Water Quality Assessment of the Waikaka Stream

Report prepared for the Waikaka Stream Catchment Group

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Jessica McIntyre, Dr Sarah Mager, & Dr Sean Connelly

Introduction

The Waikaka Stream is the local water body for the wider Waikaka community in Eastern Southland. It is used for many recreational activities, such as swimming and fishing, and runs through many farming properties in the district. The community formed a catchment group in late 2017/early 2018 to establish a way to manage the stream based on changing regulations and legislation from Environment Southland (Regional Government).

The stream's water quality is measured by Environment Southland at a single point in the catchment, close to the confluence between the stream and the Mataura River. Therefore, current recording only reflects the cumulative impact of any agricultural or other activity that may be altering the water quality of the stream.

This report presents the findings of a research project conducted at the University of Otago, assessing the overall water quality of the Waikaka Stream, and the management views of the local community. The report will first outline how data was gathered, through in-stream water quality measurements, and interviews with local farmers in the district. The purpose of this report is to present the findings of postgraduate research to the community and other stakeholders of the Waikaka Stream. These results are designed to assist in future management of the stream, working towards improved water quality outcomes for the catchment.

Methods

Sixteen sampling sites were identified along the Waikaka Stream and surrounding tributaries, to gain an accurate representation of the overall water quality. These sites were chosen based on key criteria outlined below in Table 0.1.

Table 0.1: Key criteria used to locate the 16 sampling sites along the Waikaka Stream.

Criteria	Description
Practicality	Sites had to be accessible and be safe to sample frequently.
Stream Order	Sites had to be from a mix of stream orders and contain an even number of tributaries and main stem sampling sites.
Spatial Distribution	Sites on the main stem needed to be spread evenly down the Waikaka Stream.
Underlying Environmental Characteristics	Sites were required to evenly distributed through different physiographic zones to account for intrinsic environmental variation.
Land Use	Sites needed to be distributed throughout the catchment to ensure that all major land uses in the catchment were being captured.

The distribution of the sampling sites ranged from site 1, upstream in the headwaters of the Waikaka Stream, to site 16, just above the confluence of the Waikaka and the Mataura river (Figure 0.1). The main Waikaka tributaries were captured in the sampling strategy: the main tributary had eight sampling sites, the Waikaka East (colloquially known as the Little Waikaka) had three sampling sites, while smaller tributaries were sampled at a minimum of one site (Table 0.2, Figure 0.1, Figure 0.2).

