Draft Memo

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To	Kaikoura Zone Committee
CC	
From	Kimberley Dynes

Annual lowland streams water quality update to the Kaikoura Zone Committee

1 INTRODUCTION AND PURPOSE

The Kaikoura Zone Committee have requested regular updates for water quality and ecosystem health in lowland streams, in particular Waikōau/Lyell Creek. Lowland stream water quality and ecosystem health monitoring is carried out for both Waikōau/Lyell Creek and Middle Creek. This report aims to provide an annual update explaining the current state and long-term trends for lowland stream sites in Kaikoura.

2 NUTRIENTS

Nitrogen and phosphorus are key nutrients available in water, which aquatic plants and algae need to grow. Nutrients taken up by plants in their dissolved forms are known as the plant available component. If nutrient concentrations in streams reach high enough levels, the algae and plants can grow in such large quantities that they become a nuisance; smothering or choking waterways. Smothered and choked waterways can cause flooding and a reduction in stream habitats for fish, bugs (hereafter referred to as invertebrates) and other aquatic animals. Large growths of aquatic plants and algae can severely reduce or eliminate oxygen in the water, leading to illnesses and death in fish and invertebrate (bug) populations.

Nutrients can be transported to waterways via various pathways such as overland flow and surface water run-off, or via soil peculation to groundwater; depending on the nutrient.

2.1 Phosphorus

Phosphorus can be either particulate or dissolved. The dissolved form is more readily available for plant uptake. Phosphorus binds to soil particles and consequently is not easily leached through the soil, therefore overland flow is the dominant mechanism of phosphorus transport into waterways. Sources of phosphorus include wastewater, animal effluent, phosphatic fertilizers and phosphatic rocks/soils. During periods of heavy rainfall and subsequent high flows, phosphorus concentrations can become elevated due to increased overland flow. While the immediate flux of nutrients can be short lived, the particulate phosphorus can settle out with sediment on the stream bottom and can be released under anoxic conditions or re-suspended in the water column due to disturbance of the stream bed.

Dissolved reactive phosphorus (DRP) concentrations are generally greater for the Waikōau/Lyell Creek catchment compared to Middle Creek (Figure 1). DRP concentrations in Waikōau/Lyell Creek increase with distance downstream, with the Warren Creek tributary showing greater concentrations than the mainstem site upstream at Mill Rd. Over the past 10 years, DRP concentrations for the SH1 site have shown a significant increase. Since 2013, DRP concentrations for SH1 have been elevated in comparison to the Warren Creek tributary site and the upstream site at Mill Rd.

Post-earthquake, phosphorus concentrations initially increased in the Warren Creek tributary. Similar concentrations were observed downstream for Waikōau/Lyell Creek at SH1 and the Lagoon. Since May 2017, these concentrations have decreased.

