



Chatham Islands Surface Water Summary 2022-23

Our people, our Islands, our future



chatham islands council

Environment Canterbury Science Summary:

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Key messages

The 2022/23 year of monitoring is the 18th year of regular surface water monitoring on Chatham Island. This summary records the current patterns of water quality, hydrology, climate and lake levels on the island.

The 2022/23 year was a wetter year than several previous years and was replenishing depleted water resources on the island. Hydrology and climate patterns were described and patterns of flow and rainfall across the island remained similar to previous years.

Nitrogen concentrations in water are low, but show trends of increasing concentration in many waterbodies, and increasing eutrophication or greening of many lakes and lagoon sites.

Water quality continued to show a predominance of degradation with a worsening of state, particularly lakes, and most parameters showing trends of ongoing degradation (e.g. dissolved carbon, phosphorus, nitrogen, water clarity, and microbiology (E. Coli)). These appear to be associated with land use effects, associated with currently high stock numbers on the island.

Monitoring results from several water bodies deserve closer scrutiny and explanations to determine the cause of poor water quality state or trends. These also deserve ongoing and/or further monitoring effort.

The south-west catchment including Lake Huro, Mangapē Creek, and Mangatukurewa Creek have significant water quality issues and represents a potential hazard to community values and public health. Increased and/or innovative monitoring approaches are suggested to progress further understanding and actions needed to reverse the issues degrading this catchment.

The dune lakes of Chatham Island deserve closer scrutiny as they represent a valuable and limited potable water resource. Lake Rangitai appears to have suffered excessive abstraction effects, while the Petre Bay lakes should be monitored to better understand the resource they provide, so they do not suffer a similar fate.

Te Whanga Lagoon is showing degrading water quality in the northern and central basin, but currently has good and stable water quality in the southern basin. Suggestions to improve or maintain the quality of this important lagoon feature are made.

Regular monitoring of the potentially potable groundwater resource is an omission from this program. Initial studies have indicated the features and threats to this resource and an approach to developing appropriate groundwater monitoring.

With no increase in monitoring funding, and rising monitoring costs, options have been examined to reassess or refocus the monitoring programs. These recommendations are designed to free up resources to refocus monitoring in areas that should be of higher priority to the Chatham Islands environment and community. The hydrometric and climate station network could be closed or reduced to free-up resources to allow further monitoring in the Mangatukurewa catchment, the dune lakes, Te Whanga Lagoon and establishment of a groundwater monitoring program.

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1 Introduction

Chatham Islands Council (CIC) is a unitary authority, acting as both a regional and a District council set up under its own act of parliament. Environment Canterbury has been contracted since 2005 to provide advice and services to help CIC meet their Regional Council obligations including freshwater management. The water quality monitoring of the islands has been reported regularly via summary reports (Environment Canterbury, 2014; 2015; 2016; Pattle Delamore Partners LTD, 2018) These are available on the CIC website (<https://cic.govt.nz/services/environmental-data/water-quality-data/>). Another study undertaken with concurrent gauging's showed the correlations between flow rate for smaller streams (Ritson, 2010). Recently, Pattle Delamore Partners (PDP 2020), was engaged to undertake a review and report of the environmental monitoring on Chatham Island, including both water quality and historical qualitative and quantitative hydrological data and climate records. Since then, further reports have provided updates for the 2020-2021 and 2021-2022 hydrological years (Meredith, Stevens, & Milne, 2023; Meredith, Stevens, & Barbour, 2023). This current report provides a further update of surface water monitoring (both water quality, quantity/level, and rainfall) state and trends for the main Chatham Island for the 2022-2023 year.

Other islands such as the permanently occupied Pitt Island has not been monitored or commented on in this programme. A commentary is provided on the likely influences of any trends or changes in water quality and quantity or water level state identified.

The Chatham Islands form an archipelago of 10 islands with an approximate 60 km radius, these islands were formed from a volcanic upthrust causing the catchment geology to consist of volcanic basalt, unconsolidated sand, limestone, and schist. This is overlain with peat, sand, mudstone, and silt (GNS, 2014). Up to 60% of the main island, Chatham Island, is covered in peat or peat derived soils, ranging in thickness from half a metre to over 10 metres deep (Figure 1-1).

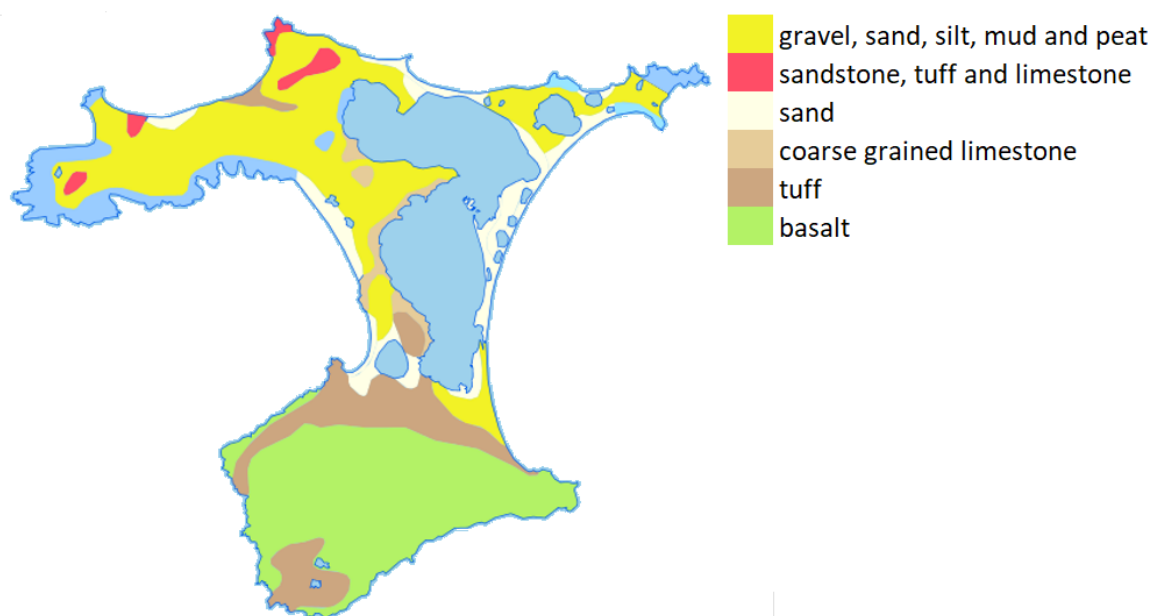


Figure 1-1: A map of Chatham Island with an overlay of the land type from the GNS - geological map of New Zealand 1:250k (GNS, 2014)

Many of the watercourses on Chatham Island drain peat basins, are highly peat stained, and often have consolidated and/or mobile peat bed materials. The peatlands (over 60% of the island area) can buffer the hydrology system from extreme weather patterns and rainfall events by acting like a sponge (rapidly absorbing and more slowly releasing water). This peat nature dominates both the resulting flow regime and water quality of the streams and rivers. These waterways are therefore a dominant and conspicuous

part of the Chatham Islands environment but are unique or different to most surface waters across mainland NZ.

The peat waters currently provide very little contribution to development and utilization of water resources on the island. These waters are not generally of suitable potable or domestic use or treatment standards, do not provide for high recreational or amenity uses, and are currently not developed for any industrial or municipal uses. They are utilised as an opportunistic livestock drinking water resource (stock water) and support the natural aquatic ecology of the island including supporting gathered foods and resources (Mahinga kai) including eels (tuna) and whitebait. There are no introduced sports fish or pest fish species in island waterways. There is therefore very little, if any, water use (water allocation for abstraction) pressure on these resources, little scope for major engineering developments (damming, diversion or channelisation), little concern for discharge of toxic contaminants generating water quality concerns or achievement of better than national bottom lines (targets), and little current biosecurity concern with these waters.

The 160 km² Te Whanga Lagoon in the northern part of the island accounts for approximately 20% of the total area of Chatham Island. It is of similar size to the other large coastal lagoon in New Zealand Te Waihora/Lake Ellesmere (197.8 km²), and larger than other lowland or coastal lakes, such as Lake Wairarapa in Wellington (78 km²), Waituna Lagoon in Southland (10.7 km²), or Lake Waikare in the Waikato Region (34 km²). It is enclosed by sand dunes to the north and east, has extensive cockle shell beds and chenier plain formations on the western beaches, and operates as a large shallow coastal lake or lagoon system. It both naturally opens to the sea through a sand barrier beach (Hikurangi channel) on the east coast, and it is occasionally necessary to be mechanically opened to the sea to prevent excessive water levels damaging roading and land infrastructure. Te Whanga lagoon is currently considered to be a brackish water lagoon with salinity up to or over 50‰ seawater. It has been open continuously for most of the past 4 years but appears to have closed most recently in February or March 2023. It was last previously mechanically opened in mid-2019 (Owen Pickles- CIC, pers. comm.), and will have been again recently mechanically opened (late 2023).

The freshwaters of the Chatham Islands are mostly highly peat stained. There are small sources of freshwater that are largely clear uncoloured water and potentially suitable for potable, domestic, and commercial use. They are largely restricted to the water contained within sand dune lakes along the western coast (Petres Bay - Lake Marakapia, Tennants Lake, etc.) and in the north (Lake Rangitai); groundwater seeps from the steeper basaltic geology generally in the south of the island, and some limited groundwater aquifers associated with the silica sand dune formations (i.e. around Lakes Marakapia, Tennants Lake etc.), or limestone sand strata (such as in the vicinity of Waitangi and along the Te One coast). This very limited natural presence of uncoloured freshwater resources results in local efforts being widespread collection and storage of roof water runoff from rainfall for domestic use outside the main township of Waitangi. These limited natural potable freshwater resources are currently or generally only under pressure during annual or sustained drought periods when rainfall collection or aquifer and lake recharge volumes become depleted. It is therefore important that these important freshwater resources are well represented in monitoring activities to allow a good understanding of their natural characteristics and limitations, and to ensure their effective management and protection for current and future use.

There are currently six Environment Canterbury operated climate/rainfall stations, three in the northern part of the island and three in the south of the island and one site monitored by the National Institute of Water and Atmospheric Research (NIWA) located at the airfield (Figure 2-1). Chatham Island also has four long term flow recorders operated by Environment Canterbury on the four largest surface water drainages (rivers) on the island. Three flow recorder sites sit alongside rainfall sensors; one of these flow recorders is on the northern half of the island and three are on the southern part of the island (Figure 2-1). The recorders measure the water height and then convert it to flow using information from the river profile, which is collected every time the river is gauged (generally 4 to 6 times per year). It is important to consider the value of the ongoing maintenance of these recorders as malfunctions can cause long gaps within the record until they are serviced again. Routine maintenance and gauging are also required to comply with National Environmental Monitoring Standards (NEMS). Their maintenance would normally be considered imperative in most areas of NZ as they would form important functions: in flood hazard warning; managing water use limitations at low flow times; and so that we can establish long term trends and determine whether there are any natural or anthropogenic influences on river flow

requiring clarification or management. However, many of these functions may be of lesser or limited relevance to a small island environment such as the Chatham Islands that do not use or respond rapidly to weather and river flow influences.

The short river length and low proximity of infrastructure adjacent to the rivers seldom make active or responsive flood hazard management on individual rainfall events an actively managed function on Chatham Island. In contrast, this is a critically important function in large catchments in mainland New Zealand and elsewhere around the world. Furthermore, most stream and river road crossings have been upgraded to modern high flow capacity culvert crossings over the past 15 years, such that there is much lesser concern for managing or preventing road washouts from waterway flooding on the island than in past decades.

The four rivers that are monitored have strong correlations between them, and to flows in other rivers (PDP 2020). Therefore, while the flow data provides valuable data on the flow regime of natural rivers, provided gaugings are maintained (Pattle Delamore Partners Ltd, PDP, 2020), it appears a luxury to maintain so many highly correlated hydrometric sites. Furthermore, the very low abstractive water use, and absence of on-line water storage use may similarly make low flow monitoring a relatively low priority function at present and in the foreseeable future. There may already be adequate data to describe the flow regimes and enable future functions to be considered from this current level of understanding without continuing this level of hydrometric monitoring indefinitely.

The water levels of two of the clear water dune lakes have had water level monitoring loggers installed in them in the past 3 years to scope an understanding the extent of their water level variability. This data may assist in understanding the current level of water storage either currently used or available for use. The recently collected data from Lake Marakapia is considered too unreliable to report and more effort is needed to establish a reliable data collection system. The data from Lake Rangitai are similarly variable, but the data patterns illustrate the utility of this type of monitoring. This data will in future enable assessment of the resource and potential sustainable water yield from these limited resources.

The groundwater resource is not currently monitored, but recently the available information on the development of groundwater resources (bores and wells) have been gathered, and some one-off measurements of bore characteristics of private bores undertaken (water depth) and more recently water chemistry. It is intended to incorporate regular groundwater monitoring and assessment of the sustainable groundwater resource in this programme in the future.

To date, strategies for monitoring the waters of the Chatham Islands have not significantly distinguished between the different water quality and waterbody types and have largely focussed on monitoring major surface water bodies covering all parts of the island. No monitoring of water is undertaken on Pitt Island or any of the other offshore islands as these have not been necessary or feasible within the existing budget.

The purpose of this water quality and quantity summary is to:

- Update and review the current state and long-term trends of the sites monitored on the Chatham Islands, and
- Provide commentary on probable cause of any change in state or trend in water quality and quantity.

Additionally, given that monitoring has been ongoing for nearly 20 years, it is also timely to consider whether the current monitoring strategy is effectively providing the necessary information for island specific water use and water management on the island.

2 Methodology and data analysis

2.1 Water quality data

Routinely monitored surface water quality sites are listed in Table 2-1 and shown on Figure 2-1. These illustrate the broad geographic distribution of sites originally set up in 2005 and reviewed by PDP 2020.

Censored data (values outside of laboratory minimum and maximum detection limits) were adjusted before analysis following Environment Canterbury's reporting methods (Environment Canterbury, 2023).

Table 2-1: List of water quality monitoring sites and their database ID numbers

Site ID	Site Name	Site ID	Site Name
SQ34829	Awamata Stm	SQ34860	Waitāmaki Ck
SQ34830	Awatōtara Ck	SQ34834	Washout Ck
SQ34844	Blind Jim's Ck	SQ34838	Whangamoe Inlet Stm
SQ34854	Mangahōu Stm	SQ34859	Lake Huro
SQ34851	Mangapē Ck	SQ34893	Lake Marakapia
SQ35078	Mangatukurewa Creek/ Nairn River	SQ34846	Lake Rangitai
SQ34841	North Trib Rakautahi	SQ34887	Lake Te Wāpu
SQ34832	Te Awainanga River	SQ34842	Tennants Lake
SQ34857	Te One Ck	SQ35082	Te Whanga Southern
SQ34863	Waimāhana Ck	SQ34843	Te Whanga Blind Jim's
SQ34849	Waitaha Ck	SQ34861	Te Whanga Waitāmaki

The current state data are presented as box and whisker plots to demonstrate the data distribution and variation in monitoring data over the past five years. A full list of water quality parameters measured is provided in Table 2-2.

Table 2-2: Water quality parameters measured at monitoring sites on the Chatham Islands

Water quality parameter	Units
Dissolved oxygen (DO)	mg/l; % saturation
Water temperature	°C
pH	Unitless
Dissolved organic carbon (DOC)	mg/L
Dissolved Reactive Phosphorus (DRP)	mg/L
Total Phosphorus (TP)	mg/L
Ammoniacal nitrogen ((NH ₄ -N)	mg/L
Nitrate and Nitrite Nitrogen (NNN)	mg/L
Dissolved Inorganic Nitrogen (DIN)	mg/L
Total Nitrogen (TN)	mg/L
Chlorophyll a	mg/L
Water clarity	m
Trophic Level Index (TLI)	Unitless
<i>E. coli</i>	MPN/100mL
Enterococci	MPN/100mL

Trophic Level Index (TLI) values have been calculated for lake and lagoon sites on the Chatham Islands using methods defined in Burns *et al.* (1999). Secchi disk was not able to be measured and so is not included in calculations. This is because sampling is from the lake edges where Secchi cannot be readily carried out. TLI therefore does not include Secchi disk measurements and is reported as a TLI3 index.

The Trophic Level Index relies on close correlation between 4 algal biomass attributes (Chlorophyll *a*, TN, TP, Secchi depth). However, any reduced water clarity of the Chatham Island lakes is primarily caused by wind resuspension of bed sediments, or from high dissolved colour and suspended peat material in peat lakes rather than from algal growth. Reduced water clarity may therefore not be a result of eutrophication and would correlate poorly with the other three TLI biomass attributes - nutrient concentrations and algal biomass. The approach of not including a clarity component in TLI was therefore considered appropriate for reporting TLI for lakes of Chatham Island as a TLI3 statistic.

At each site, the current state of the measured water quality data was assessed against the attribute state bands outlined in the New Zealand National Policy Statement for Freshwater (NPSFM 2020). The NPSFM (2020) attribute state have not been calculated annually, but have been calculated from the past five years of monitoring data, as sites are only sampled quarterly.

The long-term trend in water quality were determined using the Mann-Kendall test and the Sen slope. Trend were assessed for the last 10 years. Before display of long-term trends, each parameter at each site was required to have at least 80% available data (no more than 20% missing values). As the Chatham Island sites are only sampled quarterly, there needed to be at least 32 samples over a ten-year period to be considered suitable for determination of long-term trends. Trends were categorised into five classes: very likely degrading, likely degrading, indeterminate, likely improving, and very likely improving. A trend is classified as 'very likely' when there is a 90-100% certainty of an improving or deteriorating trend, whereas a 'likely' trend is given when there is 67–89% certainty of an improving or

deteriorating trend. The trend is assessed as 'indeterminate', if the likelihood of the trend is less than 67%. This method is consistent with the Land Air Water Aotearoa (LAWA) approach used for water quality trend assessment. All data were analysed for trends using Python software.

2.2 Hydrology data

There are four active Environment Canterbury maintained flow sites on Chatham Island and six Environment Canterbury maintained climate/rainfall recorders (Table 2-3; Figure 2-3), they are typically visited at least quarterly and during these visits the recorders are assessed, and the water courses are gauged. The relationship between the gauging and the water level was used to convert the water level data to the flow rate of the water course and to assure the quality of this conversion.

Table 2-3: Flow, rainfall, and water level monitoring sites and their IDs for the Chatham Islands

Site Name	Rainfall	Flow	Water Level
Chatham Island Aero Aws (NIWA)	986107		
The Landing at Muirsons	986206		
Waitangi at Met Station	986207		
Wharekauri at Tonys	986205		
Te Awainanga at John Days	986109		
Tuturi River at Shists Outcrop	986108	3436871	
Awamata at Old Hydro Intake	986200	3446071	
Tuku a Tamatea		3379428	
Te Awainanga at Falls		3446051	
Te Whanga Lagoon at Moropunga Island			3505766
Te Whanga Lagoon at Hikurangi Channel			3564582

Logistically, it is difficult to get gauging's at different flows but ideally gauging's are undertaken through a range of flows including both low and normal flow conditions. It may be difficult to schedule visits during high flow times and may be unsafe to undertake lone gaugings in high flow situations (PDP, 2020). During the 2022/23 hydrological year there were four visits to the Chatham Islands. Te Awainanga River was gauged once with the other three rivers being gauged three times, this reduced frequency being due to the excessive flow/height of the rivers during an April visit.

NIWA has generated/reported Chatham Island rainfall data from 1956 but there has not been one continuous record. Some historical stations were discontinued, and new stations at different locations have replaced them. This inconsistency has generated problems for long term records, and there have been efforts to ensure continuity of the records located at both the airfield or Waitangi township. The other sites around the island could be considered more discretionary.

To create a continuous long-term rainfall record on Chatham Island, data from three historical NIWA stations were combined. Chatham Islands Aws (986105) and the Waitangi site (K98601) were located near Waitangi, the largest settlement on the island, and Chatham Islands Ews (986106) which was located near the airfield. The NIWA site Chatham Islands Aero Aws (986107) was recording alongside Chatham Islands Ews from 2012 to 2018 and is still operational near the Chatham Islands airfield (Figure 2-2).

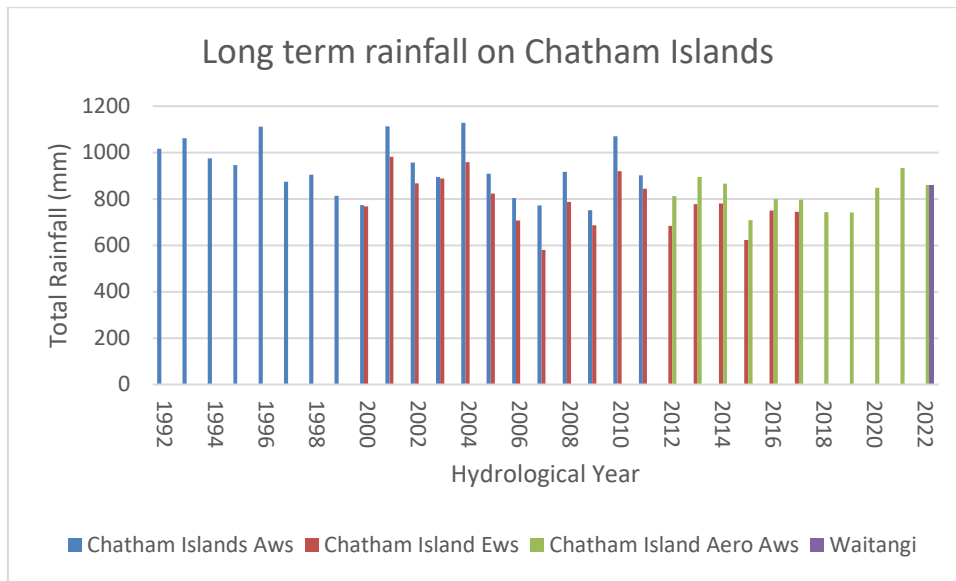


Figure 2-2: Annual rainfall over 1992 – 2022 hydrological years across four recorders in two locations, the Chatham Island airfield and Waitangi

The rainfall at Chatham Islands Aws and Chatham Islands Ews (Waitangi and the Airfield) correlated reasonably well with comparable rainfall in wetter years between 2000 – 2008 (Ritson, 2010). The Chatham Islands Aws and Environment Canterbury’s Waitangi station are recording in the same location and therefore should be correlated similarly (Figure 2-2, Figure 2-3).



Figure 2-3: Chatham Island water flow (river) and level (lagoon) and rainfall recorders. Rainfall sites are indicated as circles and water level recorders are indicated as diamonds

The National Environmental Monitoring Standard (NEMS 2019) require hydrometric gauging's to occur at sufficient intervals to maintain an accurate stage – discharge rating curve and to detect when this relationship may have changed. The gauging frequency may vary year to year but there cannot be an interval greater than 9 months in natural channels. At a site where there is a stable natural control gauging frequency can be reduced provided that the rating is well established and is checked within one month of any event that is likely to affect the rating (NEMS 2019). This can generate problems being achieved on the Chatham Islands but most sites are on stable natural controls involving bedrock outcrops.

3 Results - Water quality

3.1 Dissolved oxygen

Dissolved oxygen concentrations are variable (Figure 3-1, Figure 3-2)

Stream sites varied greatly, with some streams showing concentrations varying between zero and above 100% saturation (Figure 3-1). These are generally the streams draining peat basins and reflect high seasonal variation in flow rates. In summer these streams can become essentially stagnant and in wetter seasons flow freely with high reaeration. Many streams show dissolved oxygen concentrations well above 100% saturation showing high daytime photosynthesis (producing oxygen).

Sites in Te Whanga lagoon at Blind Jims and Waitamaki both showed a high range of dissolved oxygen and on occasion were above 150% saturation (Figure 3-2). This indicates a likely high algal biomass with high oxygen generation in daylight (photosynthesis) and lower concentrations (respiration) at night. These likely reflect a degree of increased eutrophication.

