In the matter of the Resource Management Act 1991

And

In the matter of an application for Resource Consents by Oceania Dairy Limited to construct and operate a pipeline to discharge treated wastewater into the ocean.

STATEMENT OF EVIDENCE OF HELEN REBECCA STOTT FOR OCEANIA DAIRY LIMITED

28 May 2020

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INTRODUCTION

1 My full name is Dr Helen Rebecca Stott.

2 I hold a BSc in Biochemistry from Sheffield University, UK and a PhD in *Health Risks from Wastewater Reuse* from the University of Leeds, UK.

3 I am an environmental scientist with the National Institute of Water and Atmospheric Research Limited (NIWA), Hamilton and work in the Aquatic Pollution Group.

4 I have over 20 years of experience in environmental research and consultancy focussing on wastewater treatment, water quality and health. This has included examining and predicting the environmental and public health effects of a number of wastewater treatment and disposal schemes.

5 I am a member of the International Water Association, the New Zealand Freshwater Sciences Society and I am an elected member of the technical committee for the New Zealand Land Treatment Collective.

6 Over the past 16 years, I have undertaken 14 studies assessing the public health effects from wastewater discharge from either municipal wastewater treatment plants or dairy factory processing plants. My relevant experience in the dairy sector includes health risk assessments for Fonterra Edgecumbe (2018), Fonterra Lichfield (2019), Fonterra Hautapu (2019), Fonterra Studholme (2014-2015), Fonterra Whareroa (2012-2014) and Westland Milk (2006, 2011).

7 Outfall and coastal discharge studies relevant to the proposed Oceania Dairy Ltd wastewater outfall include the Westland, Whareroa and Studholme dairy factories. I was an expert witness in health-related water quality for Fonterra's application for a new discharge consent at the Studholme dairy factory. The hydrodynamic and dispersion components of these outfall studies were carried out by others.

8 I visited the Oceania dairy factory site (6th November 2018), which included the coastline likely to be affected by the proposed outfall.

9 I have also been involved with environmental water quality assessments relating to meat processing works, assessment of human health risk associated with stormwaters, assessment of water quality in coastal recreational environments, developing guidelines for wastewater monitoring and standards for effluent discharge.

CODE OF CONDUCT

10 While this is a Council Hearing, I acknowledge that I have read and am familiar with the Code of Conduct for Expert Witnesses contained in the Environment Court Practice Note 2014, and agree to comply with it. I confirm that this evidence is within my area of expertise, except where I state that this evidence is given in reliance on another person's evidence. I have considered all material facts that are known to me that might alter or detract from the opinions I express in this evidence.

SCOPE OF EVIDENCE

11 I prepared an assessment of the effects on human health as a NIWA report titled *Microbial Risk Assessment for Oceania Dairy Limited,* dated August 2019 (NIWA Client Report 2019256HN, NIWA Project BCT19201), in association with my colleague Dr Neale Hudson. That Microbial Risk Assessment (MRA) assessed the potential human health risk effects to recreational water users associated with from the discharge of dairy factory processing wastewaters from Oceania Dairy Ltd via the proposed ocean outfall.

12 This evidence confirms the position reached in that MRA, and comments on the proposed consent conditions received from Environment Canterbury.

13 In my evidence I provide:

13.1 A discussion of the wastewater sampling undertaken at Oceania Dairy Ltd for microbiological analysis;

13.2 Considerations when conducting a screening-level Quantitative Microbial Risk Assessment (QMRA) based on the possibility of infection by *Pseudomonas aeruginosa*, *Staphylococcus aureus* or *Listeria*; and

13.3 An explanation of the potential health effects arising from the discharge from the Oceania dairy factory, focussing on microbial risk to human health.

14 In preparing this evidence I have reviewed:

14.1 The parts of the section 42A report relevant to my area of expertise; and

14.2 Submissions relevant to my area of expertise.

15 My evidence makes occasional use of footnotes, to give details of key references and key technical details.

EXECUTIVE SUMMARY

16 My key observations and conclusions are:

16.1 The original conclusions reached in the MRA remain the same. In particular, the effects of the discharge on human health will be less than minor, particularly given the conservative nature of this assessment;

16.2 When present in Oceania wastewaters, bacterial pathogens occurred in concentrations unlikely to cause public health risk following discharge into the marine environment;

16.3 The detection of milk-associated microbial contaminants in Oceania dairy processing wastewaters reinforces the need for good hygiene practices and management on site, and for periodic assessment of microbial concentrations using samples collected as close as possible to the point of discharge. These results will indicate in-situ microbial regrowth in the conveyance pipeline;

