Existing Environmental Data Summary

(LEI, 2017:A3I2)

Prepared for

Wairoa District Council

Prepared by

Lowe Environmental Impact

September 2017

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(LEI, 2017:A3I2)

Wairoa District Council

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1 EXECUTIVE SUMMARY

1.1 Introduction

The Wairoa District Council (WDC) owns and operates the Wastewater Treatment Plant (WWTP) for Wairoa. WDC holds a resource consent to discharge treated municipal wastewater into the lower reaches of the Wairoa River during out-going tides at night time (6:00 pm to 6:00 am). The consent was granted on 23 August 1999 by Hawke's Bay Regional Council (HBRC) for a term expiring on 31 May 2019. The WWTP discharge requires a replacement consent in 2019 and possible treatment system and discharge modifications.

This report brings together environmental data regarding the Wairoa River and any potential effects that arise from the current WWTP's treated wastewater discharge. This includes an overview of the climate, river flow and stages (water levels) and tidal variations which all impact on the environment of the Wairoa River.

1.2 Wairoa Climate and River Hydrology and Quality

The Te Urewera ranges influence weather systems creating rain bands during the winter months and dry westerly winds during early summer. Rainfall amounts average 1,333 mm/year with November and July the months where rainfall is at its lowest and highest respectively.

The Wairoa River is the largest river in the Hawke Bay region and has a catchment area of 3,563 square kilometres. The land uses in the catchment are mostly farming (dominated by hill country sheep and beef farming) and forestry.

The key flow statistics for the Wairoa River are shown in Table 1.1.

Table 1.1: Key Flow Statistics of the Wairoa River (Source: LAWA, 2017)

Flow Statistic	Flow Rate
Mean Flow	65 m^3/s
Median Flow	31 m^3/s
7 Day Mean Annual Low Flow (MALF)	5.8 m^3/s
Mean Annual Flood Flow	1,600 m^3/s
Lowest Recorded Flow	2.2 m^3/s
Highest Recorded Flow	2,600 m^3/s

The tidal prism ranges[1] from 3.5M m^3 to 4.1M m^3 and a tidal range of 1.2 – 1.4 m for a neap[2] and spring[3] tide respectively. The tidal prism has an inverse relationship with river flow rates. When the river flow increases the in-coming and subsequent ebb[4] tide flows decrease and during low river flows the in-coming and ebb tide flows increase i.e. during low river flows there is a greater volume of seawater entering the estuary during the in-coming tides, which can migrate up river, than occurs during higher river flows. When river flows exceed about 200 m^3/s, the river flow prevents the seawater from entering the river mouth during in-coming tides.

[1] Tidal Prism – the volume of water in an estuary between mean high tide and mean low tide.
[2] Neap Tide - a tide just after the first or third quarters of the moon when there is least difference between the high and low tides.
[3] Spring Tide – a tide just after new or full moon when there is greatest difference between the high and low tides.
[4] Ebb Tide – the period between high tide and low tide during which water flows out to sea.

Monitoring of the Wairoa River at the Railway Bridge, Wairoa Ski Club, and downstream of the WWTP discharge sites has shown such toxicants as nitrate-nitrogen and ammoniacal-nitrogen are minimal and well within the Hawke's Bay Regional Resource Management Plan (RRMP) limits. However, water clarity in the Wairoa River is the worst in the Hawke's Bay Region out of the 104 monitored sites, mainly due to the soft sedimentary geology and proportion of farmed hill country in its catchment. *E. coli* is monitored weekly every summer (November – April) and generally 78% - 88% of results are below the alert level of 260 cfu/100 ml. However, the 95th percentile is above 540 cfu/100 ml which equates to a very poor standard under the MfE/MoH guidelines for recreational water quality in relation to primary water contact. *E. coli* sources have been traced to plant, ruminant and avian origins (Gilmer, Madarasz-Smith & Wade, 2016).

1.3 Urban Discharges

AFFCO Wairoa discharge treated process wastewater into the Wairoa River several kilometres upstream of the Wairoa WWTP discharge. Monitoring reports prepared for AFFCO have generally concluded that the AFFCO discharge entering the Wairoa River has minimal effects on the river environment. The main parameter of interest monitored is ammoniacal-nitrogen. A 2013 survey concluded ammoniacal-nitrogen concentrations in the river 200 m downstream of the AFFCO discharge were less than the maximum allowable concentrations specified within the AFFCO discharge consent even when the river was flowing less than MALF[5] on an out-going neap tide and while the estuary bar was closed (worst case conditions for discharge dilution and potential for adverse effects).

Other issues that have a potential effect on the Wairoa River include stormwater. Stormwater acts as a carrier of metalloids, sediment and bacteria and is discharged at numerous locations to the river from the urban area of Wairoa. In addition, there are many rural stormwater and drain discharges to the river, and these drain more than 99.8 % of the river's catchment area.

1.4 Effects of Discharges on the Wairoa River Environment

Any effects that treated wastewater from the WWTP could be having on aquatic life, and in particular macroinvertebrates, have been shown to be limited. Surveys were conducted in 2007 and 2011 to understand any changes to sediment and aquatic biota seen at sites surrounding the current outfall and sites upstream of the outfall. Sediment and biota living in the sediment have shown no significant differences between sites at the outfall discharge and upstream from the discharge.

Untreated wastewater overflows during storm events are an issue for the WDC as these are currently unconsented. Significant rainfall events or prolonged rainfall influence the volume within the wastewater reticulation via stormwater inflow and groundwater ingress. Previous compliance reports completed by the Hawke's Bay Regional Council have suggested that, although these are unconsented, the impacts of stormwater induced wastewater overflows entering the Wairoa River are expected to be minimal because of the large dilution of wastewater by stormwater prior to its overflow and the far higher concentrations of silt and other contaminants in the flooded river receiving these discharges. WDC are reducing the frequency and volume of these discharges by addressing stormwater sources within the sewer reticulation and upgrading the pump station capacities to better cope with the flows.

Reported information to date suggests effects arising from the discharge of treated municipal wastewater and AFFCO's wastewater on the Wairoa River are undetectable downstream after reasonable mixing. Generally, a higher contaminant load is present when river flows are high,

[5] MALF is the acronym for Mean Annual Low Flow of a river, based on the lowest 7 days of flows.

whereby the influence from sources other than wastewater discharge are present (i.e. overland flow and stormwater). In addition, the effect of sediment from upstream rural sources is prominent in benthic surveys conducted in 2007 and 2011 and recent AFFCO reports. This is likely to be more of an issue than excessive dissolved contaminant levels related to treated wastewater discharges.

Although wastewater discharges to the Wairoa River carry a negative aesthetic appreciation, information currently available indicates that it is currently not causing degradation of the Wairoa River water quality or the aquatic and estuarine ecosystems that it supports.

2 INTRODUCTION

2.1 Purpose

To identify and assess environmental data that describes the present Wairoa wastewater treatment plant (WWTP) discharge receiving environment, with a focus on Wairoa River water quality, flows and tidal variations.

2.2 Background

The Wairoa wastewater treatment system operated by Wairoa District Council (WDC) requires a replacement discharge consent from Hawke's Bay Regional Council (HBRC) upon expiry of the existing consent on 31 May 2019. This may include a WWTP upgrade to improve its discharge to the environment. If continuation of the present coastal estuarine discharge is to be considered, then river quality and river discharge effects need to be assessed. Additionally, climatic variations within the Wairoa catchment will have an effect on when and how discharge of treated wastewater will occur, and indicate the potential for adverse effects.

2.3 Scope

This report covers the following:

- Data on river flow and water quality characteristics;
- Results of WDC water quality monitoring;
- Results of HBRC water quality monitoring;
- Other relevant information available on impacts of wastewater discharges into the Wairoa River; and
- Climate data.

3 INFORMATION

3.1 Sources of Information

Datasets have been provided by HBRC and NIWA for this report. Information was also provided by AFFCO and WDC.

HBRC provided dates that the Wairoa bar was opened by contractors during 2009-14, but this did not identify when the bar had closed nor how long it had been closed before HBRC re-opened the bar.

NIWA's publicly accessible Cliflo weather database was accessed to obtain daily weather data for Wairoa. This includes daily rainfall, soil moisture deficit and runoff over the period January 1997 – February 2017 and monthly mean, maximum and minimum temperatures between January 1997 and June 2017.

3.2 Dataset Descriptions

The individual datasets provided to LEI and relied upon for this report are summarised in Table 3.1 below.

Table 3.1: Summary of Available Datasets

Source	Description	Date Range	Dataset Gaps
HBRC	Daily Wairoa River flows and stage (water level), as recorded for the lower reach of the Wairoa River and the Railway Bridge site respectively	3 January 2009 – 26 January 2017	River Stage: 27/1/2009 – 3/12/2009 26/4/2011 – 28/5/2011 28/2/2012 – 5/3/2012 River Flow: 31/10/2010 – 3/11/2010 18/10/2011 – 18/11/2011 20/1/2012 – 2/2/2012 13/9/2012 – 15/11/2012 23/1/2013 – 27/1/2013 29/1/2013 – 7/2/2013 13/2/2013 – 21/3/2013 27/3/2013 – 6/4/2013 14/1/2014 – 29/1/2014 2/3/2014 – 6/3/2014 19/12/2015 – 20/12/2015 4/1/2016 – 6/1/2016 10/1/2016 – 12/1/2016 14/1/2016 – 15/1/2016 26/1/2017
HBRC	Dates of Wairoa River bar opening works by HBRC	July 1998 – June 2016	-
NIWA	Monthly Temperatures (mean, maximum and minimum)	January 1997 – June 2017	Mean: May 2009 July 2006 August 2000, 2006 September 2000, 2002, 2009, 2013 October 1997, 1998, 2001
NIWA	Daily rainfall, soil moisture deficit, and runoff for NIWA's North Clyde weather station	January 1997 - February 2017	Rainfall, Runoff and Deficit: 2/10/1998

			7/10/98 – 28/10/98 4/5/2009 – 16/6/2009 1/9/2009 – 29/9/2009 1/9/2013 – 19/9/2013 24/42014 – 12/6/2014 Runoff and Deficit Only: 29/10/98 – 18/12/98 7/9/2000 – 3/1/2001 2/11/2001 – 21/1/2002 21/9/2002 – 21/11/2002 12/8/2006 – 3/11/2006 25/5/2008 – 3/11/2008 17/6/2009 – 30/6/2009 30/9/2009 – 9/10/2009 20/9/2013 – 10/11/2013
AFFCO	Quarterly (2005-08) and monthly (2008-09) river water ammoniacal-nitrogen, BOD_5, DO, faecal coliforms, pH, TSS, and temperature at various locations.	December 2005 – April 2009	Faecal coliforms: Aug-Nov 07 at Rowing Club, Oct 08 – Apr 09 at Rowing Club and River Bar Dissolved oxygen: Oct 08 – Apr 09 at the Bar
HBRC	Quarterly (2009-12) and monthly (2012-16) river water ammoniacal-nitrogen, TSS, *E. coli*, and DO at the Railway Bridge upstream of Wairoa.	February 2009 – December 2016	-
HBRC	Weekly bathing season (November to March) river water *E. coli* at Wairoa Water Ski Club.	1 November 2010 – 13 March 2017	-
HBRC	Quarterly river water ammoniacal-nitrogen, TSS, *E. coli*, and DO downstream of the Wairoa WWTP discharge.	February 2009 – June 2012	-

4 WAIROA RIVER HYDROLOGY

4.1 General

This section covers the Wairoa River flow characteristics and tidal variations that are seen within the river.

