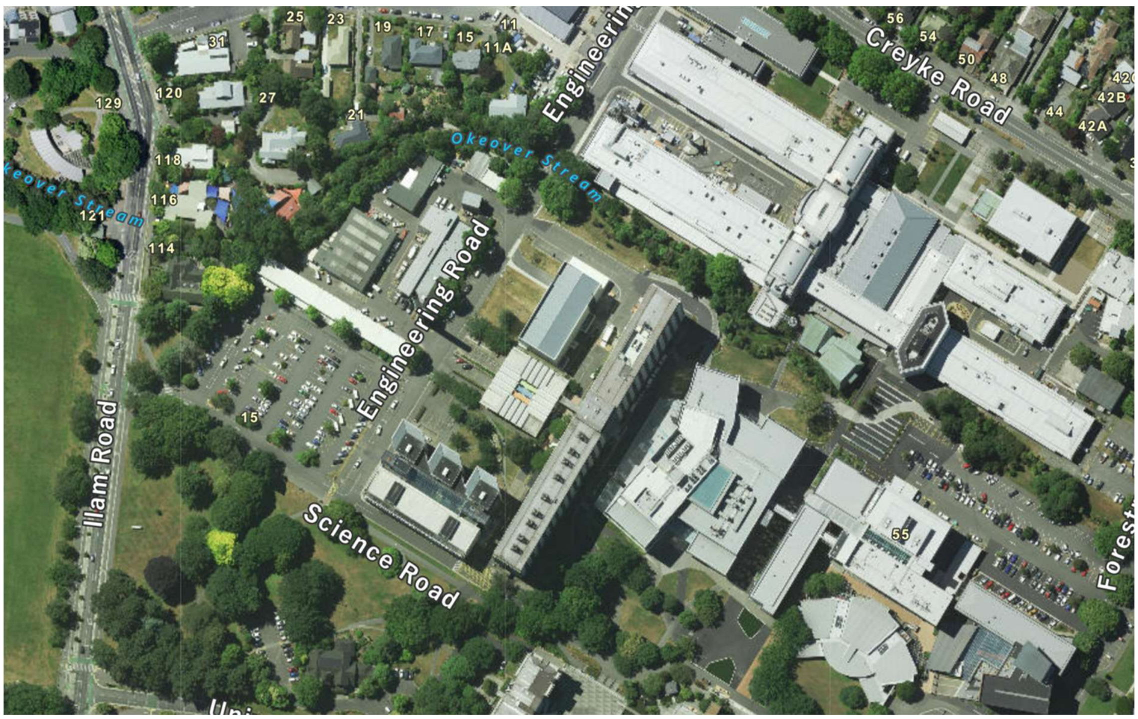
What Alert Levels are Appropriate to Maintain the Health of the Waiutuutu/Okeover Stream?

A collated report and framework for the Te Whare Wānanga o Waitaha/University of Canterbury's Sustainability Office.

October 2021



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Report	What Alert Levels are Appropriate to Maintain the Health of the Waiutuutu/Okeover Stream?
GEOG309 group number	12
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1. Executive Summary

The Okeover is a key component within the UC campus with dwindling stream health. There have been numerous attempts to restore this stream however, due to the lack of persistent monitoring and mitigation techniques the Okeover stream ecosystem is considered unhealthy.

The aim within this project is to create a monitoring framework targeting 6 key parameters to measure stream health, which include; streamflow, ecology, chemistry, Mana Whenua, water clarity & turbidity, and temperature. Our methodological approach primarily focused on the use of secondary qualitative data, as well as extensive literature reviews of relevant sources to gain an understanding of the current underlying monitoring techniques. Each parameter within the framework is assessed thoroughly, with recommended monitoring techniques as well as appropriate trigger values to assess the severity of the monitored results. With an exception of the Mana Whenua parameter which does not follow the same structure.

It is important to understand there is no hierarchy within the parameters, each parameter is of equal importance to stream health and each individual parameter has to meet a threshold collectively to obtain appropriate stream health. Our overall recommendations included the integration of all 6 parameters within a monitoring framework with the use of trigger values to effectively evaluate the status of the Okeover river.

Limitations within this project were the absence of primary data using our monitoring framework which is subject to the restrictions of COVID-19 and time constraints. We hope this monitoring framework will be of aid for future monitoring of the Okeover.

2. Introduction

2.1 Stream Health

Urban Streams are a critical component of city and human health, and act as ecological highways throughout the urban system. They protect our cities from floods, filter out harmful chemicals, and nourish a host of flora and fauna. While they are often treated as 'islands' in the urban environment, urban streams are the interlinking capillaries that transport nutrients, sediments, and biodiversity throughout the system.

Figure 1. Okeover stream near the University of Canterbury Engineering Core

Due to increased urban development around these streams, maintaining their health and capacity has become more important than ever. One polluted vessel can disrupt and influence seemingly unrelated green 'islands', or even prevent the passage of native species throughout the city.

