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solutions for your environment

memorandum

TO	Graeme Clarke	FROM	Patrick Lees
	Environment Canterbury	DATE	1 June 2018
RE	Chatham Island Water Quality Summary		

1.0 Introduction

Environment Canterbury have engaged Pattle Delamore Partners Ltd (PDP) to update the Chatham Island water quality data review for the current water year, and provide an assessment of the current state and long term trends for the Island's natural waterways, lakes and lagoons.

Water quality monitoring data is collected quarterly at 14 stream sites and 8 lake or lagoon sites on the main Chatham Island (Figure 1). Te Whanga Lagoon, the largest water body on the Island, is sampled at 3 sites. All other stream and lake sites are sampled at one location each. All sites have been sampled since 2005, except sites on the Nairn River and Te Whanga – Southern, which were first sampled in October 2006.

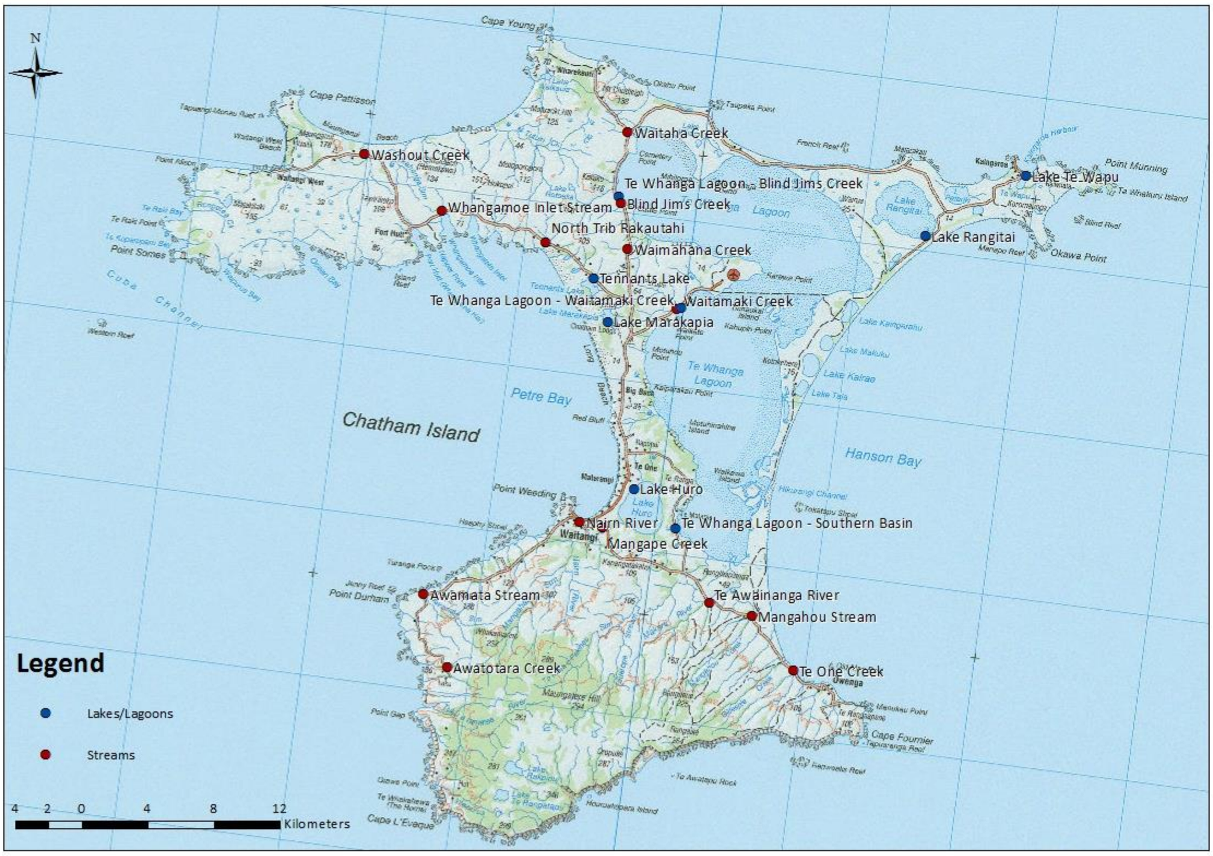


Figure 1: Routine water quality monitoring sites for stream and lakes or lagoons on Chatham Island

2.0 Data analysis methods

Water quality results were analysed for current state based on 5 years of monitoring data (2012-2017). Long term trends were assessed using all available data collected since monitoring began in April 2005 or where there is at least 10 years of data.

Trophic Lake Index (TLI) values have been calculated annually for the lake sites and attribute states, as defined in the National Policy Statement for Freshwater Management (NSP- FM).

Advice provided in McBride, 2014 and MfE, 2015, recommends that attribute states are calculated using a dataset of 20-30 records, preferably collected on a monthly basis. The Chatham Island sampling is completed quarterly. Attribute states have been calculated using 5 years of data, such that n=20.

Censored data (data with values outside the laboratory detection limits) were adjusted before analysis using the method prescribed by Environment Canterbury Water Quality Scientists. The method used is detailed in the email correspondence in Appendix 1.

Long term trends are summarised in Appendix 3. All available data has been used to assess the long term trends using a Seasonal Kendall test in the TimeTrends V6.30 software. The Seasonal Kendall test assesses significant increases or decreases (represented by Δ for significant increase or ▼ for significant decrease) and the magnitude of change represented by the relative sen slope estimator (>1 = meaningful). Significant increases and decreases were assessed using significance of $P<0.005$, $P< 0.01$, and $P<0.05$.

3.0 Results and Discussion

3.1 Dissolved Oxygen

Streams, lakes and Te Whanga Lagoon on Chatham Island are generally well oxygenated with the exception of Washout Creek and Whangamoe Inlet Stream, which often experience decreased dissolved oxygen concentrations potentially as a result of river mouth closures. Mangape Creek has continued to record a number of low dissolved oxygen concentrations over the last 4 years, which may require further consideration. Dissolved oxygen concentrations have remained fairly steady over the last 12 years of monitoring, however significant downward trends have recently been recorded for Awatotara, Mangape, and Waitamaki creeks. No other significant trends have been identified.

3.2 Water Temperature

Water temperature is fairly consistent between streams, with the shaded Awatōtara Stream, and Mangahōu Stream slightly cooler than other streams. Water temperature is also fairly consistent between the lakes and lagoon. No significant trends have been detected for water temperature variation.

3.3 pH

For many streams on Chatham Island the pH indicates acidic water, typical of peat soils. Waitaha, Blind Jims Creek, Waitāmaki Creek, Waimāhana Creek and Mangapē Creek have a more buffered pH similar to those found in Canterbury, indicating the influence of differing geology throughout the island, and a decrease of peaty soils at these sites. pH is most acidic for Awatōtara Creek which is located within a peaty catchment. pH of the lakes and Te Whanga Lagoon sites on Chatham Island are fairly similar, with median concentrations ranging from 8-9 pH. At the majority of sites, pH has been fairly steady over the 12 years of monitoring. Only Te Whanga Lagoon at Southern Basin and the Mangape Stream site showed a significant and meaningful increase.

3.4 Dissolved Organic Carbon

Similar to pH, dissolved organic carbon (DOC) concentrations differ for Blind Jims Creek, Waitāmaki Creek, Waimāhana Creek and Mangapē Creek, in comparison to other streams on Chatham Island. The volcanic peaty make up of soils on the island influence the leaching of organic matter, contributing to elevated DOC concentrations for many of the streams. Inflow streams on the north western edge of Te Whanga Lagoon show lower DOC concentrations where the catchment is comprised of less peaty soils and organic matter is likely reduced via filtration by the more sandy soils of this area.

In comparison to the streams of the island, the lakes and Te Whanga Lagoon sites have much lower DOC concentrations, with the exception of Lake Te Wāpu, which has much greater concentrations than all the other lake and lagoon sites. DOC has shown a significant change at two stream sites (Washout Creek and North Trib Rakautahi) over the past 12 years of monitoring.

3.5 Nutrients

Phosphorus – Dissolved reactive phosphorus (DRP) concentrations are greatest for Washout Creek, Whangamoe Inlet Stream and Waimāhana Creek, with significant and meaningful increases of DRP at Waimāhana Creek over the past 12 years. Total phosphorus concentrations reflect the DRP concentrations for Washout Creek, Whangamoe Inlet Stream and Waimāhana Creek. Additionally, higher concentrations of total phosphorus were observed at Mangape Creek and were greater in comparison to their dissolved reactive phosphorus concentrations, indicating increased particulate phosphorus. Elevated particulate phosphorus is potentially due to organic matter, increased run-off and soil erosion, or bankside disturbance. While elevated in comparison to dissolved reactive phosphorus, total phosphorus is significantly and meaningfully decreasing at North Trib Rakautahi, Waitaha Creek, Mangape Creek and Waitamaki Creek (Appendix 2; Table 1).

Dissolved reactive phosphorus concentrations are greatest for Lake Hurō and Te Whanga Lagoon at Blind Jims Creek and Waitāmaki Creek, however only Lake Te Wāpu and Lake Hurō have elevated total phosphorus concentrations. It is likely that the elevated total phosphorus concentrations in Lake Te Wāpu are driven by particulate phosphorus given the DRP concentration is low. These results mirror the elevated DOC concentrations in the lake and it is likely the particulate phosphorus is bound in organic matter which would also be driving the high DOC concentration. Total phosphorus concentrations for Lake Hurō, Lake Marakapia, Lake Te Wapu and Te Whanga Lagoon at Blind Jims Creek, Waitāmaki Creek and the southern basin show significant and meaningful decreasing trends over the past 12 years.

Nitrogen – Dissolved inorganic nitrogen (DIN) and total nitrogen concentrations are greatest for Washout Creek, Mangapē Creek and Lake Hurō, Te Whanga Lagoon at Blind Jims Creek and Lake Te Wāpu. Long-term nitrogen trends vary among the island. Te Awaīnanga River and Blind Jims Creek show a significantly and meaningfully decreasing trend for DIN, while all sites except Whangamoe Inlet Stream and Waitaha Creek showed a significant trend for total nitrogen indicating an increase of organic nitrogen. Lake Rangitai shows a significant and meaningful decrease for total nitrogen, while Tenant's Lake shows a significant and meaningful increase for total nitrogen.