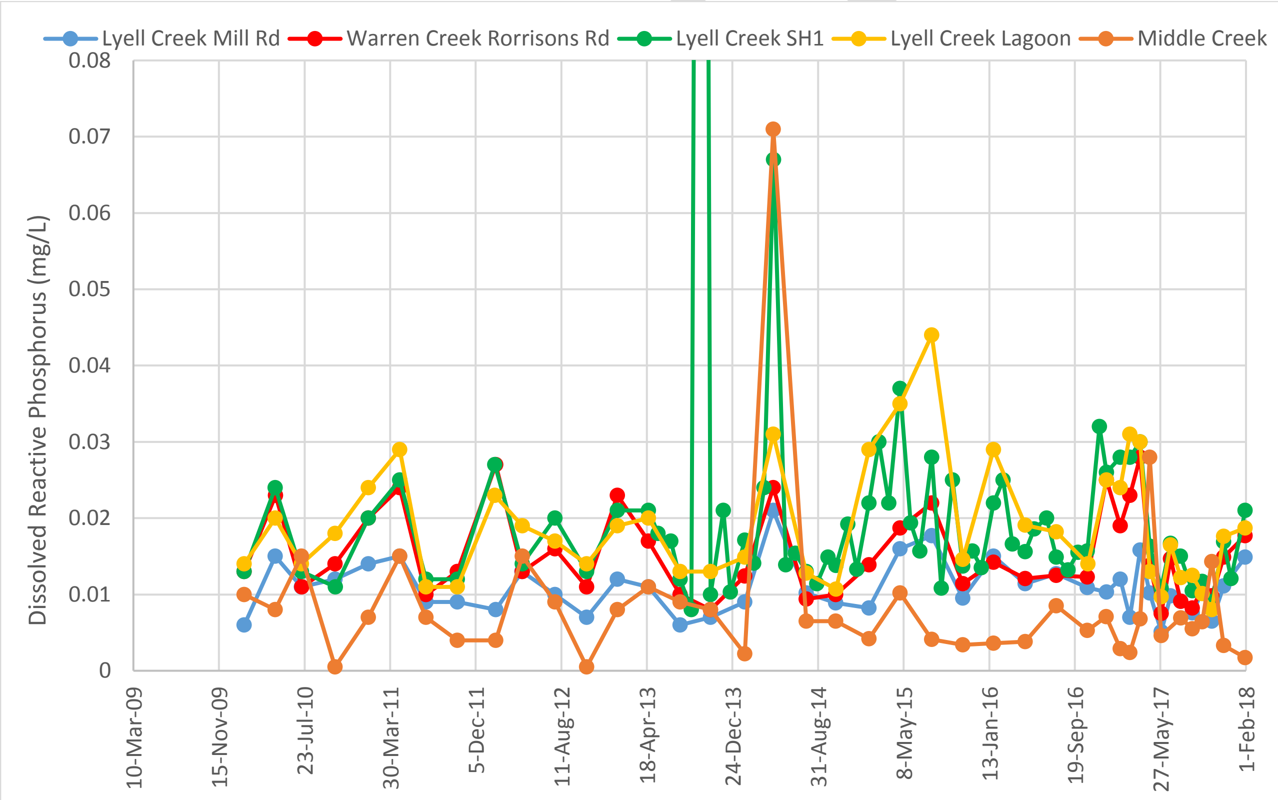

Figure 1: Dissolved Reactive Phosphorus concentrations in Waikōau/Lyell Creek and Middle Creek

2.2 Nitrogen

Nitrogen is an essential plant nutrient and a natural element of any soil. Nitrogen forms can come from a range of sources including fertiliser applications, effluent disposal, urine patches in paddocks, the breakdown of dead plant matter (grass or straw), seasonal die-off of legumes (Clovers, Lucerne, etc.), and animal or human faeces. Bacteria and other bugs in the soil or water break this nitrogen down. There are different chemical forms of nitrogen.

Some forms (including nitrite-nitrate nitrogen and ammonium-nitrogen) can be dissolved in water, and in this state, are available for uptake by aquatic plants.

Elevated ammoniacal-nitrogen and nitrate concentrations allow for nuisance algal growths in streams, however at even higher concentrations can become toxic to aquatic invertebrate and fish species. Nitrate and ammonia toxicity can influence the growth, reproduction and health of fish, invertebrates and other aquatic organisms.

Total ammoniacal nitrogen (NH4-N) concentrations show a similar trend between sites, with the exception of some spikes for Waikōau/Lyell Creek at SH1 (Figure 2). Over the past 10 - years, NH4-N concentrations have shown a significant decrease for Waikōau/Lyell Creek at Mill Rd and SH1, and Middle Creek. NH4-N concentrations do not exceed ammonia toxicity guidelines at the 95% species protection level, as described in the '*National Policy Statement for Freshwater Management*' (MfE, 2017).

Post-earthquake NH4-N concentrations initially increased for Warren Creek, and Waikōau/Lyell Creek downstream of the Warren Creek tributary (SH1 and the Lagoon). This showed a similar trend to phosphorus concentrations at these sites. During the wetter winter months in 2017, NH4-N concentrations remained elevated. These concentrations have decreased over the summer months to concentrations similar to those observed pre-earthquake.