Flow and stage[6] data has been obtained from HBRC for 2009 - 2017. Tidal information has been accessed from various reports on the Wairoa River.

The Wairoa River is the largest river in the Hawke Bay region and has a catchment area of 3,563 square kilometres. The land uses in the catchment are mostly farming (dominated by hill country sheep and beef farming) and forestry. The lower flats are used for cropping, horticulture and pasture (including some dairy farms). The township of Wairoa is located on flats adjacent to the upper section of the river's estuary.

Its upper catchment drains some of the eastern side of Te Uruwera, including Lake Waikaremoana, which is covered in unmodified native bush and receives moderate (1,500 mm/y) to high (3,200 mm/y) annual rainfall. Three hydroelectric power stations use some of the outflows from Lake Waikaremoana before discharging the water back into the river. Another hydroelectric power station is fed from a dam across Waihi Stream, which is a tributary of the Waiau River; the Waiau River drains the southern catchment of the Wairoa River catchment. The Waihi power station was identified in late 2015 as a significant source of silt entering the river system due to broken sluice gates.

The headwater catchment's high rainfall and steep gradient feeding into a low-lying meandering river channel generate frequent floods and highly variable flow rates. The tidal influence on water levels is observed almost 11 km inland from the river mouth, but the salt front does not intrude that far. The river's outlet to Hawke Bay is controlled by a natural gravel bar which is redistributed by coastal currents that occasionally close off the estuary from the sea, forcing the river flows to pass through the gravel bar instead of through a defined channel. HBRC use excavators to re-open the channel through the bar when necessary and safe to do so.

4.2 Wairoa River Flow and River Stage

The key flow statistics for the Wairoa River are shown in Table 4.1.

Table 4.1: Key Flow Statistics of the Wairoa River (Source: LAWA, 2017)

Flow Statistic	Flow Rate
Mean Flow	65 m^3/s
Median Flow	31 m^3/s
7 Day Mean Annual Low Flow (MALF)	5.8 m^3/s
Mean Annual Flood Flow	1,600 m^3/s
Lowest Recorded Flow	2.2 m^3/s
Highest Recorded Flow	2,600 m^3/s

This flow data indicates a wide variation in flows with a lowest recorded flow of 2.2 m^3/s through to a highest recorded flow of 2,600 m^3/s. A mean flow of 65 m^3/s reflects the influence of high

[6] Stage – is a term used to reflect the height of the water level above sea level or an arbitrarily assigned datum height; and in this case it refers to the water level of the Wairoa River at the main road bridge as recorded by HBRC.

flows that the Wairoa River can experience compared to a median flow of 31 m^3/s that better represents the average flow without being skewed by these extreme high flows. The lowest flows occur during summer and autumn months, while the highest flows occur during winter and spring months. Argo Environmental (2010) noted that mean monthly river flows vary between 36 m^3/s in January and 168 m^3/s in September. Winter flows during 2009-16 were higher on average than during spring months, but the highest peak flows caused by storms occurred during spring months.

Figure 4.1 presents a graph of river stage and flow at the Railway Bridge from January 2009 to January 2017, using daily data sourced from HBRC. The Railway Bridge monitoring site is 7 km from the river mouth and experiences only minor tidal influences; it provides reliable flow and depth (stage) data. Within this eight year period the highest average flows are seen during the winter months (June – August) and lowest flows are during the summer months (Nov – Feb). Occasionally high river flows occur outside the winter months. Heavy rainfall over a short period can increase river flow dramatically as shown in September 2015, when a river flow of 2,586 m^3/s was recorded (note that this was probably the largest flood event that was included in the flow statistics of Table 4.1 above).

As would be expected, the river stage follows a similar trend to river flow, whereby the highest stage is seen during winter and flood events while the lowest average stage is seen during summer. The minimum and maximum stages recorded during the 2009 – 2017 period were 1,993 mm recorded in November 2013 and 8,918 mm recorded in September 2015 respectively.

However, the effects of closures and re-opening of the bar across the estuary mouth are also apparent on the stage readings. While the bar is closed, marine inflows and river outflows are restricted, which has a damming effect and raises the height of the estuary water levels. This then backs up the lower reaches of the river so that the height of the river water level is maintained at increased elevations for several km inland (beyond the Railway Bridge which is 7 km inland) during low to moderate flows. This anecdotally also makes flooding inundation worse than would have been the case for similar storms when the bar is open. The stage height drops dramatically following re-opening of the bar, and tends to gradually rise as the bar closes off the river mouth again.

The bar opening status data is known to have been very poorly recorded, and it is apparent from the stage data in Figure 4.1 that the bar has closed and re-opened (perhaps naturally) more often than has been recorded. As a consequence of these effects of the bar on stage height readings, the stage height data needs to be interpreted with caution; elevated stage heights are not necessarily indications of increased river flow rates. An obvious example of this occurred during January to July 2016 when the river flow rates did not vary much but the stage height rose over time before suddenly peaking and then falling sharply to a low level and then repeated this cycle. The very low flows of December 2012 to May 2013 also were not reflected in the generally elevated and much more variable stage heights. Argo Environmental's 2013 report for AFFCO noted that the bar closed during late February 2013 and was only partially re-opened on 3 March 2013. The river flow rate data therefore provides a better representation of the river's hydrological variations and assimilative capacity for receiving contaminants than the stage height data.

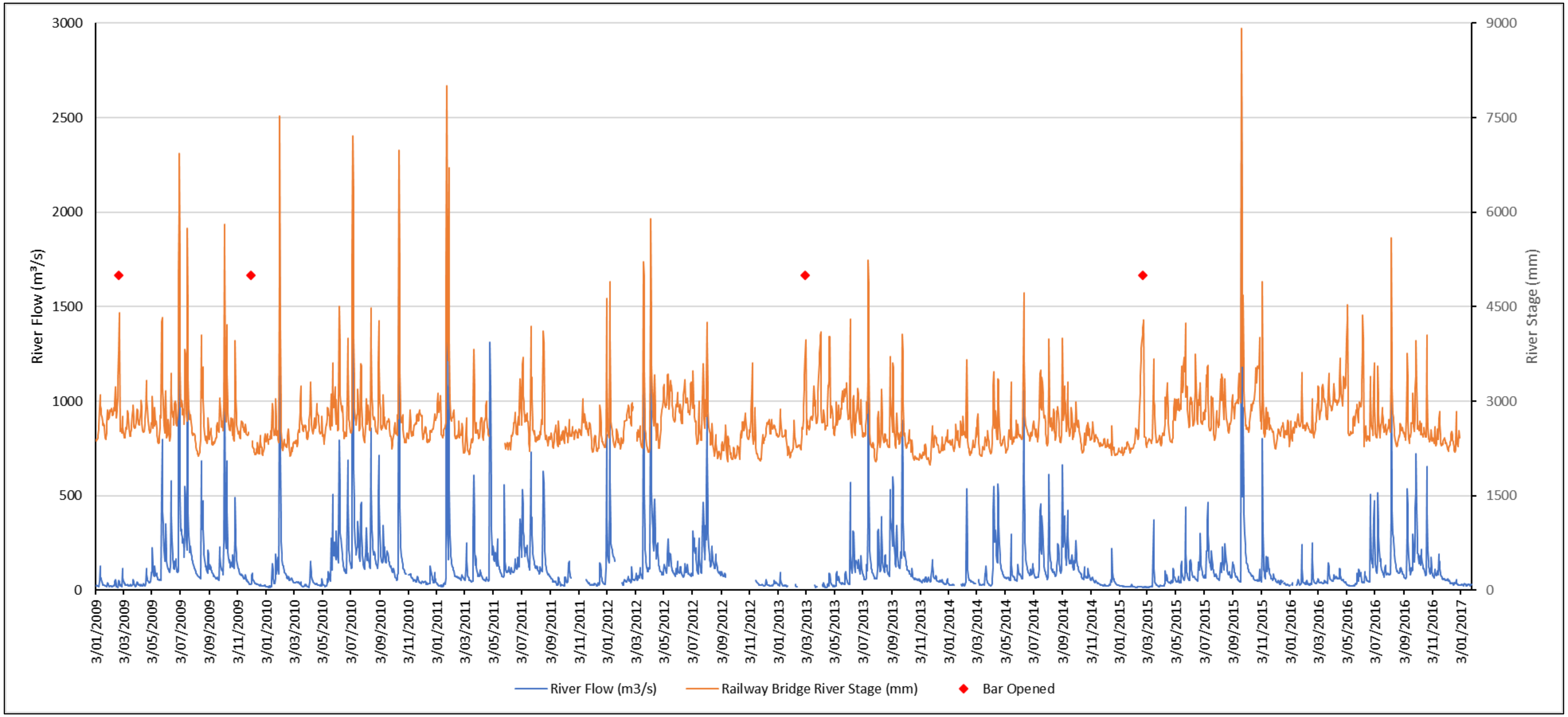

Figure 4.1: Wairoa River Stage Height and Flow Rate Recorded at the Railway Bridge (2009 - 2017) (Source: HBRC)

4.3 Tidal Ranges

The Wairoa River estuary is tidal with a neap[7] tide and a spring[8] tide range of 1.2 m and 1.4 m respectively. Table 4.2 outlines the tidal ranges and gives an estimation of the tidal prism volumes[9]. The tidal cycle of the Wairoa River estuary is not sinusoidal due to a high river flow rate whereby there is a 5.2-hour inflow and a 7-hour outflow (Argo Environmental, 2010).

Table 4.2: Tidal ranges in Wairoa River (Source: Argo Environmental, 2010)

Tidal Condition	Neap Tides	Spring Tides
Mean high water	1.5 m amsl	1.6 m amsl
Mean low water	0.3 m amsl	0.2 m amsl
Range	1.2 m	1.4 m
Tidal Prism	3,500,000 m^3	4,100,000 m^3

The effect of the tide at Wairoa is still noticeable at the Railway Bridge, some 7 km upstream from the mouth of the River, although only minor. Table 4.2 also highlights the large volume of salt water that enters and leaves the estuary every tidal cycle, with tidal prisms of 3.5 million cubic metres on a neap tide and 4.1 million cubic metres on a spring tide.

