Monitoring of the Phased Implementation of the Manuherekia Catchment Management Plan

November 2024 – March 2025

Prepared for:

Manuherekia Catchment Group

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Table of Contents

1. Introduction ... 1
1.1. Purpose ... 2
2. Methods ... 3
2.1. Monitoring sites ... 3
2.2. Flow conditions ... 5
2.3. Periphyton ... 6
2.4. Macroinvertebrate community ... 6
3. Results & Discussion ... 7
3.1. Periphyton ... 7
3.1.1. Antecedent flows ... 7
3.1.2. Community composition ... 10
3.1.3. Periphyton biomass ... 19
3.2. Macroinvertebrates ... 23
3.2.1. Macroinvertebrate community composition ... 23
3.2.2. Macroinvertebrate indices ... 27
4. Summary & Conclusions ... 30
4.1. Periphyton ... 30
4.2. Macroinvertebrates ... 32
4.3. Overall conclusions ... 33
5. References ... 34
Appendix A ... 35
Appendix B ... 38
Appendix C ... 41

1. Introduction

The Manuherekia Catchment Group (MCG) started the phased implementation of the Catchment Management Plan (CMP) developed by the late Matt Hickey of Water Resource Management as part of preparations for the reconsenting of deemed permits and the minimum flow setting process in the Manuherekia catchment. The purpose of the CMP was to manage the Manuherekia catchment as a whole, by establishing residual flows to provide for in-stream values in tributaries and to contribute to the minimum flow at the Campground minimum flow site near Alexandra and ensuring that flows are sufficient to provide for in-stream values along the length of the Manuherekia River itself.

The CMP breaks the catchment down into three catchment flow management zones – Above Falls Dam, Manuherekia and Ida Valley Management Zones. The Manuherekia Management Zone is further broken down into five Tributary Water Management Zones – Dunstan Creek, Lauder Creek, Thomson Creek, Chatto Creek and Manor Burn. The CMP sets out minimum[1] or residual[2] flows at four sites on the mainstem of the Manuherekia River (Tier 1 flow restrictions):

- 720 l/s residual flow at below Falls Dam
- 500 l/s residual flow at OAIC's intake
- 820 l/s minimum flow at Ophir
- 1,100 l/s minimum flow at Campground

Further to the mainstem minimum/residual flows on the mainstem, tributary residual flows measured in the tributary just upstream of the confluence with the Manuherekia apply to all water permits in the tributary catchment (Tier 2 flow restrictions):

- 250 l/s residual flow from Dunstan Creek
- 100 l/s residual flow from Lauder Creek
- 70 l/s residual flow from Thomsons Creek
- 100 l/s residual flow from Chatto Creek
- 15 l/s residual flow from the Lower Manorburn Dam

Site specific residual flows applied to individual water permits to maintain instream values immediately downstream of the point of take (Tier 3 flow restrictions).

These three tiers of flow restrictions would be applied in the Water Management Zones as follows:

1) Above Falls Dam Management Zone – all water permits would have tier 1 and tier 3 flow restrictions applied.
2) Manuherekia Management Zone – all water permits with points of take from the main stem would have the tier 1 minimum flow at Campground applied and all water permits in the Tributaries Management Zones would have the tier 1 minimum flows applied, tier 2 tributary residual flows applied, and any tier 3 site specific residual flow applied.
3) Ida Valley Management Zone – water permits in the Ida Valley would only be subject to tier 3 flow restrictions[3].

The CMP was partially implemented in the 2024/25 season.

[1] A minimum flow applies at a flow monitoring location within a catchment and all water users subject to that minimum flow must cease taking water (except stock drinking water and essential domestic water) when flows drop below the minimum flow at that flow monitoring flow. Minimum flows are set as part of a regional planning process.

[2] Residual flows apply to individual consent(s) and is a flow to be maintained immediately downstream of a point of take. Residual flows are set as part of a consenting process.

[3] The Ida Valley has a dry climate and its natural discharge to the Manuherekia River during low flow periods is small. Most of the water that is used for irrigation is stored in the Poolburn and Upper Manorburn Dams that are filled during the previous years of winter and spring snow melt inflows. Hence tier 1 minimum flow limits would not be applied.

The Otago Regional Council (ORC) undertakes monthly surveys of periphyton and habitat conditions at four sites in the Manuherekia catchment as part of its State of the Environment (SOE) monitoring programme. In addition to these long-term biomonitoring sites, a further ten sites were surveyed each month between November 2024 and March 2025 to broaden the coverage of periphyton and macroinvertebrate sampling during the phased implementation of CMP (see Section 2.1). This survey included sites that were located upstream of major irrigation off-takes as reference sites (or control sites) to provide an indication of the state of periphyton and macroinvertebrate communities at sites that were upstream of (and therefore unaffected by) water abstraction. The data collected from these reference sites assist in the interpretation of the results of monitoring at sites downstream of irrigation takes.

1.1. Purpose

The purpose of this report is to present the results of ecological monitoring undertaken at sites in the Manuherekia catchment on four occasions between November 2024 and March 2025 and to compare the results of this monitoring to the results of long-term monitoring results to assess the ecological state of waterways in the Manuherekia catchment during the phased implementation of the CMP.

2. Methods

2.1. Monitoring sites

Periphyton was surveyed at ten sites in the Manuherekia catchment on four occasions between December 2024 and March 2025 (Table 1; Figure 1). Of these survey sites, four were located upstream of major irrigation off-takes, for use as reference (or control) sites (marked in blue in Table 1). These sites provide an indication of the state of periphyton and macroinvertebrate communities at sites that were unaffected by water abstraction. The data collected from these reference sites assist in the interpretation of the results of monitoring at sites downstream of irrigation takes.

Further to the sites surveyed, data collected from the four additional long-term biomonitoring sites was requested from Otago Regional Council and is included in this analysis. These long-term sites are sampled on a monthly basis by ORC as part of its SOE monitoring programme (marked in green in Table 1 and Figure 1).

Table 1 Location of low flow survey sites in the Manuherekia catchment. ORC biomonitoring sites are highlighted in green and reference sites are highlighted in blue.

Management Zone	Site name	Site type	NZTM		Monitoring	
			Easting	Northing	Periphyton	Macroinverts
Manuherekia	Upper Manuherekia at ds Forks	Control site	1355169	5038916	Y	Y
	Manuherekia at Blackstone	ORC SOE	1346627	5014356	Y	Y
	Manuherekia at Ophir	ORC SOE	1331771	4999074	Y	Y
	Manuherekia downstream of MICSL intake	Impact site	1328841	4997133	Y	Y
	Manuherekia at Galloway	ORC SOE	1319841	4986021	Y	Y
Dunstan Creek	Dunstan Creek at Gorge	Control site	1344649	5033051	Y	Y
	Dunstan Creek at Loop Road	Impact site	1346596	5025913	Y	Y
	Dunstan Creek at Beattie Road	ORC SOE	1344762	5018627	Y	Y
	Dunstan Creek at Confluence	Impact site	1344625	5012983	Y	Y
Lauder Creek	Lauder Creek at Cattleyards	Control site	1332170	5016412	Y	Y
	Lauder Creek at Rail Trail	Impact site	1339006	5006366	Y	Y
Thomsons Creek	Thomsons Creek at race	Control site	1329190	5012712	Y	Y
	Thomsons Creek upstream of Sluice Channel	Impact site	1331173	5000428	Y	Y
Chatto Creek	Chatto Creek at confluence	Impact site	1325194	4992109	Y	Y

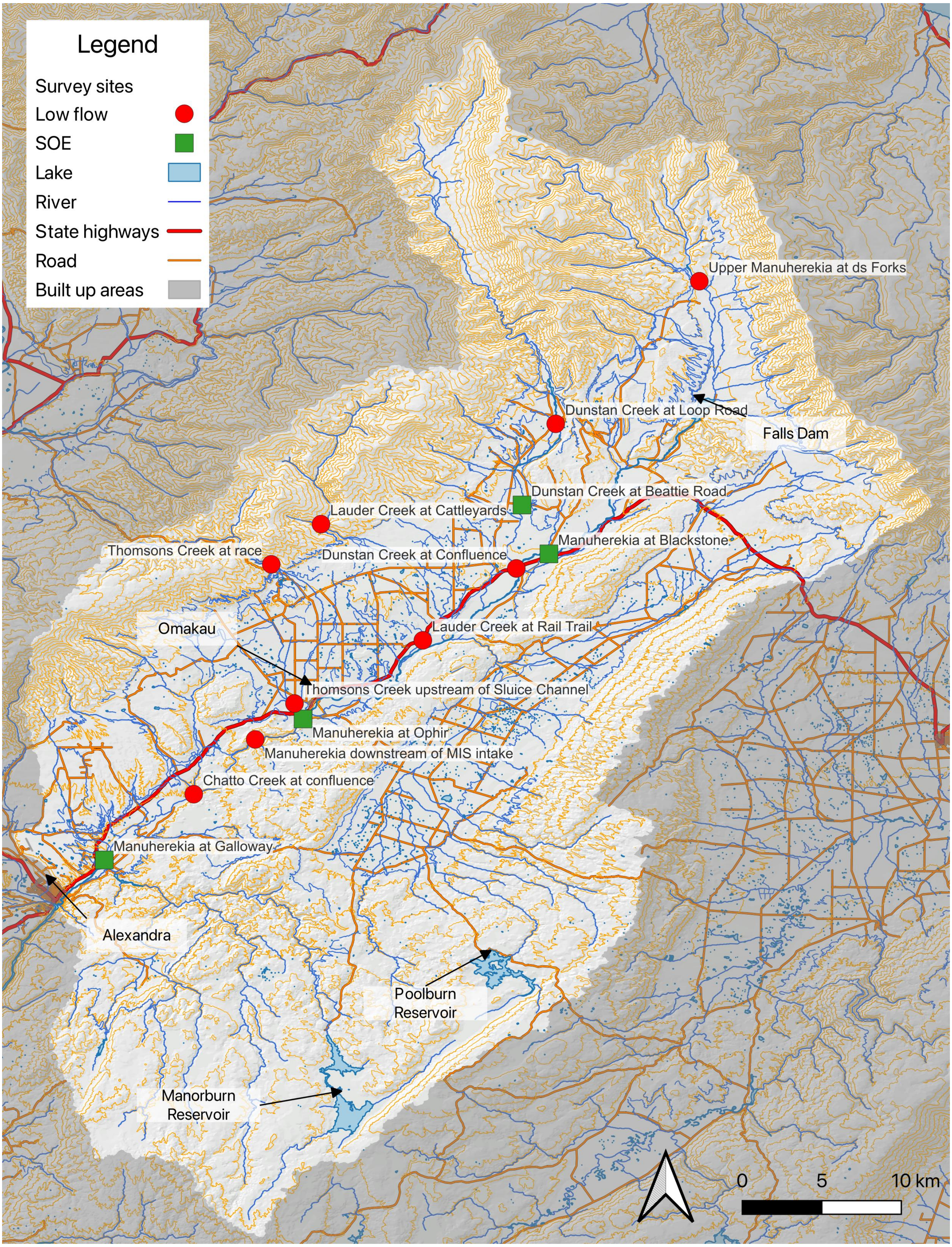

Figure 1 Map of the Manuherekia catchment showing long-term biomonitoring sites (monitored by ORC) and sites surveyed as part of CMP monitoring surveys between December 2024 and March 2025.

2.2. Flow conditions

Flows at most hydrological monitoring sites in the Manuherekia catchment dropped from high flows in early November to relatively low flows by mid-December, with low flows persisting until mid-March 2025 with a minor fresh in late January (Figure 2).

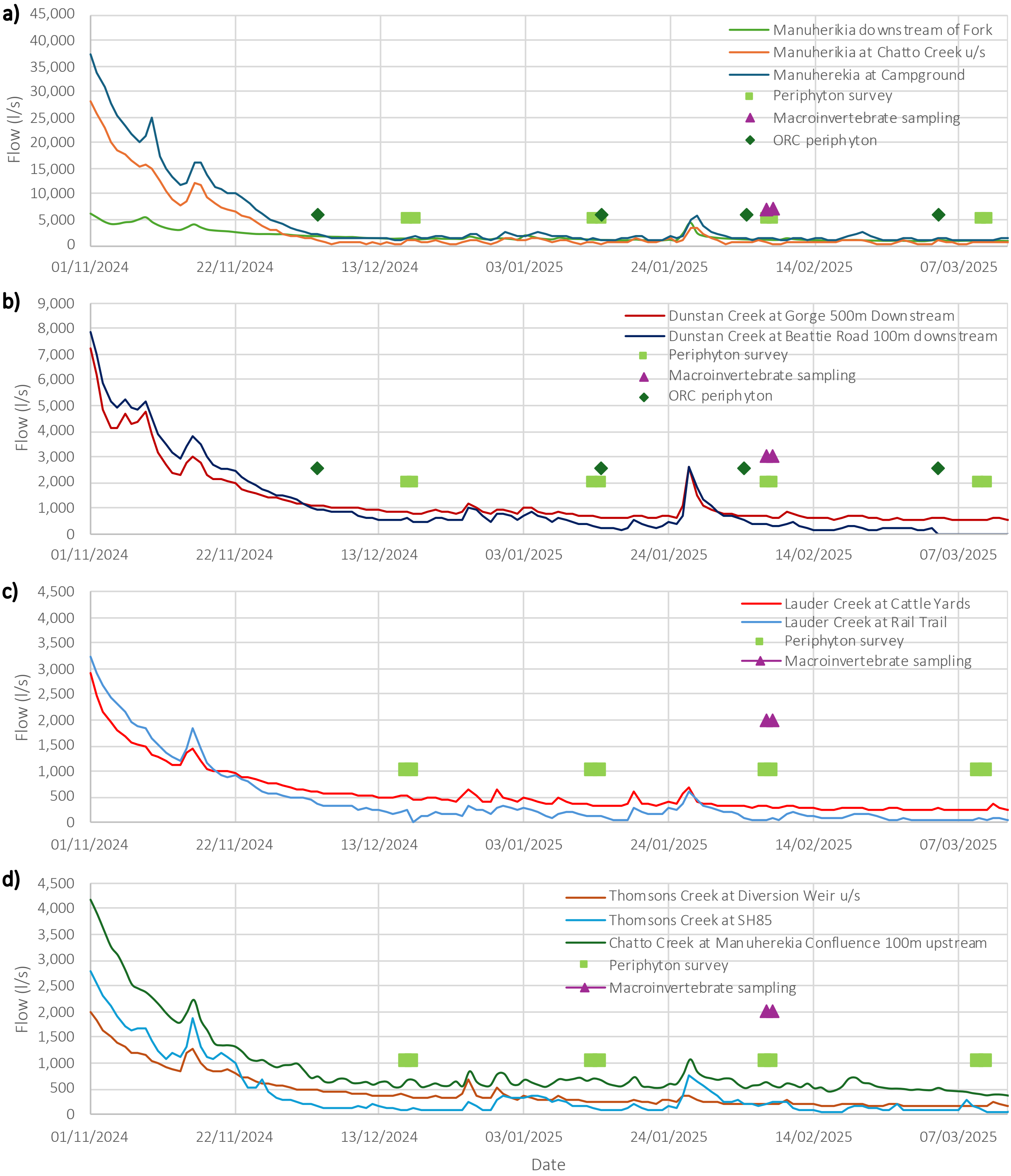

Figure 2 Hydrograph for flows at sites in the Manuherekia catchment during periphyton surveys (green squares [Freestone sites], dark green diamonds [ORC sites]) and macroinvertebrate sampling (purple triangles) between November 2024 and March2025.