3.6 Chlorophyll *a*

Chlorophyll *a* concentrations for the lakes and Te Whanga Lagoon sites reflect the levels of nutrient enrichment of each site. Chlorophyll *a* concentrations are greatest for Lake Te Wāpu and Lake Hurō, where nitrogen and phosphorus concentrations are greatest. A significant and meaningful decrease of chlorophyll *a* concentrations for Lake Hurō and Te Whanga Lagoon at Blind Jims Creek, and the southern basin are likely related to decreases of total phosphorus.

3.7 Water Clarity

Water clarity (measured by a clarity tube) of the streams on Chatham Island are heavily influenced by leaching from the peaty organic soils, therefore similar trends are observed among sites to DOC concentrations. The clearest of streams are those with the lower DOC concentrations such as Blind Jims Creek, Waitāmaki Creek and Waimāhana Creek, where the sandy soils of the stream catchments filter out particles that may reduce water clarity. Conversely, Mangapē Creek has reduced water clarity, but low DOC concentrations, suggesting the source of reduced water clarity is more related to suspended particles such as sediment, rather than discoloration of water from leaching of peat soils. Sources of suspended particles may be related to overland flow and unrestricted stock access. However, water clarity for Mangapē Creek is significantly and meaningfully improving. Additionally, water clarity for Whangamoe Inlet Stream and the North Tributary of Rangitai Stream is significantly and meaningfully improving.

Water clarity in the lakes and Te Whanga Lagoon is more related to in-lake nutrient and chlorophyll *a* concentrations, as water clarity is influenced by algal production, supported by nutrient enrichment. Water clarity for Lake Te Wāpu and Lake Hurō reflect increased chlorophyll *a* concentrations. These chlorophyll *a* concentrations indicate increased algal production, which requires elevated nutrient concentrations to support and promote algal growth; and limits the visible water clarity of a lake.

Water clarity is significantly and meaningfully increasing for both Te Whanga Lagoon at Blind Jims Creek, Lake Te Wapu and Lake Hurō in response to decreasing trends of chlorophyll *a* and nutrient concentrations over the past 12 years.

3.8 Lake Eutrophication

The trophic level index for lake and lagoon sites of Chatham Island is a calculation derived from annual average total nitrogen, total phosphorus and chlorophyll *a* concentrations; used to indicate the level of eutrophication. Results are provided in Table 2 of Appendix 3. The supertrophic and hypertrophic states of Lake Hurō and Lake Te Wāpu that were observed in 2014 – 2015 were not evident in the 2016-2017 results with both sites, indicating that they were in a eutrophic state. This was reflected in the reduction of nutrient enrichment, and subsequent reduced chlorophyll *a* concentrations. Two of the three Te Whanga Lagoon sites continued to show improvements and stabilisation of trophic levels that have occurred in recent years, reflecting the significant decline of TP in particular. However, Te Whanga Lagoon at Blind Jims Creek has continued to show the eutrophic state that was observed in the 2015-2016 year (Tables 1 and 2 in Appendix 3).

3.9 Microbial Water Quality

Microbial water quality is monitored for faecal indicator bacteria such as *Escherichia coli* (*E.coli*) in freshwater, and both *E. coli* and *Enterococci* in water with a saline influence, such as Te Whanga Lagoon and the Nairn River at the mouth. Generally, the stream sites (Mangapē Creek and Nairn River) had the greatest faecal indicator bacteria concentrations, as opposed to the lagoon and Lake Rangitai. Both Mangapē Creek and Nairn River are likely influenced by overland run-off and unrestricted stock access in grazed pasture catchments. Occasional spikes in *E.coli* for Te Whanga Lagoon at Blind Jims Creek may be caused by re-suspension of benthic sediment reservoirs of faecal bacteria during strong wind, or unrestricted stock access combined with run-off near the lakes edge. *E.coli* is showing a significant and meaningful decreasing trend for Te Whanga Lagoon at the Southern Basin. This site generally has the lowest *E.coli* concentrations.

3.10 National Policy Statement – National Objectives Framework

The National Policy Statement (NPS) was initially released in 2014 with the intention to set objectives and policies for the management of freshwater at a national level throughout New Zealand and to direct local councils towards establishing objectives and limits. The National Objectives Framework (NOF) 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 D, with the D category being below the national bottom line state. For more information refer to "*National Policy Statement for Freshwater Management 2014*" (MfE, 2014). In 2017, changes to the NPS provisions on *E.coli* were introduced. These are now based on a grading of five tests involved in establishing a category (attribute state) from Blue (A) to Red (D).

For streams in Chatham Island, nitrate-nitrate-nitrogen (NNN) for all sites falls within the "A" attribute state, indicating that nitrate toxicity is of little concern for these streams and is unlikely to have any significant effects, even on sensitive aquatic species (Table 1). Ammonia toxicity[1] results were also similar at all sites. Only one stream fall within the 'B' category, which indicates that some sensitive aquatic species may be impacted by elevated ammonia concentrations. None of the sampled streams had concentrations of NNN and ammonia greater than the NPS national bottom line for both parameters.

Ammonia toxicity results sampled at the lake and lagoon sites on Chatham Island, after pH adjustment was undertaken (as per MfE, 2015), were all within the 'A' attribute state indicating minimal concern of species loss due to ammonia toxicity at these sites,. Total nitrogen attribute states in lakes and lagoons showed a mix of sites between the 'B', 'C' and 'D' bands with Lake Te Wāpu and Lake Hurō falling below the national bottom line objective (Table 1). Total Phosphorus for Lake Te Wāpu, Lake Hurō and Te Whanga Lagoon – Blind Jims fall within the 'C' attribute state, which is mirrored by a Chlorophyll *a* attribute state of 'B' and 'B|C' for these sites (Table 1). This indicates a risk of excessive algal or plant growth at these sites, due to impacts of elevated nutrients.

E.coli results are presented in Table 2. Two stream sites were monitored for *E.coli* on Chatham Island and results showed that both sites generally had *E.coli* categories within the 'C' and 'D' attribute states. The Nairn River site had one *E.coli* category within attribute state 'E' which is the lowest attribute state within the NPS. The summary of attribute states outlines that the estimated risk to human health from swimming is > 5%. *E.coli* monitoring occurred at four lake and lagoon sites on Chatham Island. Two of the *E.coli* categories were all within the 'A' attribute state. However, in the remaining two *E.coli* categories a mixture of 'A', 'B', 'C' and 'D' attribute states occurred. The use of the 95th percentile statistic provides an indication of the upper most values observed at a site, and doesn't provide a good indication of what *E.coli* values would usually be. *E.coli* values at the lake sites are within the 'A', 'B' and 'C' bands for the other four categories, which outlines that there is a low risk of infection (1-3% predicted average infection risk).

[1] pH adjustment of ammonia concentrations must be undertaken before compliance with the numeric attribute states in the NPS can be assessed. pH adjustment was undertaken as per the recommended methods in MfE(2015) and MfE (2017)

Table 1. National Objective Framework Attribute States for Streams and Lakes on Chatham Island						
	NNN	**NH_4-N**[1]	**TN**	**TP**	**Chlorophyll a**	
	Summary	Summary	Summary	Summary	Summary	
Awamata Stream	A	A				
Awatōtara Creek	A	A				
Te Awaīnanga River	A	A				
Washout Creek	A	A				
Whangamoe Inlet Stream	A	A				
North Trib Rakautahi	A	A				
Waitaha Creek	A	A				
Blind Jims Creek	A	A				
Waitāmaki Creek	A	A				
Waimāhana Creek	A	A				
Mangapē Creek	A	B				
Mangahōu Stream	A	A				
Te One Creek	A	A				
Nairn River						
Lake Rangitai		A	B	A	A	
Lake Te Wāpu		A	D	C	B	C
Tennants Lake		A	C	B	A	B
Lake Marakapia		A	C	B	A	
Lake Hurō		A	D	C	B	C
Te Whanga Lagoon - Blind Jims Creek		A	C	C	B	
Te Whanga Lagoon - Waitāmaki Creek		A	B	B	A	
Te Whanga Lagoon - Southern Basin		A	B	B	A	

Notes:

1) *NH_4-N[1] = pH adjusted NH_4-N concentrations have been used to assess compliance with the NPSFM numeric attribute states, adjustments were undertaken as per the MfE (2015)*
2) *Cells in the table that are summarised by two colours show that the each of the summary statistics used to define the current state of the water body are within two numerical attribute states*

Table 2. National Objective Framework *E.coli* Attribute States for Streams and Lakes on Chatham Island with *E.coli* data				
	E.coli[2]			
	Median	Percent > 540 *E.coli*/100 mL	Percent > 260 *E.coli*/100 mL	95th percentile
Mangapē Creek	D	C	C	D
Nairn River	D	E	D	D
Lake Rangitai	A	C	A	D
Te Whanga Lagoon - Blind Jims Creek	A	C	A	B
Te Whanga Lagoon - Waitāmaki Creek	A	B	A	A
Te Whanga Lagoon - Southern Basin	A	B	A	D

Notes:

1) *Only sites that have E.coli data are shown*
2) *Attribute states should be determined by using a minimum of 60 samples over a maximum of 5 years*
3) *The overall attribute state must be determined by satisfying all numeric states*

Limitations

This memorandum has been prepared by Pattle Delamore Partners Limited (PDP) on the basis of information provided by Environment Canterbury. PDP has not independently verified the provided information and has relied upon it being accurate and sufficient for use by PDP in preparing the memorandum. PDP accepts no responsibility for errors or omissions in, or the currency or sufficiency of, the provided information.

This memorandum has been prepared by PDP on the specific instructions of Environment Canterbury for the limited purposes described in the memorandum. PDP accepts no liability if the memorandum is used for a different purpose or if it is used or relied on by any other person. Any such use or reliance will be solely at their own risk.

Prepared by

Patrick Lees
Environmental Scientist

Reviewed by

Laura Drummond
Senior Environmental Scientist

Steve Pearce
Technical Director

References:

McBride., G. 2014. National Objectives Framework for Freshwater: Statistical considerations for assessing progress towards objectives with emphasis on secondary contact recreation values. Prepared by National Institute of Water &Atmospheric Research Ltd. for Ministry for the Environment, Wellington. 34p.

Ministry for the Environment, 2014. National Policy Statement for Freshwater Management 2014. Wellington: Ministry for the Environment.

Ministry for the Environment, 2015. A *Draft Guide to Attributes in Appendix 2 of the National Policy Statement for Freshwater Management 2014*. Wellington: Ministry for the Environment.

Ministry for the Environment, 2017. National Policy Statement for Freshwater Management 2014. Updated August 2017. Wellington: Ministry for the Environment.

