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CRC221846 - Effect of discharge of nitrate nitrogen and pathogens on nearby groundwater users

1 Introduction

The applicants are subdividing Lot 7 DP 329735 at 46 McGrath Road Ashburton into 2 lots. As part of the subdivision a resource consent is required to discharge treated domestic wastewater to land. Application CRC221846 has been lodged for this purpose.

In the area downgradient of the applicants proposed onsite wastewater discharge to land background water quality information from wells suggest that Ministry of Heath Maximum Allowable Values (MAV) for nitrate nitrogen of 11.3mg/L and pathogens are already exceeded.

Environment Canterbury has requested further information regarding the effect of the discharge of nitrate nitrogen and pathogens on nearby groundwater users.

2 Effect of the discharge on nitrate-nitrogen levels in downgradient wells used for drinking water supply

2.1 The Local Environment

The receiving environment for this proposed onsite wastewater discharge is located within the Ashburton – Rakaia Nutrient Allocation Zone, a red zone where water quality outcomes are not being met. Many properties in the area are reliant on groundwater from private bores for domestic drinking water.

In this area nitrate-nitrogen concentrations in groundwater have been measured above the NZ Drinking Water Standard MAV of 11.3mg/L. There has been a significant nitrate nitrogen plume upgradient from the applicants' land area since the 1990's that is associated with the discharge of meat processing wastewater to land primarily by Ashburton Meat Processors Limited (AMPL), but also from the Silver Fern Farms Fairton (Silver Fern) meat processing plant.

Environment Canterbury Technical Report from 2004 titled "Nitrate contamination of groundwater in the Ashburton-Rakaia Plains" described the extent of the plume at that stage. A map showing the plume is shown in appendix 2. The map shows that the nitrate-N measurements in excess of the MAV were made in bores to the west and southwest of the applicant's land area. Bores around and downgradient of the applicant's land area all had nitrate-M concentrations less than the MAV.

AMPL have made significant changes to the way the wastewater is treated and discharged since the renewal of the previous consent. Despite there not being significant reductions in groundwater nitrate-N concentrations recorded thus far, reductions in concentrations are expected as the new procedures reduce the volume of nitrogen discharged to ground. The existing consent allows AMPL to discharge up to 400 kgN/ha/year to the land, as compared to a typical onsite wastewater application of 3 – 4 kgN/year.

AMP is currently negotiating with Ashburton District Council to discharge the process wastewater to the Ashburton Sewage network rather than to land as at present. Silver Fern closed down their meat processing factory in2017 and have since sold it. There is currently no discharge from the site.

As there is no longer a discharge from Silver Fern Farms and assuming the AMPL discharge is into the Ashburton sewerage network, there will be no high nitrogen industrial discharges to land upgradient from this site and there is expected to be a significant drop in groundwater nitrogen levels over time as a result.

2.2 Groundwater Quality Levels and Trends

There are three bores within 500 metres of the applicants' land area that have had samples tested for water quality parameters over a number of years. These bores are listed in Table 1.:

Table 1: Details of bores with water quality tests

Bore name	Depth (m)	Distance (m)	Description
L37/0918 AMPL monitoring.	14.2	440m W	86 water quality tests – 1992 to 2020 Nitrate-N concentration measured (80 samples) Minimum 1.6 mg/L (2005) Maximum 34 mg/L (1996) Average 15.35 mg/L Latest 11.2 mg/L (2021)
L37/0932	10.75	409m SW	67 water quality tests – 1992 to 2019 Nitrate-N concentration measured Minimum 7.4 mg/L (2005) Maximum 19.3 mg/L (2006) Average 12.7 mg/L Latest 12.1 mg/L
L37/0964	32.4	425m SW	66 water quality tests – 1992 to 2019 Nitrate-N concentration measured Minimum 6.9 mg/L (2005) Maximum 14.7 mg/L (2006) Average 10.2 mg/L Latest 13.0 mg/L (2021)
L37/0876	24.0	360m SW	32 water quality tests – 1992 to 2020 Nitrate-N concentration measured Minimum 8.2 mg/L (2005) Maximum 13.8 mg/L (2017) Average 11.1 mg/L Latest 10.9 mg/L (2020)

For L37/0918, located downgradient of the AMPL wastewater discharge area the trend over the 1992 to 2021 period has been reducing nitrate concentrations, with the latest sample below the MAV.

The nitrate-N concentrations measured by the testing show that nitrate levels are typically higher than surrounding areas, they vary widely over short time periods and that latest test concentrations are significantly less than maximum concentrations.

Graphs of the nitrate-N concentrations in these bores over time show that nitrate-N concentrations have typically averaged about the same level over the 2000 to 2020 time period with significant fluctuations. Graphs of the test results are attached as appendix 7.

2.3 Downgradient bores

The applicant's area is located near the edge of the Ashburton residential area, with rural farmland, including the Ashburton Airport starting about 360 metres downgradient of the land area (see appendix 1 for location map).

Table 2 shows the details of the nine bores located downgradient of the applicants' land area that could be considered within a potential groundwater contamination plume from the proposed onsite wastewater system. The potential downgradient plume from this discharge is shown on the aerial map in appendix 1.

