BEFORE INDEPENDENT HEARING COMMISSIONERS

AT HAMILTON

IN THE MATTER	of the Resource Management Act 1991
AND	
IN THE MATTER	of the hearing of submissions on Proposed Plan Change 1 to the Waikato Regional Plan

STATEMENT OF PRIMARY EVIDENCE OF DR MARTIN WILLIAM NEALE FOR FONTERRA CO-OPERATIVE GROUP LTD (SUBMITTER 74057)

BLOCK 2 HEARINGS

FRESHWATER SCIENCE

3 MAY 2019

RICHMOND
CHAMBERS

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1. EXECUTIVE SUMMARY

1.1 My technical evidence addresses issues in Fonterra's submissions that are being heard in the Block 2 hearing.

1.2 Fonterra has five manufacturing sites in the Waikato and Waipā River catchments (together, **Catchment**) that receive and process raw milk into products for the domestic and international markets. This processing generates wastewater that requires disposal, and this wastewater is treated and discharged to water or it is irrigated to land.

1.3 A Council assessment of the contribution of point sources to the Catchment's nutrient loads indicated that they are relatively small proportions of the total load, particularly for total nitrogen (7%). The point sources' proportion of the total phosphorus load is higher (18%) (Vant 2014[1]).

1.4 The contribution of Fonterra's point source discharges to the Catchment nutrient load has been estimated to be low in two separate assessments. A Council assessment concluded that Fonterra's point source discharges contributed 0.38% and 1.69% of the total phosphorus (**TP**) and total nitrogen (**TN**) loads respectively, whereas an assessment commissioned by Fonterra found slightly higher contributions (0.82% and 1.83% of the TP and TN loads respectively). The latter assessment produced a higher contribution in part because it included all five of Fonterra's manufacturing sites in the Catchment.[2]

1.5 In addition to the relatively small proportion contributed by Fonterra's point source discharges, the proportion has also been decreasing over time (2001 to 2015) due to improvements in manufacturing efficiencies (i.e. less wastewater produced), along with improvements in wastewater treatment.

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[1] Vant B. 2014. Sources of nitrogen and phosphorus in the Waikato and Waipā Rivers, 2003–12. Waikato Regional Council Technical Report 2014/56.

[2] The Council assessment included the three sites that discharge directly to water (Te Rapa, Te Awamutu and Hautapu), whereas the Fonterra assessment also included Lichfield and Reporoa, which irrigate wastewater to land.

1.6 Water quality offsetting is a management tool that can be used to achieve more effective water quality outcomes, whilst providing opportunities for technical, financial and logistical efficiencies. It is a tool used in water quality management in other countries, such as the USA and Australia, and I support the opportunity to use it in the context of proposed Plan Change 1 to the Waikato Regional Plan (**PC1**).

2. INTRODUCTION

2.1 My full name is Dr Martin William Neale.

2.2 I am a Director and Lead Scientist at Puhoi Stour Limited, an environmental science and management consultancy based in Auckland.

2.3 I have the qualifications and experience recorded in my curriculum vitae attached to this statement of evidence as **Appendix 1**.

2.4 My evidence focuses on the following matters:

(a) the point source discharges from Fonterra's manufacturing sites in the Catchment;

(b) the contribution of these point source discharges to the Catchment loads of nutrients and how they have reduced over time; and

(c) how offsetting can be used to achieve positive water quality outcomes (in response to a submission by Fish and Game).

3. BACKGROUND TO PROPOSED CHANGE 1

3.1 My involvement in PC1 commenced in October 2016 following its public notification. I was engaged to provide water quality expertise for Fonterra in relation its submission on PC1.

3.2 I am familiar with the provisions of the PC1 to which these proceedings relate. In preparing my evidence I have reviewed the following documents:

(a) Waikato Regional Plan Change 1 – Waikato and Waipā River Catchments: Section 32 Evaluation Report.

(b) Section 42A Report (**s42A Report**), Proposed Plan Change 1, Waikato and Waipā River catchments, (Parts A and B), February 2019.

3.3 I have read the evidence of Mr Gerard Willis and Ms Brigid Buckley on behalf of Fonterra, which is being submitted as part of these Block 2 hearings.

3.4 I have taken part in the expert conferencing on Table 3.11-1 as directed by the Hearing Panel minutes of 27 February and 13 March 2019. I have also read the submissions of Fish and Game, Forest and Bird and the Department of Conservation.

3.5 I have also read the Independent Commissioners' decision report, and attached conditions, very recently granting consent to continue discharges from the Fonterra's Te Awamutu site (dated 23 April 2019). This is one of the manufacturing sites within the Catchment.

Code of Conduct

3.6 Although this is a Council hearing, I have read the Environment Court's Code of Conduct and agree to comply with it. My qualifications as an expert are set out above and in Appendix 1. I confirm that the issues addressed in this statement of evidence are within my area of expertise.

4. FONTERRA'S MANUFACTURING SITES

Brief description of sites and their discharges

4.1 Fonterra owns and operates five dairy manufacturing sites in the Catchment, located at Te Rapa, Hautapu, Te Awamutu, Lichfield and Reporoa. These sites are described fully in Ms Buckley's evidence.

4.2 These sites receive raw milk from Fonterra's suppliers and process it into products for domestic and international markets. The processing of milk into various secondary products results in a range of wastewater that requires disposal. The nature of wastewater produced is described in Ms Buckley's evidence.

4.3 After on-site treatment, wastewater is either discharged to water as a conventional point source discharge, or is irrigated to land. Many of Fonterra's manufacturing sites in the Catchment and throughout New Zealand irrigate wastewater onto farmland. This recycled wastewater contains nutrients at levels useful to promote pasture growth and is intended to replace the use of conventional fertilisers, while in dry conditions the wastewater also provides a source of water. This irrigation occurs both on land owned by Fonterra as well as on land owned by third party farmers. Whether the discharge is to water or irrigated to land, Fonterra considers that it is a point source discharge.

4.4 Each of the sites and the management of wastewater are briefly described below:

(a) **Fonterra Te Rapa** began operations in 1967 and is one of Fonterra's largest sites in the country. The site has an advanced biological treatment system and treated wastewater is discharged to the Waikato River. Low strength wastewater (i.e. condensate and cooling water) is only treated if the continuous monitoring in place indicates a contamination problem. Disposal of wastewater is primarily by discharge to water, but small volumes of semi-solid waste from the treatment process are irrigated to land.

(b) **Fonterra Hautapu** began operations in 1886 and uses discharge to water and land-based irrigation for its wastewater. Low strength wastewater is chlorinated to prevent microbial growth and discharged to the Waikato River downstream of Cambridge. High strength wastewater is treated in a Dissolved Air Flotation (**DAF**) device or a Sequential Batch Reactor (a simple form of biological treatment) prior to irrigation on nearby farmland as a fertiliser replacement.

(c) **Fonterra Te Awamutu** began operations around 1915. Low strength wastewater and biologically treated wastewater is discharged to the Mangapiko Stream, a tributary of the Waipā River. The discharge of wastewater from this site has just received a decision granting consent to continue for 35 years (decision of 23 April 2019), which reflects Fonterra's planned investment of $17.1M in staged upgrades of the treatment systems at this site. Disposal of wastewater is primarily by discharge to water.

(d) **Fonterra Lichfield** began operations in 1995 and uses land-based irrigation options for all its wastewater. Low strength wastewater is treated in a series of purpose-built wetlands before discharge to land. Higher strength water is treated in a DAF device and biological treatment system prior to irrigation on nearby farmland as a fertiliser replacement.

(e) **Fonterra Reporoa** began operations in 1968 and uses land-based irrigation options for all its wastewater. The options for management of wastewater at Reporoa are currently being evaluated as part of the preparation of a consent application for this activity.

4.5 All the consents relating to the discharges described above require monitoring of the volume and composition of the wastewater discharged, and this consent compliance monitoring data forms the basis of the analysis discussed below (whether by Mr Vant on behalf of WRC or Golder Associates on behalf of Fonterra).

5. POINT SOURCE DISCHARGES

General description of point source discharges to the Catchment (Vant, 2014)

5.1 The loads and sources of nutrients in the Waikato and Waipā Catchments were most recently assessed by Vant (2014).[3] The loads of total nitrogen and phosphorus were estimated to be 11,200 tonnes/year and 950 tonnes/year respectively for the catchments.

5.2 Furthermore, Vant (2014) estimated the proportion of the catchment load of nutrients to natural, diffuse and 19 large-to-moderate point sources (**Table 1**). Point source discharges were relatively minor contributors of nutrients at a catchment scale.

Table 1: Loads and sources of Nitrogen and Phosphorus in the Waikato and Waipā Catchments (Adapted from Vant, 2014)

Discharge type	TN load (t/yr)	TP Load (t/yr)
Natural/background	3,623 (32%)	356 (37%)
Diffuse sources	6,840 (61%)	425 (45%)
Point Sources	730 (7%)	171 (18%)
Total	11,193	951

Contribution of Fonterra discharges (Vant, 2014))

5.3 The analysis undertaken by Vant (2014) also provided a high-level analysis of some of the point source discharges in the catchment, including the three Fonterra sites that discharge to water (Te Rapa, Te Awamutu and Hautapu). This analysis used a snapshot of data from 19 point sources, including six-year averages for the Fonterra discharges.[4]

[3] More recent assessment of the rivers discharging to the Hauraki Gulf was published in 2016 (WRC TR 2016/17), but there is no more recent assessment of the Waikato and Waipā Catchments (pers. comm. Bill Vant, 29 April 2019).
[4] Te Rapa (2007-2012); Te Awamutu (2008-2013); Hautapu (2006-2011).

5.4 This analysis indicated that collectively the three Fonterra point source discharges to water contribute minor proportions of the catchment nutrient loads, namely 0.38% of the Nitrogen load and 1.69% of the Phosphorus load (**Table 2**). It should be noted that this analysis excludes the two sites that irrigate wastewater to land (Lichfield and Reporoa).

5.5 Whilst the discharges collectively represent a relatively small proportion of the nutrient load at a catchment scale, it is possible that a specific discharge may contribute a greater proportion of the load in a smaller sub-catchment or to lead to mixing zone effects.

5.6 The former situation may occur for the discharge from Te Awamutu, which discharges to the Mangapiko Stream, which itself is a tributary of the Waipā River. There is no WRC monitoring on the Mangapiko Stream, so it is not possible to complete an analysis at that scale. However, the Te Awamutu discharge contributes 0.37% of the TN load and 1.8% of the TP load recorded at the Waipā River (Whatawhata) monitoring site, which is the closest downstream monitoring sites (calculated from data in Vant, 2014). Furthermore, the Assessment of Environmental Effects for the recent re-consenting process found no clear difference between nutrient concentrations (TN and TP) upstream and downstream of the Fonterra Te Awamutu discharge location (Golder, 2015).

5.7 In relation to mixing zone effects, the nature of Fonterra's point source discharges is such that effects are unlikely to occur that compromise the ability to swim over the entire length of the river. The concentration of *E. coli* in the wastewater discharges is typically low and below relevant guidelines, for example, Te Rapa median *E. coli* is 235 cfu/110mL, Te Awamutu median *E. coli* is 2 cfu/110mL and the discharge from Hautapu is chlorinated. In addition, the sources of *E. coli* in the discharges are either ruminant (from livestock) or avian (from settling ponds), both of which represent lesser health risks than human sources of *E. coli* (Scott et al, 2002).

Table 2: Loads and sources of TN and TP for Fonterra's point source discharges directly to water in the Waikato and Waipā Catchments (Adapted from Vant, 2014)

Discharge	Total Nitrogen			Total Phosphorus		
	Load (t/yr)	% point sources	% total load	Load (t/yr)	% point sources	% total load
Te Rapa	11	1.5	0.10	10.8	6.3	1.14
Te Awamutu	15	2.1	0.13	4.8	2.8	0.50
Hautapu	17	2.3	0.15	0.5	0.3	0.05
Total	43	5.9	0.38	16.1	9.4	1.69

Trends in Fonterra point source discharges (Golder, 2016)

5.8 The analysis presented by Vant (2014) provides a snapshot of the relative contributions of the Fonterra sites that discharge to water to the nutrient catchment load. It does not, and was never intended to, provide a detailed assessment of the discharges from all of Fonterra's manufacturing sites in the catchment and how they have changed over time.

5.9 Therefore, in 2015 Fonterra commissioned Golder Associates to review consent monitoring data and provide a detailed assessment of the nutrient loads from the five manufacturing sites and how the loads had changed over time (between 2001 and 2015). It was considered that assessing the effects of Fonterra's sites in an integrated manner, rather than individually, would allow Fonterra to assess the catchment level effects of its manufacturing operations and to demonstrate how it is responding to the changing statutory environment.

5.10 I was the project lead on this work whilst employed at Golder Associates and the analysis was carried out in the same way as was done by Vant (2014) to ensure consistency.

5.11 The estimates of the overall nutrient load to water and the percentage of the total Waikato river catchment load are shown in **Figure 1** for the five manufacturing sites in the Catchment. The full report is provided in **Appendix 2**.

5.12 Over the 15-year period, the discharges from the five manufacturing sites contributed an estimated average of 1.83 % and 0.82 % of the total annual catchment loads for TP and TN respectively. These estimates are slightly higher than those described by Vant (2014), but it is expected that these estimates would be higher as they include an estimate of the nutrient load from irrigation to land, whereas Vant only included discharges to water.

5.13 Furthermore, this assessment described the discharges on a site-by-site basis over the 15-year period, and analysed the data for significance of any trends.

5.14 Statistically significant reductions were observed for at least one nutrient at all sites except Lichfield. The TN annual loads significantly decreased for four sites over the length of the available data (**Table 3**).

5.15 For TP, Hautapu showed a significant decrease, Lichfield showed a significant increase, whilst Reporoa, Te Rapa and Te Awamutu showed no clear trends (**Table 4**).

5.16 It should be noted that this analysis focussed on the period 2001 to 2015, yet all the sites were operating well before this timeframe. This formal analysis is limited by the availability of sufficient monitoring data for all sites. Therefore, it does not capture any improvement in discharge quality that may occurred before 2001 associated with known improvements in wastewater treatment at these sites (described in Ms Buckley's evidence).

Figure 1: Estimated nutrient loads to the Waikato River, % of catchment load and discharge volumes for the five Fonterra manufacturing sites in the Waikato and Waipā catchments for the period 2001 to 2015

Table 3: Trends in TN discharge loads for Fonterra’s point source discharges in the Waikato and Waipā Catchments

Site	P value	SEN slope	% annual change	Comment
Hautapu	<0.001	-2.07	-7	Significant decrease
Lichfield	0.064	0.099	1.5	No trend
Reporoa	0.015	-1.18	-2.0	Significant decrease
Te Awamutu	<0.001	-2.63	-13	Significant decrease
Te Rapa	<0.001	-1.41	-11	Significant decrease

Table 4: Trends in TP discharge loads for Fonterra’s point source discharges in the Waikato and Waipā Catchments

Site	P value	SEN slope	% annual change	Comment
Hautapu	0.042	-0.02	-2.6	Significant decrease
Lichfield	0.009	0.014	4.7	Significant increase
Reporoa	0.051	0.05	1.5	No trend
Te Awamutu	0.315	-0.07	-2.2	No trend
Te Rapa	0.108	0.19	2.5	No trend

5.17 This assessment has demonstrated that the point source discharges from Fonterra’s five manufacturing sites contribute minor proportions of the TN and TP loads in the Waikato and Waipā catchments. Furthermore, the contribution of the sites to the TN load in the Waikato River has decreased significantly based on the long-term analysis because of improvements made to Fonterra's wastewater treatment systems, water re-use and product loss reduction initiatives[5].

5.18 Overall, there has been no statistically significant trend showing a reduction in Fonterra's contribution to the TP catchment load. I consider the main reason for this has been the focus on the management of nitrogen to achieve freshwater outcomes in New Zealand, which is now considered problematic (Abell et al, 2010).

5.19 In recent years, it has been widely recognised that phosphorus is of greater importance than nitrogen for improving the health of freshwater systems (e.g. Schindler et al, 2016), including some of the scientific evidence prepared for the PC1 process by the Technical Leaders Group (e.g. Verburg, 2016; Yalden & Elliott, 2015).

5.20 As a result of the focus on reducing nitrogen discharges in previous years, Fonterra responded by reducing the use of nitrogen-based cleaning chemicals in its manufacturing plants, in favour of phosphorus-based chemicals. Whilst this reduced the TN contribution, the TP contribution remained consistent or increased.

5.21 The emerging importance of phosphorus contributions to the health of the Catchment has resulted in a much greater focus on reducing phosphorus discharges from the manufacturing sites. A recent example of this can be seen at the Te Awamutu site, where reducing TP discharges was a key driver of the $17.1M investment in wastewater treatment system upgrades.

6. WATER QUALITY OFFSETTING

6.1 In the context of water quality, an offset is an action taken to counter-balance a pollutant discharged from a point source (Australian Department of Environment and Heritage Protection, 2017). Water quality offsetting has garnered much interest since the publication of the US

[5] Product loss reduction initiatives have focussed on reducing the volume of dairy product that enters the wastewater system.

Clean Water Act in 1972, which allows offsetting as a tool to manage water quality.

6.2 There may be technological, financial and logistical reasons for offsetting to be a more efficient management approach for some discharges. Furthermore, offsetting may lead to better water quality outcomes (US EPA, 2004) and reduce the overall financial and opportunity cost of achieving improvements in water quality (Corrales et al, 2013). Indeed, water quality offsetting has been a key factor in the success of restoration of the Chesapeake Bay (Stephenson et al, 2010).

6.3 However, the concept of water quality offsetting in PC1 has been conflated with biodiversity offsetting (e.g. paragraph 1109, Section 42A report). Biodiversity offsetting is more complicated than water quality offsetting and controversy remains as to some aspects. For example, the complex and unpredictable nature of biological responses to management activities means biodiversity outcomes are uncertain (e.g. Maron et al, 2016). In contrast, the outcomes of water quality offsetting are more easily quantified through the measurement of discharge loads.

6.4 In addition, and specifically in relation to PC1, the issue of proximity has been raised. For example, in biodiversity offsetting it is frequently considered important that the offset is close to the impact location, as this attempts to maintain or improve biodiversity in the ecological district (or similar geographic construct).

6.5 However, when water quality offsetting, it can be more beneficial to have the offset occur some distance from the impact location. For example, consider a discharge of a contaminant that occurs at Location X. For a variety of reasons, it may be more appropriate for the consent holder to seek to offset that discharge at location Y. If Location Y is upstream of Location X, then the beneficial effect of offsetting this discharge would apply not only to the river downstream of Location X, but also to the river between Location Y and X. In such a situation, offsetting the discharge will result in a beneficial effect over a greater length of river than would have been achieved by reducing the discharge by a similar amount at Location X

6.6 Given the potential positive benefits of such situations, I support the approach to allow offsetting upstream of discharges. Indeed, it could be argued that offsetting upstream of a discharge should be the preferred option (rather than within the same sub-catchment). I consider that this is the reason the Queensland Government policy strongly encourages offsets upstream of the point of discharge (this ensures no decline in water quality between the point of discharge and the offset locations).

6.7 Therefore, I disagree with the analysis in the Section 42A report that states that "*officers consider that additional direction towards the same sub-catchment is warranted"* for offsetting (paragraph 1117). I do note however, that the reporting officers have made no suggested changes to this policy in the tracked changes version (Section 42A report, Appendix 2).

6.8 I support the policy requiring that offsetting should be for the same contaminant (paragraph 1116). I support a change to the reference to *"significant toxic adverse effect"* (paragraph 1115), but prefer the wording proposed in the evidence of Mr Willis (*"significant adverse effects on aquatic life"*). These considerations are fundamental to the offsetting policy proposed by the State of Queensland Government (Department of Environment and Heritage Protection, 2017). That Policy also requires that the offset occurs for the same duration of the activity that is being offset.

6.9 Given the above examples, I disagree with the Forest & Bird submission that states, *“offsets are not appropriate in a water quality context”.* The basis of such a statement is unclear, particularly given the water quality offsetting frameworks that are used operationally in the USA and Australia.

