BAY OF PLENTY REGIONAL COUNCIL

PC10 Catchment N Accounting

Module 4. Lake Rotorua Science Review

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1 Executive summary

This report describes the nitrogen accounting methodology that supports Plan Change 10 (PC10). It provides a revised version of the ROTAN 2011 nitrogen budget using OVERSEER® 6.2.3 and current understanding of measured loads. Progress towards reduction targets is reported both in terms of permanent reductions and non-permanent reductions.

The ROTAN 2011 nitrogen budget has been updated to include revised land use areas, the latest groundwater boundary, and OVERSEER® 6.2.3 average land use discharge coefficients based on the Rule 11 benchmarking. The budget estimates a catchment pre attenuation annual load of 1274 tN (tonnes nitrogen) and calculates an attenuation factor of 44% to achieve the ROTAN 2011 steady state load of 755 tN. Adjusting the Integrated Framework (I.F.) reductions to use the same attenuation factor and reflect our current understanding of the gorse area in the catchment results in a post mitigation load of 446 tN which is reasonably close to the sustainable annual load of 435 tN.

Permanent nitrogen (N) reductions from the catchment are achieved through the Incentives Programme, engineering solutions, and the conversion of gorse land to bush or forestry. The Incentives Programme has achieved 11% of its OVERSEER® 6.2.3 reduction target and the Engineering Programme has removed 26% of its OVERSEER® 6.2.3 reduction target. As a result of a better understanding of the gorse coverage in the catchment, the estimated load from gorse has reduced from 30 tN to 13.9 tN. Of the 30 tN target reduction, 3% has been permanently removed through commercial agreements to convert gorse areas to forestry or bush and scrub.

Non-permanent N reductions are reductions below the allocated level that are not locked-in through commercial agreements or rules. Current state information has been used to indicate the level of non-permanent reductions in the catchment. Approximately 52% of the pastoral area in the catchment has current state information available. On average the N load from these properties is 17% below their start point[1] allocations and 9% above their 2032 allocations.

Consideration of the gaps and limitations identified in this report leads to six recommendations for further work:

- Define reporting requirements. The reporting requirements determine the information collected and the systems required to manage that information.
- Complete development of NDMS (Nutrient Data Management System). The N accounting system must be able to accurately and reliably track changes to allocations arising from N buy outs, trading between properties and shifts within properties.
- Work with OVERSEER® Limited to improve the N loss predictions in the Rotorua catchment and the model's reliability.
- Investigate catchment attenuation and the uncertainties in measured loads, modelled loads and groundwater travel times.

[1] Start Points are defined in PC10. For the purposes of this report a start point can be considered as a property's initial allocation from which reductions are made.

- Investigate N losses from lifestyle blocks. Understanding the N losses from lifestyle blocks will help inform where resources should be focused.
- Measure loads and trace losses from stormwater and sewerage systems to identify areas where reductions can be made.

2 Introduction

2.1 Rationale for this nitrogen accounting module

Plan Change 10 (PC10) introduces a new nutrient management regime for the Lake Rotorua catchment, and includes a requirement for 5-yearly science reviews via Method M2, where clause (b) states that the review will include: *Review of progress towards achieving the RPS Policy WL 6B(c) 2022 catchment nitrogen load target limit* (Bay of Plenty Regional Council (BOPRC), 2017a).

Method M2 and related matters were considered by the Water Quality Technical Advisory Group (WQTAG) during 2017 and a broad Science Review Terms of Reference (ToR) was developed. This expanded on M2(b) by noting: *This is nitrogen accounting of what has been achieved through any intervention including permanent reductions in N reductions* (Bay of Plenty Regional Council, 2017b). The ToR also noted that BOPRC should meet with DairyNZ to assess additional data DairyNZ may be able to provide[2]. The scope of this module was refined and agreed in discussion between the authors and consultant Simon Park (acting on behalf of BOPRC's Andy Bruere).

2.2 Basis for nitrogen accounting

The annual steady state nitrogen load entering Lake Rotorua was modelled in 2011 as 755 tN (Rutherford, Palliser & Wadhwa, 2011) and the sustainable lake load is 435 tN (Policy WL 6B, Regional Policy Statement, BOPRC (2014)). These two load figures form the foundation upon which the catchment nitrogen accounting is based. Through consultation with the community, the Integrated Framework (I.F.) was developed and adopted as the preferred approach to achieving the 320 tN reduction target. The I.F. achieves a 224 tN (70%) reduction by 2022, 272 tN (85%) by 2027 and the full 320 tN reduction by 2032. Responsibility for these reductions has been shared between the wider community (180 tN) and rural land owners (140 tN), with the community's reductions to be completed by 2022 and the landowners' reductions to occur in three stages; 44 tN by 2022, 92 tN by 2027 and 140 tN by 2032. The community share of the reductions will be achieved through nitrogen buy-outs (Incentives Programme), engineering solutions and a gorse removal programme. The rural land owner share will be achieved through the application of rules that reduce N allocations at the farm level over time. The ROTAN 2011 catchment budget and I.F. reductions are shown in Table 1. Note that the 'baseline' total catchment N load of 755 tN/y in ROTAN 2011, is a steady state load based on 2010 land use areas and N loss rates being held constant. This steady state load approach overcomes the complication of accounting for groundwater lag times.