Table 2: Details of downgradient bores

Bore name	Depth (m)	Distance (m)	Description
BY21/0409	36	80 SE	Domestic & stock water, no water quality testing
L37/1086	24	95 SE	Domestic & stock water, no water quality testing
L37/1202	36	205m SE	Domestic & stock water, 1 water quality sample tested April 2004 – nitrate-N 4.3 mg/L
BY21/0158	29.85	245m SE	Domestic & stock water, no water quality testing
L37/0724	21	270m SE	Domestic, 1 water quality sample tested
L37/0748	21.5	285m SE	Domestic & stock water, 1 water quality sample tested May 2004 – nitrate-N 5.5 mg/L
L37/0821	22	290m SE	Domestic & stock water, no water quality testing
L37/1644	18	350m SE	Domestic, no water quality testing
BY21/0431	36	350m SE	Domestic, no water quality testing Replacement for L37/1644

None of these bores have had samples tested for water quality parameters since 2005. Tests on two bores in this downgradient area had quality testing undertaken in 2004, with water from L37/1202 having a nitrate-N concentration of 4.3 mg/L and from L37/0748 5.5 mg/L. This suggests that the AMPL N-Plume does not extend in this direction. The N-Plume map shown in appendix 2 shows that the bores with high nitrate-N concentration are located more to the south of the applicants proposed LAS.

The test results for the bores within the N-Plume area of AMPL show that the nitrate-N concentrations have been variable over short time periods, and that for most of the bores the latest testing showed significantly lower nitrate-N concentrations than the maximum for each bore. These results suggest that while nitrate-N concentrations were near or above the MAV of 11.6 mg/L, the trend was that they were staying at a similar level over the time period. Graphs of the nitrogen concentrations over time for these bores are shown in appendix 10.

With the discharge from Silver Fern stopping and the discharge from AMPL likely to be into the Ashburton sewerage network in future it is likely that groundwater nitrate-N concentrations in the general area will reduce in future to similar concentrations measured outside this area.

Based upon these test results, and in particular the two bores downgradient of the proposed LAS with low - medium nitrate-N concentrations of 4.3 – 5.5 mg/L in 2004, as compared, the expected nitrate-N concentration in the groundwater at the site of the proposed discharge is expected to be less than the MAV at 5 – 7 mg/L.

2.4 Assessment

The assessment of the effect of the effect of the discharge on nitrate levels in downgradient wells used for drinking supply uses the design daily volume to provide a conservative assessment of effects.

The applicant proposes two land application systems, a sand trench (single pass bottomless sand filter) and subsurface irrigation dripline, that can be used on this site. The size of the site at 5,000 m^2 provides sufficient area to install these systems as well as provide for backup area in case of future issues.

The first part of the assessment models the potential nitrogen concentration of the wastewater when it reaches groundwater. The second part models the impact of the wastewater on the nitrogen concentration of the groundwater. The assessment assumes that the treatment system will provide a level of treatment at least as good as an Oasis Series 2000 system, a popular choice in this area.

Modelling the potential nitrogen concentration of the wastewater when it reaches groundwater

Sand bed LAS

Assumptions

- Assumed treatment system – Oasis Series 2000 (standard treatment setup)
- Total N concentration exiting the treatment system - 21 mg/L taken from OSET trial for the Oasis system
- LAS – sand bed with at least 600mm of 2A grade sand
- Highest water level - at least 2m below ground level
- Maximum design occupancy – 7 persons

The assessment estimated that for the design occupancy of 7 persons the N concentration entering groundwater of about 10.9 mg/L with a total N load to groundwater of 5.6 kg.

Dripline LAS

Assumptions

- Assumed treatment system – Oasis Series 2000 (standard treatment setup)
- Total N concentration exiting the treatment system - 21 mg/L taken from OSET trial for the Oasis system
- LAS – subsurface irrigation dripline installed 150mm below ground level
- Highest water level - at least 2m below ground level
- Design occupancy – 7 persons

The assessment estimated that for the design occupancy of 7 persons the N concentration entering groundwater of about 6.5.9 mg/L with a total N load to groundwater of 3.3 kg

The N concentration from both LAS's is less than the MAV and probably less than the existing groundwater N concentration. The discharge therefore should not have a significant impact on other downgradient groundwater users as it will not increase the groundwater N concentration.

The total N loads of 5.6 kg and 3.3 kg can be compared with the 95 kgN/year that pastoral farmers can apply to pastureland under the National Environmental Standards on an area the size of the applicants' land area.

Modelling the impact of the wastewater on the nitrogen concentration of the groundwater.

When the treated wastewater reaches groundwater, it mixes with the groundwater. This assessment uses a mass mixing model to assess the potential change in groundwater nitrogen concentration. The mass mixing model is detailed in Environment Canterbury publication "Guidelines For Determining Significance Of Environmental Impacts Resulting From Use Of Water For Irrigation".

Oasis Series 2000 to sand bed

Assumptions

Design wastewater volume	1,400 L/day
Treatment	Oasis Series 2000 or similar\
Land application system	Sand bed – 28 m^2

Concentration of N in groundwater	7.5 mg/L	
Concentration of N in treated wastewater	10.9 mg/L	Assessment 1 above
Transmissivity	4180 m/day	Geomean of aquifer tests
Aquifer depth	30 m	
Mixing depth	15 m	Aquifer depth less base water level
Hydraulic gradient	0.005	Piezometric contours
Drainage from land application system	18.25 m^3	

The model calculates that the n concentration of the mixed groundwater and wastewater will be about 7.53 mg/L, an increase of 0.03 mg/L. The model is shown in appendix 8.

The model for an Oasis Series 2000 discharging through dripline that the n concentration of the mixed groundwater and wastewater will be about 7.48 mg/L, a decrease of 0.02 mg/L. The model is shown in appendix 9.

2.5 Higher levels of treatment

It is possible to reduce the N concentration of the wastewater leaving the treatment system using more complex treatment systems, however the increased cost of these systems may not be required in this location, and the applicant prefers to use a system such as the Oasis Series 2000 if the treatment level is acceptable.

One such system has also been assessed to compare the expected nitrate-N concentration reaching the nearest downgradient bore used for domestic supply.