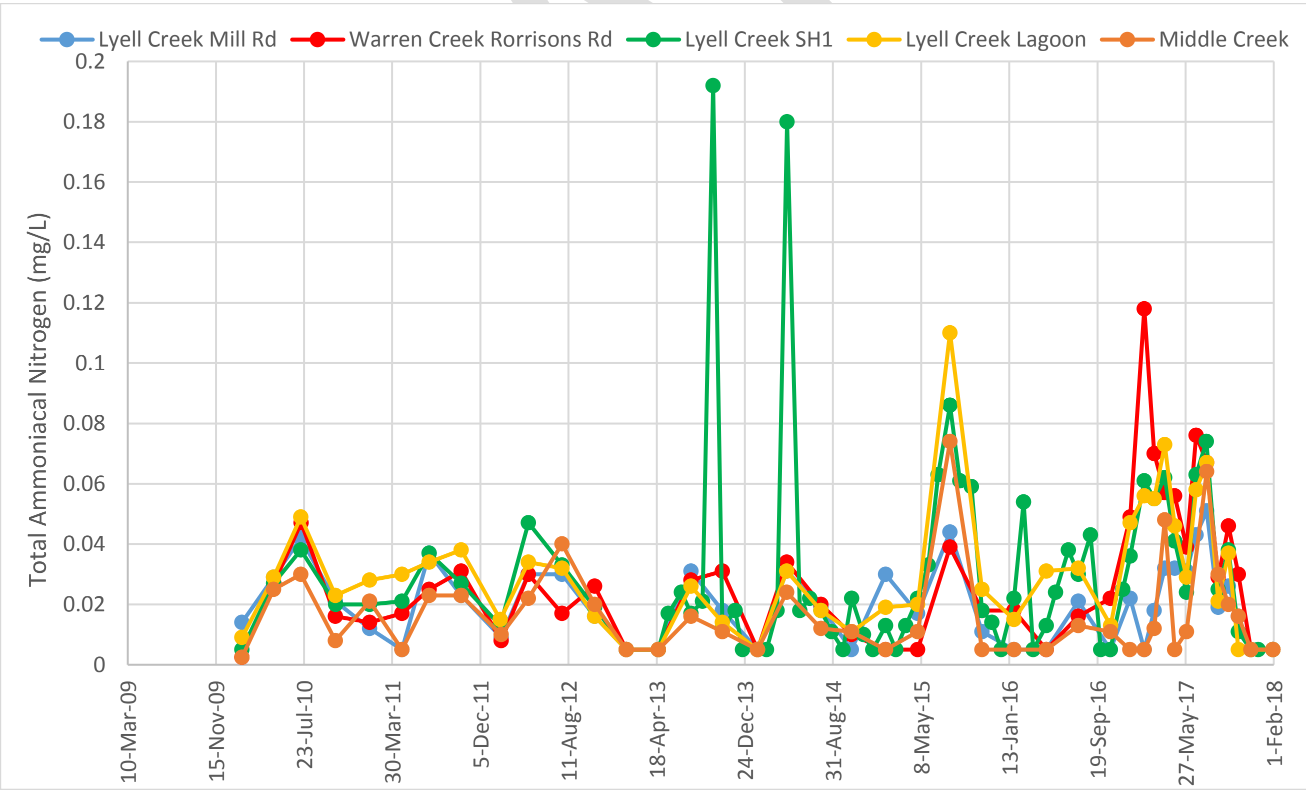

Figure 2: Total ammoniacal nitrogen concentrations in Waikōau/Lyell Creek and Middle Creek

Nitrite-Nitrate-Nitrogen (NNN) concentrations show similar seasonal trends between sites in the Waikōau/Lyell Creek and Middle Creek catchments (Figure 3). Concentrations are greatest for Middle Creek and the upper Waikōau/Lyell Creek site at Mill Rd. Concentrations are the lowest for the Warren Creek tributary. It is likely this site is influenced by groundwater flow influenced by the Kowhai River, which is low in nitrates by comparison. NNN concentrations show a seasonal pattern of elevation during the winter months. During the winter months, plant growth is limited, and the uptake of nitrogen sources is low. Nitrogen sources convert to nitrites and nitrates in the root zone, and are leached to groundwater. This is especially the case when there is more moisture in the soil profile. Over the past 10 years, NNN concentrations have shown a significant decrease for both Middle Creek, and the three Waikōau/Lyell Creek mainstem sites. No significant decrease was observed for Warren Creek. NNN concentrations do not exceed nitrate toxicity guidelines at the 95% species protection level, as described in the '*National Policy Statement for Freshwater Management*' (MfE, 2017).

Post-earthquake, NNN concentrations did not appear to be influenced. NNN concentrations were low for the duration of 2016, and did not spike until a heavy rain event in April. It is likely that this rain event flushed nitrates that were being held in the root zone, through the soil profile and into the creeks.