[2] A teleconference meeting took place on 28/3/2018 between the author, Landconnect consultant Simon Park and DairyNZ staff Tom Stephens, Justine Young and Rachael Davidson.

Table 1: Lake Rotorua catchment budget and Integrated Framework reductions adapted from ROTAN 2011.

Land use	Area (ha)	Load to Lake (tN/y)	I.F. Reductions (tN/y)				2032 Load to Lake (tN/y)
			Rules	Incentives	Engineering	Gorse	
Dairy	5050	273.2	-96	-50	-1.3	-10.0	115.5
Drystock	16125	253.2	-44	-50	-2	-10.0	147.6
Forestry	19594	72.2				-10.0	62.2
Forest Puarenga	1588	3.2					3.2
Septic tanks	308	26.2			-10		16.2
Urban Open Space	805	8.0					8.0
Lake or waterway	8257	30.0					30.0
Reticulation 2001-	300	33.7			-3.7		30.0
Tikitere	28	30.0			-30		0.0
Urban	2548	25.5			-3		22.5
Whakarewarewa	31	0.3					0.3
	54633	**755**	**-140**	**-100**	**-50**	**-30**	**435**

NB: The I.F. reductions for Incentives, Engineering and Gorse (Table 1), have previously been reported only as the totals seen in the bottom row. For the purposes of this module, it is useful to distribute those I.F. reduction totals in a plausible manner e.g. splitting the incentives reduction into equal 50 tN shares for dairy and drystock land uses. This can be adjusted in future reviews as more data on actual reductions becomes available.

The I.F. was developed using the ROTAN 2011 prediction of steady state load to lake. ROTAN 2011 used OVERSEER® Version 5 to calculate pastoral loads and these were predicted to be entering the lake; i.e. load to land from pastoral land use equalled load to lake from pastoral land. Since the development of the I.F. there have been significant improvements in our understanding of the catchment. These relate to:

- An update of the groundwater boundary (White, Tschritter, Lovett, & Cusi, 2014);
- The almost doubling of OVERSEER® modelled N predictions of the 2001-2004 farm systems (due to changes in OVERSEER® versions). This has required the adoption of an 'attenuation factor' to align modelled land loads with predicted steady state lake loads; and
- Completion of property benchmarking of 2001-2004 N discharges and land use areas for the majority of the catchment.

As a result it is necessary to confirm that the catchment budget can be reasonably adapted to include the changes and still achieve the policy objectives. Given that there has been some concern about the use of OVERSEER® in a regulatory capacity (primarily because of the variability in predicted N leaching between different model versions) the Parliamentary Commissioner for the Environment, Simon Upton, has been investigating the 'fitness-for-purpose' of OVERSEER®. PC10 has addressed the variability in absolute N leaching losses between versions by seeking relative change rather than absolute N reductions.

While OVERSEER® 6.3.0 was released in April 2018, the analysis for this module was largely completed prior to the 6.3.0 version release. A description of the changes between OVERSEER® 6.2.3 and 6.3.0 can be found in the release notes (OVERSEER®, 2018). On average OVERSEER® reported an average change in N leaching of 3.1 kg N/ha/y between 6.2.3 and 6.3.0 (from 31,900 farm files nationwide), although for the reference files used within the PC10 allocation methodology the N losses for dairy and drystock decreased by 7.73 kg N/ha (from 95.45 to 87.72 kg N/ha; 8.8 %) and

6.25 kg N/ha (34.24 to 27.99 kg N/ha; 22.3%) respectively. The amount of effort required for individual landowners to meet reduction targets in the Lake Rotorua catchment however remains unchanged between versions.

With this in mind, this module aims to provide an updated catchment N budget and report on progress towards achieving the catchment N targets within that budget. It does not attempt to update the science other than to achieve some alignment between the current nitrogen accounting methodologies and the ROTAN 2011 catchment budget. This report is also not designed to discuss the methods used to allocate nitrogen within the Rotorua catchment, or to justify the appropriateness or use of OVERSEER® within PC10[3].

3 Key questions

This report addresses the following key questions:

- What does an updated catchment budget look like, after taking account of:
    - the large changes to OVERSEER® predictions;
    - the need to consider attenuation, and;
    - our improved understanding of catchment land uses and areas.
- Using plausible reduction assumptions, can the programme still achieve the sustainable lake load (435 tN)?
- How much N has been permanently removed through reduction programmes?
- How much N has been temporarily removed as a result of landowners operating below their N allocations?

