Ecology Assessment

Ayrburn Screen Hub

Waterfall Park Developments Limited

c/o Winton Group Holdings Limited, PO 105526, Auckland 1143

Prepared by:

SLR Consulting New Zealand

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1.0	4 February 2025	Ben Crichton	Ben Ludgate	Ben Ludgate

Basis of Report

This report has been prepared by SLR Consulting New Zealand (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with Waterfall Park Developments Limited (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

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SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

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1.0 Introduction

Waterfall Park Developments Limited (WPDL) is proposing to develop a screen-production facility with associated accommodation, collectively referred to as the Screen Hub, at Ayrburn Farm, Arrowtown. The Screen Hub includes workshops/work rooms, offices, dressing rooms, backlot space, a screening room/venue, and accommodation units with landscaping, parking, and associated infrastructure (i.e., road, stormwater facilities). The stormwater facilities include a network of sediment detention ponds, rain gardens, engineered wetlands, and a treatment pond that will regulate sediment and water run-off from the Screen Hub area. The proposed construction area will be located on land adjacent to Mill Creek and an unnamed ephemeral tributary of Mill Creek (Figure 1). This consent also includes an initiative to add an in-line sediment trap (50 m long by 12 m wide) to the lower Mill Creek section within the proposed construction area, which is designed to assist with improving the water quality of Lake Hayes and downstream sections of Mill Creek. The sediment trap will capture significant amounts of sediment being transported in the creek and allow the extraction of this sediment from the system, thereby removing the sediment and trapped nutrients before they could enter Lake Hayes and contribute to water quality issues, such as cyanobacteria blooms.

SLR has been engaged by WPDL to provide an assessment of ecological effects (AEcE) for the development. This AEcE aims to describe the current ecological characteristics of the area including water quality, macroinvertebrates, aquatic plants, and fish communities and discusses the potential effects of the proposal on the existing environment.

2.0 Assessment Methodology

This AEcE is a desktop review primarily based on ongoing data collections conducted in and around Mill Creek, outlined below:

Water quality has been sampled monthly since November 2018 at three sites: Upstream, adjacent to (i.e., “Boundary”), and Downstream of the proposed Screen Hub area by WPDL (Figure 1; see photos in Appendix A). In addition, continuous loggers for turbidity have been established at the Upstream and Downstream sites. Otago Regional Council (ORC) has a long-term State of the Environment (SOE) monitoring site in Mill Creek (Fish Trap) approximately 1.5 km downstream of the proposed Screen Hub area, close to where the creek enters Lake Hayes (Figure 1).

Annually in May, macroinvertebrate surveys have been conducted at each of the four water quality sites (Upstream, Boundary, Downstream, Fish Trap), with substrate surveys also undertaken at eight locations between the Downstream and Upstream sites. Observational surveys of sports fish and redds (spawning patches) have also been conducted on several occasions annually during autumn between the Downstream and Upstream sites.

Figure 1: Map of Mill Creek and the ephemeral tributary in the Ayrburn area, with proposed Screen Hub boundary outlined in orange. Water quality monitoring sites are shown as blue points.

3.0 Existing Environment

3.1 Mill Creek Catchment

Mill Creek

Mill Creek is largely spring-fed and has a total catchment area of approximately 55 km^2. The stream is categorised as a cool dry, hill, hard sedimentary, pastoral, mid order high gradient stream (CD/H/HS/P/MO/HG) under the New Zealand River Environment Classification system. The Mill Creek catchment drains into Lake Hayes, which is approximately 1.5 km downstream of WPDL's proposed development. Historically, much of the land use within this catchment consisted primarily of cattle and sheep grazing on exotic pasture, as well as a significant amount of urban development including golf courses. However, in recent years, agricultural land use has been replaced with ongoing and planned urban development. Lake Hayes has likely undergone progressive eutrophication (nutrient enrichment) since development and intensification began in the catchment. Consequently, efforts have been made to better understand and improve the water quality of the lake, including the preparation of the 'Lake Hayes Restoration and Monitoring Plan' (Hydrosphere Research 2017).

Since 2019, Mill Creek has undergone considerable change in association with the staged construction of the Waterfall Park development. The works involved the installation of six weir structures, seven single-span bridges and two culvert crossings on, in, and over the bed of Mill Creek. Additionally, the project included the widening and reshaping of Mill Creek, and the temporary diversion and re-instatement of the creek to/from a temporary channel so works could be undertaken in the dry creek channel. Extensive riparian enhancement (fencing and planting) of the creek has also been completed as part of the Waterfall Park development.

Ephemeral Mill Creek tributary

An unnamed ephemeral spring-fed tributary of Mill Creek is located on the western side of Ayrburn Farm (Figure 1). The ephemeral watercourse is small (order 1), with a catchment area of approximately 0.43 km^2. Observations made on site suggest a typical flow to 0-2 L/s, with a predicted 100-year average recurrence interval (ARI) of 750-900 L/s (Fluent Solutions 2020).

Observations of the tributary from 2020 (reported by Ryder Environmental Limited (REL) 2020) include the wetted length of the ephemeral watercourse ranging between 300-800 m long. The tributary initially runs from north to south before turning towards the south-east and entering Mill Creek at the downstream boundary of Ayrburn Farm. The channel is mostly poorly defined, being located within a depression and without clear banks, and is only connected to Mill Creek during flood conditions. In places, there are small areas of open shallow water, some that have been formed artificially by the construction of weirs. It is likely that these areas would also dry up at times. For much of its length the channel is open to stock grazing and is dominated by pasture grasses. The south-eastern section of the channel is overgrown with willow, pine trees and other exotic vegetation, and in the lower area of the tributary near Mill Creek there is no identifiable channel.

Due to its lack of permanent flow the ephemeral watercourse does not provide any habitat for fish and only provides minimal habitat for other aquatic life. Benthic macroinvertebrates were sampled in May 2020 and the community was dominated by snails, worms, crustaceans, and fly larvae, indicative of 'poor' water quality and/or habitat condition (according to Stark 1998 MCI and SQMCI scoring). The modified, non-permanent nature of the habitat means that any aquatic life present is not of high significance (REL 2020).

3.2 Water quality and flow characteristics

Water quality monitoring has been generally completed monthly at all four water quality sites since October 2018. Therefore, below descriptions will reflect trends observed over a six-year period. ORC's Regional Plan: Water for Otago (RPW) Schedule 15 limits for Mill Creek, which are receiving water limits and targets for achieving Good Quality Water, are discussed below and are denoted in figures where appropriate. Specifically, the RPW notes that these limits are achieved when 80% of samples collected at a site, when flows are at or below median flow, over a rolling 5-year period, meet or are better than the limits in Schedule 15 (Table 15.2.2 in RPW, 2022). As all available water quality data has been presented here, including at flows above median flows, comparisons with RPW limits are indicative only.

Physical and chemical

Over the past six years, Mill Creek mean daily flows (monitored at the Fish Trap site) ranged between 0.16 and 3.46 m^3/s with a median of 0.383 m^3/s and mean of 0.434 m^3/s (Figure 2); the long-term median flow at this site is 0.383 m^3/s. According to New Zealand River Maps (Whitehead and Booker 2020), Mill Creek has an average of 10 flow events per year that exceed three times the median flow (i.e., "FRE3"), which provides an indication of 'flashiness'. For comparison, the nearby Arrow River, which has a much larger catchment than Mill Creek, has only 7 FRE3 events per year.