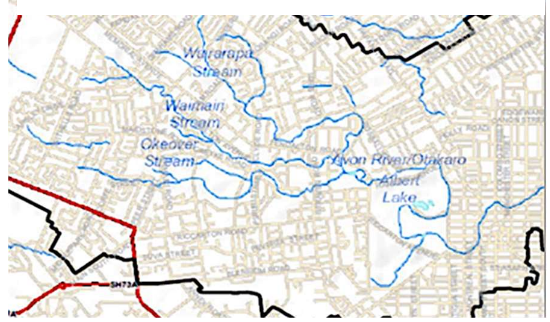

Figure 2. The head of the Avon Catchment

The University of Canterbury (UC) lies upon one of the key 'green corridors' in the Avon catchment, the spring-fed Waiutuutu/Okeover stream (Figures 1 & 2). While its importance is recognised by UC, how it should be managed and monitored is a complex question to answer. This report sets out a framework for how the health of the Okeover can be managed in an increasingly complex urban environment.

2.2 The Okeover

The Okeover Stream has been the focus of some of the longest-running ecological restoration projects in Christchurch, with several targeted initiatives being run over the past 20 years (Figure 3). These have been key at helping the stream adjust to increased sediment loads, lower water tables, and harmful runoff from nearby urban developments.

As studied by (Blakely & Harding, 2005), the physio-chemical and biological makeup of the Okeover was comparable with the neighbouring Waimairi Stream and Avon River (Figure 2) in most respects.

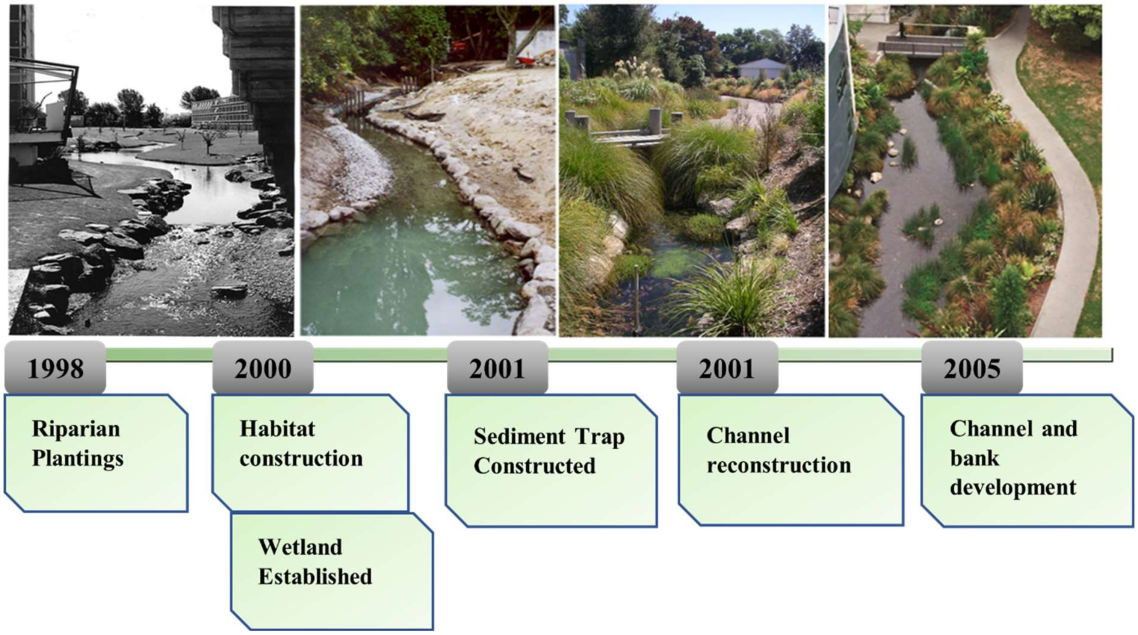

Figure 3. Key restoration initiatives along the Okeover Stream

However, the presence and concentrations of certain elements (such as heavy metals) indicated that certain aspects of the stream differed from the rest of the nearby catchment. The biological landscape also showed that some parts of the macroinvertebrate communities in the Okeover were struggling to proliferate, as opposed to the Avon and Waimairi.

Monitoring and research of the stream has been carried out by various groups at UC, such as Geography, Biological Sciences, Forestry, and Engineering departments. This data, while useful, has been of a de-centralised nature and for various purposes. To assist with the creation of a Water Monitoring Framework for the Okeover, the UC Sustainability Office partnered with our group from the GEOG309 course.

2.3 Research Focus

The primary objective of this research was to gain an in-depth understanding of the physical, chemical and cultural parameters affecting the Okeover Stream and provide a framework which could be used to assess stream health. Due to the depth and breadth of measurable factors this was refined down to a six-category framework to better integrate with both national standards and the available stream data.

