BEFORE THE ENVIRONMENT COURT
CHRISTCHURCH REGISTRY

ENV-2016-CHC-014

IN THE MATTER	of an appeal under Section 120 Resource Management Act 1991
BETWEEN	**SCHRADER MAINS LIMITED**
	Appellant
AND	**SOUTHLAND REGIONAL COUNCIL**
	Respondent

BRIEF OF EVIDENCE OF KAREN LYNETTE WILSON

GALLAWAY COOK ALLAN
LAWYERS
DUNEDIN

Solicitor on record: Bridget Irving
Solicitor to contact: Bridget Irving / Campbell Hodgson
P O Box 143, Dunedin 9054
Ph: (03) 477 7312
Fax: (03) 477 5564
Email: bridget.irving@gallawaycookallan.co.nz
Email: campbell.hodgson@gallawaycookallan.co.nz

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INTRODUCTION

1. My full name is Karen Lynette Wilson. I have the qualification of a Bachelor of Science degree from the University of Otago and have successfully completed the Intermediate Sustainable Nutrient Management in New Zealand Agriculture course.

2. I am currently employed as a Senior Environmental Scientist at Landpro Limited and have been in this role for over 2 years. Prior to this position, I was employed by Environment Southland for 15 years in a number of roles including Principal Environmental Scientist.

3. In my previous role at Environment Southland, I was appointed as convenor of the Waituna Catchment Technical Group (CTG) and the Lagoon Technical Group (LTG) (Terms of Reference, 2012). These groups were established in 2011 in order to provide Environment Southland with scientific advice on how to minimise the risk of the Waituna Lagoon shifting to an algae-dominated state. The groups comprised of independent experts and experts representing particular interests for stakeholders.

4. Since April 2015 I have been contracted by Environment Southland to contribute to the Physiographics of Southland project. This project aims to better understand and estimate spatial variation in freshwater quality and hydrochemistry at a regional scale using a physiographic approach. Nine physiographic zones have been delineated for the Southland Region. A water quality risk assessment based on the physiographic zones has informed the development of the Proposed Southland Water and Land Plan, 2016.

5. I have familiarity with water quality issues in Southland and in particular, the Waituna catchment through my involvement in various science projects while employed by Environment Southland.

CODE OF CONDUCT

6. I have read the Code of Conduct for Expert Witnesses within the Environment Court Consolidated Practice Note 2014 and I agree to comply with that Code. This evidence is within my area of expertise, except where I state I am relying on what I have been told by another person. To the best of my knowledge I have not omitted to consider any material facts known to me that might alter or detract from the opinions I express.

EVIDENCE

7. The purpose of my evidence is to discuss the potential and actual environmental effects of the proposal on water quality in the Waituna catchment. In preparing this evidence I have drawn on a number of documents and resources which are summarised in the references section.

8. I have also reviewed the application and read the evidence of the following people:

   (a) Miranda Hunter; and,

   (b) Kate Scott.

ENVIRONMENTAL SETTING

9. The application site is located at 514 Rimu – Seaward Downs Road in the Waituna catchment. A description of the property and the proposal has been described in the application and evidence of others so I do not repeat that here.

10. The primary receiving water bodies associated with the subject property are several un-named creeks (with the major one locally referred to McMillian Creek) that flow in a south-westerly direction through the applicants' property. These creeks discharge into Waituna Creek upstream of Kapuka North Road. The Waituna Creek discharges into the Waituna Lagoon along its north-western boundary. The property is also underlain by a

groundwater resource that is part of the Awarua groundwater management zone (as mapped in the Proposed Southland Water and Land Plan. It is noted that this area was previously mapped as the Waihopai groundwater management zone in the Regional Water Plan for Southland, 2010). Groundwater is assumed to predominately discharge into the Waituna Creek with some minor discharge directly into the lagoon and offshore.

11. The Waituna Lagoon is a brackish, intermittently closed and open coastal lake and lagoon (ICOLL) that is located approximately 10 kilometres east of Invercargill. The lagoon is one of the best remaining examples of a natural coastal lagoon in New Zealand and forms a unique, highly valued feature of the Southland environment (Thompson and Ryder, 2000). The lagoon and adjacent wetland area totalling 3,500 hectares was designated a Ramsar Wetland of International Importance in 1976. In 2008, this was extended to include the wider, 20,000 hectare wetland complex referred to as the Awarua Wetlands. It is noted that the Waituna Lagoon is included as a Sensitive Waterbody in the Proposed Southland Water and Land Plan (Appendix Q).

12. In addition to having international, national and regional significance, the cultural significance of the Waituna Lagoon to the Ngāi Tahu people has been recognised though a Statutory Acknowledgement in the Ngāi Tahu Claims Settlement Act 1998.

13. Historically, the Waituna Lagoon was surrounded by peat bog wetland, the drainage from which gave the lagoon its characteristic colour, low nutrient status and low pH. These features supported high ecological habitat diversity, a unique seagrass community (*Ruppia* dominated), internationally important birdlife and large areas of relatively unmodified wetland and terrestrial vegetation (Thompson and Ryder, 2000, Robertson *et al.,* 2011). In addition to its ecological importance,

the lagoon is also valued for its aesthetic appeal, biodiversity, recreational and scientific significance (Robertson *et al.,* 2011).

14. Currently, the Waituna Lagoon sits at the bottom of a small coastal catchment whose land use is dominated by agriculture including intensive sheep and beef, dairying and dairy support. As part of land development, the catchment has undergone drainage of wetland areas and clearance of indigenous vegetation. The lagoon is periodically, artificially opened to prevent flooding of adjacent farm land and to improve catchment drainage. Following an opening, the lagoon sea-barrier reforms naturally (taking a period of days to more than 12 months).

15. In 2010, it was identified that monitoring data highlighted a rapid decline in the ecological condition of the lagoon to the point it had deteriorated from a high value seagrass (*Ruppia*) dominated state to a more degraded condition with nuisance epiphyte and algal blooms and sediment anoxia causing stress to the keystone *Ruppia* species (Hamill 2011). Expert opinion at the time was that unless urgent intervention occurred, the lagoon could undergo a regime shift to an even more degraded phytoplankton dominated state which would change the fundamental values and character of the lagoon (Robertson *et al.,* 2011).

16. In response to the expert opinion, Environment Southland initiated a multi-agency and community response that incorporated a range of scientific investigations and catchment works along with changes to the opening regime and land management within the catchment. Although the nature of the response has changed over time, the response to water quality issues in the Waituna catchment are on-going.