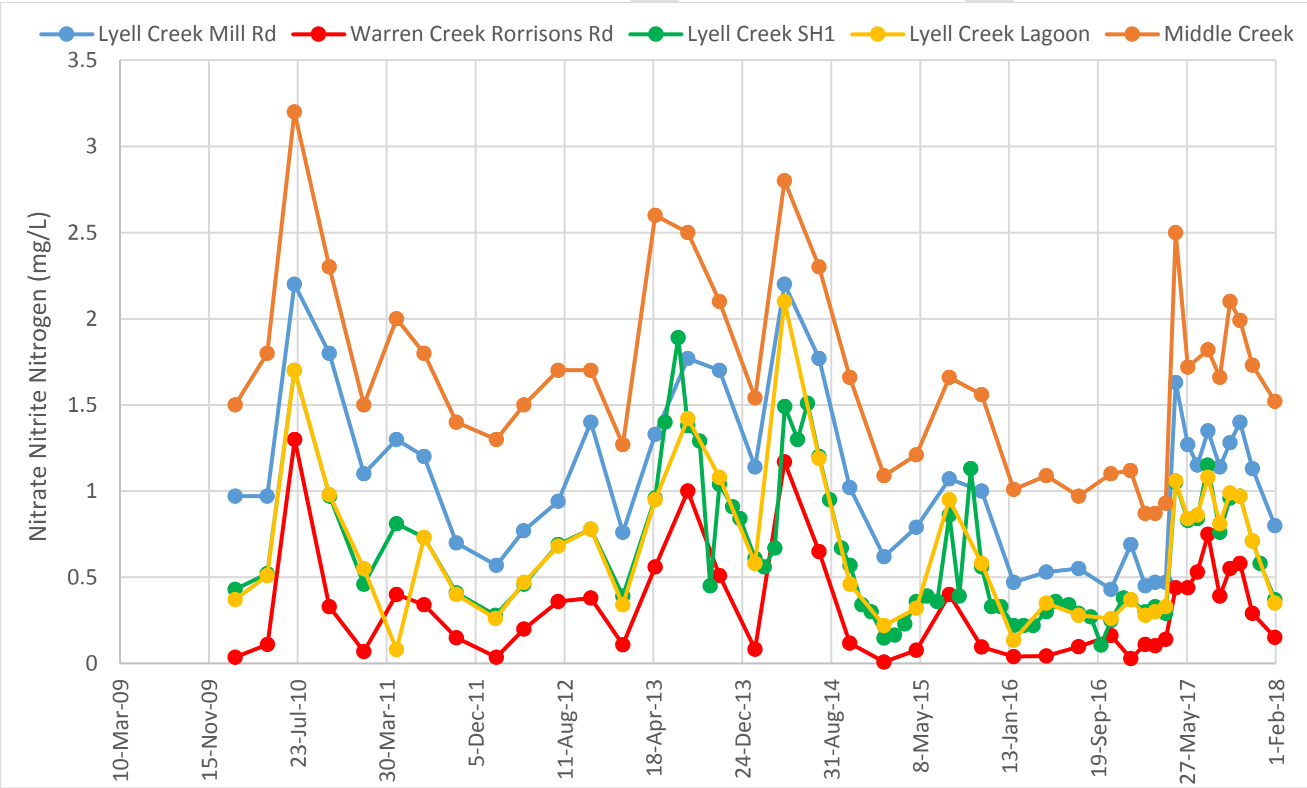

Figure 3: Nitrite-Nitrate-Nitrogen concentrations in Waikōau/Lyell Creek and Middle Creek

3 WATER CLARITY AND SEDIMENT

Water clarity is a measure of how clear or dirty the water is, due to inorganic (e.g. sediments and minerals) and organic (e.g. plant and animal matter) particles suspended in the water column. Clear water is important for aquatic ecosystems. Aquatic plants and algae require light penetration through the water column for growth as a primary food source for invertebrates and fish. Aquatic fish and invertebrate species require clear water for migratory and feeding behaviour. Solids suspended in the water column can also reduce the food value and growth of filter feeding species such as koura; and can become deposited on the stream bed when flow is reduced. Deposited sediment can smother habitats of stream invertebrate and fish, smother clean gravels essential for trout and salmon redds and native fish habitat, and act as a reservoir for bacteria and nutrients such as phosphorus and ammonia that can be released under anoxic conditions.