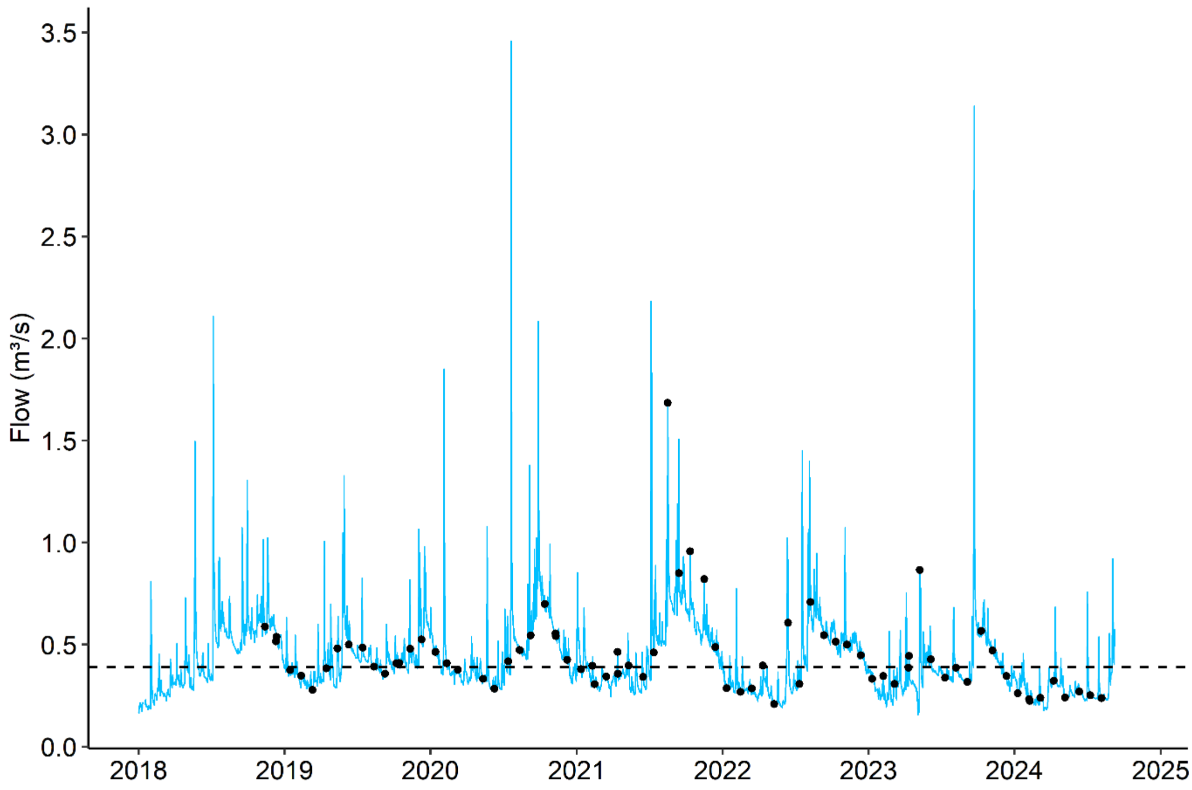

Figure 2: Mill Creek at Fish Trap mean daily flow (m^3/s), 2018 to 2024. Water quality monitoring occasions indicated by black points. The dashed line shows the median flow since October 2018 (0.383 m^3/s).

Continuous monitoring of turbidity has found that while there is high site-specific variation, turbidity readings have improved over time with generally lower and fewer intense spikes at the Downstream site and, to a lesser extent, at the Upstream site (Figure 3). CKL (2024) analysis of the turbidity data has found that in 2019, prior to construction activities in the creek, the turbidity levels at the Downstream site were more often worse than Upstream, while in recent years there has been a higher percentage of times when turbidity readings were better at the Downstream site than at the Upstream site. However, a comparison of ‘better’ or ‘worse’ values must be interpreted carefully as this does not incorporate the intensity of specific differences between sites. Overall, while turbidity at the Downstream site is often similar to, or marginally lower than, that observed in Upstream site (Figure 3), there is no consistent evidence to suggest that turbidity at the Downstream site is of ‘better’ quality overall. What is evident from the data is that although notable peaks in turbidity have still occurred at each site in recent years, the synchronicity in turbidity fluctuations at the Upstream and Downstream sites indicate that sediments were entering the creek from the upper catchment, and there were no notable sources of new sediments entering the stream from within the construction site.

Dissolved oxygen (DO) has been measured in Mill Creek at the Fish Trap from May 2023 to present day by dataloggers recording DO every five minutes. The data record shows the waters are well oxygenated, with DO saturation rarely going below 90%.

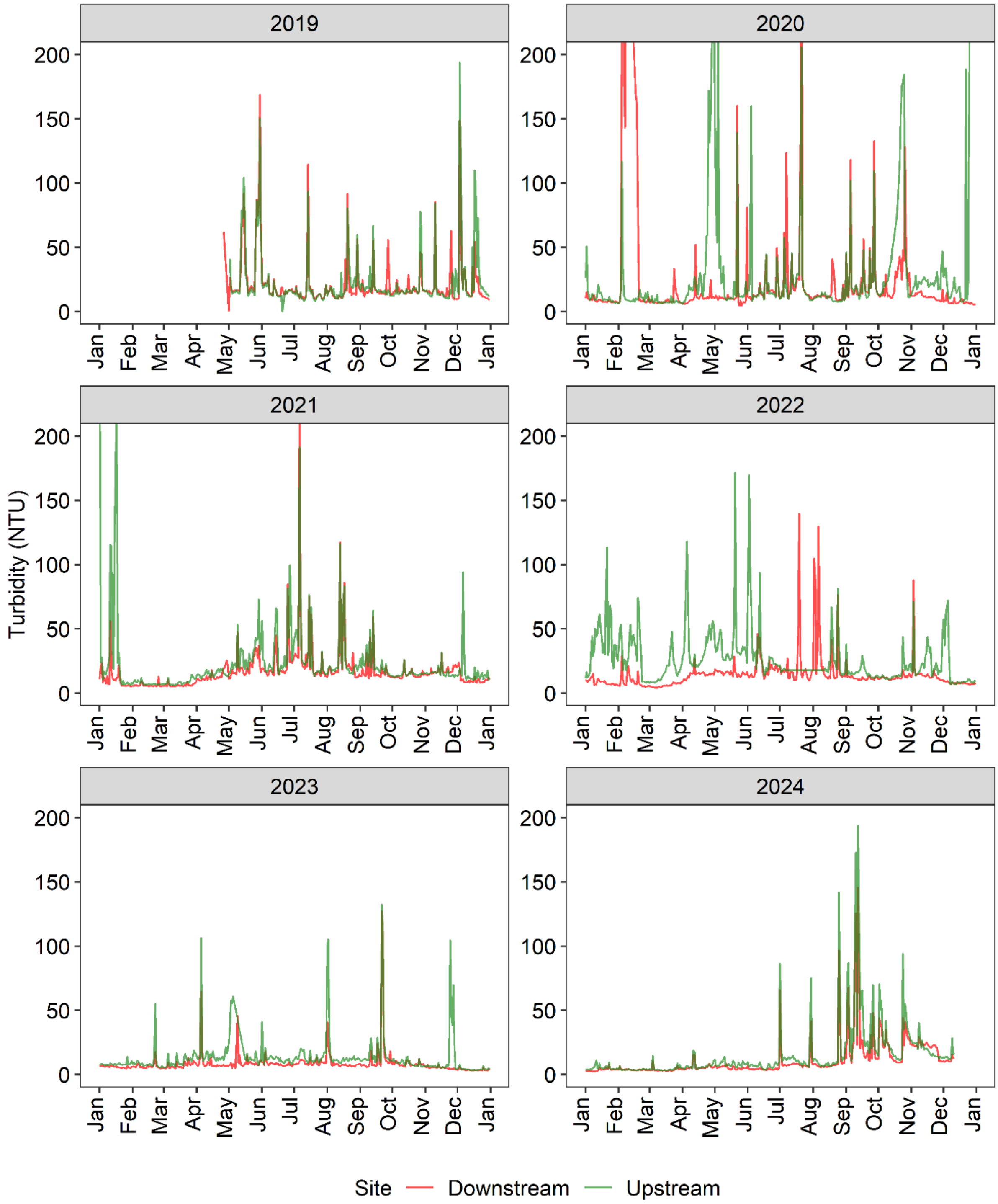

Figure 3: Turbidity (NTU), recorded by continuous monitoring loggers installed at the Downstream and Upstream monitoring sites, in Mill Creek between 2019 and 2024. Note y-axes are truncated for some years (i.e., 2020, 2021).

Comparisons of monthly sample data has found that the long-term trend for *Escherichia coli* concentrations at the Downstream and Boundary sites peaked around 2022 but have since decreased back to be similar to initial baseline levels and below the RPW limit (Figure 4a). While similar peaks in *E. coli* occurred at the Fish Trap and Upstream sites, no long-term trends were detected due to concentrations being more consistent, with fewer high concentrations (spikes), and lower overall. Similar patterns were detected for total suspended solids at the Boundary and Upstream sites (Figure 4c), and with turbidity (recorded during monthly sampling) at the Downstream, Boundary, and Upstream sites (Figure 4d), with each metric peaking around 2022 but decreasing to low levels in recent years. Note that turbidity levels in the 2023-2024 monitoring period were below the RPW limit for each site. Comparatively, pH levels have remained generally consistent over time (Figure 4b).