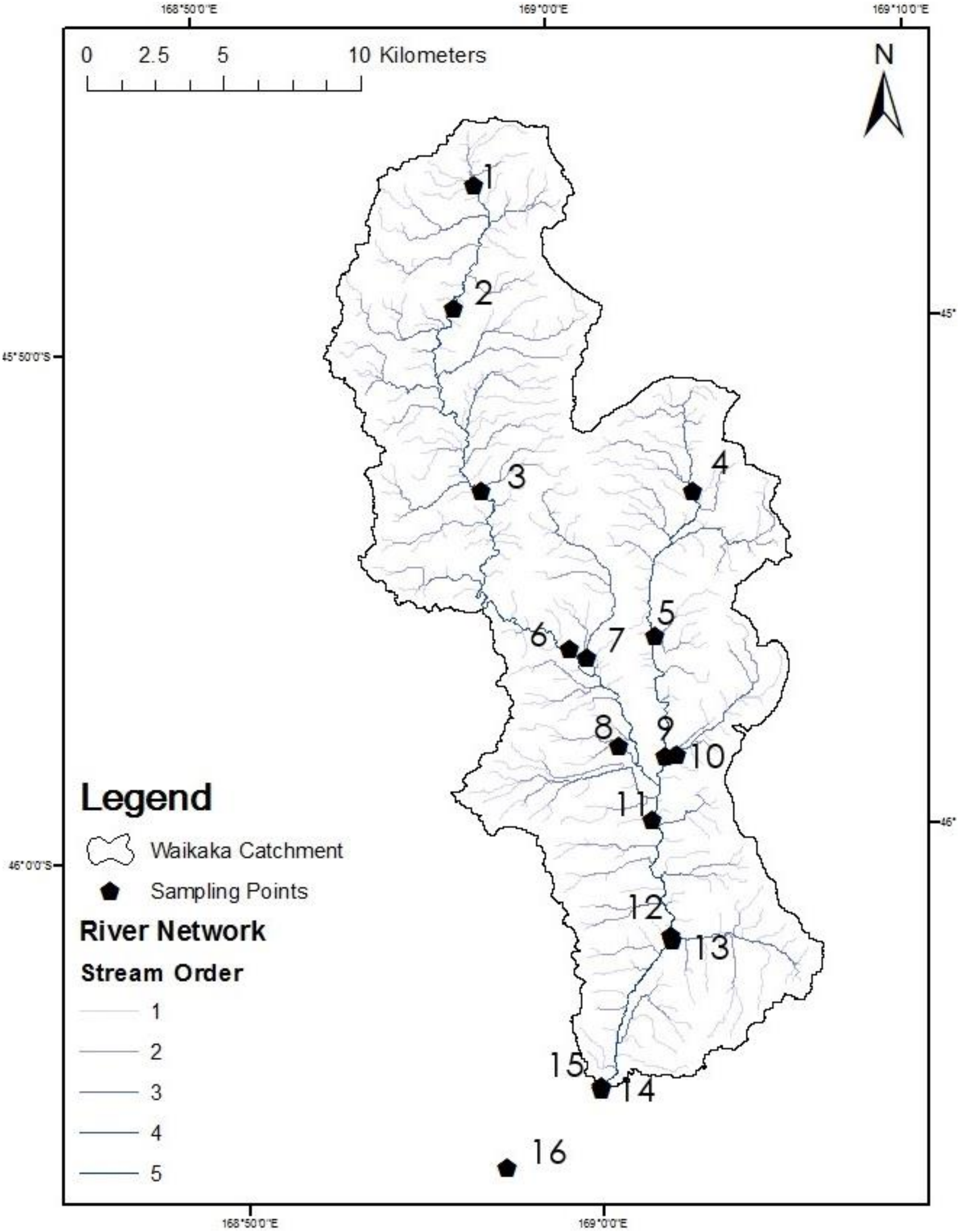

Figure 0.1: Sampling sites across the Waikaka Catchment, including the Waikaka East and other tributaries.

Table 0.2: Sampling site descriptions, including distances from the confluence, physiographic zones, underlying geology, and surrounding land uses.

Figure 0.2: Photographs of each sampling site in the Waikaka Catchment, showing the character of each section of the stream.

Monthly sampling trips were conducted over a 12-month period between October 2018 and September 2019, under baseflow conditions. At each site, time-stamped samples were taken for the analyses of *E.coli*, total coliforms, suspended material, nitrate (NO_3), ammoniacal nitrogen (NH_4), total nitrogen (TN), orthophosphate (PO_4^{3-}), and total phosphorous (TP).

Water Quality Results

The suspended sediment concentration exceeded the regulatory threshold of 2.5 mg L^{-1} at every site, with the highest levels being recorded in the upper reaches. *E. coli* follows the same trend with the highest concentrations at the upper end of the catchment. The tributaries to the stream tend to have higher *E. coli* values that most main stem sites. The nutrients (nitrogen and phosphorus) showed the opposite trend, where the highest levels were in the bottom half of the catchment, indicating cumulative impacts lead to higher concentrations of nutrients. The sites lower in the catchment exceed nutrient levels, where the upper reaches are within safe guideline concentrations (Table 0.1, Figure 0.1, Figure 0.2). Nitrate levels are all below the 1 ppm, while dissolved reactive phosphorus is above the recommended level of 50 ppb at all sites from 40km, down to the confluence of the Mataura River and Waikaka Stream. Though nitrate levels are below 1 ppm, total nitrogen levels do exceed that threshold at half of the sites (Table 0.1).