4 Approach to N accounting

PC10 allocates nitrogen using OVERSEER® 6.2.0. Relative to the OVERSEER® 5 based rural N loads used in ROTAN 2011 and the I.F., OVERSEER® 6.2.0 predicts significantly higher N loads from pastoral land use. For example, the average 2001-2004 dairy load modelled in OVERSEER® 6.2.0 is about double that modelled in OVERSEER® 5. To manage this, the reductions proposed in the I.F. from the modelled pastoral loads (through rules or the Incentives Programme) have been converted to a percentage of the relevant sector load. The rules dairy reduction target is set at 35.3% of the 2001-2004 dairy load (96/273.2 tN/y, Table 1) and the rules drystock reduction target is 17.2% of the 2001-2004 drystock load (44/252.7 tN/y, Table 1). These reduction percentages are then applied to the OVERSEER® 6.2.0 sector loads to determine individual block percentage allocations using the hybrid allocation approach described in Schedule LR One of PC10. Incentives Programme reductions are maintained at 71.4% of the combined dairy and drystock reductions. Engineering and gorse targets also need to be adjusted to allow for the attenuation factor and achieve the I.F. reductions to the lake where possible.

PC10 requires nitrogen to be allocated spatially for all pastoral land within the PC10 area based on the 2001-2004 land use. To assist with tracking progress towards the reduction targets, known

[3] For guidance on the regulatory use OVERSEER® see www.overseer.org.nz/overseer-explained/environmental-compliance

sources of nitrogen within the groundwater catchment have been assigned an N discharge and these have been located spatially in a broadly similar manner as used in ROTAN 2011.

Whilst N loads have been located spatially, PC10 enables the movement of N allocation both within and between properties. As our knowledge increases it is likely that the amount of N assigned to non-pastoral sources will also change. To track these changes and identify progress towards N targets, four spatial layers are being developed for integration into the Lake Rotorua Nutrient Data Management System. These layers are:

- Base Data 2001-2004;
- Current Allocation;
- Authorised Activity;
- Rules Monitoring.

The Base Data 2001-2004 layer contains our best estimates of the nitrogen yields from land use and other sources during the 2001-2004 period and the N allocations to achieve the PC10 reductions.

The Current Allocation layer captures changes in allocations resulting from shifts in N allocations within properties, transfers (trades) between properties and N removals through the Incentives Programme. Comparison of this layer with the Base Data 2001-2004 provides the amount of N allocation permanently removed from the catchment.

The Authorised Activity layer provides a visual representation of the activity status of each property under PC10. This layer will also show the proportion of each property's allocation that has been authorised under a resource consent. For example, a property may have a total allocation of 1000 kg N/y but be authorised to discharge 900 kg N/y. Where properties are not operating under a resource consent, the low intensity farming maximum allocation[4] will be assumed. Comparison of this layer with the Current Allocation layer will provide the amount of allocated N that is authorised to be used.

The Rules Monitoring layer will capture the most recent monitoring data for each property. By comparing this with previous monitoring data, trends describing the performance of the property can be identified. Comparison with Base Data 2001-2004, the Current Allocation and the Authorised Activity layers allows the actual N reductions to be identified.

At the time of writing this report, the system described above is under development. Whilst the Base Data 2001-2004 layer is complete, the Current Allocation layer is still in development and so progress towards targets is assessed manually. Consenting farm systems is underway and the first consent has been issued, however no monitoring has taken place. Consenting and monitoring information will enable the Authorised Activity and Rules Monitoring layers to be completed. In the future, with the processing of resource consents and the monitoring of consented and permitted activities, a more complete picture of progress towards achieving the N reduction targets will be available.

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[4] The low intensity farming maximum allocation is set at 57% of the drystock reference file. In OVERSEER® 6.2.3 this is 19.5 kg N/ha/y.

4.1 N Data sources and load assumptions to update the catchment budget

The following subsections describe the data sources and assumptions used to update the Rotorua catchment budget and I.F.). A revised catchment budget that includes the changes described in the subsections below has been developed using OVERSEER® 6.2.3 and is presented in Table 2 (Section 5).

4.1.1 OVERSEER® modelled losses

ROTAN 2011 used OVERSEER® 5.4 to estimate yields from dairy, drystock, and lifestyle land use categories. In aggregate, these land uses accounted for approximately 72% or 526 tN/y of the ROTAN 2011 steady state load of 755 tN/y. In the proposed budget (Table 2), OVERSEER® 6.2.3 has been used to predict the losses from dairy, drystock, forestry, bush and scrub, grazed trees, house blocks, urban open space and urban background losses. A total load for each land use category was estimated by calculating the average OVERSEER® 6.2.3 benchmarked[5] load and applying it to each land use category. Land uses and areas have been mapped in ArcGIS for the entire catchment based on farmer interviews and/or 2003 photography.

Schedule 1 in PC10 sets out the N allocation regime. A 35.3% (167 tN) and 17.2% (94.8 tN) reduction is achieved through rules from the dairy and drystock sectors, respectively (Table LR 6, PC10; BOPRC, 2017a). The I.F. requires that the Incentives Programme achieve a reduction of 100 tN/y in OVERSEER® 5.4 (Table LR 1, PC10; BOPRC, 2017a). To maintain proportionality with the reductions required from rural land owners (through changes to OVERSEER® predictions), the Incentives Programme target reduction has been set at 71.4% (or 187 tN) of the rules reductions. Therefore it is assumed that a reduction of 93.4 tN is achieved from both the dairy and drystock sectors. A further 16 tN is to be achieved through engineering solutions resulting in a total reduction of 45% (464.6 tN) from the pastoral area within the catchment (Table 2).