16.4 A screening-level quantitative health risk assessment (sQMRA) determined that concentrations of three bacterial pathogens (*Campylobacter*, *Listeria* and *Staphylococcus aureus*) detected in Oceania treated dairy factory wastewaters were unlikely to exceed a critical infection threshold of ID_1 (i.e., dose required to have a 1% risk of infection among an exposed population – a tolerable risk level for recreational waters in New Zealand) after dilution in the marine receiving environment;

16.5 Negligible potential adverse effects for human health resulting from direct exposure to the three candidate pathogens from windborne sea spray or direct contact were predicted;

16.6 Risks were predicted to be less than minor even in calm conditions when there may be less dilution than under normal weather conditions; and

16.7 The approach taken using the sQMRA was very precautionary for the current level of wastewater treatment applied to Oceania factory wastewaters. The advanced wastewater treatment proposed followed by UV

disinfection of wastewater will improve the current microbiological quality of Oceania Dairy Ltd wastewaters to further reduce the potential health risk from the wastewaters discharged via the outfall.

EVIDENCE

Assessment of Effects

17 As outlined above, I prepared an assessment of the effects on human health titled *Microbial Risk Assessment for Oceania Dairy Limited,* dated August 2019. My evidence does not cover the impacts from the discharge of nutrients and ecological implications and health impacts or effects on marine life which will be described by other witnesses to the hearing.

18 I visited the Oceania dairy factory and coastline with a NIWA colleague (Dr Chris Palliser who has since retired from NIWA) on 6th November 2018 to familiarise myself with current factory wastewater treatment and disposal practices, and to develop a microbial sampling programme that would provide information on the microbial characteristics of the factory wastewaters to inform the risk assessment process. All reference to measured microbiological pathogens in my evidence are based on the current treatment system. As outlined by **Mr Duder**, Oceania Dairy Ltd are proposing to treat the discharge wastewater stream with UV. This is expected to further reduce the microbial characteristics of the wastewater. My evidence is therefore conservative, as UV treatment will occur further reducing the level of microbiological pathogens.

19 The types of milk processing wastewaters produced on site at Oceania Dairy Ltd and the current and proposed treatment and disposal schemes for wastewaters from Oceania Dairy Ltd are described in the evidence of others.

20 Factory wastewaters will contain dilute amounts of raw or processed milk products from spillages and cleaning processes, dilute caustic chemical cleaning materials and microbial contaminants from either the milk processing plant and/or material washed off the dairy tankers. The Oceania Dairy Ltd wastewaters will not contain human sewage.

21 Traditional assessments of public health impacts from the discharge of treated wastewaters to coastal waters have relied on concentrations of faecal indicator bacteria, particularly the bacteria group known as enterococci.

22 Current practice for assessing health risks in situations where water quality is impacted by discharges of treated wastewaters has moved away from reliance on faecal indicator bacteria. The current New Zealand water quality microbiological guidelines for recreational waters encourage direct assessment of potential health effects considering disease-causing pathogens in the discharge[1].

23 The relationship between pathogen and indicator bacteria concentrations in dairy factory milk processing wastewaters is generally unknown. The microbiological nature of the wastewaters to be discharged from Oceania dairy factory and, after discharge, at places where the public may be exposed to diluted wastewater requires assessment for pathogens of public health significance.

Microbiological analyses of Oceania dairy factory wastewaters

24 Pathogens of public health significance in milk processing wastes are mainly bacterial pathogens, a few protozoan parasites but not viruses. Pathogens of concern are listed in Table 3.1 of my report along with the likely health consequences following infection.

25 Sampling of Oceania milk processing wastewaters was undertaken on five occasions from December 2018 to February 2019. Samples were collected from several sites, including: Dissolved Air Flotation (DAF) treated wastewaters, stored DAF treated wastewaters post lime addition, chlorinated wastewater, spray irrigated wastewater and condensate water (COW water). The rationale for selecting these sampling locations was provided in Table 4.1 of my report.

26 Micro-organisms recommended for analysis included pathogenic bacteria that could i) potentially be present in raw milk, ii) grow at low temperatures, iii) proliferate in pipeline biofilm, iv) cause infection by ingestion, and v) be aerosolised by wave action and cause respiratory infections.

27 Wastewater analysis also included faecal indicator bacteria (faecal coliforms, *E. coli* and enterococci) to aid interpretation of pathogen results; very high concentrations of these indicator organisms have been found in milk processing wastewaters at other

[1] MfE/MoH (2003). *Microbiological water quality guidelines for marine and freshwater recreational areas.* Ministry for the Environment and Ministry of Health, Wellington, New Zealand. Available from: http://www.mfe.govt.nz/publications/fresh-water/microbiological-water-quality-guidelines-marine-and-freshwater-recreation-7

dairy factories[2] and for dairy factory processing wastewaters intended for discharge via an ocean outfall[3].