Table 0.1: Median values for key variable at each site in the catchment. Variables displayed are suspended sediment concentration (SSC), total suspended material (TSM), total coliforms (TC), E. coli, total nitrogen (TN), nitrate (NO3), total phosphorus (TP), dissolved reactive phosphorus (DRP) and turbidity in units of FNU. Sites located on the main stem of the Waikaka Stream are indicated by grey highlight. Other sites are located on various tributaries. Variables that exceed the regulatory thresholds are bolded. The current regulatory thresholds are difficult to derive due to changing guidance documents and ongoing consultation. The thresholds here are derived from the NPSFM NOF Band A for nitrate, and thresholds used in MfE reporting of ANZ Guidelines (2018) but are subject to ongoing regulation changes.

Site Number	**Distance (km) from Confluence**	**SSC**	**TSM**	**TC**	***E. coli***	**TN**	**NO_3**	**TP**	**DRP**	**Turbidity**
		(mg L^{-1})		**(CFU/100ml)**		**(ppm)**		**(ppb)**		**(NTU)**
1	59.6	**10.8**	12.9	2420	**980**	0.65	0.37	35	17	2.5
2	52.2	**6.5**	10.2	921	225	0.51	0.34	31	13	3.6
3	40.5	**6.4**	8.5	1414	**488**	0.69	0.46	31	11	3.6
4	33.7	**10.7**	13.9	2420	**1414**	**1.02**	0.77	**50**	18	5.4
5	26.9	**6.0**	9.0	980	194	**1.03**	0.69	**57**	**21**	3.7

6	27.0	**5.7**	8.4	1046	179	**1.10**	0.59	**72**	18	3.8
7	27.7	**5.2**	8.4	866	166	0.65	0.52	33	12	3.6
8	22.1	**7.8**	10.3	1046	**308**	**1.16**	0.65	**76**	**30**	3.9
9	21.1	**5.2**	8.3	687	179	0.91	0.56	**58**	**22**	3.6
10	21.5	**7.0**	10.6	687	126	**1.01**	0.41	**108**	**31**	3.7
11	18.4	**4.6**	7.4	727	210	0.79	0.47	44	13	3.3
12	13.0	**5.8**	8.3	675	176	0.97	0.65	46	16	3.1
13	12.9	**4.0**	7.9	1733	**333**	**1.16**	0.54	**94**	**28**	3.5
14	6.2	**7.8**	11.4	1046	**361**	**1.23**	0.84	**69**	**24**	**5.3**
15	6.2	**5.2**	7.3	687	248	0.96	0.65	**58**	18	3.2
16	0.4	**6.6**	9.4	461	172	**1.03**	0.65	**56**	19	3.7
Environment Southland Monitoring Site		**6.6**	-	461	172	**1.0**	0.7	**56**	19	3.7
Regulatory Thresholds		2.5	-	-	260 (alert level)	1	1	50	21	5
Key		Main Stem Site			Tributary Site			**Concentration exceeding threshold**		