House blocks were modelled as part of the 2001-2004 property benchmarking. House block N losses include components for septic tanks, background losses and cultivated areas. Reductions were calculated based on 728 houses being connected to the reticulation system and a 90% N removal rate through the Rotorua waste water treatment plant (WWTP).

4.1.2 Gorse

Gorse was not included as a land use category under ROTAN 2011 however gorse and other losses resulting from land conversion were considered. Leaching losses from gorse would have been included within the monitored stream loads used to calibrate the ROTAN model. A review of gorse management options by Hamill, MacGibbon, Abbiss and Paragahawewa (2012) recommended using a root zone leaching coefficient of 38 kg N/ha/y for mature gorse, and 869 ha of gorse was identified in the Rotorua catchment (Male, 2010). This data informed the I.F. and the BOPRC gorse policy, with the estimate that 30 tN/y could be mitigated by removing all gorse in the catchment. Further detailed examination of the 2003 aerial imagery and comparison with high definition imagery collected in 2011, 2014 and 2016 refined the gorse area to 882 ha. The percentage gorse cover within this area has been estimated at 41%, giving total gorse coverage of 362 ha. This leads to a

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[5] Under Rule 11, properties were required to have their nitrogen and phosphorus losses benchmarked for the period 1 July 2001 – 30 June 2004. Approximately three quarters of the surface water catchment was benchmarked.

gorse load from land of 14 tN/y. Assuming 80% of the gorse can be removed results in a 10 tN/y reduction to land (Table 2) and after applying the attenuation factor, a 6 tN/y reduction to the lake (Table 3).

4.1.3 Rain and Whakarewarewa

ROTAN 2011 uses a total load from rain falling on the lake of 30 tN/y and 0.3 tN/y from Whakarewarewa geothermal area. This budget uses the same load assumptions.

4.1.4 WWTP discharges

Between 2001 and 2009 the Rotorua WWTP discharged an average of 56 tN/y to the Whakarewarewa Forest through the Rotorua land treatment system (RLTS) (Rutherford, 2011). Within ROTAN this was attenuated by 40% to give a calculated load to the lake of 33.7 tN/y. Discussions with Alison Lowe (RLC, pers. comm., March 2018) have confirmed that 33.7 tN/y was an average annual measured load in the Waipa Stream for the period. It is assumed that there is no attenuation beyond the measuring point and therefore 33.7 tN/y (rounded to 34 tN/y) enters the lake (Table 2).

It is assumed that RLC will maintain the WWTP N discharge at no more than the consent limit of 30 tN/y resulting in a 4 tN/y in-lake reduction when compared to the 2001-2004 lake load. It is assumed that there is further opportunity to remove N from the WWTP outflow by commercially growing and harvesting algae. An estimated 7 tN/y in-lake reduction has been assumed to be achievable between the WWTP outflow and Lake Rotorua, further reducing the WWTP load from 30 tN/y to 23 tN/y, which would be achieved as part of the 50 t engineering target (Table 3).

4.1.5 Urban land uses

ROTAN 2011 applied a background loss of 10 kg N/ha/y to both the area of reticulated housing (2548 ha) and the urban open space (UOS) areas, giving a total area 3353 ha and a total load (not including sewage) of 33.5 tN (Rutherford et al., 2011). Of this 805 ha is considered UOS.

BOPRC mapping identifies a similar area of reticulated housing, however the area of UOS is less at 522 ha. This difference is largely due to 333 ha of tree-covered parklands recorded as “bush and scrub” rather than UOS. For this budget these areas have been given the bush and scrub discharge of 3 kg N/ha/y, and the 522 ha of sportsground, golf courses and grass-covered parks identified as UOS have been given 21 kg N/ha/y, based on a limited number of benchmarked UOS properties.

Losses from reticulated housing have been considered as two components; storm water losses and leaching losses.

Macaskill, Bowman, Golding, Horrox and Phillips (2003) reported an estimated stormwater load of 9.3 tN/y over the Rotorua residential, commercial, industrial and road reserve areas. This is equivalent to 3.0 kgN/ha/y in stormwater load. Therefore 3.0 kg N/ha/y has been applied to the reticulated housing area as a stormwater load.

Macaskill et al. (2003) also reported an area of 3063 ha under residential, commercial and industrial land uses of which 43% was covered by impervious surfaces. Leaching loads are therefore calculated as 57% of the BOPRC reticulated area at 3 kg N/ha/y (Wheeler, MacCormick & Wheeler, 2010) or 1.7 kgN/ha/y over the reticulated area. An additional load of 108 kg N/ha/y (OVERSEER® 6.2.3 loss prediction for cultivated gardens) is applied to 3% of this area (3.2 kgN/ha/y over the reticulated area) to account for loads from cultivated gardens. Therefore in total the leaching load from the reticulated area is estimated to be 5 kg N/ha/y.