28 A summary of microbial analyses undertaken for Oceania dairy factory was provided in Table 4.2 of my report. A summary of methods used for microbiological analysis was provided in Appendix C of my report.

Public Health Risk Assessment from discharge of Oceania dairy factory wastewaters

29 A Quantitative Microbial Risk Assessment (QMRA) modelling approach was used to determine the potential human health effects from discharge of Oceania dairy factory into the marine environment.

30 QMRA has gained acceptance as a predictive tool for assessing the human health risks associated with wastewater disposal schemes. QMRA provides a framework to help synthesize data such as pathogen concentrations, assumed rate of ingestion or inhalation and appropriate dose-response models for representative and specific pathogens alongside water user's exposures to potentially contaminated water to estimate the level of risk such as an individual's infection or illness risk.

31 The QMRA process is described in detail in section 6 of my report.

32 Pathogens in the Oceania dairy factory wastewater will be diluted upon discharge into the receiving environment. The likely extent of dispersion and dilution that will occur following discharge from the outfall was modelled by eCoast, and is described in the evidence of **Mr Coutinho**. As a precautionary measure, I used a minimum dilution of 300 expected for shoreline impingement under calm conditions for the assessment of potential health effects.

33 A conservative approach was also taken with regard to pathogen removal in seawater; I ignored flocculation (which would increase settling) which may happen following contact of the wastewater with seawater. Pathogen inactivation (die-off following exposure to UV in sunlight etc) was also disregarded. This was done to

[2] Stott, R., McBride, G. (2018). Spray irrigation of dairy manufacturing wastewater to land. Assessment of potential human health risks from bioaerosols: Edgcumbe Dairy Factory. Report prepared for Fonterra Co-operative Ltd, *NIWA Client Report* 2018222HN January 2018 124 pages.
[3] Stott, R., McBride, G. (2015). Public health risk of discharge of Studholme dairy factory treated wastewaters to a marine outfall. NIWA Client Report HAM2015-021, Report prepared for Fonterra Co-Operative Ltd, 72 pages.

consider situations where pathogens might be rapidly transported and dispersed over the surrounding area.

34 Limited recreational activities are likely to occur in the vicinity of the proposed outfall, as identified by **Mr Greenaway** in his evidence. The exposure risk is mainly from secondary contact – individuals exposed to pathogens in bioaerosols generated from waves breaking along the shoreline. As a precautionary measure, exposure was extended to consider the risk of infections due to direct contact. The risk from shellfish consumption was not considered because the area is not designated (or known) as a shellfish gathering site.

35 The QMRA considered that people may be exposed to pathogenic organisms in dairy processing wastewaters (if present) via three possible transmission routes: inhalation of aerosols derived from water containing diluted wastewater, accidental ingestion of water during contact recreation, or skin contact with water contaminated by Oceania dairy factory wastewaters.

36 The QMRA approach accounts for the incremental health risk caused by the wastewater discharge from the outfall only; 'background' contamination (and associated health risks) arising from any other sources is not taken into account.

37 The results from the QMRA approach and key conclusions from my human health related assessment of effects are summarised below.

38 *Pseudomonas aeruginosa*, *Salmonella*, toxigenic *E. coli*, *Legionella,* and Mycobacteria pathogens (MAP, M. TB) [4], were not detected in Oceania dairy factory wastewaters during the microbial monitoring survey and were not considered further.

39 *Campylobacter, Staphylococcus aureus* and *Listeria* spp – pathogenic bacteria – were detected in Oceania dairy wastewaters and thus selected as candidates for the health risk assessment.

40 The three candidate pathogens were typically present at Oceania in low concentrations relative to those necessary to cause public health risk concerns.

41 A screening-level QMRA (sQMRA) using the candidate pathogens (*Campylobacter, Listeria* and *Staphylococcus aureus)* determined whether concentrations of these pathogens were likely to exceed a critical infection threshold of ID_1 (i.e. dose required

[4] MAP: *Mycobacteria avium* subsp. *Paratuberculosis*. M. TB. *Mycobacterium* TB complex (including *Mycobacterium avium*)

to have a 1% chance of infection among an exposed population) in the environment (i.e. following dilution). This 1% risk trigger threshold is the tolerable risk for gastrointestinal illness from recreational water contact defined as a no observed adverse effect level (NOAEL) and is below the lowest observed adverse effect level (LOAEL) for acute respiratory febrile illness in the MfE/MoH microbiological guidelines for marine recreational waters[5].