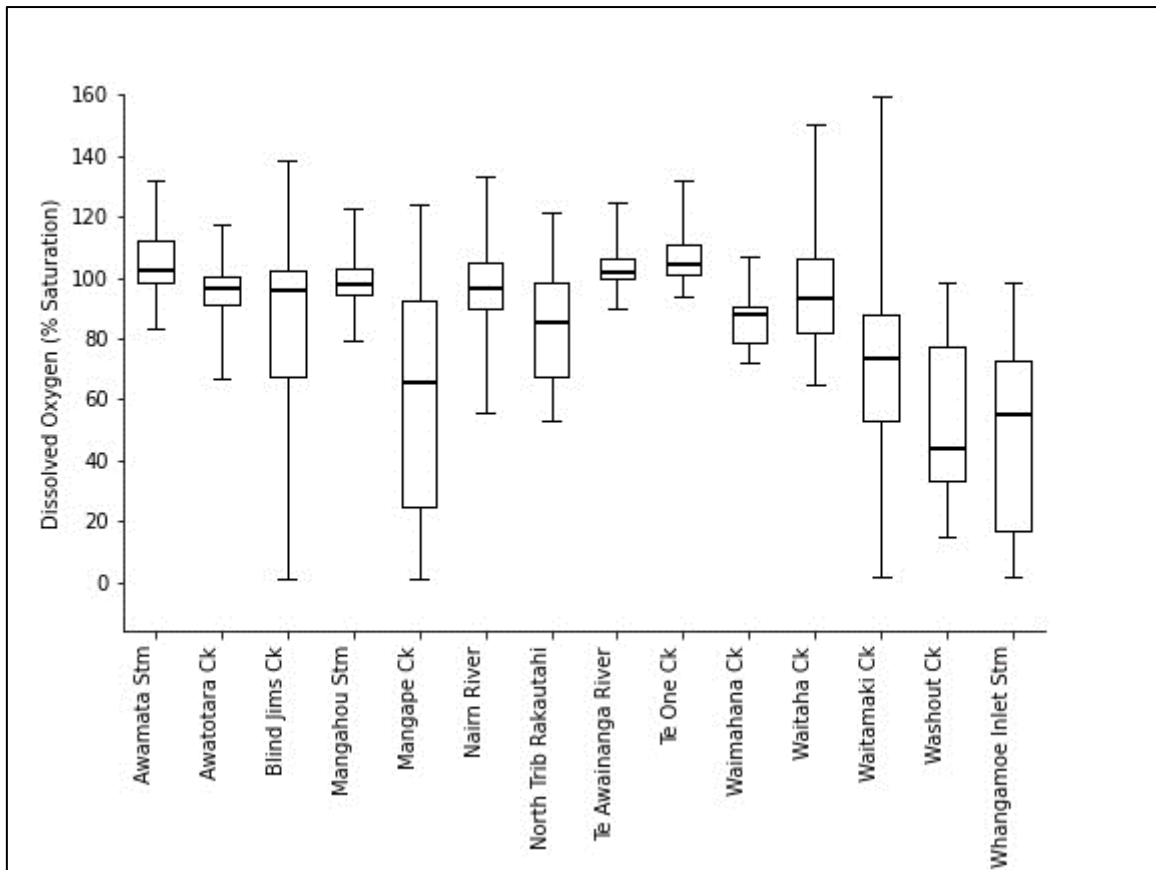


Figure 3-1: Current state of dissolved oxygen for monitored river sites on Chatham Island

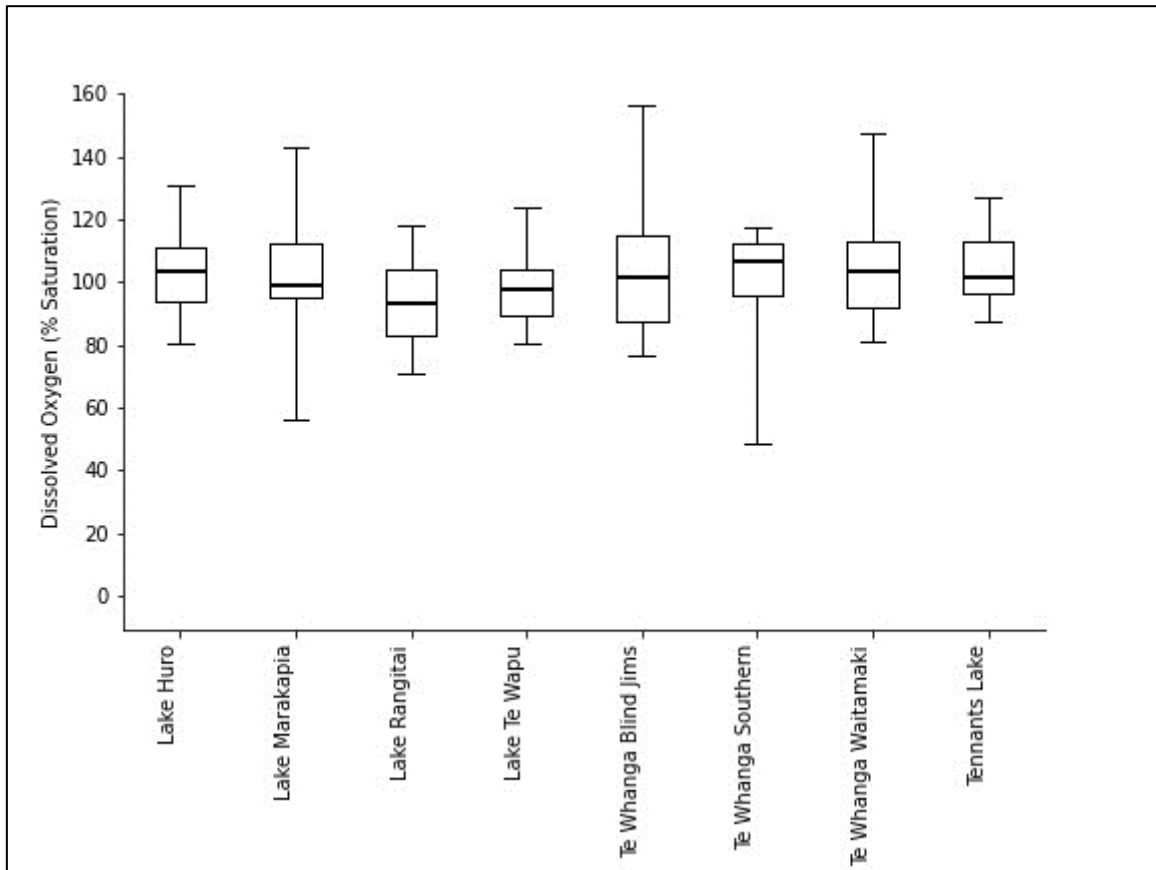


Figure 3-2: Current state of dissolved oxygen for monitored lake sites on Chatham Island

3.2 Water temperature

Water temperature in both Chatham Island streams (Figure 3-3) and lakes (Figure 3-4) are stable with limited variation (generally 8-20°C) and an absence of extreme temperatures that would be harmful to aquatic life. This is because waterways are probably thermally buffered by both the maritime climate and proximity to the sea, and the high volume of thermally buffered peat and shallow groundwater sources. Water temperature extremes are unlikely to be a significant management issue.

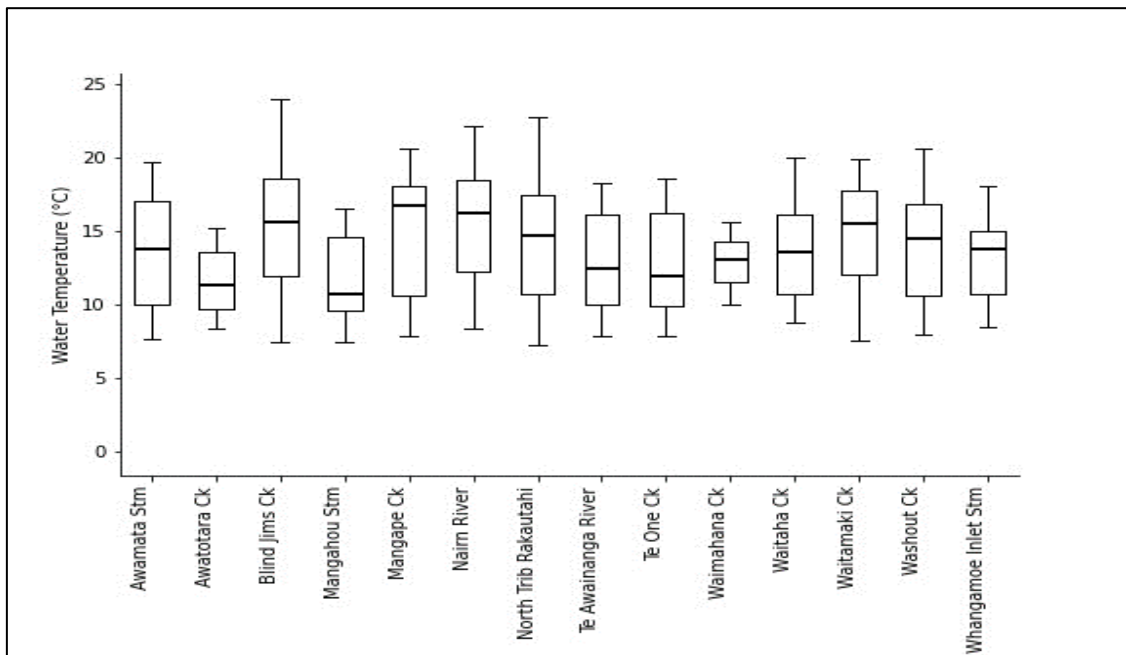


Figure 3-3: Current state of water temperature for monitored river sites on Chatham Island

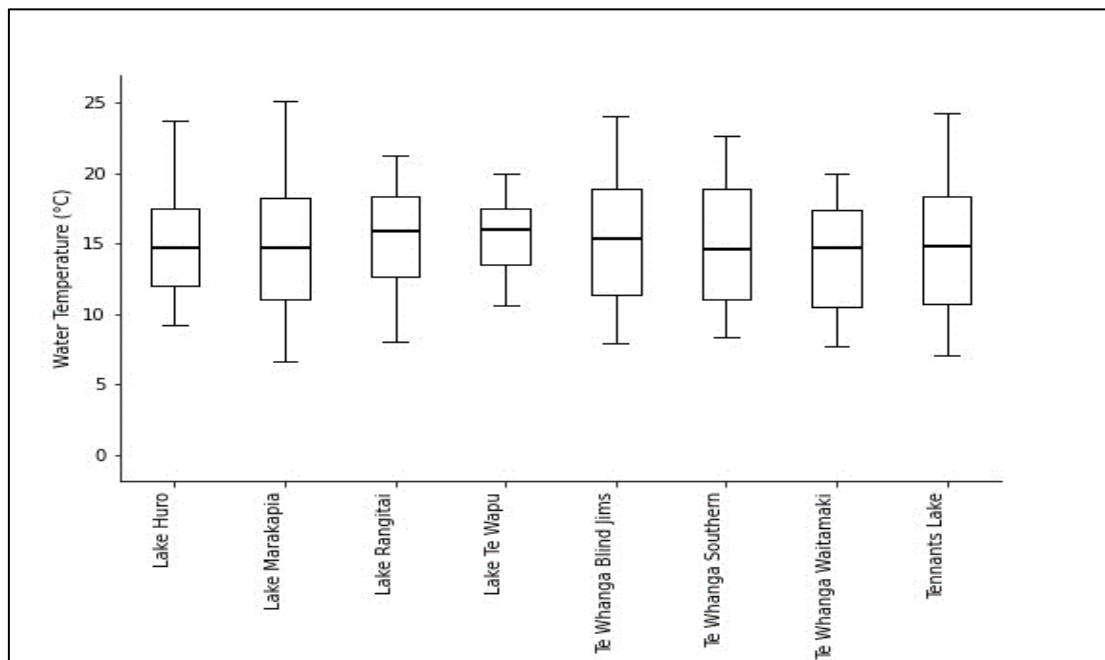


Figure 3-4: Current state of water temperature for monitored lake sites on Chatham Island

3.3 pH

The pH of Chatham streams vary greatly with some waterways strongly acidic (pH 4-5) and others alkaline (>8) (Figure 3-5). Many show a high variation (i.e. from pH 5 to 8) which shows many sites may be poorly or not strongly buffered. These results indicate the highly variable geology and nature of catchments that can vary greatly under different discharge conditions. However, despite such variability, the variable pH status may not affect the current low potable or economic use of these surface water resources. In contrast the Chatham Island lake sites have largely alkaline water (pH 8-9) (Figure 3-6).

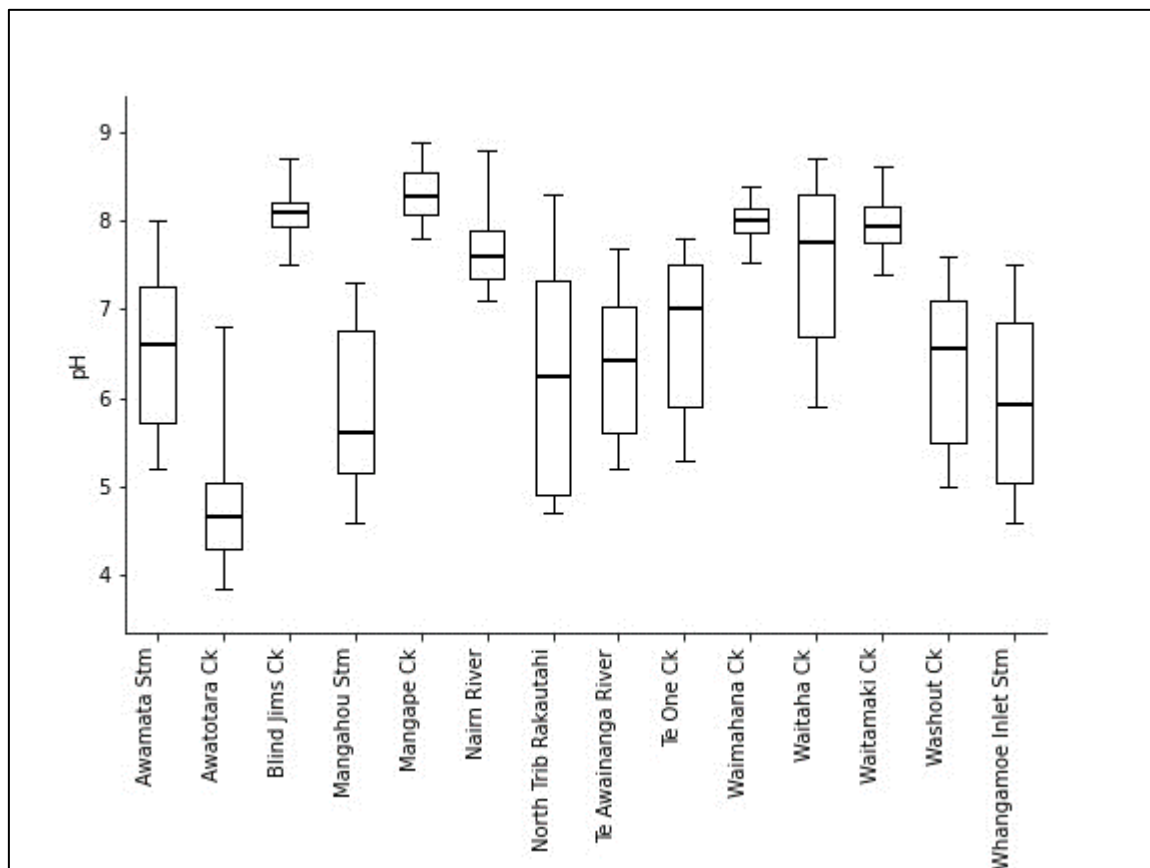


Figure 3-5: Current state of pH for monitored river sites on Chatham Island

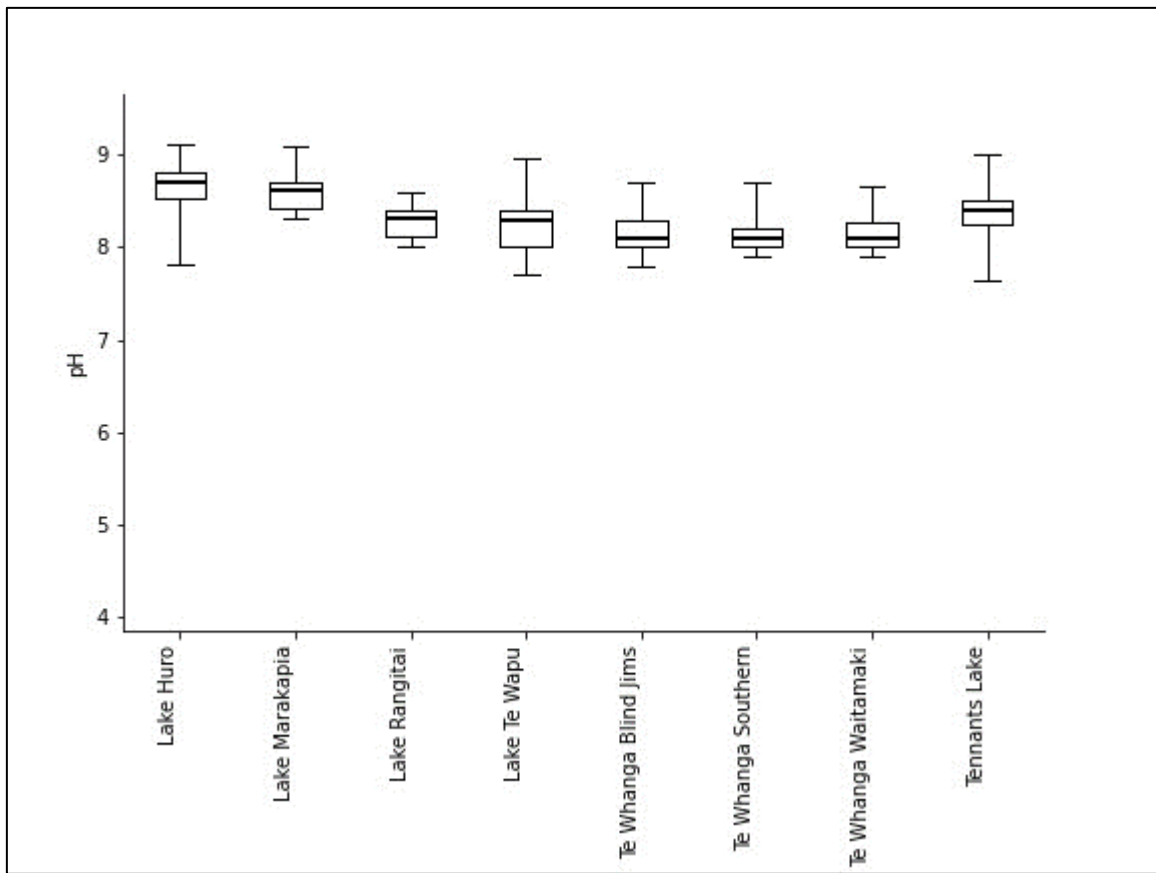


Figure 3-6: Current state of pH for monitored lake sites on Chatham Island

3.4 Dissolved organic carbon concentration

Dissolved organic carbon concentration (DOC) is not a common water quality parameter reported elsewhere in New Zealand but is very relevant on the Chatham Islands because of the peat basin water sources that are high in dissolved carbon concentrations. It is therefore important to measure and report DOC to determine whether streams, rivers and lakes are continuing to leach similar concentrations and loads of dissolved carbon. This will also give an indication of any change in the nature of the peat basins. Four streams have lower DOC than the others and could be described as exhibiting low colour, however their DOC is still high compared to mainland NZ streams. Most other streams were more highly coloured and showed DOC between 30 and 60 mg/l (Figure 3-7).

The lakes had lower DOC but were still elevated compared to most mainland NZ lakes with significant DOC concentrations (Figure 3-8). Lake Te Wapu was the only highly peat stained lake currently in the monitoring program.

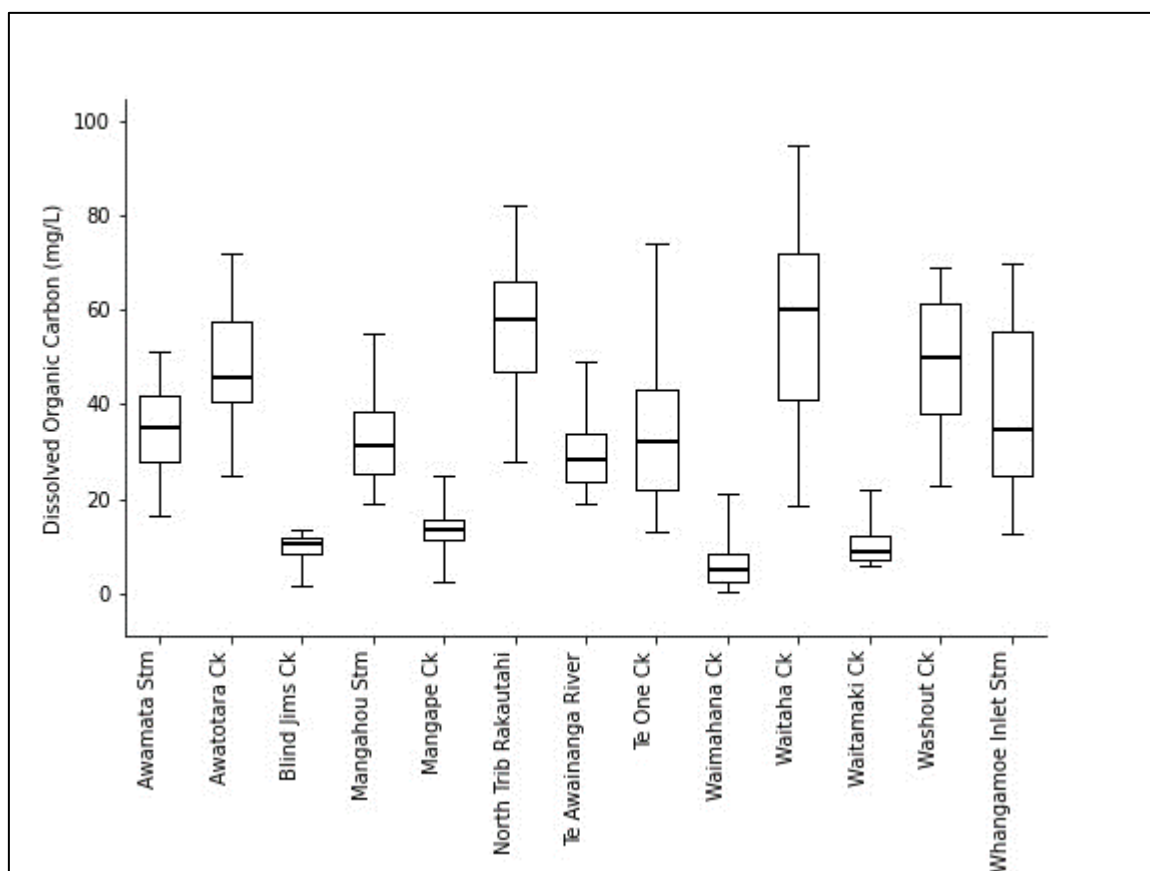


Figure 3-7: Current state of DOC for monitored river sites on Chatham Island

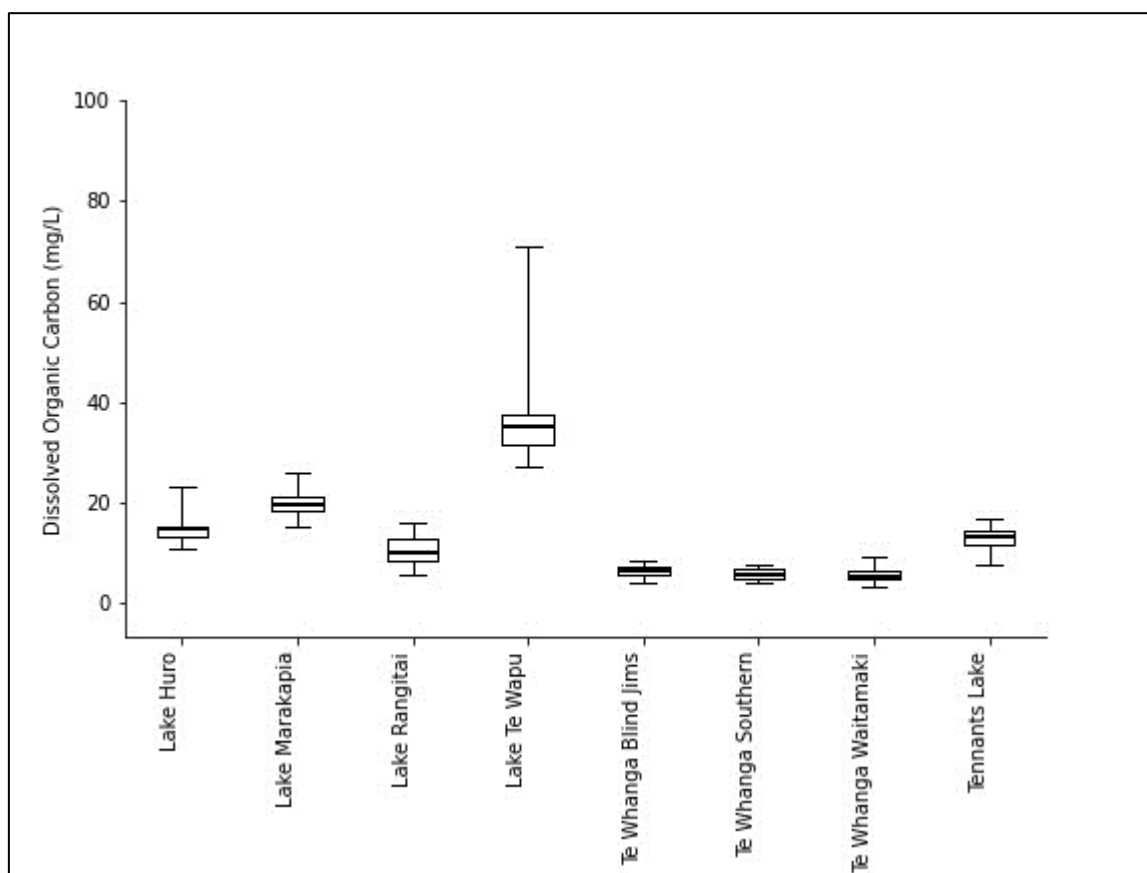


Figure 3-8: Current state of DOC for monitored lake sites on Chatham Island

3.5 Nutrients

3.5.1 Phosphorus

The Chatham Islands is generally considered a phosphorus rich geology, and very little phosphatic fertilizer has been used or imported onto the island. However, the state and trends in phosphorus concentration in waters remain very important in reporting the balance of available nitrogen and phosphorus concentrations and the development of eutrophication effects.