This approach to urban loads results in an N leaching load of 13 tN/y from reticulated housing and an urban stormwater load of 8 tN/y (Table 2).

Reductions from urban land, totalling 4 tN/y, are assumed to be possible (e.g. through fertiliser management, reductions in cultivated area, treatment of stormwater through wetlands, etc.). These reductions are split evenly between the UOS and stormwater discharges (Table 2).

4.1.6 Tikitere

Research into the N loads down the Waiohewa Stream is ongoing. N loads have been shown to be variable, probably as a result of rainfall, runoff and drainage. Currently the best estimate of the long term load is 25 tN/y of which the proposed zeolite plant is likely to be able to remove around 80% (A. Woolhouse, personal communication, March, 2018). Comparison of samples at the proposed plant site and near where the stream enters the lake indicate that in-stream attenuation is minimal (Paul Scholes, personal communication, March, 2018).

4.1.7 Roads and non-productive areas

Non-productive areas were identified during the benchmarking process and were generally areas of land such as sheds, driveways or hard surfaces. These have been given a discharge of 0.5 kg N/ha/y in line with OVERSEER's miscellaneous loss coefficient (Wheeler, 2010).

4.1.8 N attenuation factor

For the purposes of this catchment N budget, the 44% attenuation factor has been calculated to achieve a 755 tN annual lake load. This is not measured attenuation but rather a calibration factor that enables current catchment budgets to be scaled to match the predicted steady state load entering the lake after groundwater lags are considered. The same attenuation is applied to the post reduction loads to calculate the 2032 lake load. Loads that occur near to or directly at the lake have no attenuation applied. A Bay of Plenty Regional Council review of nutrient loads from septic tanks recommended that 10 g N/person/day be used to estimate N loads to lakes in the Bay of Plenty (McIntosh, 2012). Comparing this to the OVERSEER® modelled discharge of 12.27 g N/person/day (4.48 kg N/person/y) suggests an attenuation factor of 18.5% on the septic tank load. Allowing for the background losses from a typical house being attenuated at 44% gives a combined house block attenuation of 22% (Table 2).

5 Results and discussion

5.1 Updated catchment budget

The updated catchment budget is presented in Table 2. The table is split into two land use groups. Those in **bold** represent the broad land use categories developed as a result of benchmarking and sum to the catchment groundwater area. The *italicised* land uses are those with discharges occurring in one or several of the **bold** land use categories. For example the gorse discharges are spread across the Dairy, Drystock, Grazed trees, Forestry and Bush and Scrub categories. The areas of these land uses are not included in the total catchment area. Comparison with Table 1 shows that the groundwater area defined by White (2014) is 843 ha smaller than the ROTAN 2011 groundwater area.

The estimated total catchment annual load to land is 1274 tN, which is 519 tN greater than the ROTAN 2011 steady state load of 755 tN. To achieve a 755 tN lake load, 44% attenuation is applied to most land use categories.

Table 2: Updated N budget for Lake Rotorua using losses modelled in OVERSEER® 6.2.3, measured loads and attenuation factors calculated to achieve 755 tN. Applying the same attenuation factors to the land load after reductions gives a 2032 lake load of 446 tN.

Land use	Area (ha)	Load to land (tN/y)	Pre-attenuation reductions (tN/y)				Load to land before attenuation and after reductions (tN/y)	Attenuation factor	Load to lake after attenuation and before reductions (tN/y)	Load to lake after attenuation and reductions (tN/y)
			Rules	Incentives	Engineering	Gorse				
Dairy	**4990**	**473**	-167.0	-93.4	-5.0		208	44%	267	117
Drystock	**15873**	**551**	-94.8	-93.4	-11.0		352	44%	311	199
Grazed trees	**1346**	**12**					12	44%	7	7
Forestry	**9163**	**23**					23	44%	13	13
Bush and scrub	**9994**	**30**					30	44%	17	17
House	**396**	**27**			-8.8		19	22%	21	14
Reticulated	**2589**	**13**					13	44%	7	7
Urban Open	**522**	**11**			-2.0		9	44%	6	5
Lake or waterway	**8145**	**0.0**					0.0	0%	0.0	0
Non-productive	**237**	**0.1**					0.1	44%	0.1	0
Roading	**534**	**0.3**					0.3	0%	0.3	0
										0
Gorse	*882*	**14**				-10	4	44%	8	2
Rain on lake	*8082*	**30**					30	0%	30	30
WWTP 2001-2004	*1*	**56**			-18.0		38	40%	34	23*
Tikitere	*1*	**25**			-20.0		5	0%	25	5
Urban	*2589*	**8**			-2.0		6	0%	8	6
Whakarewarewa	*44*	**0.3**					0.3	44%	0.2	0
Totals	**53790**	**1274**	**-262**	**-187**	**-66.8**	**-10**	**749**		**755**	**446**

*This is a hypothetical load to the lake after assuming 7 t N removal between the WWTP outflow and the lake through algal farming or other N removal process. This is additional to the WWTP treatment and N removal processes.