2.3. Periphyton

Periphyton cover to be assessed using the Rapid Assessment Method 2 (RAM2) as described in Biggs & Kilroy (2000). This method involves estimating the periphyton percentage cover at five points across the river on four transects within a 100 m reach. Thus, 20 estimates of periphyton percentage cover (to the nearest 5%) are obtained with the periphyton classified into 12 categories (Table 2). Note that some periphyton taxa are found in several categories because it is not only their presence, but also the thickness of the mat, that is important for the evaluation of water quality (Table 2).

Periphyton biomass was analysed using Method QM-1b as described in Biggs and Kilroy (2000) by SLR Consulting.

Table 2 Periphyton categories used in RAM-2 periphyton assessments, with enrichment indicator scores and taxa that could be expected to dominate the benthic periphyton biomass. (* diatom epiphytes can give green filaments a brown colouring) (from Biggs & Kilroy 2000).

Periphyton category (on exposed surfaces)		Periphyton enrichment indicator score	Typical taxa
Thin mat/film: (under 0.5 mm thick)	Green	7	*Cymbella, Achnanthidium, Cocconeis, Ulothrix, Stigeoclonium* (basal cells), young *Spirogyra*
	Light brown	10	Assorted diatoms and cyanobacteria (*Cocconeis, Fragilaria, Synedra, Cymbella, Lyngbya, Amphithrix*)
	Black/dark brown	10	Assorted cyanobacteria (*Schizothrix, Calothrix, Lyngbya*)
Medium mat: (0.5 – 3 mm thick)	Green	5	*Stigeoclonium, Bulbochaete, Chaetophora, Oedogonium, Spirogyra, Ulothrix*
	Light brown (± dark green/black bobbles)	7	*Gomphonema, Gomphoneis, Synedra, Cymbella, Fragilaria, Navicula, Nostoc*
	Black/dark brown	9	*Tolypothrix, Schizothrix, Phormidium, Lyngbya, Rivularia*
Thick mat: (over 3 mm thick)	Green/light brown	4	*Navicula, Gomphoneis, Synedra, Rhoicosphenia, Ulothrix, Oedogonium, Microspora, Spirogyra, Vaucheria*
	Black/dark brown	7	*Phormidium, Schizothrix, Audouinella, Batrachospermum, Nostoc*
Filaments, short: (under 2 cm long)	Green	5	*Ulothrix, Oedogonium, Microspora, Spirogyra, Cladophora*
	Brown/reddish	5	*Cladophora**, Oedogonium**, Rhoicosphenia, Navicula, Batrachospermum, Diatoma*
Filaments, long: (over 2 cm long)	Green	1	*Ulothrix, Oedogonium, Microspora, Zygnema, Spirogyra, Cladophora, Rhizoclonium*
	Brown/reddish	4	*Melosira, Cladophora**, Rhizoclonium***

2.4. Macroinvertebrate community

Macroinvertebrates were assessed by collecting a composite kick-net sample from the site according to collection protocol ‘C1: hard-bottomed semi-quantitative’ as described in Stark et al. (2001) . Analysis of samples followed protocol ‘P2: 200 Individual Fixed Count with Scan for Rare Taxa’ as in Stark et al. (2001) by SLR Consulting. ORC collected macroinvertebrate samples from the Manuherekia catchment in December 2024 and given the purpose of this monitoring, macroinvertebrate samples were collected from all sites (including SoE sites) in the February 2025 survey.

MCI scores were calculated as the sum of the tolerance scores for each taxa present in the sample divided by the taxon richness, multiplied by 20 while the QMCI was calculated by first multiplying the tolerance score for each taxon by the abundance of that taxon, summing the products for each taxa and dividing by the total abundance in the sample (following Stark 1985), The tolerance scores used to calculate MCI and SQMCI scores are based on Greenwood et al. (2015) . The Average Score Per Metric was calculated by standardising MCI scores by dividing 200, standardising EPT taxa by dividing by 29 and and %EPT abundance by dividing by 100. These standardised metrics were summed and the result divided by 3, giving an ASPM between 0 and 1 (following the methods outlined in the footnote to Table 15 of the National Objectives Framework, based on the original method of Collier 2008).

3. Results & Discussion

3.1. Periphyton

3.1.1. Antecedent flows

Periphyton biomass at any time reflects the balance of two opposing processes: biomass accrual and biomass loss. The rate of cell division controls the rate of biomass accrual and is controlled by factors such as the availability of nutrients, light and water temperature (Biggs 2000a). Meanwhile, the rate of biomass loss is governed by physical disturbance (substrate instability, water velocity and suspended solids) and grazing (by invertebrates) (Biggs 2000). Consequently, when interpreting the results of periphyton surveys, it is important to consider the hydrological conditions prior to sampling occasions. Flows in excess of 3-times the long-term median flow are used as a rule of thumb to indicate flows that are high enough to reduce periphyton biomass at a site and the frequency of events of events of this magnitude (abbreviated to FRE3) is the most commonly hydrological metric used to characterise the hydrological conditions for periphyton at a site (Clausen & Biggs 1997). The amount of time between an event of 3x median flows and a sampling event is commonly referred to as the accrual period, or the period of time that processes that favour periphyton biomass accrual exceed the effect of processes that lead to biomass loss.

Table 3 summarises hydrological conditions at hydrological monitoring sites closest to biomonitoring sites sampled by ORC in the Manuherekia catchment between December 2024 and March 2025. Table 4 summarises hydrological conditions at the seven hydrological sites closest to sites surveyed as part of this study between December 2024 and March 2025.

As described in Section 2.2, hydrological conditions in the Manuherekia catchment over the 2024/25 season were characterised by flows receding from spring flows in November 2024 to low flow conditions by December, with low flows persisting through to late autumn. Flows in early November 2024 exceeded 3-times the median flow at all of the survey sites, but none of the freshes that occurred during this survey exceeded 3-times the median flow at any of the hydrological sites meaning that this survey covered a long (>120 day) accrual period (Table 3, Table 4).

Biggs (2000b) presents a graph of the relationship between accrual period and maximum benthic chlorophyll *a* biomass based on sampling of 30 New Zealand rivers sampled every 2-4 weeks for at least 13 months, with peak periphyton biomass occurring after an accrual period of between 70 and 120 days. As outlined above, periphyton biomass accrual and is controlled by factors such as the availability of nutrients, light and water temperature. Spring flows in the Manuherekia are often high as a result of rainfall and snowmelt and this, combined with the seasonal changes in light intensity[4], mean that the accrual period of 126 days covered by this study covers the highest risk period for periphyton proliferation in the Manuherekia catchment.

[4] Peak solar radiation occurs between October and February with lowest values in June based on data from NIWA SolarView Calculator.

Table 3 Summary of flow conditions at the hydrological monitoring sites closest to ORC biomonitoring sites on each occasion ORC surveyed periphyton at sites on the Manuherekia River and Dunstan Creek at Beattie Road.

Hydrological site	Survey dates	Mean flow during survey (l/s)	Accrual period (Days since 3x median)	Antecedent flows 7-d maximum flow	Antecedent flows 14-d maximum flow	Antecedent flows 28-d maximum flow
Manuherekia at Ophir	4 Dec 24	2,367	32	4,312	8,348	16,839
	14 Jan 25	2,274	73	2,988	3,205	3,510
	4 Feb 25	2,356	94	4,378	6,444	6,444
	4 Mar 25	1,841	122	1,994	2,837	2,837
Manuherekia at Chatto Creek u/s	4 Dec 24	1,055	30	2,848	6,902	16,530
	14 Jan 25	342	71	1,155	1,381	1,548
	4 Feb 25	465	92	2,304	3,575	3,575
	4 Mar 25	852	120	852	1,221	1,221
Manuherekia at Campground	4 Dec 24	2,186	31	4,628	10,257	24,842
	14 Jan 25	1,185	72	1,955	2,611	2,611
	4 Feb 25	1,368	93	4,014	5,761	5,761
	4 Mar 25	1,331	121	1,421	2,502	2,502
Dunstan Creek at Beattie Road 100m Downstream	4 Dec 24	947	31	1,517	2,491	5,141
	14 Jan 25	255	72	607	882	1,033
	4 Feb 25	500	93	1,330	2,622	2,622
	4 Mar 25	355	121	226	278	433

Table 4 Summary of flow conditions at the hydrological monitoring sites closest to the sites surveyed in this study on each sampling occasion.

Hydrological site	Survey dates	Mean flow during survey (l/s)	Accrual period (Days since 3x median)	Antecedent flows 7-d maximum flow	Antecedent flows 14-d maximum flow	Antecedent flows 28-d maximum flow
Dunstan Creek at Gorge 500m Downstream	17/18 Dec 24	833	43	958	1,111	2,105
	13/14 Jan 25	647	70	844	1,027	1,195
	7/8 Feb 25	662	95	797	2,643	2,643
	10/11 Mar 25	523	126	642	642	769
Dunstan Creek at Beattie Road 100m Downstream	17/18 Dec 24	539	44	648	947	2,538
	13/14 Jan 25	280	71	607	882	1,033
	7/8 Feb 25	332	96	732	2,622	2,622
	10/11 Mar 25	-	127	-	226	433
Lauder Creek at Cattle Yards	17/18 Dec 24	480	44	523	596	1,013
	13/14 Jan 25	338	71	479	497	660
	7/8 Feb 25	304	96	331	697	697
	10/11 Mar 25	231	127	272	280	314
Lauder Creek at Rail Trail	17/18 Dec 24	239	44	268	384	916
	13/14 Jan 25	121	71	209	326	326
	7/8 Feb 25	66	96	201	607	607
	10/11 Mar 25	61	127	69	69	214
Thomsons Creek at Diversion Weir u/s	17/18 Dec 24	355	43	399	468	886
	13/14 Jan 25	252	70	350	389	703
	7/8 Feb 25	204	95	224	384	384
	10/11 Mar 25	164	126	187	196	225
Thomsons Creek at SH85	17/18 Dec 24	110	42	202	202	1,211
	13/14 Jan 25	126	69	294	356	356
	7/8 Feb 25	227	94	269	760	760
	10/11 Mar 25	84	125	287	287	287
Chatto Creek at Manuherekia Confluence 100m Upstream	17/18 Dec 24	658	40	663	730	1,337
	13/14 Jan 25	677	67	706	783	832
	7/8 Feb 25	586	92	692	1,064	1,064
	10/11 Mar 25	376	123	509	509	706

3.1.2. Community composition

Manuherekia River sites

The periphyton community in the Upper Manuherekia at d/s Forks typified by low cover by mats or filaments, with most of the bed comprising of bare rock (no periphyton) or thin films on most occasions (Figure 4). The limited cover by thicker growths included the colonial cyanobacterium *Nostoc* (2-10% cover) and medium/thick light brown mats (including the invasive diatom *Didymosphenia geminata;* 2-14%; Figure 3) (Figure 4).

Nostoc is commonly found in fast-flowing, high-elevation sites with low levels of nutrient enrichment and coarse substrate (including bedrock) (Biggs & Kilroy 2000).

Didymosphenia geminata (hereafter, Didymo) spread rapidly after its incursion into New Zealand was recognised by Kilroy (2004) and it had been detected in many of the major catchments in the South Island by 2007 (Kilroy & Unwin 2011). Didymo has now been in the Clutha/Mata-Au catchment for at least 20 years and in the Manuherekia catchment for at least 18 years (Kilroy & Unwin 2011). Didymo commonly forms very high biomass , thick mats that cover much of the riverbed in lake outlet rivers, including the Mararoa River (where it was first identified in New Zealand; Kilroy 2004), Waiau, the Clutha/Mata-Au, Hāwea, Waitaki, Hurunui, Buller and Gowan Rivers and this has been recognised in the Manuherekia River below Falls Dam (see Manuherekia at Blackstone Hill below). Such sites are expected to have conditions that are suitable for the development of high periphyton cover and biomass including stable hydrological conditions (with high flow events moderated by the influence of lakes) and coarse substrates (dominated by boulders and cobbles). Lake outlet rivers often have low dissolved nutrient concentrations, as a result of uptake by phytoplankton within the lake, with nutrients exported from the lakes as seston (live and dead phytoplankton, live and dead zooplankton and particulate organic matter) rather than forms that are bioavailable to periphyton. Bothwell et al. (2014) summarises research in New Zealand rivers to understand the drivers of Didymo bloom formation in New Zealand rivers following the recognition that Didymo blooms did not seem to occur in spring-fed rivers despite multiple introductions. Bothwell et al. (2014) concluded that stalk production in Didymo (and therefore the production of Didymo blooms) was a response to phosphorus limitation. This accounts for patterns in the distribution of Didymo within the Manuherekia catchment, with Didymo observed in upland sites with low phosphorus concentrations, including the Upper Manuherekia at d/s Forks.

Figure 3 Photograph of thick mats of the invasive diatom *Didymosphenia geminata* in the upper Manuherekia River, 9 March 2025.

The periphyton community at the Manuherekia at Blackstone Hill in December 2024, January and February 2025 was dominated by bare substrate or thin films (73-91%), with limited cover by filamentous algae and sludge (Figure 4). Sludge refers to "unconsolidated algae that is easily detached", which is typically used to refer to detached, dead or senescent[5] algae that may accumulate on channel edges or low velocity areas. However, this category is problematic, as it can refer to various types of periphyton. It is likely that in the Manuherekia at Blackstone, "sludge" is being used to refer to older mats of Didymo that may be starting to senesce (based on the author's personal observations). Medium and thick green/light brown mats were absent in the December and January surveys, but increased between February (2%) and April 2025 (15%) (Figure 4). Similarly, cover by filamentous algae in March (23%) and April 2025 (24%) was substantially higher than the earlier surveys (1.5-13%) (Figure 4).