There is an inverse relationship between river flow rates and the flow rate of the tidal prism of seawater entering the Wairoa River. As river flow increases, the in-coming tide and subsequent ebb tide[10] flow rate decreases. At low river flow rates the in-coming and ebb tides can have an equal or greater flow rate of marine water than the river flow rate, resulting in stratified and brackish estuarine conditions which can then migrate up river for several km. River flow rates of ~200 m^3/s or greater result in zero in-coming and ebb tide flow rates of seawater at the mouth of the river; the entire flow is terrestrial and has no marine component.

Surveys of Wairoa River water quality by Argo Environmental Ltd during 2011 and 2013 on behalf of AFFCO Wairoa during out-going tides and summer low flow conditions indicated that the top 0.75-1.0 m was dominated by fresh water, while the water deeper than about 3 m was marine water. The water between 1 m and 3 m formed a graduated mixing layer. Argo also noted that the deeper salt water layer flowed about twice the speed of the surface fresh water layer.

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[7] Neap tide - a tide just after the first or third quarters of the moon when there is least difference between the high and low tides.
[8] Spring tide - a tide just after new or full moon when there is greatest difference between the high and low tides.
[9] Tidal prism - the volume of water in an estuary between mean high tide and mean low tide
[10] Ebb Tide – the period between high tide and low tide during which water flows out to sea.

5 RIVER WATER QUALITY CHARACTERISTICS

5.1 General

The ocean water quality and ecosystem health of Hawke Bay near Wairoa has not been monitored apart from summer bathing water quality checks, which are of limited value for assessing the effects of the Wairoa WWTP discharge of treated wastewater on the marine environment. As described below, the Wairoa River carries sediment, pathogens, and nutrients that have entered the river from its entire catchment, and the WWTP discharge is only a small contributor near the coastal end of the estuary.

Water quality of the Wairoa River is monitored by HBRC and AFFCO Wairoa. The results of their monitoring is outlined below. WDC do not monitor water quality of the river, as it is not required by the conditions of the resource consent to discharge treated wastewater from the Wairoa WWTP. However, they have undertaken microbenthic surveys in the vicinity of the treated wastewater discharge outlet.

Microbenthic surveys were conducted in 2007 and 2011 for WDC by EAM Consulting, with a further survey conducted in July 2017 by Triplefin (reported separately). These surveys have been undertaken to identify river health effects and trends in aquatic ecology that might relate to the treated wastewater discharge. A summary of the microbenthic survey results can be found in the Wairoa River Estuary Impact Summary Memo (LEI, 2017:A3I1a).

5.2 Hawke's Bay Regional Council Monitoring

5.2.1 State and Trends of River Quality and Ecology

The Wairoa River provides habitat for a wide range of fish, including various native species, some of which are rare or critically threatened, and exotic species including large populations of brown and rainbow trout.

Water quality monitoring in the Wairoa River has been routinely conducted by HBRC and its predecessor since 1982 as part of their State of the Environment (SOE) and earlier monitoring programmes (Ausseil, et al, 2016). Water quality indicators routinely measured are:

- Total Nutrients (Total Nitrogen (TN) and Total Phosphorus (TP))
- Dissolved Nutrients (Dissolved inorganic nitrogen (DIN) and dissolved reactive phosphorus (DRP))
- Ammoniacal Nitrogen (NH_3-N)
- Nitrate Nitrogen (NO_3-N)
- Water clarity (black disc and turbidity)
- Total suspended solids (TSS)
- Microbiological water quality indicators (*E. coli)*
- Biological indicators (Macroinvertebrate Community Index (MCI) score and periphyton cover)
- Dissolved Oxygen (DO)

The HBRC (2006) Regional Resource Management Plan (RRMP) includes several water quality guideline limits for surface water bodies. These limits apply at or below median river flow rates except for suspended solids, which apply at all flow rates. Where the RRMP does not specify limits for contaminants, it defaults to relying on the ANZECC guideline values for the protection of fresh and marine ecosystems which the RRMP uses as de-facto water quality limits. Ausseil, et al, (2016) also compared the Wairoa River water quality with a range of other guideline values.

Table 5.1 below identifies those guideline limits and the actual minimum, median and maximum values that were measured in the Wairoa River by HBRC between 2004 and 2013.

As part of assessing fresh water quality, the National Objective Framework (NOF) is used to score *E. coli*, nitrate, and ammonia concentrations for ease of reference and national consistency as part of the implementation of the National Policy Statement for Freshwater Management (NPSFM); these assessments are also presented in Table 5.2 below. Further explanation of this NOF score banding can be found in Appendix B.

Nitrogen (N) and phosphorus (P) are needed for growth of algae and aquatic plants. Low availability often limits plant growth. However, sufficiently elevated concentrations can have toxic effects on aquatic biota. This can result in eutrophication whereby water bodies become enriched with inorganic plant nutrients (N and P) and cause dense growth of plant life or algal blooms. This may occur naturally but can be enhanced due to land use intensification. All sites within the Wairoa River catchment have low to moderate total N and P (Ausseil, et al, 2016).

No improvements or deterioration were seen in dissolved nutrients during the 2004 to 2013 period. Compared with other SOE sites, the majority of the Wairoa River catchment ranks highly (top 28%) for dissolved nutrients (due to relatively low concentrations).

Table 5.1: A summary of water quality guidelines and observed quality in the Wairoa River Upstream of Wairoa (2004 – 2013) (Source: Ausseil, et al, 2016).

Parameter	Min	Median	Max	Guideline/Limit	Source
TP (mg/l)	0.004	0.026	2.200	0.033 mg/l maximum	ANZECC (2000) Lowland
DRP (mg/l)	0.002	0.006	0.043	0.010 mg/l maximum	ANZECC (2000) Lowland
DRP (mg/l)	0.002	0.006	0.043	0.015 mg/l maximum	HBRC RRMP (2006)
NH_4-N (mg/l)	0.005	0.010	0.119	0.1 mg/l maximum	HBRC RRMP (2006)
DIN (mg/l)	0.014	0.060	0.660	0.444 mg/l maximum	ANZECC (2000) Lowland
NO_3-N (mg/l)	0.001	0.040	0.373	3.8 mg/l maximum for 90% species protection from toxicity effects	Hickey (2013)
NO_3-N (mg/l)	0.001	0.040	0.373	2.4 mg/l maximum for 95% species protection from toxicity effects	Hickey (2013)
NO_3-N (mg/l)	0.001	0.040	0.373	1.0 mg/l maximum for 99% species protection from toxicity effects	Hickey (2013)
Clarity – black disc (m)	0.0	0.6	2.1	1.6 m minimum for contact recreation	ANZECC (2000); HBRC RRMP (2006)
Clarity – black disc (m)	0.0	0.6	2.1	3.5 m minimum for 'Significant' trout fishery	Hay, Hayes & Young (2006)
Clarity – black disc (m)	0.0	0.6	2.1	5.0 m minimum for 'Outstanding' trout fishery	Hay, Hayes & Young (2006)
Suspended solids (mg/l)	1.5	13.5	2,900	25 mg/l maximum	HBRC RRMP (2006)
E. coli (cfu/100 ml)	1	46	14,000	540 cfu/100 ml maximum for contact recreation	MfE/MoH (2003)

Parameter	Min	Median	Max	Guideline/Limit	Source
				(health) Red alert/Action level	
E. coli (cfu/100 ml)	1	46	14,000	260 cfu/100ml maximum for contact recreation (health) Amber alert	MfE/MoH (2003)
Faecal coliforms (cfu/100 ml)				200 cfu/100 ml maximum for contact recreation (health)	HBRC RRMP (2006)
Periphyton biomass (mg/m^2)				50 mg/m^2 maximum for biodiversity	Biggs (2000)
Periphyton biomass (mg/m^2)				120 mg/m^2 maximum for aesthetic/recreation	Biggs (2000)
MCI (MCI score)				120 minimum for 'Outstanding' trout fishery; Excellent quality	Hay and Hayes (2006); Stark and Maxted (2007)
MCI (MCI score)				100 minimum for 'Significant' trout fishery; Good quality	Hay and Hayes (2006); Stark and Maxted (2007)
DO (% saturation)				80 % saturation minimum for protection of trout fisheries	HBRC RRMP (2006)
DO (mg/l)	6.8	9.4	12.6	7.5 mg/l minimum for protection of all aquatic organisms	MfE NPS-FW NOF (2014)

Table 5.2 below identifies the NOF banding for *E. coli*, nitrate and ammonia in Wairoa River upstream of the township. In summary, *E coli* levels during median flows during the years 2009 – 2013 have been shown to fall within the "A" band bracket except for year 2011 where the Wairoa River produced a result within the "C" band.

The nitrate (toxicity) attribute assesses the chronic toxicity risk for aquatic animals. Exposure to toxic levels have been shown to have an effect on life stage (e.g. reduced growth rate or reduced gonad development compared to optimum growth conditions). The median and 95th percentile for Nitrate (toxicity) in the Wairoa River are in the "A" band, which means that there is 'unlikely to be effects even on sensitive species'.

The ammonia (toxicity) attribute has shown that during the years 2009 – 2013 ammonia levels in the Wairoa River have been relatively low during median flows. Levels have been within the "A" band which reflects no observed effect on any species tested. However, within maximum flows ammonia levels in the Wairoa River have increased to the "B" band where ammonia starts impacting occasionally on the 5% of most sensitive species.

Table 5.2: NOF Band summary for the Wairoa River upstream of Wairoa for the period 2009 – 2013 (Ausseil, et al, 2016).

Site	*E. coli* (Public health)		Nitrate (toxicity)		Ammonia (toxicity)	
	Median	95th percentile	Median	95th percentile	Median	Maximum
Wairoa River u/s Wairoa	A	<B	A	A	A	B

A ranking system has been used to indicate where the Wairoa River, upstream of the Wairoa township's commercial centre but still within the urban area (Ski Club site), ranks in comparison to 103 other monitored river sites within the Hawke's Bay Region from 2009 to 2013 (note that this timeframe differs from the 2004-13 duration summarised in Table 5.1 above) with regards to environmental parameters. Table 5.3 below summarises the median values and ranks for each parameter. The lower ranks are considered more favourable, as they represent better quality water. DIN and NO_3-N are the better ranked parameters from those tested, while black disc, turbidity, and TSS were the worst ranked parameters of all rivers for the region, indicating that this site consistently has poor clarity and a high suspended solids content.