The post attenuation factor reductions provide a picture of how the I.F. has transitioned into OVERSEER® 6.2.3 (Table 3). The total reduction through rules (148 tN/y) is 8 tN/y more than the ROTAN 2011 I.F. modelled reductions, while the Incentives Programme target is 6 tN/y more. This is a result of the pastoral reductions being proportional to sector loads and the relative proportion of pastoral load being greater under OVERSEER® 6.2.3 than under OVERSEER® 5.4. This could be due to changes in model algorithms or the area of a land use, or changes in the average discharge of a land use through changes to the benchmarking data[6].

The post attenuation reductions achieved through engineering solutions remain at the I.F. target of 50 tN/y. This has been achieved by increasing the pre-attenuation factor engineering reductions to 66.6 tN/y (Table 2). The gorse reductions after attenuation reduce to 6 tN/y, which is significantly less than the 30 tN/y target set in the I.F.

[6] The benchmarking data that forms the basis of the 2001-2004 allocation can be changed by land owners if they can provide sufficient evidence demonstrating their 2001-2004 land use.

Overall the adjustment of the ROTAN 2011 budget and I.F. into OVERSEER® 6.2.3 results in a calculated annual lake load of 446 tN which is 11 tN greater than the sustainable lake load. Increased reductions achieved by the rules and incentives programmes are more than offset by reduced reductions predicted through the gorse programme.

While this type of analysis is useful to provide guidance on how the programme is tracking, care should be taken not to place too much weight on the exact numbers. The analysis is highly dependent on the version of OVERSEER®, attenuation factors and reduction assumptions. The value in this analysis is in providing a consistent methodology to enable the relative effect of reduction programmes to be assessed against alternative options and to enable the effect of OVERSEER® version changes to be assessed.

Achieving consistency in N reporting within the Lakes Programme has, to date, been challenging with N reductions being reported (and summed) in various OVERSEER® versions. The development of the NDMS will overcome versioning issues and provide a single source of information.

Table 3: OVERSEER® 6.2.3 budget with attenuation factor applied to achieve a steady state load of 755tN.

Land use	Area (ha)	Load to lake after attenuation and before reductions (tN/y)	Post Attenuation Reductions (tN/y)				Load to lake after attenuation and reductions (tN/y)
			Rules	Incentives	Engineering	Gorse	
Dairy	**4990**	267	-94	-53	-3		117
Drystock	**15873**	311	-54	-53	-6		199
Grazed trees	**1346**	7					7
Forestry	**9163**	13					13
Bush and scrub	**9994**	17					17
House	**396**	21			-7		14
Reticulated	**2589**	7					7
Urban Open	**522**	6			-1		5
Lake or waterway	**8145**	0.0					0
Non-productive	**237**	0.1					0
Roading	**534**	0.3					0
							0
Gorse	*882*	8				-6	2
Rain on lake	*8082*	30					30
WWTP 2001-2004	*1*	34					30*
Engineering (WWTP improvements)					*-4*		
Engineering (other)					*-7*		*-7**
Tikitere	*1*	25			-20		5
Urban	*2589*	8			-2		6
Whakarewarewa	*44*	0.2					0
Totals	**53790**	**755**	**-148**	**-106**	**-50**	**-6**	**446**

*30 tN/y from the WWTP represents the load discharged at the WWTP outflow. It is assumed that there will be a further reduction of 7 tN/y between the outflow and lake presumably by algal farming or other N removal processes.

5.2 Permanent reductions relative to 2001-2004 budget

Since "Rule 11" became operative, efforts have been made to permanently reduce the N load in the catchment through commercial agreements that effectively buy N from landowners. Initially these were termed Lakes Protection Agreements and more recently they have been known as Incentives Agreements. For the purposes of reporting they have been grouped under Incentives Agreements (Table 4). In some cases these agreements take effect in the future, however all agreements shown are completed and effective by 2022. At the time of writing nine agreements have been completed achieving around 11% of the Incentives Programme OVERSEER® 6.2.3 in-lake target. Six other agreements are under negotiation with two of those nearing completion, achieving an additional 9% reduction. These have not been included in Table 4 due to the lengthy and changing nature of negotiations.

Engineering reductions include the reticulation of houses that were on septic tanks during 2001-2004 and the reductions in the WWTP N discharge. Reticulation of 728 houses that existed during the 2001-2004 period have been calculated to prevent 8.8 tN/y and 7 tN/y discharging to the land and the lake respectively. New house builds since 2001-2004 have not been included as connection of these houses does not necessarily result in an N reduction compared to the 2001-2004 land use[7].

The WWTP operates under an annual mass load consent limit of 30 tN/y. Over the past five years the plant has been at or below this limit however the year on year performance can be quite variable. For the purposes of this report it has been assumed that the plant continues to operate at its consent limit of 30 tN/y. This results in a 4tN reduction from the 2001-2004 in lake discharge level of 34 tN/y. In the future there is a proposal to allow the annual 30 tN/y consent limit to increase by the amount of N that the WWTP takes in from the rural sector through reticulation and development of rural land into house lots. The net effect on the catchment N load will be nil as it is effectively a transfer of allocation from rural to the WWTP. It is therefore reasonable to assume the 4 tN reduction is permanent. Other engineering reductions such as floating wetlands and weed harvesting were considered during the writing of this report however the removal rates were too small to be represented and not considered to be permanent.