17. In August 2015, Environment Southland published a *Strategy and Action Plan for Waituna* which describes the vision, goals

and key actions for the catchment. This document describes 11 key action points which are in summary:

- Finding out what makes the Waituna catchment important to people (AgResearch, 2015);
- Cultural Opportunities Mapping Assessment and Response (COMAR) project (planned completion date April 2016);
- Research to increase knowledge about nutrient losses and new cost-effective technologies/techniques for minimising losses (ongoing);
- Investigate potential locations and benefits for retiring land within the catchment and/or around the lagoon (mapping and cost-benefit analysis to be completed by 30 September 2016);
- Minimise environmental risk of effluent storage/disposal through compliance with discharge consents and industry-led assessments, and implementation of good management practices (at all times);
- Managing riparian, winter grazing and drain maintenance activities according to good practice guidelines and prepare annual nutrient budgets for each farm including undertaking mitigation strategies to reduce nutrient loss (ongoing);
- Review the effectiveness of bank reconstruction work and undertake additional works where suitable to reduce sediment load to the lagoon, and implement a wider stream habitat management project to restore instream and riparian habitat at priority sites (current bank restablisation completed 30 June 2015 and undertake further works as funding becomes available);

- Investigate options for management of lagoon levels with an opening/closing regime and obtain a new consent for management of lagoon openings (peer-reviewed reports to be completed by 31 December 2015);

- Identify existing on-farm wetlands and provide guidelines and assistance with their protection and protect indigenous vegetation (ongoing);

- Raise awareness of the importance of mahinga kai, how it can be accessed and the implications for the Scientific Reserve status of the lagoon (communications strategy to be completed by 30 June 2016); and,

- Monitor the *Ruppia* population and investigate the risks for *Ruppia* reestablishment (peer-reviewed report to be completed by 30 March 2017).

It is unclear whether these reports (other than those referenced) have been completed within intended timeframes.

18. It is noted that the Strategy and Action Plan for Waituna (Environment Southland, 2015) does not specify nutrient targets or catchment load limits.

19. The ecology and water quality in ICOLL's are driven by complex interactions between the opening regime, climate and catchment nutrient loads. In terms of management, there is a "trade-off" between the salinity and desiccation pressures on macrophytes from artificial opening events versus the potential for these events to flush nutrient-laden freshwater and organically-enriched sediments from the lagoon (Hamilton *et al.* 2012).

20. Modelling results by the University of Waikato show that *"under current catchment nutrient loads it is not possible to maintain a "healthy" Ruppia population in the lagoon with changes to the opening regime alone"* (Hamilton *et al.,* 2012). However, the

amount of nutrient load reductions required to sustain persistent and productive *Ruppia* beds are dependent on the opening regime adopted (Hamilton *et al.,* 2012).

21. The recommendations of the Waituna Lagoon Technical Group (2013), which were released by Environment Southland in 2015, proposed a number of targets aimed at maintaining a healthy macrophyte community and avoiding a regime shift in the Waituna Lagoon. In summary, these targets are:

    (a) >30-60% cover of *Ruppia* and other indigenous macrophytes (based on average annual percent cover at permanently wetted sites);

    (b) nutrient load limits of <125 tonnes/year for nitrogen (equivalent to a lagoon aerial loading of <90 kg N/ha/year) and <7.7 tonnes per year for phosphorus (a lagoon aerial loading of <5.7 kg P/ha/year); and,

    (c) manage the lagoon opening regime so that:

    - spring and summer time openings are avoided with a minimum water level of 2.0 metres for openings between May and June, and 1.8 metres for July openings;
    - time openings with windy periods when resuspension and flushing effect will be highest;
    - investigate the feasibility of manually closing the lagoon; and,
    - Walker's Bay is used as the standard opening location (with experimental openings at Hansen's Bay to determine whether other locations could reduce to the threat to aquatic vegetation communities while extending flushing benefits to other parts of the lagoon).

22. It was estimated the load targets were approximately 50% of the current (as at 2013) nitrogen and phosphorus inputs to the lagoon. The recommended catchment loads are *"not intended as broad brush reductions across the whole catchment, or for all farm land in the catchment, but rather as reductions in the amount of nutrients reaching the lagoon"* (Waituna Lagoon Technical Group, 2013). It was also noted that the recommended lagoon opening regime represented a change from existing practice, and is intended to maintain at least a 'moderate' lagoon state i.e. predominately fresh-water lagoon with a short marine phase (e.g. two months).

23. As yet, Environment Southland have not adopted any nutrient limits or targets for the Waituna catchment and it is my understanding that the timing, frequency, location and triggers for opening the lagoon are also yet to be determined (through a resource consent process that is underway). Environment Southland have released a schedule for rolling out freshwater limits in the Southland Region and they have stated that the Waituna catchment limit setting process will occur in conjunction with the Mataura catchment beginning 2017, with catchment limits to be developed by July 2018 (Environment Southland, 2016a).

Physiographic Zones

24. In the period since the resource consent application was lodged, Environment Southland have released a regional spatial framework that delineates the region into nine non-contiguous '*physiographic zones*'. Each zone represents distinct combinations of inherent landscape properties that result in similar influences over water quality outcomes (Hughes, *et al.,* 2016).

25. The applicants' property is located in the Gleyed physiographic zone, as shown in Figure 1. Environment Southland's physiographic zone fact sheet describes the Gleyed zone as

consisting of fine-textured, poorly drained soils that are prone to waterlogging. As a result, soils are extensively artificially drained (Environment Southland, 2016b). The artificial drainage network, which discharges into surface waterways, provides a major contaminant loss pathway particularly during heavy or sustained rainfall periods (i.e. losses are event-driven). Soils and aquifers in this zone have the ability to remove some or all nitrogen via denitrification which reduces the risk of nitrate accumulation in underlying groundwater.

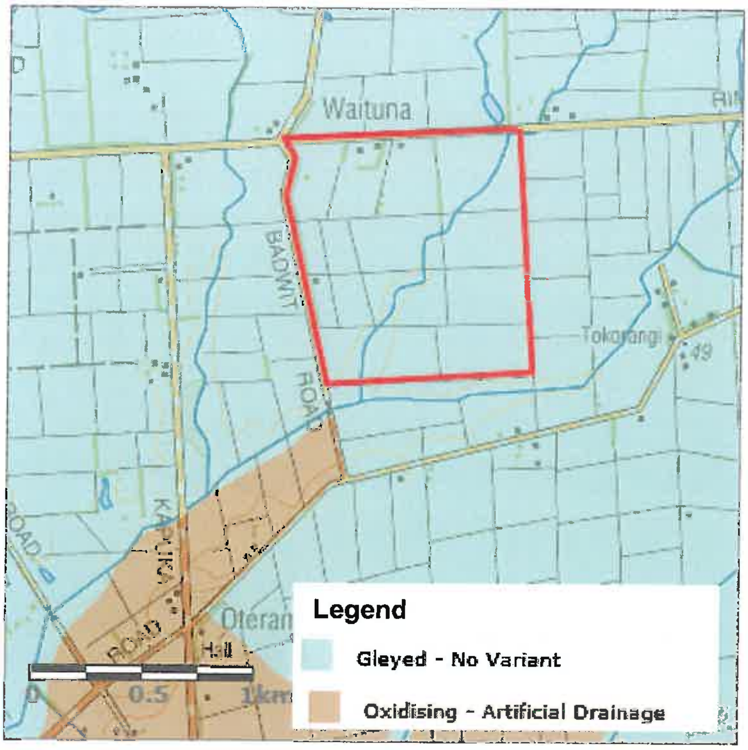

Figure 1: Partial screenshot of Environment Southland's physiographic zones, with the applicants' property shown with a red outline. The applicants' property is mapped as being within the Gleyed physiographic zone.

