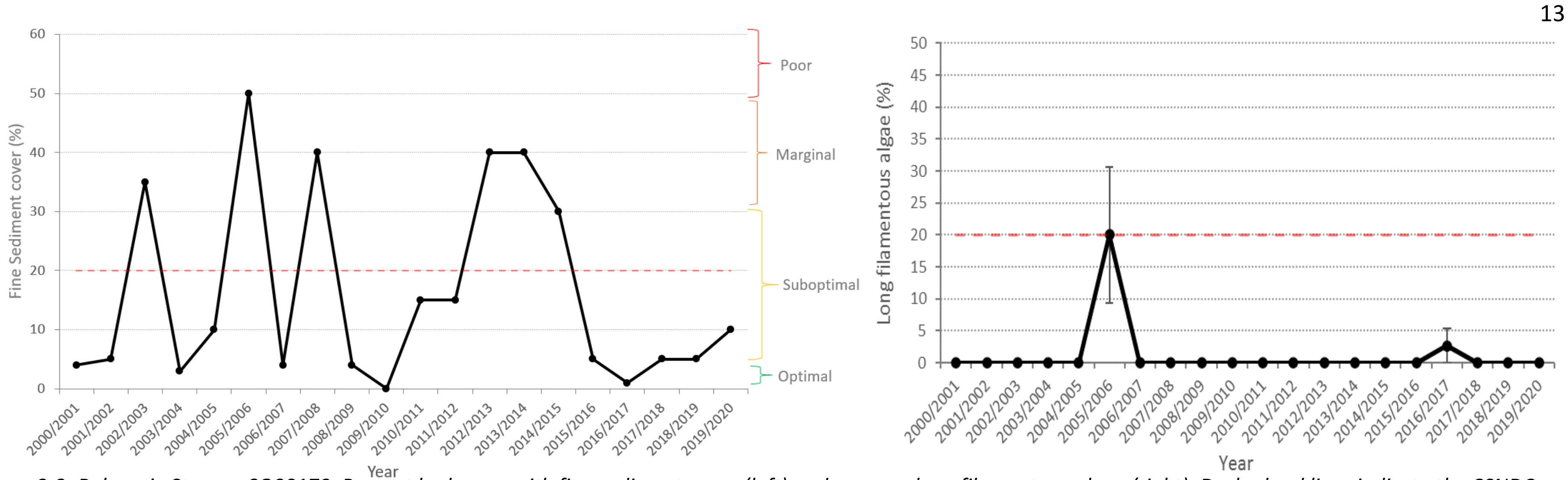

Figure 3-3: Balguerie Stream, SQ00170. Percent bed cover with fine sediment cover (left) and average long filamentous algae (right). Dashed red lines indicate the CSNDC attribute target of 20% fine sediment cover and 20% long filamentous algae cover. Note: the labels on the secondary axis correspond to the ECan RHA habitat score.

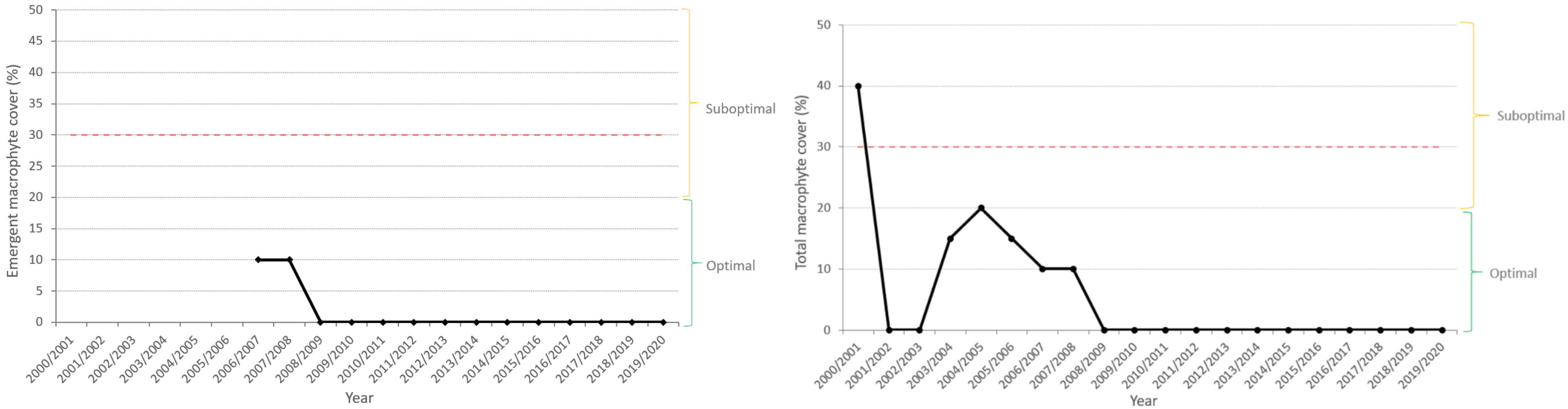

Figure 3-4: Balguerie Stream, Site SQ00170. Percent bed cover with emergent macrophytes (left) and total macrophytes (right). Dashed lines indicate the LWRP outcome of 30% cover for emergent macrophytes and the CSNDC attribute target of 30% cover for total macrophytes. Note: the labels on the secondary axis correspond to the ECan RHA habitat score.