Appendix 1: Guidelines for dealing with detection limits

Patrick Lees

From: Kimberley Dynes <Kimberley.Dynes@ecan.govt.nz>
Sent: Friday, 8 December 2017 10:59
To: Patrick Lees
Cc: Emily Gray
Subject: FW: Chathams Island data
Attachments: C03691801_Raw_Data_Chathams.xlsx

Hi Pat,

Here's some details taken from one of our reports:

1.1.1 Dealing with detection limits

Where water quality data was reported below a limit of detection (censored data), the individual detection limit was generally halved. However detection limits for each parameter are often variable and show inconsistencies due to changes in laboratory companies used, and laboratory procedures used for analysis. Therefore, where less than 40% of data for a single parameter analysed per statistical grouping (i.e. river type for state analysis or individual site for trend analysis) was below detection limits, the individual detection limit was halved. Where greater than 40% of the data analysed was below detect, each detection limit was halved by the highest detection limit of the statistical grouping for that parameter. Where greater than 70% of the data was below detect, the parameter for that statistical grouping was omitted from analysis (Ballantine, 2012). Dissolved inorganic nitrogen (DIN) was not calculated for sites where greater than 70% of values for total ammoniacal nitrogen were below detect, and therefore such a site was omitted from both total ammoniacal nitrogen and DIN analysis.

We use this for both state and trend analysis. Recently time trends has changed the way they deal with detection limits and this had led to some changes in trends. We do all our detection limit corrections ourselves prior to inputting into time trends to try and avoid any major trend discrepancies.

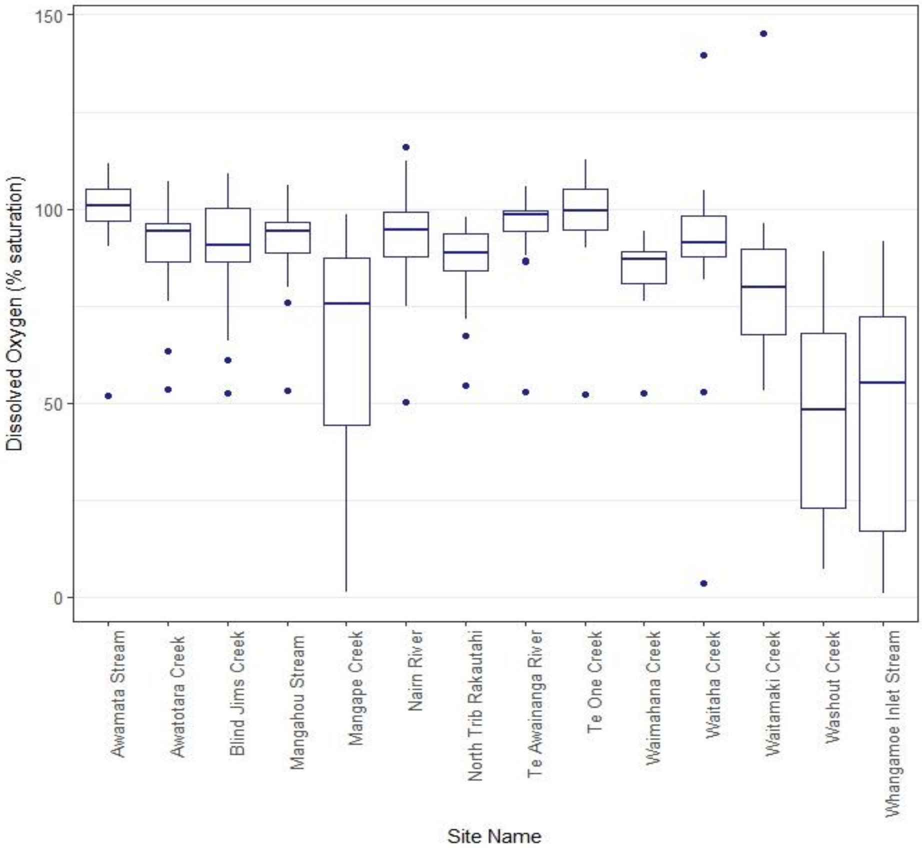
CCC sent us this blurb regarding the time trend changes:

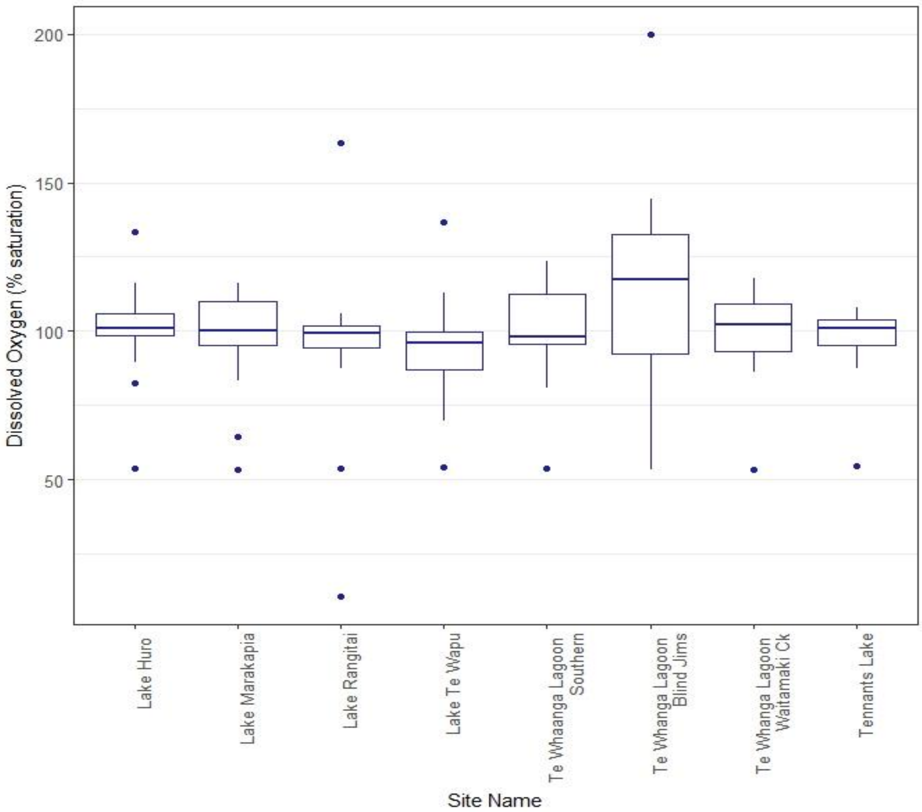
Version 5 of Time Trends was used for the 2015 temporal trends analysis, while version 6.2 was used this year. These two versions have a different way of treating values below the LOD. In version 5, the LOD is halved and then the analysis is run. In version 6.2 values below the LOD are not considered, because the software author considered that a slope cannot be calculated from a censored value (pers. comm. Ian Jowett). Initial comparison of the two Time Trends versions yielded different results for some parameters and sites (see Appendix F). Therefore, to effectively compare trends and to be consistent with methods used in previous reports, all data below the LOD was converted to half this value before being imported into Time Trends 6.2 (i.e., the same method was used as in last year's report). Because of the removal of the '<' symbol from the data, this method did not allow any warning regarding excessive values below the LOD. To ensure data were correctly analysed, the analysis was also run on the unedited data, which does give a warning. In addition, any site with more than 70% of the data below the LOD was not considered reliable for trend analysis.

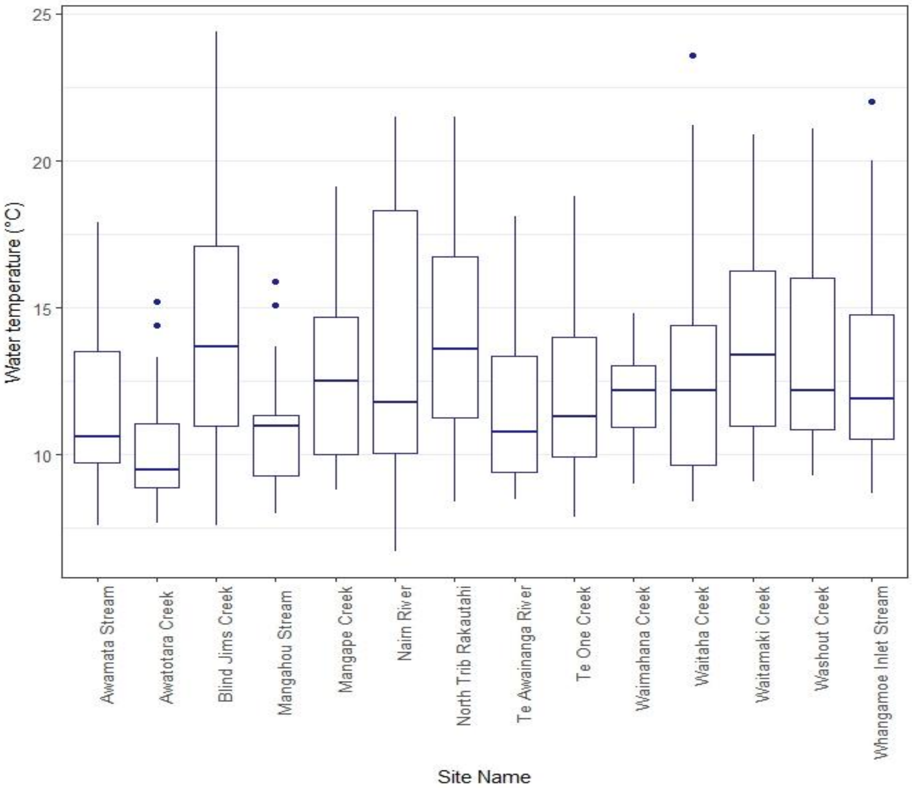
I'll leave the clarity tube data to Emily to send through ☺

From: Emily Gray
Sent: Friday, 8 December 2017 10:16 a.m.