3. Methodology

The research focus for this project was to create a framework in which various stream attributes could be assessed to gain an integrated view of the stream health. To derive the most optimum attributes data and publications from the UC Sustainability Office, Waterways Centre for Freshwater Management, and other relevant sources were analysed. The data used was qualitative and collected from secondary sources (primarily from our partner, the Sustainability Office). The dataset was then cleaned and collated into excel spreadsheets for comparison and analysis.

A list of potential candidates was then drafted and compared with existing monitoring data from the Okeover to find overlapping variables. This was done to ensure that there would be as much overlap as possible between currently monitored variables and those in the proposed framework.

Research was then conducted via literature reviews to identify the most relevant factors to stream health, and how they could be integrated into one framework. From this, prominent attributes were analysed and compared to national and international standards. This was conducted using spreadsheets in excel, with monitoring data plotted to identify features of interest. Features such as heavy metals were identified as high interest during the literature reviews (Blakely , Harding, & McIntosh, 2003) and were focussed on during this analysis.

Cultural attributes were handled with a different methodology due to the nature of their measurement and implementation. Relevant cultural values were identified during literature reviews and consultation and were included into the overarching vision and implementation of the framework.

The Framework Methodology was selected as the most useful approach for this project. This was due to the allocated time frame, lockdowns on campus, future plans for the Sustainability Office, and the available data on the Okeover.

Data collection on campus was considered, however was deemed to be insufficient due to the short timeframe and difficulty in accessing the campus during lockdown. With the Sustainability Office proposing the hire of two new interns for monitoring projects, the Framework model was deemed to be the most useful product for our project to produce.

4. Framework

4.1 Framework Models

Frameworks are models of how existing concepts and systems interlink and relate to a particular problem. This project primarily uses the 'Representational Model', which highlights the relationships between attributes and establishes their role in the overall system. The McKinsey 7S Framework was also used as inspiration for the layout.

In this model a change to one area has implications for all other areas. There is no direct hierarchy, and all areas are denoted of equal size to represent equal importance.

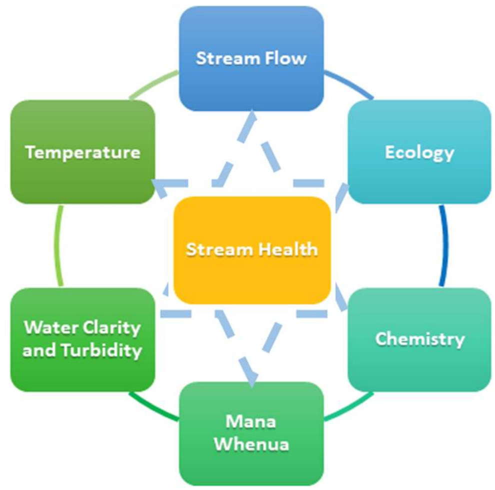

Figure 4. Proposed Stream Health Framework

4.2 Proposed Framework

The proposed framework in Figure 4 consists of six equally important categories for managing the Okeover Stream's health. These categories are all interlinked, and share common factors and variables. They are covered in-depth throughout the following sections. This framework proposes that a variety of variables underneath these headings are monitored in Figure 5.

The key relationships present are denoted below in Figure 6. They are intended as a general guide to direct monitoring efforts and future development of the stream.

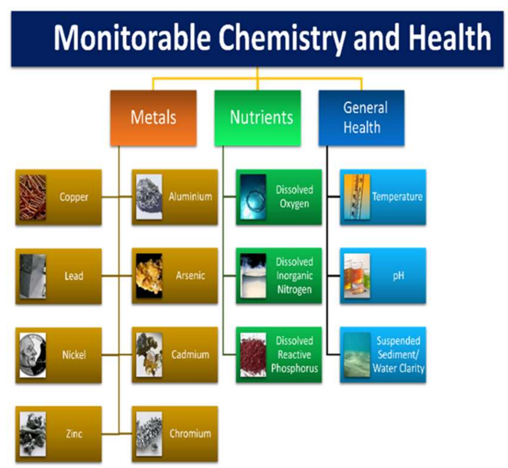

Figure 5. Proposed Monitorable Stream Variables for the Okeover

The construction of this framework was heavily influenced by the Māori concept of Tikanga (Cultural Values). The Cultural Health Index Model was set as an overarching theme and is reflected in the choice of categories and variables. While it is denoted as a sub-branch of stream health, the Cultural Health Index was one of the key inspirations for this framework and is present in both a local and wider context.