AES is a passive, on-site advanced secondary wastewater treatment system. Pump or gravity fed from a septic tank effluent is treated using naturally occurring microbes within specially designed, passively aerated pipes laid in a sand bed. The remaining highly-treated effluent is evenly dispersed via perforations in the AES pipes into the sand bed or can be collected and used for irrigation if preferred. Within the sand bed, there is further microbial breakdown.

The AES sandbed can be contained so the effluent can be recirculated through the septic tank to achieve higher levels of nitrogen denitrification of nitrate-N to N_2 gas. The OSET NTP Trial for this system achieved a nitrate-N concentration of 7.7 mg/L using a recirculation factor of 500%. In this case the treated effluent can then be discharged via a second sand bed or through dripline if there is sufficient land area.

The assessment estimated that for the design occupancy of 7 persons the nitrate-N concentration entering groundwater of about 4.1 mg/L through a sand trench and 1.3 mg/L after a dripline. His assessment is shown in appendices 6 and 7.

2.6 Summary

In terms of the effects of the applicant's discharge, the design daily volume of the discharge is a maximum of 1400 L per day and the applicant is proposing an aerated wastewater treatment system which significantly reduces the nitrogen concentration in human effluent. The applicant considers the system is best practice and the most appropriate for the site. A report prepared by Andrew Dakers assessing the relative nitrogen risks from an onsite wastewater system[1] estimates the annual loading of total nitrogen from a single aerated system is between 2.8 and 3 kg/yr before any further uptake via the land application system. Due to the source of nitrate nitrogen in the area likely being the AMP processing site, the applicant's adoption of a best practice treatment system and the minimal quantity of nitrogen that will be discharged, the applicant considers the environment effects, including cumulative effects, will be no more than minor.

The assessment is shown in appendices 4 - 9 and the spreadsheet models is provided with this report.

[1] Dakers, A 2015. Assessment of the relative nitrogen risks from an OWMS.

3 Effect of the discharge on pathogen levels in downgradient wells used for drinking water supply

The discharge of treated wastewater to land has the potential to cause effects on groundwater quality and users. Pathogens are a contaminant of concern and have the potential to cause adverse effects on human health if present.

The receiving environment is sensitive to discharges of pathogen in wastewater due to the number of domestic supply bores in the area as there is no reticulated sewerage system available in this area, although that is mitigated in part by the size of the downgradient properties which are all 1 hectare in size.

The applicant proposes to use a secondary treatment wastewater system which provides significant reductions of pathogens prior to discharge. Additionally, further reductions of pathogens will occur (via desiccation, predation, filtration etc) beneath the land application system (LAS) which has at least 1m of separation to the highest groundwater level for a sand bed LAS and about 2 metres for a dripline LAS. The expected log removal rate is likely to be in the order of 0.004-2.5 log/m for the soil layers based on research by Liping Pang[2], which will significantly reduce pathogen concentration. A study by the University of Wisconsin of soil treatment performance and cold weather operations of drip distribution systems looked at the faecal coliform concentrations at different depths below drip irrigation fields[3]. The study found very low concentrations (37 and 600 CFU/ 100ml) at depths of 450-600 mm below the drip line for secondary treated effluent.

Table 4 shows the log removal and percentage removal rates based on this assessment.

Table 4: Summary of microbial removal

	Sand bed	Dripline
Log removal	4.4	1.8
% removal	99.996%	98.534%

The assessments of microbial log removal rates for the sand bed and dripline LAS's are attached as appendix 5. The spreadsheet model is attached to the this report.

Based on the assessment the applicant considers that the potential adverse environmental effects of the discharge of pathogens in wastewater will be no more than minor, however the applicant is prepared to consider the use of disinfection if further reduction is required.

Gary Rae
Environmental Consultant
15 February 2022

Appendices

[2] L Pang 2009. Microbial removal rates in subsurface media estimated from published studies of field experiments and large intact soil cores

[3] University of Wisconsin/Madison Small scale waste management project - https:Usoils.wise.edu/sswmp/SSWMP_10.24.pdf.