[Source: Environment Southland's website: http://gis.es.govt.nz/index.aspx?app=water-and-land on 18/07/2016]

26. The Gleyed physiographic zone has been mapped on the basis of soil properties. Figure 2 shows the dominant soils on the property are Woodlands and Dacre series as mapped by the Topoclimate South soil survey (Topoclimate South, 2000).

Woodlands soils are classified as Mottled Firm Brown soils (New Zealand Soil Classification system). These soils are typically stoneless, with a silt loam texture and are imperfectly drained with a compact subsoil that is slowly permeable. Due to their drainage properties, these soils have a moderate vulnerability to waterlogging. Dacre soils are classified as Acidic Recent Gley soils and are also stoneless with a silt loam texture. These soils have poor profile drainage and commonly contain orange mottles. As a result, these soils have been assessed as having a severe vulnerability to waterlogging (Crops for Southland, 2002). Due to their poor drainage characteristics, these soils are likely to have artificial drainage where they support agricultural land uses. The soils on the property are consistent with the Gleyed physiographic zone characterisation of water quality risk.

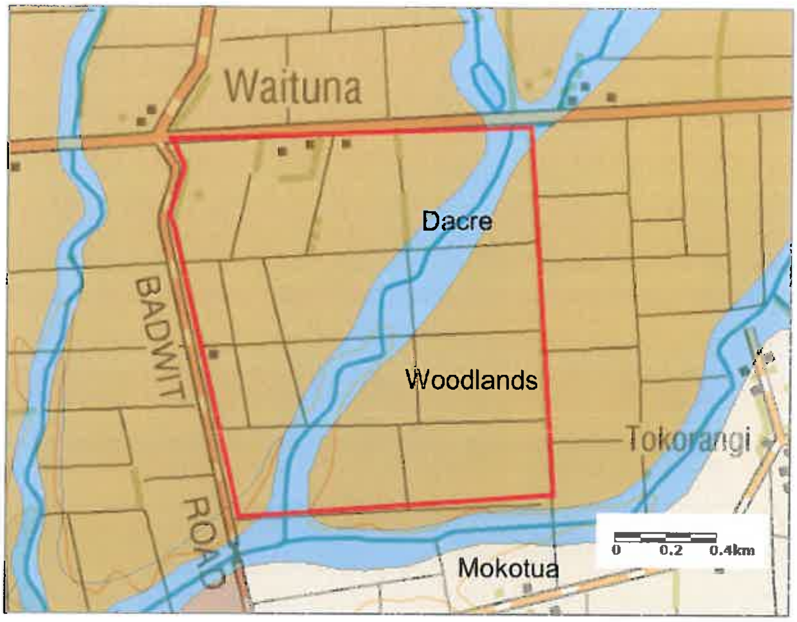

Figure 2: Partial screenshot of Environment Southland's soil types, with the applicants' property shown with a red outline. The applicants' property is mapped as being within the Woodlands, Mokotua and Waikiwi soils series (shown in brown) and Dacre, Woodlands and Titipua soils series (shown in blue). The dominant soil series are labelled in the figure.

[Source: Environment Southland's website:
http://gis.es.govt.nz/index.aspx?app=topoclimate on 27/07/2016]

EXISTING WATER QUALITY IN THE WAITUNA CATCHMENT

Groundwater

27. Regional modelling undertaken by Environment Southland (Rissmann 2011) suggests groundwater in the area around the applicants' property has low to very low denitrification potential. This means shallow groundwater is relatively sensitive to nitrate accumulation (denitrification refers to the conversion of nitrate to gaseous nitrogen or nitrous oxide by bacteria).

28. The regional 5-year median (June 2007-June 2012) nitrate concentration map (Rissmann 2012) identifies groundwater quality in this area as having nitrate levels that corresponds to minor to moderate land use impacts (i.e. nitrate (as NO_3-N) is between 1.0 - 3.5 mg/L which reflects modern day background levels) or pristine, pre-European levels (i.e. nitrate is between 0.01 – 0.4 mg/L).

29. These regional assessments are consistent with an Environment Southland technical groundwater report (Rissmann *et al.,* 2012) that, on the basis of chemistry and physical properties, characterises groundwater resources in the upper Waituna catchment as having thick, stoneless Brown soils which buffer groundwater quality from the effects of land use due to cation exchange and chemical sorption processes which are aided by longer mean residence times (in the order of months). As a result, although the aquifer has little denitrification potential, the soils buffer groundwater quality so that shallow groundwater shows little impact from land use. The main risk to water quality in the upper part of the Waituna catchment was identified as occurring in association with artificial drainage. Risks to surface water quality are discussed in the following section.

Surface Water

30. The nearest Environment Southland surface water quality state of the environment monitoring site to the applicants' property is located approximately 4.5 kilometres downstream (i.e. to the southwest) in the Waituna Creek 1 metre upstream of Waituna Road. There is an additional downstream monitoring site in the Waituna Creek at Marshall Road which is the furthest downstream monitoring site in the Waituna catchment and as such, reflects the cumulative effect of land use across most of the Waituna Creek catchment area.

31. Figure 3 shows Environment Southland's assessment of water quality in the Waituna catchment against the National Objectives Framework water quality standards in the National Policy Statement for Freshwater Management, 2014 (Ministry for the Environment, 2014). The results for the two monitoring sites in Waituna Creek show:

- Escherichia coli (*E.coli*) concentrations for secondary contact are generally good and exhibit increased health risk (less than 1%) for wading or boating;

- Nitrate toxicity in the upper Waituna Creek site may have an impact on the 20% most sensitive species. At the downstream site, nitrate toxicity can have an impact on the 5% most sensitive species;

- Macroinbertebrates (fish food) is only monitored in the downstream site and is poor;

- Periphyton (slime algae) is not monitored in the Waituna Creek.