Table 5.3 Ranking of the Wairoa Ski Club Site to Other Monitored Rivers Within the Hawke's Bay for 2009-13 (Ausseil, et al, 2016)

Parameter	Median Value	Rank
TN	0.265 mg/l	30th
TP	0.028 mg/l	67th
DIN	0.060 mg/l	19th
DRP	0.008 mg/l	35th
NO_3-N	0.040 mg/l	16th
Black Disc	0.4 m	95th
Turbidity	18.9 NTU	104th
E. coli	85 cfu/100 ml	69th
MCI	76.7	69th
TSS	70.3 mg/l	93rd

Summarising the state and trends of river water quality and ecology at the Wairoa Ski Club site the following points have been noted:

- Microbiological water quality – median water quality falls within the NPSFM's NOF "A" attribute state, which indicates that water quality is generally suitable for secondary contact (e.g. wading, boating). At times the microbiological water quality is unsuitable for primary contact (e.g. swimming). However, microbiological water quality was generally stable over time across the Wairoa catchment (Ausseil, et al, 2016).
- Dissolved Oxygen – there are no significant issues that have been noted during the monitoring period.
- Water clarity and turbidity – water clarity is generally low and turbidity is generally high (poor) at the Ski Club site. Compared to the upper reaches of the Wairoa catchment, the lower reaches have poor water clarity (Ausseil, et al, 2016). It must be noted that some areas of the upper Wairoa catchment have poor clarity, and this is due to the geology of the area dominated by highly erodible sedimentary rock layers, whereby sediment enters waterways under natural conditions (Ausseil, et al, 2016).
- Toxicants: nitrate nitrogen and ammoniacal nitrogen have been shown to be well below trigger/guideline values and fall within A or B NOF bands, indicating a low risk to aquatic ecosystem health.

HBRC's river water quality monitoring data for the Wairoa River at the Railway Bridge between February 2009 and December 2016 is presented in Table 5.4 below.

Table 5.4: Wairoa River Water Quality at the Railway Bridge for 2009-16 (Source: HBRC)

Parameter	Min	Median	Max	Guideline/Limit	Source
NH_4-N (mg/l)	<0.005	0.018	0.12	0.1 mg/l maximum	HBRC RRMP (2006)
Suspended solids (mg/l)	0.7	11	2,900	25 mg/l maximum	HBRC RRMP (2006)
E. coli (cfu/100 ml)	<1	80	14,000	260 cfu/100 ml maximum for contact recreation (health) Amber alert; 540 cfu/ 100 ml maximum for contact recreation (health) Red alert/Action level	MfE/MoH (2003)
DO (% saturation)	71	96	111	80 % saturation minimum for protection of trout fisheries	HBRC RRMP (2006)

Overall, the medians and ranges of these parameters are very similar to those of the river water quality further downstream, which indicates that the river water quality is strongly controlled by upstream rural sources and is not deteriorating as it passes the urban area and through the estuary.

5.2.2 Recreational Water Quality Monitoring

The recreational water quality monitoring programme undertaken by HBRC is an annual bathing season programme over the November to March summer period. During each bathing season, water sampling occurs across the Hawke's Bay Region and is assessed for faecal indicator contamination (enterococci and/or *E. coli*) using the MfE/MoH guidelines for recreational water quality. Within the Hawke's Bay Region 38 sites were assessed, covering marine, freshwater, estuarine/tidal, lake and estuarine/coastal environments.

The Wairoa River sampling is undertaken at the Wairoa Ski Club, upstream of the Wairoa Bridge, which is an estuarine/tidal environment adjacent to the urban area. Data for 1 November 2010 to 13 March 2017 was assessed for this report.

The 2014/15 season was the best of these years, with only one result exceeding the Alert level (i.e. > 260 cfu/100 ml) and none above the Action level for contact recreation guidelines (i.e. > 540 cfu/100 ml). The average annual frequency of breaches is 5-6 exceeding the Alert level and 2-3 exceeding the Action level, or 74 % and 88 % compliance rates respectively. Despite these poor compliance rates, the median *E. coli* count was 84 cfu/100 ml, which complies with the RRMP limit.

The 2015/16 season was the worst of these years, as results were only 80% compliant, with four results above the Action level for contact recreation guidelines and 10 results (48 %) above the Alert level. The results for the 2016/17 season were similar to the 2015/16 season.

Elevated bacteria levels within the river generally occurred after heavy rainfall, which is typical of most catchments in New Zealand, and the wetter than usual summers probably contributed to the increased frequencies and concentrations of these poor results. In addition to measuring *E. coli and* enterococci, faecal source tracking was undertaken during 2015/16 to determine faecal origin (Gilmer, Madarasz-Smith & Wade, 2016). A mixture of plant, avian and ruminant sources were identified.

Overall, the Wairoa River at the Ski Club site is classed as **Very Poor** on the national MfE/MoH recreational guideline scale, indicating the site is very susceptible to faecal pollution and microbial water quality may often be unsuitable for primary contact recreation such as swimming. However, water quality is still suitable for secondary contact (wading and boating). During the 2015/16 season, the 95th percentile of *E. coli* was 2,855 cfu/100 ml (Gilmer, Madarasz-Smith & Wade, 2016).

Further information relating to the Wairoa River water quality can be found in A3I3 – Public Health Summary Memo (LEI, 2017:A3I3).

5.3 AFFCO Water Quality Monitoring

AFFCO operates a meat processing facility in Wairoa which discharges their treated process wastewater and stormwater as two separate discharge streams into the Wairoa River. The AFFCO discharge site is located approximately 4.5 km upstream from the Wairoa River mouth and estuary.

AFFCO's river water quality monitoring data for December 2005 to April 2009 was reviewed in preparing this report. The parameters monitored during this time included ammoniacal-nitrogen, BOD_5, DO, faecal coliforms, pH, TSS, and temperature. The monitoring sites were located at the Rowing Club, immediately upstream of AFFCO's treated wastewater discharge, 100 m downstream of AFFCO's treated wastewater discharge, the Yacht Club, and the bar across the river mouth. Monitoring at the Rowing Club and the bar did not include ammoniacal-nitrogen, BOD_5, or TSS.

The median concentrations of all of these parameters at all sites including 100 m downstream of AFFCO's treated wastewater discharge were within the RRMP and ANZECC 2000 limits except for DO which was low and averaged about 54 % across all sites. Occasionally AFFCO's treated wastewater discharge increased ammoniacal-nitrogen and marginally increased TSS in the river 100 m downstream of the discharge, but had no apparent influence on other parameters at this location, and no apparent influence on any parameters further downstream.

Water quality upstream and more than 100 m downstream of this discharge was generally similar on each sampling date. The highest results upstream of the discharge and more than 100 m downstream of the discharge (ie outside of the discharge mixing zone) for ammoniacal-nitrogen (0.16 g/m^3), faecal coliforms (2,700 cfu/100 ml), and TSS (54 g/m^3) all exceeded the RRMP limits. The lowest (worst) DO reading was 21 % and this was recorded immediately upstream of AFFCO's treated wastewater discharge.

5.4 Wairoa's Stormwater Discharges

Within the Hawke's Bay region, a total of 118 individual resource consents have been identified for discharge of stormwater from urban, industrial or trade sources (Ausseil, 2011). As of February 2011, 72 % of these consents authorise discharges directly to surface freshwater (e.g. streams or rivers) with 28 % discharging to land. Within Wairoa, there is only one consented industrial/trade discharge (AFFCO) of stormwater to water (the river) and zero/no consented discharges to land from the Wairoa urban catchment area of 342 ha[11].

[11] WDC's urban catchment of 342 ha is less than 0.1 % of a total catchment of 367,032 ha for the Wairoa River.

Most stormwater discharges in the Hawke's Bay region are permitted activities which do not require resource consents. The number of permitted stormwater discharges in the Wairoa urban area are unknown, likewise the quality of Wairoa's urban stormwater is unknown but is likely to be typical for an urban catchment. Wairoa's urban stormwater discharges are also likely to be insignificant in comparison with the upstream rural sources and the generally heavy silt load already present in the river before it reaches Wairoa.

6 IMPACTS OF DISCHARGES

6.1 General

The Wairoa River receives bush country and rural runoff across more than 99.8 % of its catchment area. Within the Wairoa urban area, as it transitions to an estuarine environment, the river also receives urban stormwater and treated wastewater discharges.

6.2 Stormwater Discharges

In addition to rural stormwater discharges that predominantly carry sediment, pathogens, and nutrients, urban stormwater entering the Wairoa River also acts as a carrier of metals/metalloids, hydrocarbons, sediment, pathogens and nutrients (Ausseil, 2011).

The risk of effects caused by stormwater entering the receiving environment is determined by the sensitivity of that receiving environment. Studies[12] have shown that at locations where stormwater enters freshwater aquatic environments from an urban source there is generally poor to very poor aquatic communities when compared to a predominantly rural catchment.

In considering the impact of stormwater discharges the physical characteristics of the receiving environment should also be considered. A low gradient and/or highly depositional area of an estuary/ river is likely to be more at risk from a local accumulation of persistent contaminants distributed via stormwater than a fast flowing, gravel bottom or high energy coastal environment, where dilution and dispersion of contaminants is much greater.

Various toxic metals are often detected in stormwater and sediment within the urban stormwater network. Arsenic, cadmium, chromium, nickel and mercury are generally present at levels below the environmental guidelines, while zinc, lead and copper are generally found to be in excess of the recommended guidelines (Ausseil, 2011). This however should not be seen as a direct indication of environmental effects on the receiving environment as environmental guidelines should be applied to receiving environments and not stormwater contaminant concentration alone (i.e. after reasonable mixing of stormwater with receiving water). Urban stormwater drains may be classed as degraded environments, but they only discharge significant volumes of stormwater to waterways during and after storm events, and the waterways at such times are already carrying large loads of contaminants and flowing at faster rates. Wairoa's very small urban catchment (less than 0.1 % of the entire river catchment area) also ensures that these urban stormwater contributions to the river's water quality during storm events are insignificant.

Ausseil (2011) also noted that a NIWA study of the effects of urban stormwater in 1998 found low metal concentrations (well below tolerable dietary uptake guidelines for human consumption) in fish and shellfish in the Wairoa Estuary.

6.3 Wastewater Discharges

Several monitoring reports have been prepared by Argo Environmental Ltd as part of the AFFCO discharge consent renewal application and subsequently for demonstrating compliance with the consent conditions and environmental limits. The AFFCO monitoring reports reviewed while preparing this report are dated 2008, 2010, 2011 and 2013 and their conclusions regarding the environmental effects of the AFFCO discharge are summarised below.