Waimāhana Stream stands out for the highest median Dissolved Reactive Phosphorus (DRP) concentration (0.15 mg/L) followed by Washout Creek (0.07 mg/L) (both in the north of the island) (Figure 3-9). Streams in the south of the island had lower and less variable phosphorus concentrations. The lakes (other than Lake Te Wapu) had negligible available dissolved phosphorus (Figure 3-10).

Total Phosphorus concentrations (TP) was more variable, possibly reflected by the phosphorus content in suspended peat particles and was higher in streams than lakes (Figure 3-11, Figure 3-12).

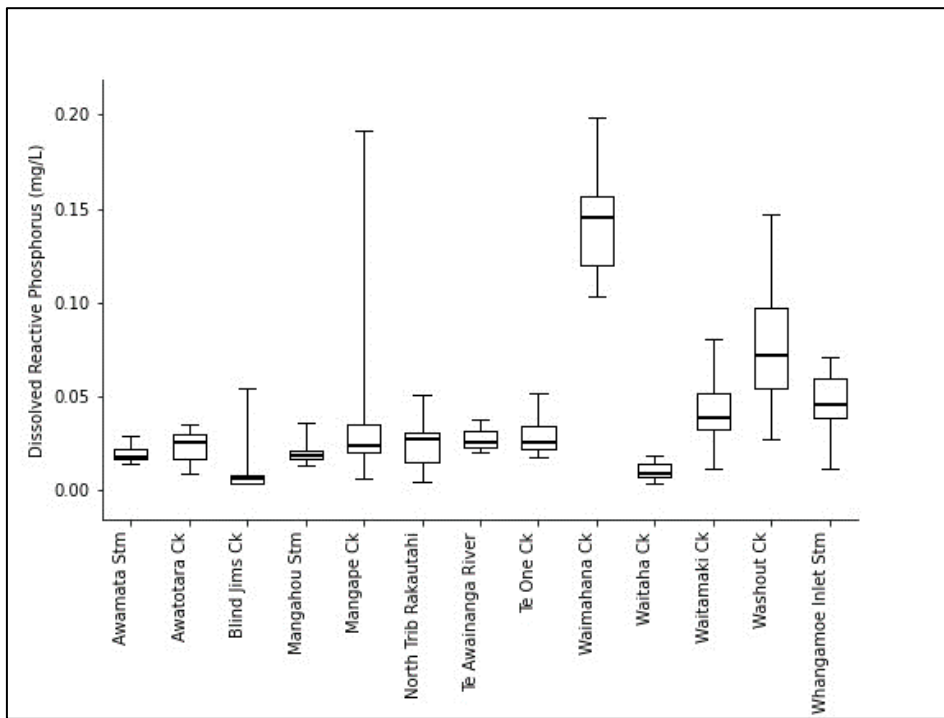


Figure 3-9: Current state of DRP for monitored river sites on Chatham Island

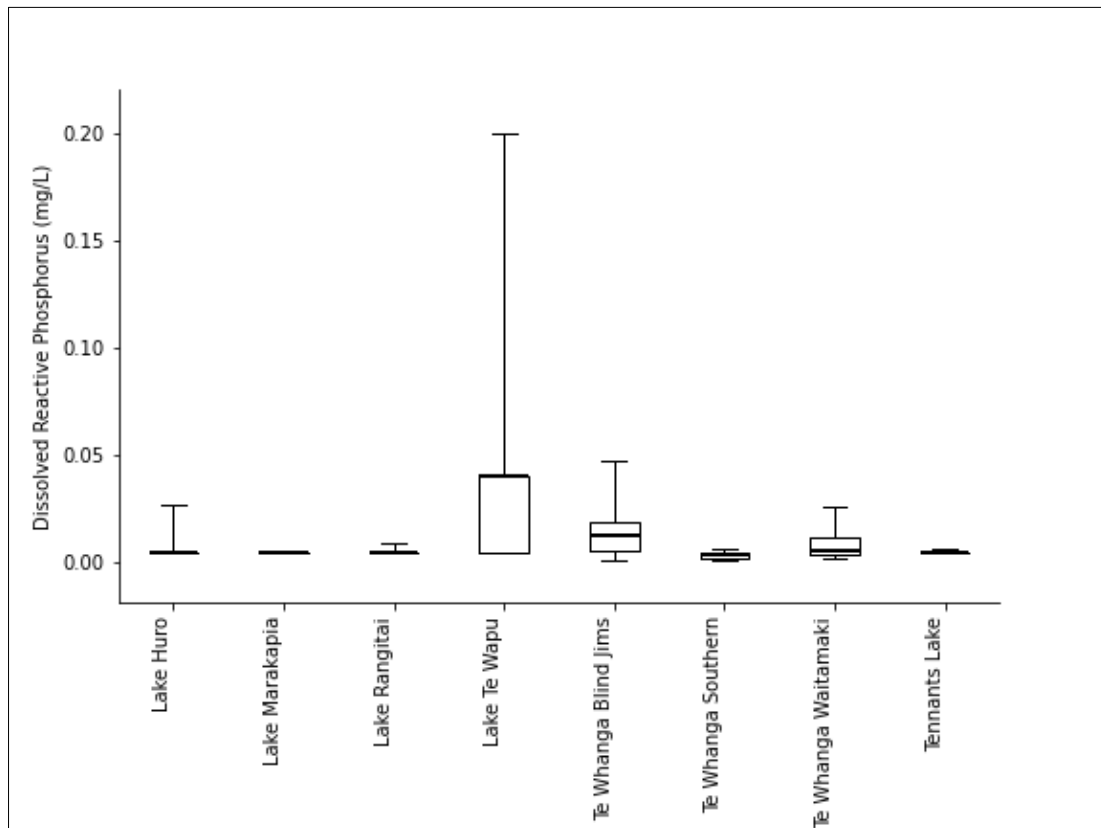


Figure 3-10: Current state of DRP for monitored lake sites on the Chatham Islands

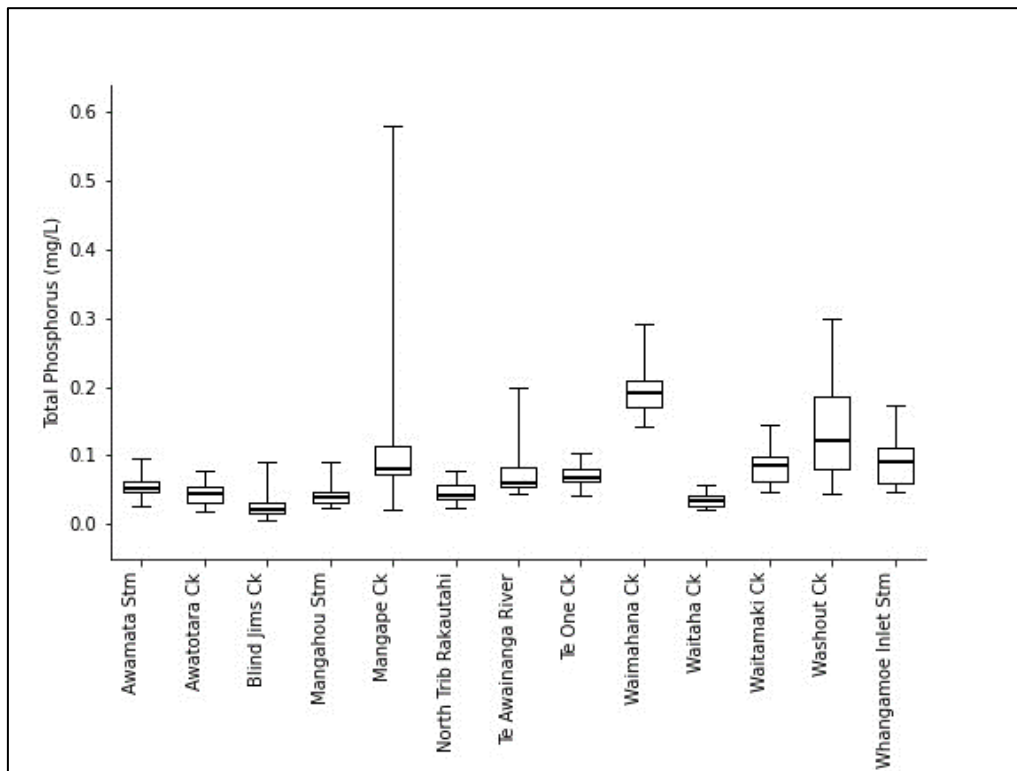


Figure 3-11: Current state of TP for monitored river sites on Chatham Island

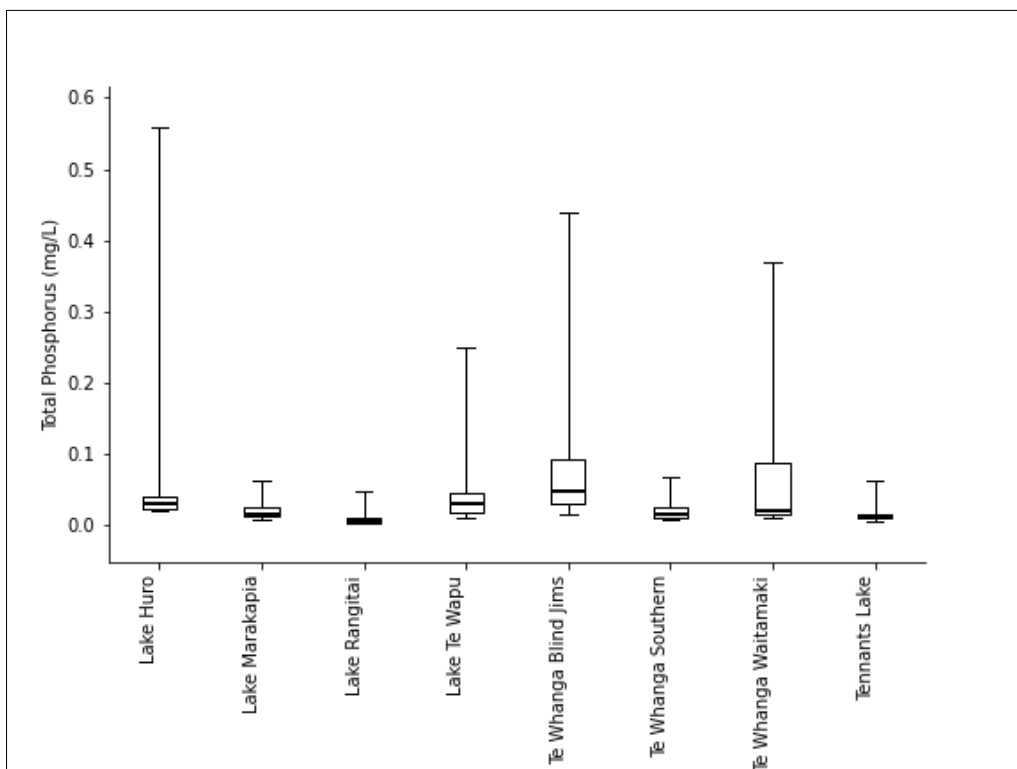


Figure 3-12: Current state of TP for monitored lake sites on Chatham Island

3.5.2 Nitrogen

Nitrogen concentrations are expected to be low on Chatham Island because nitrogen is generally derived from animal and human inputs rather than from natural geology. Ammoniacal nitrogen (NH_4N) concentrations are very low/absent except from Mangapē and Washout Creeks (Figure 3-13). These likely originate from increased animal or bird faecal and urinary sources of nitrogen. Lakes are more variable in ammonia concentrations (Figure 3-14).

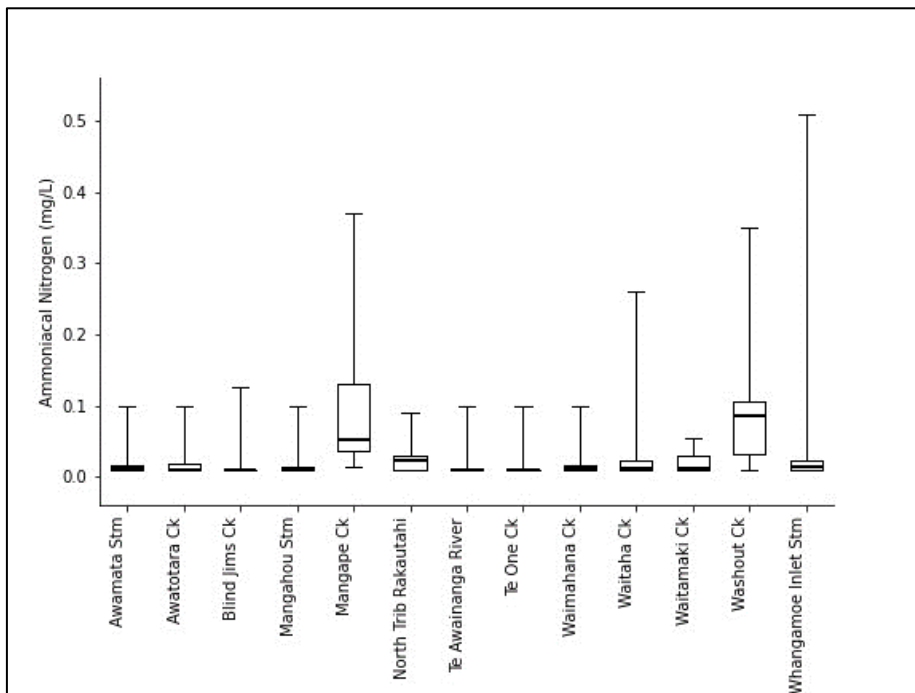


Figure 3-13: Current state of NH_4N for monitored streams on Chatham Island

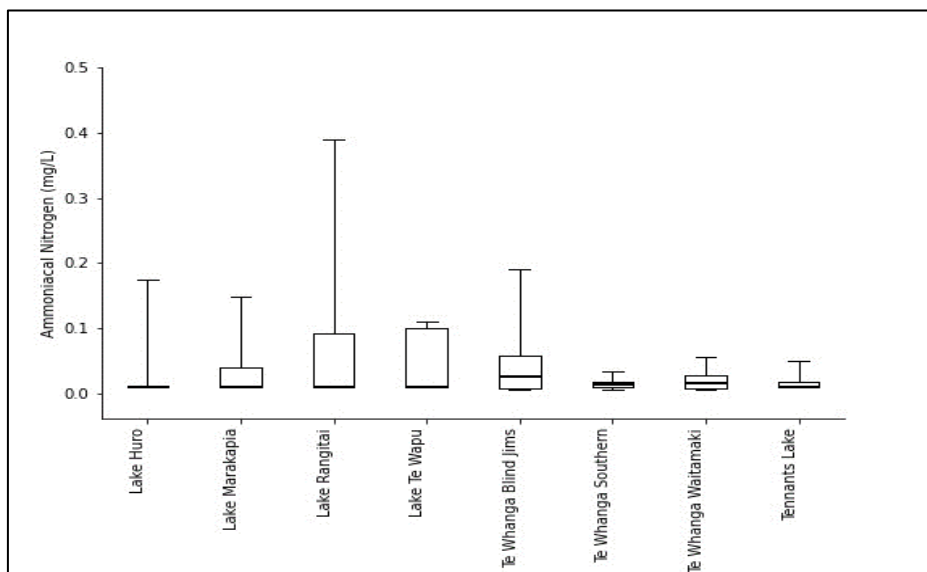


Figure 3-14: Current state of NH_4N for monitored lake sites on Chatham Island

Nitrate-Nitrite nitrogen (NNN) concentrations are very low in both streams and lakes (Figure 3-15, Figure 3-16). Sites with any appreciable NNN indicate a warning for excessive animal derived inputs (Mangapē and Waitaha Streams). Lakes are also low in NNN except for Te Whanga adjacent to Blind Jims Creek. Corresponding Dissolved Inorganic Nitrogen (DIN; ammonia+NNN) as a measure of available dissolved nitrogen is also low in both streams and lakes (Figures 3-17, Figure 3-18).

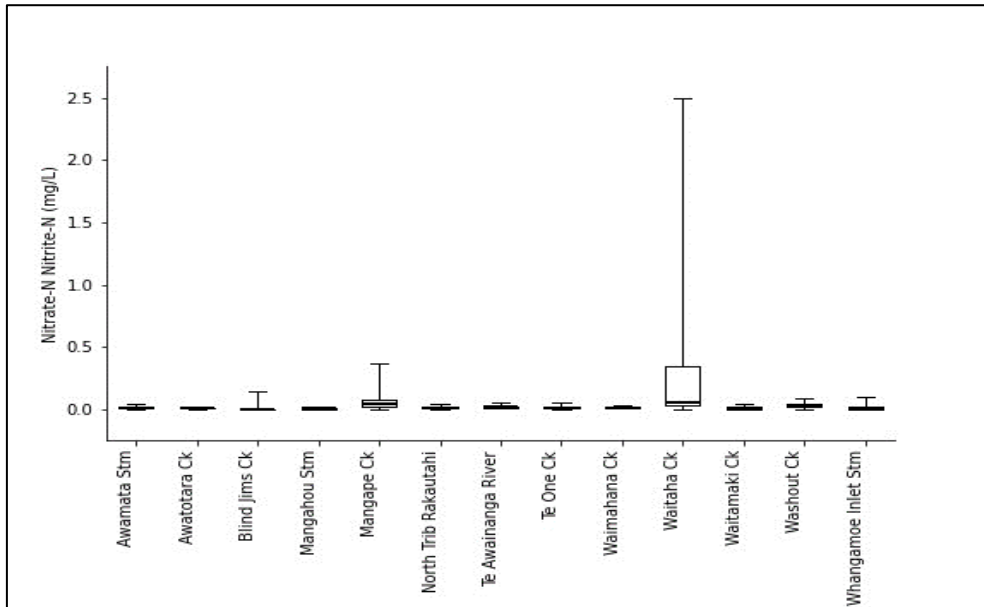


Figure 3-15: Current state of NNN for monitored river sites on Chatham Island

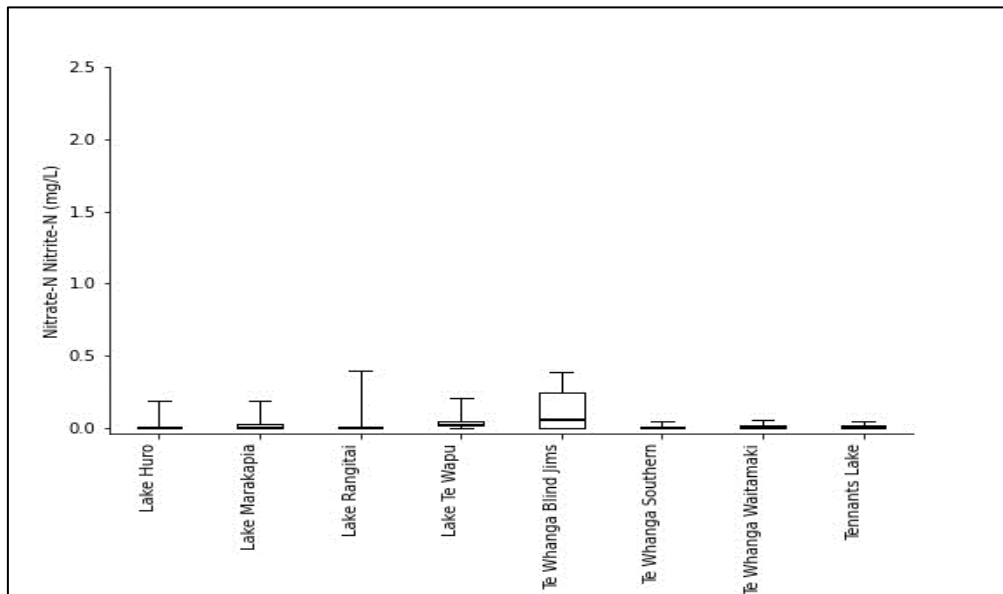


Figure 3-16: Current state of NNN for monitored lake sites on Chatham Island

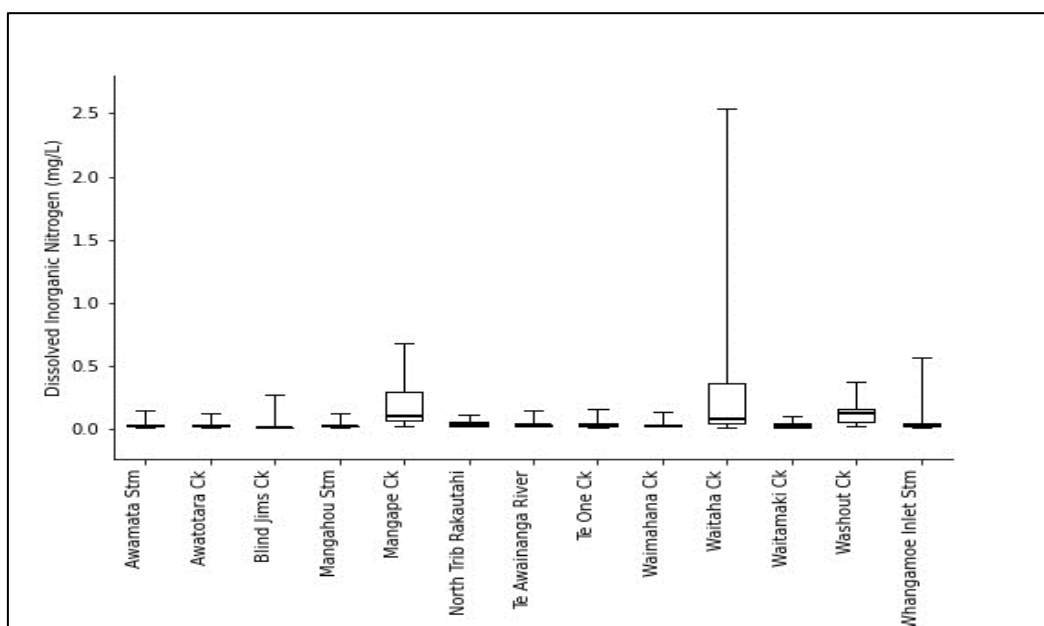


Figure 3-17: Current state of DIN for monitored river sites on Chatham Island

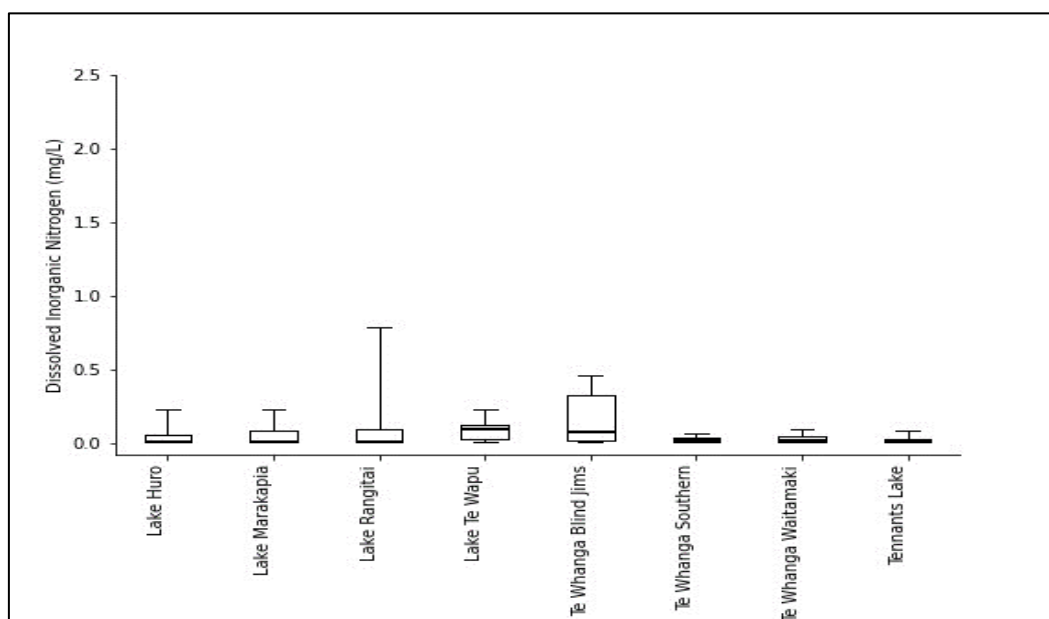


Figure 3-18: Current state of DIN for monitored lake sites on Chatham Island

Total nitrogen (TN) concentrations reflect the additional nitrogen concentrations in particulate effluent or algal biomass. The TN of streams is surprisingly high, but this likely reflects the nitrogen content of suspended peat particles (Figure 3-19). Other streams such as Mangapē may also reflect algal biomass as fed from Lake Huro. Lakes have similar TN concentrations but may represent either nitrogen in peat particles or in algal biomass or both (Figure 3-20). Lake Huro and Lake Te Wapu show the greatest peak TN concentrations and the greatest variation in concentrations indicating possible episodes of algal blooms.