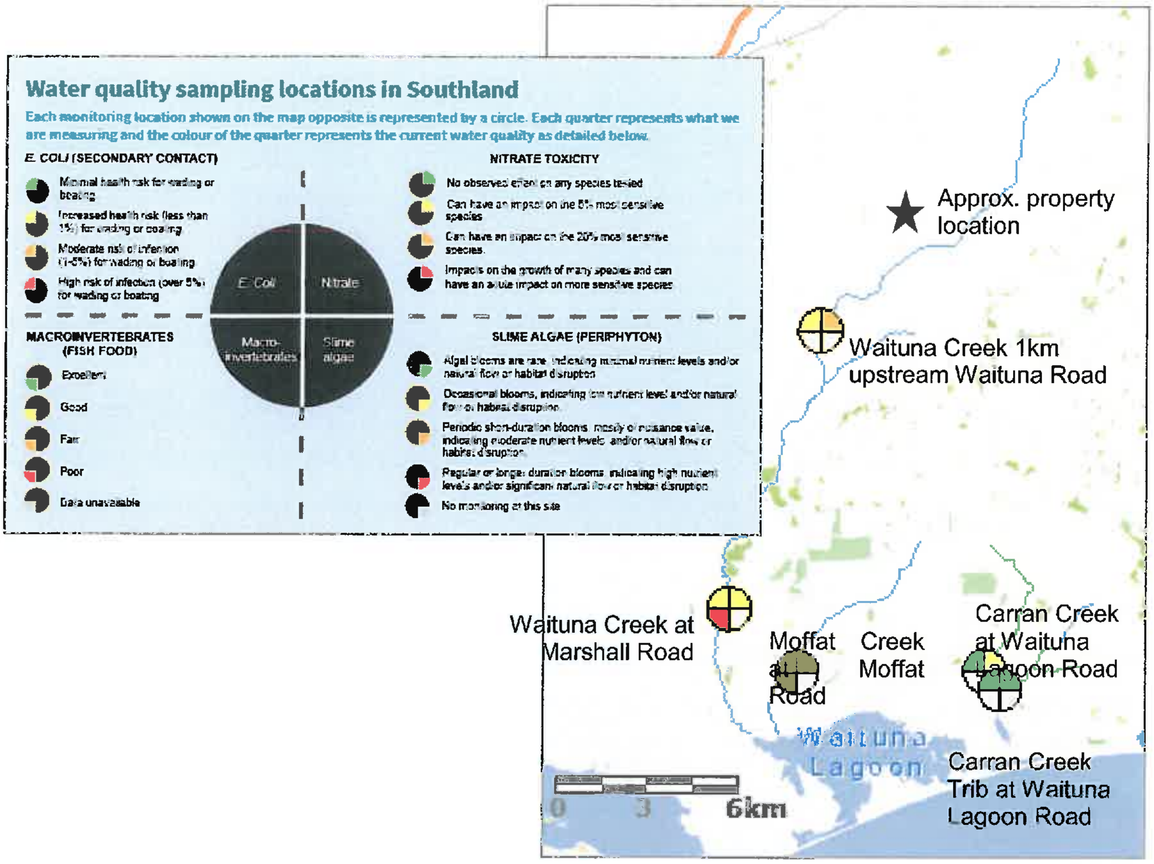

Figure 3: Partial screenshot of Environment Southland's assessment of water quality against the National Objectives Framework (July 2009-June 2014).

[Source: Environment Southland's website: http://gis.es.govt.nz/index.aspx?app=water-quality-(nof)&ext=1240408,4834152,1280957,4852611 on 18/07/2016]

32. Table 1 shows the surface water quality data from Waituna Creek compared other state of the environment monitoring sites across New Zealand (LAWA, 2016). The data show water quality in Waituna Creek is generally amongst the worst 50% and 25% of like sites for bacteria, clarity, nitrogen and phosphorus. There are no statistically significant trends in the past 5 and 10 years of monitoring, with the exception of degrading trends in pH and total oxidised nitrogen in the past 10-years of data.

Table 1: Summary of water quality in the Waituna Creek 1 metre upstream of Waituna Road

[Source: Land, Air, Water Aoteroa website https://www.lawa.org.nz/explore-data/southland-region/river-quality/waituna-creek on 18/07/2016. Note: that the website was not showing results for the Waituna Creek at Marshall Road]

		State		***Trend***	
Indicator	***Parameter***	***All sites in New Zealand***	***All lowland rural sites***	***10-year period***	***5-year period***
Bacteria	*E. coli*	Worst 25% of like sites	Worst 50% of like sites	No trend	No trend
Clarity	Black disc	Worst 50% of like sites	Best 50% of like sites	No trend	No trend
	Turbidity	Worst 50% of like sites	Worst 50% of like sites	No trend	No trend
Nitrogen	Total Nitrogen	Worst 25% of like sites	Worst 25% of like sites	No trend	No trend
	Total Oxidised Nitrogen	Worst 25% of like sites	Worst 25% of like sites	Meaningful degradation	No trend
	Ammoniacal Nitrogen	Worst 25% of like sites	Worst 25% of like sites	No trend	No trend
Phosphorus	Dissolved Reactive Phosphorus	Best 50% of like sites	Best 50% of like sites	No trend	No trend
	Total Phosphorus	Worst 50% of like sites	Best 50% of like sites	No trend	No trend
Other	pH	Best 50% of like sites	Best 50% of like sites	Significant degradation	No trend

33. Overall, the water quality data from the Waituna Creek can be assessed as being fair in relation to the National Objectives

Framework and poor in relation to other state of the environment monitoring sites across New Zealand. The main water quality issues are elevated nutrient (nitrogen and phosphorus) concentrations.

Lagoon

34. Water quality in the Waituna Lagoon fluctuates in accordance the opening and closing regime. The last published information by Environment Southland on the state of water quality in the Waituna Lagoon was in June 2014 (Environment Southland, 2014). This document states that nutrient levels in the lagoon were relatively low over the spring and summer of 2013/14 in response to flushing from the tide (the lagoon was open to the sea during this period following a mechanical opening in July 2013). A spike in chlorophyll *a* was observed between August and September 2013 however this was considered to be minor in comparison to historic records and an increase in chlorophyll *a* is typical at that time of year as water temperatures rise and windy weather mixes nutrients throughout the water column leading to phytoplankton growth.

35. In summary, the document notes that *"while the benefit of an open lagoon is that nutrient levels remain low, the downside is that the influx of salt water reduces Ruppia growth. Ruppia is a genus of aquatic plant found in Waituna Lagoon and* [is] *an indicator of lagoon health. It plays an important role in the uptake* [of] *nutrients from the water column and binding sediment with its roots"* (Environment Southland, 2014).

36. Environment Southland have indicated they are about to undertake a water quality update for the Waituna Lagoon, however this report is currently unavailable (K, Robertson *pers. coms.* 2016). Monitoring of macrophytes in the lagoon is undertaken by the Department of Conservation and the results from the 2015/16 summer show "*an average lagoon-wide total macrophyte cover of 58% and a Ruppia spp. lagoon-wide cover*

of 57%. This was almost a doubling of the summer 2015 survey lagoon-wide macrophyte cover of only 30% (Sutherland *et al.*, 2016). This increase partially reflects macrophyte re-colonisation following de-vegetation associated with the lagoon being open (Sutherland *et al.*, 2016).