[12] Stansfield (as cited in Ausseil, 2011)

The 2008 Argo report commented on the assessment of effects on the benthic ecology of the AFFCO discharge into the Wairoa River. This assessment was carried out in January 2008 during the processing of the discharge resource consent and was intended to be a repeat of the Bioresearches (1995) survey to assess the effects of the AFFCO discharge on the Wairoa River receiving environment. The survey highlighted:

- An increase in mud content at most sites from the 1995 survey. This is likely to be unrelated to the discharge of treated wastewater from the AFFCO site; and
- There were no statistically significant differences in several of the key biological species (both number and diversity) between surveys (1995 and 2008). There were however differences between locations of invertebrate abundance, but again, this is likely to be unrelated to the AFFCO discharge of wastewater and more likely attributable to natural processes and sediment loading.

Further AFFCO reporting concentrated on the amount of ammonia that entered the Wairoa River and its subsequent plume dispersion. A report by Argo Environmental dated March 2010 identifies that the median concentration of ammonia in the treated wastewater entering the Wairoa River was 22 g/m^3. At the rate of discharge and following reasonable mixing, this equates to a downstream in-river median of 0.36 g/m^3. Site-specific trigger values were determined for total ammonia in the Wairoa River downstream of the AFFCO Wairoa discharge. Protection of 95% of aquatic species required a maximum ammoniacal-nitrogen limit of 0.86 mg/l in the Wairoa River (Argo Environmental, 2010).

Results from detailed river water quality surveying by Argo Environmental across the full width and depth of the river channel at several locations in February and March 2011 showed ammoniacal-nitrogen levels upstream of the AFFCO discharge and 500m or greater downstream of the AFFCO discharge are at or below the analytical detection limits, which are well below the RRMP limit. Ammoniacal-nitrogen concentrations attributable to the AFFCO discharge were below the analytical detection limits at a distance of greater than 200 m downstream of the discharge due to dispersion of the discharged plume (Argo Environmental, 2011). This survey was undertaken when the river was flowing on an out-going tide at a rate of 50-53 m^3/s which is between median and mean annual flow rate. This demonstrates that any effects of the AFFCO discharges on contaminant concentrations and ecosystems will not occur near the Wairoa WWTP discharge, which is several kilometres downstream near the coast.

The 2013 survey by Argo Environmental repeated the 2011 monitoring programme but scaled back to only upstream and 200 m downstream of AFFCO's discharge. This survey occurred after AFFCO's appeal of the resource consent had been resolved with amended limits for ammoniacal nitrogen downstream of the discharge. The AFFCO discharge consent requires *"the concentration of total ammonia-nitrogen (NH_4-N) in the Wairoa River 200 metres downstream of the point of discharge point the Wairoa River shall not exceed the following concentrations in more than 1 out of 10 consecutive samples:*

(a) 0.8 g/m^3 during the months of November to March inclusive; and
(b) 1.1 g/m^3 during the months of April to October inclusive."

The 2013 survey measured ammoniacal-nitrogen concentrations of 0.73 g/m^3 and 0.88 g/m^3 in January and March respectively 200 m downstream of the AFFCO discharge when the river was flowing less than MALF on an out-going neap tide and while the estuary bar was closed (worst case conditions for discharge dilution and potential for adverse effects), indicating AFFCO are complying with their discharge consent even under the most challenging environmental conditions, achieving dilutions of about 50:1 within 200 m downstream of the discharge, and are unlikely to cause adverse effects on the Wairoa River's aquatic ecosystems.

In addition to AFFCO monitoring, HBRC's river water quality monitoring data for a site downstream of the Wairoa WWTP discharge of treated wastewater between February 2009 and June 2012 is presented in Table 6.1 below.

Table 6.1: Wairoa River Water Quality Downstream of WWTP Discharge for 2009-12 (Source: HBRC)

Parameter	Min	Median	Max	Guideline/Limit	Source
NH_4-N (mg/l)	0.013	0.044	0.11	0.1 mg/l maximum	HBRC RRMP (2006)
Suspended solids (mg/l)	7.1	52.5	1,210	25 mg/l maximum	HBRC RRMP (2006)
E. coli (cfu/100 ml)	< 1	160	19,000	260 cfu/100 ml maximum for contact recreation (health) Amber alert	MfE/MoH (2003)
DO (% saturation)	71	106	118	80 % saturation minimum for protection of trout fisheries	HBRC RRMP (2006)

Overall, the medians and ranges of these parameters are very similar to those of the river water quality further upstream, which indicates that the river water quality is not deteriorating as it passes the urban area and through the estuary. It is not possible to assess the immediate effects of the discharge of treated wastewater from the Wairoa WWTP because the HBRC samples were collected during daylight hours when the WWTP discharge is not occurring (this discharge is restricted to out-going tides at night time). However, it is clear from these results that there is no detectable residual wastewater contamination of the river water within a few hours of the WWTP discharge ceasing each morning.

Water quality in the river and estuary within 200 m of the current Wairoa WWTP's treated wastewater outfall has been shown to have a limited effect on aquatic biota as reported by EAM consulting (Smith, 2011). Sediment texture and chemistry have shown no signs of wastewater discharge effects. Additionally, invertebrates and other aquatic species whose habitats are close to the river floor have shown no effects that suggest discharge of treated wastewater is having an effect on their wellbeing. Siltation from upstream sources and natural variations in the alignment of the river channels through the estuary has resulted in minor effects on aquatic biota, but this cannot be attributed to the treated wastewater discharge at all. Further information can be found in the EAM reports (Smith, 2007; Smith, 2011).

6.4 Wastewater Reticulation Overflow Events

As outlined in the Summary of Wastewater and Stormwater Overflow Issues report (LEI, 2015: A1I1), stormwater enters the Wairoa sewer network and causes large flow rate peaks during and immediately following rain events. During these times, an increase in the sewer network flow rate from 1,800 m^3/d to > 6,000 m^3/d can occur. The larger flows can overwhelm the pumping and/or reticulation capacity of the sewer network which causes sewage diluted by stormwater to overflow onto land (residential properties and/or Council reserves) and then discharge into the Wairoa River. WDC are reducing the frequency and volume of these discharges by addressing stormwater sources within the sewer reticulation and upgrading the pump station capacities to better cope with the flows.

The wastewater flow rates within the reticulation are elevated as a result of:

- groundwater infiltration entering the reticulation network via faulty sewer pipe connections; and
- stormwater ingress/inflow entering the network directly from private properties.

These sources of stormwater entering the sewer network are commonly referred to as infiltration and ingress (I & I) and are most likely to occur due to heavy or persistent rainfall and high groundwater levels.

Analysis of WDC sewer pump station wet well level monitoring data (2012 – 2014) and Opus (2012) have reached the following conclusions:

- Overflow events tend to most commonly occur during larger winter rainfall events;
- Overflow events have been shown to be caused by reticulation blockages, pump failures and potentially large industrial inflows; and
- I and I from stormwater and groundwater have been shown to cause a marked increase in flows which exceed the capacity of the wastewater reticulation network.

Stormwater inflow is clearly demonstrated to be by far the major contributor to wet weather flow increases and subsequent overflows from the Wairoa sewer network. Elevated groundwater inflows contribute significantly to seasonal and wet weather flow increases but do not overwhelm the capacity of the system (except perhaps during prolonged reticulation blockages or pump failures) and do not generate sudden peak flows.

Because overflow events are caused by high rainfall, whereby stormwater and groundwater have entered the wastewater reticulation network, the Wairoa River is also likely to be flowing at a higher rate. Not only will dilution of sewage occur from I & I and the higher flow within the reticulation network, but overland mixing with stormwater dilutes the wastewater further, and an increase in contaminant loading to the river is likely to be occuring from runoff across the much larger rural catchment area. This causes the river to have a contaminant loading well in excess of its normal flow conditions, lessening the impact, if any, of the urban wastewater overflow discharges on the river. HBRC compliance reports have noted *"when uncontrolled discharges occur, the Wairoa River has elevated flows and contaminant levels from surrounding land use."* It would seem apparent that overflows from the wastewater reticulation network during storm events is therefore unlikely to cause any long-term effects on the receiving environment.

Further to this, faecal source tracking has previously been performed to determine the source of faecal contaminants entering the Wairoa River. Sources have been from plants, avians and ruminants, indicating wastewater entering the Wairoa River has a minimal contribution to faecal contaminants. More detail can be found in the A3I3 memo – Public Health Summary (LEI, 2017:A3I3).

7 WAIROA CLIMATE SUMMARY

7.1 General

Wairoa's climate data was obtained from the NIWA database, Cliflo. The data included monthly mean, maximum and minimum temperatures, and daily rainfall, soil moisture deficit and runoff over a period from January 1997 to March 2017. Statistics for this data are presented in Appendix D and summarised below. The North Clyde weather station was used to give the best representation of the Wairoa area (latitude: -39.017, longitude: 177.413), as it was closest to the centre of Wairoa and had the longest daily record with the widest range of parameters compared with other nearby weather stations. Further climate data and descriptions were accessed from the NIWA report, *The climate and weather of Hawke's Bay* (Chappell, 2013).

The climate conditions of Wairoa are determined by a general sequence of eastward moving anti-cyclones, separated by troughs, and depressions. These features determine the broad nature of the weather that will cross the region (Chappell, 2013). However, features such as the Te Urewera Ranges influence these weather patterns. During times where westerly winds are prominent, this can cause the region to experience high temperatures and dry conditions due to the sheltering nature of the ranges. When a southerly or easterly weather pattern crosses the region, the ranges enhance precipitation, leading to increased rainfall, river flows and runoff, leading to a risk of flooding of the lowlands.

7.2 Rainfall and Runoff

Figure 7.1 shows daily rainfall and runoff amounts based on 1997 – 2017 data. Runoff has been calculated by NIWA through excess precipitation less the evaporation, when there is no soil moisture deficit (0 mm). An average daily rainfall amount of 3.3 mm/day and a 95^{th} percentile of 18.7 mm has been recorded over this period. The maximum daily rainfall event during this timeframe was recorded on 24 March 2011 as 127.5 mm, which is 39 times the average daily rainfall. Generally, where rainfall amounts were high and soil deficit was at zero, runoff would closely match the rainfall.