1 Location map

2 Nitrate-N Plume from Ashburton Meat Processors Limited

3 Neighbouring bores

4 Nitrogen assessment – Oasis S 2000 to sand bed

5 Nitrogen assessment – Oasis S 2000 to dripline

6 Nitrogen assessment – AES (recirculation) to sand bed

7 Nitrogen assessment – AES (recirculation to drip line

8 Nitrogen concentration in groundwater after mixing – Oasis S2000 to sand bed

9 Nitrogen concentration in groundwater after mixing – Oasis S2000 to drip line1

10 Microbial assessment – Oasis S2000 to sand bed

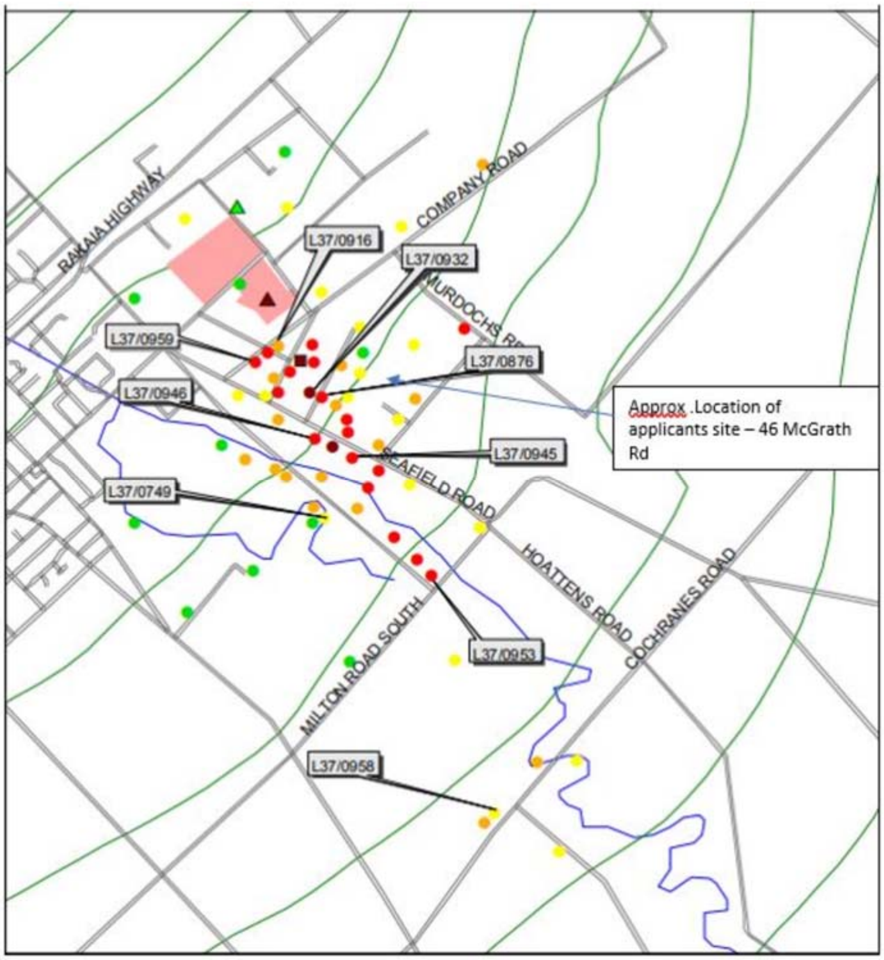
11 Microbial assessment – Oasis S2000 to dripline

12 Graphs of groundwater N concentrations in neighbouring bores

Appendix 1: Location map

The map shows the location of the land area where the proposed onsite wastewater system is to be installed and the area downgradient where any contamination plume may occur.

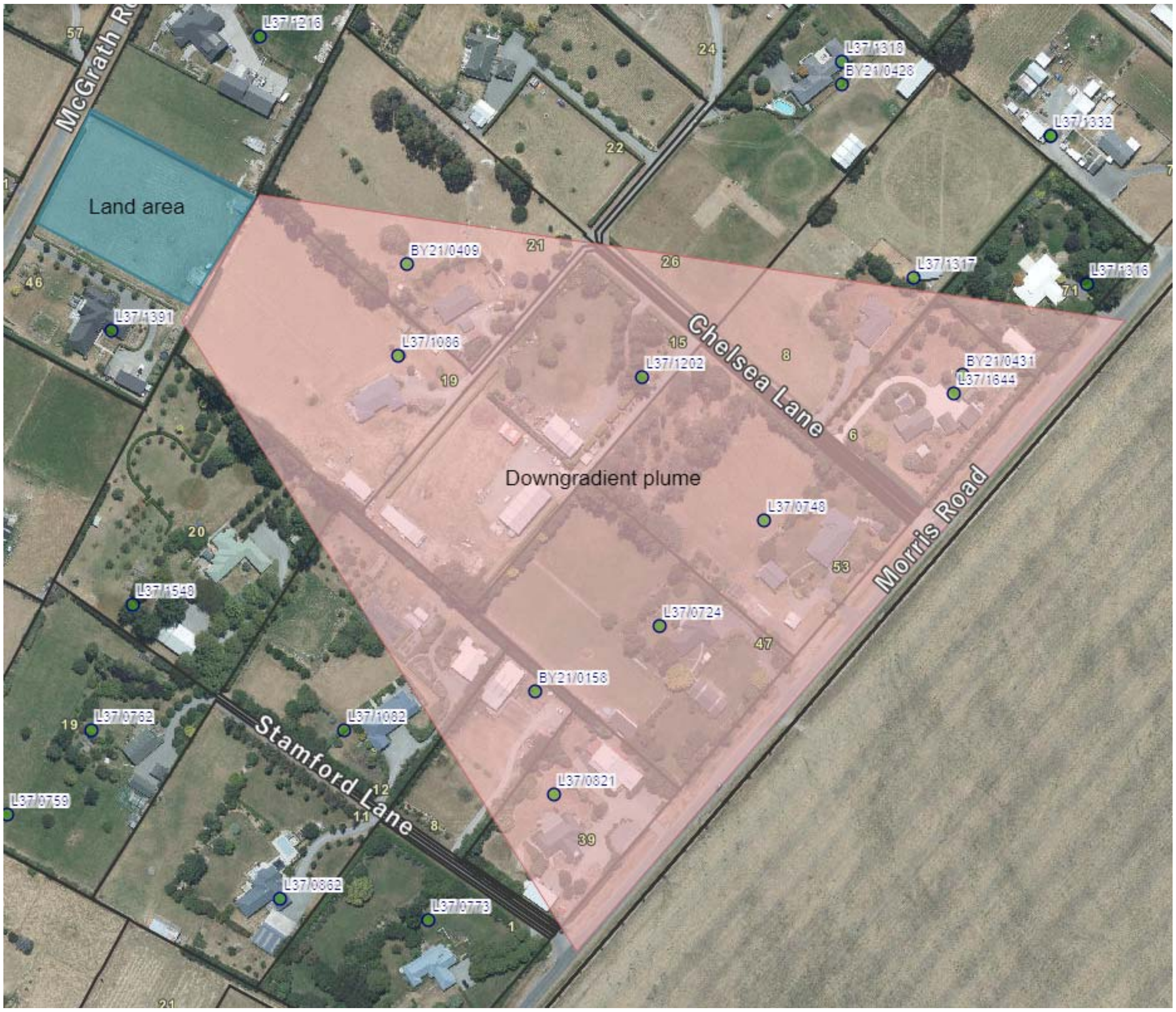
Appendix 2: Nitrate-N Plume from AMPL



2004 nitrate nitrogen concentrations sourced from 2004 Technical Report "Nitrate contamination of groundwater in the Ashburton-Rakaia Plains"

Appendix 3: Neighbouring bores

The map shows the neighbouring bores within the estimated plume downgradient of the applicant's land area.