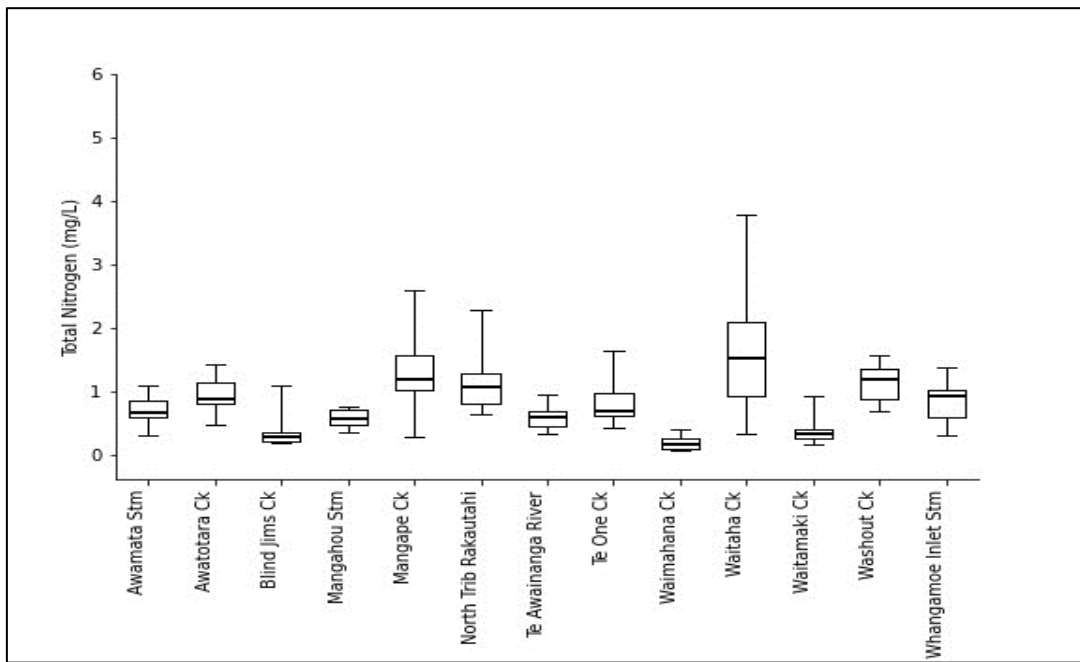


Figure 3-19: Current state of TN for monitored river sites on Chatham Island

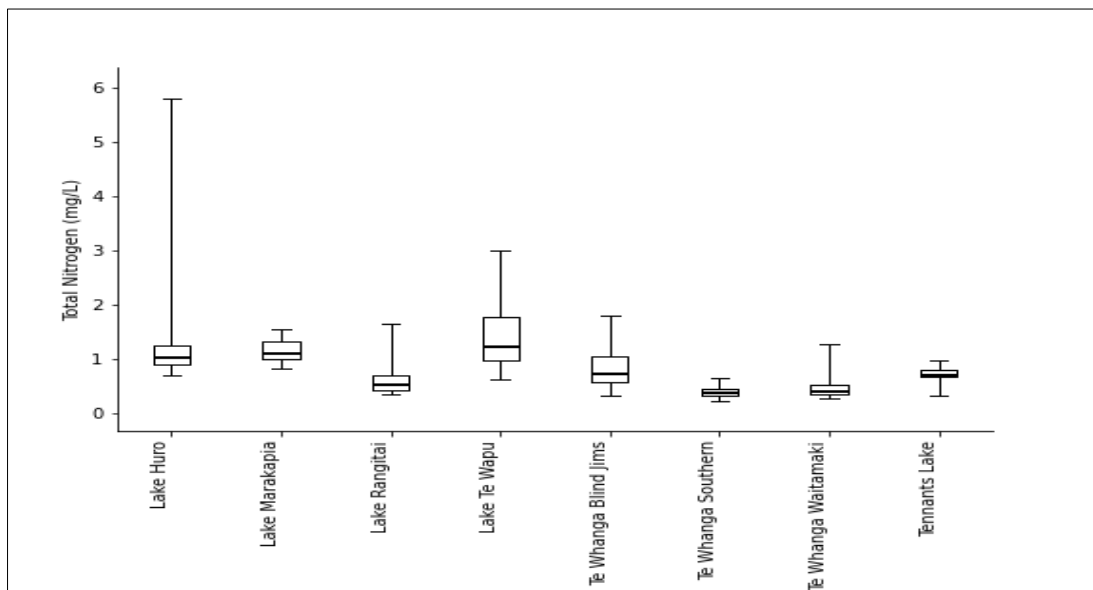


Figure 3-20: Current state of TN for monitored lake sites on Chatham Island

3.6 Chlorophyll a

Chlorophyll a (Chl a) is an indicator of the algal biomass in the water column of lakes by specifically measuring the chlorophyll pigments present. High Chlorophyll a concentration indicates existing or developing algal blooms. Lake Huro and Te Wapu show significant variation in concentrations indicating annual variations and possible episodes of algal blooms. The two northern Te Whanga lagoon sites also show a higher level of variation also indicating annual variations and possible episodes of algal blooms in the northern lagoon.

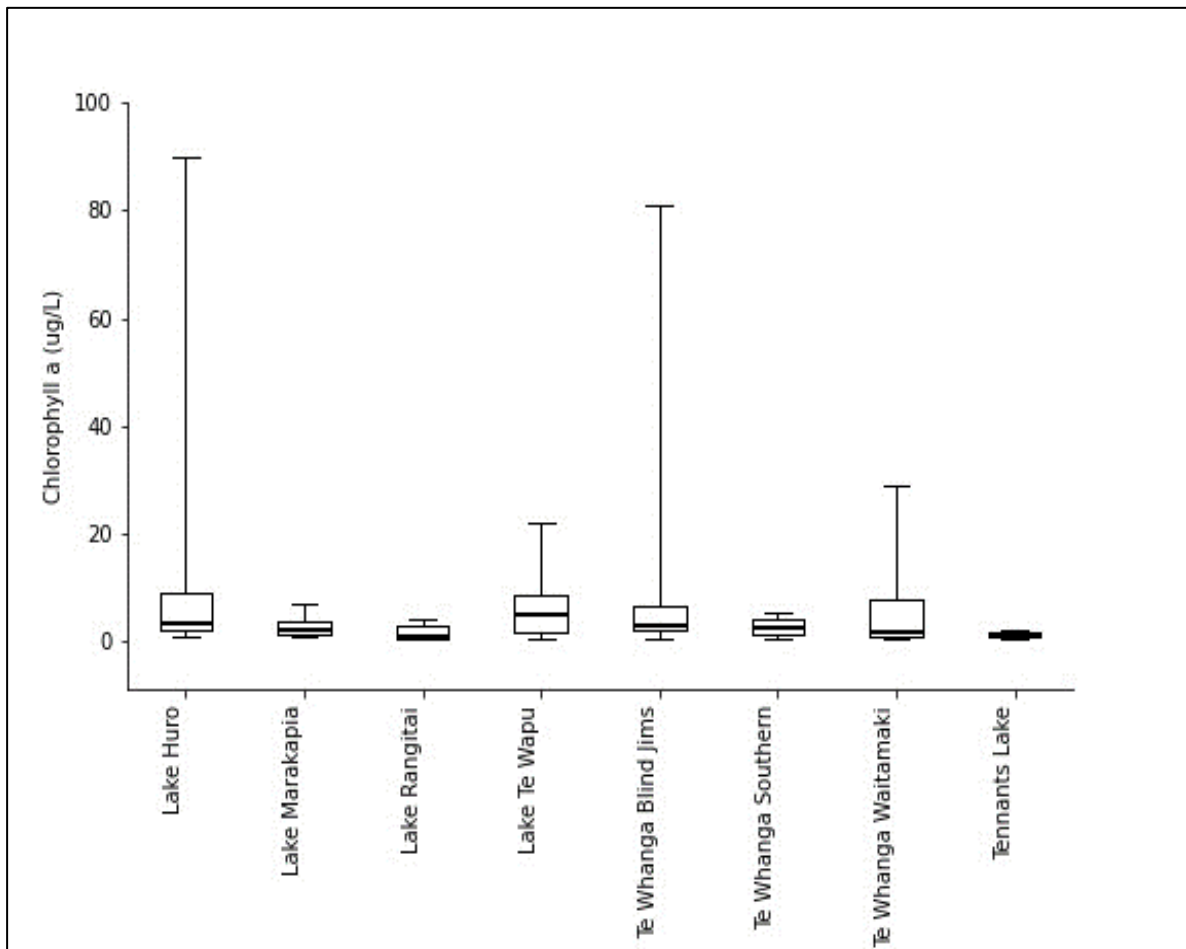


Figure 3-21: Current state of chlorophyll a for monitored lake sites on Chatham Island

3.7 Water clarity

Water clarity is measured with the SHMAK (Stream Health and Monitoring Action Kit) clarity tube, and high values indicate clear water with high transparency, while low values indicate cloudy or turbid water. Two streams have particularly high clarity compared to the other streams (Blind Jims and Waimāhana streams) while clarity in the other streams are highly variable and can often be very poor (Figure 3-22). This is mostly related to peat staining and peat particles in the water reducing clarity.

The monitored lakes have higher but highly variable water clarity than the streams, although both Lakes Huro and Te Wapu stand out as having lower or degraded water clarity (Figure 3-23).

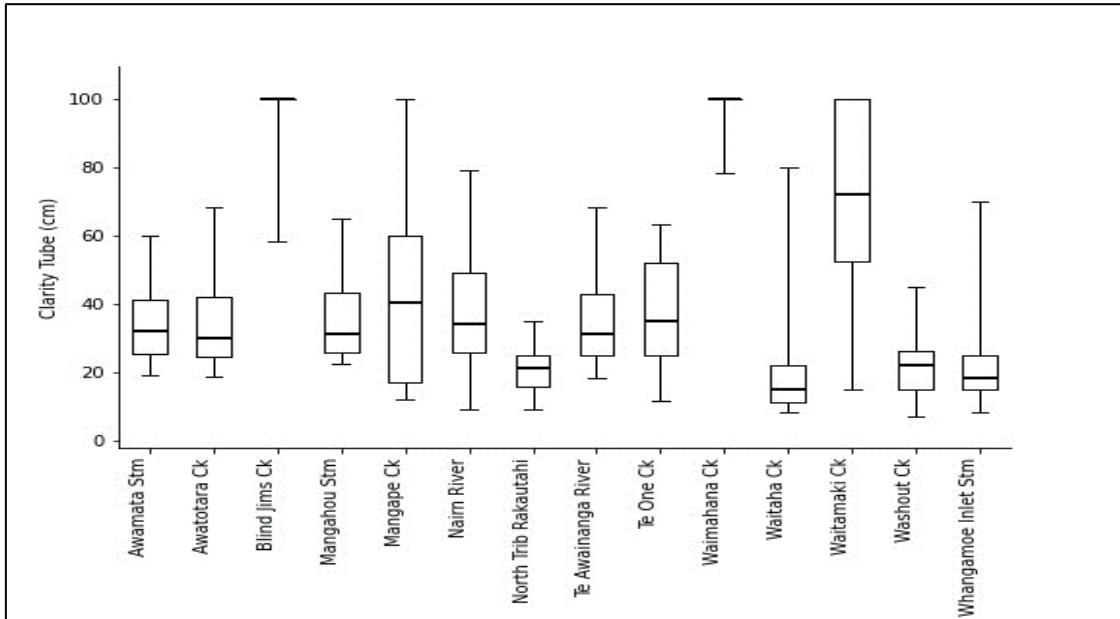


Figure 3-22: Current state of water clarity for monitored river sites on Chatham Island

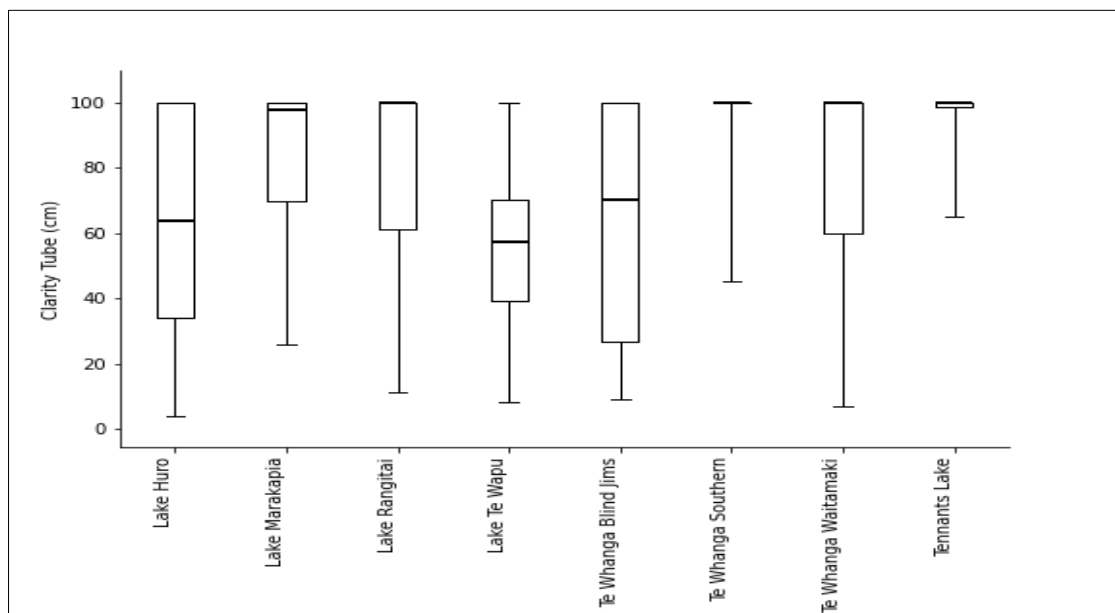


Figure 3-23: Current state of water clarity for monitored lake sites on Chatham Island

3.8 Lake eutrophication

The eutrophication state or state of nutrient enrichment of lakes (referred to as the Trophic Level Index, or TLI) is a commonly reported index that integrates several related or closely correlated parameters. Seven trophic state categories are recognised (Table 3-1).

Table 3-1: Description of trophic states

TLI	Trophic state	General description
<1	Ultra-microtrophic	Practically pure, very clean
>1-2	Microtrophic	Very clean, very low nutrient concentrations
>2-3	Oligotrophic	Clear and blue, with low levels of nutrients and algae
>3-4	Mesotrophic	Moderate levels of nutrients and algae
>4-5	Eutrophic	Green and murky, with higher amounts of nutrients and algae
>5-6	Supertrophic	Very high nutrient enrichment and high algae growth
>6	Hypertrophic	Saturated in nutrients, highly fertile, excessive algae growth

The five monitored lakes and three Te Whanga Lagoon monitoring sites are listed in Table 3-2 with calculated Trophic level index (TLI) values and category for each of the past five years and as an average over the past 5 years. The trophic state of lakes is relatively poor with most lakes graded eutrophic or worse. Tennant Lake and Lake Rangitai are the only lakes that largely remain in the Mesotrophic state (only having just strayed into the eutrophic state in 2020/21). Lake Marakapia remained relatively stable in a eutrophic state, and Lake Huro has worsened in the past two years becoming Supertrophic in 2021/22 and Hypertrophic in 2022/23. Lake Huro is the Lake indicating most serious concern as neither supertrophic nor hypertrophic state are acceptable natural conditions.

The three Te Whanga Lagoon sites indicate the Southern site in relatively stable Mesotrophic state, but the Central (Waitāmaki) and Northern (Blind Jims) sites being variable eutrophic state but then worsening in the past two years to Supertrophic and Hypertrophic state respectively. Again, these states are not acceptable natural conditions for a valued lagoon and the causes of these degrading states need to be understood.

Table 3-2: Annual trophic state for lake and lagoon sites on Chatham Island

Site	TLI					Five-year average TLI
	2018 - 2019	2019 - 2020	2020 - 2021	2021 - 2022	2022- 2023	
Lake Huro	4.67	4.73	4.88	5.38	6.28	5.19
Lake Marakapia	4.03	4.11	4.36	4.57	4.54	4.32
Lake Rangitai	2.86	3.47	4.04	3.51	3.46	3.47
Lake Te Wāpu	5.59	4.63	4.49	4.7	5.67	5.02
Te Whanga Blind Jim's	5.12	4.45	4.36	4.79	6.03	4.96
Te Whanga Southern	4.07	3.64	3.68	3.76	3.76	3.78
Te Whanga Waitāmaki	4.09	3.37	4.16	5.6	5.27	4.50
Tennants Lake	3.97	3.58	4.04	3.54	3.39	3.70

3.9 Microbial water quality

Microbial water quality (contamination with indicators of pathogenic bacteria) are not routinely monitored water quality parameters included with the routine water quality monitoring, but are a separate subset of sites in areas chosen to be either higher risk of contamination sources, or higher risk due to public accessibility/water use (i.e. contact recreation). The three freshwater sites show highly variable results all showing samples with high concentrations/contamination at maximum laboratory detection limits (2400/100ml) (Figure 3-24). The Mangatukurewa Creek (Nairn River) shows the highest median level of contamination followed by the contributing Mangapē Creek. These are both close to Waitangi and Te One communities and potentially have highest livestock numbers and corresponding high [grazing] waterfowl numbers. This monitoring indicates a significant microbiological/faecal contamination issue. The variable results in Lake Rangitai may relate more to draw down of the lake concentrating contamination sources at times.

For the Te Whanga Lagoon sites, the Northern (Blind Jims) site shows the highest degree of variability and median contamination of bacteria. This accompanies the high trophic state and other contaminants alongside this recognised beach and recreation area. For sites with a significant brackish/saline water quality, Enterococci indicators show similar patterns to E. coli. (Figure 3-25).

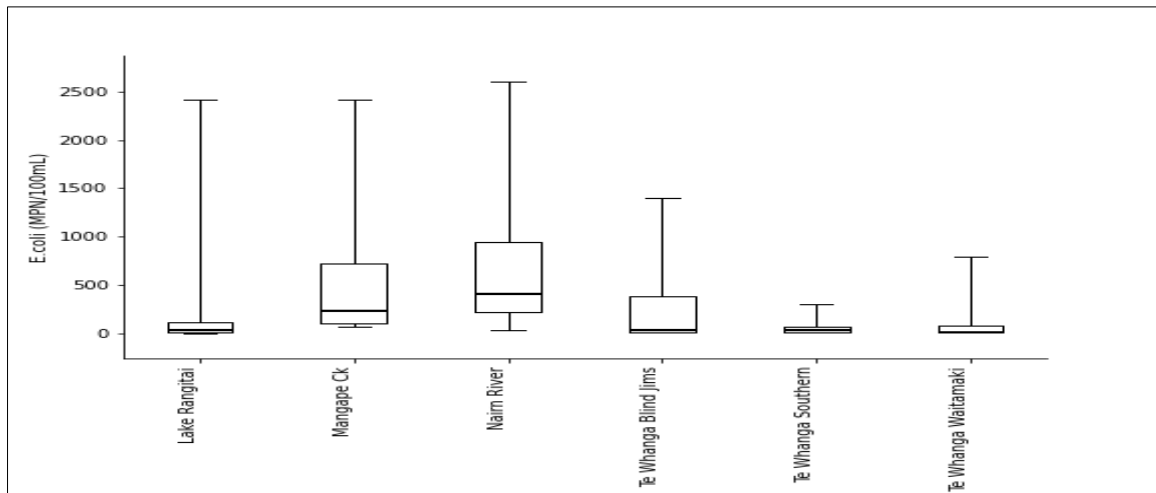


Figure 3-24: Current state of *E. coli* for monitored river and lake sites on Chatham Island

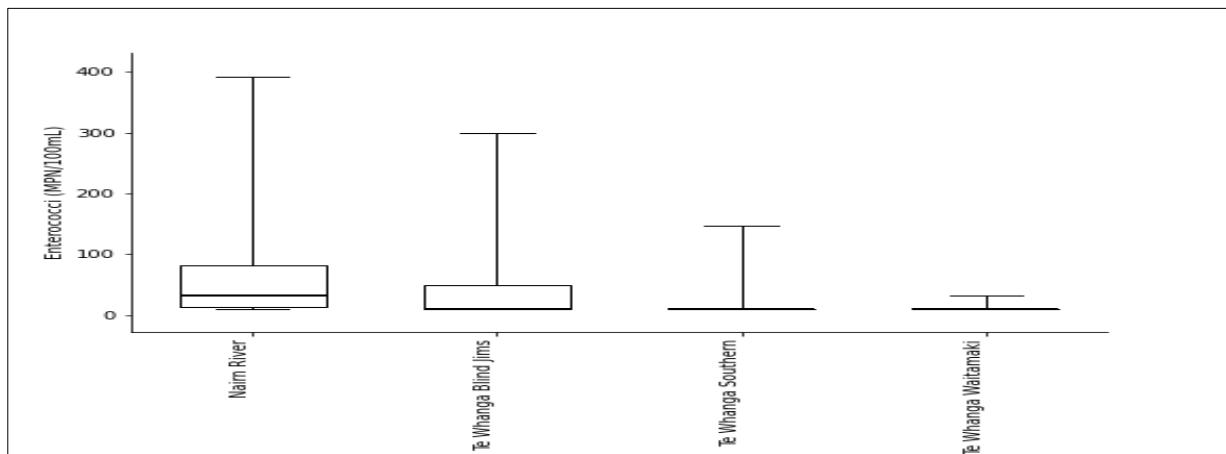


Figure 3-25: Current state of enterococci for monitored river and lake sites on Chatham Island

3.10 National Policy Statement objectives and limits

The NZ Freshwater National Policy Statement (NPS) was released initially in 2011 and variously replaced and updated in 2014, 2017 and 2020 to guide freshwater management at a national level within New Zealand and to set or guide establishment of water quality limits.