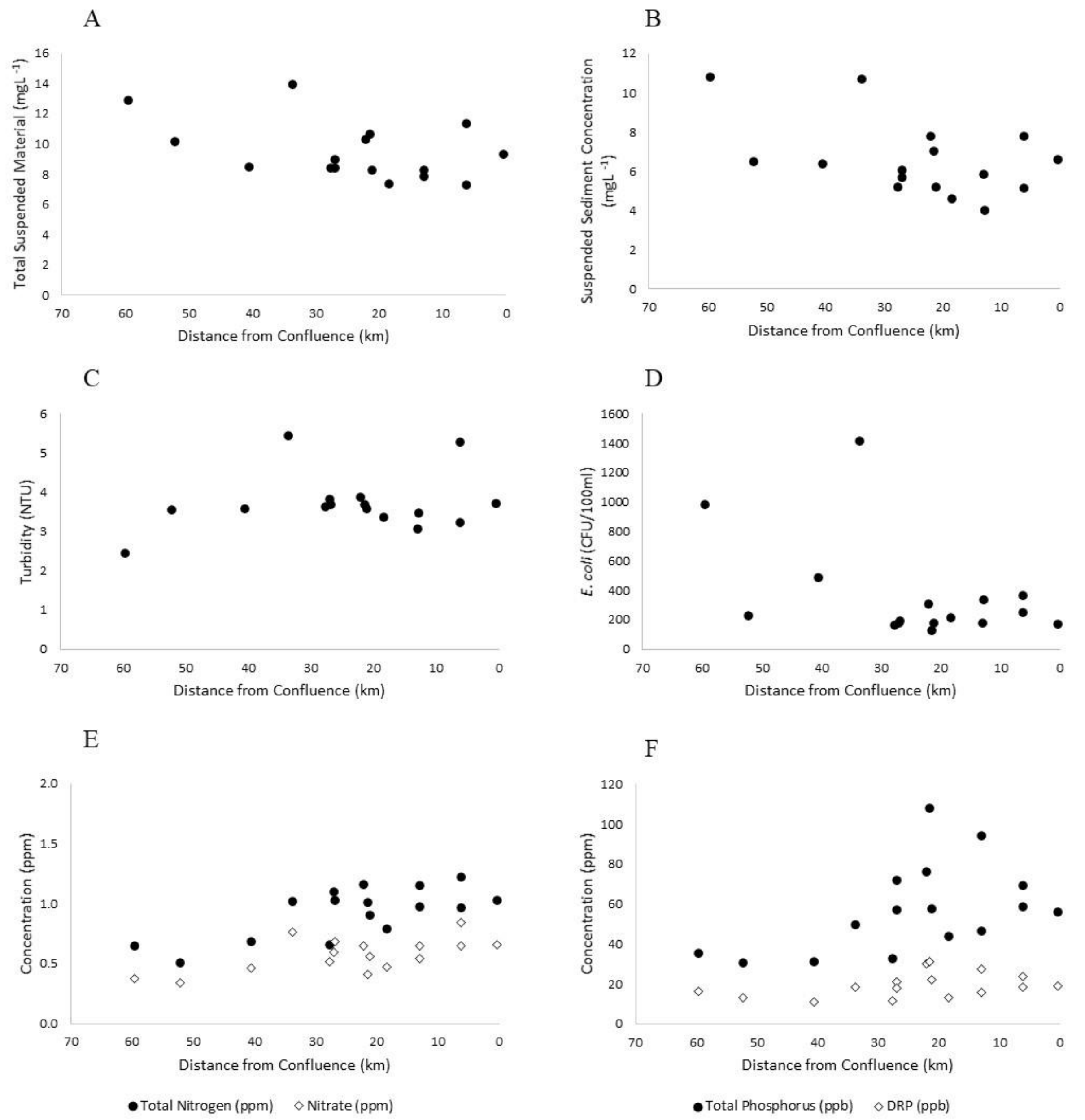

Figure 0.1 Shows the distance spread of the concentrations of measured water quality variables A) total suspended material B) suspended sediment concentration C) turbidity D) E. coli E) total nitrogen and nitrate F) total phosphorus and dissolved reactive phosphorus.