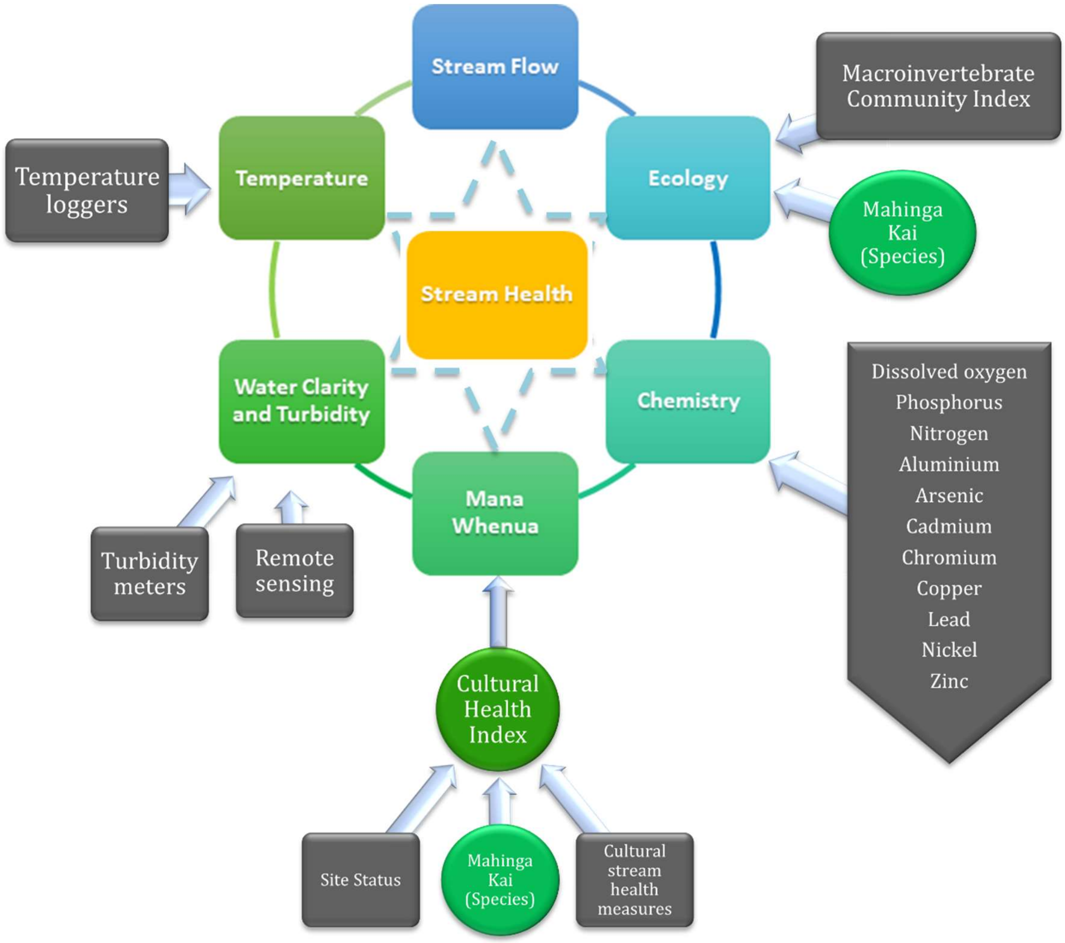

Figure 6. Key variables and relationships in the proposed stream health framework

When implimenting such a framework, it is important to note the mutual relationships present between each section. For example, an increase in stream flow can potientially result in higher sedimentation deposits, alterted temperature, varied chemistry, and even greater ecology. Likewise a change in the ecology, temperature, or another factor can results in changes across the whole system.

5. Monitoring Parameters

5.1 Streamflow

Streamflow is the amount of water flowing through a stream or river over time, it can often be referred to as discharge or quantity (Turnipseed & Sauer, 2010). The monitoring of streamflow is important for two main reasons. One being the larger the discharge, usually the larger impact the water body has on more people and ecosystems, and second being that most other variables involved in stream monitoring are proportional to discharge (Turnipseed & Sauer, 2010).

Before streamflow is measured, a site should be picked using the following guidelines in regards to (Turnipseed & Sauer, 2010), (Land Air Water Aoteroa, 2013) and (Painter, 2018):

- Access
- Location relative to points of interest and inputs
- Reasonably straight channel with parabolic cross section
- Close to the static depth measurement pole (if exists)

Streamflow is measured as $volume/time$, and is usually in m^3/sec or L/sec, however, since it cannot be measured directly it is split into three steps (Turnipseed & Sauer, 2010):

1. Measuring stream stage
    a. Setting up a static depth measurement pole to measure water level
2. Measuring discharge
    a. Creating a cross section of the stream
    b. Dividing it into segments
    c. Calculating discharge of segment using $discharge = area * velocity$
    d. Summing up the discharge of each segment
3. Stage-discharge relation
    a. Measuring stage and discharge at set intervals
    b. Measuring the above at extremely high and low river levels

It's worth noting that stage-discharge relations will get stronger as more recordings of stage and discharge are taken. This is so water level can be converted to discharge. The processes above can be done manually or with systems such as Acoustic Doppler Current Profilers (ADCP), which automate some parts (Fondriest Environmental, Inc., 2020).