Appendix 2: Current state box plots for streams, lakes and lagoons on Chatham Island



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20
15
10
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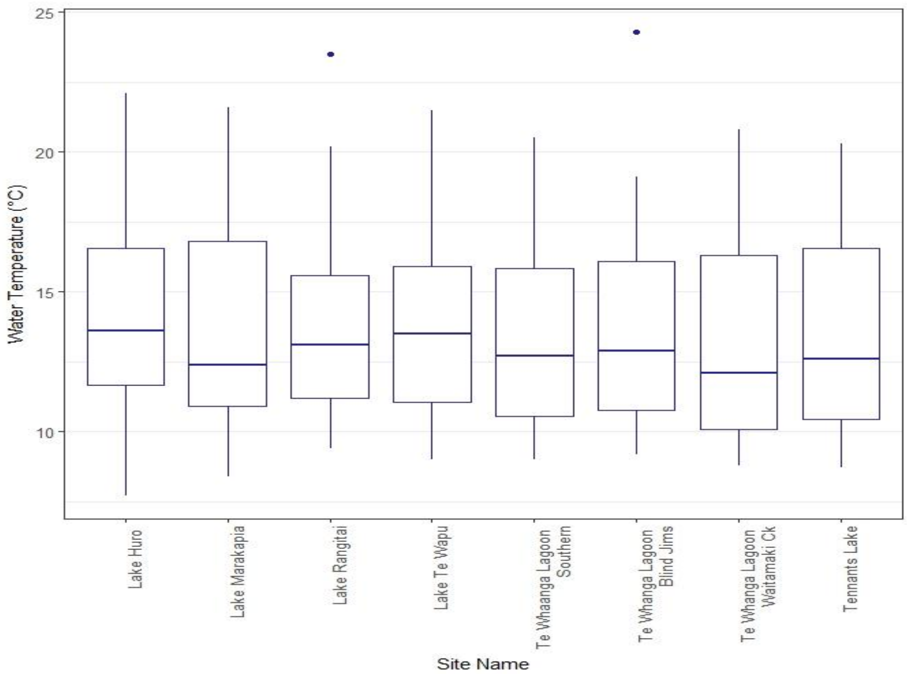
Awatotara Creek
Blind Jims Creek
Mangahou Stream
Mangape Creek
Nairn River
North Trib Rakautahi
Te Awainanga River
Te One Creek
Waimahana Creek
Waitaha Creek
Waitamaki Creek
Washout Creek
Whangamoe Inlet Stream
Site Name