7. CONCLUSIONS

7.1 Point source discharges are a relatively small part of the TN loads to the Waikato and Waipa catchment and around one fifth of the TP load. The contribution of point source discharges from Fonterra's manufacturing sites is a small (i.e. <2% for TP and <1% for TN) and decreasing proportion of the overall catchment nutrient load.

7.2 Water quality offsetting is a management tool that can be used to achieve more effective water quality outcomes, whilst providing opportunities for technical, financial and logistical efficiencies. It is a tool used in water quality management in other countries and the opportunity to use it in the context of PC1 is supported.

8. REFERENCES

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Martin William Neale
3 May 2019

APPENDIX 1

Martin Neale CV

CURRICULUM VITAE | MARTIN NEALE

Director and Lead Scientist

Dr Martin Neale is a founding director and lead scientist at Puhoi Stour. Martin has specialist scientific skills and experience in the application of scientific information to the management of the natural environment.

Martin is an active member of the science community, but he also understands how science can be applied within the environmental management framework in New Zealand to achieve positive outcomes. Martin has led and coordinated a wide range of environmental research and monitoring projects through his roles in regional government, research institutes and more recently, in a commercial consultancy

Qualifications

2004 PhD, Freshwater Ecology, University of Ulster (U.K.)

2000 MSc, Environmental Science, Bournemouth University (U.K.).

1995 BSc (Hons), Biological Sciences, University of Plymouth (U.K.)

Professional positions held

2012 – Present Honorary Lecturer, School of Biological Sciences, University of Auckland

2017 – Present, Director, Puhoi Stour Limited, Auckland.

2016 – 2017 Senior Consultant, MartinJenkins Limited, Auckland.

2015 – 2016 Principal Freshwater Scientist, Golder Associates Limited, Auckland

2013 – 2015 Manager Environmental Science, Research Unit (RIMU), Auckland Council

2007 – 2013 Senior Scientist, Research Unit (RIMU), Auckland Council

2002 – 2007 Freshwater Biologist, Centre for Ecology and Hydrology (U.K.)

Professional distinctions and awards

2013 – 2015 National Objectives Framework expert group (periphyton and invertebrates)

2011 – 2014 National Environmental Monitoring and Reporting expert group member.

2014 – 2015 NPSFM 2014 implementation working group member

2010 to present, Member of Society for Freshwater Science

2007 to present, Member New Zealand Freshwater Science Society

Publications

Total number of *peer reviewed* publications and patents	Journal articles	Books, book chapters, books edited	Conference proceedings	Patents
	17	2	6	0

Selected publications;

Neale, M.W., Storey, R.G. & Rowe, D.K. 2017. Stream Ecological Valuation (SEV): revisions to the method for assessing the ecological functions of New Zealand streams. Australasian Journal of Environment Management. 24, 392-405.

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Fonterra Co-operative Group Ltd

APPENDIX 2

Golder report on Fonterra point source nutrient loads

May 2016

WAIKATO RIVER CATCHMENT

Fonterra's Performance in Reducing Manufacturing Site Nutrient Loads to the Waikato River

Submitted to:
Dave Wright
National consents Manager
Fonterra Limited

REPORT

Report Number. 1540796-001-R-Rev1

Golder Associates

EXECUTIVE SUMMARY

Background

Fonterra Limited hold resource consents enabling it to discharge treated wastewater from five manufacturing sites in the Waikato River catchment. A number of resource consents relating to these activities expire in 2017 and 2019. The applications to renew these resource consents will be considered in an increasingly complex statutory and regulatory environment as a result of recent planning and policy developments. Therefore, Fonterra has commissioned this report to investigate the nutrient loads from the treated wastewater discharges at five sites, focussing on how the loads have changed over time and their contribution to the nutrient loads in the Waikato River catchment.

Fonterra and its service providers have undertaken monitoring of the treated wastewater discharges in accordance with its current resource consent requirements and this monitoring data forms the basis of the analysis undertaken and reported in this report. This monitoring data includes discharge volumes and the concentrations of total nitrogen (TN) and total phosphorus (TP) in the discharges from 1997 to 2015, although the specific information available for each discharge varies. This data was used to estimate the annual nutrient loads for each site consistent with the methodology described by Vant (2014). Formal trend analysis was undertaken to assess changes in nutrient loads over time and the annual loads from each site were compared with published catchment nutrient loads.

Contribution to catchment nutrient load

The contribution of the combined discharges from the five sites is small when compared with the total catchment load. Between 2010 and 2015, the discharges collectively contributed 1.2 % of the total catchment TN load (Figure 1) and 2.9 % of the total catchment TP load (Figure 2).

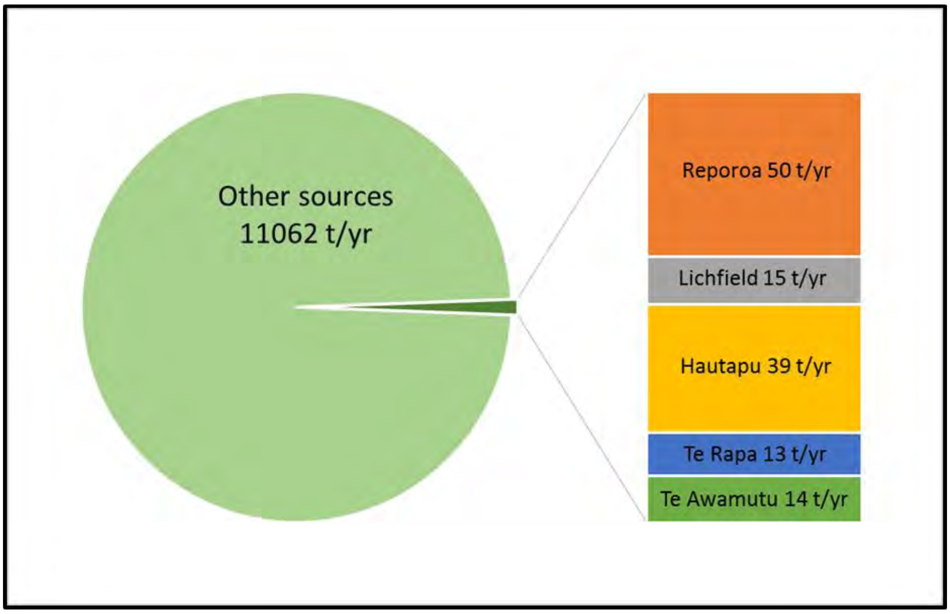

Figure 1: Estimated TN loads for the Waikato River catchment and the contributions of the Fonterra manufacturing sites.

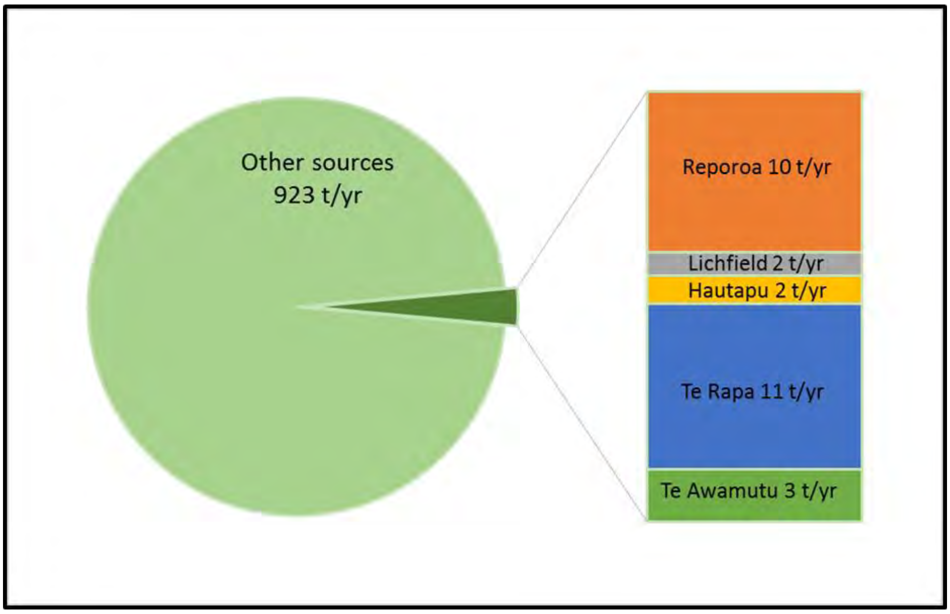

Figure 2: Estimated TP loads for the Waikato River catchment and the contributions of the Fonterra manufacturing sites.

Change over time

The temporal analysis of the discharge load was undertaken using two timeframes because of the availability of monitoring information for some consents. A long term analysis was performed using monitoring data relating to consents that have been held by Fonterra. A short term analysis was also undertaken using monitoring data relating to consents held by Fonterra and those currently or previously held by third parties.

Long term

The long term analysis indicated that the collective TN load from the five sites significantly decreased between 2001 and 2015. The Sen Slope indicated that the TN load decreased by an average of 6.4 % per year over the 15 year period, with the actual load decreasing from 156 t/yr in 2001 to 63 t/yr in 2015. On a site specific basis, significant reductions in TN load were observed at four of the five sites (Reporoa, Hautapu, Te Rapa and Te Awamutu), with the TN load at Lichfield showing no significant change.

The long term trend analysis indicated no significant changes in the collective TP load from the five sites. There was a significant reduction at Hautapu, but an increase at Lichfield resulted in there being no net change in the overall TP load.

Short term

The short term analysis included all discharges from the five sites, irrespective of the consent holder, and focussed on changes since the Vision and Strategy for the Waikato River came into effect in 2010.

The short term analysis indicated decrease in TN and TP loads since 2010. The estimated nutrient loads in 2015 are 10 % lower for TP and 2.3 % lower for TN when compared with 2010. These reduction have been driven by large reductions at the Te Rapa and Te Awamutu sites, whereas the remaining three sites have seen slight increases in nutrient loads. However, the magnitude of the decreases at Te Rapa and Te Awamutu are greater than the increases at the other three sites, resulting in an overall decrease in both TN and TP loads since 2010.

The reductions in nutrient loads since 2010 have been achieved at the same time as the volume of wastewater has increased. There has been a 22 % increase in wastewater volumes since 2010, which provides evidence that the reductions in nutrients loads have arisen because of improvements in the treatment and management of wastewater (rather than a decrease in volume).

Conclusion

It was concluded that the combined treated wastewater discharges from Fonterra's five manufacturing sites contribute a minor proportions of the total catchment TN load (1.2 %) and TP load (2.9 %) in the Waikato River. Furthermore, the contribution of the sites to the nutrient loads has reduced. Of particular relevance are the decreases in TP and TN load that have been observed since the Vision and Strategy came into effect in 2010. Fonterra's continual improvement of wastewater treatment systems and product loss reduction initiatives have also resulted in a significant decrease in the collective TN load over the longer term (15 years).

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1.0 INTRODUCTION

1.1 Report Purpose

Fonterra Limited (Fonterra) owns and operates five dairy manufacturing sites in the Waikato River catchment at Te Rapa, Hautapu, Te Awamutu, Lichfield and Reporoa. These sites receive raw milk from Fonterra's suppliers and process it into products for domestic and international markets. These products include conventional dairy products, such as milk powder, cheese, butter and cream, but also specialist protein based products that are used in the manufacture of infant nutrition products, sport drinks, nutritional supplements, pharmaceuticals and a wide range of processed food products. Fonterra also produces ethanol that is used in the production of food and drink. Fonterra's products are also used for non-food purposes, including casein for use in the manufacture of paper coatings, adhesives and plastics and ethanol that is used for personal care products and industrial applications.

The management of the Waikato River is entering a new phase as a result of the Vision and Strategy for the Waikato River published in 2010. This change is highly relevant to Fonterra in relation to its five manufacturing sites in the Waikato Region that discharge wastewater and associated dairy by-products to land and water.

This report provides an assessment of these discharges and how they contribute to the nutrient loads of the Waikato River, including an assessment of how these discharges have changed over time. Assessing the nutrient loads provides Fonterra with an opportunity to assess the catchment level effects of its manufacturing operations and to demonstrate how it is performing and responding to the changing statutory environment over all of its sites within the Waikato River catchment.

2.0 REGULATORY CONTEXT

2.1 Background

A number of resource consents relating to three of Fonterra's manufacturing sites described above expire shortly, being those permitting discharge to water at Te Awamutu (1 April 2017) and Te Rapa (1 September 2017) and to water and land at Hautapu (31 January 2019). The applications to renew these resource consents will be considered in an increasingly complex statutory and regulatory environment as a result of recent planning and policy developments.

Foremost amongst these is the Vision and Strategy for the Waikato River, which is the primary direction setting document for the Waikato River. The Vision and Strategy, which came into effect on the 25 November 2010, contains a number of objectives and strategies aimed at the restoring the Waikato River, which will be interpreted in the WRC's forthcoming Healthy Rivers: Plan for Change (due for public notification in 2016). The Collaborative Stakeholder Group, which is supporting the development of the Healthy Rivers: Plan for Change, has recently published a policy framework around achieving the Vision and Strategy objectives in stages (Waikato River Authority, 2016). The policy framework outlines a series of interim targets, which aim to deliver the required improvements in water quality in 80 years. These targets aim for a 10 % improvement in 10 years, 25 % in 20 years, 50 % in 60 years and 100 % in 80 years.

Similarly, the recent National Policy Statement: Freshwater Management 2014 (NPSFM) has significantly changed the obligations of consenting authorities by mandating the establishment of limits (for quality and quantity) supported by a National Objectives Framework. Whilst the full implementation of the NPSFM is not required until 2030, the provisions are already being interpreted in a conservative nature by the Environment Court. The NPSFM created an obligation to maintain or improve the overall quality of freshwater (NPSFM Objective A2) and the Ministry for the Environment (MfE) produced guidance outlining an 'unders and overs' approach to achieving this (MfE 2014). However, such an approach has been considered inconsistent with the RMA and unworkable by the Environment Court, which has ruled that water quality should be maintained or improved at the level of individual waterbodies (e.g., Matata Wastewater Discharge (2015 NZEnvC90) and Hawkes Bay plan change (Ngati Kahungunu decision - 2015 NZEnvC50)).

Collectively, these recent changes to the statutory and regulatory environment will increase the scrutiny on the upcoming resource consent applications for Fonterra's sites in the Waikato River catchment and more stringent controls are anticipated for the discharge of contaminants to land and water. There will be an expectation than Fonterra can show how it is managing and reducing the environmental effects of its activities on the Waikato River consistent with the Vision and Strategy.

2.2 Assessment of Effects

Fonterra has commissioned a number of reports to assess the near-field environmental effects associated with renewing the consents for Te Rapa and Te Awamutu. The assessments are site-specific, using upstream and downstream comparisons to assess the effects of a specific site's activities. Whilst such assessments are required for the resource consent process, their site-specific focus means they are limited in their ability to demonstrate Fonterra's environmental performance at a catchment scale and hence overall alignment with the Vision and Strategy.

To enable a Waikato catchment wide assessment, Fonterra has commissioned Golder to review and assess the nutrient loads from the five sites in the Waikato River catchment. Assessing the effects of Fonterra's sites in an integrated manner, rather than individually, will allow Fonterra to assess the catchment level effects of its manufacturing operations and to demonstrate how it is performing and responding to the changing statutory environment over all of its sites within the Waikato River catchment.

Furthermore, being able to compare the relative contributions of each site at a catchment scale provides an opportunity to identify priorities for management interventions that would achieve the greatest environment benefit at the greatest efficiency. Such an approach was highlighted for consideration by Fonterra in a review of the implications of the changing regulatory operating environment (Enfocus 2014), whereby Fonterra could determine how to most efficiently meet any required reduction in nutrient load by distributing the required reductions across its sites in the most cost effective manner. This approach is based on the concept that the source of a contaminant is less important than reducing the overall amount of that contaminant from entering the Waikato River.

2.3 Nutrient Loads in the Waikato River Catchment

The loads and sources of nutrients in the Waikato Catchment have most recently been assessed by Vant (2014). The loads of total nitrogen and phosphorus were estimated to be 11,200 tonnes/year and 950 tonnes/year respectively for the Waikato River catchment. Furthermore, Vant (2014) estimated the proportion of the catchment load of nutrients to natural, diffuse and point sources (Table 1).

Diffuse sources of nitrogen and phosphorus, related to catchment land use practices, were identified by Vant (2014) as the greatest contributors to the catchment loads for both nutrients. In comparison, point source discharges were relatively minor contributors of nutrients to the catchment.

Table 1: Sources of Nitrogen and Phosphorus in the Waikato River Catchment (adapted from Vant (2014)).

	Natural/background	Diffuse	Point	Total
Total Phosphorus	356 (37 %)	425 (45 %)	171 (18 %)	951
Total Nitrogen	3623 (32 %)	6840 (61 %)	730 (7 %)	11,193

Note: Units are tonnes/year (t/yr).

The analysis undertaken by Vant (2014) provides a high level assessment of some of the sources of nutrients in the Waikato River catchment, including some Fonterra discharges, but it does not, and was never intended to provide a detailed assessment of the discharges from Fonterra's five manufacturing sites in the catchment and how they have changed over time. In relation to assessing Fonterra's discharges, the key limitations of the data presented in Vant (2014) are;

- For industrial discharges, the work was focused on point source discharges to water, so does not document the specific contributions from the two Fonterra sites that discharge wastewater to land only (Lichfield and Reporoa), nor the land based discharges from Hautapu.
- The data used for the three Fonterra sites that discharge to water was restricted to six year periods (2007-12 for Te Rapa; 2008-13 for Te Awamutu; 2006-11 for Hautapu), so does not capture long term changes in discharge loads outside of these time periods.
- The analysis reported an average nitrogen and phosphorus discharge load for the specific time periods described above for the three Fonterra sites that discharge to water, so does not document change over time.

3.0 REPORT SCOPE

In order to comprehensively understand the nutrient loads to the Waikato River catchment from dairy wastewater discharges from Fonterra's manufacturing sites, Fonterra commissioned Golder Associates (NZ) Limited (Golder) to review the available consent monitoring data for the five manufacturing sites within the catchment and their wastewater discharges to water (Te Rapa, Te Awamutu and Hautapu) and land (Hautapu, Lichfield and Reporoa).

This consent monitoring data is used within this report to:

- Estimate the nutrient loads from the discharges from the five sites and how they have changed over time
- Estimate how the discharges from these sites, collectively and individually, contribute to the nutrient loads in the Waikato River.
- Assess Fonterra's manufacturing sites against the water quality improvements likely required under the Vision and Strategy.

4.0 FONTERRA MANUFACTURING OPERATIONS

4.1 Background

4.1.1 Wastewater characterisation

The processing of milk into various secondary products results in a range of wastewater and by-products that require disposal. These waste streams are classified into low strength and high strength based on the chemical composition of the water.

Low strength wastewater typically arises from:

- Condensate from milk dryers
- Cooling water
- Boiler water
- Reverse osmosis permeate
- Plant rinses and 'clean in place' (CIP) processes used to maintain food hygiene standards

High strength wastewater[1] includes:

- Sludges and biomass from wastewater treatment facilities
- Excess or out of specification dairy products
- Silo and tank sediments
- Dairy product losses

These waste streams are characterised by different concentrations of chemical constituents, of which for this report, total nitrogen (TN) and total phosphorus (TP) are of interest. Low strength wastewater typically has TN and TP concentrations of less than 100 g/m^3 and 80 g/m^3 respectively. In contrast, high strength wastewater has TN and TP concentrations of up to 11,000 g/m^3 and 3,600 g/m^3 respectively. Low and high strength wastewater is managed differently according to the environmental risks associated with the different composition.

4.1.2 Wastewater management

The TN and TP in the waste streams is largely attributable to two sources; milk (and products derived from it) and clean-in-place (CIP) acid and caustic cleaning solutions. Milk contains phosphorus and nitrogen, indeed milk is an important dietary source of these nutrients and associated amino acids. TN and TP from milk in wastewater streams represents a loss of product for Fonterra and reducing milk losses is an objective of ongoing efficiency initiatives. Fonterra also ensures manufacturing plant and pipework is clean to meet NZ Food Safety Authority regulations. The cleaning solutions that are suitable for this purpose are typically nitric and phosphoric acid based and hence their use in cleaning processes results in TN and TP entering the wastewater streams.