37. Although the 2015/16 summer macrophyte cover is within the Lagoon Technical Group (2013) target of >30-60%, the report notes *"there was still a high abundance of algae, both filamentous and phytoplankton, in the lagoon. Managing both the lagoon opening regime and nutrient loads entering into the lagoon from freshwater inputs will assist with managing both the macrophyte beds and algal growth"* (Sutherland *et al.*, 2016).

SOURCES OF NUTRIENT LOADS TO WAITUNA LAGOON

38. Nutrient loads to the Waituna Lagoon are not evenly distributed across the catchment. Due to variability in land use and inherent landscape properties (which result in spatially differing nutrient loss vulnerabilities), some areas contribute disproportionally large proportions of the nutrient load.

39. Table 2 summarises available nutrient load estimates for the Waituna Lagoon. These estimates are based on water quality and hydrological data. It is noted that in Environment Southland's last Waituna Newsletter (Issue 18 - June 2014), DairyNZ have said they are developing a water quality model to estimate total nutrient loads entering the Waituna Lagoon from the catchment (Environment Southland, 2014). The results of this project are not yet available and as such, have not been included in this evidence.

40. Table 2 shows the Waituna Creek contributes >70% of the nitrogen load to the lagoon. The Waituna Creek catchment makes up approximately 51% of the total catchment area and contributes 33% of freshwater inflows. Conversely, Waituna Creek is estimated to contribute 36% of the total organic

phosphorus load (organic phosphorus includes all phosphorus found in living or dead animals and plants as well as their wastes) with 44% of organic phosphorus loads being derived from other surface water inflows.

41. The data in Table 2 is consistent with Rissmann *et al.,* (2012) who identified three distinct hydrogeological zones in the Waituna Lagoon catchment. The Southern Waituna Zone (i.e. Waituna Creek catchment south of Caesar Road and both the Moffat and Carran Creek catchments) contains an abundance of organic carbon associated with wetland peat deposits, organic soils and to a less extent, lignite measures. In this zone, naturally oxygen-reducing conditions prevail which prevents assimilation and contamination of nitrate (through denitrification). However, in this zone there is increased risk of phosphate leakiness from organic soils reflecting the naturally higher solubility and mobility of phosphate under reducing conditions. In the Mokotua Infiltration Zone (i.e. the between Mokotua and Caesar Road), it was determined there was a high risk of nitrate leaching to underlying groundwater due to soil and aquifer properties, while in the Northern Waituna Zone (i.e. north of Mokotua), there was a high risk of nutrient loss via artificial drainage. Therefore, this assessment suggests the upper Waituna Creek catchment contributes a disproportionally high component of nitrogen to the Waituna Lagoon while the Moffat Creek, Carrans Creek and the lower portion of Waituna Creek catchment contributes a disproportionally high component of the phosphorus load.

Table 2: Source of freshwater inflows and nutrient loads to the Waituna Lagoon (derived from measured data)
[Note: the absolute values are attached in Appendix 1]

Freshwater source	***Mean annual loads for 1995-2011[a]***		***Mean annual inputs for 2001-2011[b]***			
	Total Nitrogen	***Total Phosphorus***	***Flow***	***Nitrate (NO_3-***	***Organic Phosphorus***	***Phosphate Phosphorus***

				N)		*(PO_4-P)*
Waituna Creek	80%	59%	33%	72%	36%	23%
Moffat Creek	8%	17%	7%	5%	9%	15%
Carran's Creek (including tributary)	12%	24%	11%	7%	15%	15%
Other surface water inflows*	Not assessed		22%	9%	20%	40%
Groundwater (direct to lagoon)			28%	8%	21%	7%

[a]Diffuse Sources and NIWA (2012)

[b]Hamilton *et. al,* (2012)

*Refers to areas not included in other surface inflows, and are similar to Moffat Creek and Carran's Creek tributary