To best monitor streamflow on the Okeover, discharge should be monitored at the sites of interest specified in Table 1. Discharge and stage should be monitored once every 6-8 weeks or at extreme highs and lows. Flow can then be recorded continuously by stream stage (Turnipseed & Sauer, 2010). Site, flow and stage need to logged to a central database (Painter, 2018).

Table 1. Information on sites for recording discharge on the Okeover (Painter, 2018).

Site Description	Notes	Water Level Marker	GPS Coordinates
12m downstream of Creche Bridge below Ilam Road	3m upstream of first cooling input	No	-43.52143, 172.57988
Engineering bridge	Easy access, very visible	Yes	-43.52189, 172.58327
Okeover on Clyde Road near Kate Sheppard House	Downstream of all university outputs	No	-43.52352, 172.58878

Table 2. Information about the parameters being recorded for discharge.

Parameter	Units	Frequency	Notes
Discharge	L/sec	Continuous	The more information on stage and discharge relation at different levels, the better accuracy for calculating discharge.

5.2 Ecology

Ecology is a part of biology that's involved with the relationships of organisms and their surrounding physical surroundings. Using this concept more in a stream environment investigates fish, aquatic invertebrates, and algae, and how well these organisms survive in their environment by looking into their populations. However, for the Okeover Stream the main organism that is investigated for an indication of stream heath are macroinvertebrates. This is because macroinvertebrates preferred habitat and their tolerances to different contaminants/pollution can be used to interpret the quality of habitat and the degree of water pollution (ANZECC, 2000; Hellawell, 1986).

Christchurch's urban streams ecological health has been compromised due to the wetlands being drained during the colonisation and the city being built on the plains. This has been due to low in-stream and riparian habitat heterogeneity which leaves the ecology, such as benthic macroinvertebrates, being exposed to pollutants in storm events (Blakely T. J., Harding, McIntosh, & Winterbourn, Barriers to the recovery of aquatic insect communities in urban streams , 2006). However, even with extensive riparian planting and in-stream restoration at the Okeover Stream, the benthic macroinvertebrate community hasn't had a big response to this change as caddisfly numbers are still low (Blakely & Harding, 2005). Therefore, it is important that this issue is investigated more deeply.

Winterbourn, Harding, & McIntosh, (2007) surveyed the Okeover Stream by taking samples from different areas in the stream. This was done by kick-sampling and sweeping a net through macrophytes and plants on the bank of the stream hanging in the water. These samples were then examined immediately in the laboratory.

New Zealand uses the Macroinvertebrate Community Index (MCI) to indicate water quality and overall stream health (Government, 2020). This is done by finding the percentage of each different species of macroinvertebrates ($\% \, Ephemeroptera + Plecoptera + Trichoptera$). A high MCI score indicates a greater level of stream health, and a low MCI score indicates that the stream is unhealthy and likely to be polluted. (McMurtie, 2009) discovered that the Okeover Stream is dominated by Trichopteran caddisflies. Using the trigger values for MCI-based indices in soft bottomed streams (New Zealand Government & Ministry for the Environment, National policy statement for freshwater management, 2020; Stark & Maxted, 2007). Pycnocentrodes should be 3.8, Hudsonema should be 6.5, and Hydrobiosis should be 6.7.

5.3 Chemistry

Chemical stressors can cause serious degradation of aquatic ecosystems when surrounding chemical values are too high or too low. Toxicants is a term used for chemical contaminants that have the potential to wield toxic effects at concentrations that can be experienced in the environment (ANZECC, 2000) The following chemical stressors and toxicants are considered: dissolved oxygen, phosphorus, nitrogen, aluminium, arsenic, cadmium, chromium, copper, lead, nickel and zinc. These chemical parameters were chosen on the basis of the UC waterways monitoring framework.

Dissolved oxygen is an equilibrium measure between oxygen consumption and oxygen releasing processes. "Dissolved oxygen indicates whether there is a disturbance to these competing processes and defines the living conditions for aerobic organisms" (ANZECC, 2000). Low levels of oxygen can affect aquatic aerobic organisms causing metabolic and behavioural problems (Saari, Wang, & Brooks, 2018). Phosphorus and Nitrogen can cause excess nuisance growth of aquatic plants such as periphyton and macrophytes in waterways, and cause fluctuations in dissolved oxygen and pH (ANZECC, 2000; Biggs & Kilroy, 2004; Gadd, Snelder, Fraser, & Whitehead , 2020). Algal blooms caused by excess phosphorus and nitrogen can cause problems by clogging filtration systems, limit light availability, create odours, and cause fluctuations in oxygen and pH due to eutrophication. Eutrophication is caused by cyanobacteria blooms which create a toxic hypoxic environment in which aquatic life can be stressed and die (Conley, et al., 2009).