Fonterra has a number of mechanisms in place to reduce the TN and TP content of its wastewater streams. The first two involve preventative measures to reduce the amount of TN and TP entering wastewater. The first involves ongoing initiatives to reduce milk and products entering the waste stream. The approach taken in wastewater management is to maximise the recovery of milk solids, while keeping the wastewater volumes generated to a minimum. This represents a win-win situation whereby financial losses associated with lost product and the nutrient load in the wastewater are both reduced. The second source control initiative is to reduce the use of nitric and phosphoric acid based cleaning products and Fonterra continues to trial alternative cleaning products to reduce the TN and TP loading from this source.

Once the TN and TP are in the wastewater, treatment approaches are used to reduce the nutrient concentrations in the wastewater. At a high level, this is achieved using two different approaches (sometimes in combination). Dissolved Air Flotation (DAF) is used to remove solids, fats and protein from the waste. Air is dissolved into the wastewater under pressure and is then released at atmospheric pressure in the flotation tank. The released air forms tiny bubbles which adhere to the suspended solids, fats and proteins, which float to the surface of the water and are mechanically removed.

Biological wastewater treatment systems are used at some sites. Biological treatment utilises microbiological action (under aerobic and anaerobic conditions) to consume the biodegradable contaminants in the wastewater. This results in the contaminants being removed from the water through biological processes and results in the assimilation of contaminants into biological matter (which is removed for disposal) and gaseous release of nitrogen and carbon dioxide. Both DAF and biological treatment options result in waste products (sludges) that are high in organic matter and nutrients. These are typically spread on land to provide nutrients for plant growth and replace the use of conventional fertilisers.

Depending on the wastewater management approach, each of the Fonterra manufacturing sites relies to varying degrees on surface water and land for the disposal of dairy manufacturing site wastewater. Many of Fonterra's manufacturing sites throughout New Zealand irrigate high strength wastewater (termed dairy

[1] When it is irrigated to land as a fertiliser replacement, high strength wastewater is referred to as 'dairy liquids' by Fonterra and WRC

liquids) onto farmland. This recycled wastewater contains nutrients at levels useful to promote pasture growth and is intended to replace the use of conventional fertilisers.

The focus of this report is those waste streams produced during the processing and manufacturing of dairy products and therefore other types of discharge (e.g., stormwater or human sewage) are generally excluded from the report. However, it should be noted that some sites have a combined wastewater and condensate/cooling water and stormwater discharge (e.g., Te Rapa and Te Awamutu). These low strength wastewaters such as condensates and stormwater contributes to the discharge volumes and nutrient loads at these sites. This should be borne in mind when considering the discharge volumes presented later in this report as these streams are not separately monitored.

4.2 Discharge Consents

Fonterra holds a range of consents for the five manufacturing sites that permit the discharge of wastewater to land and water in the Waikato River catchment. Historically, discharges from the five manufacturing sites have been carried out under the provisions of consents held by Fonterra and a number of other organisations, including Civil Whey Limited, D. A. Civil Limited and Central Transport Limited (CTL).

Relying on consents held by third parties for the discharge of its wastewater has been recognised as a risk by Fonterra, and in recent years most of the activities previously authorised by third party consents have been integrated into Fonterra's operations. This is evidenced by the acquisition of Civil Whey Limited and subsequent integration into Fonterra's operations through the creation of DairyFert, a wholly owned Fonterra subsidiary, in 2013. Similarly, the discharges previously carried out under consents held by CTL have recently been incorporated into DairyFert's region-wide consent (from 2016). There is only one discharge remaining that is carried out pursuant to a consent not held by Fonterra (D.A. Civil at Hautapu – see Section 4.2.2).

For the purposes of this report, the consents that have previously been held by organisations other than Fonterra have been termed 'third party' consents. This is because for the majority of the temporal scope of the report, these discharges have been permitted by consents not held by Fonterra.

The discharges permitted by Fonterra held consents and those held by third parties are both included in this report where possible, but the information available about the discharges differs between the two types of consent. This is because the provisions of third party consents, in particular the monitoring and reporting requirements, have been different from those held by Fonterra. Furthermore, the availability of the monitoring data collected under the provisions of the third party consents, which is not held in Fonterra's databases, is typically less than that for the Fonterra held consents. This issue is described in more detail in Section 5.1.

4.3 Site Descriptions

4.3.1 Reporoa

The Fonterra Reporoa site was established by the NZ Dairy Group in 1968 and is located on State Highway 5 between Rotorua and Taupo. It is a protein manufacturing site which at the peak of the season can process 2,300 m^3 of whole milk per day. Reporoa utilises land based disposal options for all of its wastewater, which is separated into two streams, high strength wastewater and low strength wastewater.

Low strength wastewater, which is mainly from process wash water and water used for cleaning processes on site, is collected into two silos and irrigated to nearby farmland using a fixed irrigation system. Fonterra holds consent to irrigate wastewater to three farms under Waikato Regional Council (WRC) consents 122961 (Reporoa Farm) and 110875 (Brennan and Leslie Farms). Collectively the two consents provide for up to 7,050 m^3 per day (3,250 m^3 at Reporoa Farm and 3,800 m^3 at Brennan and Leslie Farms).

The high strength wastewater (including whey, excess lactalbumin serum, yeast and sludges) is collected into a separate high strength waste silo and is trucked off site and applied to farmland as a replacement for conventional fertiliser. The high strength wastewater operation is managed by CTL. This has been carried out under consent number 111894 held by CTL up to the 2015 season, but from the 2016 season onwards will be covered under DairyFert's Waikato region-wide consent (AUTH132172.01.01).

4.3.2 Lichfield

The Lichfield site was constructed in 1995 and is located on State Highway 1, south of Putaruru. It is Fonterra's biggest cheese plant and able to process up to 3,200 m^3 of milk per day. Lichfield utilises land based disposal options for all of its wastewater, which is separated into two streams, low strength wastewater and high strength wastewater (which is further separated into process wastewater and dairy by-products).

Low strength wastewater, including condensate, cooling water and permeate, is directed into a series of three constructed wetlands. After being treated through the wetlands, the discharges infiltrate into ground in an overland flow system below the wetland. There is no discharge to surface water. The discharge of 1,000 m^3/day of low strength water has been provided for by consent 109425 held by DairyFert, but from the 2016 season onwards will be covered by the Fonterra held consent AUTH132861.04.01.

Process wastewater, including excess low strength wastewater and cleaning water, is treated using a DAF treatment device and then irrigated to nearby farmland to replace the use of fertilisers. Fonterra holds consents to irrigate wastewater to five farms under WRC consents 940313 (Anchor Farm (Consent AUTH132861.03.01 from 2016)) and 113312 (Woods, Ash, Skinner and The Crossing farms – collectively known as the 'Pod' farms). Collectively the two consents provide for up to 8,320 m^3 per day (4,920 m^3 at Anchor Farm and 3,400 m^3 at the Pod farms).

Dairy liquids, including wastewater sludges, tank and silo sediments and unprocessable dairy products, are exported by DairyFert to a number of farms and irrigated under the provisions of three consents (111394 (General – replaced by AUTH132172.01.01 from the 2106 season), 130347 (Pinedale) and 105884 (Waratah Block)).

The current land disposal operations from Lichfield have been operating since 2006. Prior to this date, land disposal was carried out on 215 ha of farmland under an agreement with the Lichfield Land Irrigation Company (authorised by WRC consent 940313) which ceased 31st May 2006.

4.3.3 Hautapu

The Fonterra Hautapu site commenced operations as a creamery in 1886 and is located on State Highway 1B, north of Cambridge. It is a multi-purpose manufacturing site, processing up to 4,000 m^3/day of milk. Wastewater from the site is discharged to water (low strength wastewater) and irrigated to land (high strength wastewater and treatment sludges).

Low strength wastewater, primarily permeate, condensate and plant flushes, is chlorinated to prevent microbial growth and discharged to the Waikato River via a 7 km pipeline from the factory to the river downstream of Cambridge. Fonterra holds consent to discharge 2,500 m^3/day of low strength wastewater to the Waikato River (WRC consent 961133).

Prior to 1968, all wastewater arising from the site was discharged directly to the Mangaone Stream. In 1968, the site introduced pioneering farm spray irrigation of dairy factory wastewater onto nearby farmland and has expanded this method of disposal over time. Fonterra currently holds consent to irrigate dairy liquids to nine farms under WRC consents 110637 (Buxton Farm, 1,920 m^3/day), 961142 (Bardowie and Bruntwood Farms, 4,600 m^3/day) and 121131 (Chamberlain, Chamberlain West, West, Shaw, Wiseman and King Farms, 250 m^3/ha/day). Depending on their origin from within the factory, some of this wastewater is treated before land disposal using either DAF or Sequential Batch Reactor (SBR – a simple form of biological treatment)).

High strength sludges from the treatment devices and other high strength waste (e.g., tank sediments) from the manufacturing plant are pumped to the DairyFert compound where it is applied to land as a fertiliser by DairyFert or D. A. Civil to a number of farms under the provisions of four consents (111394 (General), 130347 (Pinedale), 124575 (Walsh) and 133218 (Fencourt)).

4.3.4 Te Rapa

The Te Rapa site was established in 1967 and is located between State Highway 1 and the Waikato River just downstream of Hamilton. It is one of Fonterra's largest sites, processing up to 8,000 m^3/day of milk into milk powder and cheese.

Wastewater is treated on site and discharged to the Waikato River under a Fonterra held consent that permits the discharge 29,500 m^3/day of treated wastewater and low strength wastewater to the Waikato River (WRC consent 970032).

Low strength wastewater streams, including stormwater, condensate and cooling water, contain low levels of contaminants and are therefore directed into a mixing pond on site with no treatment apart from the settling that occurs in the drainage system. These streams are continuously monitored and are diverted to the on-site treatment plant if contamination is detected. Low strength streams are mixed with treated wastewater in this pond before being discharged to the Waikato River.

All higher strength wastewater, including process wastewater, product losses and cleaning water, is treated on site. The onsite wastewater treatment plant consists of primary (DAF) and secondary (biological) treatment systems. The secondary treatment system has been subject to various upgrades since its initial construction, including a 500m^3 anoxic selector in 1999, and a 3000m^3 anoxic tank in 2002. In 2010, a system was installed for the purpose of introducing high strength waste to ensure that there was sufficient loading to the biological plant (for denitrification). Under-loading of the WWTP had arisen from a number of loss reduction measures implemented within the production plants which reduced wastewater loads significantly. In 2011 two decanters were installed at Te Rapa for dewatering of waste activated sludge (WAS) and DAF sludge, to reduce the volume discharged to land across the Waikato. Alum dosing is also undertaken intermittently to manage the phosphorus load in the discharge.

Small volumes of treatment sludges from the treatment activities are irrigated to land by DairyFert to a number of farms under the provisions of WRC consents 111394 (General), 130347 (Pinedale), 124575 (Walsh).

4.3.5 Te Awamutu

The Te Awamutu site commenced operations around 1915 and is located on Alexandra Street in the town of Te Awamutu. It can process up to 4,800 m^3/day of milk per day into powders, butter and anhydrous milk fat.

Wastewater is treated on site using a biological treatment system and up to 12,500 m^3/day of treated wastewater is discharged to the Mangapiko Stream under the provisions of WRC consent 105421. The Mangapiko Stream is a tributary of the Waipa River, which ultimately flows into the Waikato River at Ngaruawahia.

With the exception of evaporator condensate, all low and high strength wastewater streams are treated on site. The biological treatment is an extended aeration activated sludge process, comprising two aerated ponds operating in series followed by two clarifiers in parallel.

Treatment sludges from the treatment plant and other dairy liquids are irrigated to land by DairyFert to a number of farms under the provisions of WRC consents 111394 (General), 130347 (Pinedale), 124575 (Walsh).

5.0 DATA SOURCES AND ANALYSIS

5.1 Data Availability

5.1.1 Introduction

All of the consents relating to the discharges described above require monitoring of the volume and composition of the wastewater discharged and this consent compliance monitoring data forms the basis of the analysis presented in this report. The specific requirements for monitoring vary amongst the discharge types and sites, and have evolved over time as consents and the conditions contained therein have changed. Therefore, there are differences in the type of monitoring undertaken amongst the sites and years, including variability in parameters measured, their frequency and length of data record.

It should be noted that the years used in this report refer to the dairy reporting season, rather than calendar years. Thus, 2001 or F01 refers to the dairy season 2001, which runs from 1 July 2000 to 30 June 2001, similarly 2015 or F15 refers to the dairy season 1 July 2014 to 30 June 2015

5.1.2 Fonterra consents

For the Fonterra held consents, there is a greater consistency in the monitoring undertaken (i.e., similar parameters and frequency) and in the reporting of the results of such monitoring (i.e. standard monthly or annual monitoring reports). Regular and consistent monitoring of discharge volumes and the concentration of total phosphorus and total nitrogen has been undertaken for these consents and therefore a complete dataset for all discharges permitted under consents held by Fonterra is available from 2001 onwards (i.e., 15 years).

Prior to 2001, data is available for only some of the sites (Table 2). The complete 15 year dataset is used to assess the total nutrient load permitted under consents held by Fonterra for its Waikato manufacturing sites and how it has changed over the longer term (Section 3.1). Where data exists prior to 2001, this data is used in the site specific analysis (Section 3.2). .

Table 2: The length of monitoring data record for discharges permitted by consents held by Fonterra.

Site	Water discharges	Land discharges
Reporoa	No discharge to water	1998 – 2015
Lichfield	No discharge to water	1996 – 2015
Hautapu	2001 - 2015	2001 – 2015
Te Rapa	1998 - 2015	Not applicable (see note)
Te Awamutu	1997 - 2015	Not applicable (see note)

Note. There are no land based discharges from Te Rapa and Te Awamutu that have been carried out under a consent held by Fonterra, but land based discharges have occurred under the provisions of third party consents as described in sections 4.3.4 and 4.3.5.

5.1.3 Third party consents

As described in Sections 4.2 and 4.3, discharges of wastewater from the Fonterra manufacturing sites have also been permitted by consents held by third parties. Notwithstanding that these activities are now largely covered directly by consents held by Fonterra, the monitoring and reporting previously undertaken for these consents is more variable than that for the consents held by Fonterra in longer term. Furthermore, the availability of historical monitoring data and reports is limited as the information resources are not held in Fonterra's databases.

As a result, the length of available data record for these discharges that can be reliably attributed to each of the Fonterra manufacturing sites is less than that for consents held by Fonterra. As a consequence, it has only been possible to source consistent data for these consents from 2010 onwards. Therefore the nutrient load information from these consents is restricted to the recent assessment of Fonterra's catchment nutrient load reported in section 4 (2010 – 2015) and is not included in the longer term analyses.

5.2 Data Analysis

5.2.1 Discharges to water

The monitoring data for all discharges to water includes regular measurements of volume discharged (m^3/day) and a concentration for total phosphorus and total nitrogen (measured weekly or monthly, but reported as annual mean) in the discharged water. This information was used to calculate a consistent set of discharge concentrations, daily and annual loads consistent with the methodology used by Vant (2014).

The majority of this information was sourced from annual monitoring reports required for each site under consent conditions. However, the annual report for Te Rapa did not contain information in a form that could be used for this analysis and therefore the information was sourced from the monthly monitoring reports that are required by WRC. This data was used to calculate annual loads derived from summing monthly load calculations.

To provide the catchment context for the nutrient loads for the discharges to water, the annual loads from each site were compared with the total catchment loads and point source contributions for each nutrient (Vant, 2014).

5.2.2 Discharges to land

5.2.2.1 Introduction

The monitoring data for all discharges to land includes regular assessments of volume discharged (season total) and concentrations for total phosphorus and total nitrogen (measured weekly or monthly, but reported as annual mean). This information was used to calculate an annual load of TP and TN that is applied to land.

The assessment of potential losses of nutrients to water arising from land discharges is more complex than that for discharges to water. For the discharges to water, the entire nutrient load of the discharge is transferred directly to the water body in which it is discharged. In contrast, the contribution of land discharges to the nutrient load in a water body is complicated by two factors;

- Land application of wastewater is intended to replace the use of fertilisers. As such, the nutrients in the wastewater that is applied to land are utilised by plants growing on the land, incorporated into products (either plant or animal tissue) and removed from the land, and some is retained in the soil.
- Not all nutrients that leach below the root zone reach a surface water body. This is because nutrients are subject to gaseous losses, retained in soil strata or in groundwater unconnected to surface water, or taken up by deep rooted vegetation between the root zone and water body.

In combination, the two factors described above result in only a proportion of the nutrient load applied to land contributing to the nutrient loading to the Waikato River. To account for these two processes and estimate the nutrient loss to the Waikato River, two additional calculations were used for the nutrient loads applied to land.

5.2.2.2 Approach to land based discharges

The approach taken to estimate the load to surface water from land-based discharges is summarised below, with the detailed approach to each step described in Appendix A;

1) The annual nutrient load to land (L) is calculated using volume and concentration monitoring information.

2) The proportion (P) of L that is lost from the farm is estimated using results from OVERSEER® analysis. ($L * P$)

3) The proportion of the farm losses ($L * P$) that reach the Waikato River are estimated using a transmission factor (T), thus nutrient load to the river = ($L * P$) *T.

As a result of the assumptions and caveats associated with the two analysis steps described above, it is recognised that whilst the volume of wastewater and nutrient loads (*L*) applied to land can be confidently described, there is a greater degree of uncertainty in the estimates of potential losses to water for both TN and TP from land based discharges of wastewater.

Given these assumptions and caveats, it is recommended that the estimated nutrient loads to water that are derived from the analysis of land discharges are used to indicate relative changes in those loads, rather than being used to quantify absolute loads.

To provide the catchment context for the nutrient loads for the discharges to land, the annual loads from each site were compared with the total catchment loads and diffuse source contributions for each nutrient (Vant, 2014).

5.2.3 Discharge to wetland

There is a single discharge of low strength wastewater to a series of treatment wetlands at the Lichfield site. After treatment in the wetlands, the water infiltrates into the ground through an overland flow system. The treated wastewater flows (termed effluent) from the wetland are monitored for volume and TP and TN concentrations. This information was used to calculate the nutrient loads exiting the wetland and the transmission factors for TN and TP (Clothier et. al. 2007) were used to estimate the proportion of the load that would reach the Waikato River.

5.2.4 Trend analysis

Changes in discharge loads over time were assessed using the Mann Kendall Trend test (Time Trends V3.31, NIWA, New Zealand), one of the most commonly used non-parametric methods of detecting trends statistically. The Mann-Kendall test involves computing a statistic S, which is the difference between the number of pairwise slopes that are positive minus the number that are negative. If S is a large positive value, then there is evidence of an increasing trend in the data. If S is a large negative value, then there is evidence of a decreasing trend in the data.

Trends are described using Sen Slope values, which are the median slope of all possible pairs of values (Smith et al. 1996) and indicates the magnitude and direction of the relationship. The Sen Slope is similar to a regression line, and represents the average change through the course of the data record. Hence, the statistics derived from the Sen Slope may not equate to the difference between the first and last values in the dataset. The Sen Slope values are in the same units as the data (in this case tonnes/year (t/yr)) and the analysis also provides the percentage annual change over the length of the data record. Statistical significance is indicated by P-values for the analysis of the long term datasets, determined at $P < 0.05$.

6.0 NUTRIENT LOADS FROM FONTERRA SITES

6.1 Introduction

This section of the report contains an assessment of the nutrient loads for the discharges from the five Fonterra manufacturing sites in the Waikato River catchment, which is structured into two sections.

Section 6.2 summarises the long term changes in estimated nutrient loads arising from Fonterra's manufacturing operations in the Waikato River catchment for those discharges permitted under consents held by Fonterra. It should be noted that this excludes those discharges that are permitted under consents that are not held by Fonterra (i.e., third party consents). The Fonterra overview (Section 6.2.1) covers a period of 15 years (2001 to 2015). As previously described, this analysis is limited to 15 years because a complete set of data from all Fonterra held consents is available for this timeframe. The site specific results (Section 6.2.2) include all available data for each site.