The periphyton cover at the Blackstone Hill site has previously been dominated by light brown films or mats, with this likely to include the invasive diatom, *D. geminata*, which has been identified at this site since 2008 (Olsen 2023). The elevated cover by long filaments at this site in February and March 2025 is consistent with the stable flows experienced in late 2024/early 2025 but is not an uncommon occurrence at this site (Olsen 2023). The Manuherekia at Blackstone Hill site is the closest site on the mainstem of the Manuherekia to Falls Dam (approximately 19 km downstream of Falls Dam) and there are few tributaries that enter the Manuherekia between Falls Dam and the Blackstone site (Mata and Station Creeks), meaning that flows at the Blackstone site are largely controlled by the outflows from Falls Dam. Such stable flow conditions along with the low phosphorus concentrations observed at this site (Hudson & Shelley 2019) are favourable for the development of Didymo blooms. The Blackstone site is immediately downstream of the Omakau Area Irrigation Company Ltd. (OAIC) main race intake, which is consented to take up to 1,981 l/s from the Manuherekia River. The composition and cover of periphyton at the Blackstone site is consistent with the stabilising effects of Falls Dam and good water quality at this site rather than an effect of the operation of the OAIC take.

Periphyton cover in the Manuherekia at Ophir site was higher than at either upstream site (Upper Manuherekia at ds Forks and Manuherekia at Blackstone) (Figure 4). Black/dark brown mats and filamentous algae were the most abundant periphyton type at Ophir on most occasions, with cover by green/light brown mats present on all occasions, particularly in the April survey (Figure 4). Cover by long filamentous algae and total cover by medium and thick mats were within guideline values for the protection of aesthetics/recreation and trout habitat and angling (Biggs 2000) on all sampling occasions. The cover of benthic cyanobacteria at the Ophir site in February and March 2025 surveys exceeded the Alert (Orange) level (>20%), but were less than the Alert (Red) level (50%) for potentially toxic benthic cyanobacteria in recreational water (Ministry for the Environment (MfE) & Ministry of Health (MoH) 2009). These guidelines apply to sites used for contact recreation. Under these guidelines, Alert (Orange mode) level triggers increased sampling and erection of signs warning the public of the potential risks whereas Action (Red mode) triggers public notification of the potential risks to health of cyanobacteria.

The periphyton cover and composition observed at the Ophir site between November 2024 and March 2025 is consistent with long-term patterns in community composition at this site. The higher cover of mats and filaments at this site compared with other sites on the mainstem of the Manuherekia is likely to be a result of nutrient enrichment at this site. Water quality monitoring upstream (Omakau) and downstream (Ophir) of the Omakau WWTP and Thomsons Creek inflow showed that nutrient concentrations were significantly higher at Ophir than Omakau, particularly dissolved reactive phosphorus (Table 11) (Hickey & Olsen 2020). The analysis of Hickey & Olsen (2020) indicated that Thomsons Creek accounted for less than half of the DRP load entering the mainstem between the Omakau and Ophir sites on most sampling occasions, suggesting that the Omakau WWTP discharge contributes significantly to the DRP load in the mainstem of the Manuherekia from Ophir downstream.

The increase in DRP immediately upstream of the Ophir monitoring site is expected to be less favourable for Didymo proliferation (Bothwell *et al.* 2014) and is likely to account for the reduced incidence of thick Didymo mats at sites downstream of Ophir. Water abstraction is not expected to materially affect habitat suitability for Didymo, but will increase the risk of the proliferation of filamentous algae (based on the analysis of Olsen *et al.* 2017).

[5] Scenescence refers to the process of cellular ageing or deterioration of cell function

The periphyton community in the Manuherekia at d/s MICSL take was dominated by bare substrate and thin light brown mats on all sampling occasions (Figure 4). Cover by mats was generally low (<7%), although cover by black/dark brown mats approached 25% in the December 2024 survey (Figure 4). The cover of benthic cyanobacteria at the d/s MICSL take site in the December 2024 surveys exceeded the Alert (Orange) level (>20%), but was less than the Alert (Red) level (50%) for potentially toxic benthic cyanobacteria in recreational water (MfE & MoH 2009). The low periphyton cover at this site is likely to reflect the confined nature of this reach, the steepness of the channel in this reach and topographic shading of the channel. This reach is immediately downstream of the Manuherekia Irrigation Co-operative Society Ltd. (MICSL) take in downstream of Omakau/Ophir which is consented to take up to 2,703.1 l/s from the Manuherekia River. The very low cover of periphyton at this site indicates that the operation of the MICSL take did not affect periphyton cover or composition in the 2024/25 irrigation season, despite the dry conditions experienced in the Manuherekia catchment.

Periphyton cover at the Manuherekia at Galloway site was dominated by bare substrate and thin films on all occasions (56-85%) with a mix of mats, sludge and filamentous algae. Cover by long filamentous algae and total cover by mats were within guideline values for the protection of aesthetics/recreation and trout habitat and angling (Biggs 2000) on all sampling occasions, although cover by long filamentous algae in the April 2025 survey (23%) was approaching the cover guidelines for aesthetics/recreation and trout habitat and angling. Filamentous algae are often present at this site, but cover is typically low (>5%) and have rarely exceeded 30% cover (Olsen 2023). The Galloway site is located in the lower reaches of the Manuherekia River downstream of most water takes and is the lowest reach in the Manuherekia River where the channel flowed unconstrained over a wide, gravel bed and was not shaded by surrounding topography. These characteristics increase the risk of periphyton proliferation. Periphyton cover and composition at the Galloway site in the 2024/25 season is consistent with long-term patterns in community composition and the presence of long filaments observed at this site in April 2025 is consistent with the stable flows experienced in the 2024/25 season but is not an uncommon occurrence at this site and did not exceed the 30% cover guideline for the protection of aesthetics/recreation and trout habitat and angling (Biggs 2000).

Figure 4 Periphyton cover at the four sites in the Manuherekia River and Dunstan Creek at Beattie Road between December 2024 and April 2024. Data for Manuherekia River at Blackstone Hill, Ophir and Galloway and Dunstan Creek at Beattie Road are courtesy of ORC.

Dunstan Creek sites

The periphyton community at the Dunstan Creek at Gorge site was dominated by bare (no periphyton) or thin films on most occasions, although the coverage by these groups decreased over the period (Figure 5). Cover by green/light brown mats (in this case dominated by Didymo) was relative consistent (~15%) in December, January and February surveys, but was substantially higher in March 2025 (Figure 5). Long filamentous algae cover increased between the December and February surveys, but decreased between the February and March surveys (Figure 5). Peak cover by long filamentous algae at this site (29.6%, February 2025) approached the 30% cover guideline for the protection of aesthetics/recreation and trout habitat and angling of Biggs (2000). Dark brown/black mats (*Nostoc*) were present at this site in February and March surveys (Figure 5). The Gorge site was upstream of water takes in the Dunstan Creek catchment. The dominance of Didymo at this site is consistent with the observation that it dominates upland sites with low phosphorus concentrations. Similarly, the abundance of *Nostoc* at the Gorge site is consistent with its preference for fast-flowing, high-elevation sites with low levels of nutrient enrichment and coarse substrate (Biggs & Kilroy 2000). The increase in cover of filamentous algae between December and February is consistent with the stable flow conditions over this period, while the decrease between the February and March surveys coincided with an increase in Didymo cover suggesting that the decrease in cover by filamentous algae may have resulted from competition for space with Didymo.

Periphyton at the Dunstan Creek at Loop Road site was dominated by bare (no periphyton) or thin films on most occasions, although the coverage by these groups decreased over the period (Figure 5). Cover by green/light brown mats (including Didymo) was low in December and January, but was higher in the February survey and higher again in the March 2025 surveys (Figure 5). Filamentous algae were present on all occasions, but cover in the March survey was lower than previous surveys (Figure 5). Dark brown/black mats (dominated by the benthic cyanobacteria *Microcoleus*[6], but *Nostoc* was also observed at this site) were present at this site in January and February, but cover in March was substantially higher than previous sampling occasions (16%, Figure 5, Figure 6). There are no water takes from the mainstem of Dunstan Creek upstream of the Loop Road site, with consented water takes from two tributaries being the only water takes likely to affect this site. These consents (RM11.129.01 and RM17.195.02) have a total maximum rate of take of 111.3 l/s, although both consents have residual flow conditions (50 l/s and 9 l/s respectively) and these are likely to limit the rate of take possible during low flow conditions, since the residual flow must be maintained downstream of the point of take at all times that the take is in operation. Given that the abstraction upstream of this site is limited to tributaries and was likely restricted by residual flows during the 2024/25 irrigation season, the risk of the water abstraction affecting the cover and composition of periphyton at this site is considered to be low. The cover and composition of periphyton at this site is consistent with this conclusion and the cover by both Didymo and *Microcoleus* in the March 2025 survey is more likely to reflect the preceding stable flows and favourable conditions for both these taxa at this site.

The periphyton community at the Dunstan Creek at Beattie Road was dominated by thin films on all sampling occasions, with low cover by filamentous algae and dark brown/black mats (benthic cyanobacteria) on all occasions. Figure 4 shows periphyton composition at Beattie Road between December 2024 and April 2025 for comparison with other SoE sites monitored by ORC while Figure 5 shows composition between December 2024 and March 2025 for comparison with other Dunstan Creek sites. The Dunstan Creek at Beattie Road site is downstream of most water takes in the Dunstan Creek catchment. The low cover of mats and filamentous algae at this site indicates that these takes did not adversely affect periphyton cover or composition in the 2024/25 irrigation season, despite the low, stable flows.

Periphyton community composition at Dunstan Creek at the confluence was dominated by thin films (68-90% cover) on most sampling occasions, cover by dark brown/black mats (dominated by the benthic cyanobacteria *Microcoleus*) increased between December (10%) and February (30%), with a slightly lower cover in the March survey (25%) (Figure 5). Filamentous algae were present at low levels (1.5-2%) in the January and February surveys (Figure 5). The confluence

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[6] Formerly known as *Phormidium*

site is downstream of all water takes in the Dunstan Creek catchment. Periphyton cover and composition at this site during the 2024/25 season meets guidelines for the protection of aesthetics/recreation and trout habitat and angling (Biggs 2000) but the cover of benthic cyanobacteria in February and March 2025 surveys exceeded the Alert (Orange) level (>20%) for potentially toxic benthic cyanobacteria in recreational water (MfE & MoH 2009).

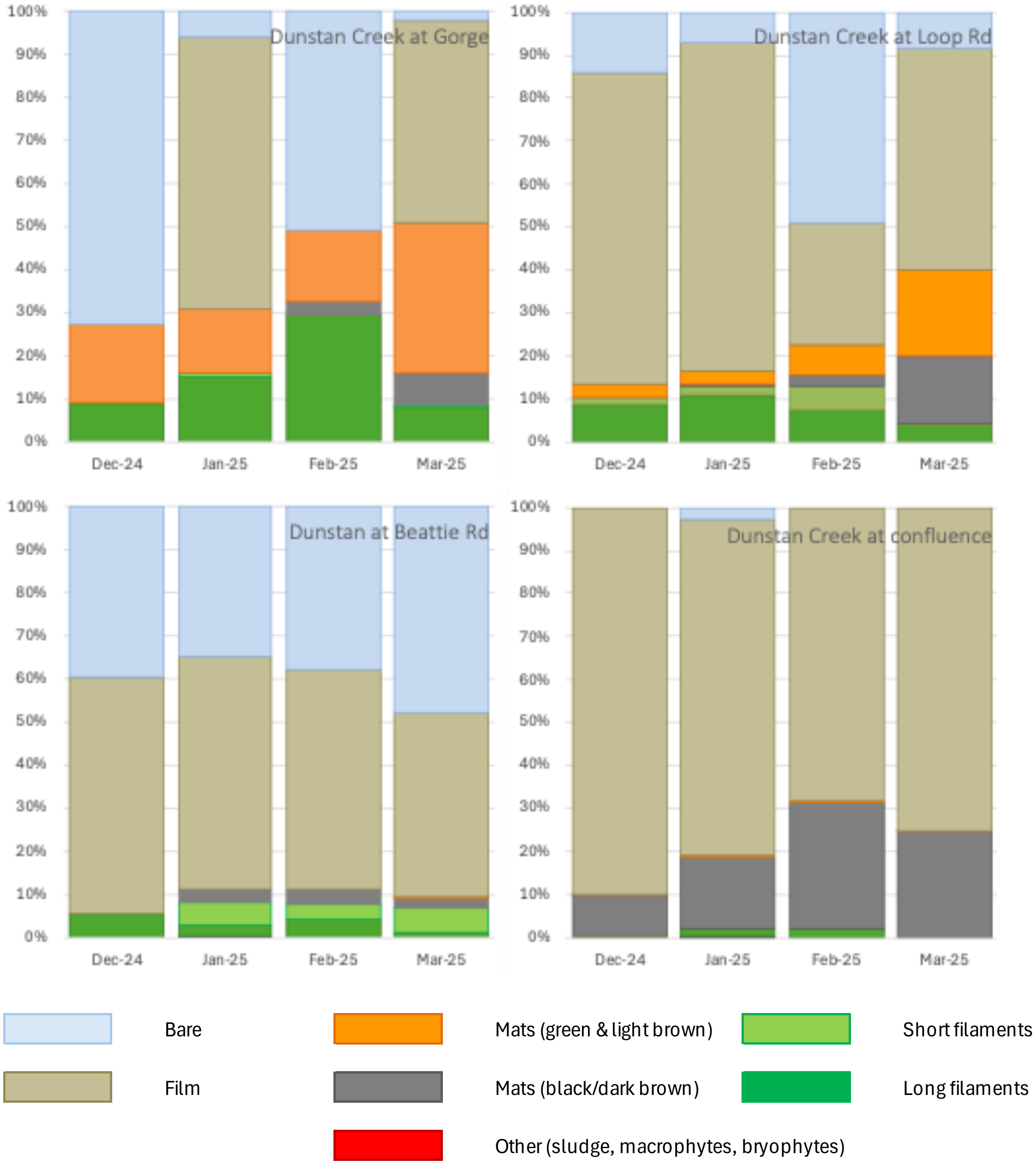

Figure 5 Periphyton cover at the four sites in Dunstan Creek between December 2024 and March 2024. Data for Dunstan Creek at Beattie Road is courtesy of ORC.

Figure 6 Photograph of benthic cyanobacteria mats in Dunstan Creek at Loop Road on 9 March 2025.

Lauder Creek sites

The periphyton community in Lauder Creek at Yards was dominated by thin light brown films on all occasions, with limited cover by medium and thick light brown mats (including Didymo) (Figure 7). The community at Lauder Creek at Cattle Yards also included low cover by the commensal cyanobacterium *Nostoc.* In comparison, periphyton cover in Lauder Creek at Rail Trail was dominated by thin and medium light brown mats , a low level of cover by long filaments in February and March (Figure 7).