Appendix 4: Nitrogen assessment – Oasis Series 2000 to Sand bed

Nitrogen discharge to land

Marriott - Haugh
46 McGrath Road, Ashburton

Occupancy	Design Occupancy
Treatment system	Oasis Series 2000
Treatment level	Standard treatment
Land application system	Sand bed (600mm)
Land area	5,000 m2

Table 1: Total Nitrogen Assessment

Calculation of Total N in the Domestic Effluent			
Daily occupancy	7	persons	Maximum design occupancy
Daily volume	200	L/person/day	Environment Canterbury - no reeduction fixtures
	1400	L/day	
Days occupancy/year	365	days	
Total N Concentration of influent	60	mg/L	Average concentration from AS/NZS 1547:2012, Table S1
Total N in wastewater	12	g/person/day	
	4.38	kg/person/year	
	30.7	kg/house/year	
Calculation of N reduction in treatment system			
Total N reduction in treatment plant	65%		Calculation to achieve OSET average N concentration
Total N concentration after treatment plant	21	mg/L	OSET NTP Trial 10 - Oasis Series 2000 mean concentration (1)
Total N reduction in sand column	35%		Ref: Crites et al 1998, Table 11-13, p 743 (2)
Total N concentration after sand column	13.65	mg/L	
Total N reduction over untreated effluent	77%		Calculated N reduction
Total N load exiting sand trench	**7.0**	kg/yr	13.65 mg/L * 1400 L/day *365 days/year
Total N exiting sand trench	**14.0**	kg/ha/yr	Over the total land area of 5000m2
N concentration below LAS	**13.7**	mg/L	Calculated N concentration ignoring rainfall
Calculation of N reduction below land application system			
Total N reduction by denitrification	20%		Gardner et al 1997
N concentration at groundwater	**10.9**	mg/L	
Total N load to groundwater	**5.6**	kg/yr	10.92 mg/L * 1400 L/day *365 days/year
	11.2	kg/ha/yr	Over the total land area of 5000m2

Notes:
(1) OSET Trials
(2) Crites at al 1998 suggests 28 -50% TN reduction for secondary treated effluent in a sand bed. 35% has been used in this assessment

Appendix 5: Nitrogen assessment – Oasis Series 2000 to Dripline

Nitrogen discharge to land

Marriott - Haugh
46 McGrath Road, Ashburton

Occupancy	Maximum design occupancy
Treatment system	Oasis Series 2000
Treatment level	Standard treatment
Land application system	Dripline
Land application system area	350 m2
Total land area	5000 m2

Table 1: Total Nitrogen Assessment

Calculation of Total N in the Domestic Effluent			
Daily occupancy	7	persons	Maximum design occupancy
Daily volume	200	L/person/day	Environment Canterbury - no reeduction fixtures
	1400	L/day	
Days occupancy/year	365	days	
Total N Concentration of influent	60	mg/L	Average concentration from AS/NZS 1547:2012, Table S1
Total N in wastewater	12	g/person/day	
	4.38	kg/person/year	
	30.7	kg/house/year	
Calculation of N reduction in treatment system			
Total N reduction in treatment plant	65%		Calculation to achieve OSET average N concentration
Total N concentration after treatment plant	21.0	mg/L	OSET NTP Trial 10 - Oasis Series 2000 mean concentration (1)
Total N load exiting Dripline	10.7	kg/yr	21 mg/L * 1400 L/day *365 days/year
	306.6	kg/ha/yr	Over the LAS land area of 350m2
Calculation of N reduction below Dripline land application system			
Total N reduction by denitrification	20%		Gardner et al 1997[3]
	61.3	kg/ha/yr	N removed by denitrification under LAS
N reduction through plant uptake	150.0	kg/ha/yr	Wheeler, Edmeades, Morton 1996[4]
Total N load to groundwater	95.3	kg/ha/yr	Over the LAS land area of 350m2
	3.3	kg/yr	
Total N concentration at groundwater	6.5	mg/L	N leached to groundwater / volume of effluent

Notes:
(1) OSET Trials
(2) Crites at al 1998 suggests 28 -50% TN reduction for secondary treated effluent in a sand bed. 2100% has been used in this
(3) Gardner et al 1997. Ecological Sustainability and On-Site Effluent Treatment Systems, Australian Jurnal of Environmental Management, 4: 144-156
(4) D. M. Wheeler, D. C. Edmeades & J. D. Morton (1997) Effect of lime on yield, N fixation, and plant N uptake from the soil by pasture on 3 contrasting trials in New Zealand, New Zealand Journal of Agricultural Research, 40:3, 397-408

Appendix 6: Nitrogen assessment – AES (recirculation) to Sandbed

Nitrogen discharge to land

Marriott - Haugh
46 McGrath Road, Ashburton

Occupancy	Design Occupancy
Treatment system	AES with recirculating sandbed
Treatment level	500% recirculation for addition N removal
Land application system	Sand bed (600mm)
Land area	5,000 m2