Water Temperature (°C)
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20
15
10
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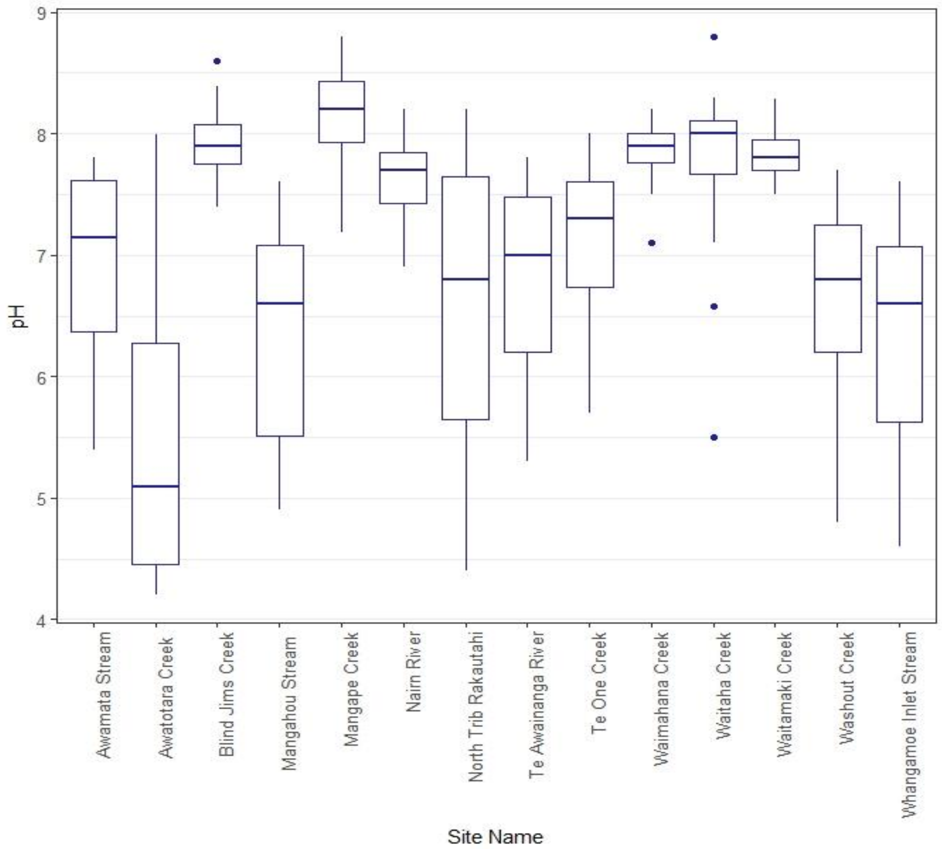
Te Whanga Lagoon Southern
Te Whanga Lagoon Blind Jims
Te Whanga Lagoon Waitamaki Ck
Tennants Lake
Site Name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8
7
6
5
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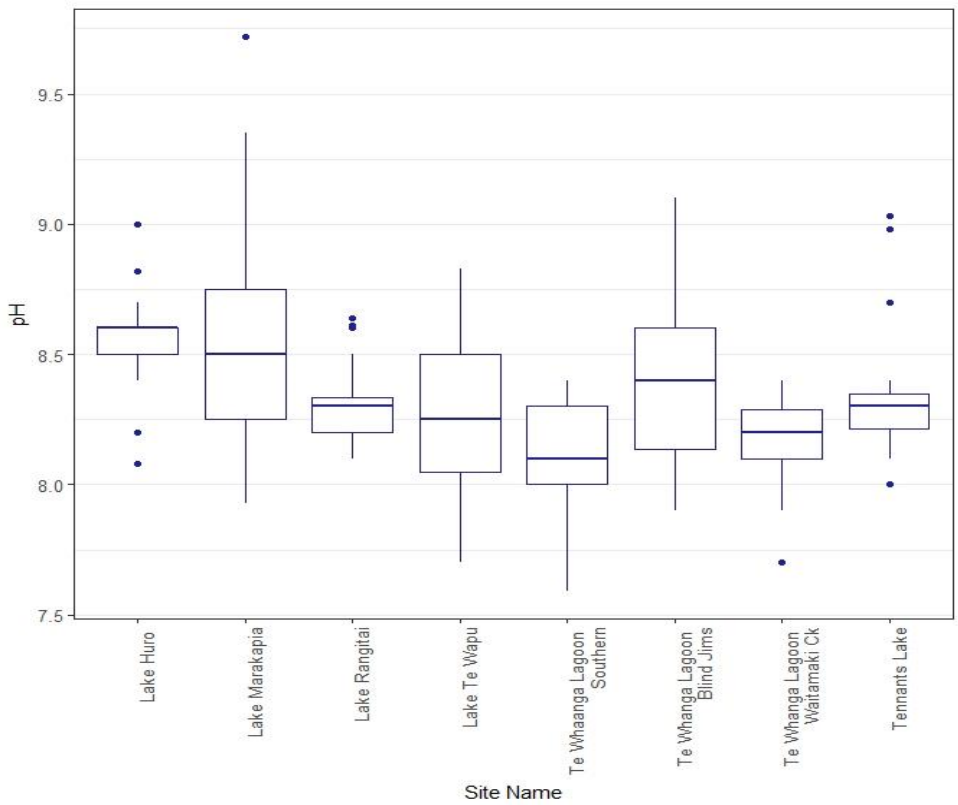
Site Name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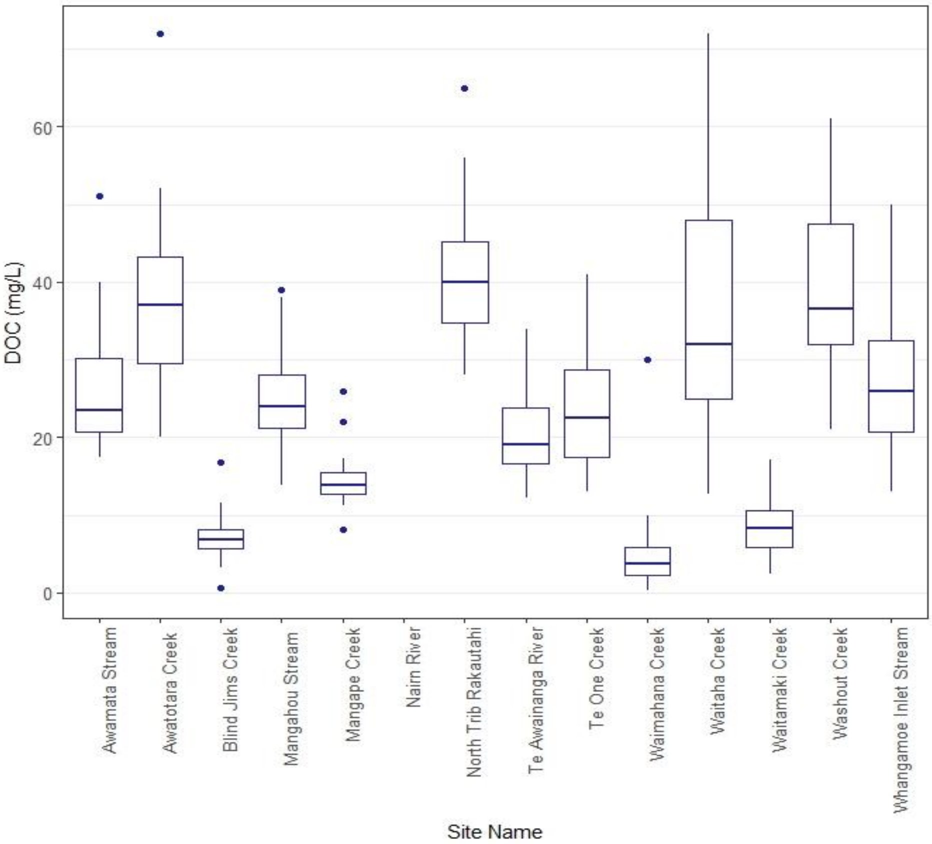
Site Name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40
60
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Awatotara Creek
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Mangape Creek
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North Trib Rakautahi
Te Awainanga River
Te One Creek
Waimahana Creek
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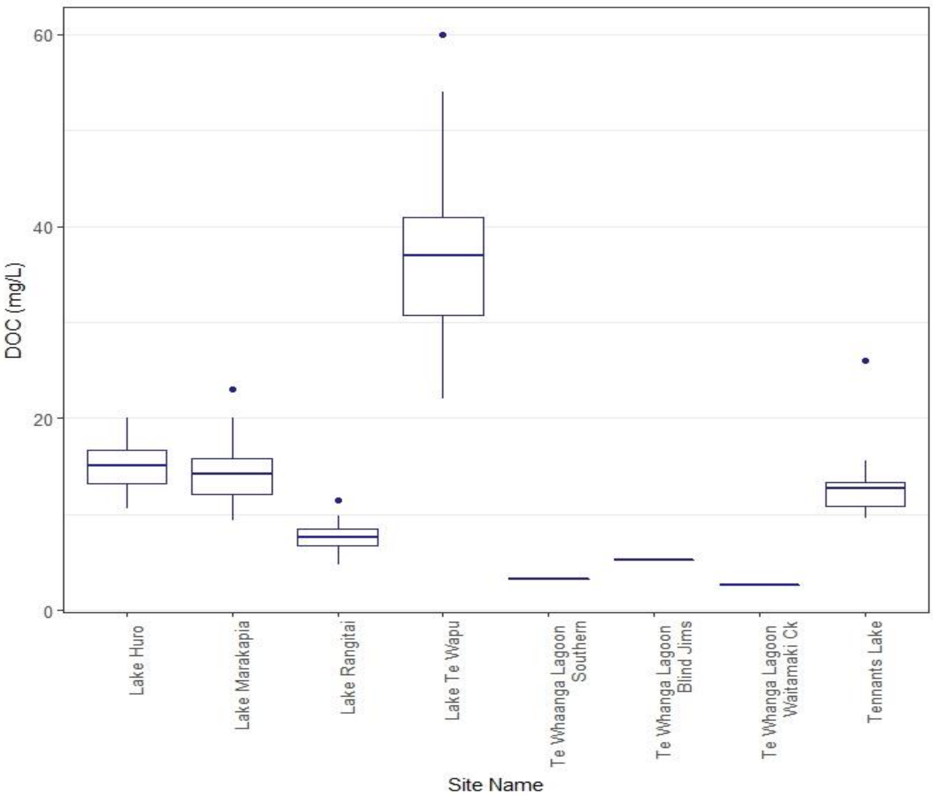
Waitamaki Creek
Washout Creek
Whangamoe Inlet Stream
Site Name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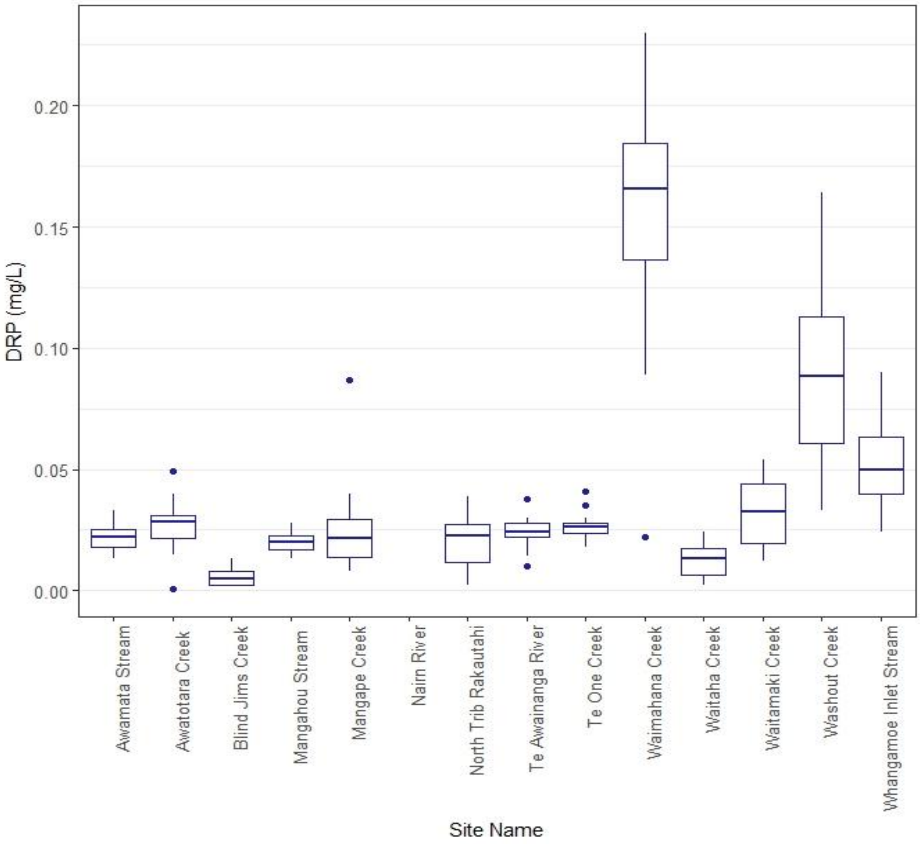
Te Whanga Lagoon Waitamaki Ck
Tennants Lake
Site Name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DRP (mg/L)
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Mangape Creek
Nairn River
North Trib Rakautahi
Te Awainanga River
Te One Creek
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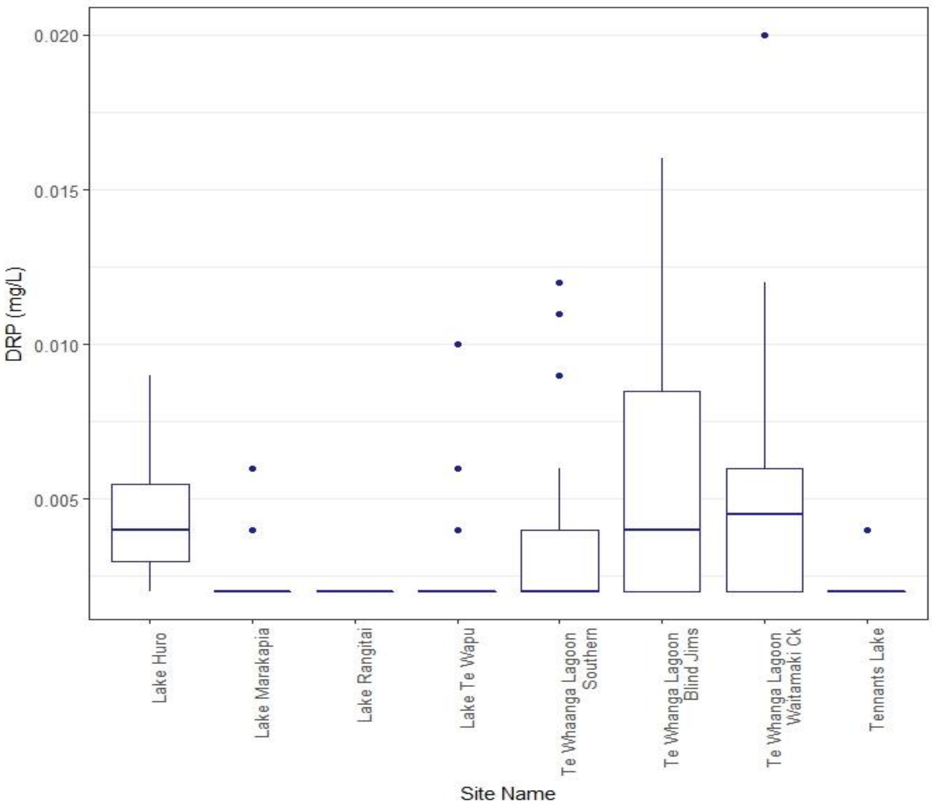