The Lauder at Yards site is upstream of water takes in the Lauder Creek catchment. The presence of Didymo at this site is consistent with the observation that it dominates upland sites with low phosphorus concentrations. Similarly, the presence of *Nostoc* at this site is consistent with its preference for fast-flowing, high-elevation sites with low levels of nutrient enrichment and coarse substrate (Biggs & Kilroy 2000). Periphyton cover at the Rail Trail site was generally within the Biggs (2000) guidelines, although the cover of medium mats exceeded the guideline for aesthetics/recreation (60% cover) in the March 2025 survey (62%).

Thomsons Creek sites

The periphyton community in Thomsons Creek at Diversion Weir was dominated by thin light brown films on all occasions, with some cover by medium black/dark brown mats (including *Nostoc*) in the March survey (Figure 7). In comparison, periphyton cover in Thomsons Creek at upstream Sluice Channel was dominated by thin light brown mats on most occasions,although medium mats were abundant in the January survey and low level of cover by long filaments (<5%) in February and March (Figure 7).

The Thomsons Creek at Diversion Weir site is upstream of water takes in the Thomsons Creek catchment. The presence presence of *Nostoc* at this site is consistent with its preference for fast-flowing, high-elevation sites with low levels of nutrient enrichment and coarse substrate (Biggs & Kilroy 2000). Periphyton cover at the upstream Sluice Channel site was generally within the Biggs (2000) guidelines, although the cover of medium mats exceeded the guideline for aesthetics/recreation (60% cover) in the February 2025 survey (77%). The presence of long filamentous green algae at the upstream Sluice Channel site likely reflect the more enriched conditions present at this site (which leads to faster accrual rate) and lower water velocities (which contributes to faster growth of filamentous algae, as high velocities and/or turbulence can snap filaments, slowing accrual) at this site compared to the upstream site as well as the long accrual period (>120 d).

Chatto Creek site

The periphyton community in Chatto Creek at Confluence site was dominated by thin light brown films on all occasions, with some cover by medium light brown mats in the January and February surveys and low cover by short filaments in the January survey (Figure 7). Periphyton cover at the Chatto Creek at Confluence site was within the Biggs (2000) guidelines on all sampling occasions.

Figure 7 Periphyton cover at sites in Lauder Creek, Thomsons Creek and Chatto Creek between December 2024 and March 2024.

3.1.3. Periphyton biomass

November 2024 – March 2025

Periphyton biomass was low at most mainstem sites surveyed between December 2024 and March 2025, although periphyton biomass in the Manuherekia River at Ophir exceeded the guideline for benthic biodiversity (50 mg/m^2 of Biggs 2000) in December 2024, January 2025 and March 2025 and approached the 120 mg/m^2 for filamentous algae on January 2025 and exceeded this guideline in the February 2025 survey (Table 5). Biggs (2000) proposes a 120 mg/m^2 guideline for periphyton communities dominated by filamentous algae and 200 mg/m^2 for communities dominated by diatoms/cyanobacteria. Periphyton cover at the Ophir site in March comprised of 44% mats (diatoms and cyanobacteria), 11% short filamentous algae and 22% long filamentous algae (Figure 5). Therefore, it could be concluded that diatoms and cyanobacteria were the dominant cover at this site and that the 200 mg/m^2 guideline would seem appropriate, meaning that the measured chlorophyll *a* biomass at the Ophir site (189 mg/m^2) fell within the guideline value. However, there is likely some effect of the abundance of filamentous algae (both short and long) on this occasion in which case the measured biomass exceeded the guideline for periphyton community dominated by filamentous algae (120 mg/m^2). In any case, the periphyton biomass measured at the Ophir site on the March sampling occasion was high and was likely to have given rise to some adverse ecological effects at this site.

Table 5 Periphyton biomass at sites in the Manuherekia catchment between December 2024 and March 2025. ORC long-term monitoring sites are shaded green and the data for these sites is courtesy of ORC. Values shaded yellow exceed the guideline values for protection of benthic biodiversity (50 mg/m^2) but are within guidelines for aesthetics/recreation and trout habitat and angling (120 mg/m^2 for filamentous algae and 200 mg/m^2 for diatoms/cyanobacteria), orange values exceed the guideline values for aesthetics/recreation and trout habitat and angling (120 mg/m^2 for filamentous algae and 200 mg/m^2 for diatoms/cyanobacteria)

Site	Chlorophyll *a* (mg per m^2)			
	Dec-24	Jan-25	Feb-25	Mar-25
Upper Manuherekia River d/s Forks	2.2	7.0	13.0	23.0
Manuherikia at Blackstone Hill	6.1	1.9	3.2	
Manuherikia at Ophir	60.4	117.9	188.8*	65.7
Manuherekia River d/s MICSL Take	12.8	4.0	3.6	4.6
Manuherikia at Galloway	18.4	30.0	34.5	11.0
Dunstan Creek at Gorge	9.2	*	54.8	45.7
Dunstan Creek at Loop Road	9.7	36.7	20.2	37.3
Dunstan Creek at Beattie Road	4.3	26.3	24.6	26.3
Dunstan Creek at Confluence	13.4	70.8	80.8	49.5
Lauder Creek at Yards	2.3	10.9	5.2	35.4
Lauder Creek at Rail Trail	26.7	1.3	34.6	7.3
Thomsons Creek at Race	1.2	5.2	2.7	5.5
Thomsons Creek u/s sluice channel	1.7	5.5	56.5	3.0
Chatto Creek at Confluence	4.6	42.5	16.6	9.0

* Cover in the Manuherekia River at Ophir on February 2025 comprised 44% mats (diatoms and cyanobacteria), 11% short filamentous algae and 22% long filamentous algae.

Given the low biomass of periphyton measured at the other sites on the mainstem of the Manuherekia, local factors likely contributed to the elevated biomass observed at the Ophir site. Such local factors include the discharge from the Omakau WWTP and nutrients entering the Manuherekia River from Thomsons Creek, both of which enter the Manuherekia River a short distance upstream of the Ophir monitoring site and introduce substantial nutrient loads to the river at this point. It is noteworthy that periphyton biomass in the Manuherekia River at both sites downstream of the Ophir site was low on all occasions, suggesting that the high periphyton biomasses observed at Ophir are localised driver(s). The Manuherekia d/s MICSL Take site is ~5 km downstream of the Ophir biomonitoring site.

Figure 8 presents plots of benthic periphyton biomass (measured as chlorophyll *a* per unit area) against the accrual time (time since the last flows exceeding three times the long-term median flow at the nearest flow site. These plots help visualise how quickly periphyton biomass accrued at the survey sites in the absence of high flow events that might have reduced the biomass of periphyton. This provides valuable site-specific information to inform the assessment of the risk of the development of nuisance growths of periphyton in the Manuherekia catchment.

Biomass at the Upper Manuherekia at d/s Forks site increased exponentially across the four sampling occasions, while biomass at the Ophir and Galloway sites increased between December (~31 days) and February (~92 days) sampling occasions before dropping by 65-68% to the March sampling occasion (~121 days) (Figure 8a). This pattern follows the accrual cycle proposed by Biggs (2000), where colonisation following a substantial disturbance is followed by exponential growth in biomass ("accrual phase") until the peak biomass is reached followed by a "loss phase" when loss processes dominate including death, autogenic sloughing and grazing until a stable "carrying capacity" is reached (as per Figure 9 of Biggs 2000). The results from the 2024/25 indicate that the time to peak biomass at the Ophir and Galloway sites is between 90 and 120 days while the time to peak biomass at the Upper Manuherekia at d/s Forks site exceeds 120 days, although based on the low biomass accrual rate observed at this site, it is possible that the time to peak biomass is substantially longer than that. This is consistent with the low water temperatures and low nutrient concentrations observed at this site relative to the Ophir and Galloway sites (Hudson & Shelley 2019).

In contrast to other sites on the Manuherekia, the highest observed biomass at the Manuherekia d/s MICSL Take occurred in December 2024 (12 mg/m^2) and was substantially lower on subsequent occasions (3.6-4.6 mg/m^2) (Figure 8a). It is possible that the peak biomass at this site had occurred prior to the December 2024 survey and that the biomass observed in January-March represented the carrying capacity biomass at this site. Periphyton cover during the December survey was dominated by medium (7%) and thick (17%) benthic cyanobacteria mats (likely *Microcoleus*), which sloughed between the December and January surveys. Given the lack of high flow events between these surveys, the biomass loss is consistent with autogenic sloughing (driven by processes within the mats), which indicates that peak biomass was reached at this site before the January 2025 survey.

Periphyton biomass in Dunstan Creek at Gorge increased between December 2024 and February 2025 (55 mg/m^2) while the biomass on March 2025 (46 mg/m^2) was lower than the value in the February survey (Figure 8b). Biomass at the Loop Road site increased between December (10 mg/m^2) and January (37 mg/m^2), was lower in February (20 mg/m^2) before increasing again by the March survey (37 mg/m^2). Considering patterns in periphyton cover, it is likely that the January peak was associated with peak cover of filamentous algae, which decreased between January and March, while the March peak was associated with peak cover of benthic cyanobacteria mats (Figure 5). Periphyton biomass at the Beattie Road site increased from a low level in December 2024 (10 mg/m^2) to stabilise between January and March (25-26 mg/m^2) (Figure 8b). Biomass at the confluence site increased between December (~31 days) and February (~93 days) sampling occasions before dropping 39% to the March sampling occasion (~121 days) (Figure 8b). This suggests that the time to peak biomass in Dunstan Creek at confluence is between 93 and 121 days.

Biomass in the upper Lauder Creek (Cattleyards) was low between December and February, but was substantially higher in March (Figure 8c) while periphyton biomass in the lower Lauder Creek site (Rail Trail) varied markedly between sampling occasions (range: 1-36 mg/m^2) with no clear pattern (Figure 8c).

Biomass in the upper Thomsons Creek (u/s Diversion Weir) was consistently low on all sampling occasion (1-6 mg/m^2; Figure 8c) while periphyton biomass in the lower Thomsons Creek site (us Sluice Channel) increased between December and February (57 mg/m^2) but had decreased markedly between the February and March surveys (Figure 8c). These findings suggest that the time to peak biomass in Thomsons Creek u/s Sluice Channel was between 69 and 125 days.

The biomass of periphyton in Chatto Creek peaked in January (42 mg/m^2, 67 days) before decreasing between January and March (Figure 8c). These findings suggest that the time to peak biomass in Chatto Creek at confluence was between 40 and 92 days.

Figure 8 Plots of the relationships between benthic biomass of periphyton (as measured by chlorophyll *a*) and accrual time at sites on the (a) Manuherekia River, (b) Dunstan Creek and (c) tributaries surveyed in the 2024/25 irrigation season. Horizontal lines represent biomass guidelines from Biggs (2000).

Long-term monitoring

Periphyton biomass (benthic chlorophyll *a*) and cover has been monitored on a monthly basis since July 2019. Based on chlorophyll *a* concentrations collected between April 2022-March 2025, the Dunstan Creek and Beattie Road, Manuherekia at Blackstone Hill and Galloway sites were in B-band, while the Manuherekia at Ophir site was in C-band (Table 6).

The values for the Manuherekia at Blackstone Hill and Galloway meet the baseline and target attribute states set out in the proposed Land & Water Regional Plan (LWRP) and are indicative of occasional blooms reflecting low nutrient enrichment and/or alteration of the natural flow regime or habitat (as per Table 2 of the NPSFM). The periphyton biomass at both the Dunstan Creek at Beattie Road and the Manuherekia at Ophir exceeded the target attribute state proposed in consultation information for the pLWRP (Table 6), although the value for Dunstan Creek at Beattie Road is close to the threshold for A-band (<50 mg/m^2).

Table 6 Comparison of chlorophyll a concentrations at four sites in the Manuherekia catchment with Table 2 of the National Objectives Framework of NPS-FM and the baseline and target attribute states proposed for the Otago Land & Water Regional Plan[7]. Calculations based on data from the period July 2021 – June 2024. Data courtesy of ORC.

		Proposed LWRP		2022-2025	
Site	n	Baseline attribute state	Target attribute state	92nd percentile	NOF band
Dunstan Creek at Beattie Road	33	A	A	53.7	B
Manuherikia at Blackstone Hill	25	B	B	74.0	B
Manuherikia at Ophir	23	B	B	187.4	C
Manuherikia at Galloway	25	B	B	70.3	B

[7] https://www.orc.govt.nz/your-council/plans-and-strategies/water-plans-and-policies/freshwater-management-units/cluthamata-au/manuherekia-rohe-area/

3.2. Macroinvertebrates

3.2.1. Macroinvertebrate community composition

Manuherekia River sites

The macroinvertebrate community at most sites in the Manuherekia River in February 2025 were numerically dominated by the common mayfly *Deleatidium* with the net-spinning caddis fly *Hydropsyche*, and riffle beetles (Elmidae) also among the most abundant taxa most sites. The macroinvertebrate community at in the Manuherekia at Ophir was subtly different to the other mainstem sites with riffle beetles (Elmidae) the most abundant taxa at this site, with the net-spinning caddis fly *Hydropsyche* also very abundant, and while the mayfly *Deleatidium* was abundant at this site, it was less abundant relative to other mainstem sites (Table 7).

The community composition at the Blackstone, Ophir and Galloway sites were consistent with the results of historical sampling at these sites (Olsen 2023). Full macroinvertebrate data from 7th/8th May 2025 is presented in Appendix B.

Table 7 Summary of macroinvertebrate community composition at five sites on the Manuherekia River on 7th February 2025. Only taxa with >100 individuals at one or more sites are included. Full macroinvertebrate data is presented in Appendix B.