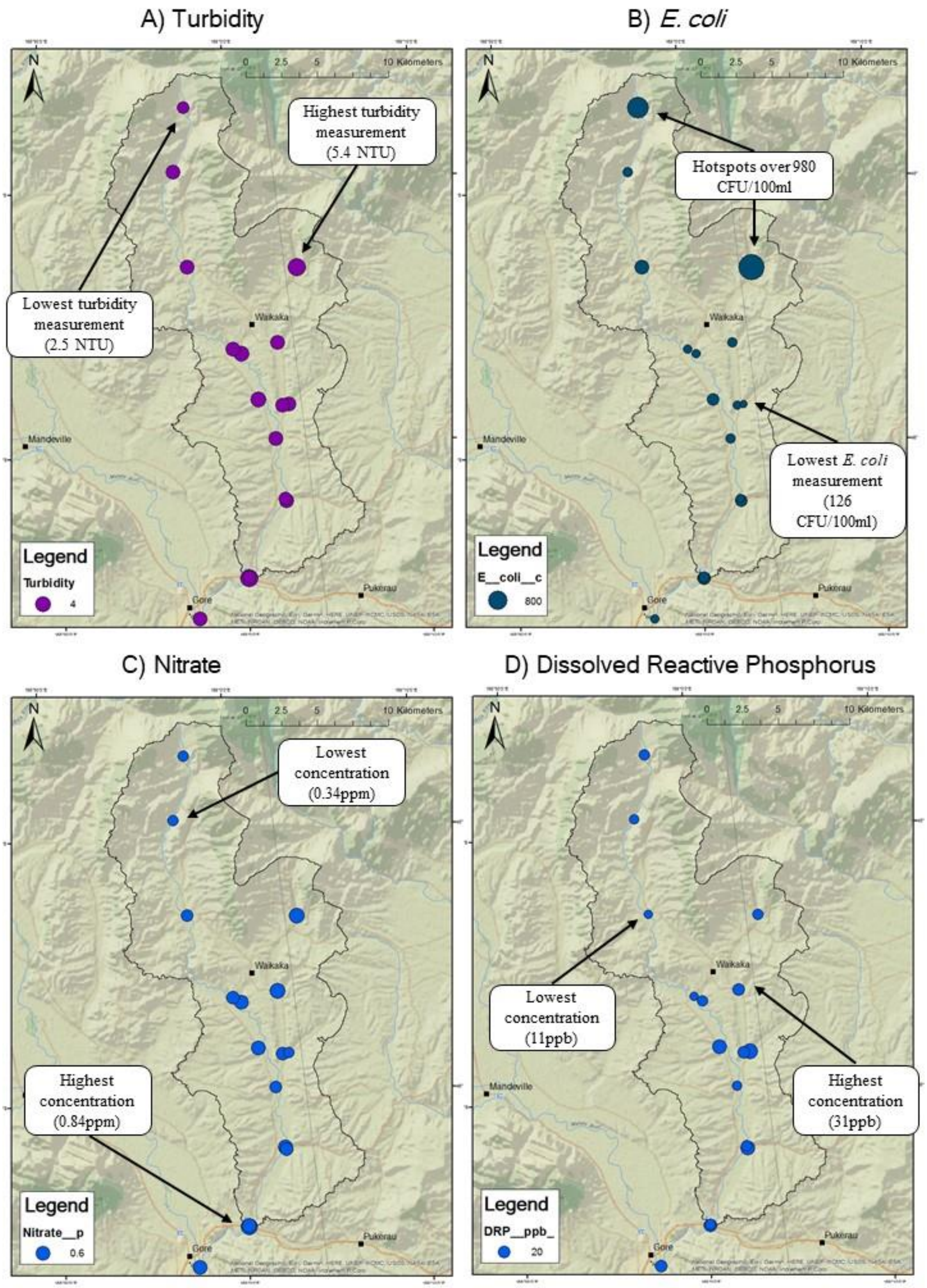

Figure 0.2: Maps showing the Waikaka Stream and key water quality variables on a spatial scale within the catchment. Variables shown are A) turbidity B) E. coli C) nitrate and D) dissolved reactive phosphorus. Dot sizes are proportional to concentration of variables, and the highest and lowest measurements are annotated.

Environment Southland have water quality data for the past 24 years. The trends in the water quality data are different for each variable, based on how long or short some records are, and the nature of that contaminant in the catchment. The variables that have an increasing trend (deteriorating water quality) are total nitrogen, nitrate, and total phosphorus (Table 0.2). Therefore, those nutrients should be the focus of future water quality interventions, so that they do not become any worse than current conditions. Faecal coliforms, ammonia and dissolved reactive phosphorus showed a decreasing trend, indicating improved water quality in terms of these three variables, which is a positive trend that the community should aim to continue.

Table 0.2: Waikaka Stream long term water quality trends, using Environment Southland data dating back to 1995. Trends were determined using Mann-Kendall trend analysis with a significance level of 0.05. A decreasing trend indicates an improvement in water quality, and an increasing trend indicates deteriorating water quality.