Nutrients

No long-term trends in dissolved reactive phosphorus (Figure 5a) or nitrate+nitrite nitrogen were detected at any Mill Creek site (Figure 5b). While dissolved reactive phosphorus has generally consistently remained below RPW limits throughout the entirety of the monitoring period to date, nitrate+nitrite nitrogen has consistently remained substantially higher than RPW limits at all Mill Creek sites. Elevated nitrogen concentrations at the Upstream site, and the absence of long-term shifts in nitrate+nitrite nitrogen, indicate these high concentrations were not a result of recent construction activities in or around Mill Creek.

Long-term shifts in ammoniacal nitrogen were detected at the Fish Trap and Boundary sites, which were associated with peaks around 2022 and declines in recent years, however such shifts were so minute that they would have minimal ecological influence (Figure 5c). Moreover, ammoniacal nitrogen at each Mill Creek site has consistently remained well below RPW limits since monitoring commenced. While a positive linear trend was detected in total nitrogen at the Fish Trap site between 2018 and 2022, it is likely that results for recent years, where there is unfortunately missing data, would have followed the subsequent declining trend observed in other metrics (Figure 5d). Similarly to turbidity, total phosphorus all sites except the Fish Trap site also peaked around 2022 and declined in recent years (Figure 5e).

Long-term water quality monitoring at Mill Creek shows that while many metrics worsened around 2022, there has been a steady improvement since, supported by enhancements to stream infrastructure such as stabilised banks and riparian plantings. Water quality is expected to remain stable as a result of these interventions. However, nitrate+nitrite nitrogen levels have remained consistently high across all sites since monitoring began, suggesting that these elevated nitrogen levels are likely attributed to groundwater and broader land use practices in the surrounding catchment, rather than recent construction.

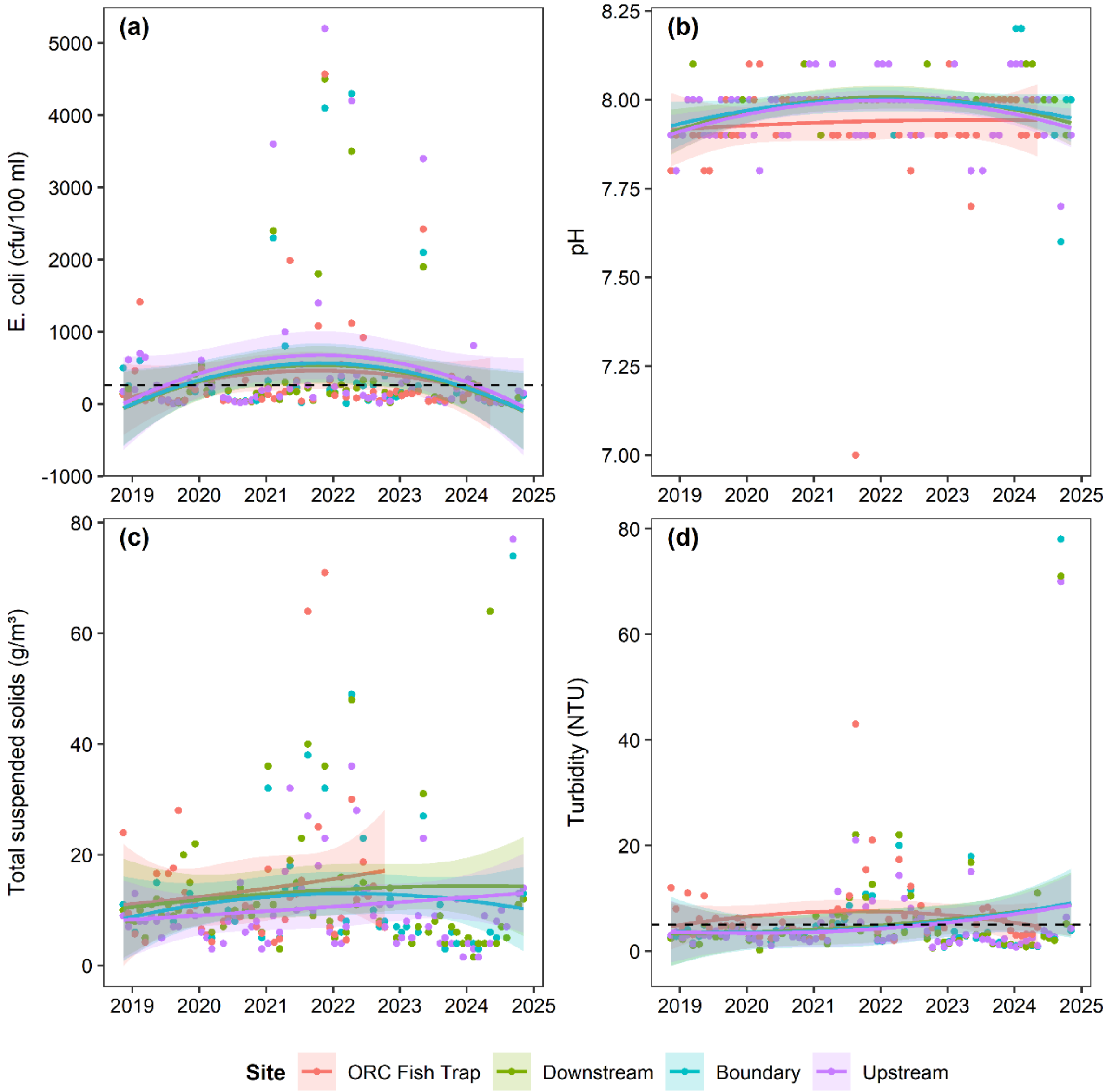

Figure 4: Long-term predicted trend (±95% confidence intervals) of physical and chemical water quality metrics at Mill Creek monitoring sites, 2019 to 2024. Dashed horizontal lines denote relevant RPW limits for *E. coli* (260 cfu/100 mL; 'a') and turbidity (5 NTU; 'd').