Waitaha Creek
Waitamaki Creek
Washout Creek
Whangamoe Inlet Stream
Site Name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DRP (mg/L)
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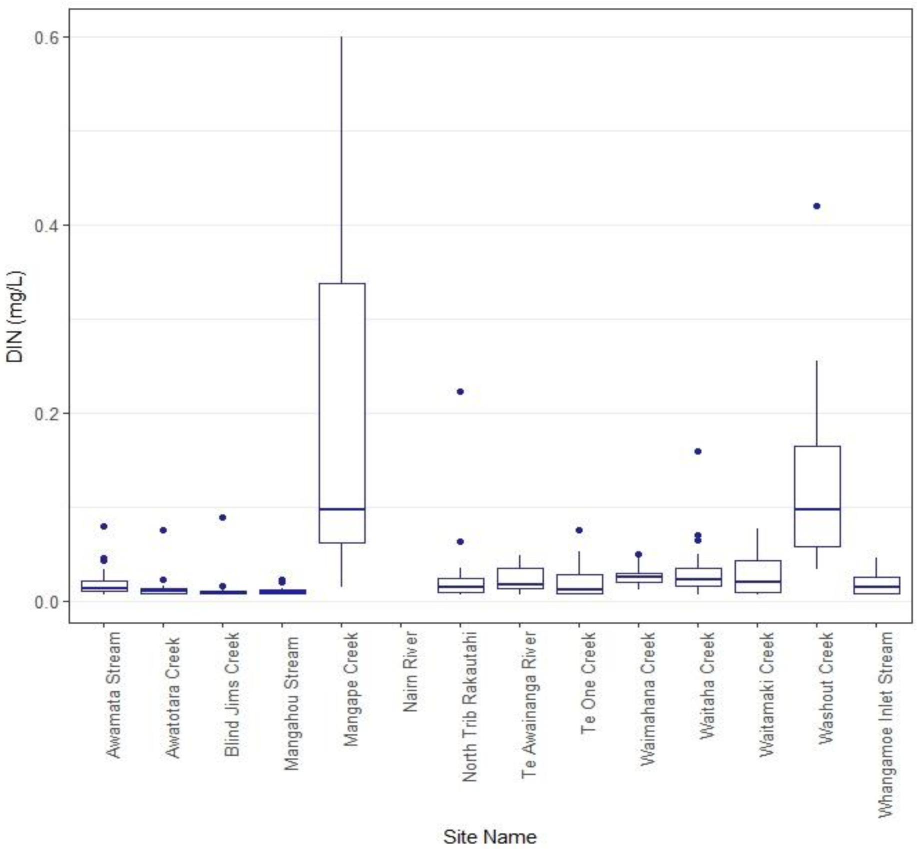
Lake Te Wapu
Te Whaanga Lagoon Southern
Te Whanga Lagoon Blind Jims
Te Whanga Lagoon Waitamaki Ck
Tennants Lake
Site Name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Nairn River
North Trib Rakautahi
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Te One Creek
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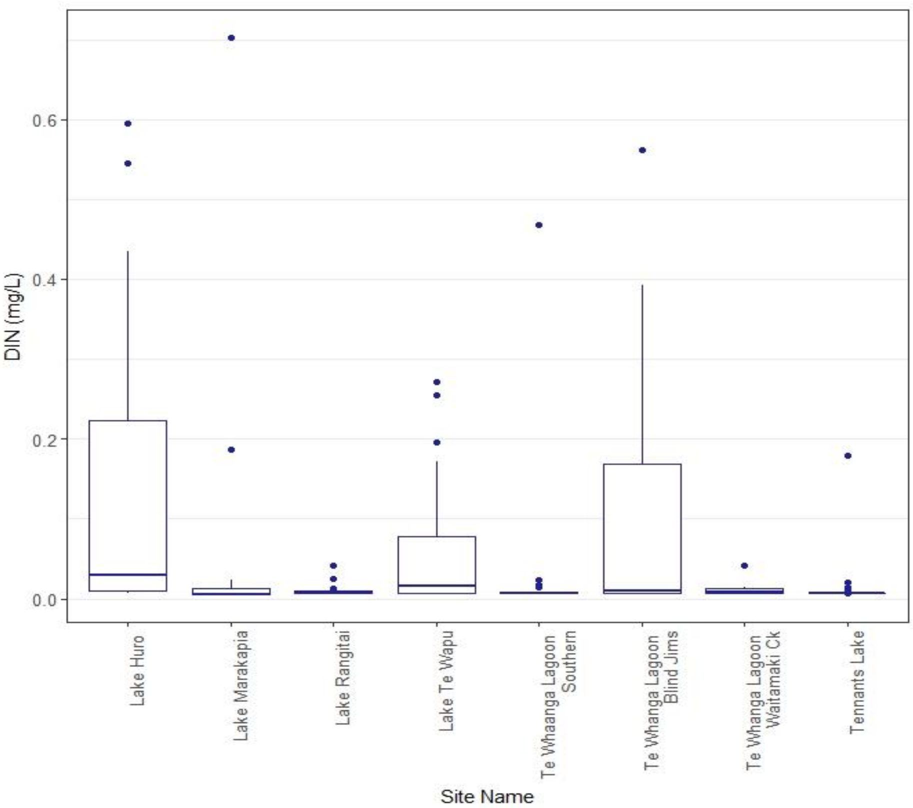
Whangamoe Inlet Stream
Site Name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Lake Marakapia
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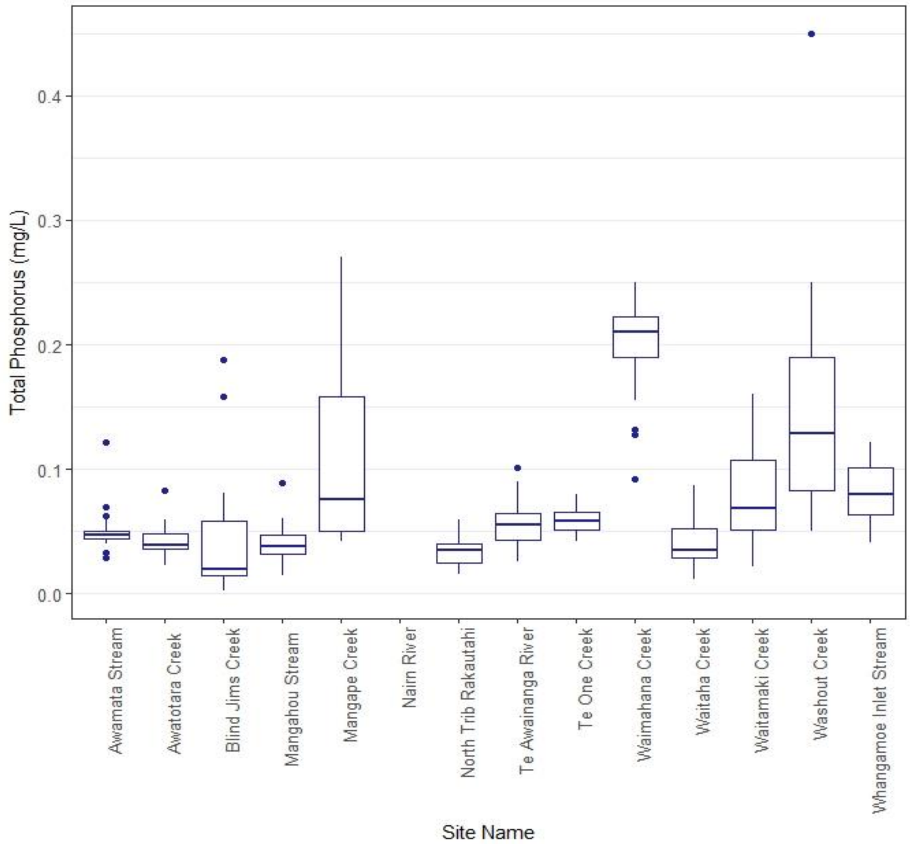
Tennants Lake
Site Name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0.3
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Blind Jims Creek
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Mangape Creek
Nairn River
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Washout Creek
Whangamoe Inlet Stream
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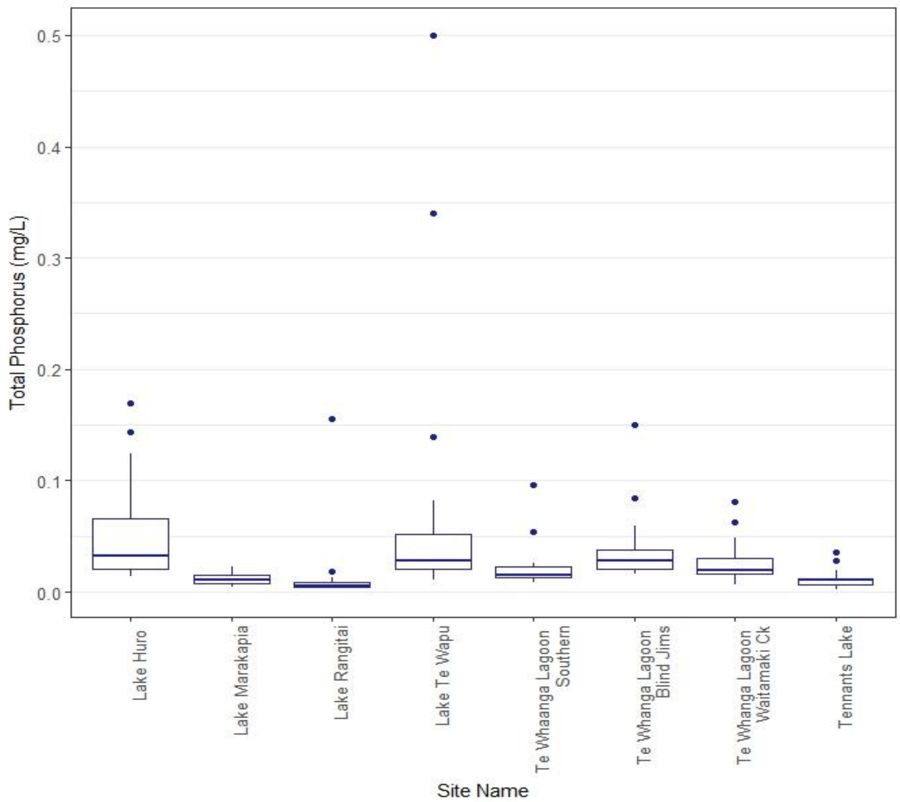
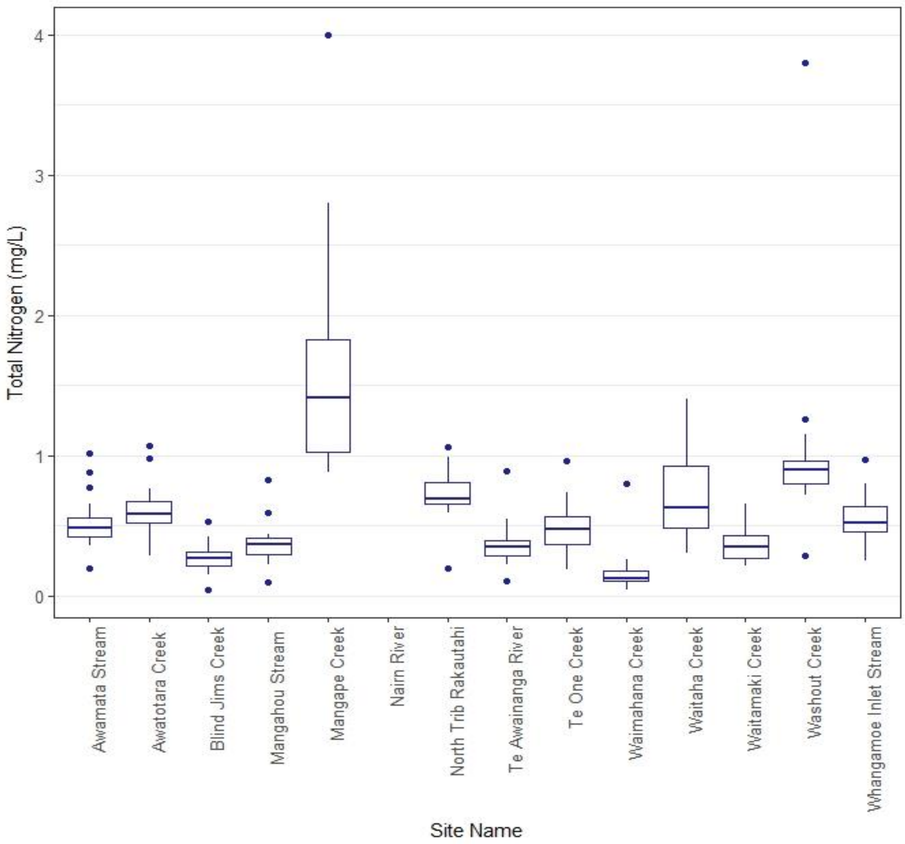
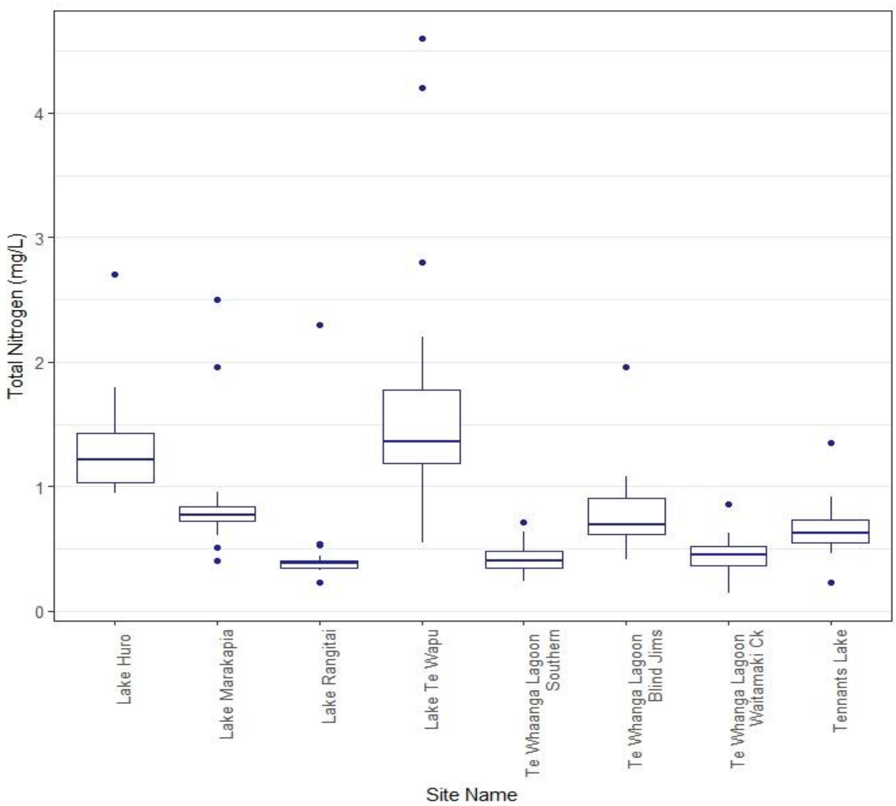
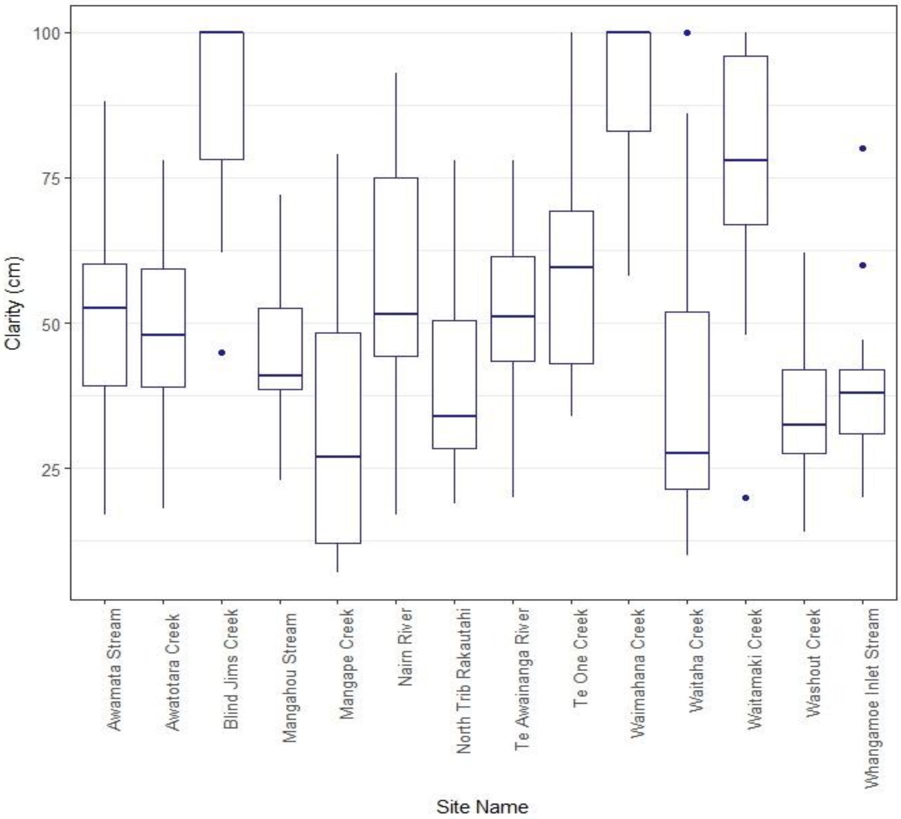
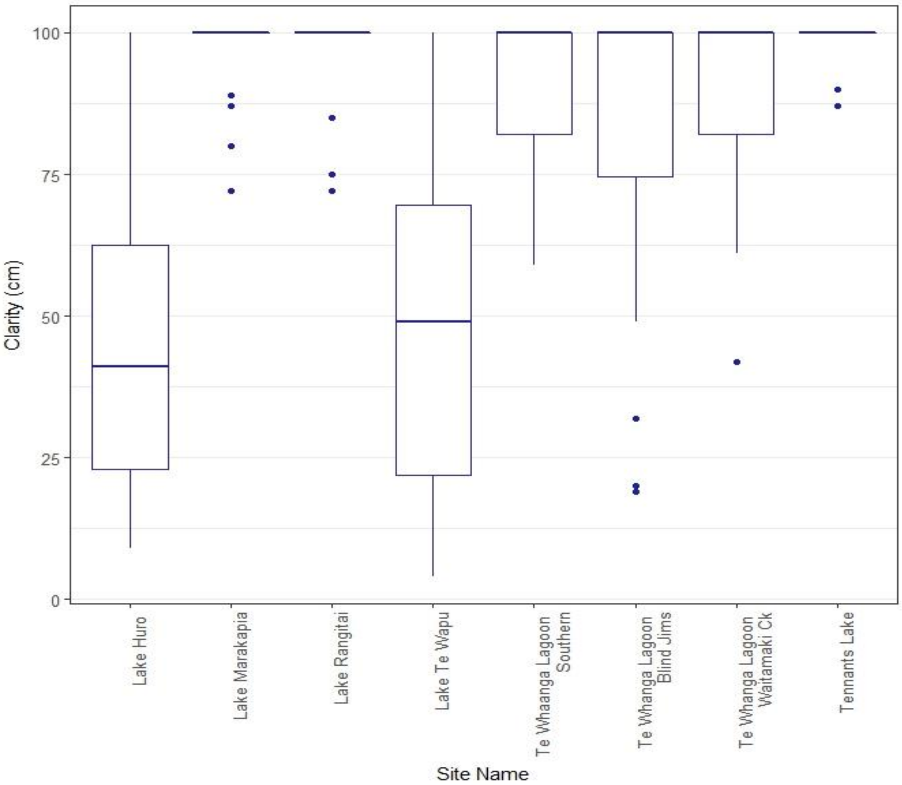
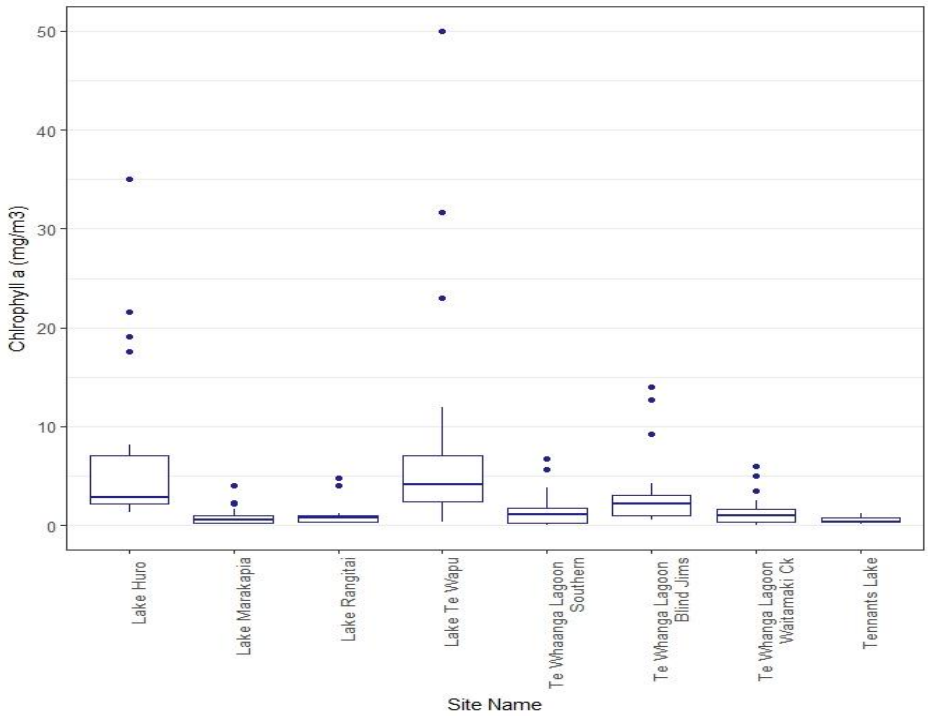