Appendix 2A within the NPS provides a framework of numeric values and attribute states for freshwater management and sets national bottom lines of minimum acceptable states for the compulsory values of ecosystem health and human health for recreation. The framework is structured in a grading-based format from A to E, with the national bottom-line state generally set at the bottom of the “C” band, and so between the “C” and “D” bands. For more information refer to “National Policy Statement for Freshwater Management 2020” (Ministry for the Environment, 2020).

The calculated National Attribute states are listed in Table 3-3.

Table 3-3: National attribute states for streams and lakes on Chatham Island

Site ID	Site	NNN		NH4N		TN	TP	Chlorophyll a	
		Median	95th %ile	Median	95th %ile	Median	Median	Median	Max
SQ34829	Awamata Stm	A	A	A	A	X	X	X	X
SQ34830	Awatotara Ck	A	A	A	A	X	X	X	X
SQ34844	Blind Jims Ck	A	A	A	B	X	X	X	X
SQ34854	Mangahou Stm	A	A	A	A	X	X	X	X
SQ34851	Mangape Ck	A	A	B	C	X	X	X	X
SQ35078	Nairn River					X	X	X	X
SQ34841	North Trib Rakautahi	A	A	A	B	X	X	X	X
SQ34832	Te Awainanga River	A	A	A	A	X	X	X	X
SQ34857	Te One Ck	A	A	A	A	X	X	X	X
SQ34863	Waimahana Ck	A	A	B	B	X	X	X	X
SQ34849	Waitaha Ck	A	B	A	B	X	X	X	X
SQ34860	Waitamaki Ck	A	A	A	B	X	X	X	X
SQ34834	Washout Ck	A	A	B	B	X	X	X	X
SQ34838	Whangamoe Inlet Stm	A	A	A	B	X	X	X	X
SQ34859	Lake Huro	X	X	B	B	D	C	B	D
SQ34893	Lake Marakapia	X	X	B	B	D	B	A	A
SQ34846	Lake Rangitai	X	X	A	C	C	A	A	A
SQ34887	Lake Te Wapu	X	X	A	B	D	C	B	B
SQ34842	Tennants Lake	X	X	A	B	C	B	A	A
SQ35082	Te Whanga Southern	X	X	A	A	B	B	B	A
SQ34843	Te Whanga Blind Jims	X	X	A	B	C	C	B	D
SQ34861	Te Whanga Waitamaki	X	X	A	B	B	C	A	C

X- Not applicable

Streams require calculation of attribute states for soluble nutrients only. The NNN (Nitrate-Nitrite -N) median and 95%ile concentrations are consistently within the “A” band attribute state except for Waitaha Creek. For the 2022/23 period, Waitaha Creek showed a 95%ile NNN in the ‘B’ band, with an elevated concentration of approximately 1-2 mg/L.

Streams were generally within the A band for median NH₄N concentration, but Mangapē Creek, Waimāhana Creek and Washout Creek had median NH₄N concentrations that fall within the “B” attribute band. However, 95%ile NH₄N concentrations for most streams fall into the “B” attribute band and only four streams remaining in the “A” band. Mangapē Creek has declined to a “C” band (from “B” band last year, 2021/22).

The lake and lagoon sites are much more variable in displaying national grades from bands A to D (Table 3-3). The NH₄N indicates a similar range to the stream sites, with Lake Huro and Marakapia in

the “B” band for median NH₄N (“A” band last year, 2021/22) and all other lake and lagoon sites remain in the “A” band. Most sites fall into the “B” band for maximum (95%ile) criteria, except Te Whanga Southern basin which is in the “A” band and Lake Rangitai which is in the “C” band.

For the lake trophic state attributes, TN median concentrations for the lakes sites worryingly mostly grade within the “C” and “D” bands (D not complying with national standards). Two of the Te Whanga sites (southern and Waitamaki) are in the “B” bands (both “C” last year, 2021/22). These are of a concern with Chatham waters generally being expected to be naturally nitrogen poor.

TP median concentration at Lake Rangitai is within the “A” attribute band, other lakes and lagoon sites are between attribute band “B” (3 sites) and “C” (4 sites). Most lakes and lagoon sites on Chatham Island have median and maximum chlorophyll a concentration between attribute band “A” and “B”. Lake Huro has a “C” chlorophyll a maximum classification. These attributes consistently flag Lake Huro of particular concern, and secondarily Lake Te Wapu of concern.

Te Whanga lagoon at Blind Jims Creek is within the “D” band for chlorophyll a max (a worse grading than the “B” grade from the previous year, 2021/22) and the Waitamaki site is graded “C”. These indicate concern for “greening” of these northern lagoon sites at times. Lake Huro also grades “D” for maximum chlorophyll a also indicating episodes of algal discolouration (bloom).

The National attributes also require calculation of bands for *E. coli* attributes (Table 3-4). These are similarly of concern as the Mangatukurewa Creek (Nairn River) shows an “E” band and Mangapē Creek, Lake Rangitai, and Te Whanga Lagoon at Blind Jims all record a “D” band. The two other Te Whanga Lagoon sites record a B and A grade respectively (north to south). The source or cause of these poor microbiological banding categories are of concern.

Table 3-4: National *E. coli* attribute states for streams and lakes on Chatham Island

Site ID	Site	% exceedances over 540/100mL	% exceedances over 260/100mL	Median	Hazen 95th percentile	Attribute Band
SQ34851	Mangape Ck	28	44	230	2246	D
SQ35078	Nairn River	35	70	413	2113	E
SQ34846	Lake Rangitai	11	16	28	>1607	D
SQ35082	Te Whanga Southern	0	5	31	273	A
SQ34843	Te Whanga Blind Jims	25	25	31	1389	D
SQ34861	Te Whanga Waitamaki	5	5	10	493	B

3.11 Water quality trends

Ten year trends were calculated for the water quality sites monitored on Chatham Island. These give an indication of whether any parameters are improving or degrading in condition or are in a stable or randomly varying state (Table 3-5a, b). These tables are displayed with colour coding indicating improvement (green) or degradation (red) rather than increasing/decreasing displayed in previous reports. This is because the previous format can be confusing as most parameters indicate degradation when parameters increase (i.e. nutrients, Chla, *E. coli*), however, other parameters can indicate improvement as parameters increase (i.e. dissolved oxygen concentration/saturation %, water clarity). Other parameters can indicate either (pH).

Chatham Islands Surface Water Summary 2022-23

Table 3-5: Calculated ten year (2013-2023) trends for parameters measured at Chatham Island Water Quality Monitoring sites. Trend categories calculated according to Snelder et al 2021. Colour coding reflects improvement (green), degradation (pink, red), or indeterminate (colourless).

Site ID	Site	Dissolved oxygen %	Water Temperature	pH	DOC	DRP	TP
SQ34829	Awamata Stm	Likely Increasing	Indeterminate	Likely Decreasing	Very Likely Increasing	Very Likely Decreasing	Likely Increasing
SQ34830	Awatotara Ck	Likely Increasing	Likely Increasing	Very Likely Decreasing	Very Likely Increasing	Likely Decreasing	Indeterminate
SQ34844	Blind Jims Ck	Likely Decreasing	Indeterminate	Very Likely Increasing	Very Likely Increasing	Indeterminate	Indeterminate
SQ34859	Lake Huro	Indeterminate	Indeterminate	Likely Increasing	Likely Decreasing	Likely Decreasing	Likely Increasing
SQ34893	Lake Marakapia	Likely Decreasing	Indeterminate	Indeterminate	Very Likely Increasing	Indeterminate	Very Likely Increasing
SQ34846	Lake Rangitai	Very Likely Decreasing	Likely Increasing	Likely Increasing	Very Likely Increasing	Very Likely Increasing	Very Likely Increasing
SQ34887	Lake Te Wapu	Indeterminate	Likely Increasing	Likely Decreasing	Very Likely Decreasing	-	Indeterminate
SQ34854	Mangahou Stm	Very Likely Increasing	Indeterminate	Very Likely Decreasing	Very Likely Increasing	Likely Decreasing	Likely Decreasing
SQ34851	Mangape Ck	Very Likely Increasing	Likely Increasing	Likely Increasing	Indeterminate	Likely Increasing	Indeterminate
SQ35078	Mangatukurewa Creek	Indeterminate	Indeterminate	Likely Decreasing	-	-	-
SQ34841	North Trib Rakautahi	Likely Decreasing	Very Likely Decreasing	Likely Decreasing	Very Likely Increasing	Very Likely Increasing	Very Likely Increasing
SQ34832	Te Awainanga River	Very Likely Increasing	Likely Increasing	Very Likely Decreasing	Very Likely Increasing	Very Likely Increasing	Likely Increasing
SQ34857	Te One Ck	Very Likely Increasing	Indeterminate	Very Likely Decreasing	Very Likely Increasing	Likely Increasing	Very Likely Increasing
SQ34843	Te Whanga Blind Jims	Very Likely Increasing	Likely Increasing	Very Likely Decreasing	Very Likely Decreasing	Very Likely Increasing	Very Likely Increasing
SQ35082	Te Whanga Southern	Likely Decreasing	Likely Increasing	Likely Decreasing	Very Likely Decreasing	Indeterminate	Indeterminate
SQ34861	Te Whanga Waitamaki	Likely Decreasing	Indeterminate	Likely Decreasing	Indeterminate	Likely Increasing	Very Likely Increasing
SQ34842	Tennants Lake	Likely Decreasing	Indeterminate	Likely Increasing	Likely Increasing	Likely Decreasing	Very Likely Increasing
SQ34863	Waimahana Ck	Likely Decreasing	Likely Increasing	Very Likely Increasing	Likely Increasing	Very Likely Decreasing	Likely Decreasing
SQ34849	Waitaha Ck	Indeterminate	Indeterminate	Likely Decreasing	Very Likely Increasing	Very Likely Decreasing	Very Likely Decreasing
SQ34860	Waitamaki Ck	Likely Decreasing	Indeterminate	Very Likely Increasing	Very Likely Increasing	Likely Increasing	Likely Increasing
SQ34834	Washout Ck	Likely Increasing	Very Likely Decreasing	Likely Decreasing	Very Likely Increasing	Very Likely Decreasing	Very Likely Decreasing
SQ34838	Whangamoe Inlet Stm	Likely Increasing	Likely Decreasing	Very Likely Decreasing	Very Likely Increasing	Likely Decreasing	Likely Increasing

Site ID	Site	NH4N	NNN	TN	Chla	Clarity	E.coli	Enterococci
SQ34829	Awamata Stm	Indeterminate	Likely Increasing	Very Likely Increasing	-	Very Likely Decreasing	-	-
SQ34830	Awatotara Ck	Indeterminate	Likely Decreasing	Very Likely Increasing	-	Very Likely Decreasing	-	-
SQ34844	Blind Jims Ck	Indeterminate	Indeterminate	Likely Increasing	-	Very Likely Increasing	-	-
SQ34859	Lake Huro	Very Likely Increasing	Very Likely Decreasing	Very Likely Decreasing	Likely Increasing	Likely Increasing	-	-
SQ34893	Lake Marakapia	Likely Increasing	Very Likely Increasing	Very Likely Increasing	Very Likely Increasing	Very Likely Decreasing	-	-
SQ34846	Lake Rangitai	Very Likely Increasing	Likely Increasing	Very Likely Increasing	Very Likely Increasing	Very Likely Decreasing	Very Likely Increasing	-
SQ34887	Lake Te Wapu	Likely Increasing	Indeterminate	Likely Decreasing	Indeterminate	Indeterminate	-	-
SQ34854	Mangahou Stm	Indeterminate	Indeterminate	Very Likely Increasing	-	Very Likely Decreasing	-	-
SQ34851	Mangape Ck	Likely Increasing	Likely Decreasing	Very Likely Decreasing	-	Likely Increasing	Likely Increasing	-
SQ35078	Mangatukurewa Creek	-	-	-	-	Very Likely Decreasing	Very Likely Increasing	Very Likely Increasing
SQ34841	North Trib Rakautahi	Indeterminate	Likely Increasing	Very Likely Increasing	-	Very Likely Decreasing	-	-
SQ34832	Te Awainanga River	Indeterminate	Very Likely Increasing	Very Likely Increasing	-	Very Likely Decreasing	-	-
SQ34857	Te One Ck	Indeterminate	Likely Increasing	Very Likely Increasing	-	Very Likely Decreasing	-	-
SQ34843	Te Whanga Blind Jims	Likely Increasing	Very Likely Increasing	Indeterminate	Very Likely Increasing	Very Likely Decreasing	Very Likely Increasing	Very Likely Increasing
SQ35082	Te Whanga Southern	Very Likely Increasing	Likely Increasing	Very Likely Decreasing	Very Likely Increasing	Likely Increasing	Very Likely Increasing	Very Likely Increasing
SQ34861	Te Whanga Waitamaki	Very Likely Increasing	Indeterminate	Indeterminate	Very Likely Increasing	Very Likely Decreasing	Very Likely Increasing	Likely Increasing
SQ34842	Tennants Lake	Likely Increasing	Very Likely Increasing	Very Likely Increasing	Very Likely Increasing	Likely Decreasing	-	-
SQ34863	Waimahana Ck	Indeterminate	Indeterminate	Very Likely Increasing	-	Likely Increasing	-	-
SQ34849	Waitaha Ck	Likely Increasing	Very Likely Increasing	Very Likely Increasing	-	Very Likely Decreasing	-	-
SQ34860	Waitamaki Ck	Indeterminate	Likely Decreasing	Likely Increasing	-	Indeterminate	-	-
SQ34834	Washout Ck	Likely Decreasing	Very Likely Increasing	Very Likely Increasing	-	Very Likely Decreasing	-	-
SQ34838	Whangamoe Inlet Stm	Very Likely Increasing	Not assessed	Very Likely Increasing	-	Very Likely Decreasing	-	-

The trend tables indicate that there are a lot of significant site specific trends in water quality (both improvement and degradation) over the past 10 years. These tables are useful for identifying significant site-specific trends for all major parameters. Summarising these trends (Table 3-6) indicates the number of sites with significance in the 5 categories, and overall proportion of sites showing increase or decrease for each parameter. Most parameters have most sites showing an increasing trend, while only two parameters (Temperature and DRP) show more sites with a decreasing trend. This indicates that water quality on Chatham Island can be considered to be under pressure and showing net degradation in most water quality parameters over the past 10 years.

Table 3-6: Number of sites showing the different trend categories for the 13 parameters measured at Chatham Island Water Quality Monitoring sites. (VLI = very likely increase; LI = Likely increase; Ind = indeterminate; LD = Likely Decrease; VLD = Very likely Decrease)

	DO%	Temp	pH	DOC	DRP	TP	NH ₄	NNN	TN	Clarity	Chla	E. coli	Entero
VLI	5	2	6	13	3	7	5	6	13	14	6	5	3
LI	4	1	5	1	4	5	6	5	2	1	1	1	1
Ind	3	11	1	4	5	6	10	7	3	2	1	0	0
LD	7	8	4	1	5	2	1	3	1	4	0	0	0
VLD	1	0	3	3	4	2	0	1	3	1	0	0	0
% Inc	45	14	58	64	33	55	50	50	50	73	88	100	100
% Dec	40	36	37	18	43	18	5	18	18	23	0	0	0

Degradation of some parameters such as DOC, water clarity, and water temperature may be explained by climatic factors, while others (nitrogen, phosphorus and Chlorophyll a) are most likely explained by

increased contaminant generation from land use/runoff from the land. These trend assessments are important for identifying priorities and actions to ensure the maintenance and improvement of water quality.

4 Hydrology

The six Environment Canterbury rainfall recorders experienced between 150 – 170 ‘rain days’ over the 2022 hydrological year totalling between 760 – 860 mm of recorded rainfall on the Chatham Islands. All six Environment Canterbury rainfall stations experience more than average rainfall (Figure 4-1). These results are consistent between sites showing that in this “wet” year rainfall days and total rainfall are very consistent across the island (both north to south and east to west). The historic (average data) shows little more variation, but are still well spread across the island.

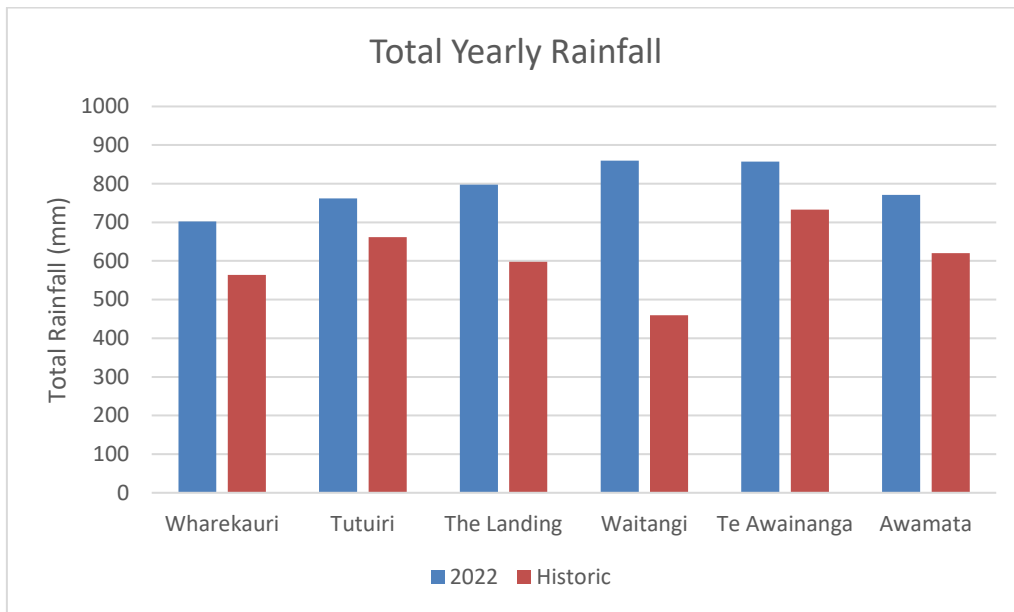


Figure 4-1: Total rainfall for the 2022 hydrological year at the Environment Canterbury rainfall recorders compared to the average total yearly rainfall

All six stations experienced a wet December and March, with most of the monthly rainfall occurring on 18 December 2022 and 18 March 2023. The six stations also experienced more than average rainfall in July and November with frequent rainfall events occurring over the months.

4.1 The Landing

The Landing rainfall recorder experienced significantly more rain in November, December, and March compared to the long-term record between 2016 and 2022 (Figure 4-2).

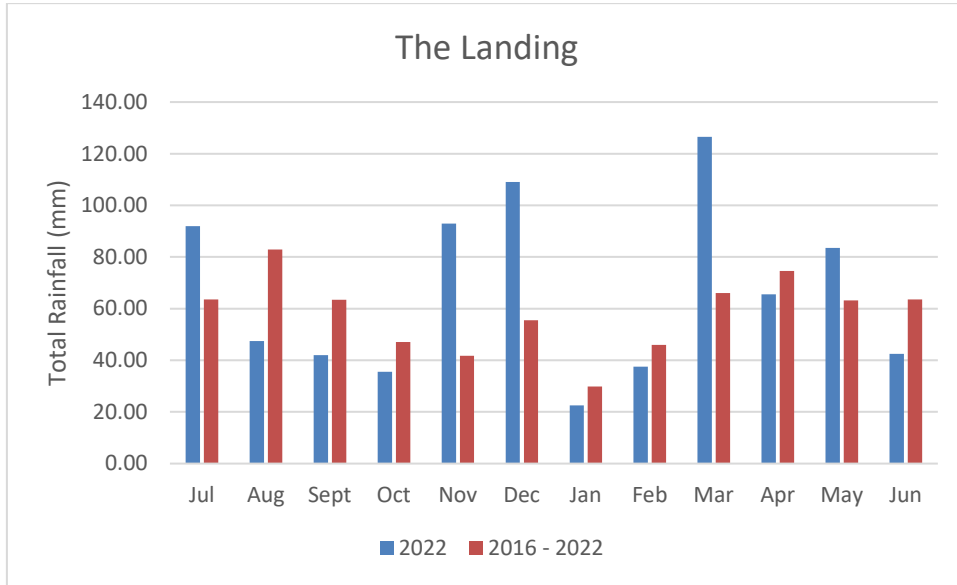


Figure 4-2: Monthly rainfall (mm) for The Landing site through the 2022 hydrological year compared to the long-term record

The Landing rainfall station experienced 797.5 mm of rain over the 2022 hydrological year with 157 days of rain. The three days with the most rain was 18 December 2022, 18 March 2023, and 31 May 2023 with 63.8 mm, 51.5 mm, and 45 mm of rain respectively (Figure 4-3).

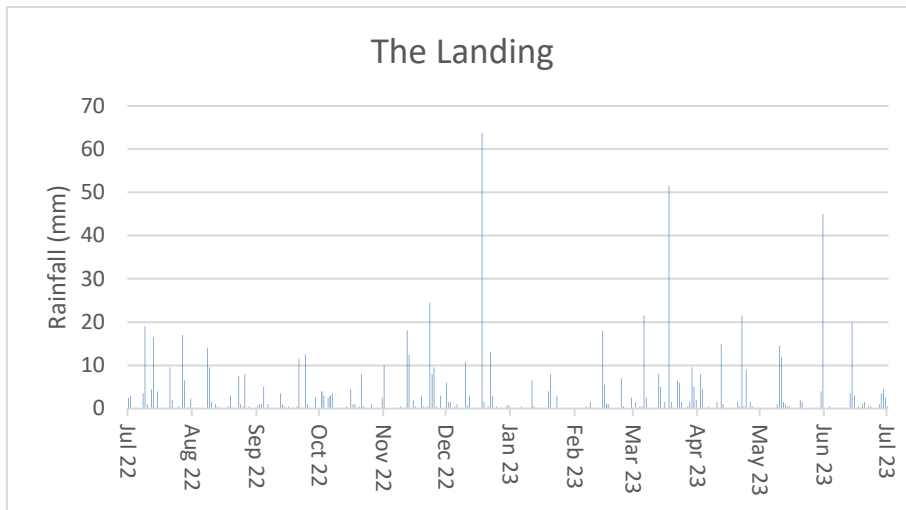


Figure 4-3: Total daily rainfall at The Landing rainfall recorder for the 2022/23 hydrological year

4.2 Waitangi

The Waitangi rainfall station was reinstated in May 2021 to ensure that a long-term record on Chatham Island was maintained, this is due to the historic Waitangi site Chatham Islands Aws, which operated from 1990 to 2012, being decommissioned. The Waitangi rainfall recorder appears to have returned to a more average amount when comparing it to the historic 1991 – 2012 record (Figure 4-4). The 2022/23 hydrological year had more rainfall November, December, and March compared to the time periods from 1991 - 2012 and 2021 - 2022 (Figure 4-4).