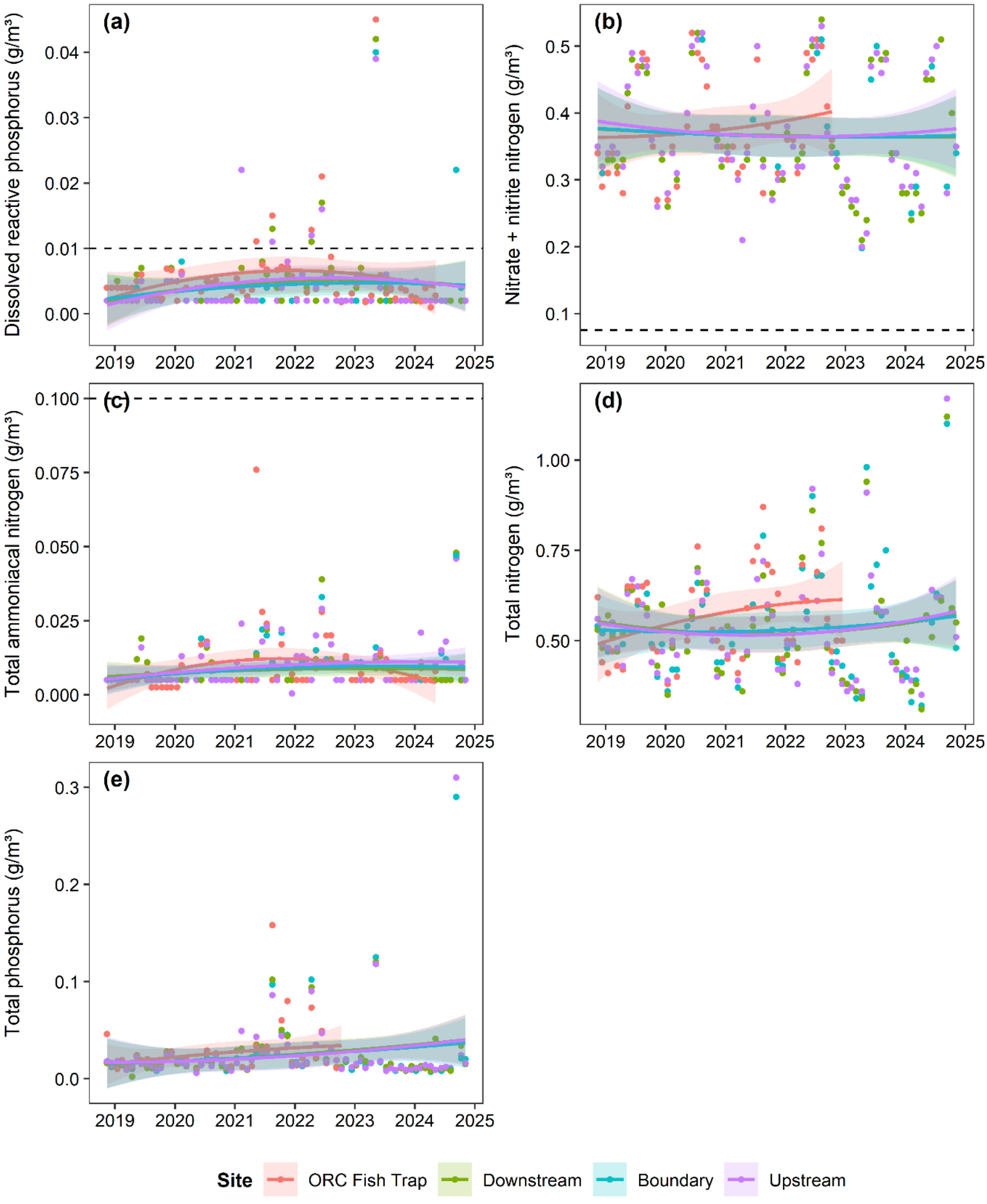

Figure 5: Long-term predicted trend (±95% confidence intervals) of nutrient concentrations at Mill Creek monitoring sites, 2019 to 2024. Dashed horizontal lines denote relevant RPW limits for dissolved reactive phosphorus (0.01 mg/L; 'a'), nitrate+nitrite nitrogen (0.075 mg/L; 'b'), total ammoniacal nitrogen (0.1 mg/L; 'c').

3.3 Instream substrate

Substrate particle size distribution has been assessed on an annual basis in Mill Creek across eight sites (Figure 6). As the 2024 sampling followed the completion of significant instream works (e.g., channel diversion, installation of instream structures), the 2024 results therefore indicate the expected longer-term substrate sizes. Substrates were highly diverse across the Mill Creek sites but were particularly so at sites near the Downstream monitoring site (substrate sites 1-3 in Figure 6) where most substrate classes were equally abundant (Figure 7). In contrast, sites further upstream, towards the Upstream monitoring site (substrate sites 6 and 8 in Figure 6), generally contained more large gravels and small cobbles. While there was some site-specific variation overall (e.g., median substrate size at Site 7 was comparatively lower than adjacent sites), these differences were likely underpinned by local stream structure and flow characteristics.

The preferred spawning habitat of brown trout is gravels within the size range 8 to 64 mm (i.e., small-medium to large gravels; Shirvell and Dungey 1983). Gravel substrates of this size were present in great proportions at most sites within Mill Creek in May 2024, but relatively less so at Sites 1, 2, 6, and 8; these substrate sites were located within observational reaches for trout where redd counts were found to be lowest overall.

Overall, the amount of fine clay/silt and sand particles at most sites was low (combined amount ≤ 20%), which is favourable for successful egg incubation; too much fine sediment can cause smothering of eggs within redds. There has been no indication that instream works associated with instream or bankside developments have resulted in any increase in fine sediments within Mill Creek to date.

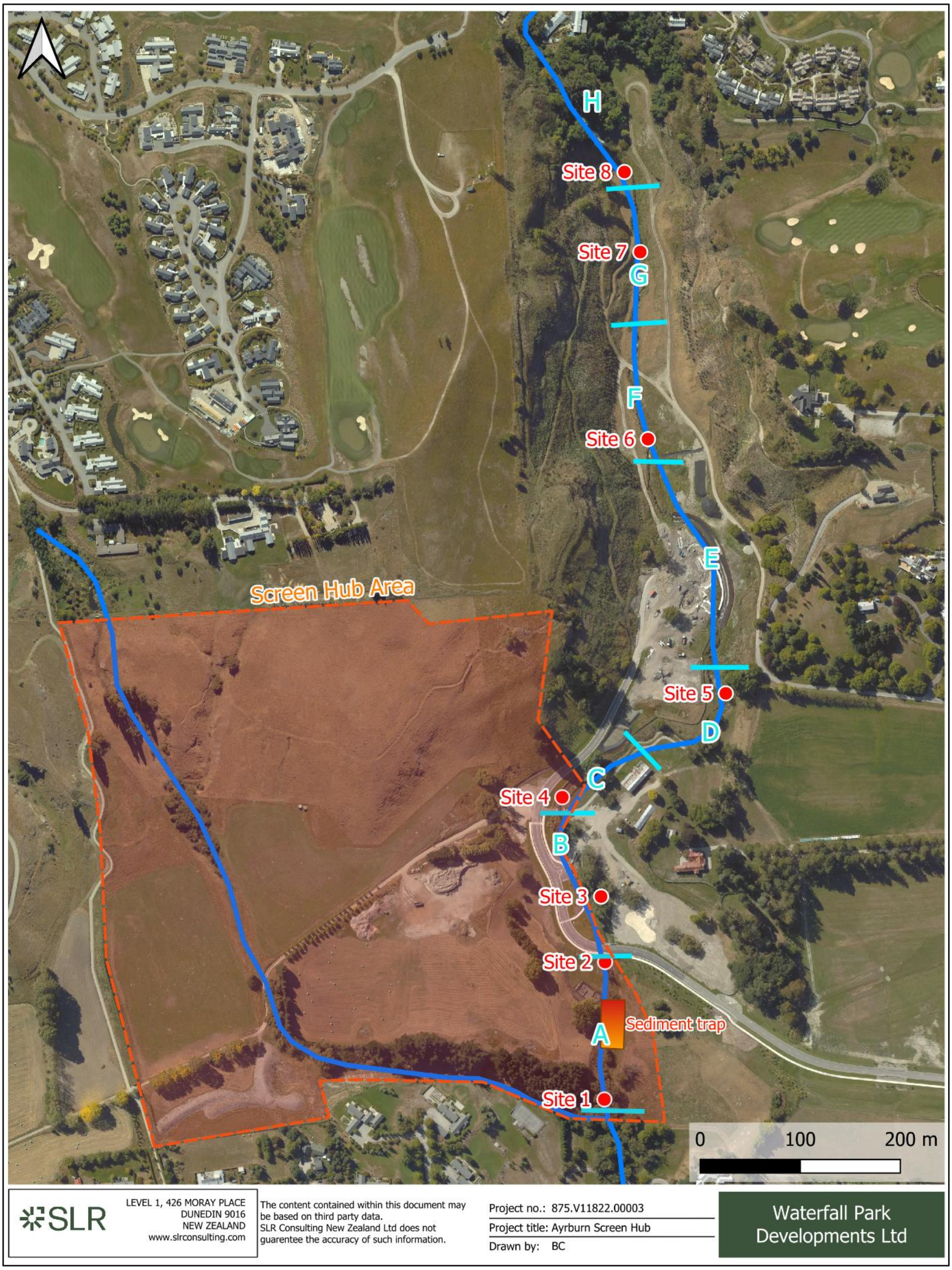

Figure 6. Map of the sediment sampling locations (numbered red points) and reaches used in bankside sports fish and redd surveys (lettered sections in light blue) in Mill Creek.