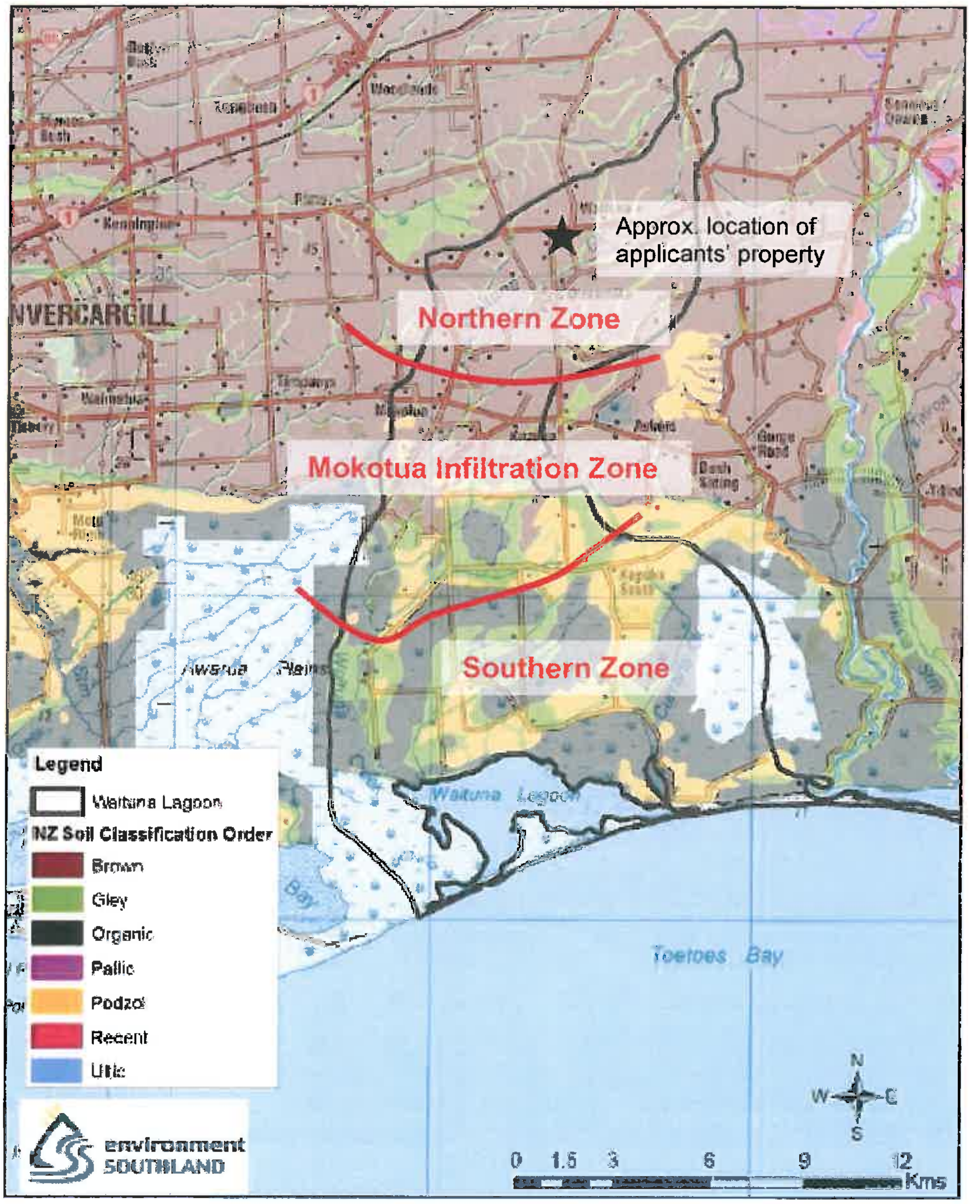

Figure 4: Soil classification (NZSC Order) and approximate boundaries of the three hydrogeological zones in the Waituna catchment. The southern boundary of the Brown soils matches the Q5 (old marine) shoreline.

[Source: modified from Rissmann, *et al.*, 2012]

EFFECTS OF THE PROPOSED ACTIVITY ON WATER QUALITY

42. Table 3 provides a summary of estimated nutrient losses for three land use scenarios on the property using Overseer® modelling (from M Hunter's evidence). Comparatively, phosphorus losses are estimated to increase under the alternative land use scenarios (i.e. proposed dairy milking platform and specialist grazing options) while nitrogen losses

are estimated to decrease under the dairy milking platform and increase under the specialist grazier scenario.

Table 3: Summary of modelled farm nutrient losses (from M. Hunter's evidence)

Farm Scenario	*Phosphorus Loss (kg P/ha/year)*	*Nitrogen Loss (kg N/ha/year)*	*Weighted Average Nitrogen Loss (mg/L)*
Existing land use (2015/16)	0.4	39	8.5
Proposed land use (dairy milking platform)	0.7	29	6.3
Alternative land use (specialist grazier)	0.5	43	8.7

43. Overseer modelling suggests that the predominant nutrient loss pathways are overland flow and/or artificial drainage for phosphorus and leaching for nitrogen (M Hunter's evidence, paragraph 14 and associated Overseer reports).

Groundwater

44. Overseer predicts the weighted average farm modelled nitrogen loss in drainage water will be 6.3 mg/L under the proposed dairy conversion. As most of this loss is predicted to occur as leaching, the dominant form of nitrogen loss will occur as nitrate (as NO_3-N). The modelled farm loss of 6.3 mg/L is well within (approximately 56%) the maximum acceptable value for nitrate in the Drinking Water Standard for New Zealand (DWSNZ) (Ministry of Health 2008) and is less than the modelled weighted average nitrogen concentration from the current land use (8.5 mg/L) and alternative land use (8.7 mg/L).

Surface Water

45. Nutrient discharge from overland flow (or surface runoff) and via artificial drainage tends to correlate positively with stream flow i.e. concentrations increase as flow increases, as illustrated in Figures 5 and 6. As a result, these are also critical pathways

for transport of nutrient loads to catchment 'sinks' (e.g. estuaries, lagoons, lakes). In contrast, surface water concentrations associated with diffuse discharge from direct access to water and leaching tends to become diluted with increased flow (adapted from Howard-Williams *et al.,* 2010).

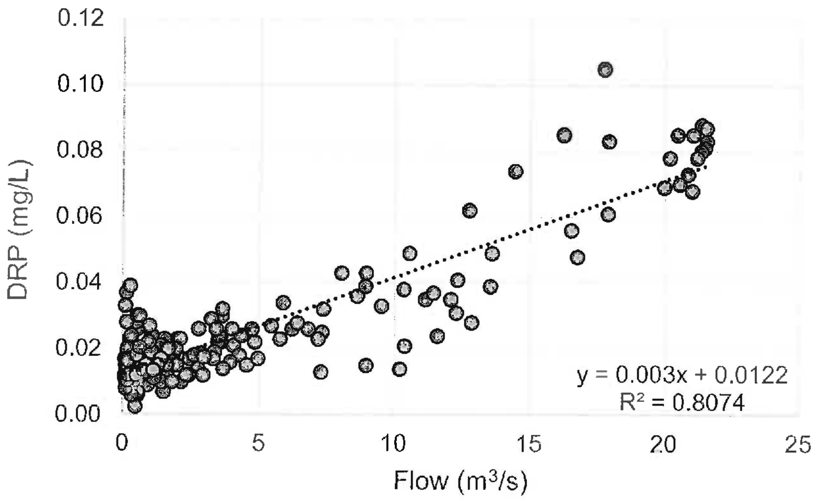

Figure 5: Dissolved reactive phosphorus (DRP) and flow data for the Waituna Creek at Marshall Road (2001-2015)
[Source: data provided by Environment Southland, 2015]

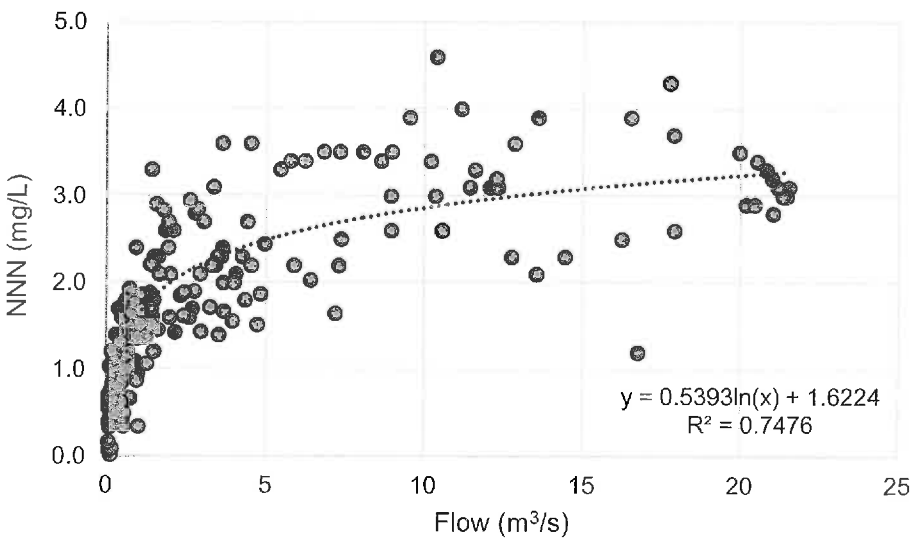

Figure 6: (Nitrate + Nitrite) - Nitrogen (NNN) and flow data for the Waituna Creek at Marshall Road (2001-2015)
[Source: data provided by Environment Southland, 2015]

46. Despite Overseer suggesting leaching is the dominant pathway for nitrogen loss from the property, Figure 7 show that nitrate loss from artificial drainage can also be high. The tile drain map for the property (in the Farm Environmental Management Plan) shows there are 7 drain outlets on the property whose catchment area cover almost all of the property area. Based on this information, I have assumed that overland flow and artificial drainage represent the dominant contaminant pathways for nutrient loss from the property to surface waterways.

