OVERSEER Nutrient Budget Review

For: Environment Southland – Pahia Dairies Ltd

Prepared by: Nicky Watt, CNMA

Date: 2nd February 2023

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Introduction

1. Regarding the consent application for Pahia Dairies Ltd, I have reviewed the following OVERSEER ® Nutrient Budget (OVERSEER) files:
   a) YE2020 for UC (v2) (Environment Southland)
   b) Proposed expanded dairy platform for LUC (v2) (Environment Southland)

2. Along with the files I have reviewed the following accompany report: "Overseer Nutrient Budget Report", prepared for part of a consent application to expand the dairy platform for a land use consent. The report was prepared by Nicole Mesman, Lumen Environmental Ltd. I have completed a robustness check on the file for sensibility based on data available and checked to ensure the modelling aligns with the OVERSEER Best Practice Data Input Standards for v6.4.3.

3. It must be assumed that the information provided in the OVERSEER files that the current farming system as modelled is a viable farming system, using actual stock and fertiliser inputs. Therefore, the actual and proposed scenario is also assumed to be appropriate for the location and climate.

4. A 'sensibility test' has been undertaken on the Pahia Dairies Ltd nutrient budgets with the following five output screens from OVERSEER forming the basis of the determination of the robustness of the nutrient budget:

   a) Is the nutrient loss consistent with what you would expect for an operation of this type and soils in this location?

   b) Does the summary of inputs and outputs make sense? Especially clover fixation and change in block pools?

   c) Check the 'Other values' block reports for rainfall, drainage, and PAW.

   d) Select the Scenario reports other values and check the production and stocking rate.

   e) Select the pasture production in the scenario report and check pasture growth.

5. Answers to each of these five points will be provided further in this report and then a final determination of the robustness of the nutrient loss to water will be provided at the end of this report.

OVERSEER AUDIT

Appropriateness of the Overseer inputs

1. The Overseer FM files submitted and stated in paragraph 1 of this report have been reviewed for consistency between the files and appropriateness of the inputs regarding the farming systems and the Overseer Best Practice Data Input Standard (BPDIS).

2. I concur that there are some deviations from the BPDIS. The soils between models have not been modelled to best management practice. There is difference of 5% or more in some soils between the Current and Proposed models.

3. The Current Model has 511 ha total area with 445 ha effective (382 ha in pasture and 63 ha of Fodder Beet cropped). The Proposed Model has 511 ha total area with 445 ha effective (394 ha in pasture and 51 ha of fodder beet cropped). The Current model has a dairy revised stocking unit of

20.7 RSU/ha compared to the Proposed model which has a RSU 20.1 RSU/ha or a 2.9 % decrease in RSU/ha (see Table 1 below).

4. Reviewing the NZ Dairy statistics for the 2019/2020 season, shows the average milk solids production on this property for the Current model at 345.1 kgMS/cow and 1060 kgMS/ha is respectively lower than the Southland Regional average of 418 kg MS/cow and lower than the Southland Regional average of 1133 kgMS/ha. The Proposed model at 345.1 kgMS/cow and 958 kgMS/ha is respectively lower than the Southland Regional average of 418 kg MS/cow and lower than the Southland Regional average of 1133 kgMS/ha.

5. The stocking rate for Current Model at 3.1 cows/ha higher than the Southland average for the 2019/2020 season of 2.76 cows/ha (Invercargill). The stocking rate for Proposed Model at 2.8 cows/ha is similar to the Southland average for the 2019/2020 season of 2.76 cows/ha (Invercargill).

6. *Table 1: Summary of Production and stocking rate*

	Current[1]	Proposed[2]
Total Ha	511	511
Effective Area (ha)	445	445
Effective Pasture Area (ha)	382	394
KgMS	338200	338200
MS kg/ha grazed	1060	958
MS kg MS/cow	345.1	345.1
Lactation Length	266	266
Dairy RSU	7913	7901
Dairy RSU/ha (effective pasture area)	20.7	20.1
Beef RSU	2512	2457
Replacement RSU	123	122
Total RSU	10548	10480
Total RSU/ha (effective area)	23.7	23.6
Cows/ha	3.1	2.8
Cows October	980	980
Cows June	778	778
Cows July	778	778
Replacements June/July	320	320
N lost kg/ha/yr	47	43

[1]YE2020 for LUC – Current

[2]Proposed expanded dairy platform for LUC- Proposed

7. There was 63 ha of kale grazed in the Current model, grazed May to September by beef animals (cows/replacements) and Proposed model had 51 ha of fodder beet grazed May to September by beef animals. This is a 19% decrease in winter grazed crop (see Table 2 below).