Surface water run-off, stock access and bank erosion are the main pathways for eroded particles into waterways, and are often elevated following heavy rainfall and freshes. Transport of particles into water can often aid the transport of other pollutants into waterways such as *E. coli*, ammonia and phosphorus which can bind to sediment. Therefore, restricting the entry of these particles to waterways can reduce the impacts of other pollutants.

In the past, Middle Creek and the upper sites in the Waikoau/Lyell Creek catchment at Mill Rd and Warren Creek, have indicated these sites are more susceptible to sediment inputs. Over the past 10 years, both Mill Rd and Warren Creek sites have shown a significant decrease in suspended sediment concentrations. In more recent years, the SH1 site has become prone to large spikes in suspended solid concentrations.

Post-earthquake, suspended solids concentrations were initially elevated for most sites. Throughout 2017 these concentrations returned to concentrations similar to those pre-earthquakes.

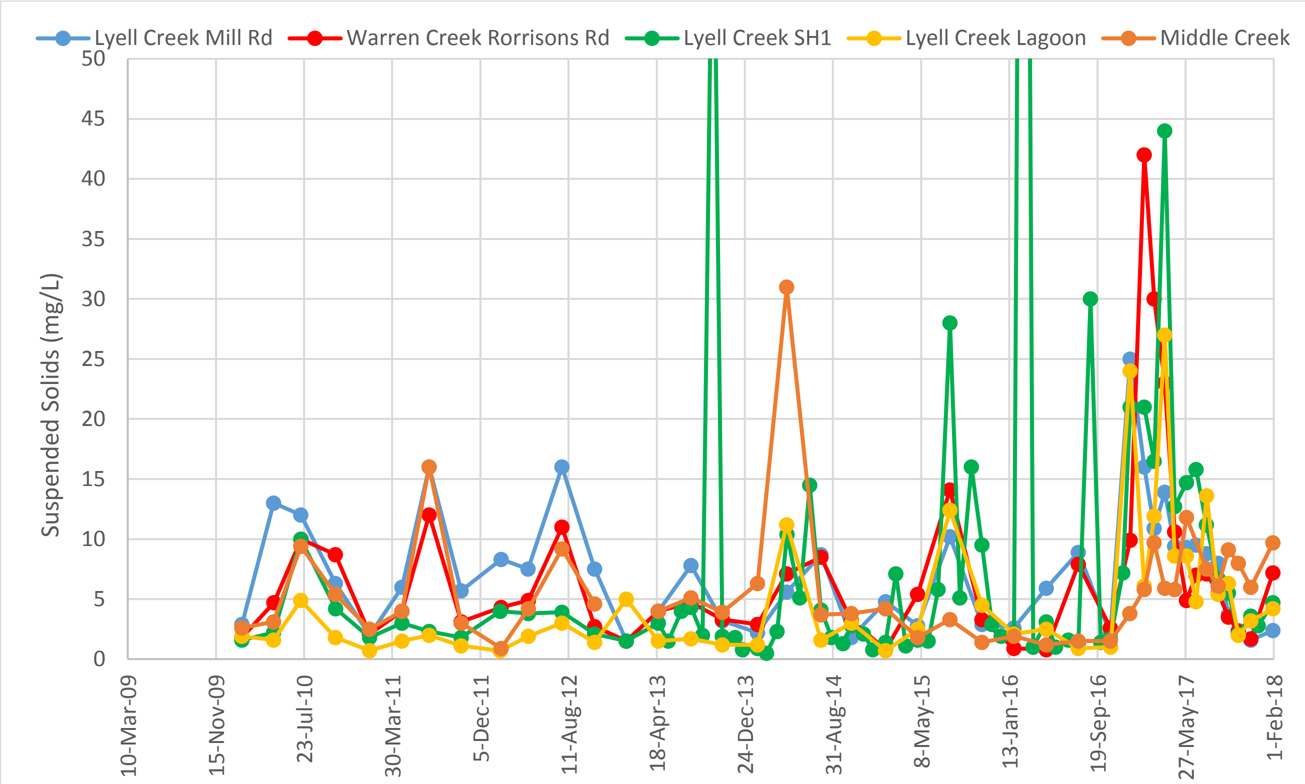

Figure 4: Suspended Solids concentrations in Waikōau/Lyell Creek and Middle Creek