3.4 Macroinvertebrates

3.4.1 Styx River – STYX 14

A total of 21 taxa, including 8 EPT taxa, were collected from the annual monitoring site in 2020, which is similar to values recorded in previous years (Figure 3-5). EPT abundance was 42% in 2020, which was an increase in value from the previous year but within the range of values recorded historically (Figure 3-5). The macroinvertebrate community includes a moderate number of pollution-sensitive taxa and community composition was indicative of fair quality. In 2020, the annual monitoring site recorded a QMCI of 4.8 which is similar to and a slight increase from the QMCI recorded in 2019, though below the CSNDC attribute target (Figure 3-5). Over the last seven years, QMCI have remained in the range of 4 to 5, which is indicative of “fair” quality (Stark & Maxted 2007 (Figure 3-5)).

Mann-Kendall trend testing showed a statistically significant decrease in taxa richness throughout the monitoring period (P=0.043, Appendix D; Table 1), though this was likely influenced by a single high value in 2013, and so unlikely to be a meaningful pattern (Figure 3-5). None of the other invertebrate community indices indicated a significant increasing or decreasing trend over the seven year monitoring period (P<0.05, Appendix D; Table 1). Therefore, the trend analysis results do not indicate a decline in ecosystem health that could be attributed to stormwater discharges.

3.4.2 Cashmere Stream – Heath 27 and Heath 28

For the two Cashmere Stream sites, a total of 21 taxa, including 7 EPT taxa, were collected from the annual monitoring in 2020. EPT abundance was 19% and 9% for these sites respectively (Table 3.4). The QCMI scores did not meet the CSNDC attribute target (Table 3.4).

3.4.3 Banks Peninsula - Balguerie Stream

Results for the 2019/2020 monitoring round show that there was a total of 25 taxa, including 12 EPT taxa. EPT abundance was 46% in 2019/2020, which is a further increase on previous years (Table 3.4). In the 2019/2020 annual monitoring round the QMCI score was 5.3, which is just above (i.e. complies with) the CSNDC attribute target of 5.0. Over the last ten years, QMCI scores have remained in the range of 4 to 5.5, which is indicative of “fair” and “good” quality (Stark and Maxted 2007; Table 2.5)

Mann-Kendall trend testing showed a statistically significant increase in taxa richness (P=0.020, Appendix D; Table 2) and EPT taxa (P=0.033, Appendix D; Table 2) throughout the monitoring period. These findings do not appear to be related to the reduction in fine sediment cover that were observed from 2013 onwards (Figure 3-3). Either there are some underlying changes in aquatic habitat or water quality characteristics that drove the increase in taxa richness or there may be potential bias related to the variability around species identification.

The QCMI exceeded the CSNDC attribute target in 2003, 2013, 2018 and 2019 (Figure 3-6), though no significant trend was identified during the monitoring period at this site. None of the remaining invertebrate community indices indicated a significant increase or decrease in trend over the monitoring period (P>0.05, Appendix D; Table 2).

The trend analysis results do not indicate a decline in ecosystem health that could be attributed to stormwater discharges.

Table 3.4: 2020 Invertebrate community results for each site

Stream	Site	Taxa Richness	EPT abundance (%)	EPT Taxa Richness	MCI	QMCI
Styx River	STYX 14	21	42	8	92	<u>4.8</u>
Cashmere Stream	Heath 27	21	19	7	81	<u>4.6</u>
Cashmere Stream	Heath 28	21	9	7	83	<u>4.2</u>
Balguerie Stream	SQ00170	25	46	12	111	5.3

Note: Results for Balguerie Stream are for the 2019/2020 summer season.

Both EPT abundance and taxa richness exclude the pollution tolerant Hydroptilidae species.

Underlined values do not meet the respective CSNDC attribute target.