Table 2: Crop Details

	Current	Proposed
Kale (ha)	63	-
Kale Yield (tDM/ha)	12	-
When grazed	May to Sept	-
Grazed by	Beef	-
Fodder Beet (ha)	-	51
Fodder Beet Yield (tDM/ha)	-	16
When grazed	-	May to Sept
Grazed by	-	Beef

8. The soil areas are not within the margin of error for all soils (see Table 3 below).

Table 3: Soil Details

	Current	Proposed	Changes (%)
Waiki_16a	159.2	164.9	+ 3.5
Kaip_9a	112.6	112.8	+ 0.2
Orep_2a	77.3	77.1	-0.3
Otwy_3a	58.6	52.4	-10.6
Orik_2b	23.3	25.5	+8.6
Piak_5b	14	12.3	-12.1

9. Supplements imported to meet cow demand (see Table 3 below). Pasture silage has been made where there was a surplus of pasture.

10. The Current model had 13.2 tDM/ha average pasture growth compared to 13.3 tDM/ha for the Proposed model (similar pasture growth). The N used on all pasture in the Current and Proposed models was 190 kgN/ha. There is expected to be 12.6 % less supplement imported and 81 % more silage harvested in the Proposed model compared to the Current model (see Table 4 below).

Table 4: Supplements imported and Harvested

	Current	Proposed
Supplements Imported (tDM)	880	770
Supplements Imported Effective Area (tDM/ha)	1.98	1.73
Silage Harvested (tDM)	24.5	150
Silage Harvested Pasture (tDM/ha)	0.08	0.42
Total Area (ha)	511	511
Effective Area (ha)	445	445
Effective Pasture Area (ha)	382	394
Dairy RSU	7913	7901
Dairy RSU/ha (effective pasture area)	20.7	20.1
Beef RSU	2512	2457
Replacement RSU	123	122
Total RSU	10548	10480
Total RSU/ha (effective area)	23.7	23.6
Cows/ha	3.1	2.8
N Fertiliser applied non -effluent area(kgN/ha)	190	190
N Fertiliser applied effluent Area (kgN/ha)	190	190
Pasture Growth (tDM/ha) - Average	13.2	13.3

Overseer Outputs

The N lost to water for the Current model was 47 kgN/ha/yr (24052 kgN/annum) compared to 43 kgN/ha/yr (22220 kgN/annum) for the Proposed model which is a 7.6 % reduction in total N loss. The P loss for the Current model was 1.8 kgP/ha/yr (945 kgP/annum) compared to 1.5 kgP/ha/yr (764 kgP/annum) for the Proposed model which is a 19.2% reduction in total P loss (see Table 5 below). It is assumed that the information provided in this farming system is modelled as a viable farming system, using actual stock and fertiliser inputs.

Table 5: OVERSEER outputs

Overseer v6.4.3	Current	Proposed
N lost to water kg/ha/yr	47	43
Total N lost kg/farm	24052	22220
P lost kg/ha/yr	1.8	1.5
Total P lost kg/farm	945	764

Other sources – N	763	757
Other sources – P	187	177

Change in block pools

11. The organic pool for N indicates the amount of N that is being either immobilized as seen by a 'positive' Organic pool N value or being mineralized as seen by a 'negative' Organic pool N value. N being immobilized is being used for increased biological activity and temporarily locked up. Once the microorganisms die the organic N in their cells is converted by mineralization and nitrification to plant available nitrate. It appears N is potentially being immobilized in both models (see Table 6 below).

12. The inorganic soil pool for P indicates the amount P that exceeds soil P maintenance as seen by a 'positive' inorganic soil P value or is less than the soil P maintenance requirements as seen by a 'negative' inorganic soil P value. Slightly greater than maintenance P was applied to Current and Proposed models (see Table 6a below).

Table 6: Change in block pool (N)

	Current	Proposed
Organic Pool	78	69
Inorganic Mineral	0	0
Inorganic Soil Pool	6	4

Table 6a: Change in block pool (P)

	Current	Proposed
Organic Pool	8	9
Inorganic Mineral	3	3
Inorganic Soil Pool	9	9

Rain/clover N Fixation

All plants, including forage crops, need relatively large amounts of nitrogen for growth and development. Biological nitrogen fixation is the term used for a process in which nitrogen gas (N2) from the atmosphere is incorporated into the tissue of certain plants. Only a select group of plants can obtain N this way, with the help of soil microorganisms. Among forage plants, the group of plants known as legumes (predominantly Clover in NZ pastures) are well known for being able to obtain N from air N2. The OVERSEER Technical Manual – Characteristics of Pasture, April 2015 indicates that biological N fixation is based on total pasture production and includes the fertiliser induced reduction in N fixation.