4 MICROBIAL WATER QUALITY

Microbial water quality is important for human and animal health due to pathogenic (disease-causing) faecal contaminants such as bacteria and viruses that can be present in streams. Faecal contamination can affect the suitability of water for potable and stock water supplies, contact recreation, and māhinga kai. *Escherichia coli* is a bacterium that is present in the gut of all warm-blooded animals and birds (cows, horses, humans, ducks, sheep etc.), and is commonly used as an indicator of recent contamination of faecal material; used under the assumption that when present, other harmful bacteria, viruses and pathogen are likely to be present. Sources of faecal contamination include direct stock access to streams and along the margins, diffuse surface water run-off containing faecal matter, direct faecal contamination from large groups of waterfowl, wastewater (e.g. septic tanks) and storm-water discharges in urban areas containing animal waste.

E. coli concentrations in the Waikōau/Lyell Creek catchment and Middle Creek are variable, with some elevated results over time (Figure 5). There are no significant trends over the past 10 years for *E. coli* in these catchments. Median and 95th percentile concentrations exceed the national bottom line guidelines from the '*National Policy Statement for Freshwater Management*' (MfE, 2017) (Figure 6). This indicates potential public health risks from faecal contamination within these catchments.

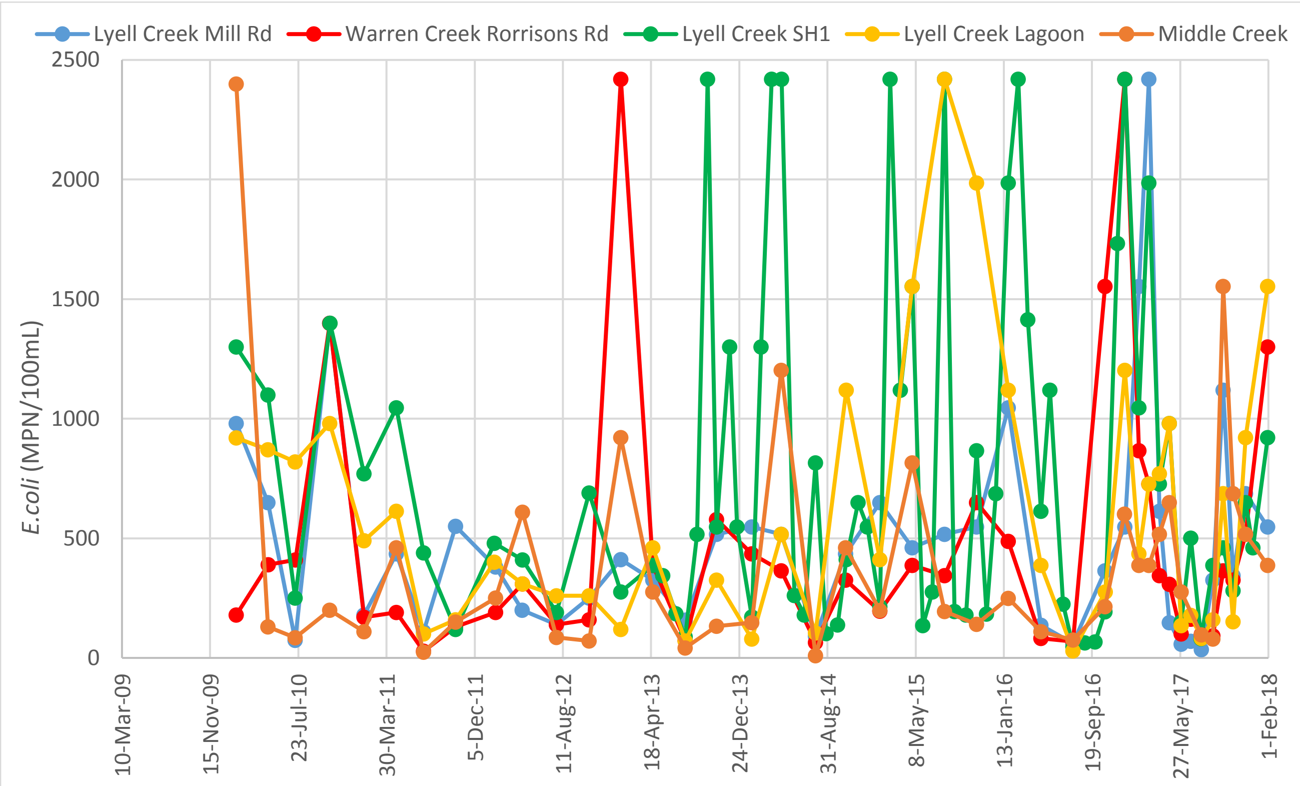

Figure 5: *Escherichia coli* concentrations in Waikōau/Lyell Creek and Middle Creek