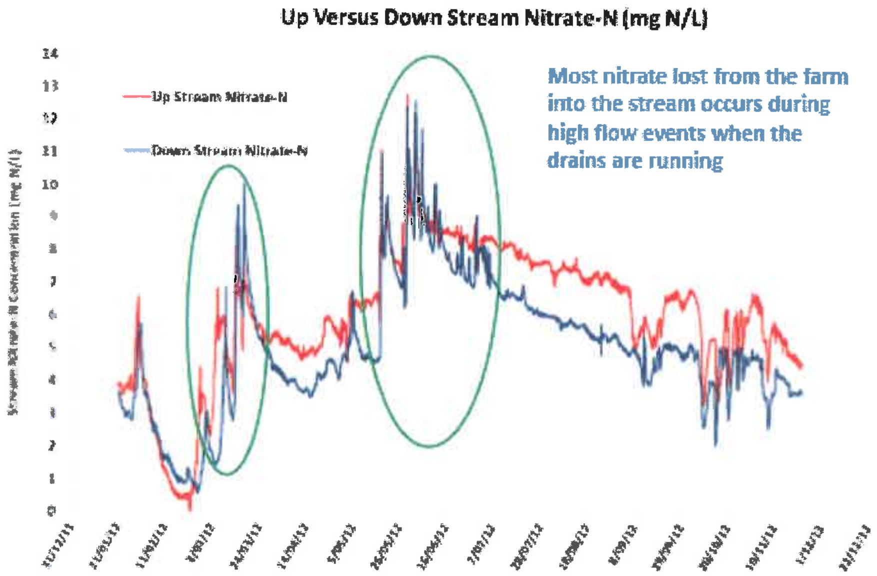

Figure 7: Upstream and downstream nitrate concentrations showing periods of nitrate loss from the Southland Demonstration Farm, Wallacetown
[Source: extracted from Cameron *et al.,* 2014]

47. Based on the monitoring data collected at the Southland Demonstration Farm, Cameron *et al.,* (2014) concluded that the majority of nitrate loss from the property occurred during spasmodic events when the farm drains were running. This typically occurred between May and the end of July during the study period (2012), when soils were near field capacity.

48. This study showed that nutrient losses via artificial drains occurred episodically, in response to rainfall events. As such, nutrient loss can be considered to be transport limited (rather than source limited).

49. Environment Southland monitoring data (http://gis.es.govt.nz/index.aspx?app=soil-moisture) show that on average, soils are near field capacity between May and September (inclusive) in Southland. Rainfall during this period more readily results in drainage (or transport) events compared to other times of the year when soil moisture conditions are typically drier (i.e. greater rainfall is required to initiate drainage events). Between May and September there are currently (2015/16) up to 759 cows and yearlings with 20 hectares (ha) of winter (forage) crops on the property. Under the proposed dairy milking platform, there would be up to 315 cows and 4 ha of winter crops which represents a reduction in the potential nutrient source during this period. Under the alternative specialist grazier land use scenario, there would be up to 1,550 cows and yearlings with 48 ha of winter crops which, of the three land use scenarios, represents the greatest potential nutrient source during the highest risk period for nutrient transport events (stock numbers are sourced Roslin Consultancy Ltd, 2016).

50. Contaminant loss from overland flow and artificial drainage are mostly derived from critical source areas and these areas often represent a small proportion of the total catchment area. This means mitigation strategies can be adopted to target times and sites where there is a disproportional loss of nutrients. Mrs Hunter's evidence discusses the mitigation strategies proposed by the applicant to address critical source areas and times. Management strategies for critical source areas are also included within the Farm Environmental Management Plan.

51. One of the key difficulties in translating a nutrient loss figure from Overseer into a predicted effect on water quality is accounting for attenuation. For overland flow, attenuation may occur in the riparian zone (referred to as lateral attenuation) or within the stream channel (referred to as instream attenuation). Lateral attenuation has been discussed in relation to the riparian buffer zones in Mrs Hunter's evidence-in-chief. Instream attenuation processes include hyporheic exchange, sediment exchange, microbial pollutant die-off in sunlit channels, long-term storage of sediments (infilling) and nutrient transformations (i.e. from dissolved inorganic nutrients to particulate nutrients and vice versa) (Howard-Williams *et al.* 2010).

52. Howard-Williams *et al.* (2010) states that streams which have the greatest instream attenuation capability are small (low order) streams with studies showing streams that have a flow rate of 500 litres per second (L/s) or less have a greater than 10 percent nutrient loss per kilometre of stream length. The un-named tributaries to Waituna Creek which run through the applicants' property fall into this category.

53. To the best of my knowledge, there have been no studies conducted on instream attenuation specifically for the Waituna catchment or within Southland. Therefore, I do not think it appropriate to estimate instream attenuation for Waituna Creek in order to quantify the effects of the subject application on water quality. Instead, I have undertaken a risk-based assessment by reviewing the likely contaminant transport pathways and associated water quality implications based on the relative magnitude of nutrient losses predicted by Overseer.

54. AgResearch modelled a 'typical' sheep and beef farm and a dairy farm using different soil and farm management practices to identify the relative contribution of nutrient losses from different sources (Robson *et al.* 2011). The report identified

urine patches and winter grazing as being the main sources of nitrogen loss with effluent application to wet soils, grazing of winter forage crops, stock access to waterways and high soil Olsen P concentrations being the important sources of phosphorous loss.

55. The applicant has fenced off waterways and established riparian buffer strips. Under the proposal, they will use deferred, low rate effluent irrigation that will not be applied within 20 metres of streams and will be managing soil Olsen P in accordance with a nutrient management plan. The applicant also proposes to winter off two-thirds of the dairy stock. Therefore, with exception of 90 cows wintered on and urine patches, the applicant will be avoiding all the high risk activities as identified by AgResearch.

56. Research from the Waituna catchment show drain clearing can be a major contributor of sediment, and mobilisation of nutrient loads to the lagoon (e.g. Olsen 2012, McDowell *et al.,* 2013). Drain clearing may also have an adverse effect on fish habitat and invertebrate populations in streams. As is noted in the Farm Environment Management Plan, all drain clearing activities on the property are currently, and will be undertaken by Environment Southland.

Lagoon

57. The scale of the activity in relation to the rest of the catchment, and the complexity of the environmental setting make quantifying the cumulative water quality effects of a specific property very difficult, if not impossible.