42 The sQMRA is a reasonable approach for determining whether the pathogens have the potential to create a measurable health risk to coastal and foreshore users. It is suitable for indicating whether further modelling is required, should the potential dose exceed ID_1 after considering dilution and exposure duration. Findings from the sQMRA were:

42.1 *Listeria spp* were present at concentrations well below the critical ingestion threshold concentration of 0.8 cells (ID_1) required to cause an infection;

42.2 The risk of receiving an infective dose of *Campylobacter* from ingestion or inhalation for adults was negligible because predicted doses were below the ID_1 (0.6 *C.jejuni*). A slight risk might exist for children under worst case scenarios but the approach taken using the sQMRA was very precautionary (e.g. maximum measured pathogen concentrations, minimum dilution, no pathogen inactivation, all *Campylobacter* species detected were considered *C. jejuni* whereas most species of *Campylobacter* are not pathogenic to humans) – these results indicated that *Campylobacter* is unlikely to cause a human health risk.

42.3 Health risk arising from aerosol inhalation, or skin lesions arising from direct contact with diluted wastewater is not predicted for *Staphylococcus aureus* (consistent with its high ID_1 of 10^5 cells).

43 Using dilution and impact assessment highly conservative scenarios, the estimated probable infection risks determined by the sQMRA are conservative.

44 The potential public health risk associated with the discharge of treated processing wastewater from Oceania Dairy is considered to be less than minor beyond the mixing zone boundary.

[5] Refer to Table H1, MfE/MoH (2003), Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas. Ministry for the Environment and Ministry of Health, Wellington, Report no. MfE 474, 124 pp (www.mfe.govt.nz/publications/water/microbiological-quality-jun03)

45 The existing DAF wastewater treatment system does not effectively reduce faecal indicator bacteria (FIB) concentrations and very elevated concentrations (>10^7 FIB/100 mL) were observed in the dairy factory wastewaters. These values suggest growth of these indicator species within the wastewater reticulation system, but not necessarily growth of pathogens – total Legionella, *Pseudomonas aeruginosa* and *Mycobacteria* spp were not detected in wastewater samples, and many results for *Listeria, Salmonella* and *Staphylococcus aureus* were reported as below the analytical method limit of detection. However, elevated concentrations of *S. aureus* (10^5/100mL) were found at concentrations at the critical threshold for skin lesions. These values reinforce the requirement for good on-site hygiene practices such as wearing gloves when handling infrastructure potentially contaminated by dairy factory wastewaters. Upgrading the wastewater treatment facilities with UV disinfection is expected to improve the quality of treated wastewaters such that the concentration of *S. aureus* would be reduced below concentrations considered of concern for skin infections.

46 The presence of pathogens in the Oceania processing wastewaters highlights the need for regular flushing and cleaning procedures, as well as periodic (e.g., quarterly) assessment of samples collected at the point of discharge to determine whether undesirable in-situ microbial regrowth is occurring in the disposal system.

47 The upgraded treatment facilities proposed for Oceania Dairy Ltd are expected to improve microbial water quality. Removal of viable organisms from dairy processing wastewaters is particularly likely following addition of UV irradiation, which effectively inactivates bacteria[6] . Advanced treatment will further reduce the potential for adverse human health effects following the discharge of processing wastewaters via an outfall into the marine receiving environment.

Section 42A report

48 The key issues from the S42A report that relate to my evidence are discussed below, along with comments on consent conditions.

49 I disagree with Dr Bolton-Ritchie in Paragraph 10 that the “expected” concentration should be treated as a mean value for the purposes of compliance in relation to the faecal indicator bacteria. To determine which statistic is the more appropriate will depend on the amount of data available. In monitoring programmes such as that implemented for this assessment, the sample size is usually small (as is the case for the Oceania wastewater microbial monitoring) and so the median is a good measure.

[6] Malayeri A. H., Mohseni, M., Cairns, B. and Bolton, J. R. (2016). Fluence (UV Dose) required to achieve incremental log inactivation of bacteria, protozoa, viruses and algae. IUVA News, 18, 41 pages

The median is also useful when data are highly variable because the true (population) median is a good indicator of central tendency for many distributions. If the population is log normal (which is typical of bacterial populations), then the true median is the same as the true geometric mean. I would recommend that the median is the metric used for compliance assessment for microbial contaminants.