Total Phosphorus (mg/L)
0.0
0.1
0.2
0.3
0.4
0.5
Lake Huro
Lake Marakapia
Lake Rangitai
Lake Te Wapu
Te Whanga Lagoon Southern
Te Whanga Lagoon Blind Jims
Te Whanga Lagoon Waitamaki Ck
Tennants Lake
Site Name

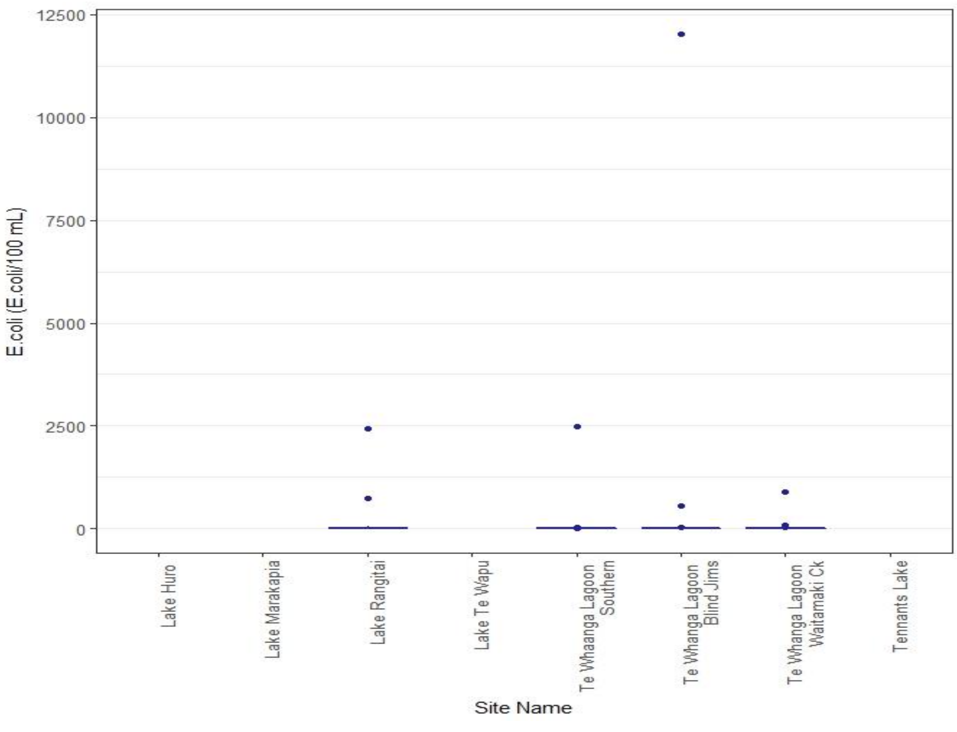

Total Nitrogen (mg/L)
0
1
2
3
4
Awamata Stream
Awatotara Creek
Blind Jims Creek
Mangahou Stream
Mangape Creek
Nairn River
North Trib Rakautahi
Te Awainanga River
Te One Creek
Waimahana Creek
Waitaha Creek
Waitamaki Creek
Washout Creek
Whangamoe Inlet Stream
Site Name