Water Quality Variable	**Years of Record**	**Trend**
Suspended sediment concentration	4 years (From 2015)	No trend
Turbidity	20 years (From 1999)	No trend
Faecal coliforms	20 years (From 1999)	Decreasing trend
E. coli	20 years (From 1999)	No trend
Total nitrogen	21 years (From 1998)	Increasing trend
Nitrate	13 years (From 2006)	Increasing trend
Ammonia	24 years (From 1995)	Decreasing trend
Total phosphorus	21 years (From 1998)	Increasing trend
Dissolved reactive phosphorus	24 years (From 1995)	Decreasing trend

The water quality index is an overall value representing the water quality of the stream at each site. It considers all water quality measurements and compares them to current regulations and threshold values to mathematically return a value between 1 and 100, where 1 is the poorest water quality, and 100 is the best. Most sites in the Waikaka Stream were deemed to be ‘poor’, as their water quality index was below 44 (Table 0.3, Figure 0.3). Site 2 was the only one with water quality above ‘poor’, and with a value of 45.4 was deemed to be of ‘fair’ water quality. The water quality index also varies over time, indicating that certain times of the year are worse than others. The winter months of May, June, and July have the lowest water quality index, which is consistent with farm practices around winter grazing (Figure 0.4).

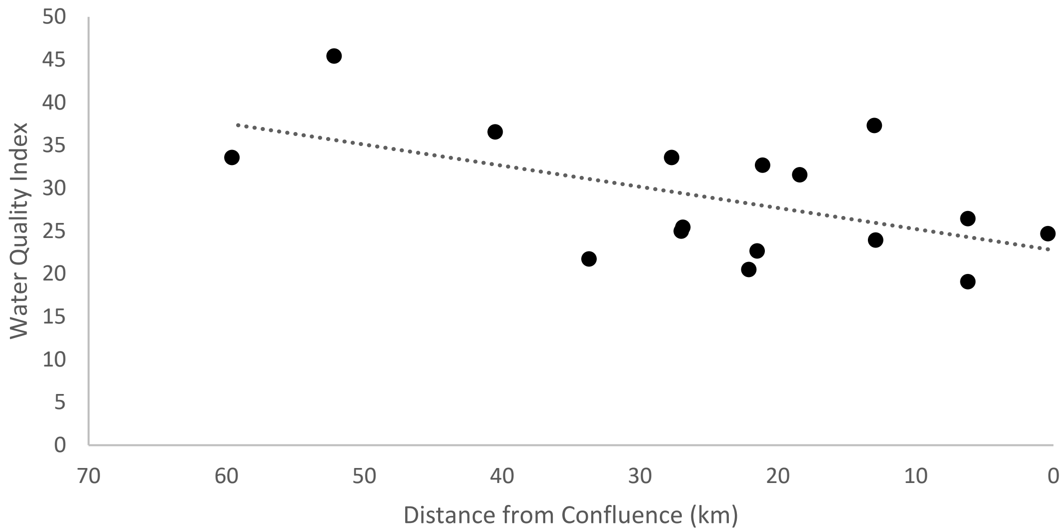

Figure 0.3: Scatterplot of the Water Quality Index throughout the Waikaka Stream.

Table 0.3: Water Quality Indices for each site, sorted according to the nature of sites, whether they are on the main stem of the Waikaka Stream, or tributaries. All sites are 'poor' apart from site 2, as their WQI is below 44.

Main Stem Sites		**Tributary Sites**	
Site & Distance from Confluence (km)	WQI	Site & Distance from Confluence (km)	WQI
1 (59.6)	33.6	4 (33.7)	21.8
2 (52.2)	45.4	5 (26.9)	25.4
3 (40.5)	40.5	6 (27.0)	25.9
7 (27.7)	33.6	8 (22.1)	20.5
11 (18.4)	31.6	9 (21.1)	32.7
12 (13.0)	37.3	10 (21.5)	22.7
15 (6.2)	26.5	13 (12.9)	23.9
16 (0.4)	24.7	14 (6.2)	19.1