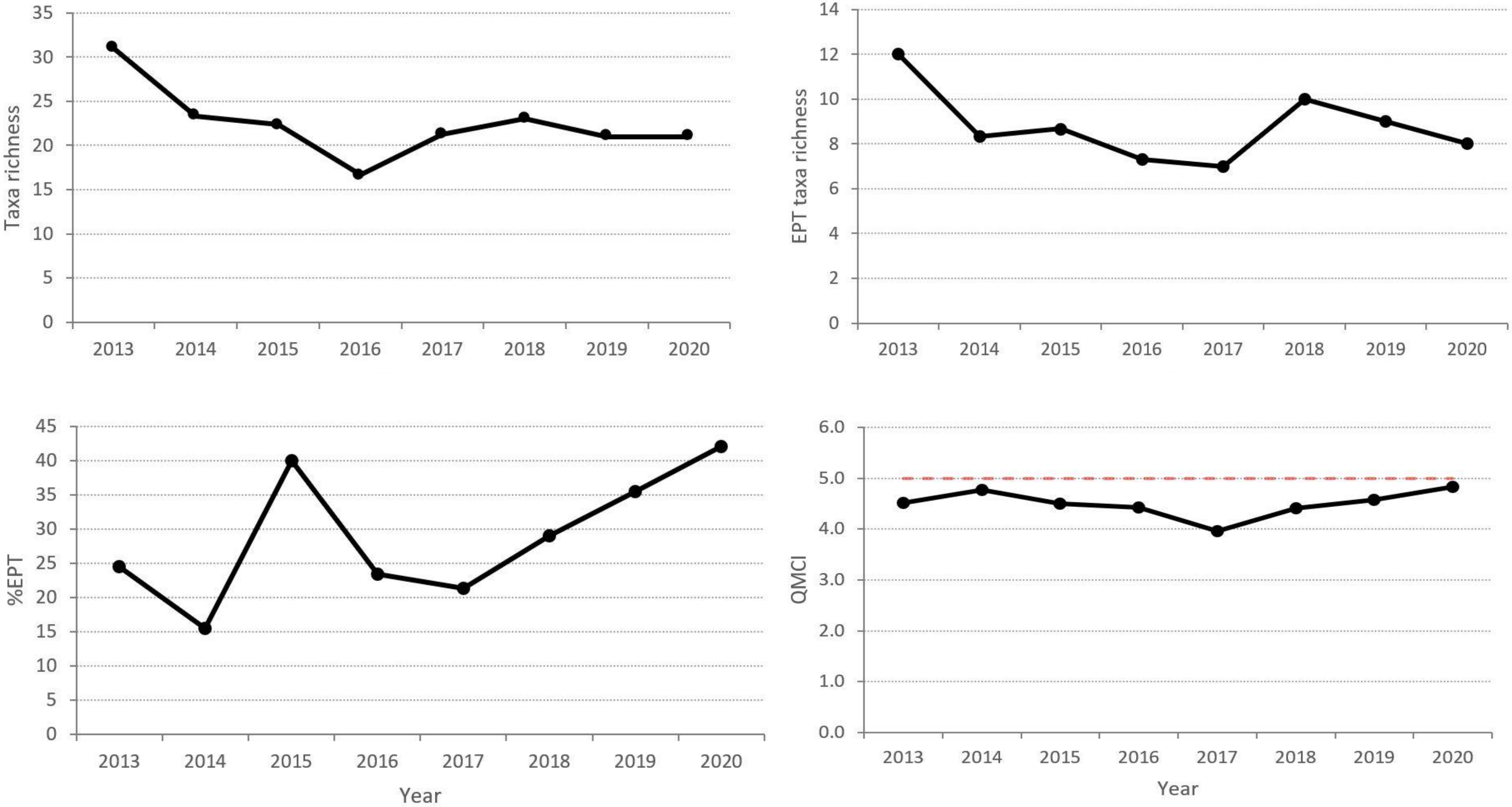

Figure 3-5: Styx River, STYX 14. Macroinvertebrate taxa richness, EPT taxa richness, percent EPT abundance, and QMCI scores. Dashed line in the QMCI plot indicates the CSNDC attribute target of a minimum of 5.0.