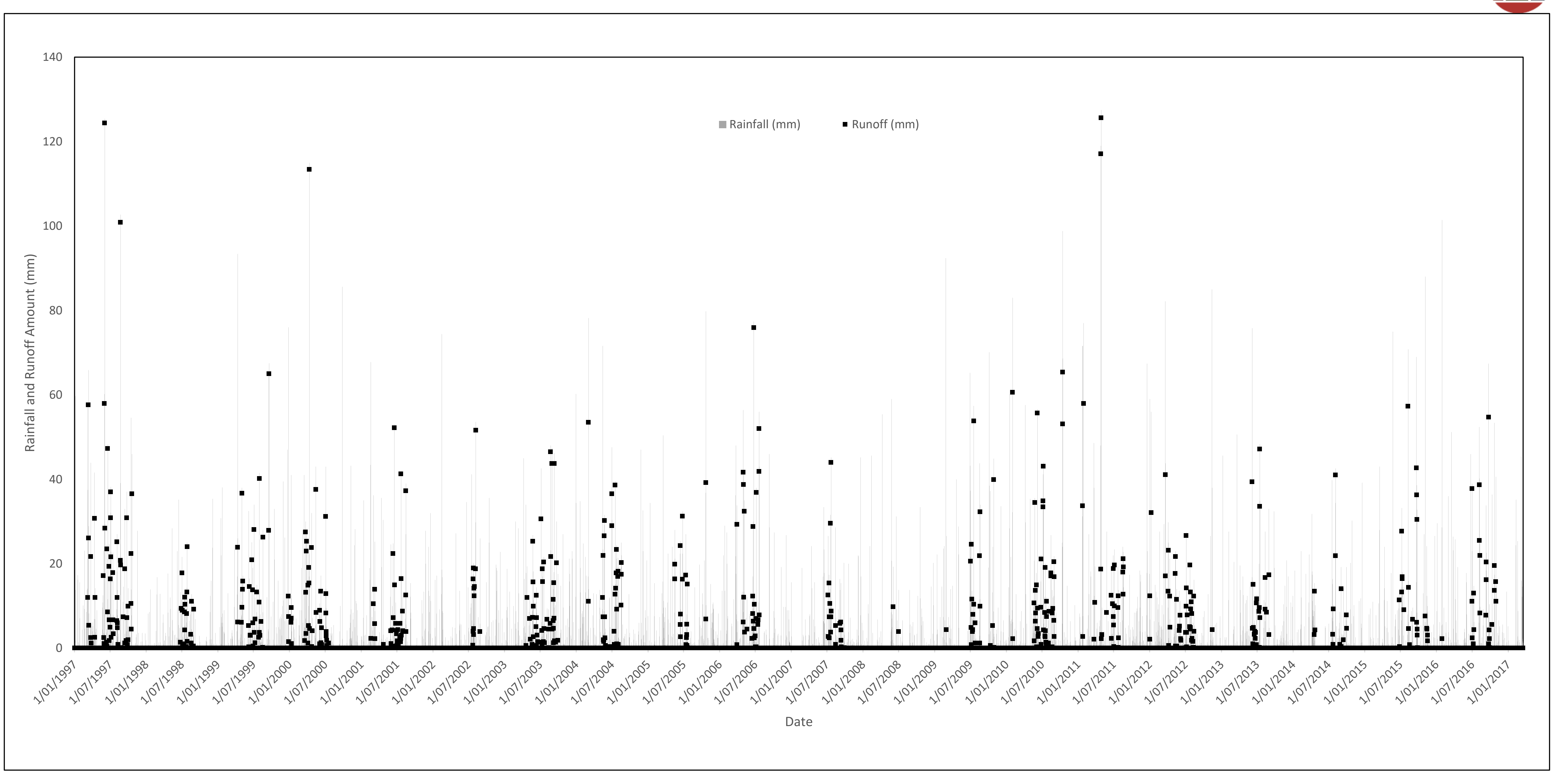

Figure 7.1: Daily Rainfall and Runoff for Wairoa During 1997-17 (Source: NIWA Cliflo Database)

Figure 7.2 shows the monthly average rainfall from 1997 to 2017. Wairoa has an average total rainfall of 1,333 mm/y. Rainfall is evenly spread throughout the year with a moderate winter increase. February, November, and December are the months where rainfall is lowest (75-80 mm/month average), while July is highest (140 mm/month average). The frequency of rainfall days at Wairoa is greatest during winter (June and July). Table 7.1 shows the numbers of rain days (0.1 mm rain days – light rain) and wet days (1 mm – heavy, more persistent rain), as averaged from 1981 – 2010 (Chappell, 2013). Just under a third of the year Wairoa has wet days with 44% of the year being rain days.

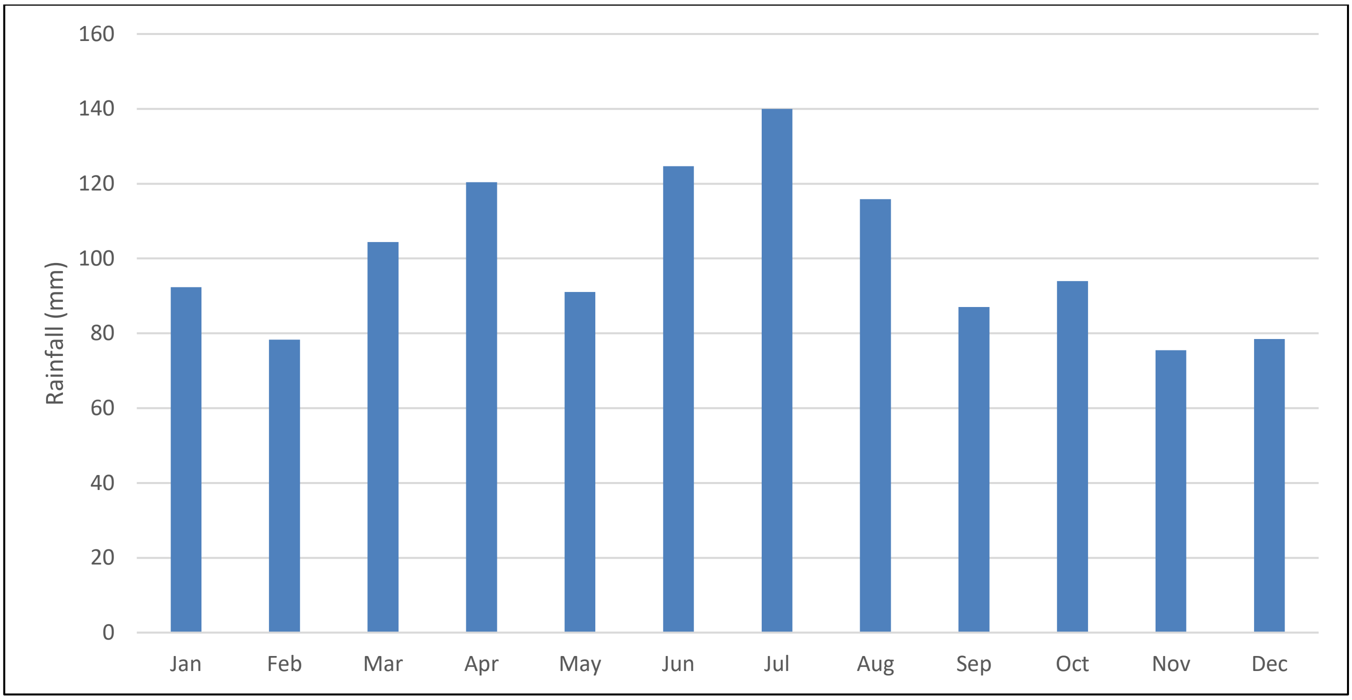

Figure 7.2: Wairoa Monthly Average Rainfall (1997 - 2017). (Source: NIWA Cliflo database).

Table 7.1: Numbers of days per month with rain (0.1 mm/day) and wet days (1 mm/day). (Source: NIWA Cliflo Database)

Month	**>0.1 mm Rain Days**	**>1 mm Wet Days**
Jan	12	8
Feb	11	8
Mar	12	9
Apr	14	10
May	14	10
Jun	15	11
Jul	17	13
Aug	15	10
Sep	13	9
Oct	13	8
Nov	12	9
Dec	12	8
Annual	**159**	**112**

Heavy rainfall can occur within the Hawke's Bay with southerly and easterly flows, including tropical cyclone depressions that occasionally pass along the coast (Chappell, 2013). Intense rainfall also occurs during thunderstorms. Significant weather events that have affected Wairoa and its surrounds include ex-tropical cyclone Bola (March 1988). The town bridge collapsed, dividing the main centre of Wairoa and North Clyde in two and destroying the town's water supply (Chappell, 2013); June 1997 saw a deep low pressure system move down the North Island and stall close to Mahia Peninsula. This caused numerous slips and closed SH 2 between Wairoa and Napier.

Conversely, dry spells longer than 15 days with less than 1 mm rainfall are common throughout the late spring, summer and autumn periods. An average dry spell lasts 19 days. Wairoa has an average of 1.7 dry spells per year. In Wairoa, the longest recent dry spell was 27 days, from 3 to 29 November 1994 (Chappell, 2014).

7.3 Soil Moisture Deficit

Soil moisture is directly related to the amount of evapotranspiration and rainfall. When evapotranspiration is greater than the amount of rainfall, a soil moisture deficit occurs. Typically, a greater soil deficit is shown in the warmer months where rainfall is lower and evapotranspiration is high. Likewise, the opposite effect is seen during the cooler months. July and August typically have very low soil moisture deficits due to a higher rainfall and fewer hours of sunshine combined with cooler temperatures resulting in lower evapotranspiration rates. Soil moisture deficit is highest during December to February each year. Figure 7.3 presents a graph of the average monthly soil moisture deficit for 1997-2017.

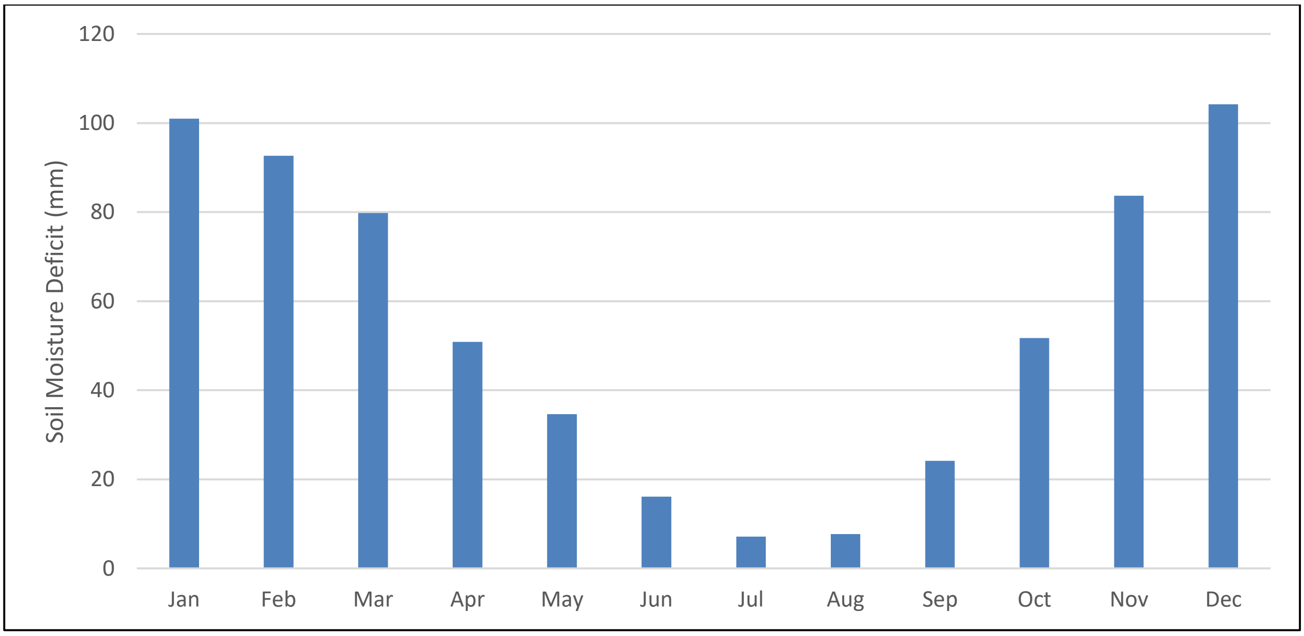

Figure 7.3: Monthly Average Soil Moisture Deficit at Wairoa (1997-2017). (Source: NIWA Cliflo Database).