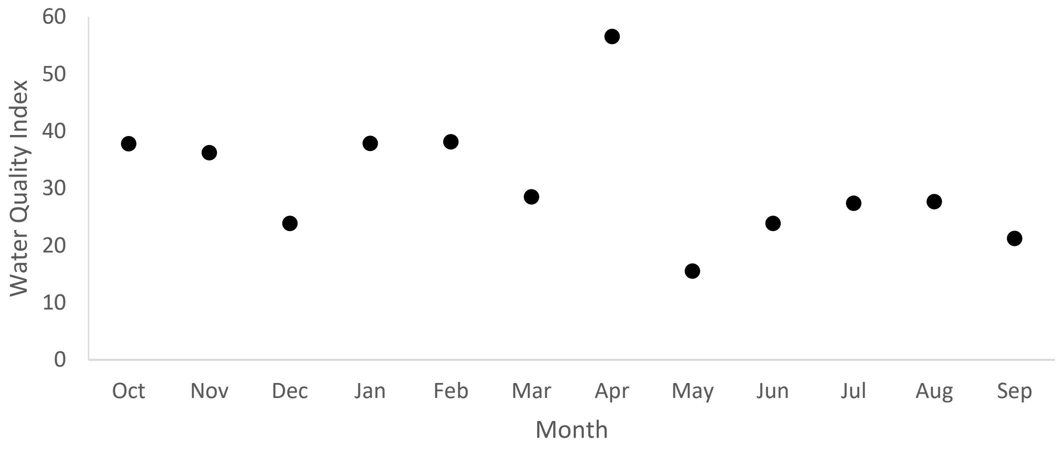

Figure 0.4: The Water Quality Index in the Waikaka Stream over a year period, from October of 2018, to September of 2019.

Principle component analysis was carried out to observe patterns amongst variables. The results showed that in the Waikaka Stream, all nutrient variables showed similar trends to each other (Figure 0.5). Meanwhile, the sediment and bacteria variables measured showed similar trends to each other, giving two distinct categories of variable behaviour. These clusters indicate that there are two different behaviour patterns of contaminants in the Waikaka Stream. Therefore, management efforts may need to reflect that, and think about the sources and transport methods for each group of variables. It also means that an improvement in one variable is likely to indicate improvement in other variables in the same cluster. These results are specific to the Waikaka Stream and assist in establishing the variables that are of concern, and which other variables they are related to.

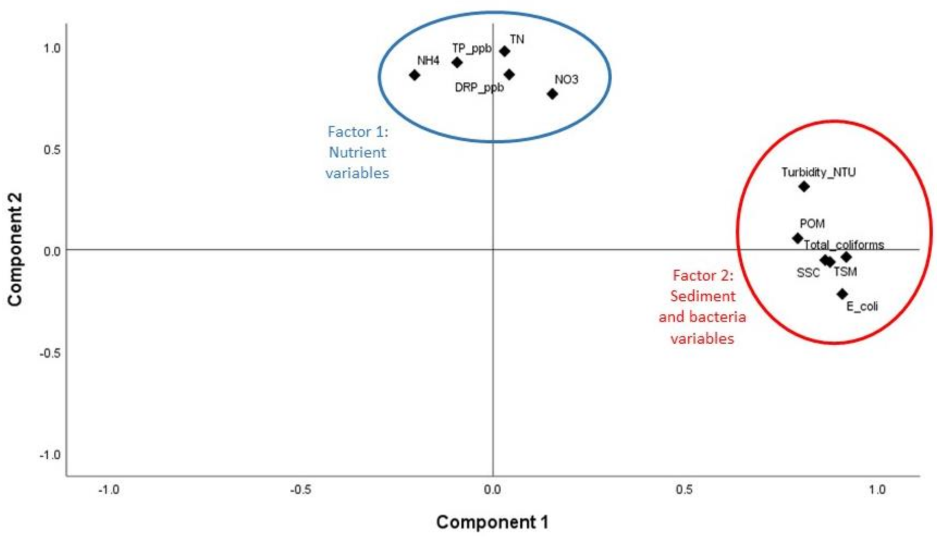

Figure 0.5: Component plot in rotated space, identifying the key components of each cluster (result of PCA).

Function of the Waikaka Stream Catchment Group

Community Catchment Groups are not an entirely new concept in the realm of Environmental Management, and historically have gone by many different names. However, Southland has recently experienced a surge in community groups forming, for a variety of different reasons. The Landcare Trust New Zealand, and Regional Authority Environment Southland have supported the Southland Catchment Groups as they have formed and established themselves through meetings and workshops.