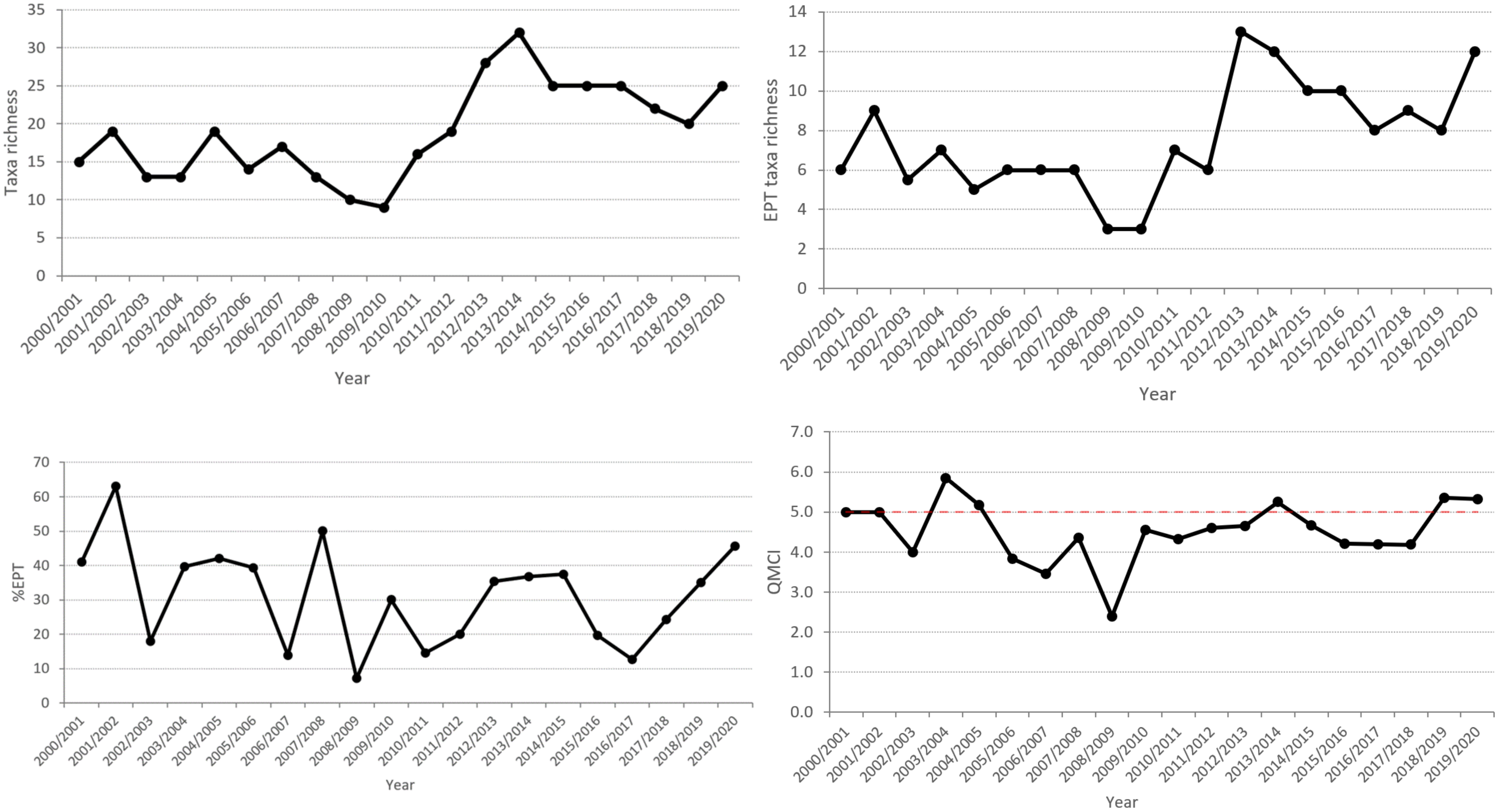

Figure 3-6: Balguerie Stream, Site SQ00170.Macroinvertebrate taxa richness, EPT taxa richness, percent EPT abundance, and QMCI scores. Dashed line in the QMCI plot indicates the CSNDC attribute target of a minimum of 5.0.

3.4.4 Macroinvertebrate community composition

The non-metric multidimensional scaling (NMDS) plot depicts the similarities /differences in the presence and abundance of the macroinvertebrate community overtime at each site. The NMDS yielded a two-dimensional solution with a stress value of 0.09 for all sites, this indicates a good representation of the similarities between sites (Clarke, 1993).

There is clear separation of the Styx River (STYX 14) macroinvertebrate community and the Heathcote River macroinvertebrate community (Heath 27 and Heath 28) mainly due to the abundance of the pollution sensitive mayfly *Deleatidium sp* and the stoney cased caddisfly *Pycnocentrodes aureolis*. Both of these species are generally more sensitive to changes in water and habitat quality.

Of interest is whether there is a shift in invertebrate composition over time that may suggest a change in the environmental conditions within the stream. Results showed that the macroinvertebrate community at STYX 14 between 2015 to 2020 remained consistent and was represented by a macroinvertebrate community dominated by a mix of pollution sensitive and tolerant species *Potamopyrgus antipodium, Pycnocentrodes aureolis, Deleatidium_sp, Oligocheata, Pycnocentria evecta, Ferrissia, Ostracoda, Paracalliope sp*. However, in 2019 and 2020 there was a slight shift which was associated with a decrease in the relative dominance of *P. antipodarum*.

The Heathcote River sites (Heath 27 and Heath 28) macroinvertebrate community were dominated by pollution tolerant taxa including *P. antipodarum, Paracalliope sp,* and *Sphaeridae sp*; and the cased caddisfly *Hudsonema sp.*

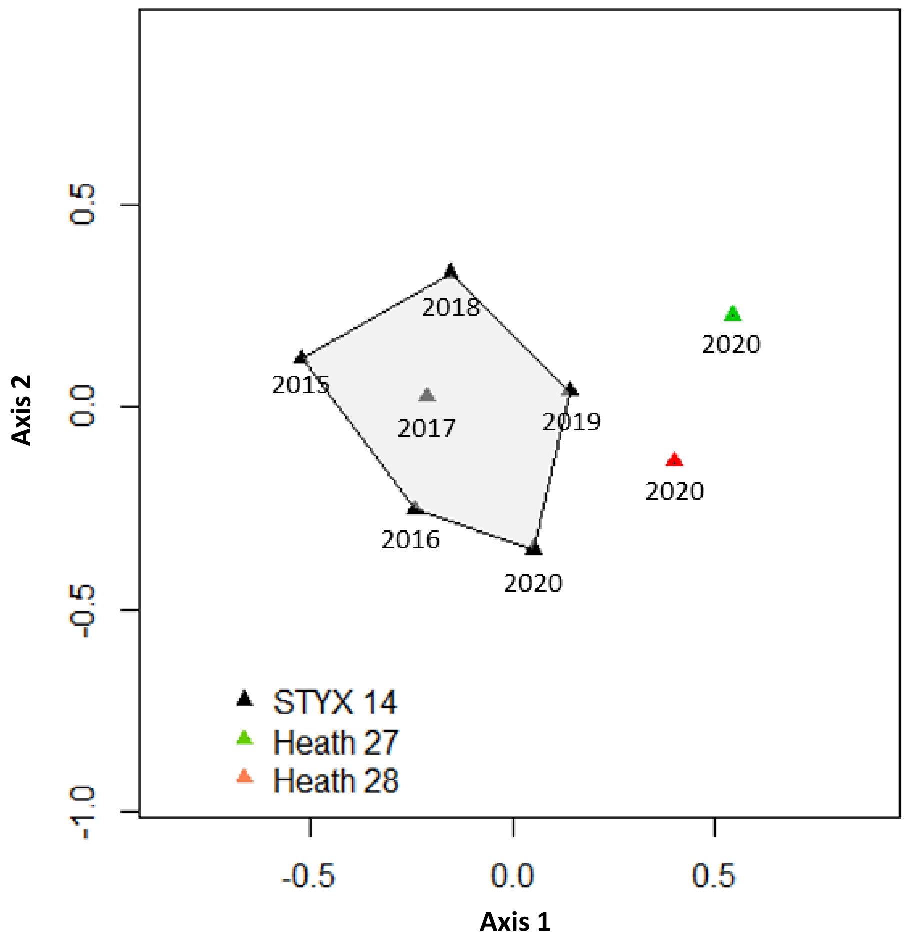

Figure 3-7: NMDS plot of macroinvertebrate communities for all sites. Sampling years are displayed below each site sample. Plot stress is 0.09.