Section 6.3 documents the discharges from the Fonterra sites, including those discharges undertaken pursuant to third party consents, since 2010 to provide an assessment of the changes that have occurred since the Vision and Strategy for the Waikato River came into effect.

6.2 Fonterra Consented Discharges

6.2.1 Fonterra overview

6.2.1.1 Catchment contribution

The estimated nutrient loads to water and the percentage of the total Waikato river catchment load are shown in Figure 3 for the five manufacturing sites in the Waikato River catchment. The same data is shown in Appendix B, but with the contribution shown by discharge type (water or land) rather than by site.

The results provide an assessment of the contribution of Fonterra's five manufacturing sites to the total nutrient loads to the Waikato River catchment. Over the 15 year period, Fonterra discharges have contributed an estimated 1.83 % and 0.82 % of the total annual catchment loads for TP and TN respectively.

Discharges to water account for the majority of the discharge volume (Appendix B), comprising 76 % of the volume, 77 % of the TP load and 54% of the TN load in 2015 (Table 3). The discharges to land contribute a disproportionate amount of the TN load (46 %) when compared to the contribution to the discharge volume (24 %), which reflects that more high strength wastewater is discharged to land.

Table 3: Summary of the land and water discharges to the total Fonterra discharges (2015 data).

Discharge type	Discharge volume	TP load	TN load
Land	2,836,135	3.66	28.72
Water	8,856,360	12.07	33.91
Total	**11,692,495**	**15.73**	**62.64**

Notes. Units are m^3/yr for volume and t/yr for nutrient loads.

6.2.1.2 Site contributions

Discharge volume and TP load to water is dominated by Te Rapa, contributing 61% of the total Fonterra discharge and 56 % of the TP load to water in 2015 (Table 4). Despite this relatively high volume, the TN discharge from Te Rapa is relatively low proportion of the total Fonterra discharge (17 %), which may be a consequence of the barometric leg water being part of the Te Rapa discharge. In contrast, the Hautapu site contributed 17 % of the discharge volume in 2015, but 46% of the collective TN load.

Table 4: Summary of site contributions to the total Fonterra discharge (2015 data).

Site	Discharge volume	TP load	TN load
Reporoa	568,568	2.63	8.41
Lichfield	709,363	0.40	6.69
Hautapu	1,962,259	1.14	28.95
Te Rapa	7,109,105	8.90	10.34
Te Awamutu	1,343,200	2.66	8.25
Total	**11,692,495**	**15.73**	**62.64**

Notes. Units are m^3/yr for volume and t/yr for nutrient loads.

Figure 3: Estimated nutrient loads to the Waikato River, % of catchment load and discharge volumes for the five sites in the Waikato River catchment for the period 2001 to 2015.

6.2.1.3 Total nitrogen

The key temporal result from this catchment wide analysis of all Fonterra-consented discharges is the highly statistically significant decrease in TN loads for discharge to water and total discharge (combined land and water) (Table 5). The Sen Slope from the trend analysis shows that the estimated total TN load has decreased by 5.5 t/yr or 6.4 % per year over the course of the data record. The actual collective TN load from the Fonterra sites has decreased from 156 t/yr in 2001 to less than 63 t/yr in 2015.

The volume of discharged wastewater has been relatively stable over this time period with no strong increasing or decreasing trends, indicating that the decrease in TN load has arisen because of reductions in the TN concentration in the discharges, rather than a reduction in discharge volume. This is an important finding as it indicates that the reductions in TN load to the river have been achieved by reducing the losses of milk products and cleaning chemicals during manufacturing and improving the performance of the WWTPs.

6.2.1.4 Total phosphorus

The TP load does not show a statistically significant change, although the trend analysis indicates a minor increase over the 15 year period (Table 5). The result for TP is in part due to the unusual results obtained in the 2010-11 season, where Te Rapa and Te Awamutu recorded higher than average TP loads.

Table 5: Mann-Kendall trend analysis for nutrient loads to water from Fonterra's five Waikato manufacturing sites (2001 to 2015).

Discharge	Parameter	S	P	SEN slope	% annual change	Comment
Water	TP	27	0.198	0.12	1.10	No trend
Water	TN	-91	**<0.001**	-5.20	-9.58	**Significant decrease**
Land	TP	1	1.000	0.002	0.06	No trend
Land	TN	-29	0.166	-0.24	-0.85	No trend
Total	TP	17	0.322	0.16	1.00	No trend
Total	TN	-87	**<0.001**	-5.48	-6.37	**Significant decrease**

6.2.2 Site specific assessments

6.2.2.1 Reporoa

Fonterra holds consent for the discharge of wastewater from the Reporoa site to land and monitoring data is available from the 1998 season (18 years). There have been no significant changes in discharge volumes and estimated TP loads from the Reporoa site. (Figure 4).

The key temporal result from the Reporoa sites is the statistically significant decrease in TN loads (Table 6). The Sen Slope from the trend analysis shows that the TN load has decreased by 0.18 t/yr or 1.96% per year over the course of the data record. The actual TN load has decreased from 14.8 t/yr in 1998 to 8.4 t/yr in 2015.

Over the 18 year period, Reporoa discharges have contributed an estimated 0.35% and 0.09% of the total catchment annual loads for TP and TN respectively.

Table 6: Mann-Kendall trend analysis for nutrient loads to land from the Reporoa manufacturing site (1998 to 2015).

Discharge	Parameter	S	P	SEN slope	% annual change	Comment
Land	TP	33	0.051	0.051	1.528	No trend
Land	TN	-65	**0.015**	-0.184	-1.961	**Significant decrease**

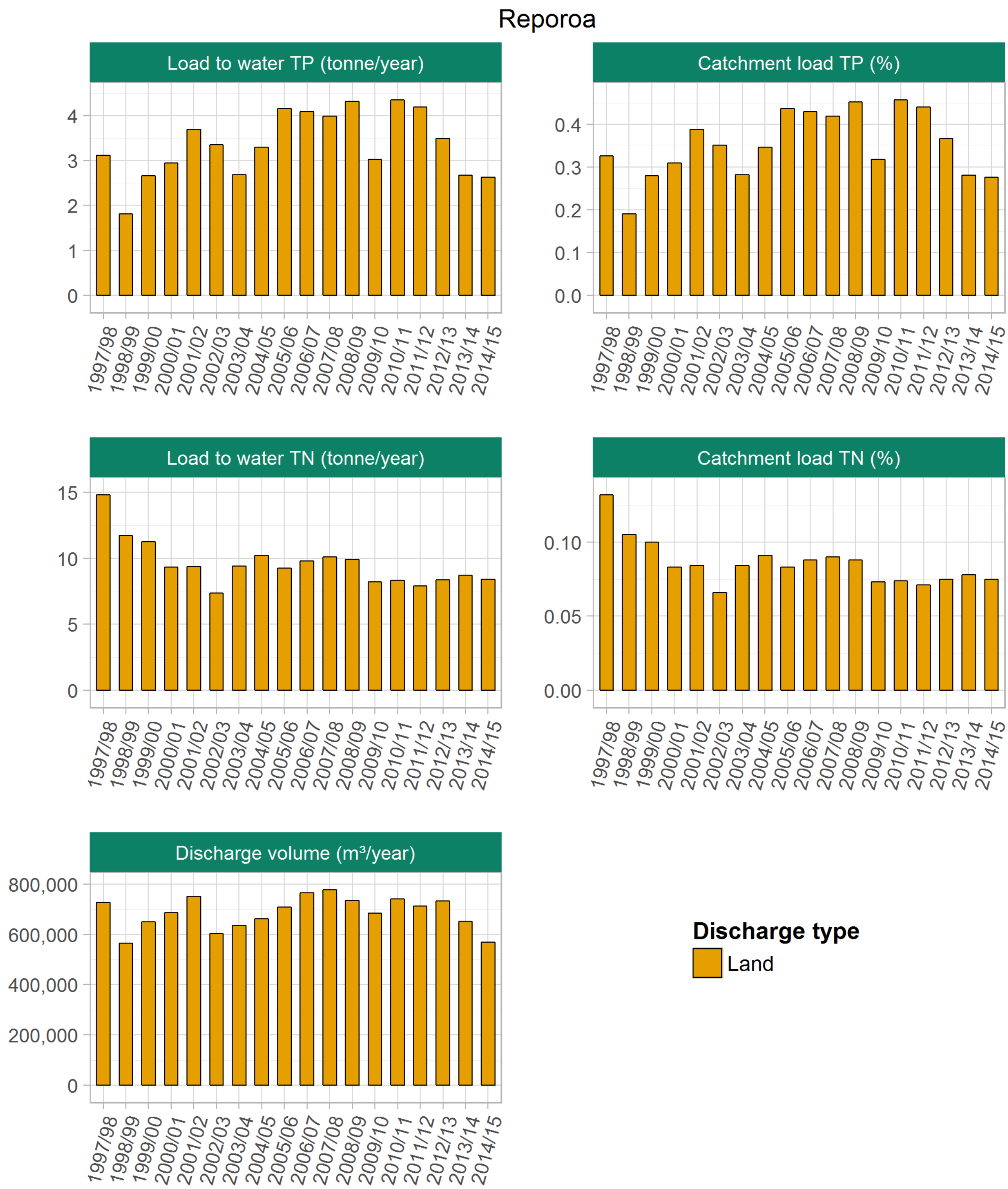

Figure 4: Estimated nutrient loads to the Waikato River, % of catchment load and discharge volume for the land based discharges from the Reporoa manufacturing site for the period 1998 to 2015.

6.2.2.2 Lichfield

Fonterra holds consent for the discharge of wastewater from the Lichfield site to land and monitoring data is available from the 1996 season (20 years). The discharge volumes during this time have increased (Figure 5).

The key temporal result from the Lichfield site is the statistically significant increase in TP loads (Table 7). The SEN Slope from the trend analysis shows that the TP load has increased by 0.014 t/yr or 4.67% per year over the course of the data record. The actual load increased from 0.18 t/yr in 1996 to 0.4 t/yr in 2015. The increase in TP load has been driven by the increase in volumes discharged to land as a result of increased milk processing capacity at the Lichfield site, rather than any increase in the concentration of TP in the irrigated wastewater. Indeed, the wastewater concentration for TP has decreased over the course of the date record from 119 g/m^3 in 1996 to 64 g/m^3 in 2015 (Figure 15 in Appendix B).

The TN load from Lichfield has remained stable, with no significant trend identified.

Over the 20 year period, Lichfield discharges have contributed an estimated 0.03 % and 0.06 % of the total catchment annual loads for TP and TN respectively.

Table 7: Mann-Kendall trend analysis for nutrient loads to land from the Lichfield manufacturing site (1996 to 2015).

Discharge	Parameter	S	P	SEN slope	% annual change	Comment
Land	TP	20	**0.009**	0.014	4.67	**Significant increase**
Land	TN	20	0.064	0.099	1.536	No trend

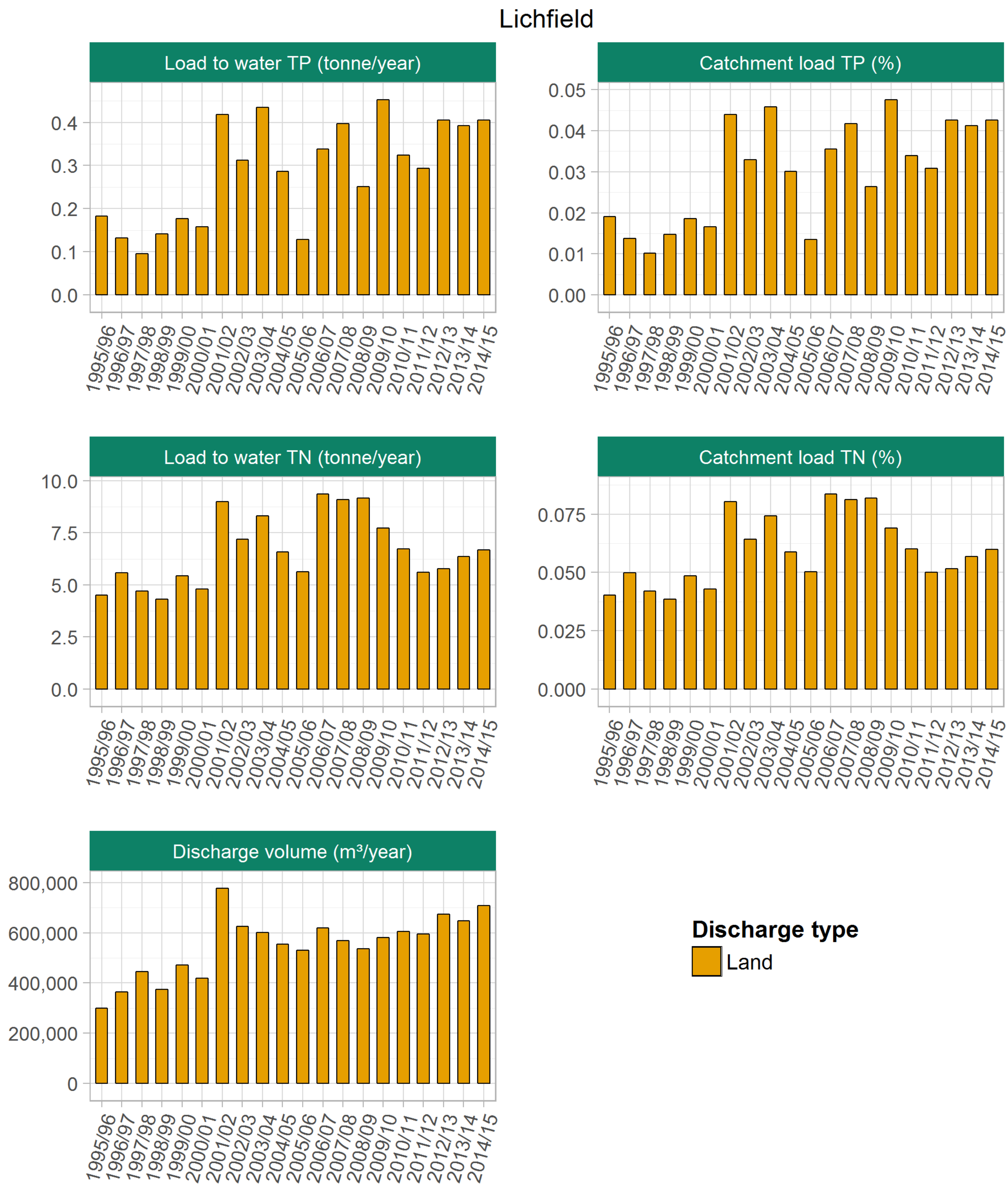

Figure 5: Estimated nutrient loads to the Waikato River, % of catchment load and discharge volume for the land based discharges from the Lichfield manufacturing site for the period 1996 to 2015.

6.2.2.3 Hautapu

Fonterra holds consent for the discharge of wastewater to both land (irrigation) and to water (low strength water to the Waikato River) from Hautapu and monitoring data is available for both from the 2001 season (15 years). The discharge volumes during this time have remained stable (Figure 6). Figure 5 shows the combined information for the land and water discharges from Hautapu. The information is shown separately for the two discharge types in Appendix C (Figures 14 to 17).

The trend analysis for the Hautapu site shows a highly statistically significant decrease in estimated TN and TP loads (Table 8). The TN load from all discharges decreased from 62 t/yr in 2001 to 29 t/yr in 2015 and the TP load decreased from 1.8 t/yr in 2001 to 1.1 t/yr in 2015. The Sen Slope from the trend analysis shows that the TN load has decreased by 2.17 t/yr or 5.1 % per year over the course of the data record and TP load by 0.04 t/yr or 2.9 % per year.

For the discharge to water, the estimated TN load has decreased from 48 t/yr in 2001 to 15 t/yr in 2015 and the TP load decreased from 0.8 t/yr in 2001 to 0.5 t/yr in 2015. The Sen Slope from the trend analysis shows that the TN load to water has decreased by 2.07 t/yr or 6.99 % per year over the course of the data record and TP load by 0.02 t/yr or 2.63 % per year.

For the discharges to land, the estimated nutrient loads do not show a significant trend, however the analysis indicates that estimated nutrient loads to land have decreased slightly over the period 2001 to 2015. The TN load was 0.98 t/yr in 2001 compared with 0.62 t/yr in 2015 and the TP load was 0.98 t/yr in 2001 compared with 0.62 t/yr in 2015.

The decreases in estimated nutrient loads from Hautapu are largely a result of decreases in the discharge loads to water, but it is important to note that the trend analysis also indicates a non-significant decrease in loads from land discharges of both nutrients. This indicates that the decrease in load to water has not occurred because of an increase in loads to land (for Fonterra held consents). Fonterra holds consent to discharge wastewater to eight farms and the nutrient load from each of these since 2001 is provided in Table 9.

Over the 15 year period, Hautapu discharges have contributed an estimated 0.14 % and 0.37 % of the total catchment annual loads for TP and TN respectively.

Table 8: Mann-Kendall trend analysis for nutrient loads to water and land from the Hautapu manufacturing site (2001 to 2015).

Discharge	Parameter	S	P	SEN slope	% annual change	Comment
Water	TP	-42	**0.042**	-0.02	-2.63	**Significant decrease**
Water	TN	-88	**<0.001**	-2.07	-6.99	**Significant decrease**
Land	TP	-35	0.092	-0.01	-2.47	No trend
Land	TN	-33	0.113	-0.16	-1.29	No trend
All	TP	-61	**0.003**	-0.04	-2.90	**Significant decrease**
All	TN	-87	**<0.001**	-2.17	-5.10	**Significant decrease**

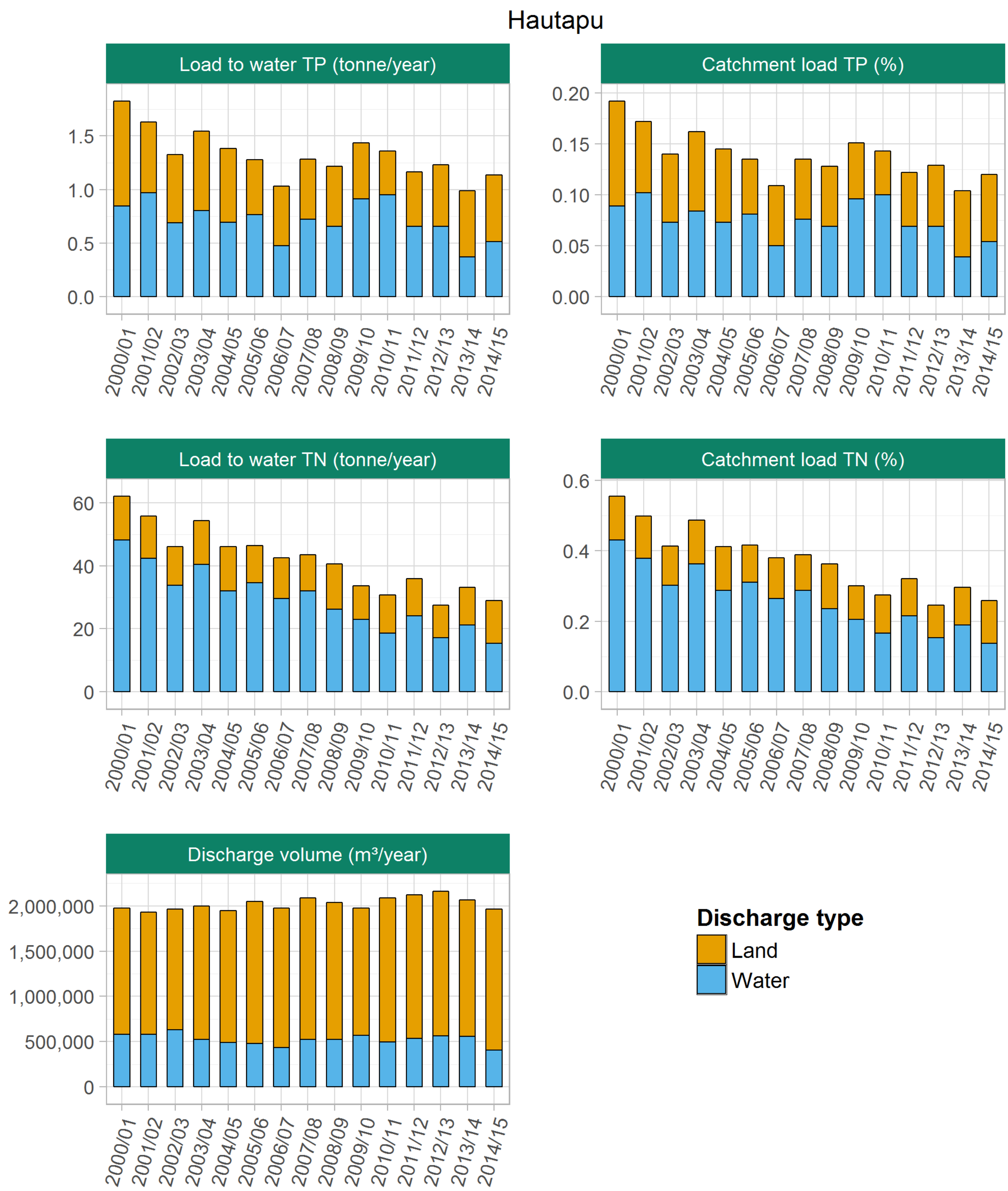

Figure 6: Estimated nutrient loads to the Waikato River, % of catchment load and discharge volume for the water and land discharges from the Hautapu manufacturing site for the period 2001 to 2015.