13. The Biological fixation for the Current model is 61 compared to the Proposed model at 48 (see table 7 below).

14. The average N added to the Current and Proposed models is 155 kgN/ha and 149 kgN/ha for the whole farm.

15. The lower biological fixation for the Proposed model compared to the Current model can be explained by reduction in stocking rate and the decrease in supplement imported.

Table 7: Biological fixation

	Current	Proposed
Biological Fixation	61	48

Average N applied to whole farm kg/ha/yr	155 (190 to non-effluent and effluent pasture)	149 (190 to effluent and non-effluent pasture)

Pasture Production

16. The average effluent N inputs for the Current model was 66 kgN/ha from liquid to pasture and 70 kgN/ha for the Proposed model from liquid to pasture (see table 8 below).

17. Fertiliser inputs of N for the Current model to effluent and non-effluent pasture was 190 kgN/ha. Fertiliser inputs of N to pasture onto effluent and non-effluent area was 190 kgN/ha pasture in the Proposed model.

18. Liquid effluent is applied onto pasture block for all the models was applied all year-round using a Low application method. Solid effluent from the pond was applied for both Current and Proposed models in November and February.

Table 8: Pasture production and N inputs (fertiliser and effluent)

	Current	Proposed
Effluent Liquid Area (ha)	150	123
Effluent Solids Area (ha)	210.5	230.4
Pasture Growth (tDM/ha/yr)	13.2	13.3
N Fertiliser inputs (kg/ha/yr)		
Effluent/Non effluent	190	190
N Effluent Inputs (kg/ha/yr)		
Effluent Liquid	66	70
Effluent Solids	9	8
Total N Inputs (kgN/ha/yr)		
Effluent Liquid	256	260
Effluent Solids	199	198

19. The pasture production for all models has been modelled as varying based on topography, climate, and development status.

20. Fertiliser inputs of N are low for the Current and Proposed models (see Table 8).

21. It is assumed the Current model represent the actual farm system with actual stock, crop area and fertiliser inputs, it is assumed that the pasture production is accurate and reasonable.

22. Long term pasture growth in Southland between 1979 and 2012 indicated that average pasture growth for newer pastures was 12.7T DM/ha/yr.

23. The dairy pasture production for the Current model was 13.2 tDM/ha compared to 13.3 tDM/ha for the Proposed model which is respectively 3.8% and 4.5% higher than the Southland average.

24. Current/Proposed model: Allowing for the Overseer model assuming an average metabolisable energy (ME) value of 10.5 MJME/kgDM for pasture and South Island pastures have a ME value closer to 11 MJME/kgDM the models output of pasture growth would drop by 4.5%. Also, the Current Model has used actual data and have been rotating crops which means new pasture which can account for 15-20% improvement in pasture growth. This more than accounts for the higher pasture growth.

25. The animal distribution is modelled as 'Relative pasture yield' and 'Based on animals present on block' with 'Default Grazing Months' for all models.

Mitigations Modelled

26. Reporting out lined the following: As described in the Overseer Nutrient Budget Report for Pahia Dairies Ltd prepared Nicole Mesman, Lumen Environmental Ltd, there are several mitigation measures indicated to mitigate N loss that have been included in the Proposed modelling. The below table details if the mitigation measures have been included in the proposed scenario and if they are accurately modelled.

Table 9: Mitigation option for Proposed scenario

Decreased Winter Crops	Yes, the area of winter crop is dropped from 63ha kale in the Current Model to 51 ha fodder beet (19% decrease) in the Proposed model
Decrease in imported supplement	Yes, Supplement imported has decreased by 12.6%

27. It is important that these mitigation measures are measured and monitored as if they are not adhered to the N loss reductions proposed may not occur.

28. Some good management practices assumed in Overseer are maintain accurate and auditable records of annual farm inputs, outputs and management practices (Overseer output is only as good as the data entered); Fertiliser is being applied according to the Fertmark and Spreadmark Codes of Practice; Feed is stored to minimise leachate and soil damage; Compliant effluent systems as defined by DairyNZ; Stock exclusion from water ways; Irrigation efficiency greater than 80%; farm race and bridge/culvert nutrient runoff is directed to paddocks; grazing managed to minimise losses from critical source areas.

29. Overseer will account for bad practices such as nitrogen (N) applied that exceeds the plants' ability to absorb the excess N, application of N in the winter, high stocking rates, land left fallow between crops and irrigating high water application rates causing N drainage to name a few.