4 Conclusion

Aquatic habitat and macroinvertebrate communities at the Styx River annual monitoring site in 2020 were comparable to previous years. The macroinvertebrate community includes a moderate number of pollution-sensitive taxa and community composition was indicative of fair quality. In 2019 and 2020 the relative abundance of *P. antipodarum* was lower, this has resulted in a slight shift in composition of the macroinvertebrate community. Most parameters complied with CSNDC water quality and instream habitat attribute target levels, with the exception of fine sediment cover, DO (% saturation) levels and a slightly lower QCMI. None of the significant trends detected in the 2020 monitoring round indicate declining ecosystem health that could be attributed to stormwater discharges.

Aquatic habitat and macroinvertebrate communities at the two Cashmere Stream sites are within the expected range for urban/rural impacted streams. The macroinvertebrate community included a moderate number of pollution-sensitive taxa, both the QCMI scores and community composition were within the expected range and variation for a sediment impacted urban/rural stream. DO (% saturation) levels recorded at the time of the site visit did not meet the CSNDC attribute targets, nor did fine sediment cover results at both sites. As this was the first year of sampling these sites it is not possible to draw any conclusions in regard to potential effects of stormwater discharges or trends. Continued annual monitoring (in line with the CSNDC consent conditions) of the water quality, instream habitat and the macroinvertebrate community will enable the sites habitat quality and ecological values, and any observable trends, to be determined.

The macroinvertebrate communities and aquatic habitat at the Balguerie Stream annual monitoring site over the 2019/2020 monitoring period were comparable to recent years. The macroinvertebrate community includes a moderate number of pollution-sensitive taxa and community composition was indicative of good quality. The significant trends observed for macroinvertebrate taxon richness (both overall and EPT specific) do not indicate a decline in ecosystem health attributed to stormwater discharges and did not appear to be linked to the decrease in fine sediment cover. The monitored parameters complied with the CSNDC instream habitat attribute target levels.

5 Recommendations

It is recommended that monitoring of the aquatic habitat and macroinvertebrate communities is continued. Annual monitoring over longer periods of time are likely to be needed before robust trend analysis can be undertaken, although this is data dependent.

Alignment of field monitoring methodologies between the CSNDC and the ECan SoE programme should be considered. Especially for those parameters that have a specific attribute targets set out in the CSNDC (e.g. fine sediment cover and macrophyte cover). If CCC are to further utilise available ECan data at a greater number of sites it is recommended that field methodologies are aligned to ensure consistency. Alternatively, a prescribed method for converting ECan RHA habitat scores to the required CSNDC percent cover should be determined.

6 References

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Stark, J. D., and Maxted, J. R. (2007). A user guide for the Macroinvertebrate Community Index. Report prepared for the Ministry of the Environment. Cawthron Report No. 1166.

7 Applicability

This report has been prepared for the exclusive use of our client Christchurch City Council, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

We understand and agree that this report will be used by Christchurch City Council in undertaking its regulatory functions in connection with the Comprehensive Stormwater Discharge Consent (CRC190445).

Tonkin & Taylor Ltd

Report prepared by:	Authorised for Tonkin & Taylor Ltd by:
....	....
Patrick Lees and Ashleigh Johnston	Dean Miller
Ecologists	Project Director