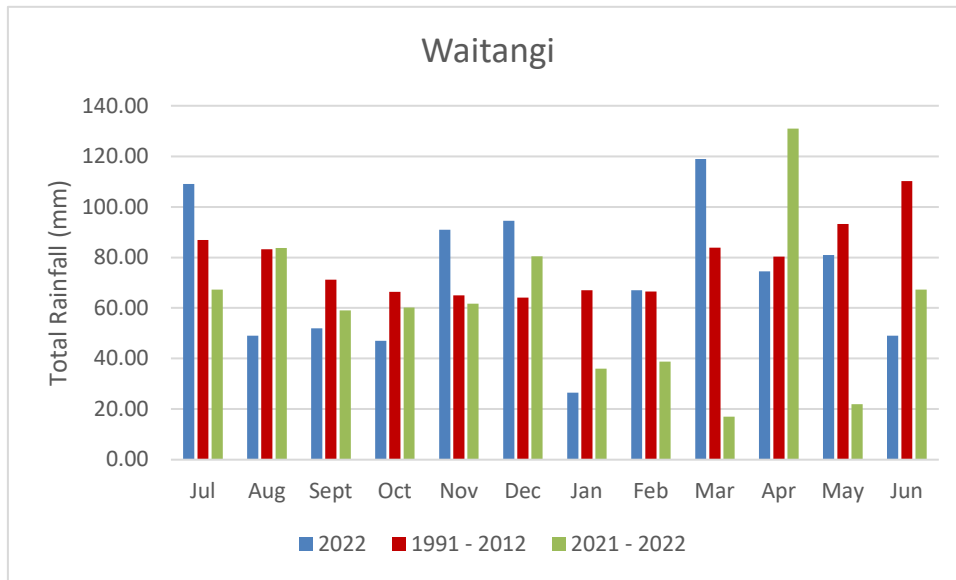


Figure 4-4: Monthly rainfall (mm) for the Waitangi site through the 2022/23 hydrological year compared to the long term record

The Waitangi rainfall station experienced 859.5 mm of rain over the 2022 hydrological year with 170 days that rained, which was the highest number of days and volume of rain on the Chatham Islands for the 2022 hydrological year. The Waitangi rainfall recorded a maximum of 45.5 mm of rain on 18 December 2022 followed by 40 mm on 18 March 2023 (Figure 4-5).

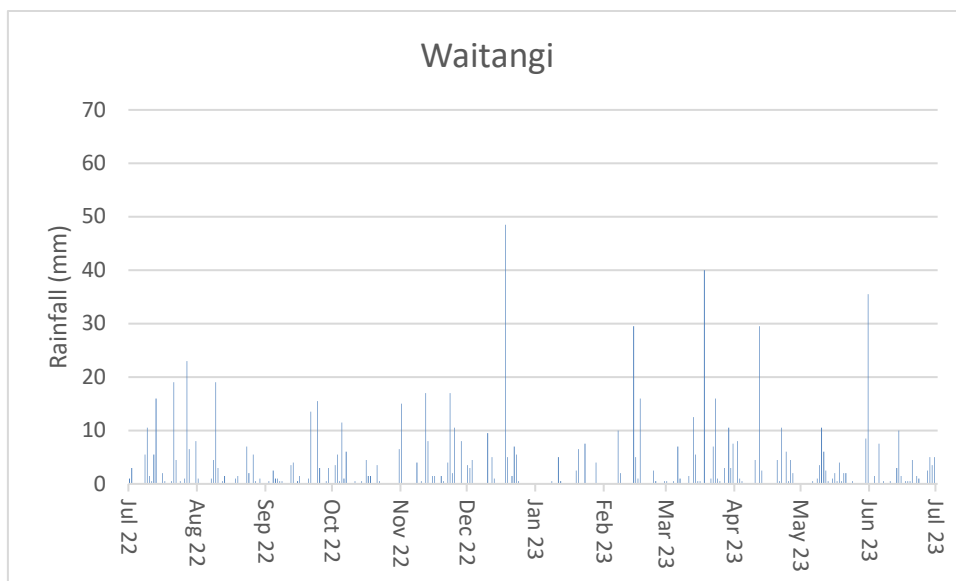


Figure 4-5: Total daily rainfall at the Waitangi recorder for the 2022/23 hydrological year

4.3 Wharekauri

The Wharekauri rainfall recorder had a drier than average August, September, October, and January when compared to the average rainfall per month between 2016 and 2022 (Figure 4-6).

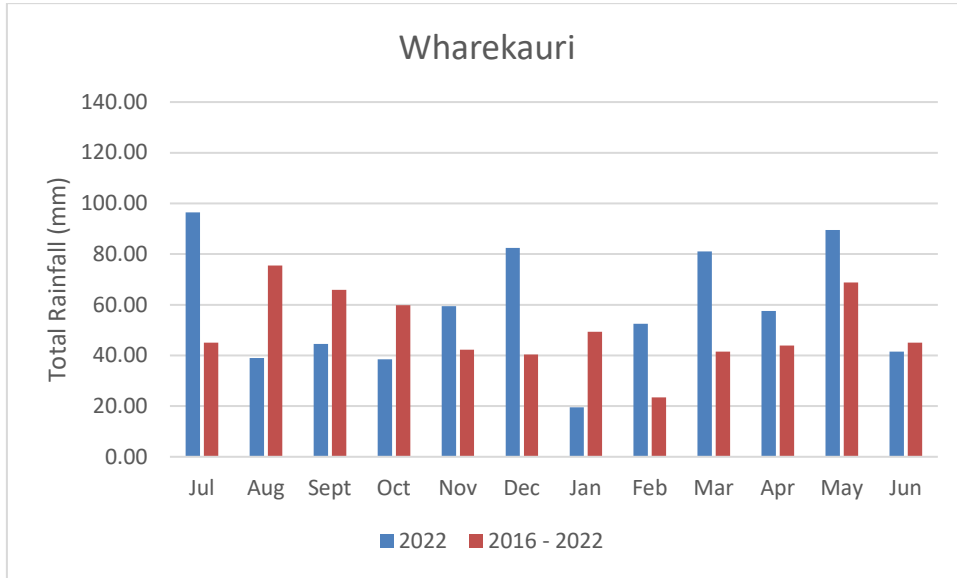


Figure 4-6: Monthly rainfall (mm) for the Wharekauri site through the 2022/23 hydrological year compared to the long-term record

The Wharekauri recorder experienced 702 mm of rain over 149 days with 41.3 mm of rain on 18 December 2022 and 59.5 mm of rain on 31 May 2023. These two days of rain accounted for over half of the rain in their respective months (Figure 4-7).

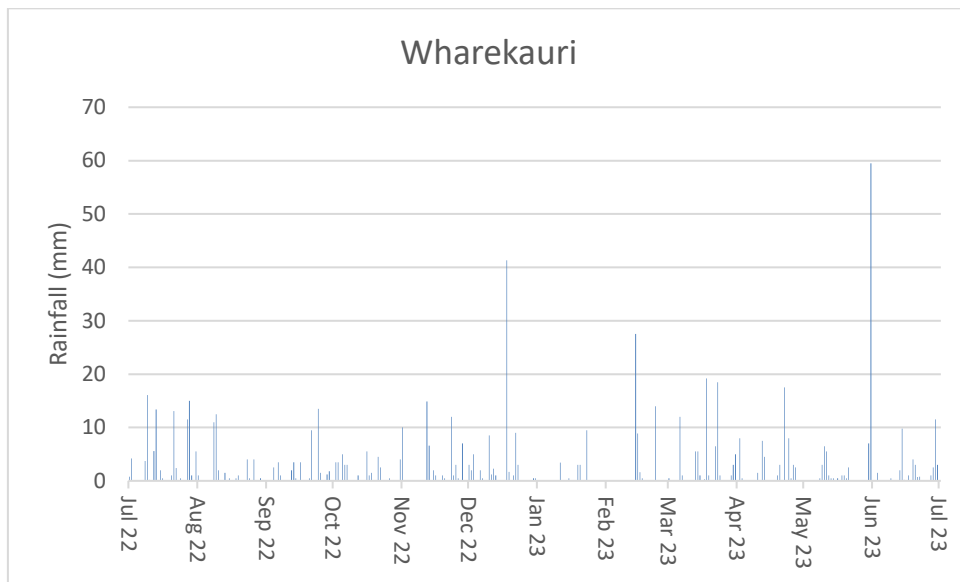


Figure 4-7: Total daily rainfall at the Wharekauri recorder for the 2022/23 hydrological year

4.4 Te Awainanga

The Te Awainanga rainfall recorder had missing record between 14 to 29 September 2022, where the Awamata and Waitangi recorders had 45.5 mm and 38.5 mm of rain respectively. The Te Awainanga stage site had a rise of approximately 600 mm which indicates a rainfall event that was not recorded by the station.

The Te Awainanga flow recorder has a missing record of 15.5 days between 6 and 22 November 2022 due to an issue with communications. Figure 4-8 and Figure 4-9 contain synthetic data between 2 May 2023 to 20 June 2023 as it was an incomplete period.

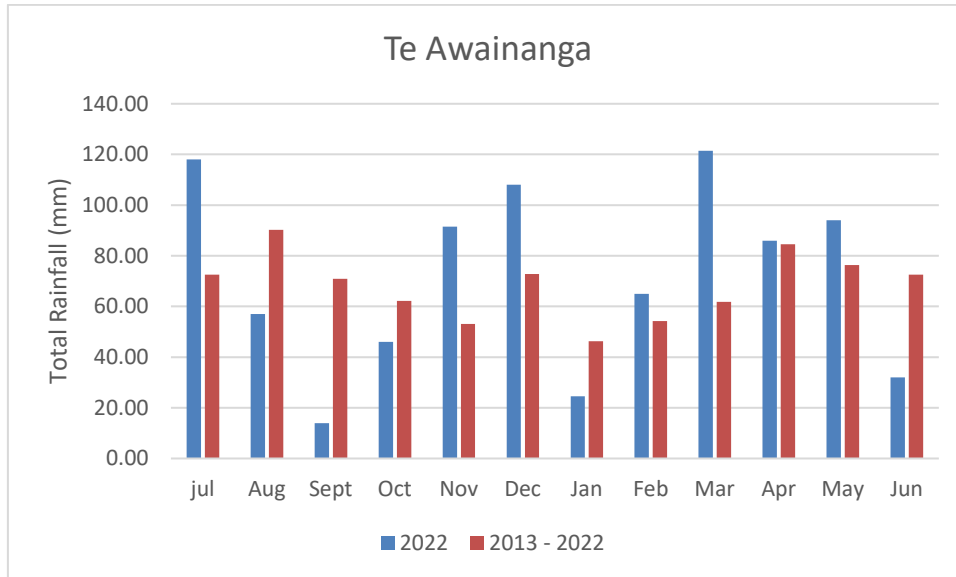


Figure 4-8: Monthly rainfall (mm) for the Te Awainanga site through the 2022 hydrological year compared to the long term record

The Te Awainanga flow recorder has a 7D MALF (Mean Annual Low Flow) of 0.318 m³/s, a 7D annual low flow for the 2022 hydrological year of 0.328 m³/s, and a minimum recorded flow of 0.3 m³/s (Figure 4-9). The rainfall recorder had a maximum rainfall of 47 mm on 18 December 2022 followed by 46 mm on 18 March 2023 and 31 May 2023.

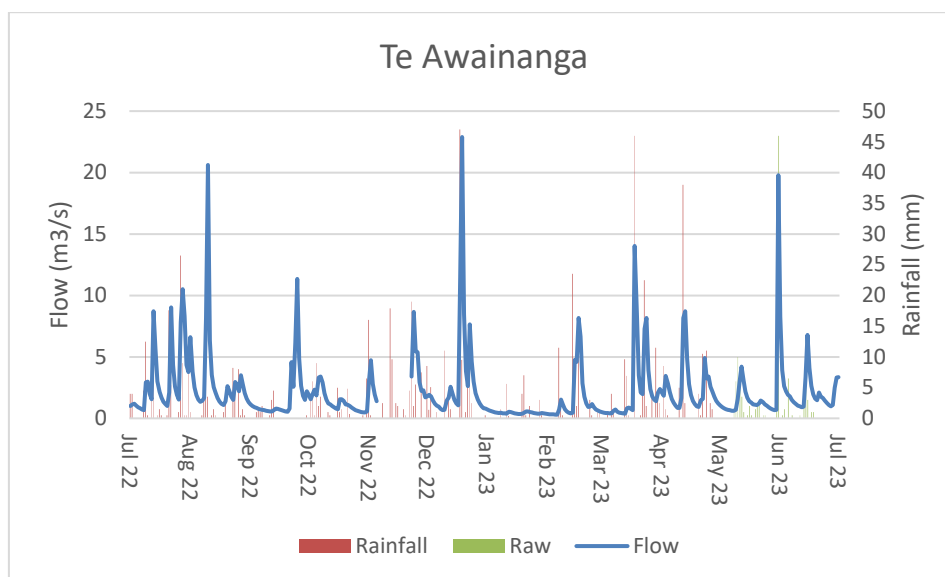


Figure 4-9: Daily mean flow at the Te Awainanga flow recorder over the 2022 hydrological year along with the associated rainfall for the period

4.5 Tutuiri

The Tutuiri rainfall recorder illustrated a wetter than average November, December, and March (Figure 4-10).

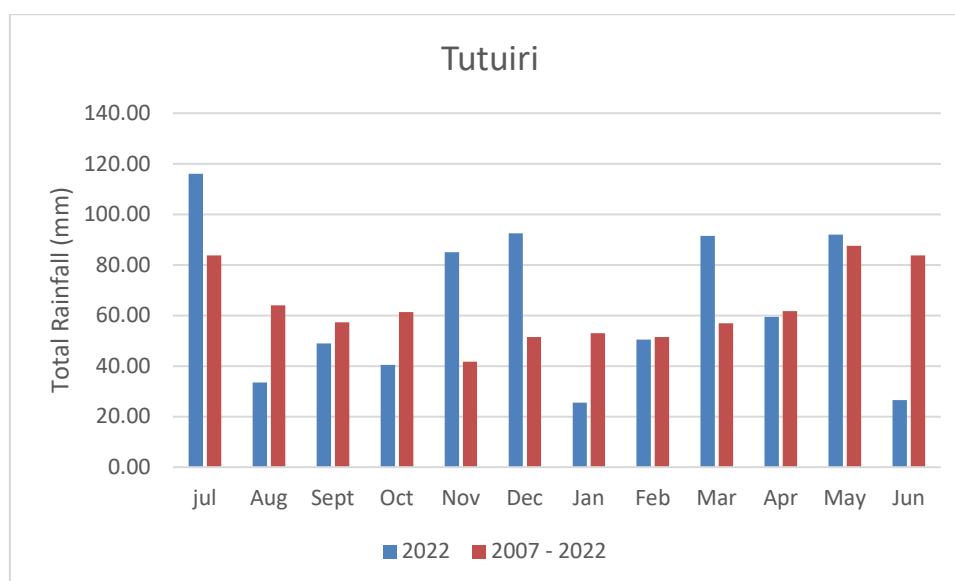


Figure 4-10: Monthly rainfall (mm) for the Tutuiri site through the 2022 hydrological year compared to the long term record

The Tutuiri flow recorder had an annual low flow of only 0.001 m³/s with a 7D MALF of 0.002 m³/s. The river had a zero minimum flow and therefore experienced dry reaches, however, this has been observed almost every year since 2006 (Figure 4-11). The two largest rainfall events of 43.5 mm of rain on 18 December 2022 and 51 mm rainfall on 31 May 2023 corresponded to the two largest peaks in daily mean flow of 3.5 m³/s and 6.67 m³/s on their corresponding days.

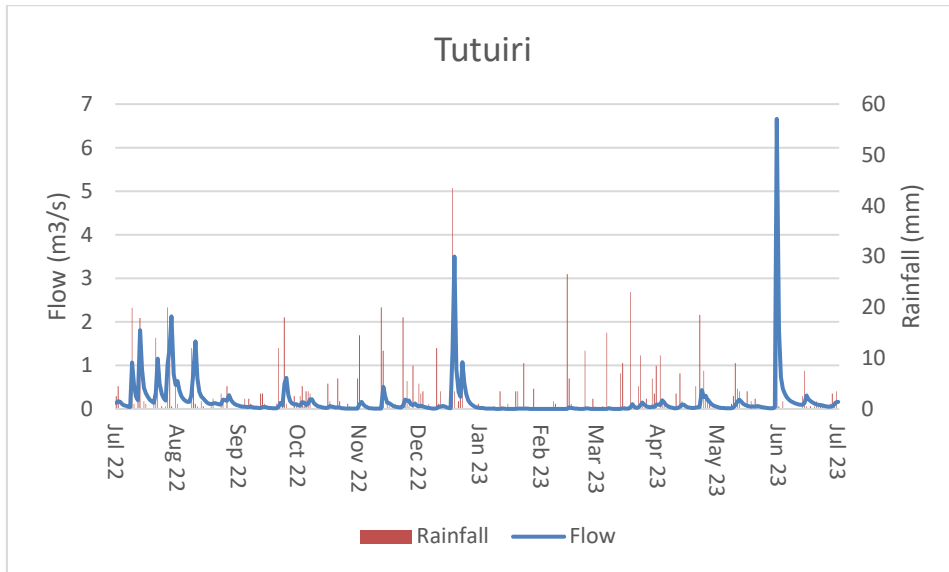


Figure 4-11: Daily mean flow at the Tutuiri flow recorder over the 2022 hydrological year along with the associated rainfall for the period

4.6 Awamata

The Awamata rainfall station had a wet July, November, December, February, and March with 771.5 mm of rain over 155 days (Figure 4-12). It experienced 48 mm of rain on 18 December 2022, 37 mm of rain on 17 February 2023, and 30 mm of rain on 14 February 2023.

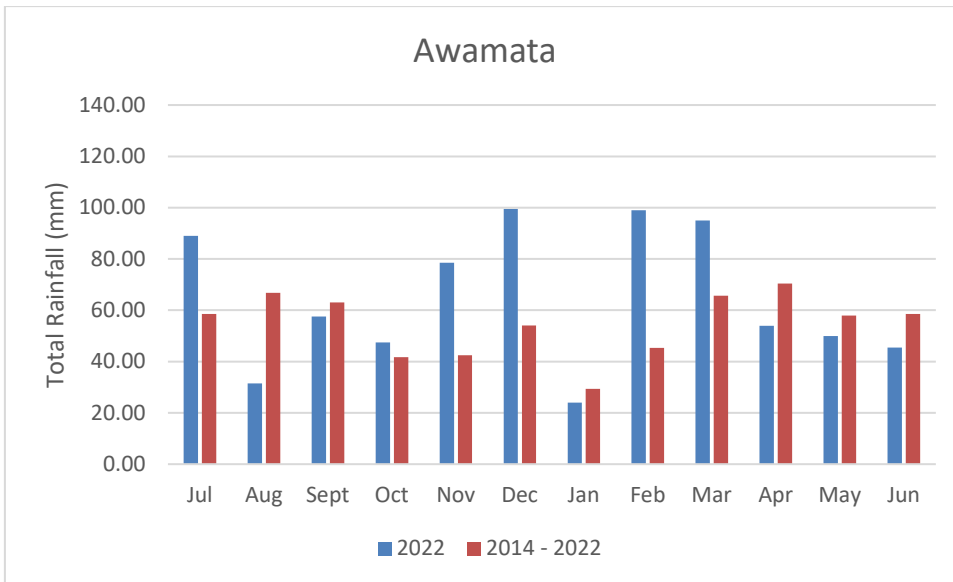


Figure 4-12: Monthly rainfall (mm) for the Awamata site through the 2022 hydrological year compared to the long term record

The Awamata flow recorder has a missing record from 1 June to 10 June and had a 7D MALF of 0.013 m³/s and a 2022 hydrological year 7D annual low flow of 0.013 m³/s and a minimum recorded flow of 0.01 m³/s (Figure 4-13). The December and March peaks correspond to the largest rainfall events indicated within the rainfall data with flows of 3.38 m³/s and 2.47 m³/s respectively.

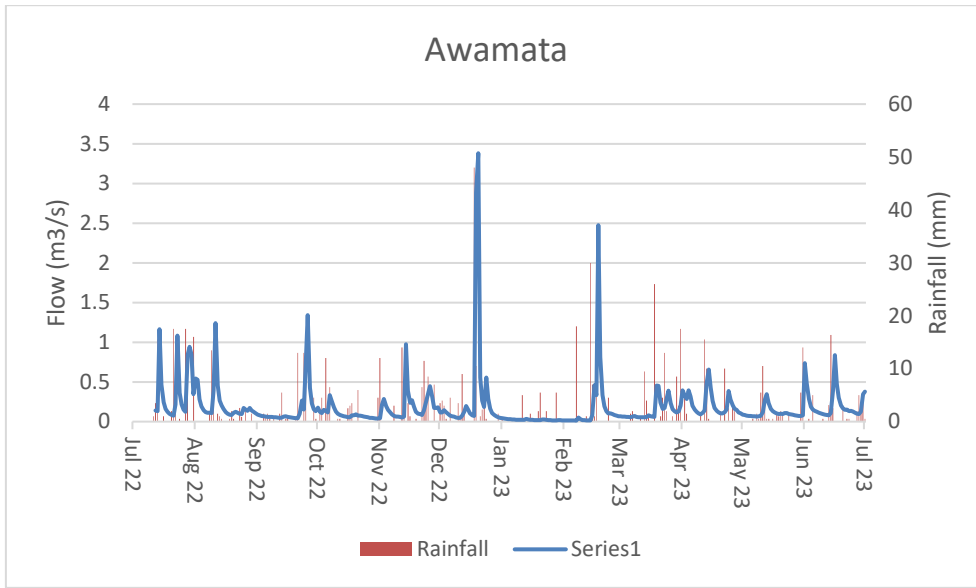


Figure 4-13: Daily mean flow at the Awamata flow recorder over the 2022 hydrological year with the associated rainfall station

4.7 Tuku a Tamatea River

Tuku a Tamatea has a missing record of 51.6 days between August to October 2022 and a missing record of 24 days in June 2023 due to a failure of the flow recorder. It had a minimum flow of 0.06 m³/s, an annual low flow of 0.07 m³/s and has a 7D MALF of 0.064 m³/s (Figure 4-14).

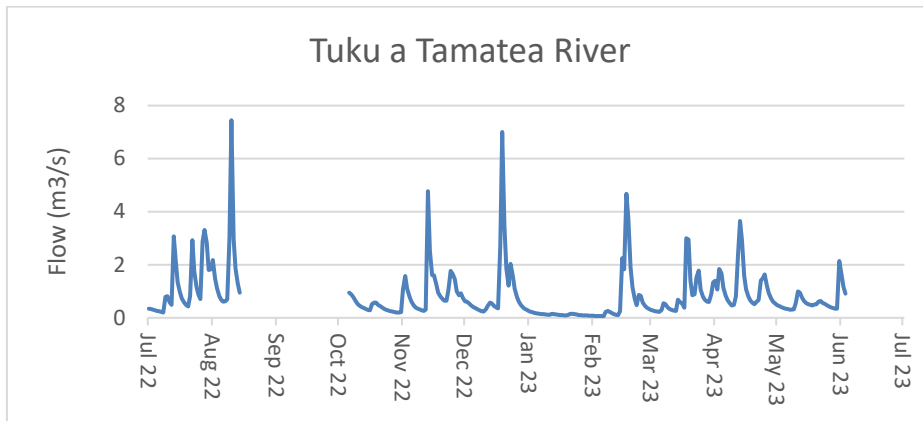


Figure 4-14: Daily mean flow at the Tuku a Tamatea flow recorder over the 2022 hydrological year

5 Water level

5.1 Te Whanga lagoon

Te Whanga Lagoon has two water level recorders, one at Hikurangi channel (the current lagoon outlet to the sea on the eastern coast) and one at Moropunga Island (on the northern end of the lagoon). The water level variation at Hikurangi Channel is strongly influenced by the tide when the lagoon mouth is open, while the water level variations at Moropunga Island are less influence by tidal movements and more influenced by wind driving water up and down the main axis of the lagoon. Both however, are useful indicators of lagoon water level, and reflect risk or hazard to island infrastructure surrounding the lagoon (i.e. inundation of roads, beaches, etc.).

The Influence on the water level in Te Whanga lagoon due to mechanical mouth openings and natural mouth closures is not well documented (PDP 2020). For the proper management of the lagoon, it is recommended that the openings of the Te Whanga Lagoon be recorded (PDP 2020). This is still not currently available on council files or website. However, it should be possible to infer mouth openings from the Hikurangi channel water level recorder records, based on identifying rapid decreases in lagoon water height, and from the recommencement of daily tidal water level fluctuations in the record. Corresponding mouth closures should also be able to be inferred from steady increases in lagoon water level and a corresponding absence of daily tidal water level fluctuations.