The formation of a Catchment Group indicates several things. First the desire of the community to take collective action, and ownership of their local water body. The community aspect of this form of management is a major strength, as it brings together differing ideas, and offers a space for productive discussion and shared learnings. The group also encourages more farmers and community members to engage in environmental management, growing the community and capacity for improvements. Having a large proportion of the catchment buy in to the community management group shows the willingness of farmers to be involved, and to encourage neighbours and community members to also involve themselves. The groups offer a platform for the sharing of information, whether scientific or otherwise. Information can be disseminated more easily and is more palatable to the community, making Catchment Groups in general a useful format of environmental management, as well as scaling down to catchment level, allowing the focus to be on a smaller area and therefore more manageable. Catchment Groups also give the community a more formal voice through the organisation, which can be useful in working with other stakeholders.

Other areas in New Zealand have seen Community Groups be involved in Environmental Management over time. The experience of other groups proves that communication between all stakeholders must be open and transparent for the best outcomes. The Waikaka Stream Catchment Group has previously and continues to engage with useful stakeholders and other organisations, which increases the opportunity for shared learnings.

Future Recommendations

The following recommendations are based on the research findings, including the community structure and resources available. The goals and direction of both the Waikaka Stream water quality and the Catchment Group will guide these recommendations and the process is fluid, meaning that they will constantly change as the external and internal conditions of the catchment change.

Land Practices

- Land practices should follow an adaptive management framework. Scientific knowledge should be used to identify known source areas and develop a monitoring strategy to observe potential outcomes and improvements.
- Pest control should be undertaken in the upper reaches of the catchment to manage wild deer and duck populations, hopefully reducing *E. coli* levels.
- Where practical, recommended best practice management should be exercised, including fencing off waterways, closely monitoring fertiliser use, and providing buffer strips to reduce the impact of cumulative pollutants, and decrease the likelihood of bank collapses. Cultivation and intensive grazing should be minimised in steep areas to reduce the transport potential of contaminants. Farmers should endeavour to reduce intensification in areas that are high risk to the stream, while intensifying lower risk areas, to better target land use for optimisation without adverse effects to the Stream.

The Waikaka Stream Catchment Group

- Establish a formal structure and framework for succession.
- Expand the committee to support the chairperson(s) and devolve the workload amongst more community members. Ensure the committee is diverse to capture different perspectives, but leave the decision-making group small enough for productivity.
- Engage with as many community members as possible to encourage farmer buy-in to community management in the form of the catchment group.

- Diversify voices within the group, including engaging Māori perspectives to capture their interconnected worldview in relation to environmental management. Runanga engagement is currently lacking and needs to be increased for accurate representation, and shared learnings.
- Seek and receive further support and guidance from regional authorities and private business institutions to formulate goals and action plans. Increased sharing of ideas between groups can be facilitated by designated authorities or institutions, to ensure that successes are shared and scaled out to other regions. One such area where guidance could be given, surrounds monitoring that can be carried out by the community group, providing a higher resolution of water quality data. Institutions could also offer funding, resources and support to assist groups in moving forward with plans to better water quality. Environment Southland should continue to work with groups on education, to try and address the disconnect in water quality perceptions and scientific results.
- Stakeholders should commit to non-statutory collaboration to establish sustainable solutions that can then be implemented by Environment Southland, ensuring that decisions are based on all perspectives, and stakeholders build trust to be able to work more efficiently together for the benefit of the environment, and power dynamics will also be more balanced, resulting in a democratic freshwater management system.
- Stakeholders in the Waikaka Catchment should aim for small successes, which will offer tangible proof to the community that the process is effective, building trust and confidence between participants in the management process.

Future research

More research is required into the nature of catchment groups in New Zealand, predominantly into their function within the current environmental management framework, due to the rapidly changing nature, and diversification of community catchment groups. Further research is needed into how catchment groups work with regional government, and where the balance lies between being involved in decision making, advocacy, awareness, and education. It is unclear how catchment groups can be most useful, and there is overlap potential with so many stakeholders becoming involved, leading to some groups becoming redundant, or duplicating the work of other institutions.