(Gadd, Snelder, Fraser, & Whitehead , 2020) state that copper and zinc are key toxicants in urban streams and are usually used as measures for stormwater input. These toxicants can originate from impermeable surfaces such as galvanized and copper roofing material and wastewater pipes (Wicke, Cochrane, O'Sullivan, Cave, & Derksen, 2014). Toxicants such as these are usually transferred to the ecosystem through stormwater drains, with little to no treatment in New Zealand (Williamson, Mills, & Auckland Regional Council, 2009). Over 40% of the Okeover catchment is impermeable surfaces, which means these parameters are found in very high concentrations in the Okeover stream (Sustainability Office, 2015). (Hickey & Clements, 1998) found that waterbodies with the highest metal concentration levels also showed the greatest toxicity to benthic macroinvertebrates.

(Gadd, Snelder, Fraser, & Whitehead , 2020) and (Larned, Snelder, Unwin, & McBride, 2016) both used similar collection methods for chemical parameters. For nitrate and phosphorus colorimetric test kits were used in sample measurement. (Gadd, Snelder, Fraser, & Whitehead , 2020) filtered metals through a variety of membranes such as "0.45 µm membrane filters, ICP-MS; Filtration through GF/F filters (0.7 µm), GFAA; Filtration through 0.45 µm membrane filters, ICP-MS" (Gadd et al., 2020).

The trigger levels for the chemical parameters were found from the Australian and New Zealand Environment and Conservation Council (ANZECC, 2000), National Policy Statement for Freshwater Management (NPS-FW) ((New Zealand Government & Ministry for the Environment, National policy statement for freshwater management, 2020) and Canterbury Land and Water Regional Plan (CLWRP) (Environment Canterbury, 2019). These can be seen in table 3 below for the various chemical parameters mentioned above. Dissolved oxygen has a national bottom line of 5.0mg/L for a 7-day mean minimum as set by the NPS-FW. Dissolved reactive phosphorus shall be less than 0.016mg/L as set out by the CLWRP which is also between the C grade level of >0.010 and <0.018mg/L as set by the NPS-FW. Nitrate has a national bottom line of 2.4mg/L (annual median) as set by the NPS-FW while dissolved inorganic nitrogen shall be less than 1.5mg/L as set by the CLWRP. The CLWRP states that the Okeover stream needs a protection level of 90%. Aluminium levels should be less than 80(µgL-1). Arsenic should be less than 94(µgL-1). Cadmium should be[iii] less than 0.4(µgL-1). Chromium VI should be less than 6(µgL-1). Copper should be less than 1.8(µgL-1). Lead should be less than 5.6(µgL-1). Nickel should be less than 13(µgL-1). Zinc should be less than 15(µgL-1).

Table 3. Chemical parameters and their relevant trigger levels found from the Australian and New Zealand Environment and Conservation Council (ANZECC, 2000), National Policy Statement for Freshwater Management (NPS-FW) (New Zealand Government, 2020) Canterbury.

Chemical	**99% (µgL-1)**	**95% (µgL-1)**	**90% (µgL-1)**	**80% (µgL-1)**	**NPS-FW**	**CLW RP**
Dissolved Oxygen					5.0mg/L (7-day mean minimum)	
Dissolved Reactive Phosphorus					>0.010 and <0.018 mg/L (median)	<0.016mg/L
Nitrate	17	700	3400	17000	2.4mg NO3/L (Annual Median)	
Dissolved Inorganic Nitrogen						<1.50 mg/L
Aluminium	27	55	80	150		
Arsenic III	1	24	94	360		
Arsenic V	0.8	13	42	140		
Cadmium	0.06	0.2	0.4	0.8		
Chromium VI	0.01	1	6	40		
Copper	1	1.4	1.8	2.5		
Lead	1	3.4	5.6	9.4		
Nickel	8	11	13	17		
Zinc	2.4	8	15	31		

Copper, chromium-6 and zinc concentrations from the WQ Master Spreadsheet were above the guideline level for all 13 data points. On one occasion each, copper concentrations were 76 times higher than the limit, chromium reached 27 times higher than the limit and zinc reached 17 times higher than the limit. When comparing levels with this study these parameters may need to be adjusted to the lower 80% trigger levels before remediation work can commence. However, copper was still at concentrations higher than its 80% trigger level on all 13 of these data points.

5.4 Mana Whenua

A key parameter that was identified in this project for the Okeover stream are cultural values held with Tikanga (Māori values). Tikanga Māori is a key component of freshwater monitoring and management. Waterbodies hold a close relationship with tribal identity and genealogy of Māori tradition which is why the customary practices, ethics, values and kaitiakitanga (guardianship) of fresh water management is complex and an important regime to include within this monitoring framework (Hamsworth , Awatere, & Robb, 2016).

Recently, Iwi kaitiakitanga values are recognised in legislation but are one to be desired as interpretation of local bodies. The New Zealand Resource Management Act (New Zealand Government, 1991) states to "recognise and provide for the relationship of Māori and their culture and traditions with their ancestral lands, water, sites, waahi tapu and other taonga" and "to have particular regard to kaitiakitanga, the ethic of stewardship, and the efficient use and development of natural and physical resources." The 2014 national Policy statement also recognises efforts to incorporate Māori values and ethics within freshwater management in relation to the Treaty of Waitangi and Te Mana o Te Wai (Stewart-Harawira, 2020).