ORDER	TAXON	Tolerance value (original)	Tolerance value (updated)	Manuherekia River d/s Forks (reference)	Blackstone	Ophir	d/s MICSL Take	Galloway
COLEOPTERA	Elmidae	6	6	200	1240	1360	500	680
CRUSTACEA	*Paracalliope*	5	5			40		
DIPTERA	Tanytarsini	3	5	30		220	20	20
	Orthocladiinae	2	4	80	60	260	40	1
	Austrosimulium	3	6	20	60	20	120	140
EPHEMEROPTERA	*Austroclima*	9	6	10	20	120	940	260
	Deleatidium	8	7	1520	2280	900	2020	3280
MEGALOPTERA	*Archichauliodes*	7	8	20	1	20	60	1
PLECOPTERA	*Zelandoperla*	10	8	1				
TRICHOPTERA	*Beraeoptera*	8	7	10				
	Olinga	9	9	290	40	20	20	1
	Pycnocentria	7	5	90	440	280		1260
	Pycnocentrodes	5	6	250	160	280	160	60
	Hydrobiosis	5	8	30	40	1	1	60
	Hydropsyche	4	8	350	860	1120	920	1100
	Hudsonema	6	4		180	20	1	1
MOLLUSCA	*Physa = Physella*	3	2			160	1	
	Potamopyrgus	4	5		1	620	240	40
OLIGOCHAETA		1	5	80	780	20	1	1
Number of taxa				**27**	**20**	**26**	**21**	**18**
Number of invertebrates				**3096**	**6187**	**5585**	**5127**	**6966**
Number of EPT taxa				**15**	**11**	**11**	**10**	**9**
% EPT taxa				**56**	**55**	**42**	**48**	**50**
% EPT abundance				**85**	**65**	**50**	**80**	**87**
MCI score (revised TVs)				**141**	**121**	**109**	**121**	**118**
QMCI score (revised TVs)				**6.97**	**6.39**	**6.13**	**6.73**	**6.61**
ASPM (revised TVs)				**0.69**	**0.54**	**0.47**	**0.58**	**0.59**

Dunstan Creek sites

The composition of the macroinvertebrate community varied between sites in Dunstan Creek during the February 2025 survey (Table 8). The most abundant macroinvertebrate taxon in Dunstan Creek at Gorge (reference site) on 7th February 2025 were oligochaete worms, with chironomid midge larvae (Orthocladiinae) and the common mayfly *Deleatidium* also abundant (Table 8). The abundance of oligochaete worms and chironomid midges at this site was consistent with the high biomass and cover of Didymo and filamentous algae at this site in the February 2025 survey (see Section3.1.2).

The horn-cased caddis fly *Olinga* and the mayfly *Deleatidium* were the most abundant taxa at the Loop Road site while the mayfly *Deleatidium,* riffle beetles (Elmidae), the horn-cased caddis fly *Olinga* and the sand-cased caddis fly *Pycnocentria* dominated the Beattie Road site (Table 8). Riffle beetles (Elmidae), chironomid midge larvae (Orthocladiinae) and the mayfly *Deleatidium* dominated the confluence site (Table 8).

Table 8 Summary of macroinvertebrate community composition at four sites on the Dunstan Creek on 7th February 2025. Only taxa with >100 individuals at one or more sites are included. Full macroinvertebrate data is presented in Appendix B.

ORDER	TAXON	Tolerance value (original)	Tolerance value (updated)	Dunstan Creek Gorge (reference)	Loop Road	Beattie Road	Confluence
COLEOPTERA	Elmidae	6	6	320	220	1000	2260
CRUSTACEA	*Paracalliope*	5	5				
	Tanytarsini	3	5	1	20	20	40
	Orthocladiinae	2	4	680	200	400	1340
	Austrosimulium	3	6	40	1	240	180
EPHEMEROPTERA	*Austroclima*	9	6	120	140	20	60
	Deleatidium	8	7	600	360	1260	1280
MEGALOPTERA	*Archichauliodes*	7	8	20	20	80	20
	Zelandoperla	10	8	1			
TRICHOPTERA	*Beraeoptera*	8	7		10		
	Olinga	9	9	120	430	480	160
	Pycnocentria	7	5	400	70	500	520
	Pycnocentrodes	5	6	160	180	140	80
	Hydrobiosis	5	8	20	30	100	160
	Hydropsyche	4	8	260	240	60	220
	Hudsonema	6	4		20	40	20
MOLLUSCA	*Physa = Physella*	3	2				
	Potamopyrgus	4	5	1	10	1	60
OLIGOCHAETA		1	5	6420	140	60	40
Number of taxa				**26**	**31**	**22**	**23**
Number of invertebrates				**9250**	**2239**	**4467**	**6524**
Number of EPT taxa				**14**	**15**	**13**	**13**
% EPT taxa				**54**	**48**	**59**	**57**
% EPT abundance				**19**	**71**	**60**	**39**
MCI score (revised TVs)				**134**	**132**	**134**	**134**
QMCI score (revised TVs)				**5.29**	**6.76**	**6.40**	**5.89**
ASPM (revised TVs)				**0.45**	**0.63**	**0.57**	**0.50**

Lauder Creek sites

The most abundant macroinvertebrate taxa in Lauder Creek at Cattle Yards (reference site) on 8th February 2025 were the mudsnail *Potamopyrgus*, the horn-cased caddis *Olinga* and the mayfly *Deleatidium*, while the Lauder Creek at Rail Trail was dominated by the mayfly *Deleatidium*, the sand-cased caddis fly *Pycnocentria,* the net-spinning caddis fly *Hydropsyche* and the mudsnail *Potamopyrgus* (Table 9). The macroinvertebrate community at the downstream site on Lauder Creek includes more taxa that are tolerant of poor water and/or habitat quality compared to the upstream site (Table 9) although it is not possible to distinguish the relative impacts of the changes in water quality, habitat and flows between these two sites.

Thomsons Creek sites

The most abundant macroinvertebrate taxa in Thomsons Creek at Race on 6th April 2024 the mudsnail *Potamopyrgus*, and the cased caddis fly *Pycnocentrodes* while the most abundant macroinvertebrate taxa in Thomsons Creek upstream of the Sluice Channel were riffle beetles (Elmidae), the mayfly *Deleatidium*, and the mudsnail *Potamopyrgus* (Table 9). The differences in macroinvertebrate community between the two sites on Thomsons Creek are consistent with a deterioration in water and/or habitat quality between these two sites, although it is not possible to distinguish between the contribution of changes in water quality, habitat and flows to differences in community composition between these two sites.

Chatto Creek Site

The most abundant macroinvertebrate taxa in the lower reaches of Chatto Creek on 6th April 2024 were the mudsnail Potamopyrgus, the mayfly Deleatidium and the sand-cased caddis fly Pycnocentria (Table 9).

Table 9 Summary of macroinvertebrate community composition at sites on the Lauder, Thomsons and Chatto Creeks on 7th February 2025. Only taxa with >100 individuals at one or more sites are included. Full macroinvertebrate data is presented in Appendix B.

ORDER	TAXON	Tolerance value (original)	Tolerance value (updated)	Lauder Creek at cattle yards	Lauder Creek at Rail Trail	Thomsons Creek at Race	Thomsons Creek at Sluice channel	Chatto Creek at Confluence
COLEOPTERA	Elmidae	6	6	140	360	140	2420	680
CRUSTACEA	*Paracalliope*	5	5		360	20	180	40
	Tanytarsini	3	5	40	60		80	20
	Orthocladiinae	2	4	220	40	60	160	120
	Austrosimulium	3	6	180	80	20	20	
EPHEMEROPTERA	*Austroclima*	9	6	1	20	20	20	
	Deleatidium	8	7	1040	3080	400	1320	2900
MEGALOPTERA	*Archichauliodes*	7	8	40	1	1	1	60
	Zelandoperla	10	8	120		1		
TRICHOPTERA	*Beraeoptera*	8	7	160		20		
	Olinga	9	9	1940		300		
	Pycnocentria	7	5	820	880	240	20	1940
	Pycnocentrodes	5	6	220	1	1560	40	40
	Hydrobiosis	5	8	60	20	20	220	60
	Hydropsyche	4	8	140	500	80	40	260
	Hudsonema	6	4		80	220	100	40
MOLLUSCA	*Physa = Physella*	3	2				60	
	Potamopyrgus	4	5	2920	500	1980	440	6140
OLIGOCHAETA		1	5	200	140	260	320	1
Number of taxa				**25**	**23**	**28**	**21**	**19**
Number of invertebrates				**8365**	**6226**	**5468**	**5524**	**12404**
Number of EPT taxa				**14**	**8**	**15**	**9**	**7**
% EPT taxa				**56**	**35**	**54**	**43**	**37**
% EPT abundance				**55**	**74**	**53**	**33**	**42**
MCI score (revised TVs)				**139**	**103**	**119**	**108**	**111**
QMCI score (revised TVs)				**6.42**	**6.27**	**5.70**	**6.02**	**5.59**
ASPM (revised TVs)				**0.58**	**0.51**	**0.55**	**0.39**	**0.41**

3.2.2. Macroinvertebrate indices

Manuherekia River

MCI and QMCI scores for the Upper Manuherekia at ds Forks (reference site) on 7th February 2025 were all in A-band, indicating that water and/or habitat quality at this site was excellent, while the ASPM score for this site was also in A-band consistent with a macroinvertebrate community with high ecological integrity, consistent with the reference conditions present at this site (Table 10).

MCI scores for the mainstem at Blackstone, downstream of the MICSL take and Galloway sites on 7th February 2025 were in B-band indicating mild organic pollution or nutrient enrichment, while the MCI score for the Ophir site (C-band) indicated moderate organic pollution or nutrient enrichment (Table 10). MCI scores for the mainstem of the Manuherekia meet or exceed the target attribute state for MCI proposed in the proposed Otago Land and Water Plan (pOLWP) (Table 10). QMCI scores for the Blackstone and Ophir sites were in B-band indicating mild organic pollution or nutrient enrichment, while QMCI scores for the downstream of the MICSL take and Galloway sites were in A-band consistent with pristine conditions (Table 10). ASPM scores for all mainstem sites downstream of Falls Dam were in B-band indicating mild to moderate loss of ecological integrity (Table 10).

MCI scores at long-term monitoring sites (Blackstone, Ophir and Galloway) on 7th February 2025 exceeded the long-term median scores for these sites (Table 10).

Macroinvertebrate metrics for sites on the mainstem of the Manuherekia River on 7th/8th February 2025 do not suggest that water abstraction affected the composition of macroinvertebrate communities in the Manuherekia River. The metrics for the Ophir site suggest that water and/or habitat quality at this site is worse than at other mainstem sites, but this is better accounted for by the local effects of the discharge from the Omakau WWTP and nutrients entering the Manuherekia River from Thomsons Creek and the resulting changes to periphyton cover and biomass.

Dunstan Creek

The macroinvertebrate indices for the Dunstan Creek at Gorge (reference site) on 7th February 2025 ranged from A-band (MCI) to C-band (QMCI) (Table 10). The range of metrics for this site makes interpretation challenging. The MCI score (A-band) suggests that most macroinvertebrate taxa present at this site were sensitive to organic pollution and/or nutrient enrichment, while the QMCI score (C-band) was a result of the very high numbers of Oligochaete worms in the sample, likely reflecting the high cover and biomass of Didymo and filamentous algae at this site on this occasion (see Section 3.1.2). The ASPM score (B-band) was consistent with a macroinvertebrate community with mild to moderate loss of ecological integrity (Table 10).

MCI scores at the three other sites in Dunstan Creek sampled on 7th/8th February 2025 were in A-band, indicating excellent water/habitat quality at these sites (Table 8). MCI scores for all sites in Dunstan Creek exceeded the target attribute state for MCI proposed in the pOLWP (Table 8). QMCI and ASPM scores for the Loop Road site (A-band) were consistent with excellent water/habitat quality at this site while QMCI and ASPM scores at the Beattie Road and Confluence sites (B-band) were consistent with mild- to moderate effects on macroinvertebrate communities at these sites (Table 8). The MCI score at Beattie Road on 7th February 2025 exceeded the long-term median scores for this site (Table 10).

While the macroinvertebrate indices changed from upstream to downstream sites in Dunstan Creek, such changes would be expected to occur naturally as a result of changes in the physical habitat (channel gradient, substrate size) and water quality (as per Hudson & Shelley 2019). Given that MCI scores for all sites in Dunstan Creek exceeded the target attribute state for MCI proposed in the pOLWP and are other metrics were in B-band at downstream sites, there is no indication that water abstraction adversely affected macroinvertebrate community composition in Dunstan Creek in the 2024/25 season.

Lauder Creek

The MCI score for Lauder Creek at Cattleyards (reference site) on 7th February 2025 was in A-band consistent with reference conditions while the QMCI and ASPM score for this site were in B-band consistent with mild to moderate effects on macroinvertebrate community at this site (Table 10). In comparison, the MCI score for Lauder Creek at Rail Trail fell in C-band, suggesting moderate organic pollution or nutrient enrichment while the QMCI and ASPM scores for this site were in B-band consistent with mild to moderate effects on macroinvertebrate community at this site (Table 10).

The macroinvertebrate community in the lower Lauder Creek included more taxa that were tolerant of degraded conditions, but the tolerance of the most abundant taxa at both sites was similar. These changes are consistent with the deterioration in water quality observed between these two sites (Hudson & Shelley 2019) although it is possible that water abstraction contributed to the differences in macroinvertebrate community composition between these two sites in Lauder Creek. However, the small differences in QMCI and ASPM between these two sites indicate that any impact on macroinvertebrate communities in Lauder Creek in February 2025 was limited.

Thomsons Creek

Macroinvertebrate metrics for Thomsons Creek at u/s Diversion Weir (reference site) on 7th February 2025 were in B-band consistent with mild to moderate effects on macroinvertebrate community at this site (Table 10). In comparison, the MCI and ASPM scores for Thomsons Creek at Rail Trail fell in C-band, suggesting moderate organic pollution or nutrient enrichment while the QMCI score for this site were in B-band consistent with mild to moderate effects on macroinvertebrate community (Table 10).

The MCI score for the lower Thomsons Creek site indicated that this community included more taxa that were tolerant of degraded conditions compared to the upstream site, while the lower ASPM is consistent with there being fewer sensitive taxa (such as mayflies, stoneflies and caddis flies, collectively known as EPT taxa) and that EPT taxa made up a smaller proportion of the macroinvertebrate community at the lower site compared with the upstream site (Table 7, Table 10). These changes are consistent with the deterioration in water quality observed between these two sites (Hudson & Shelley 2019), although it is possible that water abstraction contributed to the differences in macroinvertebrate community composition between these two sites in Thomsons Creek.

Chatto Creek

Macroinvertebrate metrics for the lower Chatto Creek site (confluence) on 7th February 2025 were in B-band which indicates that the macroinvertebrate community at this site was mild to moderately impacted (Table 10).

Table 10 Summary of macroinvertebrate indices for sites in the Manuherekia catchment on 7th/8th February 2025. * denotes long-term SoE sites.