Table 9: Annual nutrient loads from each of the eight farms used for the discharge of wastewater from Hautapu.

Farm	Nutrient	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Bardowie	TN	5.7	5.2	4.1	4.2	4.0	4.1	4.2	3.0	4.0	2.8	3.6	3.5	3.2	3.1	3.4
	TP	0.7	0.5	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.2	0.0	0.3	0.3	0.3	0.3
Bruntwood	TN	3.3	2.9	2.6	3.3	3.0	2.3	2.8	2.0	3.4	2.7	2.8	2.7	2.4	2.9	3.0
	TP	0.1	<0.1	<0.1	0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.1
Buxton	TN	2.7	2.7	2.1	2.5	2.8	2.0	2.3	3.6	2.7	2.1	2.3	2.3	2.0	2.1	2.8
	TP	0.1	0.1	0.1	0.1	0.1	<0.1	0.1	0.1	0.1	0.1	<0.1	0.1	0.1	0.1	0.1
Chamberlain	TN	n/a	0.2	1.3	1.4	1.4	1.2	1.3	0.9	1.5	1.0	1.1	1.1	1.0	1.3	1.5
	TP	n/a	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
King	TN	0.8	0.8	0.7	0.8	0.9	0.7	0.9	0.6	0.9	0.8	0.8	0.8	0.7	0.8	0.9
	TP	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Shaw	TN	1.1	1.1	1.0	1.0	1.2	1.0	1.1	0.8	1.2	0.9	1.0	1.0	0.7	1.1	1.1
	TP	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Wiseman	TN	0.5	0.5	0.4	0.6	0.6	0.5	0.5	0.4	0.6	0.5	0.5	0.5	0.5	0.4	0.5
	TP	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
West	TN	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.3	0.4
	TP	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	<0.1	<0.1

Notes. Units are t/yr for nutrient loads. No data from Chamberlain Farm in 2001 (irrigation commenced in 2002 season) and prior to 2013 for West (irrigation commenced 2014 season).

6.2.2.4 Te Rapa

Fonterra holds consent for the discharge of wastewater from the Te Rapa site to the Waikato River and monitoring data is available from the 1998 season (18 years). The discharge volumes during this time have remained stable (Figure 7).

The key temporal result from the Te Rapa site is the highly statistically significant decrease in TN loads (Table 10). The SEN Slope from the trend analysis shows that the TN load has decreased by 1.49 t/yr or 11.76 % per year over the course of the data record, such that the TN load decreased from 68.4 t/yr in 1998 to 10.3 t/yr in 2015. This is attributed to a step change in load following the commissioning of an on-site wastewater treatment plant in 1999, but also a result of continual improvements between 2000 and 2015.

The TP load from Te Rapa has remained stable, with no significant trend identified.

Over the 18 year period, Te Rapa discharges have contributed an estimated 0.86 % and 0.18 % of the total annual catchment loads for TP and TN respectively. However, TN contributions from Te Rapa have decreased to 0.13 % of the total annual catchment load for TN since the commissioning of the wastewater treatment plant in 1999 (2000 to 2015 data).

Table 10: Mann-Kendall trend analysis for nutrient loads to water and land from the Te Rapa manufacturing site (1998 to 2015).

Discharge	Parameter	S	P	SEN slope	% annual change	Comment
Water	TP	51	0.058	0.30	3.79	No trend
Water	TN	-111	**<0.001**	-1.49	-11.76	**Significant decrease**

6.2.2.5 Te Awamutu

Fonterra holds consent for the discharge of wastewater from the Te Awamutu site to the Mangapiko Stream and monitoring data is available from the 1997 season (19 years). The discharge volumes during this time have shown a minor decrease (Figure 8).

The key temporal result from the Te Awamutu site is the highly statistically significant decrease in estimated TN loads (Table 11). The Sen Slope from the trend analysis shows that the TN load has decreased by 2.82 t/yr or 12.76 % per year over the course of the data record. The actual TN load decreased from 56.3 t/yr in 1997 to 8.2 t/yr in 2015. The TP load from Te Awamutu has remained relatively stable, with no significant trend identified.

Over the 19 year period, Te Awamutu discharges have contributed an estimated 0.4 % and 0.23 % of the total annual catchment loads for TP and TN respectively.

Table 11: Mann-Kendall trend analysis for nutrient loads to water and land from the Te Awamutu manufacturing site (1997 to 2015).

Discharge	Parameter	S	P	SEN slope	% annual change	Comment
Water	TP	-21	0.484	-0.05	-1.45	No trend
Water	TN	-111	**<0.001**	-2.82	-12.76	**Significant decrease**

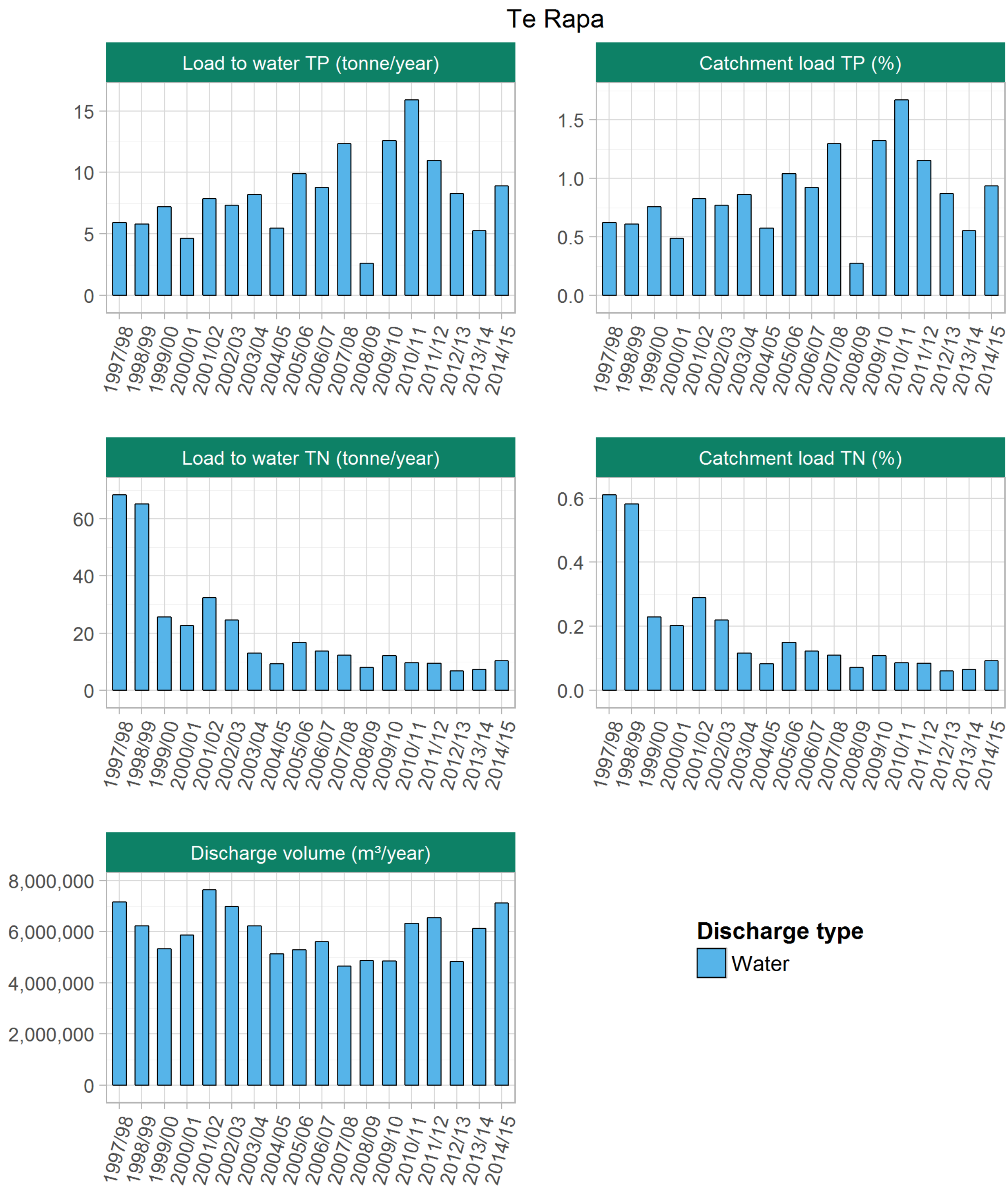

Figure 7: Estimated nutrient loads to the Waikato River, % of catchment load and discharge volume for the water discharges from Te Rapa manufacturing site for the period 1998 to 2015.

Figure 8: Estimated nutrient loads to the Waikato River, % of catchment load and discharge volume for the water discharges from Te Awamutu manufacturing site for the period 1997 to 2015.

6.2.3 Summary

The analysis of long term changes in nutrient loads from discharges permitted under Fonterra held consents shows a statistically significant decrease in cumulative TN load from all five sites. Four of the sites (Reporoa, Hautapu, Te Rapa and Te Awamutu) showed significant decreases in estimated TN load over time, with the remaining site (Lichfield) showing no significant change. This analysis indicated that the estimated TN load from the five sites has decreased by 5.5 t/yr or 6.4 % per year between 2001 and 2015, such that the collective TN load has decreased from 156 t/yr in 2001 to less than 63 t/yr in 2015.

The cumulative TP loads for all sites showed no significant change and can be considered to be stable between 2001 and 2015. No significant change was observed at three sites (Reporoa, Te Rapa and Te Awamutu), with one site (Hautapu) showing a decrease in TP load and one site showing an increase (Lichfield). Hautapu was the only site to show a decrease in both TN and TP loads. Lichfield was the only site to show an increase in either TN or TP loads over time and it is considered that this is a result of the increase in discharge volumes during this period as a result of increased milk processing capacity.

Discharge volume and TP load to water was dominated by Te Rapa, contributing 61 % of the total Fonterra discharge and 56 % of the TP load to water in 2015. However, based on the Te Rapa water balance (Bansal, 2015), approximately a third of the discharge volume at Te Rapa is barometric leg water, which is essentially recycled river water that is not chemically modified at the Te Rapa site. Despite this relatively high volume, the TN discharge from Te Rapa was relatively low (17 %) and comparable with the smaller sites. In contrast, the Hautapu site contributed 17 % of the discharge volume in 2015, but 46 % of the collective TN load.

Discharges to water constitute the majority of the discharge volume (76 %) and represented 77 % of the TP load and 54 % of the TN load in 2015. These results indicate the discharges to land contribute a disproportionate amount of the TN load (46 %) when compared to the contribution to the discharge volume (24 %), which is likely a result of the preferred approach of irrigating high strength wastewater to land rather than discharge to water.

6.3 All Discharges (since 2010)

6.3.1 Fonterra overview

This section of the report provides a description of the estimated nutrient loads from all wastewater discharges from Fonterra's manufacturing sites, including those permitted by consent held by Fonterra or a third party. As previously described, this analysis is limited to post-2010 because of the completeness and availability of monitoring data collected under consents not held by Fonterra. However, this analysis does allow a complete assessment of Fonterra's nutrient loads to the Waikato River since the Vision and Strategy came into effect.

The estimated nutrient loads from Fonterra's manufacturing activities have decreased since the Vision and Strategy came into effect in 2010 (Table 12 and Figure 9). The decrease in nutrient loads has occurred at the same time as an increase in wastewater discharge volumes over the same period, indicating that the decrease in load is likely to have occurred through improvements in the treatment and management of wastewater (rather than a decrease in wastewater volumes).

The estimated TP load to water from all Fonterra discharges to the Waikato River in 2015 has decreased by 3 t/yr or 10 % compared with 2010 (i.e., the year the Vision and Strategy came into effect). Similarly, the estimated TN load in 2015 has decreased by 3.4 t/yr or 2 % compared with 2010.

The decrease in nutrient load is driven by large reductions in the contaminant load of the discharges that are permitted under Fonterra consents (6.3 t/yr or 29 % for TP and 24 t/yr or 28 % for TN). The nutrient loads from discharges authorised by third party consents have increased over the same period (3.3 t/yr or 41 % for TP and 21 t/yr or 37 % for TN). However, these increases have been smaller in magnitude than the decreases for discharges under Fonterra consents, and therefore there has been a net decrease in TP and TN loads from Fonterra's manufacturing sites since 2010.

Table 12: Discharge volumes and estimated nutrient loads to water for all wastewater discharges from the five manufacturing sites for the period 2010 to 2015.

	2010	2011	2012	2013	2014	2015
Volume						
Fonterra consent	9,588,836	11,233,916	11,383,024	10,023,490	10,813,962	11,692,495
Third party consent	1,186,882	1,288,244	1,432,645	1,451,186	1,507,466	1,725,919
Total	10,775,718	12,522,160	12,815,669	11,474,676	12,321,428	13,418,414
TP to water						
Fonterra consent	22.0	28.8	20.6	16.3	11.2	15.7
Third party consent	8.1	9.2	9.5	8.5	8.9	11.4
Total	30.1	38.0	30.1	24.8	20.1	27.1
TN to water						
Fonterra consent	86.6	68.6	71.1	53.1	62.5	62.6
Third party consent	56.4	61.4	59.7	64.4	66.0	77.0
Total	143.0	130.0	130.8	117.5	128.5	139.7

Notes. Units are m^3 for volume and t/yr for nutrient loads. The 2015 third party consent data includes a movement of 52,725 m^3 of wastewater to the Reporoa site that was irrigated to land (which equated to a TP load of 0.96 tonnes and a TN load of 5.8 tonnes), however it could not be determined which site this wastewater originated from. Therefore, it is included in the summary table above, but excluded from the site specific tables below.

6.3.2 Catchment contribution

The results in Table 12 have provided an estimated of the annual nutrient loads that Fonterra's manufacturing sites contribute to the Waikato River catchment. The nutrient loads arising from these sites can be put into context by comparison with the catchment wide estimates for 2003–2012 (Vant, 2012).

All discharges from the Fonterra sites, whether permitted by a consent held by Fonterra or a third party, represent minor contributions to the total catchment load (Table 13). Collectively, the five manufacturing sites contributed an estimated 131 t/yr of TN during the 2010-2015 period, which represents 1.17 % of the annual TN catchment load estimated by Vant (2014). The estimated contribution to the annual TP load was 27.8 t/yr, which represented 2.92 % of the annual TP catchment load.

In addition to estimating the total catchment load, Vant (2014) also estimated the TN and TP loads arising from point and diffuse sources in the catchment. To enable a valid comparison of the nutrient loads from the Fonterra discharges with the estimates for point and diffuse sources described by Vant (2014), Fonterra's discharges directly to water were considered to be point sources and discharges to land were considered diffuse sources.

Table 13: Mean annual nutrient loads for Fonterra's five manufacturing sites compared with catchment wide estimates from Vant (2014) for the period 2010-2015.

Source	TN load		TP load	
	t/yr	% catchment load	t/yr	% catchment load
Reporoa	50.1	0.45	10.4	1.09
Lichfield	14.5	0.13	1.5	0.16
Hautapu	38.8	0.35	1.8	0.19
Te Rapa	13.3	0.12	10.7	1.13
Te Awamutu	14.0	0.13	3.4	0.36
Total Fonterra sources	130.7	1.17	27.8	2.92
Other sources	11062.3	98.83	923.2	97.08

Notes: Percentages based on estimated catchment loads of 11,193 t/yr for TN and 951 t/yr for TP (Vant, 2014).

6.3.2.1 Comparison with other point sources

Based on the estimate of nutrient loads from 19 moderate to large point sources described by Vant (2014), Fonterra's point sources discharges represent relatively small contributions to the total nutrient loads arising from point sources in the Waikato River.

Collectively the three manufacturing sites that discharge directly to water, contribute an estimated 5.60 % of the TN load and 8.65 % of the TP load attributed to point sources. In contrast, Vant estimated that 58 % of the TN load from point sources came from three sites (Hamilton sewage treatment plant, Kinleith Mill and Horotiu meatworks) and 48 % of the TP from point sources came from just two sites (Hamilton sewage treatment plant and Kinleith Mill).

Table 14: Mean annual nutrient loads for Fonterra's three manufacturing sites with point source discharges compared with point source estimates from Vant (2014) for the period 2010-2015.

Source	TN load		TP load	
	t/yr	% point source load	t/yr	% point source load
Hautapu	19.9	2.73	0.7	0.41
Te Rapa	9.3	1.27	10.3	6.02
Te Awamutu	11.7	1.60	3.8	2.22
Total Fonterra point sources	40.9	5.60	14.8	8.65
Other point sources	689.1	94.40	156.2	91.35

Notes: Percentages based on estimated point source loads of 730 t/yr for TN and 171 t/yr for TP (Vant, 2014). Vant (2014) estimates for Hautapu TN load of 17 t/yr and TP loads of 0.5 t/yr, Te Rapa TN load of 11 t/yr and TP load of 10.8 t/yr and for Te Awamutu TN load of 15 t/yr and 4.8 t/yr for TP.

6.3.2.2 Comparison with other diffuse sources

The total nutrient load from diffuse sources was estimated by Vant (2014) by calculating the total nutrient load for the catchment and subtracting the loads attributed to point sources and naturally occurring (or background) sources. Based on this estimate of nutrient loads from diffuse sources, Fonterra's diffuse source discharges represent relatively small contributions to the total nutrient loads arising from diffuse sources in the Waikato River.

Collectively the five sites contribute an estimated 1.31 % of the TN load and 3.20 % of the TP load attributed to diffuse sources in the catchment. The vast majority of the nutrient loads attributed to diffuse sources by Vant are from other sources.

Table 15: Mean annual nutrient loads for diffuse source discharges from Fonterra's manufacturing sites compared with diffuse source estimates from Vant (2014) for the period 2010-2015.

Source	TN load		TP load	
	t/yr	% diffuse source load	t/yr	% diffuse source load
Reporoa	50.1	0.73	10.4	2.45
Lichfield	14.5	0.21	1.5	0.35
Hautapu	18.9	0.28	1.2	0.28
Te Rapa	4.0	0.06	0.4	0.09
Te Awamutu	2.3	0.03	0.1	0.02
Total	89.8	1.31	13.6	3.2
Other diffuse sources	6750.2	98.69	411.4	96.8

Notes: Percentages based on estimated diffuse source loads of 6840 t/yr for TN and 425 t/yr for TP (Vant, 2014).

6.3.3 Site contributions

As with the discharges permitted under Fonterra held consents, the cumulative discharge volume from all discharges (including third party consents) is dominated by the Te Rapa site (Figure 9), which contributed 53 % of the total Fonterra discharge volume to water in 2015. Despite this relatively high volume, the TN discharge from Te Rapa is relatively low (13 %) and comparable with the smaller sites, although Te Rapa remains a large source of TP (34 % in 2015). In contrast, the Reporoa site contributed 8 % of the discharge volume in 2015, but an estimated 41 % of the collective TP load and 42 % of the collective TN load.