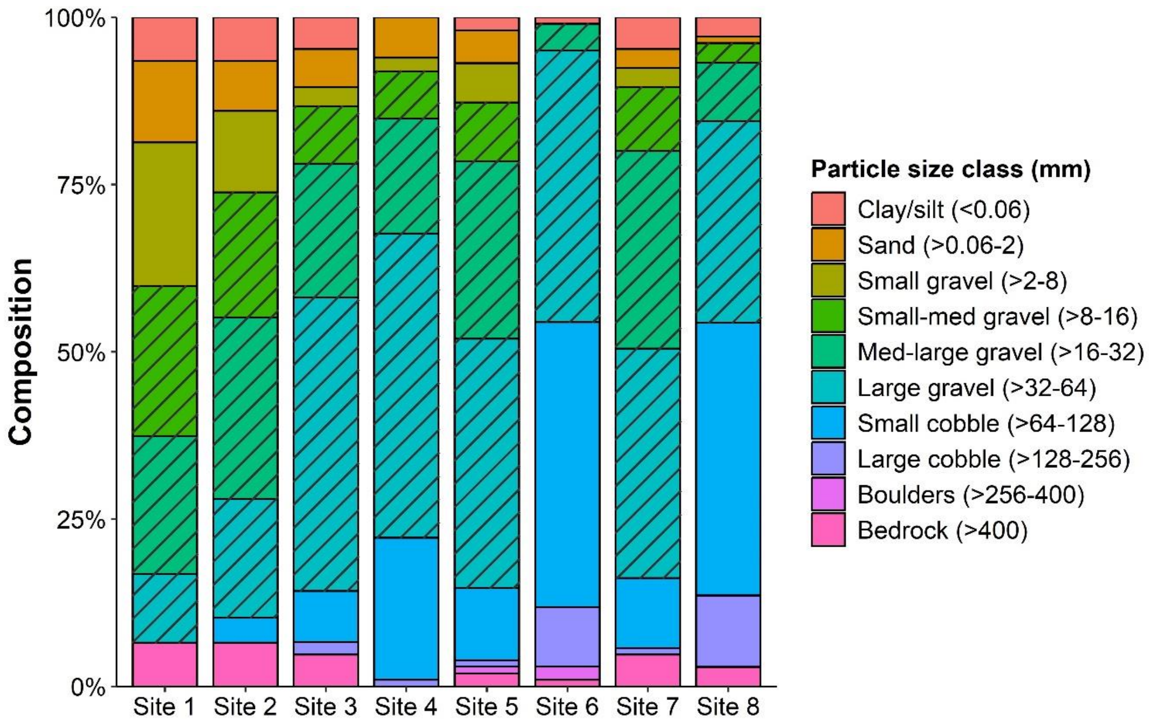

Figure 7: Composition of particle size classes in substrate samples across Mill Creek sites, May 2024. Site numbers in order from Downstream (1) to Upstream (8). Gravels suitable for trout spawning (size range 8 to 64 mm) are dashed.

3.4 Periphyton

Periphyton (algae) communities were sampled at each of the four Mill Creek water quality monitoring sites in January 2019 (REL 2020). Periphyton monitoring found that cover and biomass was typically low in Mill Creek within Waterfall Park, at the Boundary and Downstream sites. Higher periphyton levels were however observed further upstream, at the Upstream site. This difference was likely related to the variation in substrate between these sites, with the substrate upstream being dominated by larger and more stable substrates which are more favourable for periphyton growth than the smaller gravels found in downstream areas. Both mat and filamentous periphyton growth forms have been observed in Mill Creek, including the invasive algae *Didymosphenia geminata*.

Monitoring of periphyton communities was previously undertaken annually by the ORC at the Fish Trap site (discontinued in 2018). ORC periphyton biomass data from this site for 2011 to 2016 indicated ‘poor’ to ‘fair’ habitat quality (data sourced from the LAWA website; REL 2020), which is comparable to REL surveys.

No further sampling of periphyton in Mill Creek has occurred since 2019, however given the dominance of gravels throughout the creek, periphyton communities are expected to remain at low cover and biomass levels.

3.5 Benthic macroinvertebrates

A total of 24 benthic macroinvertebrate taxa were identified across the four Mill Creek sites in the most recent 2024 sampling event, with 16 taxa being found at the Upstream site, 20 taxa at Boundary, 17 taxa at Downstream, and 12 taxa at Fish Trap (Appendix B). Despite this site-specific range in taxa richness, the number of sensitive Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies) (EPT) taxa (excluding the more tolerant *Hydroptilidae*) was the same at all sites (six). However, the percentage of EPT taxa in invertebrate samples was higher at the Fish Trap site (50%) than other sites (30-38%). Overall, communities at each site were dominated by *Deleatidium* mayflies, *Pycnocentria* caddisflies, and *Potamopyrgus* snails. Following the scoring of Stark (1998), Macroinvertebrate Community Index (MCI) scores at all sites were indicative of 'fair'/'poor-fair' habitat quality, however the more ecologically robust semi-quantitative MCI (SQMCI) scores indicated that habitat quality at the Fish Trap and Downstream sites was 'excellent', Boundary was 'good' and Upstream was 'fair-good'.

Long-term macroinvertebrate monitoring suggests that overall taxa richness and EPT taxa richness has decreased at the Fish Trap and Upstream sites, whereas the Boundary and Downstream sites have remained relatively stable or inconsistently variable (Figure 8a,b). Percent EPT taxa richness has also remained stable or variable at all sites except at Fish Trap, where percent EPT richness has increased in recent years (Figure 8c).

Long-term MCI scores have consistently remained indicative of 'fair' habitat quality at all sites (Figure 8d). In contrast, SQMCI scores have remained variable but 'fair' on average at the Upstream site and variable between 'good' and 'excellent' at the Boundary site. SQMCI scores at the Fish Trap and Downstream sites have substantially improved over recent years, going from 'fair-good' to 'excellent' (Figure 8e).

Ultimately, the increased densities of sensitive macroinvertebrate taxa in recent years indicates that development works in Mill Creek have not negatively impacted the local macroinvertebrate communities. On the contrary, it is likely that the recent habitat improvements at Mill Creek have facilitated the development of a healthier freshwater ecosystem overall.

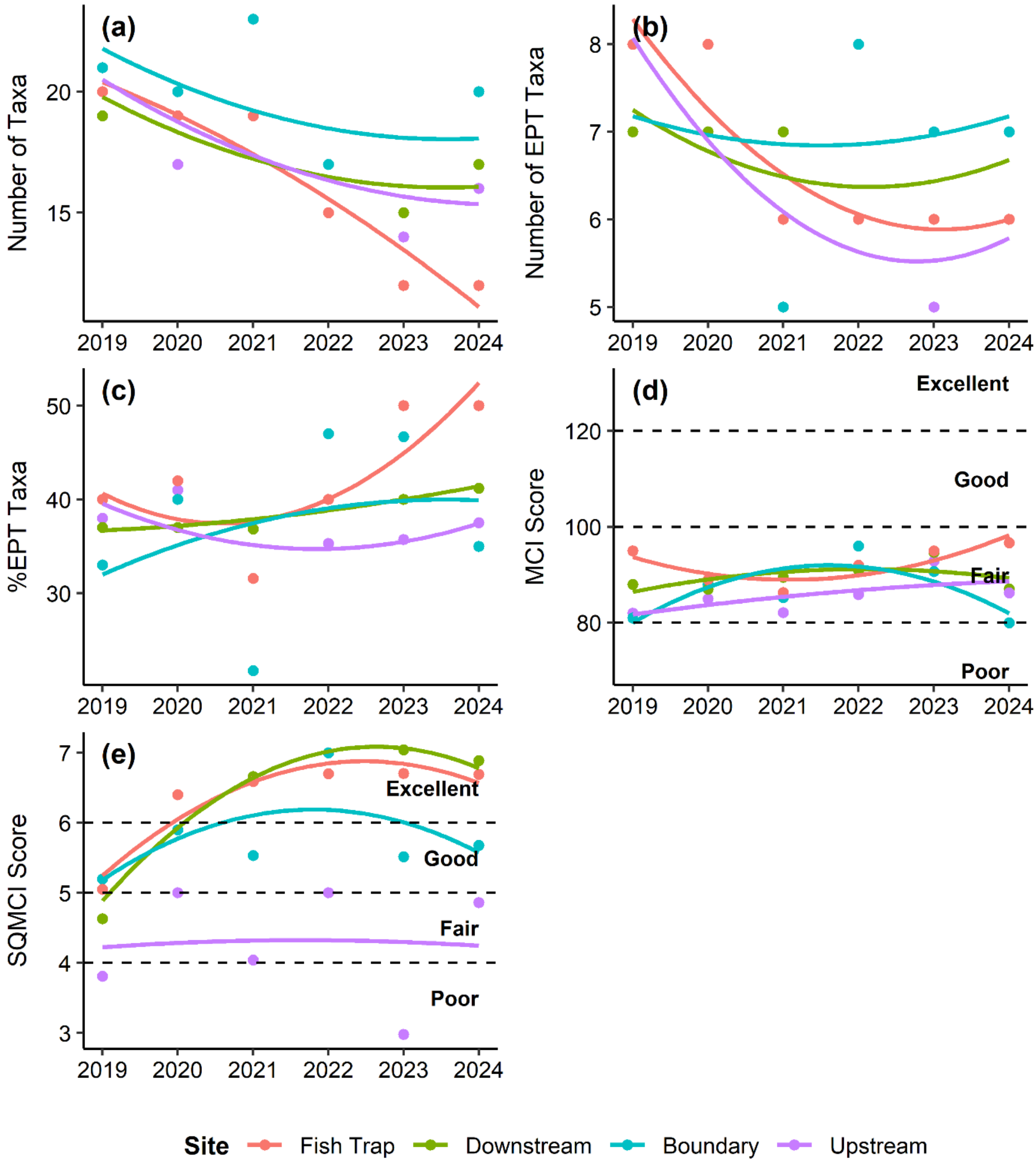

Figure 8: Long-term macroinvertebrate metrics across Mill Creek sites. Regression lines represent a line of best fit but may not accurately reflect trends due to the sample size being too small for reliable statistical analysis and when there is high metrics variability.