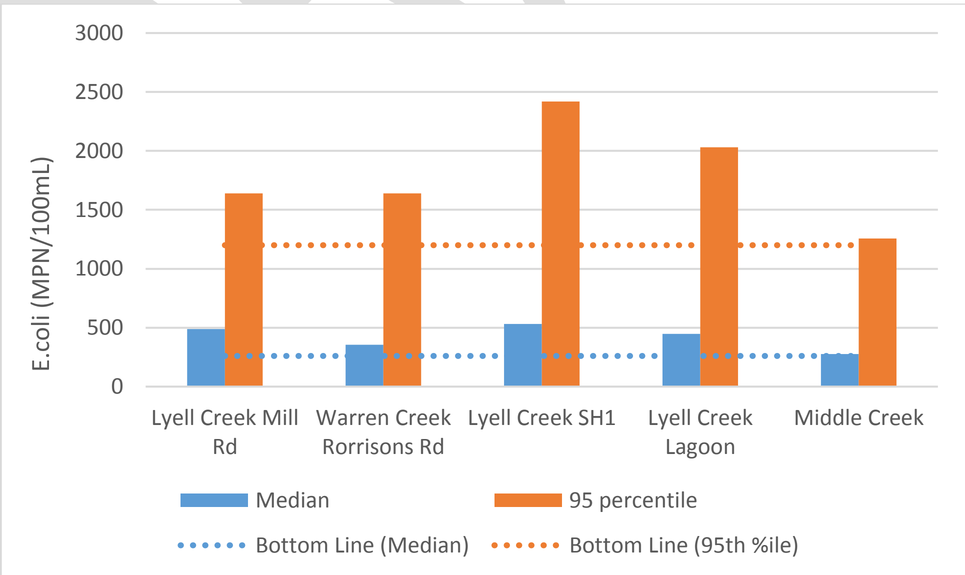

Figure 6: Median and 95th percentile *E. coli* concentrations for Waikōau/Lyell Creek and Middle Creek over the past 5 years

5 AQUATIC ECOSYSTEM HEALTH

The health of an aquatic ecosystem reflects the quality and quantity of water flowing in the stream and the habitat of the stream bed and banks. The health of the ecosystem can be assessed by the number and types of aquatic organisms and plants living in the stream.

Invertebrates are animals with no backbone. In streams these include worms, snails, insects and other small animals living on or within the streambed. Many insect larval stages live in streams and then emerge as flying or crawling adults. Invertebrates are a good indicator of aquatic health because they live in the water throughout the year and respond over time to changes in water quality, surrounding land use and their physical habitat, e.g. increases in sediment or algae.

Assessments of invertebrate communities include a determination of both the abundance and diversity of types. Different invertebrates have variable responses to water and habitat quality. Some species are more sensitive to degraded habitat and water quality and are therefore more likely to suffer from degradation; however other species are more tolerant and likely to be present in abundance when habitat and water quality is compromised. Analysis of the invertebrate data considers the numbers and types of taxa that are sensitive or tolerant to degraded water and habitat quality.

The Quantitative Macro-Invertebrate Community Index (QMCI) is a score based on the number and type of invertebrate species found in streams. Some invertebrates are very tolerant to pollution while others very sensitive. Each invertebrate species is given an individual score based on their response to habitat and water quality. The type and number of invertebrates is quantified to generate an overall QMCI score. If large numbers of invertebrates that are known to be sensitive to pollution are found in a stream, then a higher QMCI score is given, as this indicates there is less pollution in that stream.

Aquatic ecosystem health sites monitored in the Waikōau/Lyell Creek catchment and Middle Creek generally do not meet the LWRP minimum QMCI objective of 5.