The volumes of discharges occurring under the provisions of third party consents are much less than those discharges occurring under Fonterra's consent. For the period 2010 to 2015, the third party discharges constitute 12 % of the discharge volume. Consequently, the nutrient load from the third party discharges is less that the Fonterra consented discharges. However, there is a disproportionate nutrient load arising from these discharges compared with the volume discharged. For the period 2010 to 2015, the third party consents constitute 34 % of Fonterra's overall estimated TP load and 49 % of the TN load. This finding is a result of the third party consents mainly covering the management of high strength wastewater, whereas low strength wastewater is typically managed under the provision of Fonterra held consents.

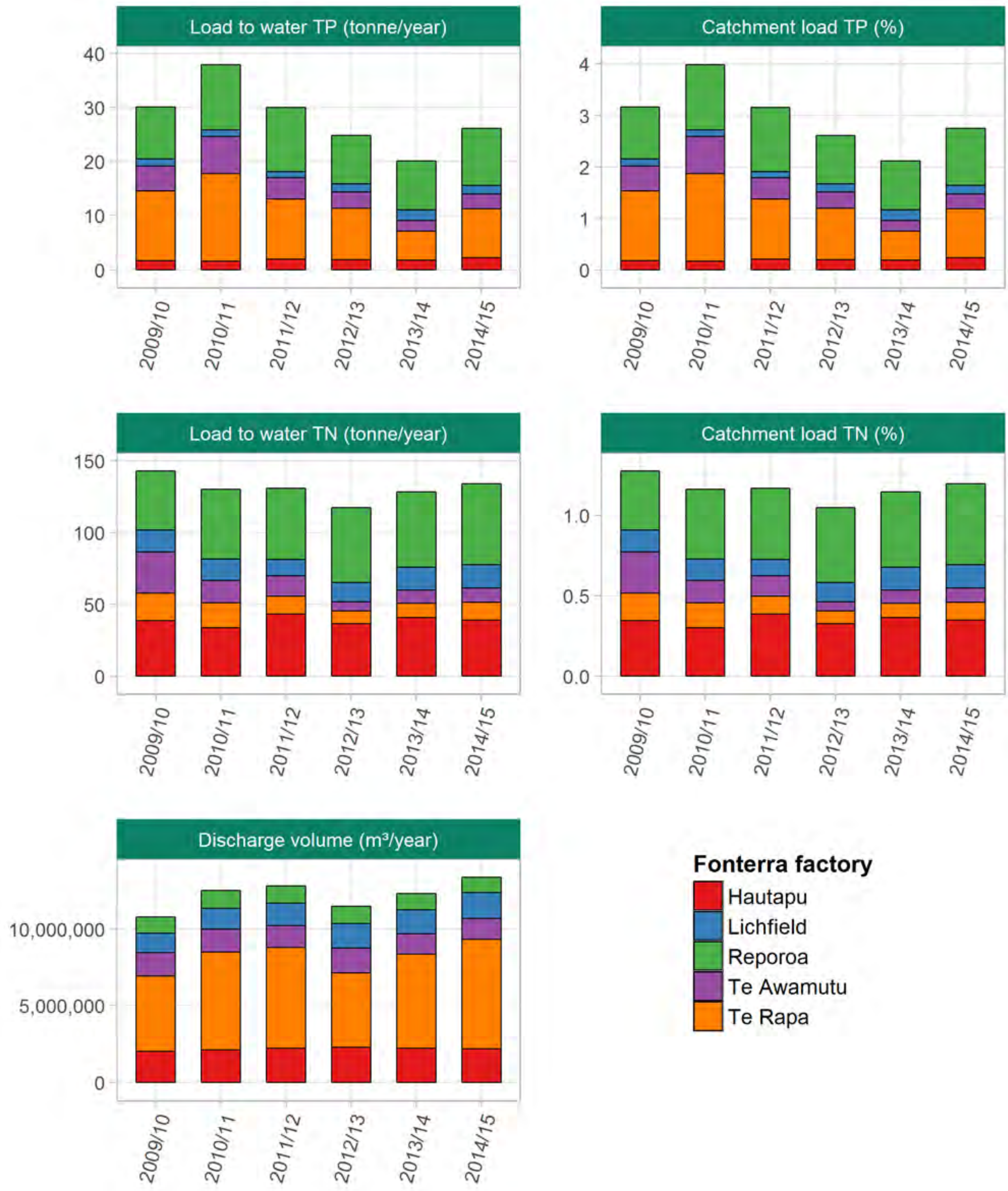

Figure 9: Discharge volumes, estimated nutrient losses to water and % of catchment load for all discharges from the five sites in the Waikato River catchment for the period 2010 to 2015

6.3.4 Site specific assessments

6.3.4.1 Reporoa

The discharge volumes and nutrient loads to water are shown in Table 16 for the Reporoa site and includes all discharges whether the consent is held by Fonterra or a third party.

The estimated nutrient loads from Reporoa have increased since the Vision and Strategy came into effect in 2010. The estimated TP load to water from all Reporoa discharges to the Waikato River in 2015 has increased by 1 t/yr compared with 2010. Similarly, the estimated TN load in 2015 has increased by 15 t/yr compared with 2010. These increases in nutrient load have been driven by increases in the discharges authorised under third party consents. In contrast, the discharges for the Fonterra held consents have remained stable during this period.

The volumes of discharges occurring under the provisions of third party consent are less than those discharges occurring under Fonterra's consent. For the period 2010 to 2015, the third party discharges constitute 38 % of the discharge volume. However, the nutrient load from the third party discharges is greater than that for the Fonterra consented discharges. For the period 2010 to 2015, the third party consents constitute 67 % of Fonterra's overall estimated TP load and 83 % of the TN load. This finding is a result of the third party consents mainly covering the management of high strength wastewater, whereas lower strength wastewater is typically managed under the provision of Fonterra held consents.

Table 16: Discharge volumes and estimated nutrient loads to water for wastewater discharges from the Reporoa manufacturing site for the period 2010 to 2015.

	2010	2011	2012	2013	2014	2015
Volume						
Fonterra consent	684,602	740,257	712,682	732,917	651,580	568,568
3rd party consent	382,630	425,210	428,160	403,340	421,221	437,780
Total	1,067,232	1,165,467	1,140,842	1,136,257	1,072,801	1,006,348
TP to water						
Fonterra consent	3.0	4.4	4.2	3.5	2.7	2.6
3rd party consent	6.6	7.8	7.7	5.4	6.3	8.0
Total	9.6	12.2	11.9	8.9	9.0	10.6
TN to water						
Fonterra consent	8.2	8.3	7.9	8.4	8.7	8.4
3rd party consent	33.0	40.1	41.8	43.9	43.9	47.9
Total	41.2	48.4	49.7	52.3	52.6	56.3

Note: Units are m^3 for volume and t/yr for nutrient loads.

6.3.4.2 Lichfield

The discharge volumes and nutrient loads to water are shown in Table 17 for the Lichfield site and includes all discharges whether the consent is held by Fonterra or a third party.

The estimated nutrient loads from Lichfield have marginally increased since the Vision and Strategy came into effect in 2010. The estimated TP load to water from all Lichfield discharges to the Waikato River in 2015 has increased by 0.2 t/yr compared with 2010. Similarly, the estimated TN load in 2015 has increased by 0.7 t/yr compared with 2010. As with the Reporoa site, these increases in nutrient load have been driven by increases in the discharges authorised under third party consents. In contrast, the discharges for the Fonterra held consents have decreased during this period.

The volumes of discharges occurring under the provisions of third party consent are greater than those discharges occurring under Fonterra’s consent. For the period 2010 to 2015, the third party discharges constitute 57 % of the discharge volume. Consequently, the nutrient load from the third party discharges is greater than that for the Fonterra consented discharges. For the period 2010 to 2015, the third party consents constitute 74 % of Lichfield’s overall estimated TP load and 55 % of the TN load.

Table 17: Discharge volumes and estimated nutrient loads to water for wastewater discharges from the Lichfield manufacturing site for the period 2010 to 2015.

	2010	2011	2012	2013	2014	2015
Volume						
Fonterra consent	581,282	606,039	595,789	674,355	647,363	709,363
3rd party consent	660,580	762,592	851,338	913,718	900,355	978,891
Total	1,241,862	1,368,631	1,447,127	1,588,073	1,547,718	1,688,254
TP to water						
Fonterra consent	0.5	0.3	0.3	0.4	0.4	0.4
3rd party consent	0.9	0.9	0.8	1.1	1.6	1.2
Total	1.4	1.2	1.1	1.5	2.0	1.6
TN to water						
Fonterra consent	7.7	6.7	5.6	5.8	6.4	6.7
3rd party consent	7.6	8.1	5.8	7.7	9.4	9.5
Total	15.4	14.8	11.4	13.5	15.8	16.1

Note: Units are m^3 for volume and t/yr for nutrient loads.

6.3.4.3 Hautapu

The discharge volumes and nutrient loads to water are shown in Table 18 for the Hautapu site and includes all discharges whether the consent is held by Fonterra or a third party.

The estimated nutrient loads from Hautapu have marginally increased since the Vision and Strategy came into effect in 2010. The estimated TP load to water from all Hautapu discharges to the Waikato River in 2015 has increased by 0.5 t/yr compared with 2010. Similarly, the estimated TN load in 2015 has increased by 0.3 t/yr compared with 2010. As with the Reporoa and Lichfield sites, these increases in nutrient load have been driven by increases in the discharges authorised under third party consents. In contrast, the discharges for the Fonterra held consents have decreased during this period.

The volumes of discharges occurring under the provisions of third party consent are much less than those discharges occurring under Fonterra's consent, but have shown a large increase since 2010. For the period 2010 to 2015, the third party discharges constitute 6 % of the discharge volume, but this has increased from 3.5 % in 2010 to 11 % in 2015. The nutrient load from the third party discharges is less than that for the Fonterra consented discharges. For the period 2010 to 2015, the third party consents constitute 32 % of Lichfield's overall estimated TP load and 18 % of the TN load.

Table 18: Discharge volumes and estimated nutrient loads to water for wastewater discharges from the Hautapu manufacturing site for the period 2010 to 2015. The breakdown of the Fonterra consented discharges to water (river line) and land (farm irrigation) is shown in italics.

	2010	**2011**	**2012**	**2013**	**2014**	**2015**
Volume						
Fonterra consent	1,973,412	2,086,110	2,120,838	2,163,383	2,064,639	1,962,259
To water	*569,765*	*497,130*	*535,090*	*560,640*	*557,355*	*404,055*
To land	*1,403,647*	*1,588,980*	*1,585,748*	*1,602,743*	*1,507,284*	*1,558,204*
3rd party consent	72,310	52,698	121,760	122,357	168,687	236,950
Total	2,045,722	2,138,808	2,242,598	2,285,740	2,233,326	2,199,209
TP to water						
Fonterra consent	1.4	1.4	1.2	1.2	1.0	1.1
To water	*0.9*	*1.0*	*0.7*	*0.7*	*0.4*	*0.5*
To land	*0.5*	*0.4*	*0.5*	*0.5*	*0.6*	*0.6*
3rd party consent	0.3	0.2	0.8	0.6	0.8	1.1
Total	1.7	1.6	1.9	1.8	1.8	2.2
TN to water						
Fonterra consent	33.7	30.7	35.9	27.6	33.1	29.0
To water	*23.0*	*18.6*	*24.1*	*17.2*	*21.2*	*15.4*
To land	*10.7*	*12.1*	*11.8*	*10.4*	*11.9*	*13.6*
3rd party consent	5.1	3.1	7.5	9.0	7.8	10.2
Total	38.8	33.8	43.4	36.6	41.0	39.1

Note: Units are m^3 for volume and t/yr for nutrient loads.

6.3.4.4 Te Rapa

The discharge volumes and nutrient loads to water are shown in Table 19 for the Te Rapa site and includes all discharges whether the consent is held by Fonterra or a third party.

The estimated nutrient loads from Te Rapa have decreased since the Vision and Strategy came into effect in 2010. The estimated TP load to water from all Te Rapa discharges to the Waikato River in 2015 has decreased by 3.8 t/yr compared with 2010. Similarly, the estimated TN load in 2015 has decreased by 6.7 t/yr compared with 2010. These decreases have resulted from decrease in nutrient loads authorised by Fonterra (as a result of improvements in treatment and/or on-site management of wastewater) and third party consents.

The volumes of discharges occurring under the provisions of third party consents are much less than those discharges occurring under Fonterra's consent, but have decreased since 2010. For the period 2010 to 2015, the third party discharges constitute 0.4 % of the discharge volume, but this has decreased from 1.0 % in 2010 to 0.2 % in 2015. Consequently the nutrient load for the third party discharges is much less than that for the Fonterra consented discharges. For the period 2010 to 2015, the third party consents constitute 4 % of Te Rapa's overall estimated TP load and 28 % of the TN load.

Table 19: Discharge volumes and estimated nutrient loads to water for wastewater discharges from the Te Rapa manufacturing site for the period 2010 to 2015.

	2010	2011	2012	2013	2014	2015
Volume						
Fonterra consent	4,853,770	6,317,785	6,542,990	4,835,155	6,130,175	7,109,105
3rd party consent	50,090	35,809	18,539	2,662	7,135	11,805
Total	4,903,860	6,353,594	6,561,529	4,837,817	6,137,310	7,120,910
TP to water						
Fonterra consent	12.6	15.9	11.0	8.3	5.3	8.9
3rd party consent	0.3	0.3	0.1	1.3	0.1	0.1
Total	12.8	16.2	11.1	9.6	5.4	9.0
TN to water						
Fonterra consent	12.2	9.6	9.4	6.7	7.2	10.3
3rd party consent	6.8	7.6	2.8	2.3	2.5	1.9
Total	19.0	17.3	12.3	9.0	9.7	12.3

Note: Units are m^3 for volume and t/yr for nutrient loads.

6.3.4.5 Te Awamutu

The discharge volumes and nutrient loads to water are shown in Table 20 for the Te Awamutu site and includes all discharges whether the consent is held by Fonterra or a third party.

The estimated nutrient loads from Te Awamutu have decreased since the Vision and Strategy came into effect in 2010. The estimated TP load to water from all Te Awamutu discharges to the Waikato River in 2015 has decreased by 1.9 t/yr compared with 2010. Similarly, the estimated TN load in 2015 has decreased by 18.5 t/yr compared with 2010. These decreases have resulted from decrease in nutrient loads authorised by Fonterra (as a result of improvements in treatment and/or on-site management of wastewater) and third party consents.

The volumes of discharges occurring under the provisions of third party consents are much less than those discharges occurring under Fonterra's consent, but have decreased since 2010. For the period 2010 to 2015, the third party discharges constitute 0.8 % of the discharge volume, but this has decreased from 1.4 % in 2010 to 0.6 % in 2015. Consequently the nutrient load for the third party discharges is much less than that for the Fonterra consented discharges. For the period 2010 to 2015, the third party consents constitute 3 % of Te Awamutu's overall estimated TP load and 18 % of the TN load.

Table 20: Discharge volumes and estimated nutrient loads to water for wastewater discharges from the Te Awamutu manufacturing site for the period 2010 to 2015.

	2010	2011	2012	2013	2014	2015
Volume						
Fonterra consent	1,495,770	1,483,725	1,410,725	1,617,680	1,320,205	1,343,200
3rd party consent	21,272	11,935	12,848	9,109	10,068	7,768
Total	1,517,042	1,495,660	1,423,573	1,626,789	1,330,273	1,350,968
TP to water						
Fonterra consent	4.5	6.8	3.9	2.9	1.9	2.7
3rd party consent	0.1	0.1	0.1	0.1	0.1	0.1
Total	4.6	6.9	4.0	3.0	2.0	2.7
TN to water						
Fonterra consent	24.7	13.2	12.2	4.7	7.1	8.2
3rd party consent	3.9	2.4	1.8	1.5	2.4	1.8
Total	28.6	15.6	14.1	6.2	9.5	10.1

Note: Units are m^3 for volume and t/yr for nutrient loads.

6.3.5 Summary

6.3.5.1 Changes since 2010

The analysis of changes in estimated nutrient loads from all discharges since 2010 indicates decreases in the combined TN and TP loads from Fonterra's five manufacturing sites (Table 21). Collectively, the estimated TP load in 2015 for the five manufacturing sites is 3.0 t/yr lower than in 2010, which equates to a 10 % reduction. Similarly, the estimated TN load was 3.3 t/yr lower in 2015 when compared with 2010, which equates to a 2.3 % reduction.

Table 21: Summary of change in nutrient loads for Fonterra's manufacturing sites between 2010 and 2015.

Source	Total nitrogen (TN)			Total phosphorus (TP)		
	2010	2015	Change	2010	2015	Change
Reporoa	41.2	56.3	+15.1	9.6	10.6	+1.0
Lichfield	15.4	16.1	+0.7	1.4	1.6	+0.2
Hautapu	38.8	39.1	+0.3	1.7	2.2	+0.5
Te Rapa	19.0	12.3	-6.7	12.8	9.0	-3.8
Te Awamutu	28.6	10.1	-18.5	4.6	2.7	-1.9
Total	143.0	139.7	-3.3	30.1	27.1	-3.0

Notes. Units are m^3 for volume and t/yr for nutrient loads. The 2015 total includes a movement of 52,725 m^3 of wastewater to the Reporoa site that was irrigated to land (which equated to a TP load of 0.96 tonnes and a TN load of 5.8 tonnes), however it could not be determined which site this wastewater originated from.

These decreases in nutrient loads have occurred at the same time as a 22 % increase in wastewater volumes between 2010 and 2015, indicating that the decrease in load has occurred as a result of the improvement in the treatment and management of wastewater.

The decrease in collective nutrient loads since 2010 has been dominated by relatively large reductions at the Te Rapa and Te Awamutu sites, whereas the remaining three sites have seen slight increases in nutrient loads. The magnitude of the decreases at Te Rapa and Te Awamutu are greater than the increases at the other three sites, resulting in an overall decrease in both TN and TP loads.

The decrease in estimated nutrient loads has been driven by relatively large reductions in the discharges that have been achieved under Fonterra consents of 6.3 t/yr for TP and 24 t/yr for TN. However, the nutrient loads from discharges authorised by third party consents have increased over the same period. The magnitude of the third party consent increases (3.3. t/yr for TP and 20.6 t/yr for TN) are less than the decreases for the Fonterra held consents, hence the net change is a decrease in overall nutrient loads of 3.0 t/yr for TP and 3.3 t/yr for TN.

The increases in the nutrient loads for the third party consents can be attributed to the increases in wastewater volume from the three sites that rely more heavily on land based irrigation for wastewater disposal (i.e., Reporoa, Lichfield and Hautapu). In contrast, Te Rapa and Te Awamutu, which have on-site biological wastewater treatment plants and rely on discharges to water for disposal of treated wastewater show decreases in nutrient loads, whether they are permitted by a Fonterra or third party consent.

6.3.5.2 Catchment contribution

The analyses of the nutrient loads presented in Section 6.3.2 have provided an estimate of the annual loads of TN and TP that the five Fonterra manufacturing sites contribute to the Waikato River catchment. This analyses incorporates all discharges, including those carried out under Fonterra and third party consents and shows that collectively, the five sites represent relatively minor contributions to the total catchment load estimated by Vant (2014). The Fonterra discharges represent an estimated 1.17 % of the TN load and 2.92 % of the TP load.

7.0 SUMMARY

7.1 Nutrient Load Contribution

7.1.1 Fonterra overview

This report has provided an assessment of the nutrient loads from Fonterra's five manufacturing sites in the Waikato River catchment in order to provide Fonterra with a catchment wide assessment of its historical and current performance and identify sites with potential opportunities for improvement.

The contribution of the discharges from Fonterra's manufacturing sites to the catchment wide nutrient loads occurring to the Waikato River is low. Between 2010 and 2015, the nutrient loads from all discharges, whether to land or water and whether the consent is held by Fonterra or a third party, contributed an estimated 2.9 % and 1.2 % of the total annual catchment loads for TP (Figure 10) and TN (Figure 11) respectively.