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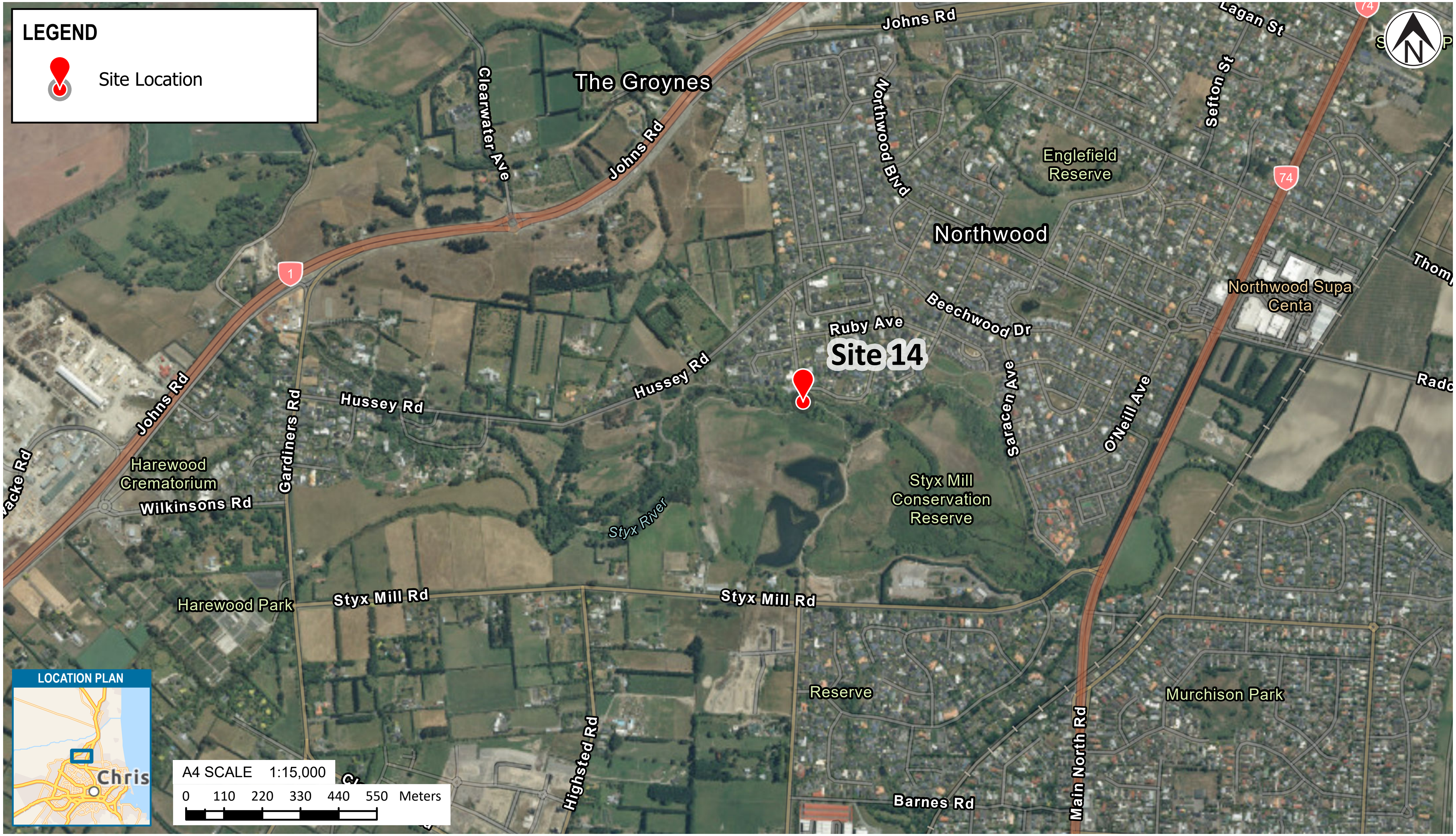
Appendix A: Monitoring Site Locations

- **Figure 7-1: CCC monitoring site location for Site 14 within Styx Mill Reserve.**
- **Figure 7-2: CCC monitoring site locations for Heath 27 and Heath 28 within the Cashmere Stream.**
- **Figure 7-3: CCC monitoring site location for SQ00170 within the Balguerie Stream, Banks Peninsula.**



C:\Users\ando\Documents\ArcGIS\Projects\CCC Sampling Sites (1013562.0000R)\CCC Sampling Sites (1013562.0000R).aprx Layout: FIG1 - Styx River 2020-Jun-02 11:21 AM Drawn by ANDO

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First version	0	ANDO

PROJECT No. 1013562.0000R

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CLIENT **CHRISTCHURCH CITY COUNCIL**
PROJECT **CCC ANNUAL AQUATIC ECOLOGY MONITORING**
TITLE STYX RIVER
SCALE (A4) 1:15,000
FIG No. FIGURE 7 .1
REV 0

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CLIENT **CHRISTCHURCH CITY COUNCIL**
PROJECT **CCC ANNUAL AQUATIC ECOLOGY MONITORING**
TITLE CASHMERE STREAM
SCALE (A4) 1:18,000 FIG No. FIGURE 7.2 REV 0

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CLIENT CHRISTCHURCH CITY COUNCIL
PROJECT CCC ANNUAL AQUATIC ECOLOGY MONITORING
TITLE BALGUERIE STREAM
SCALE (A4) 1:15,000 **FIG No.** FIGURE 7 .3 **REV** 0

Appendix B: ECan Habitat Assessment Field Sheet

Data entered to DB?BY:

Habitat Assessment

Stream Name:_____________________ **Photo No.** ________ **Number of pottles:** _____

Site No. _____________ **Sample No.** ___________ **Date:** _____________ **Weather:** _________________

Water colour: (0) clear (1) brown/yellow (2) green (3) milky/grey **Water Clarity:** (1) clear (2) opaque (3) turbid

Catchment Scale Features **Easting**_________________ **Northing**__________________ **Temp**________ **Cond**________

Habitat Parameter	**Category**			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
18. Broad scale catchment landuse upstream – affecting stream inputs	Undisturbed native vegetation – forest, scrub or tussock	Disturbed native vegetation and/or exotic forest and/or low intensity grazing	moderate intensity pastoral landuse or low impact horticulture	Intensive pastoral landuse (dairy/deer) to intensive horticulture, urban/industrial
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1

Habitat Parameter	**Category**			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
Immediate landuse beyond the riparian zone at site	Undisturbed native vegetation – forest, scrub or tussock	Disturbed native vegetation and/or exotic forest and/or low intensity grazing	moderate intensity pastoral landuse or low impact horticulture	Intensive pastoral landuse (dairy/deer) to intensive horticulture, urban/industrial
19 SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1
20 SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1

Riparian and Bank Features

Habitat Parameter	**Category**			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
Width of natural Riparian Vegetative Zone to nearest human influenced landuse (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
21 SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1
22 SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1