The detail of understanding lagoon water level recordings are best illustrated in the sequence of figures in Figure 5-1. The data in these figures are very recent (some are beyond the current hydrological season) but illustrate the detail in the (15 minute) recorder data. The four figures illustrate: a) daily variation in tidal amplitudes seen in one week of data while the lagoon mouth is open; b) one month of data while the mouth is open; c) three months of data and an engineered mouth opening in the middle of the record; and d) 12 months of data showing a mouth opening and mouth closing event.

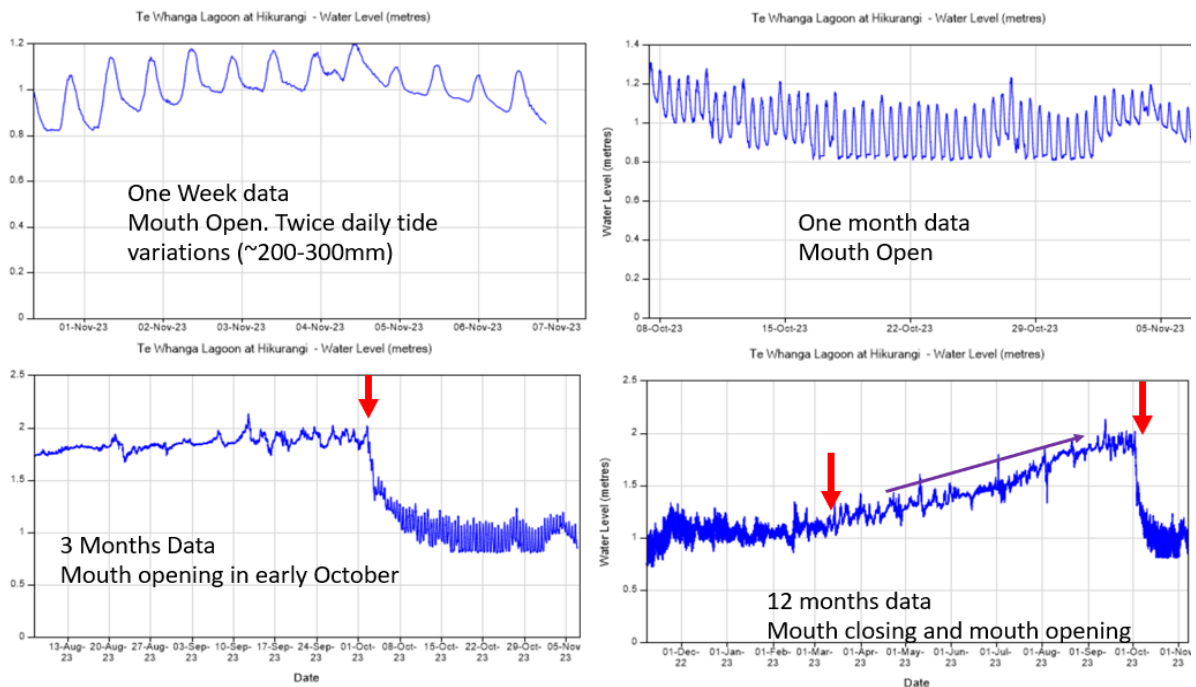


Figure 5-1: Displays of various water level data at Hikurangi channel in 2022/23 illustrating different features of the water level record over different time bases

Red arrows indicate lagoon [channel] opening and closure events.

These inferences can be hindered at times by both Te Whanga Lagoon water level recorders having some gaps in their long term daily mean record, when the recorders may be compromised by incidents such as debris or weed beds interfering with or covering the loggers. A strong indicator of the Hikurangi Channel mouth opening is a large and sudden decrease in water level, this has occurred two times since 2016 (purple arrows in Figure 5-2) and will have occurred a third time in late 2023 (beyond the current displayed record).

The indicative timings of corresponding mouth closures in 2017 and 2019 (red arrows in Figure 5-2) cannot be determined with high accuracy because of data gaps, but a mouth closure in 2023 can be inferred more accurately from the complete data record in 2023 (Figure 5-1). The first red arrow (in 2017) may not be a true mouth closure, as the closure pre-dated these records in 2016 (Figure 5-3). The extended period of mouth closure in 2016-2017 shows a more complicated pattern with two periods of water level rise (winter/spring, and autumn/winter respectively), and a period of mid-summer slower nett lagoon water loss (as a result of evaporative losses and low summer lagoon in-flows; Figure 5-3).

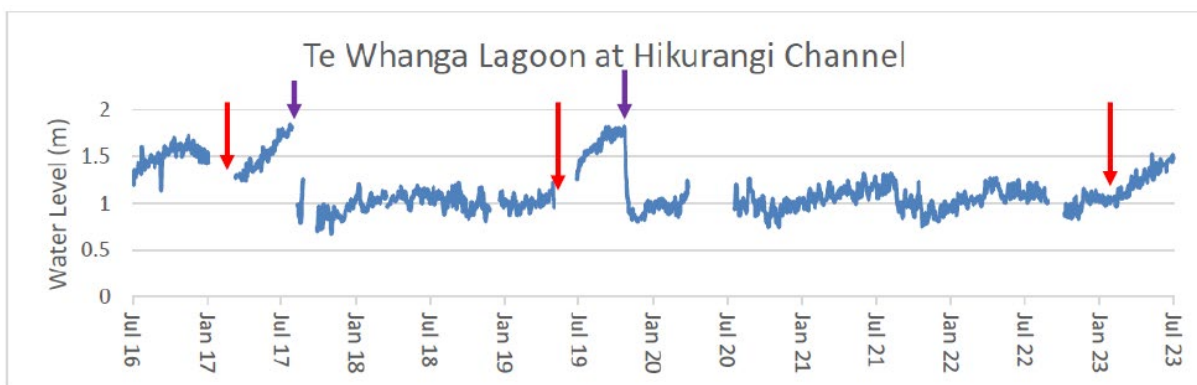


Figure 5-2: Daily average water level in Te Whanga Lagoon at Hikurangi Channel between 2016 and 2022 hydrological years

Red arrows indicate lagoon [channel] closure when lagoon levels increase, and purple arrows indicate channel opening when lagoon levels rapidly decrease.

The strong indication of the Hikurangi Channel mouth opening can be seen in closer detail in individual years of record. Over 2016 and 2017, the mouth closed sometime in autumn between March 2016 and May 2016 when the water level fluctuated around 1.0 m (Figure 5-3). The water level record lost the daily 0.2 m variation (tidal noise) and rose steadily from over winter/spring from May 2016 to November 2016. Water levels then slowly dropped from December 2016 to April 2017, probably reflecting lower stream flow inputs to the lagoon and high evaporative water losses over the summer season (a period of nett water loss from the lagoon over this period). Lagoon levels then steadily rose again from May 2017 until a mechanical channel opening in August 2017. This caused lagoon water levels to rapidly drop by over one metre (from 1.8 m to 0.8 m; Figure 5-3). Following the opening the lagoon then regained the daily 0.2 m level fluctuation (or tidal noise) in the record.

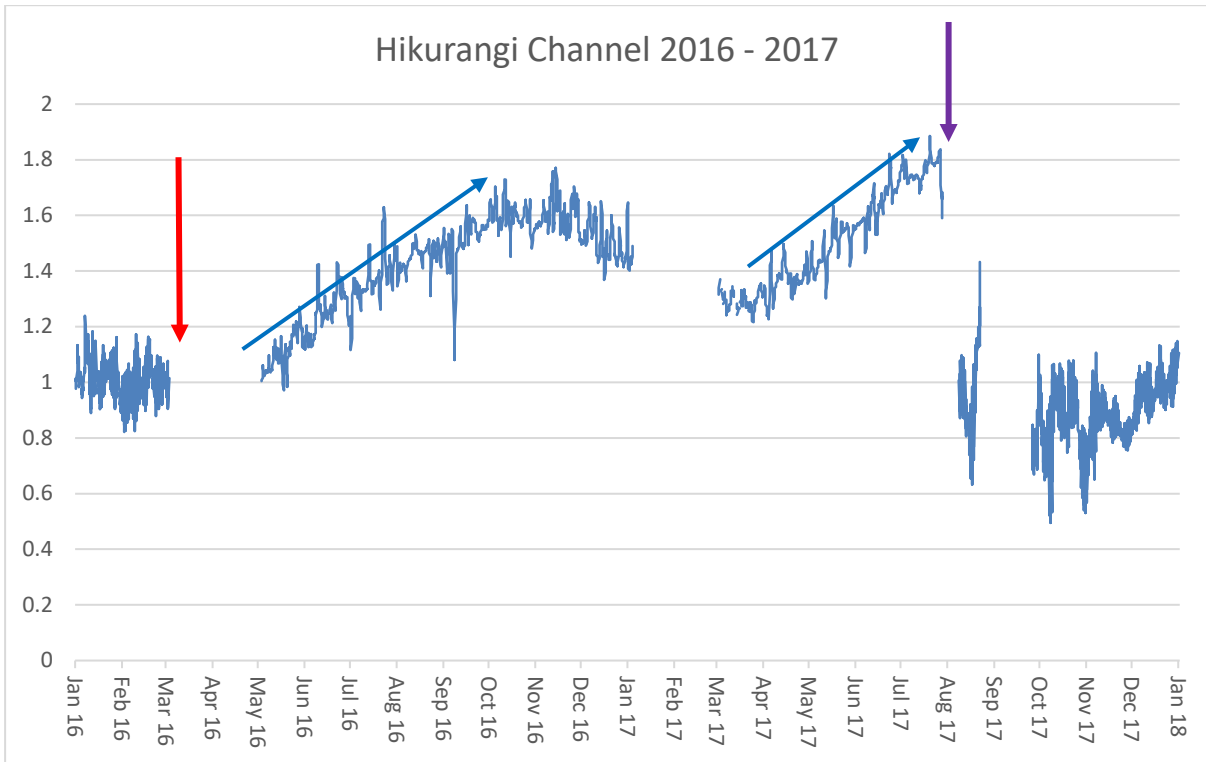


Figure 5-3: 6 hourly mean water level for Hikurangi Channel during 2016 and 2017
 Red arrow indicates approximate mouth closure, purple arrow indicates mouth opening. Blue arrows indicate rates of water level rise.

The Te Whanga Lagoon mouth closed in April 2019 and remained closed until late October 2019 (Figure 5-4). The water level had risen from 1.0 m to 1.8 m before the mouth was reopened.

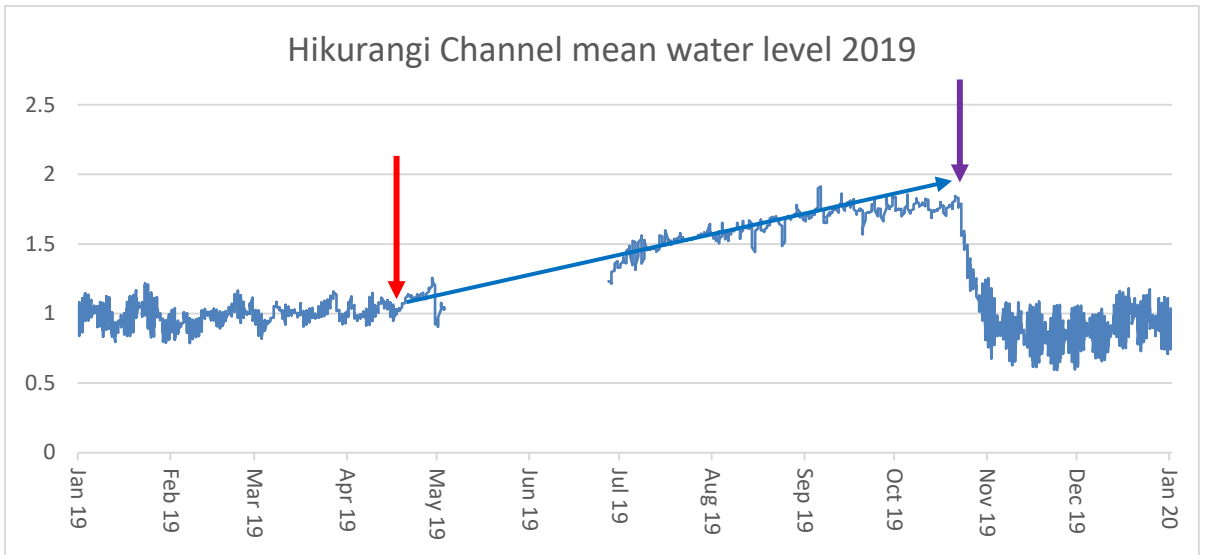


Figure 5-4: 6 hourly average mean water level at Hikurangi Channel for 2019
 Red arrow indicates approximate mouth closure, purple arrow indicates mouth opening. Blue arrow indicates rates of water level rise.

The most recent record of mouth level dynamics at Hikurangi channel are in 2022/23 (Figure 5-5). The lagoon mouth had been open in this record from at least July 2022 to March 2023. On approximately the 8th March the lagoon mouth closed, as the daily tidal variation was lost and the lagoon water level

began to rise. This is the third record of mouth closure illustrated here. A subsequent reopening is beyond this record and hydrology reporting year (but demonstrated in Figure 5-1).

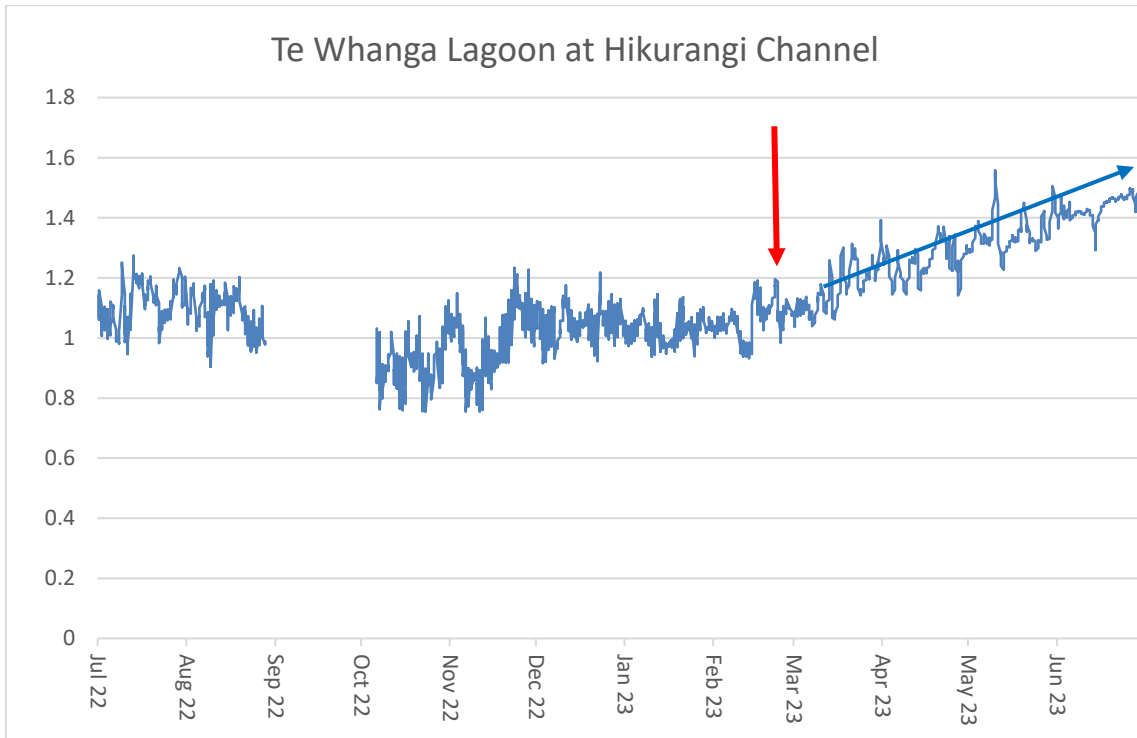


Figure 5-5: 6 hourly mean water level at the Te Whanga Lagoon at Hikurangi Channel water level recorder for the 2022 hydrological year

Red arrow indicates approximate mouth closure. Blue arrow indicates rates of water level rise.

The tidal influence at the Hikurangi Channel water level recorder can also be seen when comparing the water level in Figure 5-3 and Figure 5-4 to satellite imagery over 29 March 2023 and 26 April 2023 where the mouth of the lagoon visibly closes (Figure 5-6), and the hydrograph is no longer influenced by the tides.

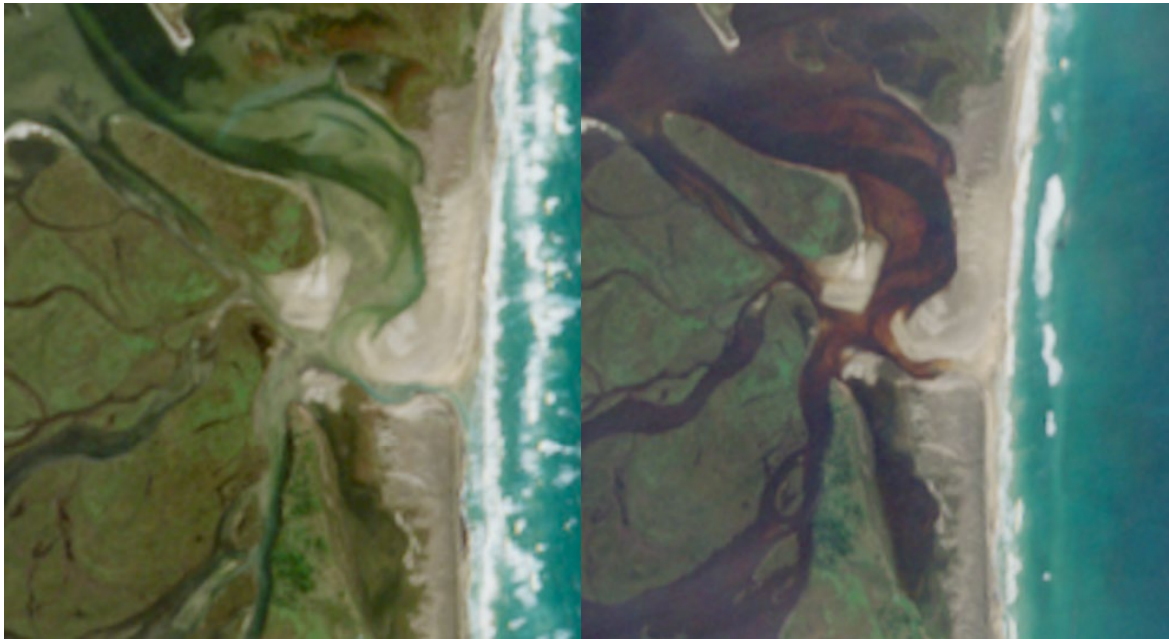


Figure 5-6: Satellite imagery of Hikurangi Channel from Copernicus Sentinel Data 2023 (Copernicus, 2023). Imagery is from 29 March 2023 and 26 April 2023

The water level recorder at Moropunga Island at the north end of Te Whanga lagoon is not strongly influenced by the tides but is more influenced by wind fetch along the north-south axis of the lagoon. Short term (i.e. daily) water level variation may be explained by differing northerly and southerly winds (Figure 5-7). Water level is also affected by the mouth closures at Hikurangi Channel, this can be seen in the long term time series where the water level increases and decreases in line with the mouth openings identified in Figure 5-3 (Figure 5-7). However, data gaps are also more prevalent in the Moropunga Island data as the level recorder is more prone to disruption from becoming stranded in or with plant and debris material accumulating on the logger infrastructure.

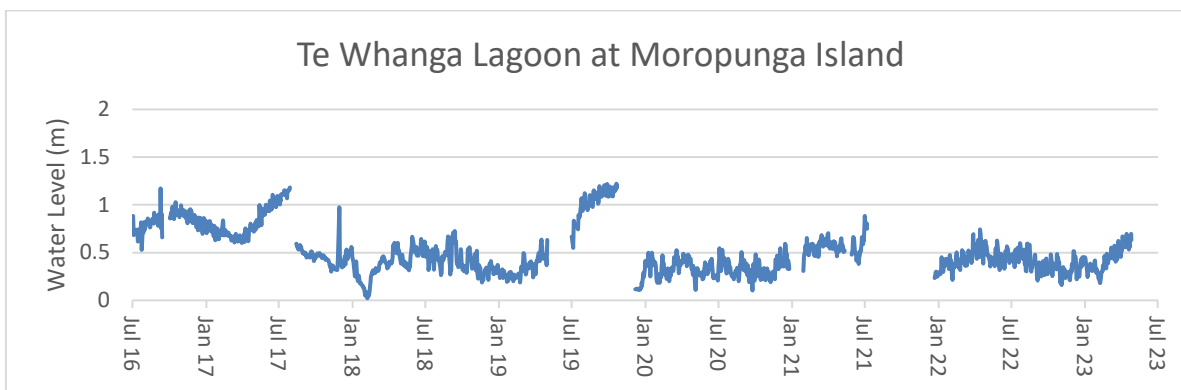


Figure 5-7: Daily average water level at Moropunga Island between 2016 and 2022 hydrological years

In more detail, these variation in lagoon water level features are best illustrated in the 2022/23 hydrological year at the Moropunga Island recorder (Figure 5-8). This shows a much higher daily variation in water level often up to 0.4 m rather than the Hikurangi Channel regular tidal variation of 0.2 m and does not exhibit the regular daily “noise” generated by tides. The Moropunga Island recorder data is therefore not as good for identifying or displaying mouth closure and openings but illustrates other important features such as the level variations caused by wind and wave fetch along the axis of the lagoon. These wind driven water level features are also important to fully understand lagoon levels

and to allow management or protection of natural and infrastructure features particularly at high lagoon water levels.

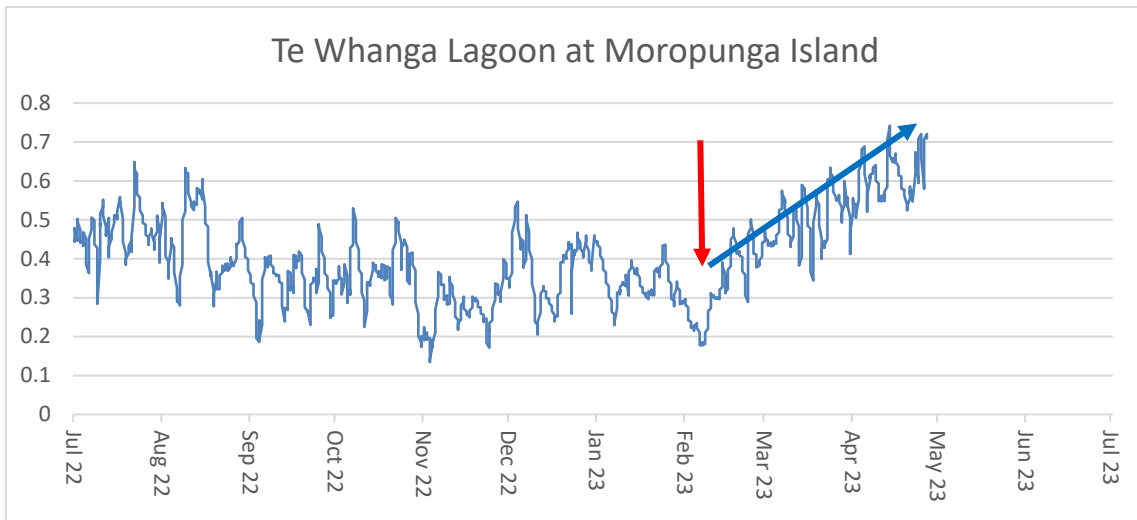


Figure 5-8: 6 hourly mean water level for the Te Whanga Lagoon at Moropunga Island recorder during the 2022 hydrological year. (red arrow indicates lagoon outlet closure)

5.2 Water levels at dune lakes

We have attempted to record water levels at two dune lakes in 2022/23 to illustrate similar management purposes to the Te Whanga lagoon water level record. A recorder installed in Lake Marakapia had too much data error to display any useful images. This record was largely to examine natural water level variation before too much pressure was put on extraction from this resource.

A level logger was also installed in Lake Rangitai to record the current high levels of variation in lake level since a pumping station was installed to reticulate water to the township of Kaingaroa and neighbouring stock water needs. The recorder has had similar data quality issues to Lake Marakapia but is reproduced in Figure 5-9 to illustrate the potential management utility of this type of data.