7.4 Wind

Wind patterns that cross the Hawke's Bay are influenced by the orography, with the region generally being less windy than other parts of New Zealand. In less exposed areas, there is a tendency for wind to channel down river valleys. The more exposed areas of Hawke's Bay, for example Mahia Peninsula, have a larger percentage of strong winds than more sheltered sites.

Spring tends to be the windiest season throughout the region. Gale force winds can occur in any month but are most common throughout winter.

Wind speeds are known to be affected diurnally, that is, the greatest wind speeds occur in the early afternoon due to heating of the land surface being most intense at this time, encouraging strong winds to be brought down closer to the land surface. Additionally, with the exception of winter, onshore sea breezes are common during the afternoon throughout the year, even more so during times of weak pressure gradients (Chappell, 2013).

High wind speeds are generally rare in lowland areas (>55 km/hr), but are more frequent in exposed areas (e.g. Mahia Peninsula). These higher speeds generally have a northwest or southwest direction. During times when strong winds flow in a west-northwest direction, these winds descend from the ranges to the lowlands bringing warm gusty and dry foehn winds (Chappell, 2013).

7.5 Temperature

Being a coastal settlement, Wairoa tends to have higher temperatures than what are experienced further inland. Maximum and minimum temperatures are higher than those experienced inland due to the influences from Hawke Bay and the Pacific Ocean. The prevailing westerly winds bring dry warm foehn winds in the lowland areas during the summer months, this results in Wairoa having an average 50 days per year where temperature exceeds 25°C (Chappell, 2013).

Figure 7.4 shows the monthly average temperature between January 1997 and June 2017. The general trend shows January (19°C) and February (19°C) to be the warmest months with July (9.5°C) the coolest.

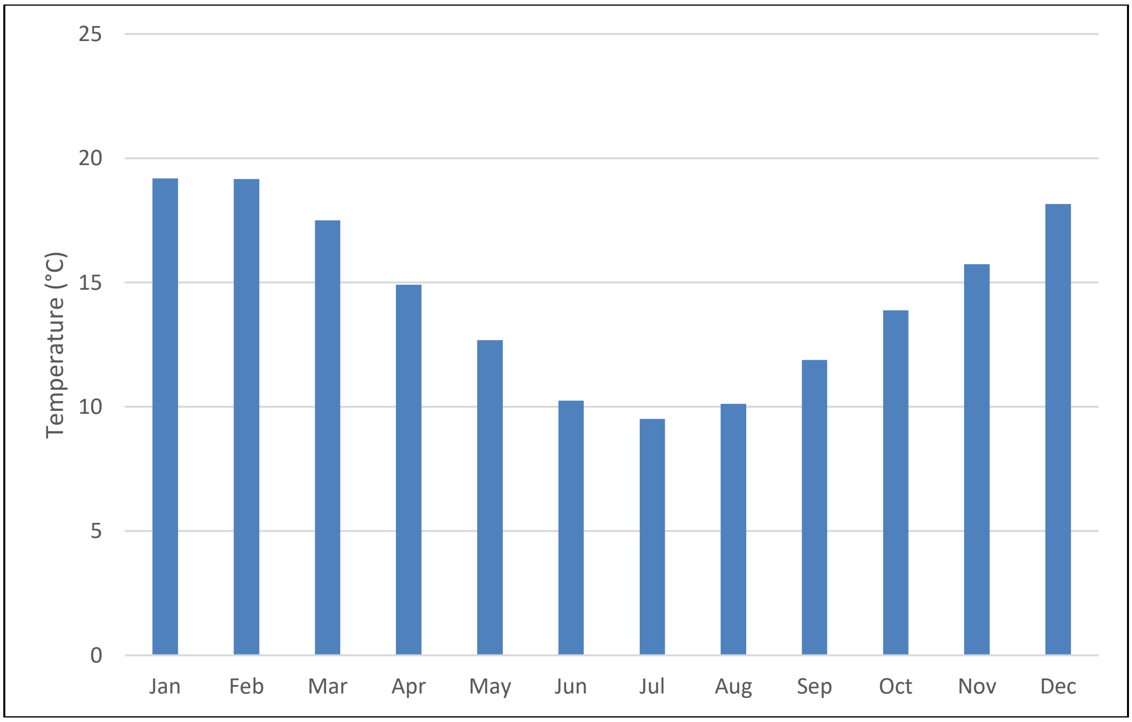

Figure 7.4: Monthly Average Temperature for Wairoa (1997-2017). (Source: NIWA Cliflo Database).

Minimum and maximum monthly temperatures between January 1997 and May 2017 are shown in Figure 7.5 and follow a similar trend throughout the year whereby the warmest temperatures typically occur during January or February, and the coldest temperatures typically occur during June or July. February 1998 proved to be the hottest month with the highest maximum temperature of 28.2°C and the highest minimum temperature of 16.8°C. The coolest month during this period was August 1999 with the lowest minimum temperature of 3.3°C.

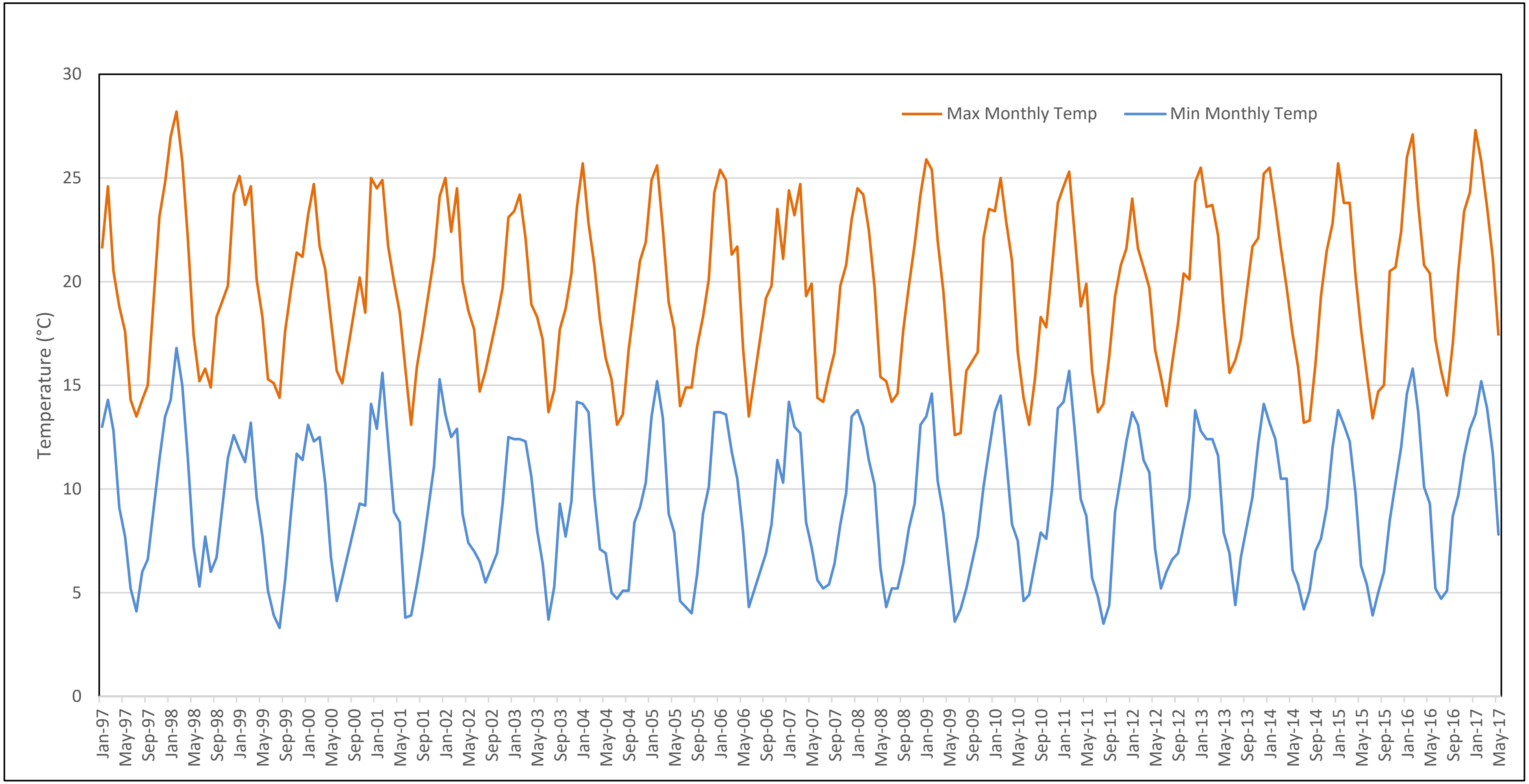

Figure 7.5: Monthly minimum and maximum temperatures for Wairoa (1997-2017). (Source: NIWA Cliflo Database).

8 CONCLUSIONS

This report has summarised the environmental and climatic features of the Wairoa River and Wairoa Region respectively.

River flow characteristics have shown that the median flow of 31 m^3/s will be influenced by tidal patterns within the lower reaches of the Wairoa River (up to about 7 km inland). When flows are at or above 200 m^3/s the in-coming and ebb tides have no influence on water flows in the lower Wairoa River; the flow of river water prevents seawater entering the mouth of the river estuary. The bar across the mouth of the estuary to Hawke Bay naturally closes and needs to be periodically re-opened by HBRC. While the bar is closed, marine inflows and river outflows are limited, and the height of the river water level during low to moderate flow conditions increases for several km inland more than when the bar is open.