3.6 Fish

Fish species recorded from Mill Creek, based on replicate environmental DNA (eDNA) samples taken from the Fish Trap site in May 2023 (from Wilderlab[1]), include brown trout (*Salmo trutta*), common bully (*Gobiomorphus cotidianus*), Gollum galaxias (*Galaxias gollumoides*), grass carp (*Ctenopharyngodon idella*) and European perch (*Perca fluviatilis*). eDNA samples from Lake Hayes (in December 2023 and April 2024) found the same species, except for Gollum galaxias, and also found kōaro (*Galaxias brevipinnis*).

The presence of grass carp in the samples is suspected to have come from fish that escaped from authorised releases in contained ponds near Queenstown. The presence of Gollum galaxias is uncertain, given the known distribution of Gollum galaxias does not extend to the Clutha River catchment.

Records from the New Zealand Freshwater Fish Database indicate the presence of brown trout, common bullies, and kōaro in Mill Creek, with perch, common bully, and brown trout recorded in Lake Hayes.

Common bully is a native species with a conservation status of 'Not Threatened' (Dunn *et al.* 2018). Kōaro is a native species with a conservation status of 'At Risk – Declining' (Dunn *et al.* 2018). Brown trout and perch are both introduced sports fish species.

Only two of these fish species have been found in Mill Creek within the vicinity of Ayrburn Farm: brown trout and kōaro. An electric fishing survey undertaken in Mill Creek by REL in July 2018 found 19 juvenile brown trout (length range 55-115 mm) within the Ayrburn Farm area and two kōaro approximately 300 m further upstream.

Mill Creek is an important spawning tributary for brown trout. Since 2019, bankside observations of trout have been undertaken in May and June between the Downstream and Upstream sites, with the 2024 sampling also including an event in April. In 2024, a large population of brown trout was observed throughout Mill Creek, particularly in the mid to upper reaches where there was a greater availability of ideal spawning gravels (Figure 9a). The most significant activity was recorded during May and June, coinciding with the upstream migration of trout from Lake Hayes to spawn. Additionally, trout redds were most prominent in the mid reaches (Figure 9b), where ideal spawning gravels were abundant. Redd counts were notably higher in May, suggesting that this was the peak spawning period.

Long-term trout observations have either remained stable but low or have declined in recent years and redd counts have increased in upper-mid catchment reaches. It is important to note that there will be high variability with bankside trout observations used to determine trout population size in Mill Creek due to the high availability of instream refuges (e.g., steep/undercut banks) and the increased cover provided by riparian plantings. While instream refuges and riparian vegetation can obstruct trout observations, these characteristics provide many positive benefits including being ideal habitats for trout and the broader stream ecosystem. Moreover, although some reaches may appear to not have good spawning conditions, these distinct habitats are likely still valuable refuge, nursery, or feeding grounds for juvenile trout or native fish species that will generally be missed when undertaking bankside surveys.

[1] https://www.wilderlab.co.nz/explore

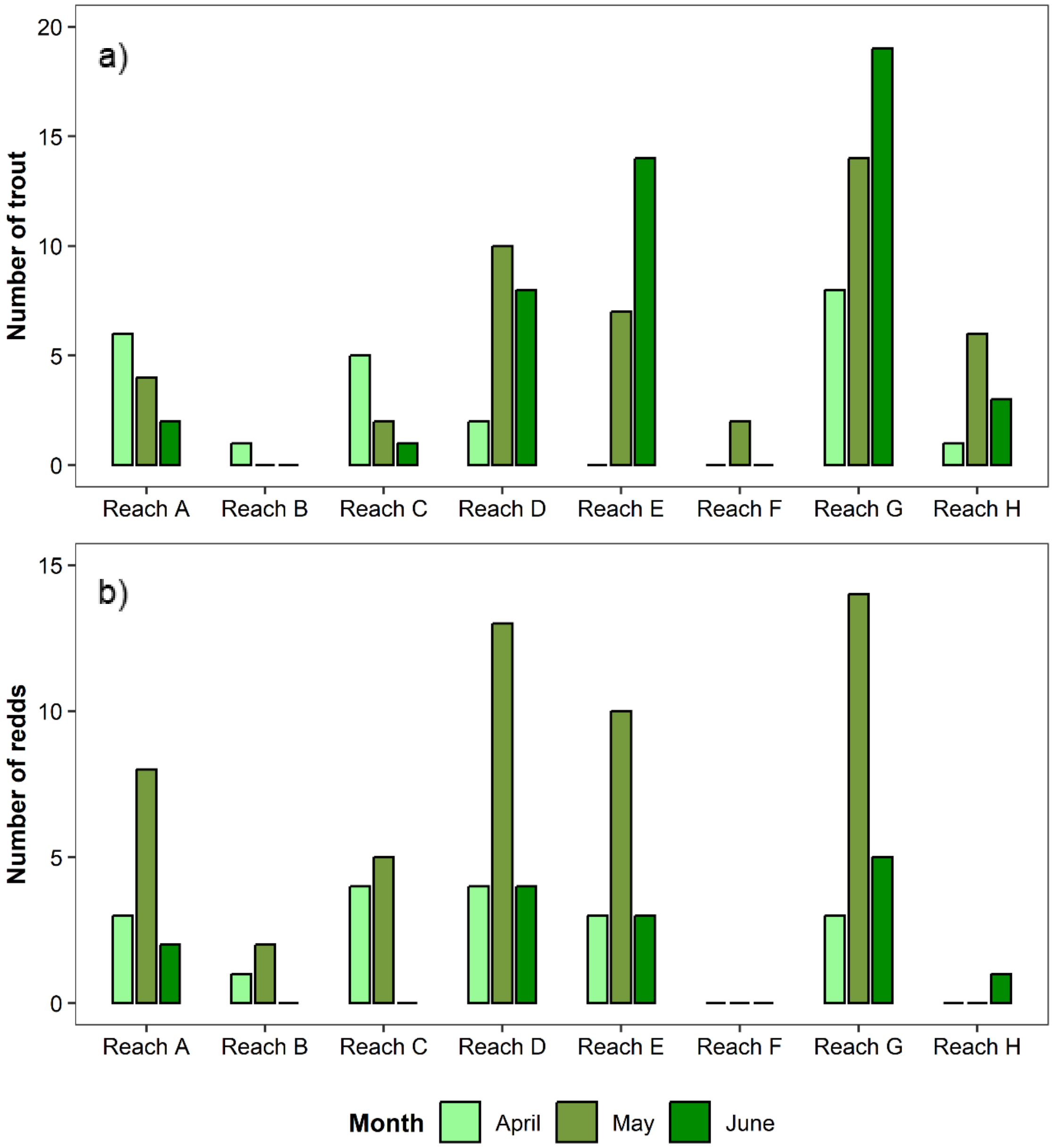

Figure 9: Number of brown trout (a) and redds (b) observed across Mill Creek reaches, 2024. Reaches in order from downstream (Reach A) to upstream (Reach H) (see Figure 6).

3.7 Summary

Overall, the current state of the aquatic ecosystem in Mill Creek is of generally good quality and while several long-term water quality metrics worsened around 2022, all metrics have decreased back to low baseline levels in 2024. Moreover, with more stable and less disturbed instream and riparian habitats, Mill Creek water quality will likely remain more consistently healthy in the long-term. Notably, in 2024 sampling, all water quality metrics met relevant RPW limits except nitrate+nitrite nitrogen, which has remained consistently variable but high since monitoring commenced. These consistently high nitrogen levels suggest that they were not directly related to the construction activities in Waterfall Park, but rather were more likely due to unrelated activities in the upper catchment. Despite the western ephemeral tributary being unable to support a healthy ecosystem, Mill Creek supports a healthy macroinvertebrate community and adequate feeding, refuge, and breeding grounds for a relatively large trout population.

4.0 Assessment of effects

4.1 Sediment trap

The creation of an in-line sediment trap (50 m long by 12 m wide) in Mill Creek will result in disturbance of the stream bed, the alteration of instream habitat, and will require stream diversions and dewatering.