5.4.1 Recommendations

Through research of literature and secondary data a well-developed process for incorporating Tikanga into our monitoring framework stood out, A cultural health index (CHI). The current Okeover monitoring plans have not included any previous cultural health indexes which is why I will review the process and requirements of developing a CHI catered to the Okeover stream. It is important to note that CHI has to be designed specifically in regards to a single waterway, it is not flexible to use a CHI model for other waterways.

The CHI was originally designed to provide iwi with a tool to express their cultural values, it was originally trialled in Taieri and Kakaunui catchments during 1997-2003 (Tipa & Teirney, 2006), it provides a holistic Māori approach to water management, taking into consideration a range of culturally important variables such as mauri, taonga (flora and fauna), and mahinga kai (Young, Hamsworth, Walker, & James, 2008). The CHI largely came about during the release of the RMA as it became a 'requirement' to emphasize the importance of Mana Whenua involvement.

A cultural health index offers an evaluation of stream health in the structure of three different key components:
Site status: Whether the site is of traditional significance, will Tangata Whenua return to this site.
Mahinga Kai: A rating from 1-5 which is composed of four elements which is then averaged. (Number of Mahinga Kai species present, number of species of traditional significance still present, access to the site, would tangata whenua return to the site as they once did).
Cultural stream health: An average of 1 to 5 for 8 different indicators (water quality, water clarity, flow and habitat variety, catchment land use, riparian vegetation, riverbed condition/sediment, use of riparian margin and channel modification.

This index is developed by the Ministry for the Environment, in collaboration with Ngai Tahu and the University of Otago (Ministry for the Environment, 2019; Tipa & Teirney, 2006).

5.4.2 Requirements

To achieve and use the CHI it is important to use local tribal knowledge to assess the stream health in conjunction with historic conditions. In terms of the Okeover stream it is important to identify mana whenua for the Okeover to assist in identifying certain cultural indicators, locations of importance and an overall understanding of what's the expected outcome and what regeneration of the stream will look like. A series of meetings as well as site walkovers to gain a comprehensive understanding will be required. Continuing and developing a relationship with mana whenua will be recommended with continuation of stream remediation, for future decisions.

It is a strong recommendation that a CHI should be incorporated into the overall monitoring system and monitored as regularly as other indicators. Not only is it critical to understand that Mana Whenua input needs to be considered but is also required through the success for the CHI to be effective as a baseline of the overall regeneration goal.

5.4.3 Limitations

There are limitations to this process and the interpretation of recorded results which is largely due to difficulty obtaining baseline information without historic data or knowledge. This process also largely relies on the historic knowledge of the Okeover site by Mana Whenua. Data collection errors are also a common occurrence due to experience or skill and whether this is consistent. (Young, Hamsworth, Walker, & James, 2008) However, there are extensive literary records of the Okeover and its historic nature. These limitations are just as common as other Western monitoring frameworks.

5.4.4 Trigger Values

To incorporate trigger values within a cultural health indicator is reliant on the knowledge of the historical baseline or where all three parameters (1. site status, 2. Mahinga kai, 3. Cultural stream health) are able to function. To incorporate at trigger level for these parameters, there is no set recommendation or guidelines and is dependent on communication with Mana Whenua to identify appropriate levels and where mitigation strategy will need to be apparent.

5.5 Water Clarity and Turbidity

Water clarity is determined by how far light can penetrate through the water and is an important measure of stream health as it is a key factor for aquatic ecosystems (Fabricius, Logan, Weeks, Lewis, & Brodie, 2016). The variable that changes this is turbidity. Turbidity is an index of cloudiness of water and measures how light is scattered by suspended sediment in waterways (ANZECC, 2000; Gadd, Snelder, Fraser, & Whitehead , 2020; Grobbelaar, 2009; LAWA, 2021), which is measured in Nephelometric Turbidity Units (NTU).

Water clarity is measured by a combination of in-stream turbidity meters and remote sensing. (Ehmann, Kelleher, & Condon, 2019) used two small unmanned aircraft systems (sUAS) to get aerial photography and a submersible turbidity metre to get in situ observations of turbidity within 10 minutes of each flight. This process was carried out once a day in the given time period.

Water clarity levels need to be above the national bottom line of 1.34m set out by the National Policy Statement (New Zealand Government & Ministry for the Environment, National policy statement for freshwater management, 2020). (ANZECC, 2000) sets out an upper limit of 5.6 (NTU) for lowland New Zealand rivers. An upper chronic limit is the lowest tested concentration that did cause an unacceptable amount of adverse effect on one or more biological measurements and above which all tested concentrations also caused such an effect.