58. Specifically, the difficulties in assessing the land use effects of a property on water quality in the Waituna Lagoon are complicated by the opening/closing regime and a lack of knowledge on ICOLL's. The complexity and uncertainty in predicting water quality effects on a highly dynamic system are

illustrated by the fact that once the lagoon has been mechanically opened to the sea, it may remain that way for anywhere between hours to over a year (Larkin, 2013). The effect of a particular activity on water quality in the lagoon will be very different in a freshwater dominated lagoon compared to a saline, tidal lagoon.

59. Numerical models can be used to test the effects land use has on surface water quality (for example Catchment Land Use for Environmental Sustainability (CLUES)). However in my opinion, given the effective property area represents less than 0.6 percent of the total catchment area, and given the relatively small changes in nutrient loss estimated by Overseer® modelling, it is my opinion that such an approach would not result in any measureable modelled change to water quality and would be well within the margin of error. Hence this approach has not been taken.

CONCLUSIONS

60. Water quality in the Waituna Creek can be generally described as fair (in relation to the standards in the National Objectives Framework in the NPSFM) with the main concerns being excessive levels of nutrients; specifically, nitrogen and phosphorous. Groundwater quality under the property is modelled as being pristine to exhibiting moderate land use impacts (i.e. nitrate (as NO_3-N) is <3.5 mg/L), with the overlying soils likely providing some potential for denitrification due to their poor internal drainage. It is noted that within the aquifer, there is little potential for denitrification to occur (Rissmann, 2011).

61. In 2010, concern over the ecological health of the Waituna Lagoon resulted in Environment Southland initiating a multi-agency and community response. As yet, no nutrient limits or targets have been formally adopted by Environment Southland and the Waituna catchment limit setting process (as required

under the NPSFM) is not scheduled to occur until 2017 -2019, in conjunction with the Mataura catchment (Environment Southland 2015). However, it is noted that the Waituna Lagoon Technical Group recommend nutrient load limits of <125 tonnes/year for nitrogen (equivalent to a lagoon aerial loading of <90 kg N/ha/year) and <7.7 tonnes per year for phosphorus (a lagoon aerial loading of <5.7 kg P/ha/year). These targets are estimated to be approximately 50% of 2013 nutrient loads.

62. The applicant has modelled three land use scenarios using Overseer: the existing land use (2015/16), the proposed conversion to a dairy milking platform and an alternative specialist grazing land use. The results show nitrogen loss is lowest under the proposed conversion (29 kg N/ha/year) while under this scenario, phosphorus loss is estimated to increase from 0.4 kg P/ha/year to 0.7 kg P/ha/year (from the current land use). Although Overseer can not be used to quantify water quality effects, the modelled outputs are the best available numerical assessment of nutrient discharge from the property, particularly for nitrogen. If there is an increase in phosphorus loss from the property, it could contribute to additional periphyton growth and add to eutrophication issues in the Waituna Lagoon. Mrs Hunter's evidence indicates there are some difficulties modelling phosphorus loss in Overseer however, effective management of critical source areas can significantly decrease the amount of phosphorus loss. Adoption of good management practices that are not modelled in Overseer will likely result in phosphorus losses below that predicted by Overseer (Mrs Hunter's evidence, paragraph 23).

63. It is my assessment that the dominant contaminant pathways associated with this property are overland flow and artificial drainage to surface waterways, with some potential for nitrate leaching to underlying groundwater. Contaminant losses via overland flow and artificial drainage are typically episodic, and event-driven. As such, mitigations that target critical source

areas and times (i.e. wet periods) will have the greatest influence over reducing effects on water quality.

64. Overall, I conclude there will be a negligible change in water quality as a result of the proposal subject to the activity being carried out in accordance with proposed consent conditions.

Karen Wilson
Landpro Ltd

28th July 2016

APPENDIX 1

APPENDIX 1 - REFERENCES

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APPENDIX 1 – NUTRIENT LOADS TO WAITUNA LAGOON

Hamilton *et. al*, (2012)

Table 1: Total annual flows and nutrient loads for phosphorus (PO_4-P and organic P) and nitrogen (NH_4-N, NO_3-N and organic N) for Waituna Lagoon inflows (derived from measured data) and outflow (derived from model (DYRESM-CAEDYM) output), averaged over the calibration/validation period (2001–2011).

Inflow	Flow (m^3 yr^{-1})	PO_4-P (t yr^{-1})	Organic P (t yr^{-1})	NH_4-N (t yr^{-1})	NO_3-N (t yr^{-1})	Organic N (t yr^{-1})
Waituna Creek	50,887,511	1.09	3.44	4.79	99.33	40.94
Moffat Creek	10,309,310	0.71	0.88	0.68	6.49	10.97
Carren Creek	12,838,949	0.56	1.33	1.41	8.92	11.08
Carren Creek tributary	4,076,090	0.17	0.09	0.10	0.19	2.53
Other surface 1*	18,351,461	1.27	1.57	1.20	11.55	19.53
Other surface 2*	15,354,630	0.64	0.32	0.36	0.70	9.52
Groundwater	43,822,337	0.31	2.02	0.57	10.52	18.27
Total freshwater inflows	*155,640,787*	*4.75*	*9.64*	*9.11*	*137.70*	*112.85*
Tidal inflow	352,060,290	3.52	3.52	1.76	10.56	86.25
Total inflows	*507,701,077*	*8.27*	*13.16*	*10.87*	*148.26*	*199.10*
Outflow	518,221,964	5.14	4.04	8.82	135.43	61.26
Difference between total inflows and outflow	*-10,520,887*	*3.13*	*9.12*	*2.04*	*12.83*	*137.84*
Nutrient retention (recycling and burial) as a proportion of total inflow	*NA*	*0.38*	*0.69*	*0.19*	*0.09*	*0.69*

* Refers to areas not included in other surface inflows that are similar to Moffat Creeks, and Carren Creek tributary, respectively.
N.B. Tidal inflows and outflow are dependent on lagoon opening regime. These data are for 2001–2011 only.

Diffuse Sources and NIWA (2012)

Table 7.5 Total annual loads and relative contributions of the three main catchments discharging into the Waituna Lagoon (as determined by load estimation Method 3).

	TSS	NO_3-N	NH_4-N	TN	DRP	TP
Marshall Rd (t/y)	894.9	112.0	11.3	165.8	1.5	6.0
Marshall Rd (%)	77.2	86.7	85.4	81.1	50.1	62.0
Carran Creek (t/y)	166.4	9.3	1.2	21.3	0.6	2.0
Carran Creek (%)	14.4	7.2	9.0	10.4	20.9	21.0
Moffat Creek (t/y)	97.4	7.8	0.7	17.3	0.9	1.7
Moffat Creek (%)	8.4	6.1	5.6	8.4	29.0	17.1
Total	**1158**	**129.1**	**13.2**	**204.4**	**3.1**	**9.7**