Habitat Parameter	**Category**			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
Riparian vegetation type (score each bank riparian zone)	Dominant vegetation type is undisturbed native shrub or forest with understory, wetland vegetation, tall tussock grasses	Dominant vegetation type is introduced trees (willow, poplar, conifers), and/or mixed scrub with some loss of under story	Relatively ungrazed or unmanaged exotic grasses, scrub, rocks, gravel etc.	Highly grazed or mown surfaces, pasture grasses and weeds, through to bare ground, roads, buildings
23 SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1
24 SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1

Data entered to DB?BY:

Habitat Parameter	Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
Completeness of Riparian vegetation cover between stream and adjacent landuse	Riparian vegetation provides complete ground cover with no appreciable breaks or tracks	Occasional breaks or scars in vegetation cover (1-5 in reach)	Breaks in vegetation cover common (6-10+), some active erosion evident.	Vegetation sporadic through to bare land/active erosion
25 SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1
26 SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1

Habitat Parameter	Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
27 SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1
28 SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1

Reach Scale Parameters

Habitat Parameter	Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
29. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1

Habitat Parameter	Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
30. Frequency of Riffles (or bends) / Velocity-Depth Combinations	Great diversity of channel widths and depths forming a series of riffles, runs and pools; large variation in velocity throughout the stream (all 4 velocity/depth patterns present)	Little diversity in channel width, good diversity in stream depth, velocity still variable throughout stream. (3 velocity/depth patters present).	Little diversity in channel width and depth, velocity within channel only slightly variable. (2 velocity/depth patterns present)	No change in both channel width and depth, constant velocity throughout channel (or no velocity).
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1

Data entered to DB?BY:

Habitat Parameter	Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
31. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.	The bends in the stream increase the stream length 2 to 3 times longer than if it was in a straight line.	The bends in the stream increase the stream length 2 to 1 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long distance.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1

Habitat Parameter	Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
32. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills 75-50% of the available channel; or <50% of channel substrate is exposed.	Water fills 25-50% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1

Instream habitat quality parameters

Habitat Parameter	Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
33. Instream habitat/ Roughness - Cover for instream fauna.	Greater than 70% of substrate favourable for faunal cover/ utilisation and fish cover – mixture of cobble, boulder, snags, undercut banks etc.	40-70% cover of suitable habitat including cobbles, boulders logs and snags	Only 20-40% cover is suitable habitat – habitat dominated by fine or unstable sediments, lack of instream cover features	Little stable cover or habitat, substrate open, fine, unstable.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1

Habitat Parameter	Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
34. Substrate heterogeneity and quality	Wide range of substrate sizes (<4), of angular nature and well packed, no size class > 50%. Bedrock, Boulder (>25), Large cobbles (12-25), Small cobbles (6-12), Gravel (0.5-6), Sand (<0.5), mud/silt.	3-4 size classes, some interstitial spaces filled with silt, no size class > 50%.	2-3 size classes, interstitial spaces rare, usually dominated by > 50% one class	One or two cobble sizes dominate substrate, cobbles more rounded and loser packing, interstitial spaces rare
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1

Habitat Parameter	Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
35 Embeddedness/Siltation	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment. 5 10 15 20 25%	Gravel, cobble, and boulder particles are 30-50% surrounded by fine sediment. 30 35 40 45 50 %	Gravel, cobble, and boulder particles are 55-75% surrounded by fine sediment. 55 60 65 70 75 %	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment. 80 85 90 95 100 %
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1

Data entered to DB?BY:

Habitat Parameter	Category			
	Optimal	Suboptimal	Marginal	Poor
36. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1

Habitat Parameter	Category			
	Optimal	Suboptimal	Marginal	Poor
38. Emerged Macrophyte presence	Rooted macrophytes largely absent (less 20 %) – stony substrate with periphyton or moss/bryophytes, not obstructing flow patterns	Small areas of rooted emerged macrophytes (20 to <50%) in flowing channel, not obstructing flow patterns	Significant (≥50 – 80 %) of bed or channel affected by emergent macrophytes on edges, reducing water velocities in places	Emerged macrophytes dominate channel and clogging waterway, 80 – 100%
SCORE ___	10 9	8 7 6	5 4 3	2 1

Habitat Parameter	Category			
	Optimal	Suboptimal	Marginal	Poor
39. Submerged Macrophyte presence	Rooted macrophytes largely absent (less 20%) – stony substrate with periphyton or moss/bryophytes, not obstructing flow patterns	Small areas of rooted submerged macrophytes (20 to <50%) in flowing channel, not obstructing flow patterns	Significant (≥50 – 80%) of bed or channel affected by submerged macrophytes in channel reducing water velocities in places	Submerged macrophytes dominate channel and clogging waterway, 80 – 100%
SCORE ___	10 9	8 7 6	5 4 3	2 1

Data entered to DB?BY:

Periphyton (on exposed surfaces)	**Run 1**					**Run 2**					**Run 3**				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
1.Thin mat/film (< 0.5mm thick): Green															
2 Light brown															
3 Black/dark brown															
4. Medium mat (0.5-3mm thick): Green															
5 Light brown															
6 Black/dark brown															
7. Thick mat (> 3mm thick): Green															
8 Light brown															
9 Black/dark brown															
10. Filaments, short (<2cm long): Green															
11 Brown/reddish															
12. Filaments, long (≥2cm long): Green															
13 Brown/reddish															
14 **No Periphyton**															