5.6 Temperature

Temperature is an important parameter in the Okeover stream as the majority of the baseflow comes from air-conditioning inputs from the University and is a source of thermal pollution (ANZECC, 2000; Fondriest Environmental Inc, 2014; Painter, 2018). Temperature governs the aquatic biota that can live in the ecosystem (ANZECC, 2000; Michaud, 1991). Changes in temperature are more likely to cause stress and death in waterways as well as changes in fish movement (Fondriest Environmental Inc, 2014; NIWA, 2020). Chemical parameters are also closely linked to the temperature of a waterbody. Water temperatures can increase the solubility and therefore toxicity of elements. These elements include heavy metals such as copper, cadmium, zinc and lead as well as compounds such as ammonia (ANZECC, 2000; Fondriest Environmental Inc, 2014; Khan , et al., 2006; Michaud, 1991).

(Braun, Reynolds, & Patterson, 2015) vertically installed a one-meter piece of rebar to attach three different temperature logger devices. These three temperature loggers were located at 15cm below the water level, at water level, and at 15cm above the water level. All loggers were started at the same time and took a sample every two hours for a period of one year. In the WQ Master spreadsheet it states that YSI continuous logger data was used for temperature.

We recommend putting one temperature logger above the air-conditioning input in order to get a temperature baseline before cooling water input. A temperature logger would also need to go below the air-conditioning input in order to see the effect this has on the temperature.
(Environment Canterbury, 2019) states that the maximum temperature for a spring-fed plains stream is 20°C for wadable rivers up to 600mm in depth (Environment Canterbury, 2019) also states that the average change in temperature for the same water quality class shall not exceed an average change of 2.0°C.

6. Recommendations and Conclusions

Through intensive research processes, we are recommending the UC Sustainability council to utilise this framework for monitoring the Okeover Stream using the selected parameters identified within this report. The proposed and summarised monitoring recommendations and parameters are as follows:

1. Measuring streamflow on the Okeover is a key component for quantifying the number of inputs that the university puts into the stream. Having a continuous measurement of this gives a base context to other recorded parameters.
2. Incorporating a Macroinvertebrate Index (MCI) is important, as it monitors biodiversity among macroinvertebrates within the Okeover Stream. This will help to understand if stream health is improving or deteriorating over time with annual monitoring. The three dominant species in the Okeover Stream are Pycnocentrodes, Hudsonema and Hydrobiosis.
3. Monitoring stream chemistry will use the 90% trigger level set in Table 3 to determine which chemical parameters need improvement. Monitoring may need to start before the trigger level are used to determine if they are too high, low, or even appropriate for the relevant parameter. In the case of copper, an 80% trigger level may be more appropriate than 90% due to the high concentrations.
4. Incorporating a Cultural Health Indicator (CHI) within the overall monitoring framework is needed to effectively represent Iwi cultural values of the Okeover into the remediation process. Direct contact and involvement of Mana Whenua should help run an effective and successful monitoring plan.
5. The NPS states that water clarity needs to be above the bottom line of 1.34m. ANZECC also sets out a turbidity upper limit of 5.6NTU for lowland New Zealand rivers.
6. The CLWRP states that the temperature in the stream should be less than 20°C while also not exceeding (+/-) 2°C of the stream’s average temperature which will need further monitoring to confirm.
7. All recorded data needs to be stored on a centralised database that is accessible to everyone wanting to view information on the Okeover. This provides an open and organised way to use, add and maintain data.

Table 4. Parameters showing recommendations of variables to measure. Including their names, units, frequencies and trigger values.

Parameter Class	Parameter Name	Units	Frequency	Trigger Value
Streamflow	Discharge	L/sec	Continuous	
Macroinvertebrates	Pycnocentrodes	MCI	Annual	3.8
	Hudsonema	MCI	Annual	6.5
	Hydrobiosis	MCI	Annual	6.7
Chemistry	Refer to Table 3			
Mana Whenua	Cultural Health Indicator	CHI	n/a	n/a
Water Clarity and Turbidity	Clarity	m	Quarterly	1.34m
	Turbidity	NTU	Continuous	5.6NTU
Temperature	Temperature	°C	Continuous	20°C

The trigger values for the parameters are all based on frameworks and recommendations from policies and plans such as the Australian and New Zealand Environment and Conservation Council (ANZECC), National Policy Statement (NPS) Canterbury Land and Water Regional Plan (CLWRP) and United States Geological Survey (USGS).

In conclusion, the monitoring plan of the Okeover contains many parts that are all interlinked with each other. While it's strongly recommended that UC Sustainability Office monitor these based on this framework, it is highly possible that there may be unknown parameters. This information will become more evident as the monitoring plan goes on, but the ability to investigate other parameters is vital. This framework has tried to lower the chances of there being a feedback loop between the sites and parameters being recorded – as the two can sometimes interfere with each other when there are assumptions made.

7. References

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