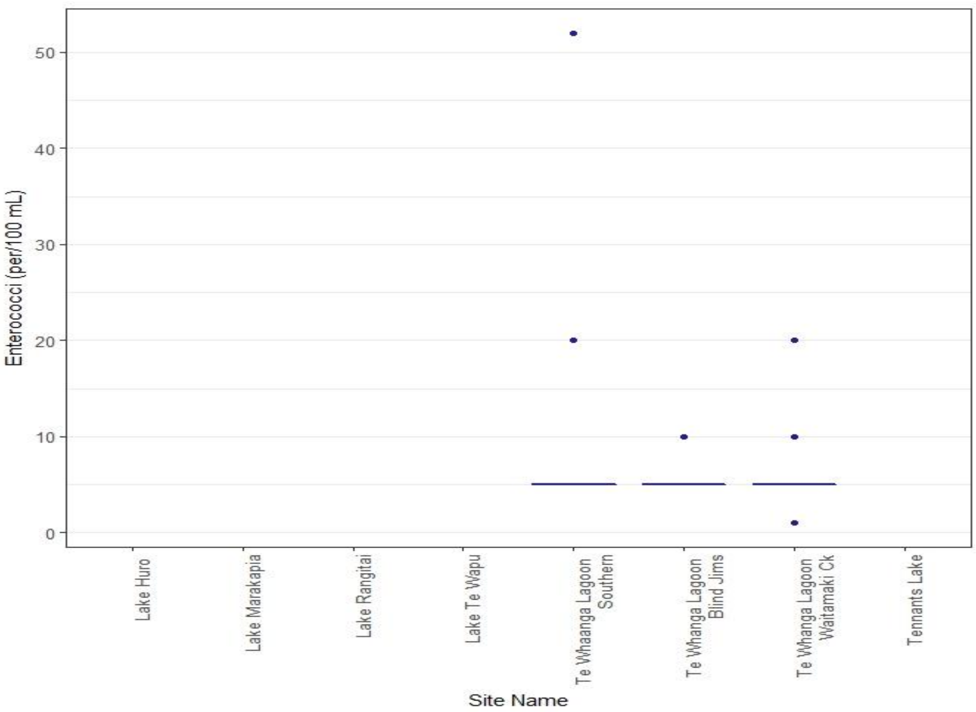

Total Nitrogen (mg/L)
0
1
2
3
4
Lake Huro
Lake Marakapia
Lake Rangitai
Lake Te Wapu
Te Whaanga Lagoon Southern
Te Whanga Lagoon Blind Jims
Te Whanga Lagoon Waitamaki Ck
Tennants Lake
Site Name


Clarity (cm)
100
75
50
25
Awamata Stream
Awatotara Creek
Blind Jims Creek
Mangahou Stream
Mangape Creek
Nairn River
North Trib Rakautahi
Te Awainanga River
Te One Creek
Waimahana Creek
Waitaha Creek
Waitamaki Creek
Washout Creek
Whangamoe Inlet Stream
Site Name


Clarity (cm)
100
75
50
25
0
Lake Huro
Lake Marakapia
Lake Rangitai
Lake Te Wapu
Te Whanga Lagoon Southern
Te Whanga Lagoon Blind Jims
Te Whanga Lagoon Waitamaki Ck
Tennants Lake
Site Name


Chlrophyll a (mg/m3)
50
40
30
20
10
0
Lake Huro
Lake Marakapia
Lake Rangitai
Lake Te Wapu
Te Whaanga Lagoon Southern
Te Whanga Lagoon Blind Jims
Te Whanga Lagoon Waitamaki Ck
Tennants Lake
Site Name


E.coli (E.coli/100 mL)
12500
10000
7500
5000
2500
0
Lake Huro
Lake Marakapia
Lake Rangitai
Lake Te Wapu
Te Whaanga Lagoon Southern
Te Whanga Lagoon Blind Jims
Te Whanga Lagoon Waitamaki Ck
Tennants Lake
Site Name


Enterococci (per/100 mL)
0
10
20
30
40
50
Lake Huro
Lake Marakapia
Lake Rangitai
Lake Te Wapu
Te Whaanga Lagoon Southern
Te Whanga Lagoon Blind Jims
Te Whanga Lagoon Waitamaki Ck
Tennants Lake
Site Name

Appendix 3: Long term trends for streams, lakes and lagoons on Chatham Island 2005-2017

	Dissolved Reactive Phosphorus	Dissolved Inorganic Nitrogen	Total Nitrogen	Total Phosphorus	Dissolved Organic Carbon	Clarity Tube	Dissolved Oxygen % saturation	pH	Water Temperature	Chlorophyll *a*	*E. coli*	*Enterococci*
Awamata Stream	NS	NS	Δ*** 7.701	NS	NS	NS	NS	NS	NS	-	-	-
Awatotara Creek	NS	NS	Δ*** 7.567	NS	Δ* 2.331	NS	▼* -0.816	NS	NS	-	-	-
Te Awaīnanga River	NS	▼* -4.533	Δ**8.109	NS	NS	NS	NS	NS	NS	-	-	-
Washout Creek	NS	NS	Δ**4.19	NS	Δ*2.79	Δ*4.439	NS	NS	NS	-	-	-
Whangamoe Inlet Stream	NS	NS	NS	NS	NS	Δ***5.328	NS	NS	NS	-	-	-
North Trib Rakautahi	NS	NS	Δ**5.756	▼*-3.646	Δ*2.15	Δ***5.42	NS	NS	NS	-	-	-
Blind Jims Creek	▼*** -6.949	▼*-7.075	Δ***10.141	NS	NS	NS	NS	NS	NS	-	-	-
Waitaha Creek	NS	NS	NS	▼*-7.517	NS	Δ*5.053	NS	NS	NS	-	-	-
Mangape Creek	NS	NS	Δ*2.779	▼***-6.05	NS	Δ*9.924	▼*-1.714	Δ*0.971	NS	-	NS	-
Mangahōu Stream	NS	NS	Δ***8.902	NS	NS	NS	NS	NS	NS	-	-	-
Te One Creek	NS	NS	Δ**5.758	NS	NS	NS	NS	NS	NS	-	-	-
Waitamaki Creek	NS	NS	Δ*5.625	▼***-5.246	NS	Δ***6.172	▼*-2.433	NS	NS	-	-	-
Waimāhana Creek	Δ*5.025	NS	Δ**6.836	NS	NS	Δ*1.912	NS	NS	NS	-	-	-
Nairn River	-	-	-	-	-	Insufficient data	Insufficient data	Insufficient data	NS	-	NS	▼**-10.789
Tennants Lake	Insufficient data	Insufficient data	Δ***6.478	NS	NS	NS	NS	NS	NS	NS	-	-
Te Whanga Lagoon - Blind Jims	Insufficient data	Insufficient data	NS	▼***-10.367	Insufficient data	Δ***5.673	NS	NS	NS	▼***-18.827	▼*-25.968	NS
Lake Rangitai	Insufficient data	Insufficient data	▼*-4.05	NS	NS	NS	NS	NS	NS	NS	NS	-
Lake Hurō	Insufficient data	Insufficient data	NS	▼***-18.281	NS	Δ***16.663	NS	NS	NS	NS	-	-
Te Whanga Lagoon - Waitamaki Ck	Insufficient data	Insufficient data	NS	▼***-8.827	Insufficient data	NS	NS	NS	NS	NS	NS	NS
Lake Te Wapu	Insufficient data	Insufficient data	NS	▼*-8.554	NS	Δ*6.603	NS	NS	NS	NS	-	-
Lake Marakapia	Insufficient data	Insufficient data	Δ***3.246	▼*-6.727	NS	NS	Insufficient data	NS	Insufficient data	NS	-	-
Te Whaanga Lagoon - Southern	Insufficient data	Insufficient data	NS	▼***-8.581	Insufficient data	NS	Insufficient data	Δ*0.501	Insufficient data	▼*-10.889	Insufficient data	Insufficient data

NS = not significant   * P<0.05   ** P<0.01   *** P<0.005   Insufficient data = Insufficient data (<10 years or <40 samples) required for trend analysis   – = No sample taken

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Appendix 4: Summary TLI results

Table 1: Annual Trophic State for Lake and Lagoon sites of Chatham Island

Site Name	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-2017
Tenant's Lake	Eutrophic	Mesotrophic	Mesotrophic	Mesotrophic	Mesotrophic	Mesotrophic	Mesotrophic
Lake Hurō	Hypertrophic	Supertrophic	Supertrophic	Eutrophic	Supertrophic	Eutrophic	Eutrophic
Lake Marakapia	Mesotrophic	Mesotrophic	Mesotrophic	Mesotrophic	Mesotrophic	Mesotrophic	Mesotrophic
Lake Rangitai	Eutrophic	Mesotrophic	Mesotrophic	Oligotrophic	Oligotrophic	Oligotrophic	Mesotrophic
Lake Te Wāpu	Hypertrophic	Supertrophic	Supertrophic	Supertrophic	Hypertrophic	Eutrophic	Eutrophic
Te Whanga Lagoon - Blind Jims Creek	Supertrophic	Supertrophic	Eutrophic	Mesotrophic	Mesotrophic	Eutrophic	Eutrophic
Te Whanga Lagoon - Southern Basin	Eutrophic	Eutrophic	Mesotrophic	Mesotrophic	Eutrophic	Mesotrophic	Mesotrophic
Te Whanga Lagoon - Waitāmaki Creek	Eutrophic	Eutrophic	Mesotrophic	Mesotrophic	Mesotrophic	Mesotrophic	Mesotrophic

Table 2: Description of Trophic States

TLI	Tropic state	General Description
<1	Ultra-microtrophic	practically pure, very clean, often have glacial sources
1-2	Microtrophic	very clean, often have glacial sources, very low nutrient enrichment
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