30. The Overseer modelling completed for Pahia Dairies Ltd does not have any of the 'Bad Practices' as suggested in paragraph 29, and it would be assumed the FEMP would cover any good management practices (not limited to) outlined in paragraph 28.

CONCLUDING COMMENTS

Determination of the robustness of the nutrient loss to water

31. The questions below were described at Paragraph five of this report. Whilst these have been answered throughput this report, this section summarizes the answer to each question to make an overall conclusion about the robustness of the nutrient budgets.

Is the N loss consistent with what you would expect for an operation of this type and soils in this location?

32. Based on my experience, the N loss estimates are reasonably consistent with an operation of this scale and types of soil present.

Does the summary of inputs and outputs make sense? Especially clover fixation and change in block pools?

33. The Biological fixation for the Current model is 61 compared to the Proposed model at 48.

34. The average N added to the Current and Proposed models is 155 kgN/ha and 149 kgN/ha for the whole farm.

35. The lower biological fixation for the Proposed model compared to the Current model can be explained by reduction in stocking rate and the decrease in supplement imported.

Check the 'Other values' block reports for rainfall, drainage, and PAW.

36. The rainfall and soil information have been entered based on protocols for the location. The soils between models have not been modelled to best management practice. There is difference of 5% or more in some soils between the Current and Proposed models.

Production and stocking rate

37. The Current model has a dairy revised stocking unit of 20.7 RSU/ha compared to the Proposed model which has a RSU 20.1 RSU/ha or a 2.9 % decrease in RSU/ha (see Table 1 below).

38. Reviewing the NZ Dairy statistics for the 2019/2020 season, shows the average milk solids production on this property for the Current model at 345.1 kgMS/cow and 1060 kgMS/ha is respectively lower than the Southland Regional average of 418 kg MS/cow and lower than the Southland Regional average of 1133 kgMS/ha. The Proposed model at 345.1 kgMS/cow and 958 kgMS/ha is respectively lower than the Southland Regional average of 418 kg MS/cow and lower than the Southland Regional average of 1133 kgMS/ha.

39. The stocking rate for Current Model at 3.1 cows/ha higher than the Southland average for the 2019/2020 season of 2.76 cows/ha (Invercargill). The stocking rate for Proposed Model at 2.8 cows/ha is similar to the Southland average for the 2019/2020 season of 2.76 cows/ha (Invercargill).

40. It is assumed that the Current model is based on actual year end information.

Select the pasture production in the scenario report and check pasture growth.

41. Long term pasture growth in Southland between 1979 and 2012 indicated that average pasture growth for newer pastures was 12.7T DM/ha/yr.

42. The dairy pasture production for the Current model was 13.2 tDM/ha compared to 13.3 tDM/ha for the Proposed model which is respectively 3.8% and 4.5% higher than the Southland average.

43. Current/Proposed model: Allowing for the Overseer model assuming an average metabolisable energy (ME) value of 10.5 MJME/kgDM for pasture and South Island pastures have a ME value closer to 11 MJME/kgDM the models output of pasture growth would drop by 4.5%. Also, the Current Model has used actual data and have been rotating crops which means new pasture which can account for 15-20% improvement in pasture growth. This more than accounts for the higher pasture growth.

44. The animal distribution is modelled as 'Relative pasture yield' and 'Based on animals present on block' with 'Default Grazing Months' for all models.

45. I have assumed an adequate level of robustness around the Current model of actual Overseer Modelling as it is based on an actual farming system, and with that, I have assumed actual stock and fertiliser inputs used.

    The data input protocols have been followed with some deviations. This leads to a **medium** level of robustness for the relevant input data for example, climate, soils, and pasture type. Based on the level of robustness of the inputs and outputs in the Proposed and Current Overseer model, I consider that the robustness of the nutrient loss estimates for the Current and Proposed model to be **medium**. This is due to the follow:

Please explain why some of the soils, between the Current and Proposed models, have a difference of greater than 5%.

References:

New Zealand Dairy Statistics 2019/2020. Produced by LIC and DairyNZ 2020. https://www.dairynz.co.nz/publications/dairy-industry/new-zealand-dairy-statistics-2019-20/

Overseer Definition of Terms, previously Technical Note 6. May 2016
Overseer Technical Manual – Characteristics of Pasture, April 2015

Smith. L. C. 2012. Proceedings of the New Zealand Grassland Association 74: 147-152 (2012) *Long Term pasture growth patterns for Southland New Zealand: 1978-2012.* www.grassland.org.nz/publications/nzgrassland_publication_2284.pdf

https://www.dairynz.co.nz/media/5793235/average-pasture-growth-data-south-island-2020-v1.pdf