The installation of an in-line sediment trap (see Figure 10 for smaller examples located in the upper Mill Creek catchment) will necessitate the temporary diversion of Mill Creek and the direct disturbance of the streambed. Stream diversions can isolate water containing fish and macroinvertebrates, directly reducing available habitat for aquatic communities, and dewatering of the isolated area can directly remove the animals from the river. Timing of diversions need to be carefully managed to avoid potential spawning periods for fish, as dewatering can isolate spawning areas from flowing water which is required to support development of fish eggs/larvae. Timing of works between January and March will avoid the spawning and migrating periods for fish potentially present in the area, however adults and larval fish could be present. Fish are likely to avoid disturbed areas, but fish salvages will be required during the trap construction when the stream is dewatered and diverted. Following diversion of the stream, and fish salvage, disturbance of the isolated stream bed should be completed under dry conditions to ensure sediment discharges into downstream environments is minimised.

The sediment trap will be positioned between sediment sampling sites 1 and 2 (see Figure 6), areas characterised by a diverse range of sediment sizes and moderate suitability for trout spawning (Figure 7). Additionally, the ‘Downstream’ macroinvertebrate site, located just below the sediment trap, and the ‘Fish Trap’ site further downstream, both offer habitats of ‘Excellent’ quality based on SQMCI scores. The streambed modification for the sediment trap will also take place within a known trout spawning area (‘Reach A’ in Figure 6), where between 2-6 adult trout and 2-8 redds were observed during the 2024 bankside sports fish surveys (Figure 9). Note that bankside fish surveys do not provide an accurate representation of fish densities or community composition in the direct construction area. While the project will result in the direct loss of some spawning habitat and high-quality macroinvertebrate habitat, the sediment trap is expected to enhance downstream spawning sites and improve rearing conditions in Lake Hayes by reducing the accumulation of fine sediment. Moreover, sediment traps are known to often be used as pool refuges which provide low flow resting and feeding habitats for freshwater fish. The suitability for the sediment trap to provide fish habitat will also be enhanced by riparian plantings which provide shading and cover.

Figure 10: Examples of existing sediment traps located in the upper Mill Creek catchment. Top photo from Friends of Lake Hayes. Bottom photo from Mana Tāhuna Charitable Trust (2023).

4.2 Sediment trap maintenance

The maintenance of the sediment trap will involve temporarily diverting Mill Creek through a bypass channel to allow for the excavation of accumulated sediment. As with the initial sediment trap installation, fish salvages will be required to safely remove fish first from the sediment trap when water is diverted and later from the bypass channel when water is redirected back over the trap. If a water intake pump is utilised at any stage (e.g., to remove residual water from the trap), the pump inlet must be equipped with an appropriately designed fish screen to prevent the ingress of small fish.

Excavation of trapped sediment is likely to result in a brief sediment flush into Mill Creek when the trap is rewetted, either from residual sediments within the trap or from material that has accumulated in the bypass channel. To mitigate environmental impacts, the trap should be rewetted slowly by rediverting a small portion of the main flow through until the trap is full and running at a similar turbidity to the creek. The excavated sediment must be transported to a suitable disposal site, such as an approved clean fill dump site or an area positioned in a suitable location, sufficiently far from waterways and stabilised with grass to eliminate the risk of runoff and subsequent resuspension into aquatic systems.

Regular monitoring of sediment levels within the trap is essential to ensure timely emptying before it becomes excessively full, which could compromise its ability to effectively capture and settle sediments. It is also important to consider the potential for high-flow events to scour and mobilise previously settled sediment, which could contribute to unintended releases. Therefore, maintenance practices must strike a balance between the frequency of sediment removal (to manage costs and minimize the disturbance caused by sediment plumes) and the effectiveness of the trap in reducing sediment resuspension risks. This balanced approach will ensure the trap remains functional while minimising ecological impacts.

4.3 Sediment discharge during construction

Without proper erosion and sediment control, sediment discharge is possible during construction of the sediment trap and Ayrburn Screen Hub development, especially through surface runoff during high rainfall and works in and adjacent to Mill Creek. Sediment discharges can affect water quality and downstream macroinvertebrate and fish communities by altering the water's chemical and physical properties and affecting periphyton, a food source for invertebrates. Moreover, increased sedimentation can fill refuges and interstitial gaps between boulders and coarse gravels which are key refuges and spawning grounds for macroinvertebrates and fish.

It is recommended that bulk earthworks are undertaken in spring and summer when periods of fine weather are more frequent. The use of ‘clean water’ diversion channels, to capture and divert water from surfaces above the exposed works sites and convey the water around earthworks, should reduce the amount of water moving through disturbed sites. Additionally, the use of ‘dirty water’ diversion channels, to capture and carry sediment-laden stormwater to sediment retention ponds, should reduce the potential for sediment inputs to waterways. The use of sediment retention ponds, including existing ponds used for previous works associated with the Ayrburn Development, will allow for sediments to settle out from the water column. It is recommended that water quality is monitored at the outlet of the sediment retention pond to ensure contributions to Mill Creek are not ecologically harmful.

Ultimately, considering best-practice erosion and sediment controls and guidelines are followed during the development of the proposed stormwater management system, sediment retention ponds, and sediment trap, the effects of sediment discharges during construction on aquatic life will be no more than minor.

4.4 Contaminant spills and pest introduction

The presence of construction machinery on site presents a risk of contaminants (e.g., diesel, lubricants) entering watercourses, with the potential to harm aquatic life. Machinery brought to the site from elsewhere may also spread pest species. While didymo has been historically found in Mill Creek, care should still be applied to prevent further spread throughout Mill Creek and to other local watercourses, especially near waterways following construction.

Best-practice guidelines recommend that:

- Storage of chemicals and fuels will be as far as practicably possible from waterways and concentrated flows, and the refuelling of machinery will occur in a designated refueling bay.
- All waste outputs are mitigated and removed from site.
- Weeds will be treated prior to disturbance of natural surfaces, with weed free topsoil retained for reuse.

Considering such guidelines are followed, the effects of contaminant discharges on aquatic life will be no more than minor.

4.5 Concrete

Careful management of concrete use during the construction phase is essential to minimise environmental risks, particularly near waterways. Concrete-related activities can pose a significant threat to aquatic ecosystems, as concrete dust, runoff from fresh concrete, and the washing of concrete equipment can introduce harmful contaminants into the water. These contaminants, such as lime, can rapidly increase the pH to highly alkaline levels, compromising water quality and potentially leading to fish kills and other ecological disturbances.

To mitigate these risks, concrete should only be used under controlled conditions. Specifically, all concrete work should be carried out during dry weather and confined to dry riverbeds to prevent materials from entering water systems. Furthermore, strict protocols for handling, washing, and disposing of concrete and related materials should be implemented to further safeguard the surrounding environment. Regular monitoring and contingency plans should also be in place to promptly address any accidental discharges.

4.6 Stormwater discharge post development

Following the completion of construction activities, future stormwater discharges can contain contaminants (e.g., suspended sediments, oxygen demanding substances, toxicants, and elevated nutrient levels) that can have different water quality attribute values (e.g., temperature, conductivity) to current discharges and therefore have the potential to adversely affect water quality and ecological communities in the receiving water of Mill Creek.

The proposed stormwater management concept for the Ayrburn Development provides for collection of stormwater runoff from roofs, roads, and open space and conveyance in a network system of gardens and wetlands leading to a stormwater detention pond, developed as part of the long-term stormwater management system for the site. Stormwater management for the Screen Hub area includes a network of sediment detention ponds, rain gardens, engineered wetlands, and a treatment pond that will regulate sediment and water run-off from the area. For frequent minor rainfall events, the infiltration of water to ground in the swales, rain gardens, and treatment pond would minimise the discharge of stormwater from the additional impervious surfaces to Mill Creek. It is possible that the lower reaches of the ephemeral tributary will receive less stormwater runoff due to the placement of intercepting diversion channels in the western development area, which could lead to increased desiccation events.

Although the greater stormwater drainage can contain contaminants, the stormwater detention pond and other stormwater management features should mitigate these inputs by allowing contaminants to settle. Moreover, in storm events the pond should capture and treat the “first flush” (i.e., the initial runoff from the surface), which typically carries the highest load of contaminants.

4.7 Positive effects

The proposed development will result in a change of land use for Ayrburn Farm, with existing land use including a vineyard, carpark, storage area for developments, and open pasture. Associated with this land use change could be a reduction in nutrient loss through leaching to groundwater. The groundwater system below Ayrburn Farm is connected to Lake Hayes, with groundwater from the Mid Mill Creek Aquifer emerging to the surface at Rutherford Road Springs and discharging to the lake from the north-western edge (Rekker 2020).