Site	pLWRP targets MCI	Long-term median MCI (2010-2024)	7th/8th February 2025		
			MCI score	SQMCI score	ASPM
Upper Manuherekia River d/s forks			141	6.97	0.69
Manuherekia River @ Blackstone*	B	101	121	6.39	0.54
Manuherekia River @ Ophir*	C	105	109	6.13	0.47
Manuherekia River d/s MICSL take			121	6.73	0.58
Manuherekia River @ Galloway*	C	105†	118	6.61	0.59
Dunstan Creek @ Gorge			134	5.29	0.45
Dunstan Creek @ Loop Road			132	6.76	0.63
Dunstan Creek @ Beattie Road*	B	119	134	6.40	0.57
Dunstan Creek @ confluence			119	5.89	0.50
Lauder Creek @ cattle yards			139	6.42	0.58
Lauder Creek @ Rail Trail			103	6.27	0.51
Thomsons Creek @ race			119	5.70	0.55
Thomsons Creek u/s sluice channel			108	6.02	0.39
Chatto Creek @ confluence			111	5.59	0.41

† Time period considered 2019-2024

4. Summary & Conclusions

4.1. Periphyton

Mainstem sites

The dominance of Didymo in the Upper Manuherekia and at the Blackstone site (which is the closest site to Falls Dam) is consistent with the observation that it dominates upland sites with low phosphorus concentrations (Boothwell. The increase in cover of filamentous algae at the Blackstone and Galloway sites is consistent with the stable flow conditions over this period. Cover of mats and filamentous were within the Biggs (2000) guidelines at all sites in the mainstem of the Manuherekia River, but the cover of benthic cyanobacteria exceeded the Alert (Orange) level (>20%) for potentially toxic benthic cyanobacteria in recreational water (MfE & MoH 2009) at the Ophir site on most occasions and at the d/s MCSL take site on one occasion (December 2025).

Periphyton biomasses at sites in the mainstem of the Manuherekia River were within the Biggs (2000) guidelines at all sites except at Ophir, which exceeded the guideline for the protection of aquatic biodiversity (50 mg/m^2; Biggs 2000) on all occasions and exceeded 120 mg/m^2 on one occasion (February 2025) (Table 11). However, the 120 mg/m^2 guideline applies to periphyton dominated by filamentous algae, while that diatoms and cyanobacteria were the dominant cover at this site and that the 200 mg/m^2 guideline would seem more appropriate, meaning that the measured chlorophyll *a* biomass at the Ophir site (189 mg/m^2) fell within the guideline value. In any case, the periphyton biomass measured at the Ophir site on the March sampling occasion was high and was likely to have given rise to some adverse ecological effects at this site.

The results of this survey show that periphyton at all but one of the mainstem sites was within guideline levels and consideration of the pattern of biomass accrual across the long (>120 day) period of stable flows suggests that the risk of periphyton biomass exceeding guideline levels is low at sites other than Ophir. The Ophir site had high total cover by mats and filamentous algae and elevated biomass during these surveys. These observations at the Ophir site are likely a result of substantial nutrient inputs immediately upstream of this site from the discharge from the Omakau WWTP and the inflow from Thomsons Creek combined with the stable conditions in the 2024/25 season.

Dunstan Creek

Periphyton biomass at the Gorge (reference site) and confluence exceeded the guideline for the protection of aquatic biodiversity (50 mg/m^2; Biggs 2000) on one and two occasions respectively, while periphyton biomass at Loop Road and Beattie Road sites were within guidelines on all occasions (Table 11).

The cover by mats were within the Biggs (2000) guidelines at all sites in Dunstan Creek, although cover of filamentous algae at the Gorge site (reference) almost reached the 30% guideline on one occasion, while cover of filamentous algae at all of the other sites in Dunstan Creek were well within this guideline (Table 11). However, cover of benthic cyanobacteria at the confluence site exceeded the Alert (Orange) level (>20%) for potentially toxic benthic cyanobacteria in recreational water (MfE & MoH 2009) on two occasions (Table 11). The pattern of biomass accrual across the >120 day accrual period suggests that periphyton biomass at Gorge and Confluence sites is likely to exceed the guideline for the protection of aquatic biodiversity (50 mg/m^2; Biggs 2000), the risk of higher guidelines (120 and 200 mg/m^2) being exceeded at these sites is low. Biomass accrual at other sites in Dunstan Creek suggest that periphyton biomass is unlikely to exceed guideline values.

The dominance of Didymo at the Gorge is consistent with the observation that it dominates upland sites with low phosphorus concentrations. In studies in the Manawatu-Wanganui region, Wood & Young (2011, 2012) identified river flow and nutrient concentrations as the key parameters influencing the occurrence and abundance of *Microcoleus* with greatest coverage occurs when DRP is very low (ca. < 0.01 mg/L), but DIN concentrations were sufficient for growth (ca. > 0.1 mg/L). Further investigations of phosphorus uptake from sediment trapped within *Microcoleus* mats suggested that this may account for its ability to proliferate at very low DRP concentrations (Wood et al. 2014). These studies indicate that the low DRP concentrations in the lower Dunstan Creek (Hudson & Shelley 2019) and stable flow conditions likely contributed to the elevated cover of benthic cyanobacteria at the confluence site observed during these surveys.

Other tributaries

Periphyton biomass and cover at the reference sites in the upper reaches of Lauder Creek and Thomsons Creek were within the Biggs (2000) guidelines on all occasions (Table 11). Cover by mats exceeded the 60% guideline at downstream sites on both Lauder and Thomsons Creek on one occasion, while the biomass at Thomsons Creek at us Sluice Channel site exceeded the guideline for the protection of aquatic biodiversity (50 mg/m^2; Biggs 2000) on one occasion. Periphyton biomass and cover at the Chatto Creek site were within all of the Biggs (2000) guidelines on all occasions (Table 11). The pattern of biomass accrual at tributary sites in the 2024/25 season suggest that periphyton biomass is unlikely to exceed guideline values sites other than Thomsons Creek upstream of the Sluice channel. Biomass at this site increased exponentially from low levels in December (1.7 mg/m^2) and January (5.5 mg/m^2) to 56.5 mg/m^2 in the February survey before dropping to low levels again in the March survey. Further investigation of the processes governing the very rapid rate of change in biomass at this site would be required to assess the risk of higher biomass guidelines being exceeded.

Table 11 Comparison of periphyton biomass with biomass and cover guidelines of Biggs (2000) and contact recreation guidelines (MfE & MoH 2009).

	Biggs (2000)					MfE & MoH (2009)
Waterbody/Site	Biodiversity	Aesthetics/ recreation (1 November -30 April)	Trout habitat & angling	Diatoms/ cyanobacteria cover (60% >0.3 mm thick)	Filamentous algae (30% >20 mm long)	Red alert >50% cover cyanobacteria
Manuherikia River						
d/s Forks (reference)	✓	✓	✓	✓	✓	✓
Blackstone	✓	✓	✓	✓	✓	✓
Ophir	X	~	~	✓	✓	✓
D/s MICSL Take	✓	✓	✓	✓	✓	✓
Galloway	✓	✓	✓	✓	✓	✓
Dunstan Creek						
Gorge (reference)	X	✓	✓	✓	~	✓
Loop Road	✓	✓	✓	✓	✓	✓
Beattie Road	✓	✓	✓	✓	✓	✓
Confluence	X	✓	✓	✓	✓	✓
Lauder Creek						
Yards (reference)	✓	✓	✓	✓	✓	✓
Rail Trail	✓	✓	✓	X	✓	✓
Thomsons Creek						
Diversion Weir (reference)	✓	✓	✓	✓	✓	✓
U/s sluice channel	X	✓	✓	X	✓	✓
Chatto Creek						
Confluence	✓	✓	✓	✓	✓	✓

Comparison to target attribute states for periphyton

Analysis of long-term periphyton biomass at Manuherekia at Blackstone Hill and Galloway indicate that these sites meet the baseline and target attribute states set out in the proposed Land & Water Regional Plan (LWRP). The periphyton biomass at both the Dunstan Creek at Beattie Road and the Manuherekia at Ophir exceeded the target attribute state proposed in consultation information for the pLWRP, although the value for Dunstan Creek at Beattie Road (54 mg/m^2) is close to the threshold for A-band (<50 mg/m^2).

4.2. Macroinvertebrates

Macroinvertebrate Community Index scores at most sites sampled in February 2025 fell within the A- or B-band, with the exception of the Manuherekia at Ophir, Lauder Creek at Rail Trail and Thomsons Creek upstream of Sluice Channel, which fell within the C-band (Table 12). QMCI scores fell within the A- or B-band at most sites, with the exception of Dunstan Creek at Gorge which fell within the C-band (Table 12). Notably, this site was a reference site, suggesting that the macroinvertebrate taxa that were tolerant of organic pollution/nutrient enrichment were abundant at this site. Rather than indicating organic pollution or nutrient enrichment at this site, this likely reflects the proliferation of Didymo and filamentous algae at this site. ASPM scores fell within the A- or B-band at all sites during this survey (Table 12).

MCI scores for three of the four long-term sites met the proposed target attribute state, the long-term median MCI score at the Blackstone site (102) fell well below the threshold for B-band (110) (Table 12), likely reflecting the dominance of the periphyton at this site by Didymo and filamentous algae.

The MCI scores at the Manuherekia at Blackstone and Galloway sites in February 2025 were higher than the long-term median, while QMCI and ASPM scores are consistent with the long-term scores for these sites (Table 12). The MCI and ASPM scores measured at the Manuherekia at Ophir in February 2025 were consistent with the long-term median scores for this site, while the QMCI score was below the long-term median (Table 12). The MCI score measured at the Dunstan Creek at Beattie Road in February 2025 was higher than the long-term score for this site, while QMCI and ASPM scores were below the long-term medians (Table 12).

Table 12 Comparison of macroinvertebrate indices with target attribute states and long-term statistics for long-term monitoring sites. * = ORC long-term sites, data for these sites courtesy of ORC.

	7th/8th February 2025			LWRP MCI Target	2020-2024 median		
Site name	MCI	QMCI	ASPM		MCI	QMCI	ASPM
Upper Manuherekia at ds Forks	A	A	A				
Manuherekia at Blackstone*	B	B	B	B	C (102)	B (6.22)	B (0.54)
Manuherekia at Ophir*	C	B	B	C	C (110)	A (6.60)	B (0.52)
Manuherekia downstream of MICSL intake	B	A	B				
Manuherekia at Galloway*	B	A	B	C	C (105)	A (6.89)	B (0.55)
Dunstan Creek at Gorge	A	C	B				
Dunstan Creek at Loop Road	A	A	A				
Dunstan Creek at Beattie Road*	A	B	B	B	B (117)	A (7.22)	A (0.65)
Dunstan Creek at Confluence	A	B	B				
Lauder Creek at Cattleyards	A	B	B				
Lauder Creek at Rail Trail	C	B	B		-	-	
Thomsons Creek at race	B	B	B		-	-	
Thomsons Creek upstream of Sluice Channel	C	B	C		-	-	
Chatto Creek at confluence	B	B	B		-	-	

4.3. Overall conclusions

The Manuherekia Catchment Group started the phased implementation of the Catchment Management Plan (CMP) in the 2024/25 irrigation season. The phased implementation of the CMP coincided with hydrological season dominated by dry conditions, with flows in the Manuherekia catchment dropping from high spring flows in November 2024 with low, stable flows occurring from mid-December until mid-March. These conditions provided an excellent opportunity to assess the ecological effects of the phased implementation of the CMP, as the long period of low, stable flows were favourable for periphyton proliferation, with elevated risk of the development of nuisance periphyton growths that may adversely affect instream values.

Monitoring in the Manuherekia catchment during the 2024/25 irrigation season found that sites on the mainstem at Blackstone, downstream of the MICSL take and Galloway met all periphyton guidelines and macroinvertebrate objectives on all survey occasions. These results suggest that the flow management on the mainstem of the Manuherekia achieved acceptable ecological outcomes during a season dominated by low stable flows.

The Manuherekia at Ophir stands out as the poorest site in the Manuherekia catchment. Whilst the low, stable flows experienced in the 2024/25 irrigation season contributed to the outcomes observed at this site, the localised extent of this impact suggests that this primarily results from inputs of nutrients from both the Omakau WWTP and Thomsons Creek.

In the Dunstan Creek sub-catchment, the Gorge site had the poorest ecological outcomes including the dominance of Didymo and filamentous algae which reached levels that likely affected macroinvertebrate community composition at this site. Ecological outcomes were generally good at downstream sites, although elevated periphyton biomass and high cover of benthic cyanobacteria the confluence site likely reflect a combination of low DRP concentrations in the lower Dunstan Creek (Hudson & Shelley 2019) and stable flow conditions in the 2024/25 season.

In both the Lauder and Thomsons Creek sub-catchments, differences in periphyton composition and/or biomass and macroinvertebrate indices between the upper (reference) sites and sites in the lower catchment are consistent with some deterioration in ecological state of these streams, although in most respects the lower sites meet guidelines and ecological objectives. As for Dunstan Creek, it is likely that a combination of changes in water quality between these sites (Hudson & Shelley 2019) and the stable flow conditions in the 2024/25 season contributed to the differences in ecological outcomes between these sites.

Monitoring in the lower Chatto Creek during the 2024/25 irrigation season found that periphyton biomass and cover met all periphyton guidelines and that macroinvertebrate indices (all B-band) for this site were consistent with objectives set out in the pOLWP.

The dry conditions experienced in the Manuherekia catchment between late November 2024 and March 2025 provided an excellent opportunity to assess the efficacy of the CMP to manage flows in the Manuherekia catchment to providing for ecological values in the Manuherekia River and its tributaries, keeping in mind that the CMP was not fully implemented in the 2024/25 season. The results of these surveys are promising, indicating that the implementation of the CMP is likely to be an effective way to provide for ecological systems in the Manuherekia River and its tributaries. This study also highlights the interaction between water quality and flow conditions in determining periphyton outcomes and emphasises the need for an integrated management approach to achieve good ecological outcomes in the Manuherekia catchment.

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Appendix A

Periphyton cover data

Raw periphyton cover data collected at survey sites between December 2024 and March 2025 are presented in Tables 13-17 Raw periphyton cover data for ORC biomonitoring sites December 2024 and April 2025 (courtesy of ORC) are presented in Table 18.

Table 13 Periphyton cover at sites in the upper and mainstem Manuherekia between December 2024 and March 2025.

		Upper Manuherekia at ds Forks				Manuherekia at downstream of MICSL take			
Category	Thickness	01/12/2024	01/01/2025	01/02/2025	01/03/2025	01/12/2024	01/01/2025	01/02/2025	01/03/2025
Thin green film	<0.5mm	0	10	0	0	0	0	0	0
Thin light brown film	<0.5mm	2	0	91.2	76.9	50.5	83.25	95.2	89.8
Thin black/dark brown film	<0.5mm	0	0	0	0	0	0	0	0
Medium green mat	0.5-3mm	0	0	0	0.05	0	0	0	0
Medium light brown mat	0.5-3mm	6	0	0.5	7.25	1	0	0	0
Medium black/dark brown mat	0.5-3mm	1.6	3.9	5.75	9.65	7.25	0.5	1.05	0.1
Thick green/light brown mat	>3mm	1.05	1.95	2.1	6.2	0.5	6.5	0	0
Thick black/dark brown mat	>3mm	0.5	0	0	0	17	0	0	0
Short green filaments	<2cm	0.15	0.5	0	0	0	0	0	0
Short brown/reddish filaments	<2cm	0	0	0	0	0	0	0	0
Long green filaments	>2cm	0.3	0.95	0	0	0	0	0	0
Long brown/reddish filaments	>2cm	0	0	0	0	0	0	0	0
Sludge		0	0	0	0	0	0	0	4.5
Bryophytes		0	0	0	0	0	0	0	0
Macrophytes		0	0	0	0	0	0	0	0
Total algal % cover		11.6	17.3	99.55	100.05	76.25	90.25	96.25	94.4

Table 14 Periphyton cover at sites in the Dunstan Creek between December 2024 and March 2025.