Eight gorse agreements have been completed, removing around 1.5 tN/y and 0.8 tN/y to the land and the lake respectively (attenuation factor of 44%). This is a 6% reduction from the revised 14 tN/y available or a 3% reduction relative to the 30 tN/y I.F. target. There are four gorse agreements currently under negotiation (at time of writing).

Table 4: OVERSEER® 6.2.3 reductions achieved to date through Integrated Framework reduction programmes.

Reduction Programme	Number of agreements	N removed from lake by 2022 (OVR 6.2.3 tN/y)	2022 in Lake Reduction Target (OVR 6.2.3 tN/y)	Percentage removed
Incentives	9	11.4	105.6	11%
Engineering	*N/A*	12.8	50	26%
Gorse	8	0.8	30.0	3%

5.3 Non-permanent reductions relative to baseline and targets

PC10 requires the submission of OVERSEER® analyses as part of its reporting requirements for various rules. It is anticipated that these will provide a good indication of what is happening in the catchment. Comparisons can then be made between the current allocations (start point allocations adjusted for incentives reductions, trading and other permanent changes to nitrogen discharge allocation (NDA)) and current farm performance, providing insight into progress towards the property's 2032 NDA and the non-permanent reductions achieved by rural land owners.

[7] The N load from the land during 2001-2004 will determine whether the addition of a house after this period results in an increase or decrease in N load.

As at April 2018, no farm performance data had been collected, however as part of the preparation for consents some properties had provided an OVERSEER® analysis describing their current farm systems (Current State (CS)). In Table 5, the number and area of CS reviews are grouped by dominant land use and review year. The total effective area for which current state information has been supplied is 11543 ha or about 52% of the pastoral area. The data indicates that some dairy properties may have converted to drystock, however the data is captured at the property level and is too coarse to indicate the exact area of land that has changed from dairy to drystock or vice versa.

Table 5: Dominant land use, year, number and area of Current State reviews.

2001-2004 Dominant land use	CS Review year	Current dominant land use	Number of properties	Total area (ha)	Effective area (ha)
Dairy	**1314**	Dairy	1	229	202
	1415	Dairy	3	709	582
	1415	Drystock	1	40	39
	1516	Dairy	19	5293	4402
	1516	Drystock	4	198	168
	1617	Dairy	2	206	200
	1617	Drystock	1	87	87
Drystock	**1415**	Drystock	9	725	590
	1516	Drystock	36	5708	3529
	1617	Drystock	23	2402	1746
Grand Total			**99**	**15597**	**11543**

The CS data represents almost all 2001-2004 dairy properties and about a third of the drystock area in the catchment. The different OVERSEER® versions used to predict property CS makes direct comparisons of loads unreliable; updating the data was not warranted given the changeable nature of the data. Area weighted percentage reductions have been calculated to demonstrate the required reductions, progress towards the reduction targets and the additional effort required to achieve those targets on a catchment basis (Table 6). The numbers are indicative only because the different assessment years, OVERSEER® versions and incomplete data are all likely to affect the result.

Using an area weighted average, the CS farm systems are discharging about 17% less than start point allocations and about 9.4% more than 2032 NDAs.

Table 6: Average area weighted percentage reductions for the 2001-2004 dominant land use. Percentage reductions are shown for start point (SP) to Nitrogen Discharge Allocation (NDA), start point to current state and current state to NDA.

2001-2004 Dominant Land use	Number of properties	Effective area (ha)	Reduction from SP to NDA (%)	Reduction from SP to CS (%)	Additional reduction to get to NDA from CS (%)
Dairy	31	5679	31.7%	18.7%	13.0%
Drystock	68	5865	15.9%	13.6%	2.3%
All	99	11543	26.4%	17.0%	9.4%

An area-based approach provides insight into the progress over the whole catchment but can mask individual property progress because large changes on one or two properties may influence the data significantly. Considering the information on a property basis provides better insight into the targets and progress by property (Table 7).

On average, dairy properties have reduced total N discharge by 17% and of the 31 properties, 23 have reduced their N discharge relative to their start point. Drystock properties have not reduced total N discharge on average, however 38 properties demonstrate reductions and 30 properties have increased their discharges relative to their start point. It is worth noting that the variation is high which demonstrates the considerable variability in how individual properties are affected.

Table 7: Dominant 2001-2004 land use and average percentage reductions calculated by property. Percentage reductions are calculated for start point to NDA and start point to current state.