The overall goal of the Lake Hayes Management Strategy (ORC 1995) is ‘To improve the water quality of Lake Hayes, to achieve a standard suitable for contact recreation year round and to prevent further algal blooms’. A major concern for the management of the lake has been reducing phosphorus inputs to the lake (ORC 1995, Hydrosphere Research 2017). Phosphorus inputs are a particular concern because phosphorus binds to sediments, typically in the form of phosphate, through adsorption or incorporation into minerals. Under certain conditions, such as low oxygen levels (anoxia) in the bottom waters, phosphorus can be released back into the water column. This release promotes the growth of algae and aquatic plants, leading to eutrophication, a process where excessive nutrients cause algal blooms, reduced water clarity, oxygen depletion, and harm to aquatic ecosystems. Over time, this cycle can degrade water quality and biodiversity in lakes.

The main source of phosphorus to the lake is through surface water, predominantly via Mill Creek. Phosphorus losses from Ayrburn Farm under the land use at the time of an assessment in 2020 were estimated at 4 kg/year (Mudge and Lee 2020). Phosphorus is primarily lost via run-off from the land, particularly during high rainfall events, with the erosion and mobilisation of sediment carrying particulate phosphorus within surface water. Stormwater management at Ayrburn will help reduce sediment inputs to Mill Creek. During high rainfall events the ephemeral watercourse will also transport phosphorus lost from the surrounding land to Mill Creek (and ultimately Lake Hayes). For most of its length, the ephemeral watercourse is currently open and its banks dominated by pasture grasses. Proposed riparian planting in these areas will be beneficial to shade the watercourse and help filter any runoff to the channel.

The proposed land use change to the Screen Hub can be expected to reduce phosphorus and faecal bacteria inputs to surface water through the installation of some hard surfaces (i.e. preventing surface erosion), the revegetation of the ephemeral watercourse, and the stormwater detention pond will also capture and treat the “first flush” runoff, which typically carries the highest sediment load.

Hudson *et al.* (2023; a NIWA report) estimated contaminant loads entering Lake Hayes from the Mill Creek catchment and estimated approximately 81% of the total phosphorus load entering Lake Hayes entered Mill Creek upstream of the Waterfall Park area. Hudson *et al*.

(2023) recommended reviewing the mitigation actions proposed by Goeller *et al.* (2020[2]; a NIWA report), which was a report scoping diffuse pollution mitigation options for Mill Creek. According to Hudson *et al.* (2023), these mitigation actions included maintaining and restoring existing wetlands and riparian buffers, constructing sediment traps along the main stem of Mill Creek to capture total suspended solids and total phosphorus, livestock exclusion (particularly in the upper catchment), channel restoration in the lower catchment to slow movement of water and reduce bank erosion, re-establishing riparian vegetation and making use of riparian buffer elements such as grass filter strips, mixed vegetation buffers and shrubs and trees. Many of these recommendations, such as riparian vegetation and buffers, channel restoration, and livestock exclusion, have already been implemented as part of the wider Waterfall Park development and are proposed as part of the proposed Screen Hub development.

The proposed sediment trap (50 m long by 12 m wide) in the main stem of Mill Creek is estimated to be able to capture and hold 1,500 tonnes (900 m^3) of sediment. Calculations on water velocities and sedimentation are discussed in the CKL (2025) Stormwater Management Plan. This sediment trap is a further implementation of the mitigation actions proposed by Goeller *et al.* (2020) and will likely also provide significant benefits to the lower reaches of Mill Creek and especially to Lake Hayes. Comparatively, a similar existing sediment trap in the upper Mill Creek catchment, which is 30 m in length and 12 m wide, collected approximately 700 tonnes (360 m^3) of sediment in 11 months. With the majority of phosphorus and sediment inputs entering Mill Creek in the upper catchment, the location of this larger sediment trap at the Ayrburn Farm lower in the Mill Creek catchment will not only mitigate any sediment inputs locally around the site, but also the more substantial inputs originating from the broader catchment. Regular excavation of sediment from the trap is proposed and will be required by consent conditions volunteered by WPDL, to ensure the trap remains effective at capturing sediments from the wider catchment and significantly reducing sediment inputs into Lake Hayes.

Overall, the proposed developments associated with the Screen Hub and specifically the addition of a large sediment trap low in the Mill Creek catchment should provide further ecological benefits and improvements to the local area of Mill Creek through to Lake Hayes itself. Notably, these proposed works, in addition to the extensive works stabilising and planting the banks of Mill Creek throughout the Waterfall Park development area, will contribute significantly to reducing sediment and phosphorus loads entering the waterway. The combined impact of these measures is anticipated to mitigate nutrient loss, enhance water quality, and promote ecological health. By addressing key sources of phosphorus and sedimentation, these initiatives align with other initiatives to support the long-term goal of improving the water clarity and ecological balance of Lake Hayes, while also demonstrating a commitment to sustainable land use and environmental stewardship in the region.

[2] Goeller, B.C., Sukias, J., and Hughes, A. 2020. Scoping of diffuse pollution mitigation options for Mill Creek. NIWA client report prepared for Friends of Lake Hayes Society, Inc., Otago Regional Council, Queenstown Lakes District Council, Department of Conservation, 2020009HN: 71.

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6.0 Closure

Sincerely,

SLR Consulting New Zealand

Ben Crichton, PhD
Project Consultant

Ben Ludgate
Principal Ecologist

7.0 Feedback

At SLR, we are committed to delivering professional quality service to our clients. We are constantly looking for ways to improve the quality of our deliverables and our service to our clients. Client feedback is a valuable tool in helping us prioritise services and resources according to our client needs.

To achieve this, your feedback on the team's performance, deliverables and service are valuable and SLR welcome all feedback via https://www.slrconsulting.com/en/feedback. We recognise the value of your time and we will make a $10 donation to our Charity Partner - Lifeline, for every completed form.

Appendix A Mill Creek Water Quality Site Photographs

Ecology Assessment

Ayrburn Screen Hub

Waterfall Park Developments Limited

SLR Project No.: 875.V11822.00003

4 February 2025

Figure A.1: Mill Creek, 'Fish Trap' monitoring site, 2024.

Figure A.2: Mill Creek, 'Downstream' monitoring site, 2024.

Figure A.3: Mill Creek, 'Boundary' monitoring site, 2024.

Figure A.4: Mill Creek, 'Upstream' monitoring site, 2024.

Appendix B Mill Creek Macroinvertebrate Community 2024

Ecology Assessment

Ayrburn Screen Hub

Waterfall Park Developments Limited

SLR Project No.: 875.V11822.00003

4 February 2025

Table B.1: Benthic macroinvertebrate communities in Mill Creek, May 2024. Coded abundance categories from Stark (1998). Sites in order from downstream to upstream.

ORDER	TAXON	MCI tolerance value	Fish Trap	Downstream	Boundary	Upstream
COLEOPTERA	Elmidae	6	A	A	R	R
CRUSTACEA	Ostracoda	3	R		C	C
DIPTERA	*Austrosimulium*	3		R	R	R
	Empididae	3			R	R
	Maoridiamesa	3		C	VVA	A
	Mischoderus	4	R			
	Muscidae	3	R		R	R
	Orthocladiinae	2		C	R	A
	Paralimnophila	6		R		
	Tanytarsini	3			R	
EPHEMEROPTERA	*Deleatidium*	8	VVA	VVA	VVA	A
MOLLUSCA	*Gyraulus*	3		R	C	C
	Physa = Physella	3		R		
	Potamopyrgus	4	A	VA	VA	VA
	Sphaeriidae	3		R	C	
NEMATODA	NEMATODA	3			R	
OLIGOCHAETA	OLIGOCHAETA	1	VA	A	A	A
TRICHOPTERA	*Hudsonema*	6		A	C	R
	Hydrobiosis	5	C		C	R
	Hydropsyche - Aoteapsyche	4	R	A	VA	R
	Oxyethira	2		R	R	
	Psilochorema	8	C	C	C	R
	Pycnocentria	7	VA	VA	VVA	VA
	Pycnocentrodes	5	A	C		
Number of taxa			**12**	**17**	**20**	**16**
Number of EPT taxa (incl. Hydroptilidae)			**6**	**7**	**7**	**6**
Number of EPT taxa (excl. Hydroptilidae)			**6**	**6**	**6**	**6**
% EPT taxa (incl. Hydroptilidae)			**50**	**41**	**35**	**38**
% EPT taxa (excl. Hydroptilidae)			**50**	**35**	**30**	**38**
MCI score			**97**	**87**	**80**	**86**
SQMCI score			**6.7**	**6.9**	**5.7**	**4.9**

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