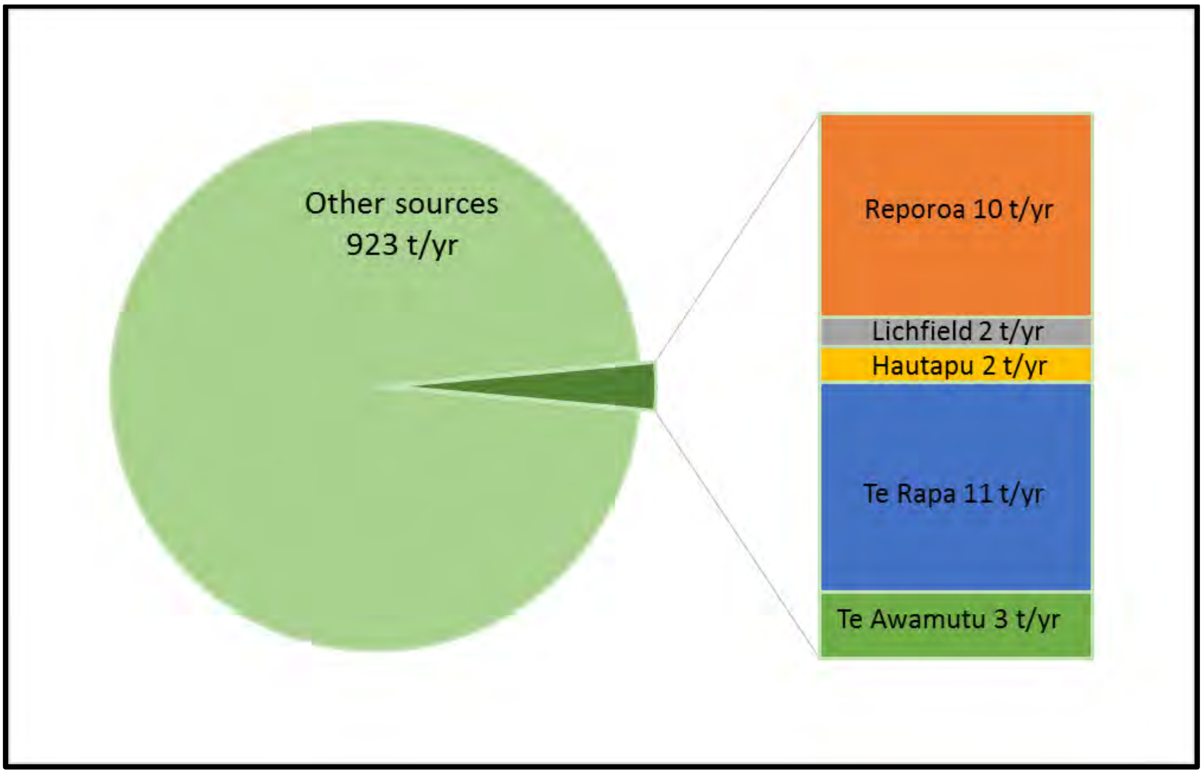

Figure 10: Estimated TP loads for the Waikato River catchment and the contributions of the Fonterra manufacturing sites.

The analysis of changes in estimated nutrient loads from discharges since 2010 indicates decreases in the cumulative TN and TP load for the five manufacturing sites. Estimated nutrient loads in 2015 are 10 % lower for TP and 2 % lower for TN when compared with 2010 (the year the Vision and Strategy came into effect). These decreases in nutrient loads have occurred at the same time as a 22 % increase in the wastewater volumes generated by Fonterra between 2010 and 2015, indicating that the decrease in nitrogen and phosphorus load has occurred as a result of reductions in product losses and improvement in the treatment and management of wastewater.

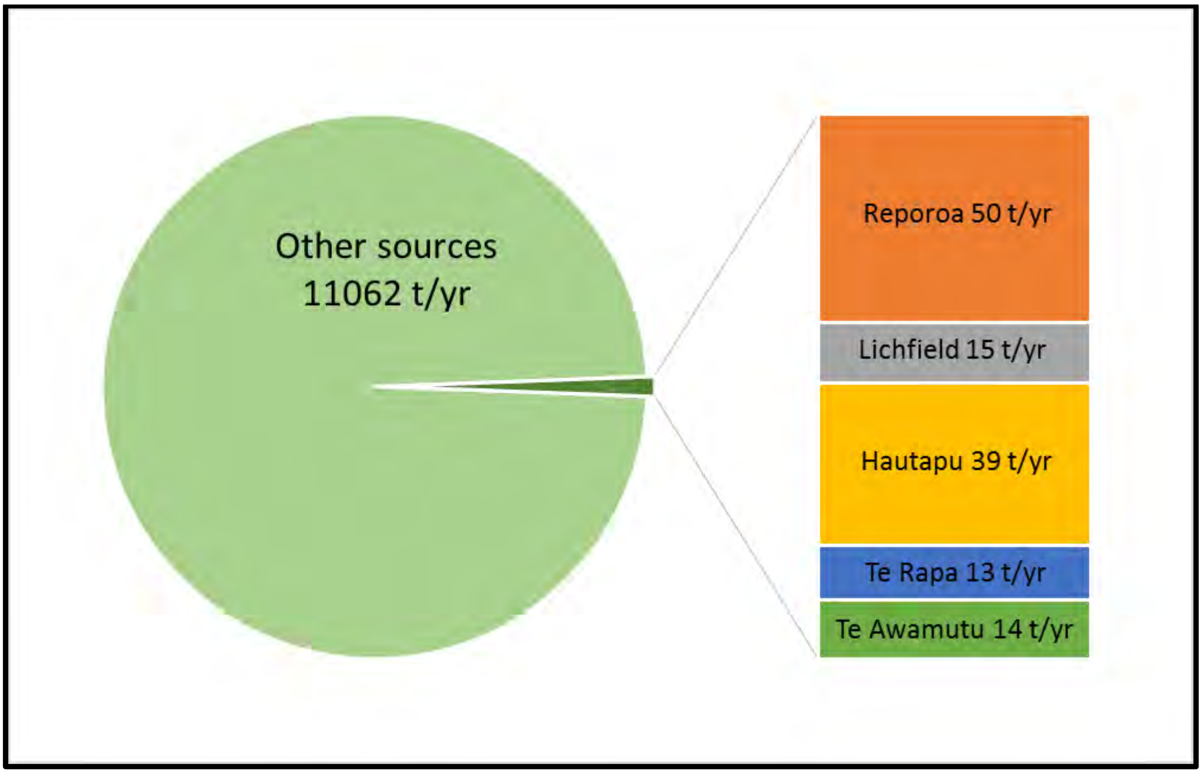

Figure 11: Estimated TN loads for the Waikato River catchment and the contributions of the Fonterra manufacturing sites.

7.1.2 Site specific assessments

The Te Rapa site discharges the greatest volume of treated wastewater of all five sites (53 % of total discharge in 2015), but it contributed a disproportionately low TN load (13 %), indicative of the high level of performance of the wastewater management activities at this site. In contrast, the Reporoa site contributed only 8 % of the total discharge volume in 2015, but a disproportionately high TP (41 %) and TN (42 %) load. A similar situation occurred at Hautapu, which constitutes 17 % of the total discharge volume, but 29 % of the total TN load contributed within the catchment by Fonterra.

The relatively high ratio of discharge volume to nutrient loads from these two sites compared with the other three Fonterra sites, indicates that the management of wastewater could be improved to match the performance of the other sites. For example, Hautapu has a relatively simple wastewater treatment approach compared with Te Rapa and Te Awamutu which both utilise biological treatment. Furthermore, Te Rapa and Te Awamutu have comprehensive, automated systems in place to detect product losses into the wastewater system. These systems include CCTV monitoring of key areas of the site and continuous water chemistry monitoring to detect product losses as soon as they occur. In contrast, product loss detection at Hautapu relies on the manual daily collection of water samples and subsequent testing, which may result in a delay in the detection of losses or non-detection for intermittent losses. Notwithstanding the current performance of the Te Awamutu site, there remains potential to improve the performance of its WWTP to be more consistent with the discharge concentrations achieved by the Te Rapa WWTP.

The disproportionately high nutrient loads from the Reporoa site are primarily a result of the land irrigation of high strength wastewater previously carried out under the provisions of a third party consent (Table 16). These irrigation activities cover a wide range of farms across the Waikato Region, for which losses to water have been based on a generic model for a generic dairy farm. This assumption, together with the greater uncertainty about the losses originating from land disposal mean the absolute nutrient loads from this activity should be used with caution. Nevertheless, the disposal of wastewater under the provisions of consents held by third parties has been recognised as a risk, and Fonterra have taken a more active role in these activities in recent years. This is evidenced by the acquisition of Civil Whey Ltd and subsequent integration into Fonterra's operations through the creation of DairyFert. Similarly, the activities at Reporoa referred to above have recently (from the 2016 season) been brought under the provisions of DairyFert's Waikato region wide consent.

An important consideration about the irrigation of wastewater to land is that is designed to act as a replacement for the use of conventional fertilisers. The key issue is that if Fonterra ceased to irrigate wastewater to these farms, there would likely be an increase in conventional fertilisers to replace the nutrients provided by the wastewater. Such a situation could represent a perverse outcome for the management of nutrient loads in the Waikato catchment because overall nutrient loads would increase through additional use of fertilisers to replace the nutrients currently provided by wastewater irrigation. Therefore, this disposal option should be considered as recycling of nutrients and when well managed, result in a positive outcome for the overall management of nutrients in the Waikato catchment.

7.2 Long Term Changes

The longer term temporal analysis (2001 to 2015) of the discharges undertaken for this report show that the contribution to the TN load of the Waikato River from discharges undertaken pursuant to Fonterra held consents has decreased significantly over this period. The total TN loads from Fonterra's five manufacturing sites was 156 t/yr in 2001 and had reduced to 63 t/yr in 2015. No significant trend was apparent in the total TP loads, therefore the TP load was considered to be stable over this time period.

It should be noted that the long term temporal assessment is limited to those discharges which have been authorised under consents held by Fonterra. However, this analysis shows that where Fonterra has had direct control over the management of its wastewater, there is very strong evidence of continual improvement and subsequent reductions in nutrient loads discharged to the Waikato River catchment. This finding suggests that the integration of discharges that have previously been undertaken pursuant to consents held by third parties into Fonterra's operations, should be viewed as a positive step that is likely to result in improved wastewater management and consequential reductions in nutrient loads to the catchment.

The long term decreases in TN load have occurred at multiple sites and have been a result of step changes in treatment approaches and continual improvement over time. The Te Rapa site provides a useful example of this and shows how Fonterra has invested in both significant infrastructure upgrades that have resulted in step changes, whilst also implementing operational improvements that have resulted in incremental improvements over time. For example, the Te Rapa site had a large WWTP installed and commissioned in 1999 to treat the site's wastewater. However, the TN load has continued to decrease since the commissioning of the WWTP, arising from upgrades and operational improvements to the WWTP and other activities on site aimed at reducing product losses to the wastewater system. These loss reduction activities have been so effective at reducing wastewater loads that the performance of the WWTP was affected by under loading. This was addressed in 2010, by the installation of a high strength waste loading system to ensure there was sufficient carbon for the microbiological denitrification processes to work efficiently.

7.3 Conclusion

In conclusion, the treated wastewater discharges from Fonterra's five manufacturing sites contribute minor proportions of the TN and TP loads in the Waikato River catchment. Furthermore, the contribution of the sites to the TN load in the Waikato River has decreased significantly based on the long term analysis as a result of Fonterra's continual improvement of wastewater treatment systems and product loss reduction initiatives. These initiatives have also resulted in decreases in TN and TP loads to the Waikato River since the Vision and Strategy came into effect in late 2010.

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APPENDIX A

Approach to calculating nutrient loads from land-based discharges

Estimating Farm Nutrient Losses

Nutrient budgets are commonly used to estimate the losses of N and P from farm operations. It is impractical to monitor nutrient losses for individual farms, so farm scale models have been developed to model nutrient flows and fates on farm systems. In New Zealand, OVERSEER® (Shepherd & Wheeler, 2012) is currently the recommended tool for predicting the nutrient losses from a wide range of farm types. All models, including OVERSEER®, involve the simplification of numerous complex processes and hence the predictions that such models make will always involve uncertainties (Shepherd et al. 2013). These uncertainties have been estimated to be in the order of 30 % for N (Wheeler, 2013) and 28 % for P (McDowall, 2013) losses predicted by the model.

Notwithstanding the uncertainties around the predicted losses, OVERSEER® is the only tool that currently provides a mechanism to consistently account for the on-farm uptake of nutrients and hence provide an assessment of the potential nutrient losses to water as a result of the land discharge of wastewater. As OVERSEER® does not directly report the proportion of nutrient lost to water from added nutrients, these were calculated by Dr Jeff Brown of Fonterra's Environmental Technical Group thus;

% lost below rootzone = 'To water' x 100 / (Fertiliser, lime & other + Effluent added)

Where a farm has multiple wastewater irrigated blocks, for example differing soil types or dairy shed effluent irrigation combined with wastewater irrigation, an area weighted average has been used to calculate the mean % loss for the areas receiving wastewater. Further, where a site discharges to more than one farm, the farm specific ratio was applied to the proportion of the nutrient load discharged to that farm.

For nitrogen, the % lost to water (Table 3) typically ranges from 18 to 37 % of the total N inputs from wastewater, other fertilisers and any dairy shed effluent (i.e., 1/5th to 1/3rd of the nutrients added are lost).

For phosphorus, the % lost to water typically ranges from 0.4 to 2.4 % which is typical for flat wastewater irrigated farms with soil Olsen P values above 100 mg/kg. For the Reporoa farms, OVERSEER® predicts much greater losses, resulting from the following combination of factors:

1. High soil Olsen P.
2. Slope – need to have as rolling which increases risk.
3. Longer irrigation season for Reporoa which also increases risk.
4. Phosphate retention 51 % at Reporoa versus 85 % at Lichfield.

All these lead to higher 'risk scores' within OVERSEER® which then cause greatly elevated P loss predictions. The Overseer authors specifically issue a warning that the results should be used with caution because they are outside the model calibration range.

OVERSEER® assessments have been completed for most of the farms that Fonterra hold the discharge consent for the 2014 or 2015 seasons. However, OVERSEER® assessments have not been completed for the years before 2014 and therefore the results of the current OVERSEER® analysis has been applied to the data from these years. It should be recognised that this adds uncertainty to the assessment of historical nutrient losses as it likely that farming practices and conditions have changed over time.

Furthermore, there is no OVERSEER® assessment for some specific land discharges, including:

- Lichfield for the activities undertaken by the Lichfield Lands Irrigation Company prior to 2006
- The satellite farms at Hautapu
- Most of the farms where truck spreading of waste sludges has been undertaken by Dairyfert (Civil Whey) and CTL.

For the Lichfield and Hautapu situations, the mean N and P losses from the OVERSEER® analysis of the farms that receive wastewater from Lichfield and Hautapu were applied (Table 3).

For the farms that have been operated under the provisions of third party consents, specific OVERSEER® assessments have been completed for Waratah and Fencourt farms only (Table 4). In order to estimate proportional loss of nutrients for farms without OVERSEER® budgets, two models were created. The first for a generic dairy farm (based on an average central plateau dairy farm, where dairy liquids are used as replacements for conventional fertilisers at a loading of 150 kgN/ha/yr) and the second for a generic cropping farm (which are primarily used for producing maize rather than dairy farming – often termed 'cut and carry' operations). The loss predictions for cropping farms are typically lower than dairy farms as these have no or low animal urine contributions and high P retention soils. Fencourt Rd has only 6 % of the added nitrogen lost because this farm effectively practices a 'duration controlled' grazing regime where stock only grazes pasture for limited hours each day (which reduces urine patch contribution to leaching), with the rest of the time spent in a cowhouse or feedpad where effluent is collected.

These loss predictions were used to estimate nutrient losses from land disposal of dairy wastewater and sludges under Fonterra consents (Table 22) and third party consents (Table 23).

Table 22: The proportion of nutrients lost to water as predicted by OVERSEER® for farms where the consent is held by Fonterra

Site	Farm	P lost to water (%)	N lost to water (%)
Reporoa	Reporoa Farm	14	28
Reporoa	Brennan Farm	20	37
Reporoa	Leslie farm	14	37
Lichfield	Anchor Block	0.4	18
Lichfield	Woods	1.3	35
Lichfield	Ash (Henderson)	1.7	22
Lichfield	Skinner	1.6	23
Lichfield	The Crossing	2.4	26
Hautapu	Buxton	0.7	18
Hautapu	Bardowie	2.1	18
Hautapu	Bruntwood	0.6	27
Lichfield/Hautapu mean		1.4	23

Table 23: The proportion of nutrients lost to water as predicted by OVERSEER® for farm and farm types where consent is held by a third party

Company	Farm	P lost to water (%)	N lost to water (%)
DairyFert	Waratah	2.8	12
DairyFert	Cropping farm	0.3	9

Company	Farm	P lost to water (%)	N lost to water (%)
CTL & DairyFert	Generic dairy farm	5.7	28
D. A. Civil	Fencourt	3.1	6

Estimating Off-farm Attenuation

The loss of nutrients between the rootzone and receiving water body has been termed ‘attenuation’ and transmission factors have been calculated for the Waikato River catchment, which estimates the proportion of the nutrient loss from farms that is transmitted to the river (Clothier et al. 2007).

In the case of the Waikato River catchment, transmission factors have been calculated by Clothier et al. (2007) using information about the sources and transport of nutrients in the Waikato River catchment from Alexander et al. (2002). These transmission factors indicate that on average across the Waikato River catchment, 55 % of the nitrogen and 45 % of the phosphorus that is lost from a farm will reach the Waikato River. Therefore, this proportional reduction was applied to the nutrient loads from land discharges after the losses from the farms were identified using OVERSEER®. However, it should be recognised that the transmission factor will vary depending on the local geology, groundwater hydrology and chemistry, vegetation types and distance to the Waikato River.

APPENDIX B
Discharge summary by discharge type.

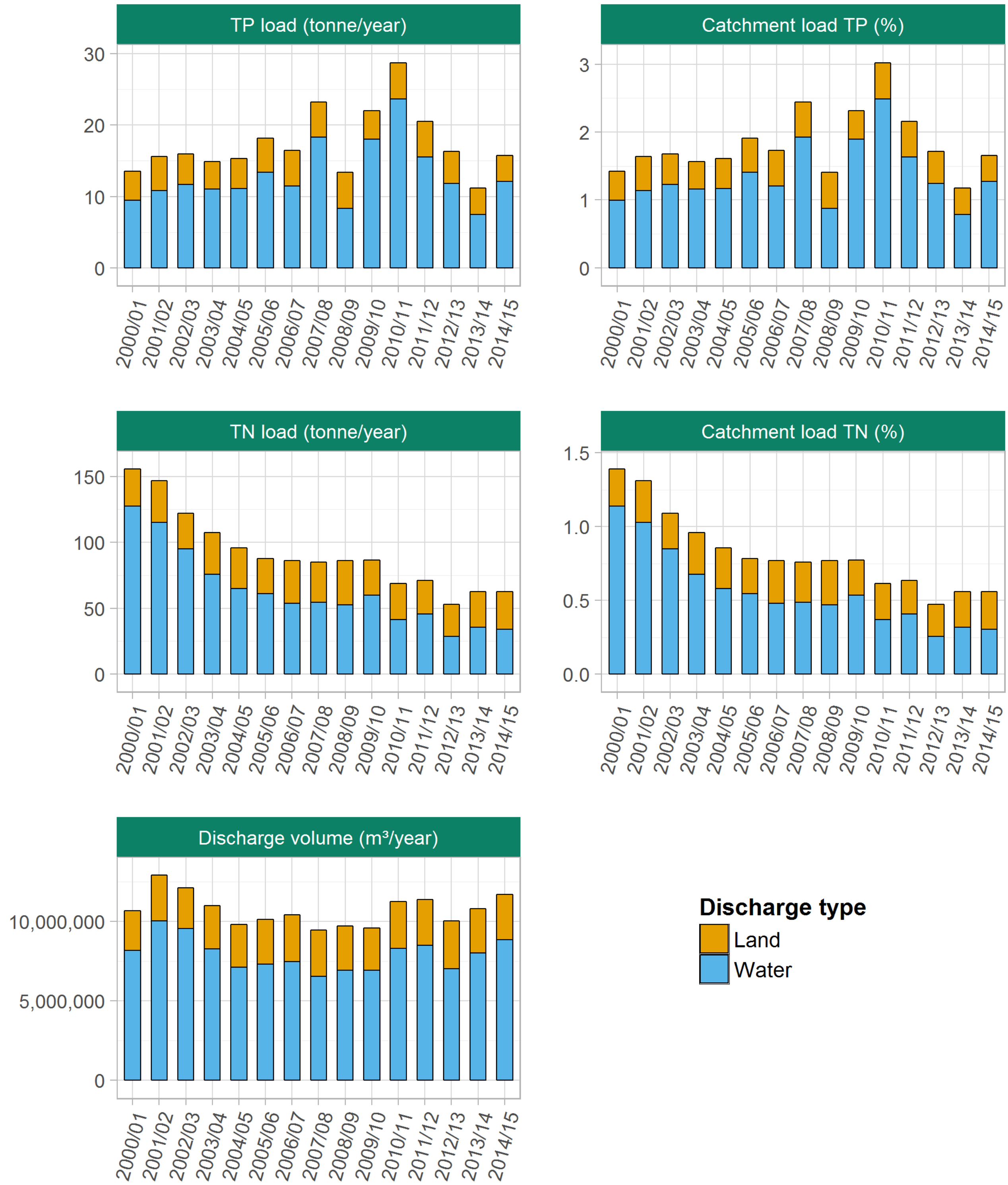

Figure 12: Discharge volumes, nutrient losses to water and % of catchment load for the five sites in the Waikato River catchment for the period 2001 to 2015 by discharge type.