Table 2: Total Nitrogen Assessment

Calculation of Total N in the Domestic Effluent			
Daily occupancy	7	persons	Maximum design occupancy
Daily volume	200	L/person/day	Environment Canterbury - no reeduction fixtures
	1400	L/day	
Days occupancy/year	365	days	
Total N Concentration of influent	60	mg/L	Average concentration from AS/NZS 1547:2012, Table S1
Total N in wastewater	12	g/person/day	
	4.38	kg/person/year	
	30.7	kg/house/year	
Calculation of N reduction in treatment system			
Total N reduction in treatment plant	87%		Calculation to achieve OSET average N concentration
Total N concentration after treatment plant	7.8	mg/L	OSET NTP Trial 13 - AES 2000 mean concentration (1)
Total N reduction in sand column	35%		Ref: Crites et al 1998, Table 11-13, p 743 (2)
Total N concentration after sand column	5.07	mg/L	
Total N reduction over untreated effluent	92%		Calculated N reduction
Total N load exiting sand trench	**2.6**	kg/yr	5.07 mg/L * 1400 L/day *365 days/year
Total N exiting sand trench	**5.2**	kg/ha/yr	Over the total land area of 5000m2
N concentration below LAS	**5.1**	mg/L	Calculated N concentration ignoring rainfall
Calculation of N reduction below land application system			
Total N reduction by denitrification	20%		Gardner et al 1997
N concentration at groundwater	**4.1**	mg/L	
Total N load to groundwater	**2.1**	kg/yr	4.056 mg/L * 1400 L/day *365 days/year
	4.1	kg/ha/yr	Over the total land area of 5000m2

Notes:
(1) OSET Trials
(2) Crites at al 1998 suggests 28 -50% TN reduction for secondary treated effluent in a sand bed. 35% has been used in this assessment

Appendix 7: Nitrogen assessment – AES(recirculation) to Dripline

Nitrogen discharge to land

Marriott - Haugh
46 McGrath Road, Ashburton

Occupancy	Maximum design occupancy
Treatment system	Oasis Series 2000
Treatment level	Standard treatment
Land application system	Dripline
Land application system area	350 m2
Total land area	5000 m2

Table 3: Total Nitrogen Assessment			
Calculation of Total N in the Domestic Effluent			
Daily occupancy	7	persons	Maximum design occupancy
Daily volume	200	L/person/day	Environment Canterbury - no reeduction fixtures
	1400	L/day	
Days occupancy/year	365	days	
Total N Concentration of influent	60	mg/L	Average concentration from AS/NZS 1547:2012, Table S1
Total N in wastewater	12	g/person/day	
	4.38	kg/person/year	
	30.7	kg/house/year	
Calculation of N reduction in treatment system			
Total N reduction in treatment plant	65%		Calculation to achieve OSET average N concentration
Total N concentration after treatment plant	21.0	mg/L	OSET NTP Trial 10 - Oasis Series 2000 mean concentration (1)
Total N load exiting Dripline	10.7	kg/yr	21 mg/L * 1400 L/day *365 days/year
	306.6	kg/ha/yr	Over the LAS land area of 350m2
Calculation of N reduction below Dripline land application system			
Total N reduction by denitrification	20%		Gardner et al 1997[3]
	61.3	kg/ha/yr	N removed by denitrification under LAS
N reduction through plant uptake	150.0	kg/ha/yr	Wheeler, Edmeades, Morton 1996[4]
Total N load to groundwater	95.3	kg/ha/yr	Over the LAS land area of 350m2
	3.3	kg/yr	
Total N concentration at groundwater	6.5	mg/L	N leached to groundwater / volume of effluent

Notes:
(1) OSET Trials
(2) Crites at al 1998 suggests 28 -50% TN reduction for secondary treated effluent in a sand bed. 2100% has been used in this
(3) Gardner et al 1997. Ecological Sustainability and On-Site Effluent Treatment Systems, Australian Jurnal of Environmental Management, 4: 144-156
(4) D. M. Wheeler, D. C. Edmeades & J. D. Morton (1997) Effect of lime on yield, N fixation, and plant N uptake from the soil by pasture on 3 contrasting trials in New Zealand, New Zealand Journal of Agricultural Research, 40:3, 397-408

Appendix 8: Nitrogen concentration in groundwater after mixing – Sand bed

Nitrogen concentration in groundwater after mixing

Marriott - Haugh
46 McGrath Road, Ashburton

Occupancy	Design Occupancy
Design wastewater volume	1400 L/day
Treatment system	Oasis Series 2000 or similar
Treatment level	Standard treatment
Land application system	Sand bed (600mm)
Land area	5,000 m2

Calculation of Nitrogen concentration in groundwater after mixing				Calculation Co = (CiQn + CnQn)/(Qi + Qn) - Note 1
Concentration of N in groundwater	Cn	7.5	mg/L	
Concentration of N in wastewater input	C_1	10.9	mg/L	
Flow of groundwater				
Transmissivity		4180		Geomean of aquifer tests in surrounding bores (see calculation)
Aquifer depth		30	m	
Hydraulic conductivity (T/10)		139		
Mixing zone	(z)	15	m	Aquifer depth = xm, water level = y m, mixing zone = z m)
Hydraulic gradient (i)		0.005		Ashburton Rakaia 2010 bores <50m (20m/3905m)
Q_n		3814.25	m^3	GW flow over year
Flow of input (drainage)				
Length of LAS parallel to direction of GW flow		1.8	m	
Additional drainage		18.25	m	Drainage from wastewater applied to LAS - see calculation
Q_i	(L * 1m * additional drainage)	32.85	m3	Annual drainage through LAS
N Concentration of output		7.53	mg/L	N concentration of drainage miced with groundwater
change in N concentration		0.03	mg/L	

Bores for Transmissivity		
L37/0720	41.2	9000
L37/0030	38.7	8500
L37/1264	40.3	1800
L37/1171	30	1600
BY21/0376	33	5798
Geomean		4180.868

Note 1: Ecan document - GUIDELINES FOR DETERMINING SIGNIFICANCE OF ENVIRONMENTAL IMPACTS RESULTING FROM USE OF WATER FOR IRRIGATION