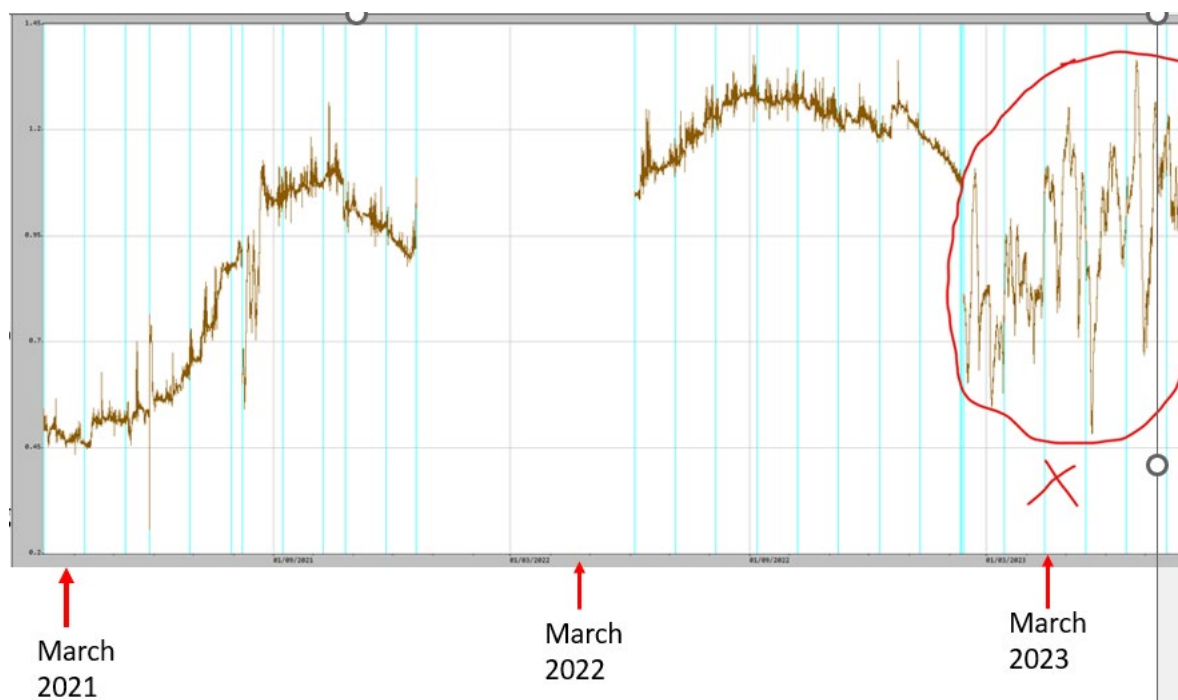


Figure 5-9: Screenshot of raw recorder water level data from Lake Rangitai to illustrate the potential type of data that can be obtained from a highly abstraction exploited lake

This figure shows the lake being at a very low water level in March 2021 when it had previously been drawn down by high abstractive use over 2019/20/21. The lake level then rose over 0.8 m over winter 2021 as winter rains began refilling the lake. In spring/early summer 2021/22 the lake level began to decrease again as abstractions and evaporation exceeded rainfall inflow. There was then a significant data gap as the recorder was compromised, possibly by debris or aquatic plant beds compromising the logger. In autumn/winter 2022 the lake had refilled some more and reached a more stable lake level (possibly close to full?). The lake level was reducing again in summer 2023 before the data became erratic and unreliable (again probably compromised by debris or weed beds). We do not propose or recommend any detailed use of this data because it is unaudited and does not pass all quality checks, but we consider it provides an illustration of how individual lake water level data can be acquired and interpreted to better understand resource availability and effects in these dune lakes.

Any lake that is or may come under abstractive resource use pressure should be monitored in this manner to establish natural level (or resource volume) variation to allow more structured management in the future. The clear water dune lakes warrant such scrutiny.

6 Discussion

6.1 General water quality

Water quality at a network of sites on Chatham Island has now been carried out since 2005. This represents an 18 year record for some sites, and allows for increasingly informed comment on the characteristics, state, and trends of water quality on the island. It also allows reporting against national attribute states and can put Chatham's water quality in context with waterways from the rest of New Zealand.

The water quality of Chatham Island is dominated by the peat soil and peat basin nature of the island, such that most waters are peat stained and may contain suspended peat particles. This can complicate interpretation as the natural dissolved and particulate organic peat material itself may strongly influence many parameters such as water clarity and Total nutrient concentrations. The peat nature can also strongly influence water quality as it is generally anoxic (without oxygen), has reduced water permeability, and so does not support high rates of leaching or high groundwater transport rates of contaminants (particularly nitrogen). It is therefore not surprising that sites across the Chatham Island grade very well (A and B grades) for low concentrations of dissolved Nitrate-N and Ammonia-N, but conversely stand out as high for DOC and often exhibit low water clarity.

Dissolved nutrient concentrations (nitrogen and phosphorus) are generally a significant management issue in New Zealand waterbodies, because they generally drive eutrophication issues (growth of phytoplankton or periphyton). However, the very low use of synthetic fertilisers, the low intensity of pastoral farming, and limited cropping and horticulture contribute to an expectation of nutrient issues being low on Chatham Island. However, scrutiny is warranted as many waterways may discharge to lakes or Te Whanga lagoon which may subsequently show responses.

The low soluble Nitrogen concentrations on Chatham Island is not necessarily an indication of an absence of water quality issues, as corresponding Total nitrogen and phosphorus in lakes and lagoons are high and generate high and increasing trophic states of these lakes. This may be an indication that nutrients on Chatham Island are not lost or transported as oxidised soluble forms (i.e. nitrate) but as complex organic forms. These organic forms may remain just as available to fuel plant and algal growth. Reporting of state and trend in water quality must therefore carefully consider the contaminant loss forms and pathways, rather than become complacent on reporting low levels of important national parameters (i.e. Nitrate, DRP).

Other parameters such as faecal/microbiological contaminants are also elevated and grade very poorly (E grade) in places. This provides further evidence that maintaining and improving water quality on Chatham Island is important and may be a challenge.

The trend assessments in parameters/attributes are also concerning, as there are a predominance of degrading (worsening) trends in most site specific and parameter specific assessments. As with elsewhere in New Zealand this indicates that surface waters are coming under increased pressure from land use and land management. The land use on Chatham Island is not intensive, and does not generally rely on use of irrigation, or artificial fertilisers, but stocking rates and features such as stock access to waterways and lake and lagoon edges can still be significant issues. Periods reflecting difficulty in transporting livestock off the island can lead to unintended high stocking rates, and can be significant pressures on water quality and the environment in some years. Climate can also be a significant issue with water quality influenced by particularly dry and wet periods/years when water residence time, particularly in lakes and lagoons, can become extended or shortened. These may directly influence water quality or exacerbate the effects of changes in water quality concentrations and loads.

It is therefore important to continue to monitor water quality on Chatham Island and be prepared to discuss and consider actions to address poor state, failure to achieve national attribute standards, or address degrading trends. As with elsewhere in New Zealand there is a requirement to maintain and improve water quality especially if it is in a poor state and/or degrading.

6.2 Site specific water quality issues

6.2.1 Mangatukurewa Creek and catchment (including Lake Huro)

Mangatukurewa Creek (previously called the Nairn River) and its various sub catchments stand out as a catchment deserving further scrutiny of its existing and future water quality. This is because of the indications of poor water quality, and corresponding higher risks associated with the highest population, and tourist density in this area.

The contributing Lake catchment (Lake Huro) stands out in this report as having degraded from eutrophic to supereutrophic to hypertrophic (the worst category) over the past three years. The lake currently has a very distinct green and turbid water appearance. Such degradation is of concern both for the state of the lake, and receiving water bodies as it drains through to the Mangatukurewa Creek and Waitangi waterfront.

Lake Huro has not been monitored for its specific phytoplankton community, and it is uncertain whether the shift in eutrophication state may also involve a change in the dominant phytoplankton community. As the lake is now “hypertrophic” there is a risk that this may involve growth of cyanobacteria or other problem or nuisance algae blooms in the lake. If there are potentially toxic cyanobacteria blooms these may be of significant toxic concern as livestock drink from the lake and downstream catchments draining the lake. These include Mangapē Creek that drains from the lake to Mangatukurewa Creek, and will then flow from Mangatukurewa Creek and out onto Waitangi beach in a well populated area. Cyanobacteria could pose a toxic risk to wildlife, livestock and the public in all of these waterbodies, and any shellfish within Waitangi bay.

The cause of the degradation of Lake Huro is unclear but it may be caused to by a number of factors (livestock, waterfowl, as well as community facilities). A number of more targeted monitoring initiatives are warranted to identify the respective contaminant (nutrient) sources and to begin the restoration of this catchment to reverse this poor state and degrading trends.

The contributing stream (Mangapē Creek), that delivers water from Lake Huro and the extensive grazed and ungrazed wetlands between Lake Huro and Mangatukurewa Creek, often shows the poorest water quality on the island (often Grade E). There are potentially a number of reasons for this, including grazing and stock access issues to the waterways, high wildfowl (swan and duck) use of the area, and the discharges from the poor quality and significantly degrading Lake Huro. The area is also bordered by the Te One community and may be a drainage pathway for any incompletely treated effluent from most of these dwellings and businesses.

It is also of concern that Mangapē Creek has in the past been used as water source that domestic or livestock water sources have been abstracted (pumped) from and useable at times of drought and poor availability of other potable water sources. We have observed the local community members filling IBC water containers from Mangapē Creek in times of drought. This indicate a further risk or hazard if creek water is used in this way without identifying the possible or potential risks.

Like Lake Huro, Mangapē Creek and the extensive areas they drain deserves more scrutiny and targeted monitoring initiatives. However, it also needs to be looked at in a more holistic fashion considering both the upstream lake catchment and drainage restrictions through to the Mangatukurewa Creek and to the sea. The Mangatukurewa Creek has constricted drainage in its lower reaches, and has significant tidal reaches, and tidal water exchanges. This can increase the water residence time in both the creek and the sub catchments. It has previously been suggested as being an ICOLL (Intermittent Closing and Opening Lake or Lagoon) (MPA 2015; T&T 2022), but in the past 15 years of monitoring the mouth of the Mangatukurewa Creek has not been seen or understood to completely close like true ICOLLs tend to do. Community comment has been that outflow under the bridge out to the sea has over recent years become increasingly constricted with sand accumulation and higher bed levels.

This river outflow siltation issue was raised during the new port construction proposals, affecting sedimentation in Waitangi Bay and the Creek outlet (MPA 2015). The port redevelopment consents required a “Coastal Processes Monitoring Plan” and annual reporting of coastal and river mouth profile

surveys. These acknowledge the potential problem and that dredging of the river mouth area may be needed. Reporting to date (T&T 2022) do not acknowledge this as a significant consequence of the wharf construction. There deserves to be further scrutiny of this issue, to ensure that outflow of Mangatukurewa Creek does not become further constricted and dredging of the creek outlet to the sea does not become necessary.

Restricted creek drainage can lead to increasingly stagnant or waterlogged water quality attributes. Many residences along Mangatukurewa Creek are old historic dwellings and have old or poor domestic water treatment and disposal facilities (i.e. septic tanks). There is also a significant amount of derelict material along these creek edges (including marine engines). There is also an absence of fencing to restrict stock access, and at times casualty stock have been observed drowned in the tidal creek reaches. Overall, there are many issues that need to be considered in managing water quality outcomes of the creek and Waitangi Beach.

A number of more targeted monitoring initiatives are warranted to help explain and begin the restoration of this degraded state and trend. The first of these is establishing routine water quality monitoring in Mangatukurewa Creek. It is a tidal waterway, and so to date has not been included in the routine monitoring program (other than microbiological sampling). However, there is an increasing national requirement to consider monitoring tidal waterways as these reaches are often considered particularly sensitive receiving environments with important risks or hazards associated with them.

The siltation and creek outflow restriction of Mangatukurewa Creek may be better addressed by a refocus of some elements of the Wharf upgrade Coastal processes management plan monitoring (MPA 2015; T&T2022) to more closely monitor the creek outflow condition, rather than just adjacent beach profiles and photo points. This could also be addressed with installation of continuous monitoring of creek water levels to record whether water levels (both high and low tide levels) are increasing and to help determine a threshold critical water level that could trigger or require intervention (dredging).

Finally, the close proximity of Te One and Waitangi communities to this catchment also give further concern as recreational use of these waters is higher than elsewhere on Chatham island and pose potential health risks. This includes both river reaches and where the river water flows out across the beach to Waitangi Bay.

The Waitangi and Te One communities also produce the greatest sources of potentially pathogenic municipal effluent, such as the concentration of separate treatment systems along Te One or the community treatment and disposal facility at Waitangi. These warrant further scrutiny given the potential risks of any discharges to these natural catchments associated with them.

Any refocus of the environmental monitoring programs on Chatham Island should concentrate any available or freed up resources on monitoring systems for this catchment as a priority.

6.2.2 Dune lakes

The dune lakes deserve particular scrutiny primarily because they represent an important but very limited potential potable/domestic water resource on the island. The Petre Bay lakes (Marakapia, Tennants, etc.) lie in extensive sand dune sequences rather than within peat basins. Therefore, their water is particularly clear, not brackish, and does not contain water quality components difficult to treat or remove. This resource should therefore be acknowledged for protection or careful management to secure this water resource for present and future generations.

These lakes are already exhibiting poor grades for Nitrogen concentrations in the water (C and D grades) which could lead to greening, or visible algal growth in the lakes. There is also uncertainty as to the degree to which water levels remain stable and are not drawn down. Developments, such as the additional buildings associated with Henga Lodge, suggest these developments that would inevitably require addition potable water resources and produce corresponding waste, should be carefully considered and managed. This includes their potable water sources, their effluent disposal, and activities that they attract into the lake catchments.

The Petre Bay lakes deserve additional monitoring effort to establish their current state and natural variation, such as their natural water level regime, and water quality challenges. An unresolved issue is whether these lakes behave as independent aquifers or are part of a combined aquifer for all of these lakes.

Another notable dune lake issue is Lake Rangitai, that over recent years has been developed as a water resource for Kaingaroa and as a reticulated stock water supply. It has been drawn down to very low levels over recent years. Water quality degraded as it was drawn down, and has not greatly improved since. This development failed to question or determine the sustainable yield, or even take steps to determine the water yield requirements. It represents a clear example of insufficient management of a very valuable or limited resource (clear domestic water). Increased monitoring of lake levels and rates of water abstraction would be fruitful further monitoring initiatives, and these should be consolidated as monitoring resources are refocused or become available.

6.2.3 Creeks of the western shore of Te Whanga Lagoon

Monitoring of the creeks along the western shoreline of Te Whanga lagoon over ten years ago indicated that contaminant yields (nutrient loads) to Te Whanga lagoon were similar (on an area specific basis) from all contributing stream catchments. Therefore, a focus on reducing nutrient loads are necessary from all catchments draining into Te Whanga if water quality of Te Whanga lagoon is to be maintained. However, the central and northern basins of Te Whanga lagoon are poorly flushed compared to the Southern basin (which is adjacent to the Hikurangi Channel outlet). It is therefore not surprising that the poorest water quality, and most degrading trends occur in the northern basin of the lagoon (Blind Jims) adjacent to the north-western stream mouths. These are also increasingly developed and used recreational resources/reserves. It is therefore increasingly important that contaminant (nutrient input) from these streams is managed or reduced, as the current degrading trends and poor water quality in these areas is contrary to the requirement or expectation of recreation reserve development and appreciation of the adjacent lagoon environment.

Livestock access to lagoon edge areas (particularly along the northern shoreline of the lagoon) regularly occur and illustrate that it is shorelines as well as contributing stream/creek channels and catchments that must be protected/managed to minimise nutrient and other contaminants accumulating in these lagoon basins.

To reverse the currently degraded state, and degrading trends, of the northern basins of Te Whanga Lagoon will require greater attention to management (particularly livestock intrusion) into contributing streams and along lagoon shorelines.

6.2.4 Te Whanga Lagoon

Te Whanga Lagoon is a large and significant resource of Chatham Island and is a notable asset or value that is particularly recognised in [treaty] settlements and management strategies. It is important to monitor this water body in total to clarify or validate community perceptions of its state and to assure its appropriate management. The three lake edge monitoring sites reflect a bare minimum for determining state and trends and identifying issues.

The Southern basin of the lagoon is in the best water quality state. This is because most freshwater inflow (85%) is from the southern (Te Awainanga) catchment, and the outlet to the sea (Hikurangi Channel) is also from the southern basin. The Southern basin appears to have good and stable water quality because it has good water quality grades (A or B), low bacteria (A grade), and the trophic level is stable and not increasing. However, the Te Awainanga River nitrogen concentrations are increasing, and at times the lagoon southern basin Nitrogen grades have dipped into C grade (2021, 2022). This indicates that even the southern basin of the lagoon is not immune from degradation, and the land use of the greater Te Awainanga catchment should not be ignored. It is much easier to “maintain” than to try to restore or rehabilitate the lagoon should it show a degrading state, particularly from increasing nitrogen loads. Such nitrogen concentrations/loads inevitably originate from the land/ land use.

We have already specifically discussed the northern basins of the lagoon and degrading state and trends, particularly associated with stream inputs and lake edge stock access (section 6.2.3). However, the shallow and poorly flushed nature of the northern half of the lagoon make it particularly sensitive.

As discussed later in this report, water level management and carefully considered brackish/salinity state should also be considered. Further issues such as development of potentially toxic cyanobacteria blooms, and/or other problem or noxious [algal] species should also be considered so that conditions do not favour their establishment or proliferation in Te Whanga lagoon.

6.2.5 Groundwater

We have not specifically monitored or discussed groundwater of Chatham Island in this report, but groundwater is the other valuable and limited potentially potable water resource on the island. We have established that there are a reasonable number of groundwater wells/bores established in areas on the island and have some initial one-off measurements of groundwater water depth and groundwater water quality. However, the extent of the resource, and its potential yield are uncertain but are likely to be relatively low.

The early water quality indications from bores are that groundwaters are hard (high calcium) anoxic (no oxygen) and can have traces of brackish [salty] components. The groundwater is considered a necessary, but not favoured, drinking water resource for many, but may become increasingly crucial water resource for the island if water sources become limited. It is therefore important that monitoring elements are used to both understand and protect the integrity and sustainability of the currently utilised groundwater resource.

Establishing monitoring of groundwater levels in bores and determining the water quality of indicator bores would be an important initiative to understand and manage this resource.

Any refocus of the environmental monitoring programs on Chatham Island should concentrate any available or freed up resources on groundwater monitoring systems to protect or secure this resource for future generations.

6.3 Hydrology

The hydrology data from the four hydrometric sites do not illustrate any particularly notable changes other than that 2022/23 was a wetter year moving out of the past dryer years, and with generally higher flows, and more floods and freshes. The variation in flow behaviour between the sites is relatively low, reflecting the maritime influence and island nature of Chatham Island.

Such hydrometric networks are a key monitoring feature of regions in New Zealand and throughout the world, however, they become of lesser relevance in an island context. This is because with the low geographic relief, strong maritime influence, and short catchments on Chatham Island, there is limited proactive management use of the hydrometric data or knowledge.

Catchments are so short that there is little if any attempt to anticipate or respond to developing flood hazards. Furthermore, there is little infrastructure or assets at risk at the terminal ends of most catchments. Only the Mangatukurewa Creek (Nairn River) catchment has infrastructure at risk at its lower reaches and entry to the sea. It is significantly throttled by tidal reaches, and for that reason has not currently been a flow monitored catchment.

Furthermore, there is very little abstractive water use on the island and so a hydrometric database to manage low flow water availability (allocation and minimum flows) is also not warranted at present or anticipated into the future.

Therefore, the current 18 years of recent flow records establish a very good understanding of stream and river flow regimes and risks but, it may be un-necessary to continue this data gathering indefinitely. Review of the logistical efforts in maintaining part or all of the hydrometric network may free up resources for other monitoring initiatives or priorities.

6.4 Climate stations

The maintenance of 6 climate stations on the island has enabled close correlations between river flows and rainfall, and establishing the variability in rainfall across the island. The 2022/23 data collection has illustrated a wetter (La Nina) weather pattern making up moisture deficits from past years. These are useful data, but are not highly used by any island group or function. NIWA had previously published an understanding of the magnitude and patterns of rainfall across the island and this climate station network has largely verified rather than challenged that previous finding (Pearce, 2016). Furthermore, more land owners are increasingly using or establishing their own climate stations for farming purposes, and University researchers on the island (Massey University) have been donating climate stations to schools and community groups.

For these reasons, the ongoing or indefinite maintenance of this climate station network appears unnecessary or a luxury. In the face of no increase in monitoring funding and an increasing requirement to refocus or address other monitoring issues it appears reasonable to reduce this climate station network.

6.5 Lake and lagoon level network

6.5.1 Te Whanga Lagoon

Te Whanga Lagoon water level loggers have been maintained for many years, but not previously been reported on within Environment Canterbury's science reports or reviews. The information contained within this report illustrates that the analysis or interpretation of this data is can be very valuable in determining previous lagoon closures and mouth openings and provide valuable insight for decision making processes, such as when mechanical openings of the mouth could or should occur. This information will also be very useful for discussion of target lagoon water levels and mouth opening regimes, to generate some future focused consensus.

Current records illustrate that when the lagoon is open a tidal amplitude of approximately 200 mm is seen twice daily. However, in the northern basin tidal fluctuations are lost, but wind fetch amplitudes of 400 mm water level rise and fall are not uncommon.

Records over periods of lagoon closure (2016-2023) can provide useful indicative information for proactive lagoon management such as estimating average rates of water level rise over closure periods (autumn/winter/spring). The recent record provides four periods of steady lagoon water level rise (Table 6-1). Despite these being over different years and climatic conditions, the rate of lagoon level rise are remarkable similar, ranging from 3.8 to 4.7 mm/day. An average lake level rise of 4mm/day corresponds with a nett inflow/increase of 7400 l/s (or 7.4 m³/s) of freshwater to the lagoon. This assumes a lagoon area of 160 km² and accounts for both inflow and evaporative or seepage losses.

Table 6-1: Average water level rise estimated for four events (2016-2023) when the lagoon mouth was closed

Year	start month	stop month	level rise mm	days	rise mm/day
2016	May	October	641	168	3.8
2017	March	July	584	124	4.7
2019	April	October	740	187	4.0
2023	March	June	440	110	4.0

These records and calculations can allow anticipation of when critical water levels may compromise infrastructure such as roading and provide greater capacity to discuss and proactively schedule lagoon opening rather than reactively responding when lagoon water levels become critical.

6.5.2 Dune lake network

Water level recorders were installed in Lake Rangitai and Lake Marakapia to assess the value of proactive management of lake levels in these water resources. The water level recorder in Lake Marakapia was unreliable and did not produce meaningful data over the past year. Learnings from this will assist future initiatives.

The water level recorder in Lake Rangitai was also poor, but produced some indicative information that illustrated the potential and value of this approach. We consider where resources allow, that routine continuous water level monitoring of many of the dune lakes are warranted to allow or ensure proactive management of the water resource.

7 Conclusion

This reporting of environmental monitoring on Chatham Island for the 2022/23 year allows an update of the state and trends in water quality, hydrology and climate. It adds to 18 years of monitoring data. This analysis has added additional analysis of lagoon and lake water levels that have not previously been reported on.

The water quality has generally continued to worsen or degrade with many parameters and sites illustrating that water quality has not been maintained or improved. The program has focussed largely on land use effects or drivers, but climate patterns can also play a part in changes in state and trends.

The 2022/23 was somewhat wetter and with more rainfall than the previous dry years. There has also been more requirement to manage Te Whanga lagoon with mouth closures and openings.

This analysis has also allowed consideration of whether the monitoring programme could be reviewed to accommodate other issues or resources not currently monitored. This is an important consideration where funding for monitoring has not been increasing, and yet costs and requirements are increasing. It is appropriate to review the relevance and effectiveness of monitoring programs at least every 10 years.

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