50 In Paragraph 17, Dr Bolton-Ritchie recommends fortnightly monitoring for bacterial contaminants – I endorse this recommendation for treated wastewaters sampled at the factory site. I recommend that grab samples be taken for microbial analysis because dairy factory wastewaters can exhibit considerable diurnal fluctuations in physico-chemical conditions (such as pH), which could have a detrimental effect on bacteria during prolonged storage in 24-hour composite samples. The monitoring of the wastewater immediately prior to discharge (at the inspection chamber) is required much less frequently, for example quarterly for the first two years and then five yearly.

51 I consider the calculation used to determine the concentration of nutrients and suspended solids at the edge of the mixing zone in Table 4 (Paragraph 41) by Dr Bolton-Ritchie incorrect because the sum of the seawater median (referred to as local median in Table 4) and wastewater median should be divided by the total volume. This has implications for DIN and DRP estimated concentrations at the edge of the mixing zone which I consider to be 0.042 mg/L and 0.0055 mg/L respectively which consequently do not trigger the 80th percentile local guideline values.

Conditions

52 I have reviewed the conditions proposed in consent CRC201194, and make the following observations:

52.1 The interim trigger concentration values for indicator bacteria and pathogens stated in Condition #16 are appropriate as median values as shown in the table but not as maximum values as stated in the accompanying text because there is always a chance the maximum can be exceeded and so the maximum does not offer the same level of control as a median value;

52.2 If some form of microbial trigger levels are to be included in the consent, I suggest that trigger values should be for faecal indicator bacteria only, with trigger values for pathogen used in an advisory manner only. A condition could be included that indicates that “following review of 24 months data, microbial indicator triggers may need to be reviewed if pathogen concentrations are higher than expected” or similar;

52.3 If pathogen trigger levels are to be included in the consent, I suggest that *Staphylococcus aureus* is also monitored, to be consistent with paragraphs 38 and 39, where I indicated that *S. aureus* was detected in Oceania dairy processing wastewaters in high concentrations (around 10^5 per 100mL). Whilst the inclusion of *Pseudomonas aeruginosa* appeals to consenting conditions for a discharge of dairy wastewaters similar to that from Studholme dairy factory, *P. aeruginosa* was not detected in Oceania wastewaters during the short exploratory monitoring study. Although it is possible that *P. aeruginosa* is present in Oceania wastewaters (but was not detected), it would be prudent to also monitor for *S. aureus* in the interim 2-year monitoring. Results from this monitoring period should be reviewed to determine an appropriate bacterial pathogen for further monitoring and for ongoing assessment of treated wastewater quality, as outlined in Condition #20;

52.4 If microbial trigger values are included, then a rolling median based on 10 samples (arising from fortnightly sampling) will be suitable for assessing the quality of the treated wastewater for discharge; and,

Commissioners' Questions

53 My response to the s42A report in relation to my area of expertise are provided in Paragraphs 49-51. Responses to questions regarding the discharge consent conditions (as they relate to microbial contaminants) are provided in Paragraphs 52.1 -52.4. Below I address outstanding matters regarding hydrodynamic modelling, the performance of the future wastewater treatment plant, and the potential for in-situ regrowth of microbial contaminants.

54 Dilution percentiles were provided at each exposure site from hydrodynamic modelling and, as requested by NIWA, did not include microbial inactivation for a more precautionary approach. Modelling uncertainty is addressed with the conservative approach taken in the QMRA, where potential health risk in calm conditions at the shoreline directly onshore from the outfall were estimated using minimum dilution values.

55 Upgrading the current wastewater treatment system to include advanced treatment and UV disinfection will improve the microbiological quality of treated wastewater and reduce the concentrations of microbial contaminants.

56 The microbial quality of UV-treated wastewaters at the factory site may be compared with that of water samples collected prior to the outfall, if practical. These results could be used to check for deterioration of wastewater during conveyance between the factory and discharge site. Recommendations for monitoring were discussed in Paragraph 50.

SUMMARY AND CONCLUSION

57 The effects on human health arising from the discharge of processing wastewater from Oceania Dairy Ltd are considered to be less than minor. Adverse effects are not predicted to occur because the risk of infection from pathogens detected in dairy processing wastewaters was less than the tolerable risk levels for primary contact with recreational waters. Estimates of risk were conservative, consistent with the precautionary approach taken to consider highly conservative scenarios.

58 The upgraded treatment facilities proposed for Oceania Dairy Ltd will achieve effective levels of microbial removal and inactivation that will further reduce human health risk arising from the discharge of treated dairy processing wastewaters into the marine receiving environment.

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Rebecca Stott

28 May 2020