		Dunstan Creek at Gorge				Dunstan Creek at Loop Road			
Category	Thickness	01/12/2024	01/01/2025	01/02/2025	01/03/2025	01/12/2024	01/01/2025	01/02/2025	01/03/2025
Thin green film	<0.5mm	0	0	0	0	0	0	0	0
Thin light brown film	<0.5mm	0	63.25	0	46.8	72.4	76.4	28.1	51.6
Thin black/dark brown film	<0.5mm	0	0	0	0	0	0	0	0
Medium green mat	0.5-3mm	0	0	0	0.25	0	0	0	4.75
Medium light brown mat	0.5-3mm	0	0	0	0.5	1	0	0	0
Medium black/dark brown mat	0.5-3mm	0	0	0	0	0	0.25	1.65	3
Thick green/light brown mat	>3mm	18.3	15	16.4	34.35	2.35	3	7.1	15.25
Thick black/dark brown mat	>3mm	0	0	3.1	7.2	0	0	1	12.75
Short green filaments	<2cm	0	0.5	0	0.5	1.5	2.4	5.7	0.5
Short brown/reddish filaments	<2cm	0	0	0	0	0	0	0	0
Long green filaments	>2cm	8.9	15.25	29.55	8.25	8.75	10.7	7.2	3.65
Long brown/reddish filaments	>2cm	0	0	0	0	0	0	0	0
Sludge		0	0	0	0	0	0	0	0
Bryophytes		0	0	0	0	0	0	0	0
Macrophytes		0	0	0	0	0	0	0	0
Total algal % cover		27.2	94	49.05	97.85	86	92.75	50.75	91.5

Table 15 Periphyton cover at sites in the Dunstan and Chatto Creek between December 2024 and March 2025.

		Dunstan Creek at confluence				Chatto Creek at confluence			
Category	Thickness	01/12/2024	01/01/2025	01/02/2025	01/03/2025	01/12/2024	01/01/2025	01/02/2025	01/03/2025
Thin green film	<0.5mm	0	0	0	0	0	0	0	0
Thin light brown film	<0.5mm	89.95	78.1	68.4	73.75	100	89.25	96.25	99.3
Thin black/dark brown film	<0.5mm	0	0	0	0	0	0	0	0
Medium green mat	0.5-3mm	0	0	0	0	0	0	0	0
Medium light brown mat	0.5-3mm	0	0.65	0	0	0	8.25	3.5	0
Medium black/dark brown mat	0.5-3mm	9.75	16.65	0.75	4.25	0	0	0	0
Thick green/light brown mat	>3mm	0.05	0	0.1	0.25	0	1.25	0	0.2
Thick black/dark brown mat	>3mm	0	0	28.75	20	0	0	0	0
Short green filaments	<2cm	0.25	0	0	0	0	1.25	0	0
Short brown/reddish filaments	<2cm	0	0	0	0	0	0	0	0
Long green filaments	>2cm	0	1.6	2	0	0	0	0	0
Long brown/reddish filaments	>2cm	0	0	0	0	0	0	0	0
Sludge		0	0	0	0.75	0	0	0	0
Bryophytes		0	0	0	0	0	0	0	0
Macrophytes		0	0	0	0	0	0	0	0
Total algal % cover		100	97	100	100	100	100	99.75	99.5

Table 16 Periphyton cover at sites in the Lauder Creek between December 2024 and March 2025.

		Lauder at Cattleyards				Lauder at Rail Trail			
Category	Thickness	01/12/2024	01/01/2025	01/02/2025	01/03/2025	01/12/2024	01/01/2025	01/02/2025	01/03/2025
Thin green film	<0.5mm	0	0	0	0.25	0	0	0	0
Thin light brown film	<0.5mm	82	96.6	96.1	97.9	58.75	41.5	81.5	9.75
Thin black/dark brown film	<0.5mm	0	0.75	0	0	0	0	0	0
Medium green mat	0.5-3mm	0	0	0	0	0	0	0	0
Medium light brown mat	0.5-3mm	1.5	0	2	0	23.75	35	0	61.75
Medium black/dark brown mat	0.5-3mm	0.5	0.35	1	1.55	0	0	0	0
Thick green/light brown mat	>3mm	6.55	2.25	0.6	0	17.5	0	0	0
Thick black/dark brown mat	>3mm	0	0	0.05	0.25	0	0	0	0
Short green filaments	<2cm	0	0.05	0	0.05	0	0	0	0
Short brown/reddish filaments	<2cm	0	0	0	0	0	0	0	0
Long green filaments	>2cm	0	0	0	0	0	0	4.5	0.5
Long brown/reddish filaments	>2cm	0	0	0	0	0	0	0	0
Sludge		0	0	0	0	0	10	0	0
Bryophytes		0	0	0	0	0	0	0	0
Macrophytes		0	0	0	0	0	0	0	0
Total algal % cover		90.55	100	99.75	100	100	86.5	86	72

Table 17 Periphyton cover at sites in the Thomsons Creek between December 2024 and March 2025.

		Thomsons Creek at Race				Thomsons Creek at us Sluice Channel			
Category	Thickness	01/12/2024	01/01/2025	01/02/2025	01/03/2025	01/12/2024	01/01/2025	01/02/2025	01/03/2025
Thin green film	<0.5mm	0.25	0	0	0	0	0	0.25	0
Thin light brown film	<0.5mm	9	97.25	95.15	93.15	83.25	17.5	96	97.05
Thin black/dark brown film	<0.5mm	0	2.5	0	0.25	0	0	0	0
Medium green mat	0.5-3mm	0	0	0	0	0	0	0	0
Medium light brown mat	0.5-3mm	1	0.25	0	0.25	0	76.65	0	0
Medium black/dark brown mat	0.5-3mm	0	0	0	5.1	0	0	0	0
Thick green/light brown mat	>3mm	0	0	0	0.25	0	0	0	0
Thick black/dark brown mat	>3mm	0	0	0.1	0	0	0	0	0
Short green filaments	<2cm	0	0	0	0	0	0.85	1.25	0.15
Short brown/reddish filaments	<2cm	0	0	0	0	0	0	0	0
Long green filaments	>2cm	0	0	0	0	0	0	2.5	2.8
Long brown/reddish filaments	>2cm	0	0	0	0	0	0	0	0
Sludge		0	0	0	0	0	0	0	0
Bryophytes		0	0	0	0	0	0	0	0
Macrophytes		0	0	0	0	0	0	0	0
Total algal % cover		10.25	100	95.25	99	83.25	95	100	100

Table 18 Periphyton cover at ORC biomonitoring sites in the Manuherekia catchment between December 2024 and April 2025. Data courtesy of ORC.

	Manuherikia at Blackstone Hill					Dunstan Creek at Beattie Road				
	04/12/2024	14/01/2025	04/02/2025	04/03/2025	11/04/2025	04/12/2024	14/01/2025	04/02/2025	04/03/2025	11/04/2025
Thin black/dark brown film	0	0	0	0	0	0	0	0	4.5	8
Thin green film	0	0	0	2	0	0	0	0.5	0	0.5
Thin light brown film	46	58	55	27	17	74.5	65	60	61	50.5
Medium black/dark brown mat	0	0	0	0	5	0	0	0	0	0
Medium green mat	0	0	0	0	0	0	0	0	0	0.5
Medium light brown mat	0	0	2	13	0	0	0	0	1	0
Thick black/dark brown mat	0	0	0	0	0.5	0	3.75	4	3	2
Thick green/light brown mat	0	0	0	0	15	0	0	0	0	3
Short brown/reddish filaments	3	2.5	0	5	11	0	6.25	4	8	5.5
Short green filaments	0	0	0	1	0.5	0	0	0	1	0.5
Long brown/reddish filaments	9.5	5.25	1.5	7.5	12	5	3	5	1	7.5
Long green filaments	0	0.25	0	9.5	0.5	2.5	0	0	0.5	1
Bryophytes	0	0	0	0	0	0	0	0	0	0
Macrophytes	0	0	0	0	0	0	0	0	0	0
Sludge	15	6	6	2.5	17.5	0	0.5	0	0	0
Total algal cover	**58.5**	**66**	**58.5**	**65**	**61.5**	**82**	**78**	**73.5**	**80**	**79**

	Manuherikia at Ophir					Manuherikia at Galloway				
	04/12/2024	14/01/2025	04/02/2025	04/03/2025	11/04/2025	04/12/2024	14/01/2025	04/02/2025	04/03/2025	11/04/2025
Thin black/dark brown film	0	0	0	0.5	0	0	0	0.5	0	0
Thin green film	0	0	0	0	0	0	9	3	7	0
Thin light brown film	24.5	27	13.5	22	26	38.5	38	35.5	35	33.5
Medium black/dark brown mat	0	0.5	0	0	0	0	0	0	0	0
Medium green mat	0	0	0	0	0	0	0	0	0	0
Medium light brown mat	15.5	0.5	10.5	13	5.5	4	0	2.5	3.5	15.5
Thick black/dark brown mat	23	37.5	33	24	16	0.5	0.5	0.5	0	0.5
Thick green/light brown mat	0	7.5	0	0	23	0	0	0	0	2.5
Short brown/reddish filaments	10	4	10.5	5	4.5	5.5	0	1	1.5	0.5
Short green filaments	1.5	0	0	0	1	0	0	0	1.5	0
Long brown/reddish filaments	7	5.5	12.5	15.5	15.5	5.5	0	14.5	3	23
Long green filaments	4	6.5	9	5	1.5	0	0.5	0	1.5	0
Sludge	4	0	0	0	0	10.5	19.5	10.5	4.5	0
Bryophytes	0	0	0	0	0	0	0	0	0	0
Macrophytes	0	0	0	0	0	0	0	0	0	2.5
Total algal cover	**85.5**	**89**	**89**	**85**	**93**	**54**	**48**	**57.5**	**53**	**75.5**

Appendix B

Macroinvertebrate data

Raw macroinvertebrate data collected from fourteen sites in the Manuherekia catchment on 7th/8th February 2025 are presented in Table 19.

Table 19 Macroinvertebrate data for fourteen sites in the Manuherekia Catchment collected as part of monitoring with the phased implementation of the Catchment Management Plan in February 2025.

ORDER	TAXON	Tolerance value (original)	Tolerance value (updated)	Manuherekia River d/s Forks	Manuherekia River at Blackstone	Manuherekia River at Ophir	Manuherekia River at MICSL Take	Manuherekia River at Galloway	Dunstan Creek at Gorge	Dunstan Creek at Loop Road	Dunstan Creek at Beattie Road	Dunstan Creek at Confluence	Lauder Creek at cattle yards	Lauder Creek at Rail Trail	Thomsons Creek at Race	Thomsons Creek at sluice channel	Chatto Creek at Confluence
ACARINA		5	3											20	20		
COLEOPTERA	Elmidae	6	6	200	1240	1360	500	680	320	220	1000	2260	140	360	140	2420	680
	Hydraenidae	8	8							1			20				
	Berosus	5	4		1					10							
CRUSTACEA	*Paracalliope*	5	5			40								360	20	180	40
	Paraleptamphopus	5	7			1											
	Ostracoda	3	3			20	1	20						1	40	1	40
DIPTERA	Ceratopogonidae	3	6			20											
	Maoridiamesa	3	7	1			40			10		20	1	1	20		1
	Polypedilum	3	2			1								40			
	Tanytarsini	3	5	30		220	20	20	1	20	20	40	40	60		80	20
	Orthocladiinae	2	4	80	60	260	40	1	680	200	400	1340	220	40	60	160	120
	Stictocladius	9	7	10													
	Tanypodinae	5	5						1	10			20				
	Muscidae	3	4	10	1	1	20	1	1	1	1	20		1	1	1	1
	Austrosimulium	3	6	20	60	20	120	140	40	1	240	180	180	80	20	20	
	Tabanidae	3	8	1					1	1							
	Aphrophila	5	9	20						1							
	Eriopterini	9	9	1					1	1	1	1	1				
	Molophilus	5	6														1
EPHEMEROPTERA	*Austroclima*	9	6	10	20	120	940	260	120	140	20	60	1	20	20	20	
	Coloburiscus	9	9	10					1	1	1	1	1				
	Deleatidium	8	7	1520	2280	900	2020	3280	600	360	1260	1280	1040	3080	400	1320	2900
	Nesameletus	9	8	1	1		20		1	20	1	1	40		20		
HEMIPTERA	*Sigara*	5	2													1	
MEGALOPTERA	*Archichauliodes*	7	8	20	1	20	60	1	20	20	80	20	40	1	1	1	60
PLECOPTERA	*Austroperla*	9	9												1		
	Stenoperla	10	9	1					1	1	1	20	20				
	Zelandobius	5	7	10					20						20	20	
	Zelandoperla	10	8	1					1				120		1		
TRICHOPTERA	*Beraeoptera*	8	7	10						10			160		20		
	Olinga	9	9	290	40	20	20	1	120	430	480	160	1940		300		
	Pycnocentria	7	5	90	440	280		1260	400	70	500	520	820	880	240	20	1940
	Pycnocentrodes	5	6	250	160	280	160	60	160	180	140	80	220	1	1560	40	40
	Costachorema	7	9	10	1	20	1		20	30	1	20	20				
	Hydrobiosis	5	8	30	40	1	1	60	20	30	100	160	60	20	20	220	60
	Neurochorema	6	6							1					1		
	Psilochorema	8	7	40	1	20	1	40	20	50	60	1	1	20	1	60	20
	Hydropsyche	4	8	350	860	1120	920	1100	260	240	60	220	140	500	80	40	260
	Oxyethira	2	3						20	10				20			
	Hudsonema	6	4		180	20	1	1		20	40	20		80	220	100	40
	Polyplectropus	8	3			1											

Table 19 Macroinvertebrate data for fourteen sites in the Manuherekia Catchment collected as part of monitoring with the phased implementation of the Catchment Management Plan in February 2025.