2001-2004 Dominant Land use	Number of properties	Effective area (ha)	Average property reduction from SP to NDA (%)	Standard deviation SP to NDA (%)	Average property reduction from SP to CS (%)	Standard deviation SP to CS (%)
Dairy	31	5679	27%	26%	17%	23%
Drystock	68	5865	9%	17%	0%	46%
All	99	11543	14%	22%	5%	41%

The gains shown in Table 7 are not fixed and can be absorbed through intensification at any time, however the figures indicate that on average many farms have recently been operating at lower N discharge levels than their start points and are progressing well towards achieving their 2032 NDAs. The reductions shown do not include the permanent reductions achieved through the incentives and gorse programmes.

6 Limitations and gaps in understanding

The ability to report on progress towards reduction targets is dependent on good data capture and processing. Currently our ability to do this is limited by a number of factors including:

- PC10 being under appeal to the Environment Court resulting in uncertainties that slow implementation.
- Monitoring and reporting on resource consents and permitted activities has not started.
- Processes and systems to manage data are in development but incomplete.
- Reporting requirements are not yet defined.

In developing an updated catchment budget a number of assumptions needed to be made to achieve a sensible budget.

Because of the increased OVERSEER® pastoral loads as a result of the version change, an attenuation factor has been applied across land loads to match the ROTAN 2011 lake load. The attenuation factor of 44% fits within the 32%-50% range and is very close to the 42% most likely value identified in ROTAN Annual (Rutherford, 2016), however both ROTAN and this budget calculate an attenuation "factor" by difference rather than applying a measured attenuation level. To improve the catchment budget a good understanding of attenuation throughout the catchment is needed along with further investigation into the relative losses between pastoral, tree and urban land uses.

The discharge from non-benchmarked properties is estimated. Of the 22208 ha of pastoral land in the catchment (including areas of grazed trees), 4928 ha was not benchmarked and is given the average discharge according to land use sector – dairy or drystock. This non-benchmarked area is largely made up of lifestyle properties but also includes areas of larger dairy and drystock properties that fall outside the Rule 11 boundary and inside the groundwater boundary. As PC10 is implemented it is likely that our understanding of the losses from this area will improve.

A gap also exists in our understanding of urban losses. Whilst the losses from the WWTP are closely monitored and understood, the leaching and stormwater losses from the urban area could be investigated further. With an estimated load of 10 kgN/ha/y over 3111 ha, the urban area may offer some significant opportunities to remove N from the catchment.

7 Recommendations for future actions

PC10 spatially allocates nutrients throughout the catchment. This allocation is essential to drive and track progress towards a sustainable lake N load and meet community expectations. It is also an essential part of providing certainty to business in a new, nitrogen-constrained environment. The approach to updating the catchment budget described in this report shows that while OVERSEER® and the science that is informing OVERSEER® is changing, the focus on relative change used in the allocation methodology maintains the intended scale of reductions identified in the I.F. However to properly drive change, provide certainty, and track progress towards targets, a robust data collection and management system must be developed. This is underway but not yet complete.

The variation in OVERSEER® N loss predictions between versions for the same farm system can cause considerable consternation to the farming and science communities. Whilst some change is welcome, for example the introduction of new mitigation options, other change can lower trust and create uncertainty. PC10 has gone some way towards mitigating this issue by expressing allocations as percentages of an average 2001-2004 farm system (reference file) and through the use of farm plans. However, OVERSEER® version changes can still affect individual farms significantly where there is a change to load predictions from specific farm practices, biophysical features or programming errors are introduced into the model's algorithms.

Linked to questions on the OVERSEER® N loss predictions are questions around the uncertainties in measured stream loads and the relationship between measured stream loads and the modelled root zone N loss predictions from OVERSEER®. It is outside the scope of this report to comment on aspects other than nutrient accounting, however there is a clear connection between modelled OVERSEER® N losses, attenuation, groundwater travel times and measured stream loads. Improvements in understanding around any of these components will lead to improvements in nutrient accounting.

The benchmarking data is one of the key sets of information supporting the allocation methodology. This data provides the best picture of nutrient losses from the rural sector. There are two significant information gaps in this data: non-benchmarked pastoral land and the urban area. There is around 4900 ha of non-benchmarked pastoral land for which the 2001-2004 N loads are currently being estimated. Much of this land is close to the lake. A better understanding of the N loads from these areas and the effect on the lake may identify good mitigation opportunities and improve estimates of catchment loads. The urban area is around 3000 ha. Although this area is small and the nutrient loads are estimated to be small, the stormwater and sewage systems provide accessible nutrient loads that can be accessed and improved.

In summary the recommended future actions (in suggested order of priority) are:

1. Define reporting requirements. The reporting requirements determine the information collected and the systems to manage that information.
2. Complete development of NDMS (Nutrient Data Management System). The N accounting system must be able to accurately and reliably track changes to allocations arising from buy outs, trading between properties and shifts within properties.
3. Work with OVERSEER® Limited to improve the N loss predictions in the Rotorua catchment and the model's reliability.
4. Investigate catchment attenuation and the uncertainties in measured loads, modelled loads and groundwater travel times.
5. Investigate N losses from lifestyle blocks. Understanding the N losses from lifestyle blocks will help inform where resources should be focused.
6. Measure and trace loads from stormwater and sewerage systems to identify areas where N reductions can be made.

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