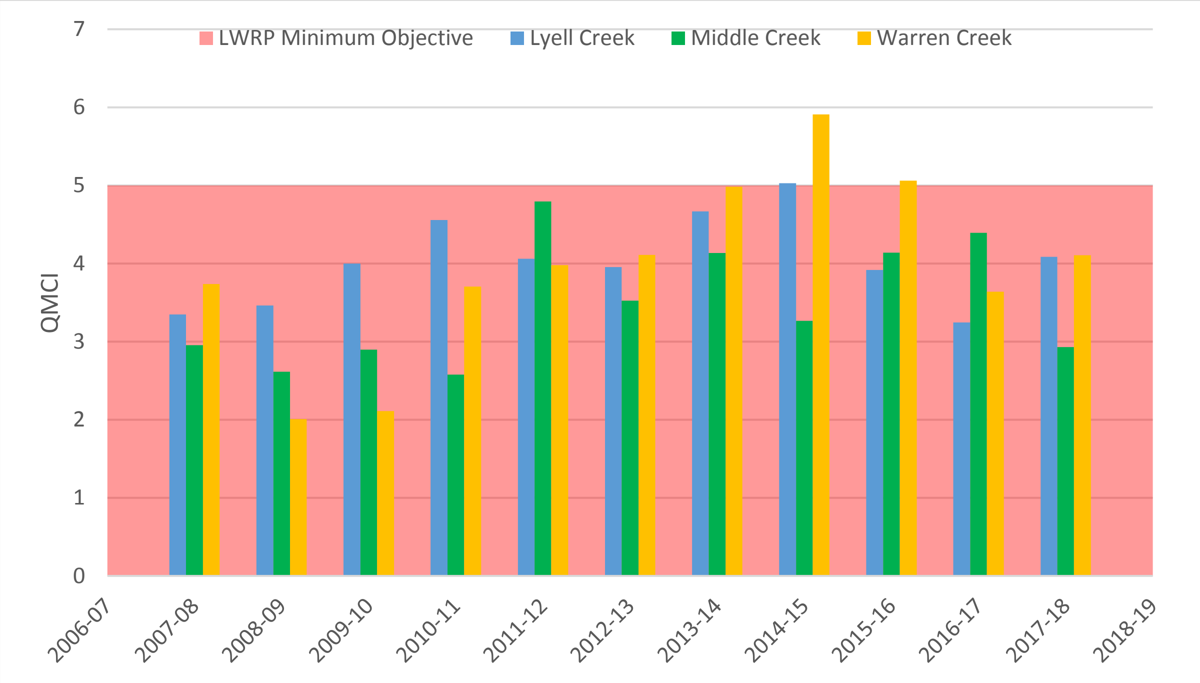

Figure 7: QMCI scores for Waikōau/Lyell Creek and Middle Creek

6 SUMMARY

In the past 10-years, gains have been made in the Waikōau/Lyell Creek and Middle Creek catchments with dissolved forms of nitrogen (NH4-N and NNN) and suspended solids concentrations showing significant decreases at some sites. However, phosphorus has increased for Waikōau/Lyell Creek at SH1. This is likely due to large one-off spikes in phosphorus that have increased in frequency.

Post-earthquake, there was an initial increase in overland flow contaminants such as suspended solids, phosphorus and ammoniacal nitrogen. This is likely due to the mobilisation of sediment and these associated nutrients, and greater erosion potential. The directional change in overland and subsurface flow pathways may have been altered due to the earthquake, whereby these contaminants may no longer have been intercepted by buffers such as riparian planting. These contaminant concentrations have since returned to levels similar to those seen pre-earthquakes.

Nitrate concentrations did not appear to be influenced by the earthquake. Concentrations over the 2016-17 summer following the earthquake were low. This may have been influenced by a dry period where there was limited flushing of nitrates through the soil profile and uptake by plants in the root zone. Following a heavy rainfall event in April 2017, nitrate concentrations increased. This is likely due to an excess of nitrates being held in the soil profile, which were subsequently flushed with the rainfall event.

Aquatic ecosystem health monitoring indicates poor stream health for lowland streams in Kaikoura. Suspended solids that settle out in the slow flowing water can cause embeddedness in stream gravels, and smother the stream bed. This takes up the spaces between gravels where invertebrates live, thus reducing their available habitat. Aquatic plants in the streams also have the potential to smother stream bed habitats and entrap suspended solids. Growth of aquatic plants is supported by plant available nutrients (nitrogen and phosphorus) in these streams. While gains have been made in NH4-N and NNN concentrations, further decreases may be required to supress aquatic plant growth.