Widths and depths

	T1	**T2**	**T3**	**T4**	**T5**
Width					
Depth 1					
Depth 2					
Depth 3					
Depth 4					
Depth 5					

Hazards

Anything that future samplers should be aware of. (e.g. dogs, stock in paddock, land owners, electric fences etc)

Type	**Description/Location**	**How to avoid in future?**

Data entered to DB?BY:

Site map & Comment (include any obvious features that will help future samplers find the correct site)

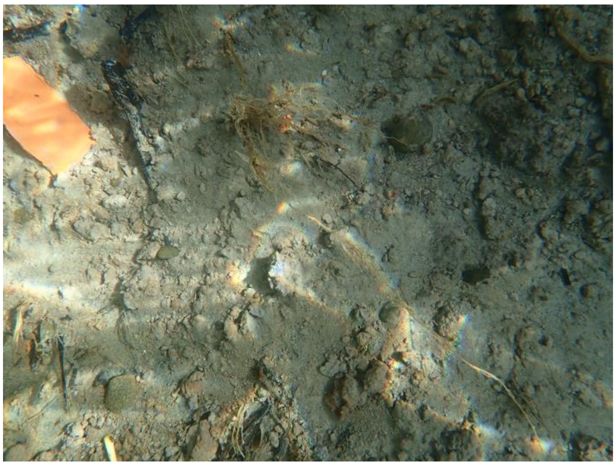
Check list

Sample labelled with date, site number and name, sample number, E and N and pottles numbered correctly? ☐
Photos taken up and downstream and wide-angle location? ☐
Site info including observations, changes to site details or location, additional directions? ☐

Appendix C: Site Photographs from 2020

Styx Mill Reserve	
 *Photograph.C1: Styx Mill Reserve. Upstream end of the monitoring reach, looking downstream.*	 *Photograph C2: Styx Mill Reserve. Downstream end of the monitoring reach, looking upstream.*
 *Photograph C3: Styx Mill Reserve, instream habitat images, showing macrophyte abundance.*	 *Photograph C4: Styx Mill Reserve, instream habitat images, showing streambed sediment, cobble and debris cover.*

Cashmere Stream – Heath 27	
	
Photograph C5: Cashmere Stream – Heath 27. Upstream end of the monitoring reach, looking downstream.	*Photograph C6: Cashmere Stream - Heath 27 Downstream end of the monitoring reach, looking upstream.*
	
Photograph C7: Cashmere Stream - Heath 27. Instream habitat images, showing macrophyte abundance.	*Photograph C8: Cashmere Stream - Heath 27. Instream habitat images, showing streambed sediment, cobble, debris and scattered macrophyte cover.*

Cashmere Stream – Heath 28	
 *Photograph C9: Cashmere Stream – Heath 28. Upstream end of the monitoring reach, looking downstream.*	 *Photograph C10: Cashmere Stream – Heath 28. Downstream end of the monitoring reach, looking upstream.*
 *Photograph C11: Cashmere Stream – Heath 28. instream habitat images, showing macrophyte abundance.*	 *Photograph C12: Cashmere Stream - Heath 28. Instream habitat images, showing sediment, pebble, and debris cover.*

Appendix D: Summary Results of Statistical Tests

Mann-Kendall trend test results for habitat and invertebrate variables for the Styx River. These results statistically test trends over time and use data for all eight monitoring years (2013-2020). Two weak, but statistically significant trends were detected (P<0.05)[1].

Table 1: Mann-Kendall trend test results for habitat and invertebrate variables for the Styx River

Variable	Median value	Kendall statistic	Z	P-value	Percent annual change
Fine Sediment Cover	46	14	1.608	0.054	6.044
Long filamentous algae cover	0	-3	-0.436	0.406	0
Emergent macrophyte cover	8	3	0.249	0.406	11.111
Total macrophyte cover	33	-4	-0.371	0.360	-4.401
Taxa richness	22	-15	-1.745	**0.043**	-2.253
EPT taxa richness	9	-6	-0.619	0.274	-4.118
Percent EPT	27	12	1.361	0.089	11.52
QMCI	4.5	0	0	0.548	0.062

Table note: Values in **Bold** indicate P-values that are considered statistically significant.

[1] Only eight years of monitoring data has been used to assess trends, therefor there is a level of uncertainty to the results Generally, the more data points available for a site, the more statistical power for detecting a trend. Trend calculations should be undertaken on the longer time series data to reduce this uncertainty.

Table 2: Mann-Kendall trend test results for habitat and invertebrate variables for the Balguerie Stream

Variable	Median value	Kendall statistic	Z	P-value	Percent annual change
Fine Sediment Cover*	7.5	4	0.098	0.922	0.000
Long filamentous algae cover	0	3	0.126	0.900	0.000
Emergent macrophyte cover*	0	-24	-2.100	**0.035**	0.000
Total macrophyte cover*	5	-75	-2.986	**0.003**	0.000
Taxa richness	19	72	2.323	**0.020**	2.821
EPT taxa richness	7	66	2.134	**0.033**	2.857
Percent EPT	35	-30	-0.941	0.347	-0.947
QMCI	4.6	11	0.325	0.745	0.291

Table note: Values in **Bold** indicate P-values that are considered statistically significant.

Habitat variables with a * have had the ECan RHA habitat score transferred to a percentage scale.