APPENDIX C

Site specific discharge assessments

9.0 REPOROA

Figure 13: Reporoa wastewater discharge annual volume and TP characteristics (discharge concentration, total annual load applied to land, estimated potential loss to water, % of total Waikato River catchment TP load and % of the Waikato River catchment TP load attributed to diffuse sources.

Figure 14: Reporoa wastewater discharge annual volume and TN characteristics (discharge concentration, total annual load applied to land, estimated potential loss to water, % of total Waikato River catchment TN load and % of the Waikato River catchment TN load attributed to diffuse sources.

10.0 LICHFIELD

Figure 15: Lichfield wastewater discharge annual volume and TP characteristics (discharge concentration, total annual load applied to land, estimated potential loss to water, % of total Waikato River catchment TP load and % of the Waikato River catchment TP load attributed to diffuse sources.

Figure 16: Lichfield wastewater discharge annual volume and TN characteristics (discharge concentration, total annual load applied to land, estimated potential loss to water, % of total Waikato River catchment TN load and % of the Waikato River catchment TN load attributed to diffuse sources.

11.0 HAUTAPU

Figure 17: Hautapu wastewater land irrigation annual volume and TP characteristics (discharge concentration, total annual load applied to land, estimated potential loss to water, % of total Waikato River catchment TP load and % of the Waikato River catchment TP load attributed to diffuse sources.

Figure 18: Hautapu wastewater land irrigation annual volume and TN characteristics (discharge concentration, total annual load applied to land, estimated potential loss to water, % of total Waikato River catchment TN load and % of the Waikato River catchment TN load attributed to diffuse sources.

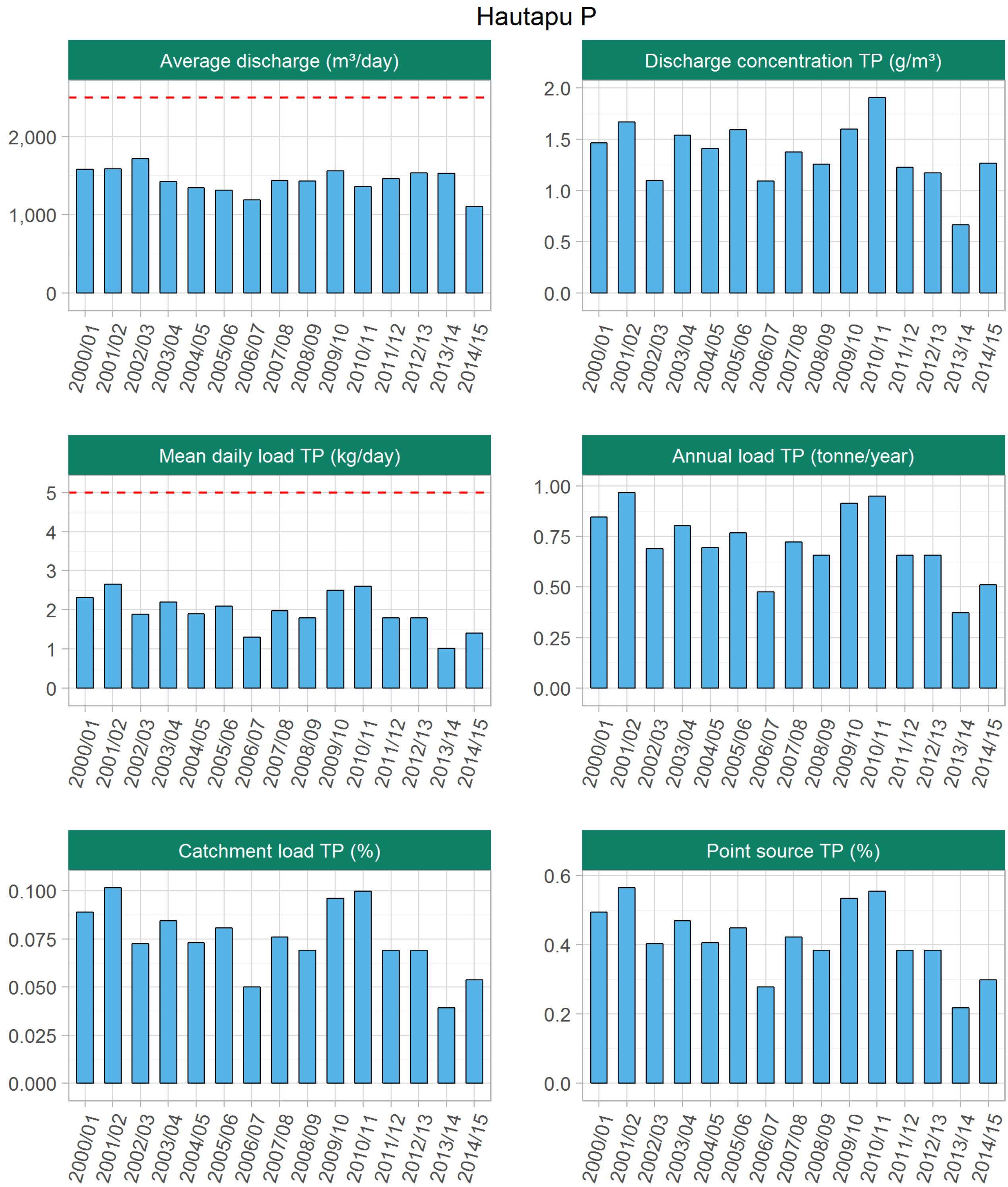

Figure 19: Hautapu wastewater discharge to water average daily discharge and TP characteristics (discharge concentration, mean daily load, total annual load, % of total Waikato River catchment TP load and % of the Waikato River catchment TP load attributed to point sources. Red dashed lines are consent limits.

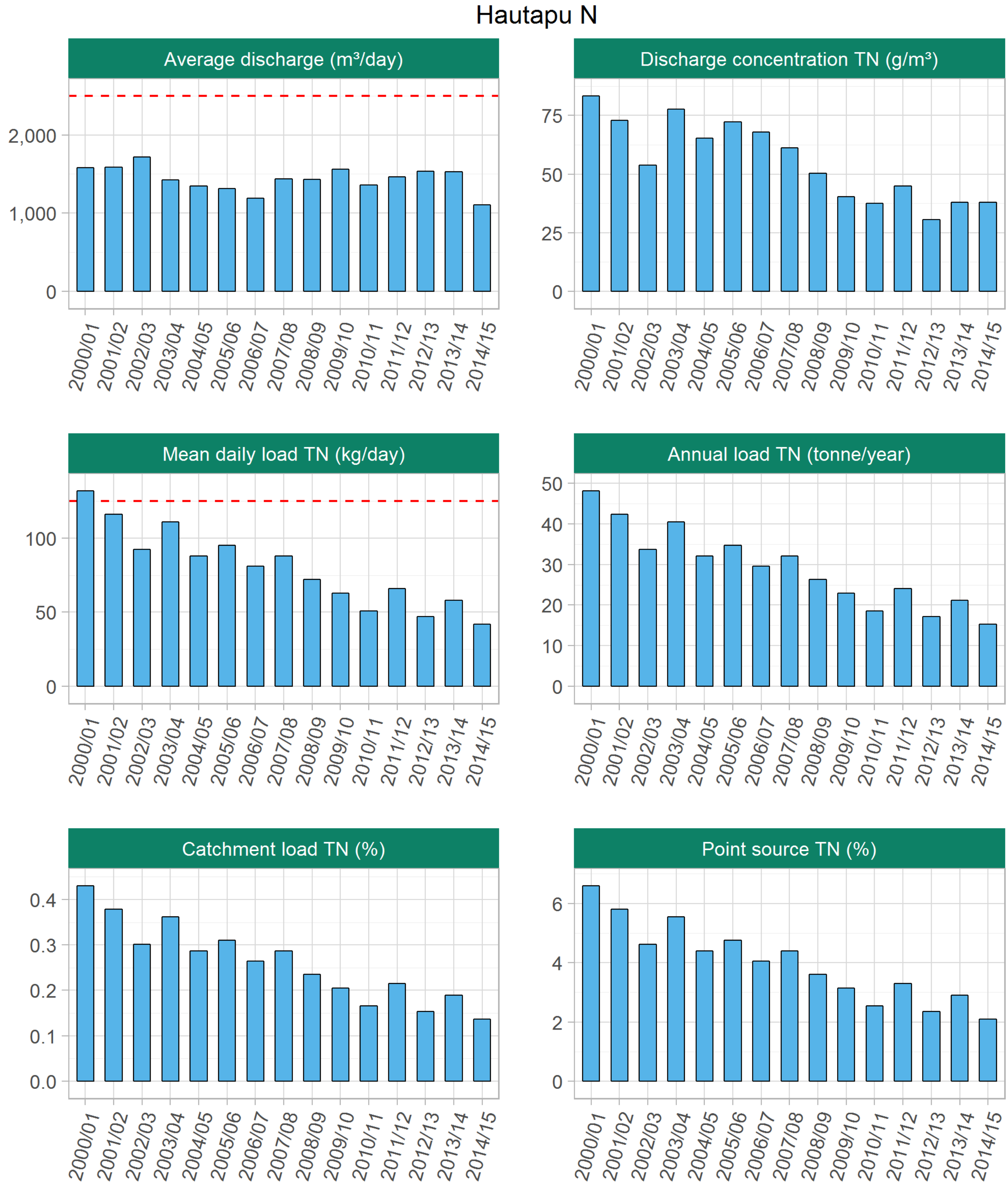

Figure 20: Hautapu wastewater discharge to water average daily discharge and TN characteristics (discharge concentration, mean daily load, total annual load, % of total Waikato River catchment TN load and % of the Waikato River catchment TN load attributed to point sources. Red dashed lines are consent limits.

12.0 TE RAPA

Figure 21: Te Rapa wastewater discharge to water average daily discharge and TP characteristics (discharge concentration, mean daily load, total annual load, % of total Waikato River catchment TP load and % of the Waikato River catchment TP load attributed to point sources. Red dashed lines are consent limits

Figure 22: Te Rapa wastewater discharge to water average daily discharge and TN characteristics (discharge concentration, mean daily load, total annual load, % of total Waikato River catchment TN load and % of the Waikato River catchment TN load attributed to point sources. Red dashed lines are consent limits.

13.0 TE AWAMUTU

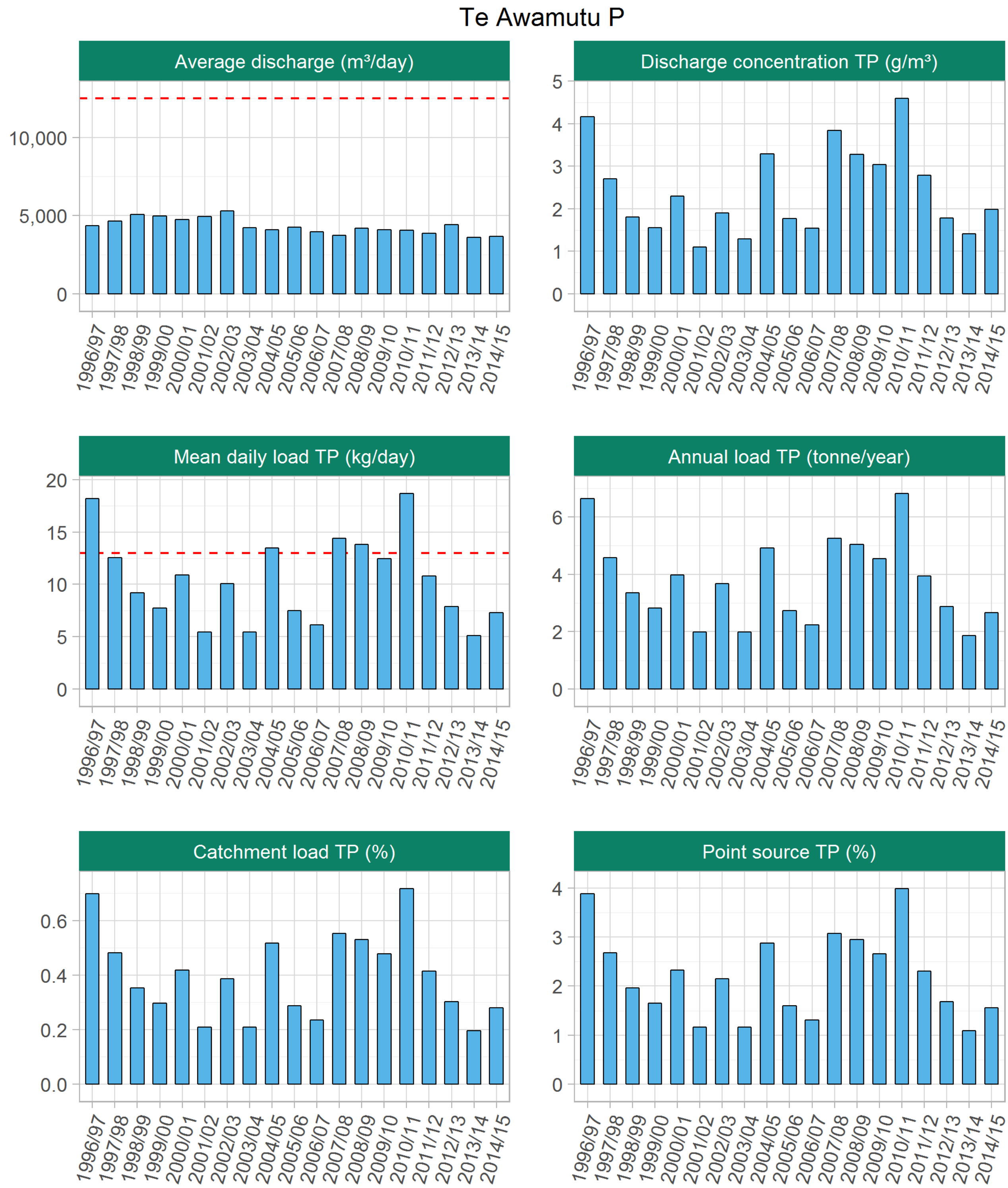

Figure 23: Te Awamutu wastewater discharge to water average daily discharge and TP characteristics (discharge concentration, mean daily load, total annual load, % of total Waikato River catchment TP load and % of the Waikato River catchment TP load attributed to point sources. Red dashed lines are consent limits

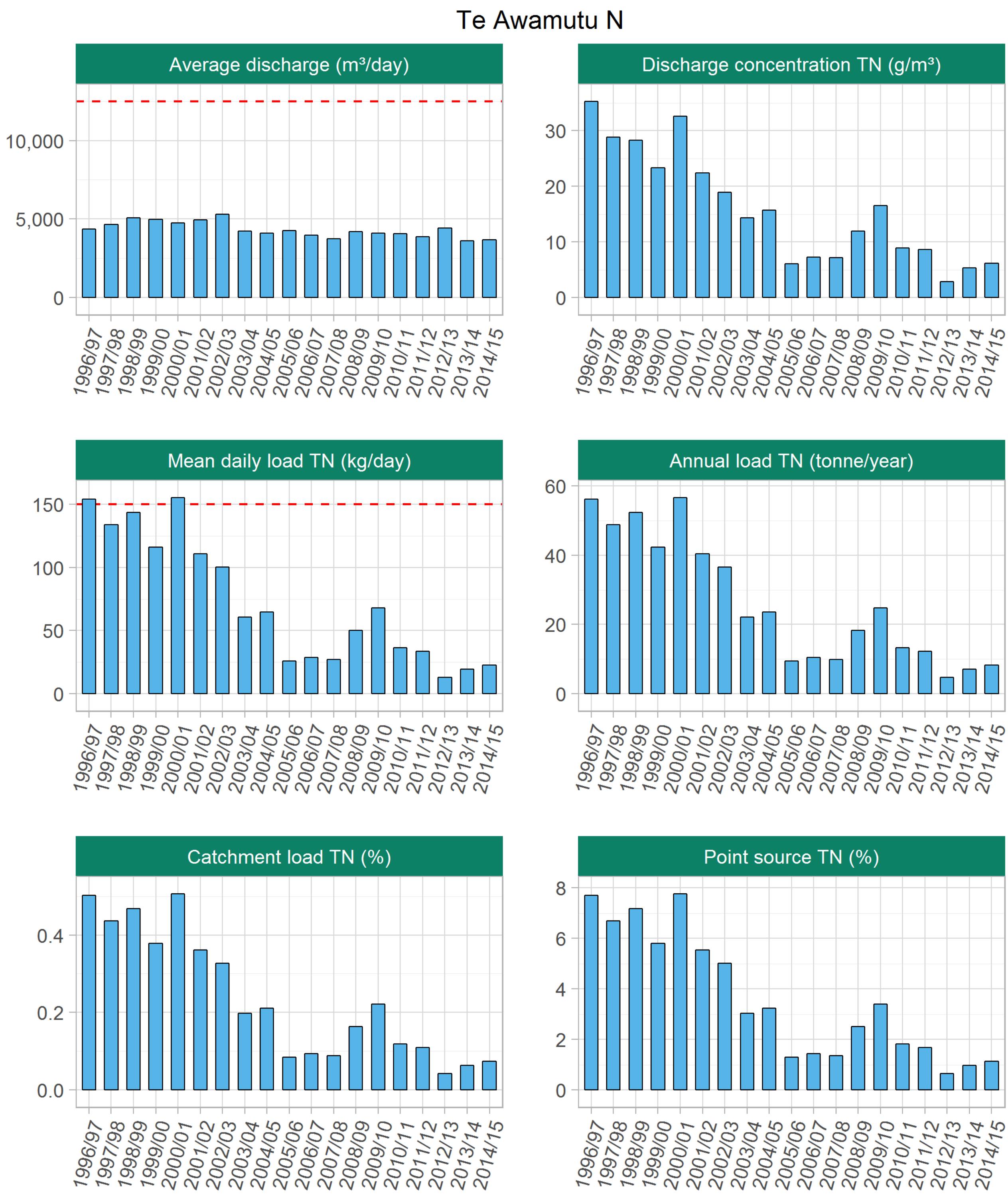

Figure 24: Te Rapa wastewater discharge to water average daily discharge and TN characteristics (discharge concentration, mean daily load, total annual load, % of total Waikato River catchment TN load and % of the Waikato River catchment TN load attributed to point sources. Red dashed lines are consent limits.

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