Appendix 9: Nitrogen concentration in groundwater after mixing – Drip Line

Nitrogen concentration in groundwater after mixing

Marriott - Haugh
46 McGrath Road, Ashburton

Occupancy	Design Occupancy
Design wastewater volume	1400 L/day
Treatment system	Oasis Series 2000 or similar
Treatment level	Standard treatment
Land application system	Dripline (300 m2)
Land area	5,000 m2

Calculation of Nitrogen concentration in groundwater after mixing Calculation Co = (CiQn + CnQn)/(Qi + Qn) - Note 1

Concentration of N in groundwater	Cn	7.5	mg/L	
Concentration of N in wastewater input	C_1	6.5	mg/L	
Flow of groundwater				
Transmissivity		4180		Geomean of aquifer tests in surrounding bores (see calculation)
Aquifer depth		30	m	
Hydraulic conductivity (T/10)		139		
Mixing zone	(z)	15	m	Aquifer depth = xm, water level = y m, mixing zone = z m)
Hydraulic gradient (i)		0.005		Ashburton Rakaia 2010 bores <50m (20m/3905m)
Q_n		3814.25	m^3	GW flow over year
Flow of input (drainage)				
Length of LAS parallel to direction of GW flow		5	m	
Additional drainage		18.25	m	Drainage from wastewater applied to LAS - see calculation
Q_i	(L * 1m * additional drainage)	91.25	m3	Annual drainage through LAS
N Concentration of output		7.48	mg/L	N concentration of drainage miced with groundwater
change in N concentration		-0.02	mg/L	

Bores for Transmissivity

L37/0720	41.2	9000
L37/0030	38.7	8500
L37/1264	40.3	1800
L37/1171	30	1600
BY21/0376	33	5798
Geomean		4180.868

Note 1: Ecan document - GUIDELINES FOR DETERMINING SIGNIFICANCE OF ENVIRONMENTAL IMPACTS RESULTING FROM USE OF WATER FOR IRRIGATION

Appendix 10: Microbial assessment – Sand bed

Microbial Removal in Subsurface Media

Marriott-Haugh, McGrath Road Ashburton

Contaminant source On-site treatment system - Single Pass Bottomless Sand Trench

Subsurface Media	Description	Depth/Length (m)	Removal Rate (log/m)	Total Log_{10} reduction	Source (Pang)
Soil				0.0	Table 10
Sub-soil				0.0	Table 10
Distribution material	2A Sand	0.6	7	4.2	Table 8
Vadose zone	Sandy gravels	1.1	0.36	0.4	Table 11
Aquifer	to nearest downgradient dwelling	78	0.004	0.3	Table 12
Total Microbial Log_{10} Reduction				4.9	
Percentage reduction				99.999%	

Notes
Assumes 2 metres from land treatment system to the downgradient boundary
Minimum separation distance to groundwater of 500 mm

Appendix 11: Microbial assessment - Dripline

Microbial Removal in Subsurface Media

Marriott-Haugh, McGrath Road Ashburton

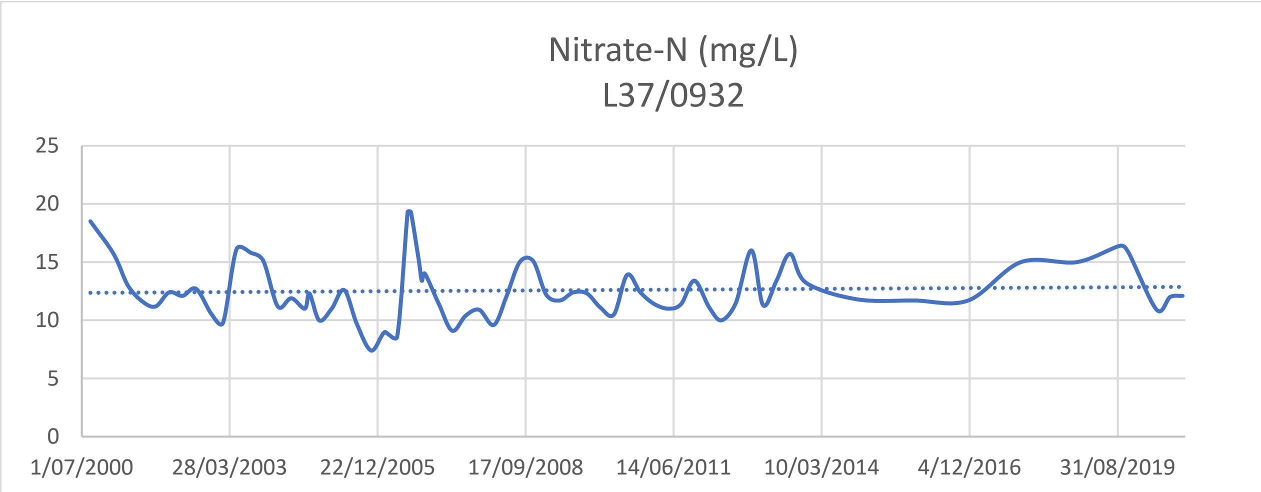
Contaminant source   On-site treatment system - to Sub-surface irrigation dripline

Subsurface Media	Description	Depth/Length (m)	Removal Rate (log/m)	Total Log_{10} reduction	Source (Pang)
		0	2.5	0.0	Table 10
Topsoil		0.1	2.5	0.3	Table 10
Subsoil - sandy silt		0.3	2.5	0.8	Table 10
Vadose zone	Sandy gravels	1.45	0.36	0.5	Table 11
Aquifer	to nearest downgradient dwelling	78	0.004	0.3	Table 12
Total Microbial Log_{10} Reduction				1.8	
Percentage reduction				98.534%	