ORDER	TAXON	Tolerance value (original)	Tolerance value (updated)	Manuherekia River d/s Forks	Manuherekia River at Blackstone	Manuherekia River at Ophir	Manuherekia River at MICSL Take	Manuherekia River at Galloway	Dunstan Creek at Gorge	Dunstan Creek at Loop Road	Dunstan Creek at Beattie Road	Dunstan Creek at Confluence	Lauder Creek at cattle yards	Lauder Creek at Rail Trail	Thomsons Creek at Race	Thomsons Creek at sluice channel	Chatto Creek at Confluence
MOLLUSCA	*Physa = Physella*	3	2			160	1									60	
	Potamopyrgus	4	5		1	620	240	40	1	10	1	60	2920	500	1980	440	6140
	Sphaeriidae	3	2												1		40
NEMERTEA		3	2		20	40								1			
OLIGOCHAETA		1	5	80	780	20	1	1	6420	140	60	40	200	140	260	320	1
PLATYHELMINTHES		3	4												1		
Number of taxa				**27**	**20**	**26**	**21**	**18**	**26**	**31**	**22**	**23**	**25**	**23**	**28**	**21**	**19**
Number of invertebrates				**3096**	**6187**	**5585**	**5127**	**6966**	**9250**	**2239**	**4467**	**6524**	**8365**	**6226**	**5468**	**5524**	**12404**
Number of EPT taxa				**15**	**11**	**11**	**10**	**9**	**14**	**15**	**13**	**13**	**14**	**8**	**15**	**9**	**7**
% EPT taxa				**56**	**55**	**42**	**48**	**50**	**54**	**48**	**59**	**57**	**56**	**35**	**54**	**43**	**37**
% EPT abundance				**85**	**65**	**50**	**80**	**87**	**19**	**71**	**60**	**39**	**55**	**74**	**53**	**33**	**42**
MCI score (original TVs)				**124**	**111**	**100**	**103**	**103**	**118**	**115**	**122**	**119**	**127**	**91**	**111**	**97**	**93**
QMCI score (original TVs)				**6.75**	**5.82**	**5.32**	**6.74**	**6.82**	**2.40**	**6.17**	**6.38**	**5.50**	**6.10**	**6.52**	**5.01**	**5.76**	**5.52**
ASPM (original TVs)				**0.66**	**0.53**	**0.46**	**0.55**	**0.57**	**0.42**	**0.60**	**0.55**	**0.48**	**0.56**	**0.49**	**0.54**	**0.38**	**0.38**
MCI score (revised TVs)				**141**	**121**	**109**	**121**	**118**	**134**	**132**	**134**	**134**	**139**	**103**	**119**	**108**	**111**
QMCI score (revised TVs)				**6.97**	**6.39**	**6.13**	**6.73**	**6.61**	**5.29**	**6.76**	**6.40**	**5.89**	**6.42**	**6.27**	**5.70**	**6.02**	**5.59**
ASPM (revised TVs)				**0.69**	**0.54**	**0.47**	**0.58**	**0.59**	**0.45**	**0.63**	**0.57**	**0.50**	**0.58**	**0.51**	**0.55**	**0.39**	**0.41**

Appendix C

Comparison of macroinvertebrate indices

The Macroinvertebrate Community Index (MCI), semi-quantitative MCI (SQMCI) and quantitative MCI (QMCI) are all calculated using tolerance values for macroinvertebrate taxa present in a sample (or samples) collected from a site. The original tolerance values were given in Stark (1985) and were based on data from sites in Taranaki while some tolerance scores have been assigned based on professional judgement. This led to tolerance values being generated in inconsistent ways between and within regions. To address this, Greenwood et al. (2015) used a national-scale aquatic invertebrate dataset to develop an objective computational process to produce tolerance values for as many macroinvertebrate taxa as possible, at a range of taxonomic levels, for both hard-bottomed and soft-bottomed streams.

Despite the important and much-needed work of Greenwood et al. (2015), adoption of the updated tolerance values has been spotty. In the National Environmental Standard (NEMS) for Macroinvertebrates, it is stated that *"It is recognised that the Macroinvertebrate Community Index (MCI) 'pollution' tolerance values were developed more than 30 years ago and some macroinvertebrate taxa lack a tolerance value. Greenwood et al. (2015) presented a combined set of revised or new MCI tolerance values for 234 taxa found in hard-bottomed streams across New Zealand. However, at the present time, these values are not widely in use. Until such time as an updated national data set is formally introduced, the tolerance values presented in Annex D shall apply under this Standard."* The position stated in the NEMS is flawed. It ignores advancements in knowledge, technology and analytical methods since the early 1980s by continuing to use the tolerance values based on analysis conducted in the 1980s using the methods and technology of that time on a dataset collected from a limited geographical area over a limited time period and values based on "expert judgement" rather than tolerance values based on an objective computational analysis of a national dataset using open-source scripts. This position is inconsistent with the requirement for expert witnesses not to "omit material facts" known to them. Failing to acknowledge the shortcomings of the original scores and that there are now robust scores based on a national dataset is arguably both an omission and material to the outcome and conclusions drawn from such analysis. The argument that the Greenwood et al. (2015) scores are not in wide use is self-fulfilling, since regional councils are expected to follow the NEMS.

Table 20 presents the tolerance values of Stark (1985) and the corresponding tolerance value from Greenwood et al. (2015) for all taxa identified from samples collected from sites in the Manuherekia catchment in this survey. The relationship between the two sets of tolerance values is presented in Figure 9. It is evident that some of the updated tolerance values of Greenwood et al. (2015) are substantially different from the original tolerance values, with updated tolerance values varying by as much as 5 units (higher and lower) compared with the original tolerance values (Table 20). The changes in tolerance value in these samples were not random, with taxa with low original tolerance values (≤5) typically having higher revised tolerance scores, while revised tolerance values were higher than the original for taxa with original tolerance values (≥9) (Figure 9).

Macroinvertebrate Community Index (MCI) values calculated using the revised tolerance values of Greenwood et al. (2015) were consistently higher by approximately 10 units compared to those calculated using the original tolerance values (Figure 10). In comparison QMCI calculated using revised tolerance values was higher than QMCI scores calculated using the original tolerance values for lower values but converging at higher values were similar (Figure 10). The regression analysis for QMCI scores excluded the values for Dunstan Creek at Gorge because the QMCI value calculated using the original tolerance values (2.40) was markedly different to the values calculated using the revised tolerance values (5.29). This discrepancy was a result of the very high numbers of oligochaete worms in the sample from this site and the marked difference between tolerance values (tolerance value of 1 (original) vs. 5 (Greenwood et al. 2015)). Average Score Per Metric (ASPM) values calculated using the revised tolerance values of Greenwood et al. (2015) were very similar to those calculated using the original tolerance values (Figure 10).

Table 20 Comparison of tolerance values of Stark (1985) and the corresponding tolerance value from Greenwood et al. (2015) for taxa in samples collected from sites in the Manuherekia catchment in this survey.

ORDER	TAXON	MCI tolerance value	MCI (Greenwood et al. 2015)	ORDER	TAXON	MCI tolerance value	MCI (Greenwood et al. 2015)
ACARINA	ACARINA	5	3	HEMIPTERA	*Sigara*	5	2
CRUSTACEA	*Paracalliope*	5	5	MEGALOPTERA	*Archichauliodes*	7	8
	Paraleptamphopus	5	7	PLECOPTERA	*Austroperla*	9	9
	Ostracoda	3	3		*Stenoperla*	10	9
COLEOPTERA	Elmidae	6	6		*Zelandobius*	5	7
	Hydraenidae	8	8		*Zelandoperla*	10	8
	Berosus	5	4	TRICHOPTERA	*Beraeoptera*	8	7
DIPTERA	Ceratopogonidae	3	6		*Olinga*	9	9
	Muscidae	3	4		*Pycnocentria*	7	5
	Austrosimulium	3	6		*Pycnocentrodes*	5	6
	Tabanidae	3	8		*Costachorema*	7	9
	Aphrophila	5	9		*Hydrobiosis*	5	8
	Eriopterini	9	9		*Neurochorema*	6	6
	Molophilus	5	6		*Psilochorema*	8	7
	Polypedilum	3	2		*Hydropsyche*	4	8
	Tanytarsini	3	5		*Oxyethira*	2	3
	Maoridiamesa	3	7		*Hudsonema*	6	4
	Orthocladiinae	2	4		*Polyplectropus*	8	3
	Stictocladius	9	7	MOLLUSCA	*Physa = Physella*	3	2
	Tanypodinae	5	5		*Potamopyrgus*	4	5
EPHEMEROPTERA	*Coloburiscus*	9	9		Sphaeriidae	3	2
	Austroclima	9	6	NEMERTEA		3	2
	Deleatidium	8	7	OLIGOCHAETA		1	5
	Nesameletus	9	8	PLATYHELMINTHES		3	4

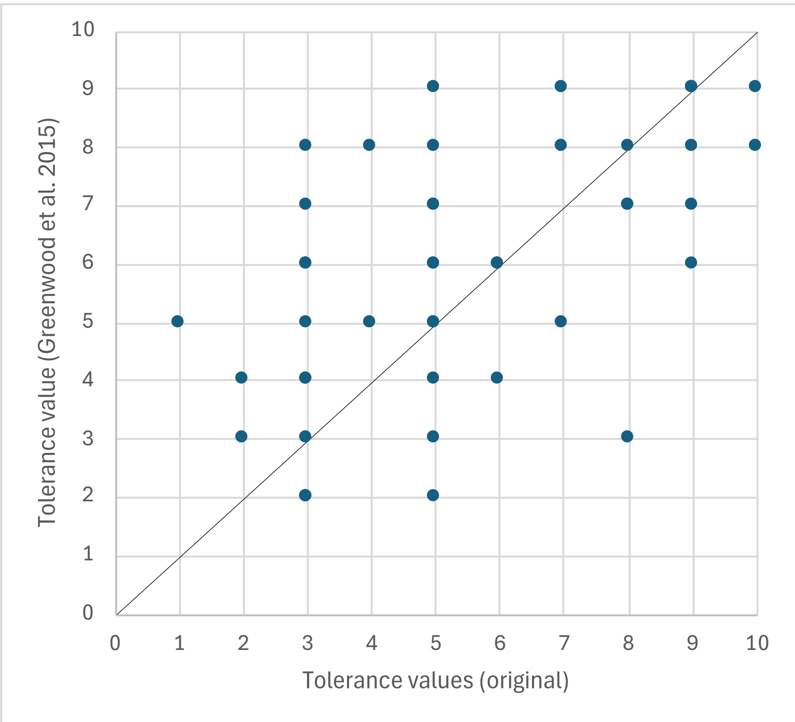

Figure 9 Plot comparing tolerance values of Stark (1985) and the corresponding tolerance value from Greenwood et al. (2015) for taxa in samples collected from sites in the Manuherekia catchment in this survey.

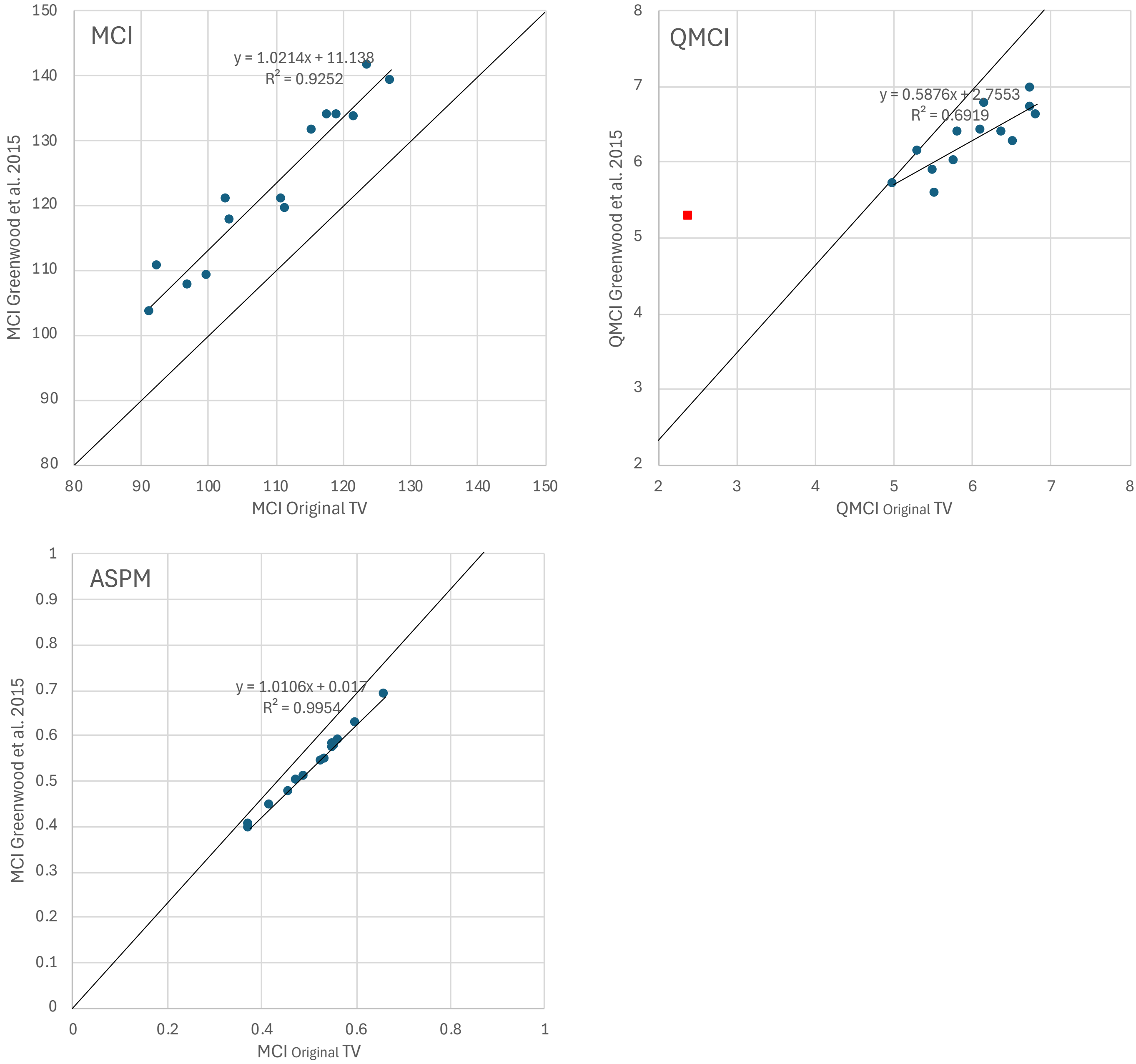

Figure 10 Comparison of MCI, QMCI and ASPM scores calculated using tolerance values (TV) from Stark (1985) (original TV) with scores based on the updated tolerance values of Greenwood et al. (2015). The QMCI values represented by the red square was not included in the regression analysis – see text for discussion.