When the Wairoa River is in flood there is the largest effect on water quality. This is mainly driven by stormwater which is mainly from rural land uses with less than 0.1 % from urban areas. Not only from stormwater and overland flow entering the river and contributing contaminants and sediment, but wastewater overflows from the reticulated sewer are more likely to occur. Any effect on the river from wastewater overflows is minimal due to the flooded river already carrying high loads of contaminants and a high dilution rate of the discharges by stormwater and river flows. WDC are reducing the frequency and volume of these discharges by addressing stormwater sources within the sewer reticulation and upgrading the pump station capacities to better cope with the flows.

Monitoring of the Wairoa River at the Railway Bridge, Wairoa Ski Club, and downstream of the WWTP discharge sites by HBRC has shown that nutrients and toxicants such as nitrate-nitrogen and ammoniacal-nitrogen are minimal and well within the RRMP limits, however, water clarity is the poorest in the Region due to the soft sedimentary geology and high proportion of farmed hill country in its catchment. Overall, the medians and ranges of water quality parameters are very similar at all locations near Wairoa, which indicates that the river water quality is strongly controlled by upstream rural sources and is not deteriorating as it passes the urban area and through the estuary, despite the inputs of urban stormwater, AFFCO's treated wastewater and Wairoa WWTP's treated wastewater. Although wastewater discharges to the Wairoa River carry a negative aesthetic appreciation, information currently available indicates that it is currently not causing degradation of the Wairoa River water quality or the aquatic and estuarine ecosystems that it supports.

E. coli levels are monitored every summer season from the Ski Club site (November- April). The average annual frequency of breaches is 5-6 exceeding the Alert level (i.e. > 260 cfu/100 ml) and 2-3 exceeding the Action level for contact recreation guidelines (i.e. > 540 cfu/100 ml). These equate to 74 % and 88 % compliance rates respectively and resulted in a "very poor" rating under the MfE/MoH guidelines for contact recreation water quality. Despite these poor recreational guideline compliance rates, the median *E. coli* count was 84 cfu/100 ml, which complies with the RRMP limit. Generally, *E. coli* creates the largest concern for users of the Wairoa River. Faecal tracking has indicated plant, ruminant and avian origins.

Wairoa's climate is influenced by the surrounding hill country and Te Urewera ranges. Rainfall events have a large impact on river flow and stage. Rainfall is fairly evenly spread throughout the year with a moderate winter increase. Soil moisture deficit is highest during December to February each year. Winds tend to be strongest from the north-west or south-west. The proximity of Wairoa to the Pacific Ocean creates a warmer climate than that which is experienced inland. Generally Wairoa's warmer months are January and February and the coolest months are June and July.

9 REFERENCES

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10 APPENDICES

Appendix A Summary of Water Quality Statistics by River Flow
Appendix B Ecosystem Health NOF Band Tables
Appendix C NOF Band Results
Appendix D Monthly Average Rainfall and Soil Moisture Deficit

APPENDIX A

Summary of Water Quality Statistics by River Flow

Table 10.1: Summary of Water Quality Statistics for Wairoa River Upstream of Wairoa by River Flow Rate (2009 - 2013) (Ausseil, et al, 2016)

Flow	Statistic	Turbidity (NTU)	SS (mg/L)	*E. coli* (cfu/100ml)	TP (mg/L)	DRP (mg/L)	TN (mg/L)	NO3-N (mg/l)	NH4-N (mg/l)	DO (mg/L)	DO (%)	pH	Temp (°C)
All Flows	Minimum	1.8	1.5	1	0.009	0.002	0.114	0.001	0.005	6.8	71	7.6	6.9
	Median	18.9	20	85	0.028	0.008	0.265	0.040	0.005	9.4	97	8	14.6
	Maximum	1510	2900	14000	2.200	0.029	2.879	0.580	0.119	12.6	111	8.6	22.4
	Mean	170.3	246.2	1483	0.186	0.010	0.512	0.109	0.015	9.6	94	8.1	14.8
	Std. Dev.	393.3	672.9	3567	0.464	0.008	0.647	0.138	0.023	1.7	9	0.2	4.8
	Count	26	29	28	29	29	27	27	29	27	26	27	28
3 x Median	Minimum	1.8	1.5	1	0.009	0.002	0.114	0.001	0.005	6.8	71	7.6	7.5
	Median	7	7.1	60	0.018	0.005	0.223	0.012	0.005	8.9	95	8.1	15.3
	Maximum	225	137	1900	0.114	0.022	0.180	0.300	0.035	11.9	103	8.6	22.4
	Mean	24.5	23.9	222	0.030	0.007	0.235	0.057	0.009	9.1	92	8.1	15.7
	Std. Dev.	49.5	32.6	464	0.025	0.006	0.099	0.080	0.008	1.5	9	0.3	4.8
	Count	20	23	22	23	23	21	21	23	21	20	22	22
Median Flow	Minimum	1.8	1.5	1	0.009	0.002	0.114	0.001	0.005	6.8	71	7.7	9
	Median	5.6	6.7	52	0.016	0.005	0.182	0.008	0.005	8.7	92	8.1	16.1
	Maximum	65	137	1300	0.114	0.016	0.300	0.092	0.035	11.9	103	8.6	22.4
	Mean	13.1	20.7	161	0.029	0.006	0.187	0.018	0.009	8.8	91	8.1	16.7
	Std. Dev.	17.2	34.3	330	0.027	0.004	0.057	0.027	0.009	1.5	10	0.2	4.4
	Count	14	16	15	16	16	14	14	16	15	14	16	16

APPENDIX B

Ecosystem Health NOF Band Tables

Escherichia coli **NOF attribute table**

Value	Ecosystem health		
Freshwater Body Type	Lakes and Rivers		
Attribute	*E. coli* *		
Attribute Unit	*E. coli* /100 mL (number of *E.coli* per hundred millilitres)		
Attribute State	**Numeric Attribute State**	**Sampling Statistic**	**Narrative Attribute State**
A	≤ 260	Annual median	People are exposed to a very low risk of infection (less than 0.1% risk) from contact with water during activities with occasional immersion and some ingestion of water (such as wading and boating).
		95th percentile	People are exposed to a low risk of infection (less than 1% risk) when undertaking activities likely to involve full immersion.
B	>260 and ≤ 540	Annual median	People are exposed to a low risk of infection (less than 1% risk) from contact with water during activities with occasional immersion and some ingestion of water (such as wading and boating).
		95th percentile	People are exposed to a moderate risk of infection (less than 5% risk) when undertaking activities likely to involve full immersion. 540/100 ml is the **minimum acceptable state** for activities likely to involve full immersion.
C	>540 and ≤ 1,000	Annual median	People are exposed to a moderate risk of infection (less than 5% risk) from contact with water during activities with occasional immersion and some ingestion of water (such as wading and boating). People are exposed to a high risk of infection (greater than 5% risk) from contact with water during activities likely to involve full immersion.
National Bottom Line	**1,000**	Annual median	
D	>1,000	Annual median	People are exposed to a high risk of infection (greater than 5% risk) from contact with water during activities with occasional immersion and some ingestion of water (such as wading and boating).

Figure 10.1: NOF band for E. Coli and associated attribute state (Source: Ausseil, et al, 2016)

Nitrate NOF attribute table

Value	Ecosystem health		
Freshwater Body Type	Rivers		
Attribute	Nitrate (Toxicity)		
Attribute Unit	mg NO_3-N/L (milligrams nitrate-nitrogen per litre)		
Attribute State	**Numeric Attribute State**		**Narrative Attribute State**
	Annual Median	**Annual 95th Percentile**	
A	≤ 1.0	≤ 1.5	High conservation value system. Unlikely to be effects even on sensitive species.
B	>1.0 and ≤ 2.4	>1.5 and ≤ 3.5	Some growth effect on up to 5% of species.
C	>2.4 and ≤ 6.9	>3.5 and ≤ 9.8	Growth effects on up to 20% of species (mainly sensitive species such as fish). No acute effects.
National Bottom Line	**6.9**	**9.8**	
D	>6.9	>9.8	Impacts on growth of multiple species, and starts approaching acute impact level (i.e. risk of death) for sensitive species at higher concentrations (> 20 mg/l).

Figure 10.2: NOF band for Nitrate and associated attribute state (Source: Ausseil, et al, 2016)

Ammonia NOF attribute table

Value	Ecosystem health		
Freshwater Body Type	Lakes and Rivers		
Attribute	Ammonia (Toxicity)		
Attribute Unit	mg NH_4-N/L (milligrams ammoniacal-nitrogen per litre)		
Attribute State	**Numeric Attribute State**		**Narrative Attribute State**
	Annual Median*	**Annual Maximum***	
A	≤ 0.03	≤ 0.05	99% species protection level. No observed effect on any species.
B	>0.03 and ≤ 0.24	>0.05 and ≤ 0.40	95% species protection level. Starts impacting occasionally on the 5% most sensitive species.
C	>0.24 and ≤ 1.30	>0.40 and ≤ 2.020	80% species protection level. Starts impacting regularly on the 20% most sensitive species (reduced survival of most sensitive species).
National Bottom Line	**1.30**	**2.20**	
D	>1.30	>2.20	Starts approaching acute impact level (i.e. risk of death) for sensitive species.

*Based on pH 8 and temperature of 20°C
Compliance with the numeric attribute states should be undertaken after pH adjustment.

Figure 10.3: NOF band for Ammonia and associated attribute state (Source: Ausseil, et al, 2016)

APPENDIX C
NOF Band Results

Parameter	Annual Median Values for Wairoa Water Ski Club				
	2009	2010	2011	2012	2013
Nitrate mg NO_3-N/L (milligrams nitrate-nitrogen per litre)	0.023	0.142	0.170	0.013	0.026
Ammonia mg NH_4-N/L (milligrams ammoniacal-nitrogen per litre)	0.016	0.013	0.005	0.005	0.005
E. coli (cfu/100 ml)	10	128	661	75	75

APPENDIX D

Monthly Average Rainfall, Soil Moisture Deficit & Temperature (1997 – 2017)

Month	Average Monthly Total Rainfall (mm)	Average Daily Soil Moisture Deficit (mm)	Average Monthly Temperature (°C)
Jan	92.3	101.0	19.2
Feb	78.3	92.6	19.2
Mar	104.4	79.8	17.5
Apr	120.4	50.9	14.9
May	91.1	34.6	12.7
Jun	124.6	16.1	10.2
Jul	140.0	7.1	9.5
Aug	115.8	7.7	10.1
Sep	87.1	24.1	11.9
Oct	93.9	51.7	13.9
Nov	75.5	83.7	15.7
Dec	78.5	104.2	18.2
Annual Average	**1333.2**	**54.5**	**14.4**