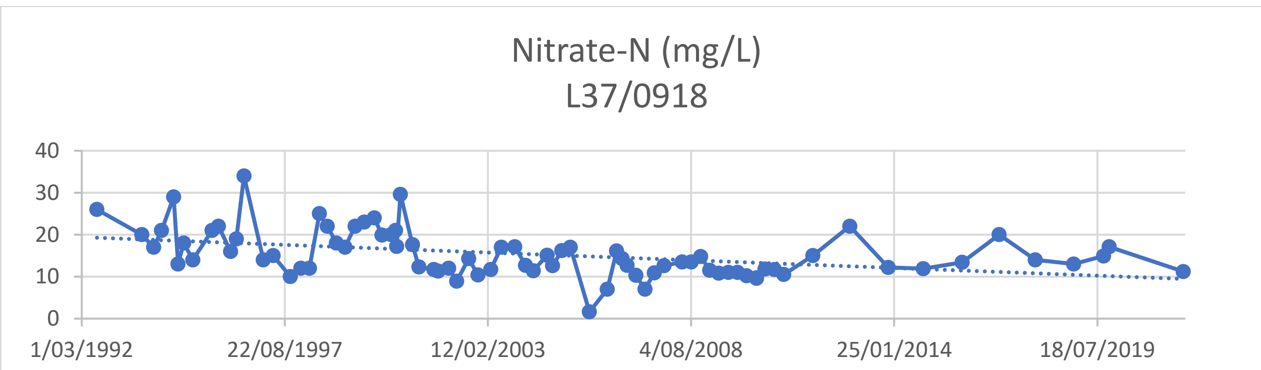
Notes
Dripline installed 150 mm below ground level
Minimum of 1.25 metre depth from dripline to highest groundwater
Assumes minimum 2 metres from land treatment system to the downgradient boundary

Appendix 12: Groundwater Nitrate-N Concentrations

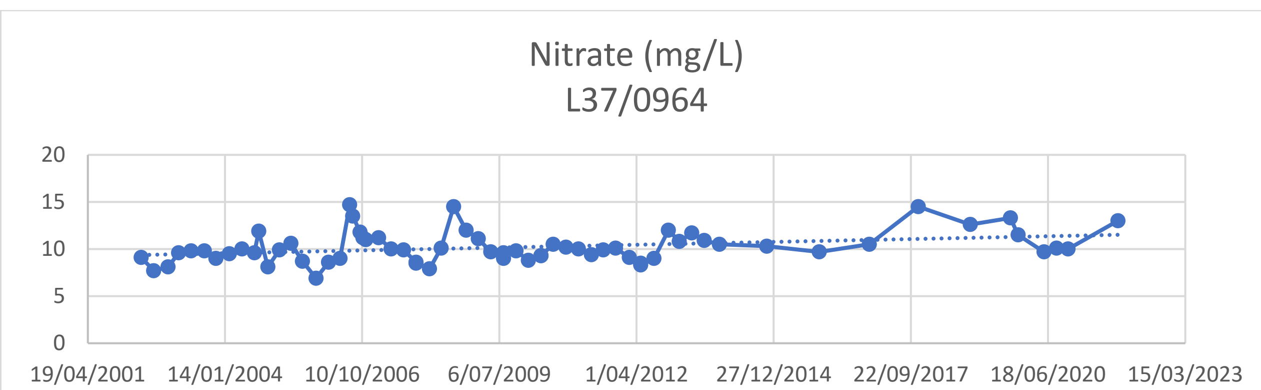
L37/0932



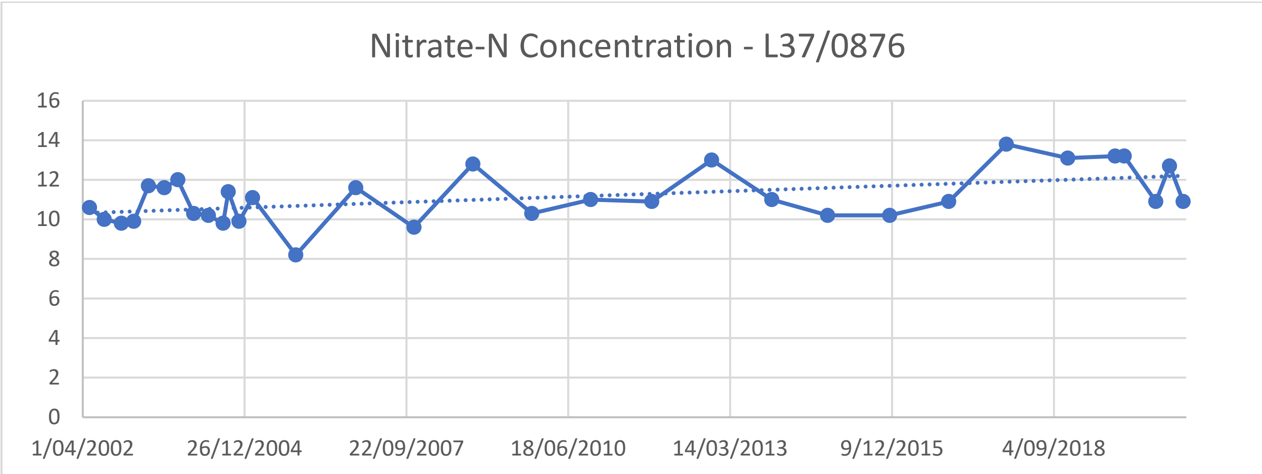
L37/0918



L37/0964



L37/0876


Nitrate-N Concentration - L37/0876
16
14
12
10
8
6
4
2
0
1/04/2002
26/12/2004
22/09/2007
18/06/2010
14/03/2013
9/12/2015
4/09/2018