BEFORE THE TASMAN DISTRICT COUNCIL

Under	the Resource Management Act 1991
In the matter of	of an application by **THE NELSON REGIONAL SEWERAGE BUSINESS UNIT** for the resource consents to continue applying biosolids to land on Moturoa/Rabbit Island.

STATEMENT OF EVIDENCE OF JEREMY PAUL BENNETT

FOR THE NELSON REGIONAL SEWERAGE BUSINESS UNIT

11 MAY 2022

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STATEMENT OF EVIDENCE OF JEREMY PAUL BENNETT

Introduction

1 My full name is Jeremy Paul Bennett. I am a Senior Groundwater Scientist with Tonkin & Taylor Ltd. My areas of expertise include hydrogeological conceptualisation and modelling of groundwater flow and solute transport.

2 I hold a Master of Science in Applied Environmental Geoscience (2015) and a Doctor of Science (2018) in Hydrogeology, both from the University of Tübingen, Germany. I am a Certified Environmental Practitioner with the Environmental Institute of Australia and New Zealand. I have 11 years' experience of consulting experience in environmental site investigation and hydrogeology and have worked in New Zealand, Australia and Germany.

3 I am the groundwater lead for the Nelson Regional Sewerage Business Unit Moturoa/Rabbit Island biosolids application re-consenting team. In this role, I have completed an assessment of effects on groundwater of biosolid application at Moturoa / Rabbit Island[1].

4 While this is a Council-level 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 that I 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

5 In my evidence I will outline the following:

5.1 The hydrogeological setting and groundwater conditions at the site;

5.2 Characterisation of contaminant sources;

5.3 The availability and likely quantity of contaminants to enter groundwater and migrate to the coastal environment;

5.4 Estimates of potential peak contaminant concentrations in the coastal environment using analytical fate and transport modelling; and

5.5 Comments on Officer's Report.

[1] Tonkin & Taylor Ltd, August 2020. *Moturoa / Rabbit Island Biosolids Application: Groundwater Assessment*. Prepared for Nelson Regional Sewerage Business Unit.

5.6 Comments on submissions where relevant to my evidence.

Overview of project and changes since lodgement

6 In August 2020, I completed the Groundwater Assessment[1]. The scope of this assessment was to:

6.1 Review available information relating to the quality and quantity of biosolids applied and groundwater quality and levels, as well as existing consent conditions and published guidance documents for biosolids application in New Zealand[2,3];

6.2 Develop a hydrogeological conceptual model and identification of relevant contaminant fate and transport parameters and estimates of nutrient uptake from plantation forestry;

6.3 Complete an assessment of the availability and likely quantity of contaminants to enter groundwater, as well as the potential for key contaminants to migrate to the coastal environment. This assessment was restricted to contaminants cited in the published guidance documents[2,3] and for which there was sufficient site-specific information to complete an assessment; and

6.4 Undertake analytical fate and transport modelling to estimate potential peak contaminant loading on the coastal environment.

7 The following changes have been made to the original Groundwater Assessment of August 2020:

7.1 Additional routine monitoring of biosolids, soil and groundwater chemistry and groundwater levels has been conducted by others on behalf of NRSBU. This additional information has been incorporated into this evidence. Key changes since lodgement include:

Additional Operational Data

7.2 The mean annual total volume of biosolids application used in the groundwater assessment has been revised to 32,900 m^3/year based on the average application rates from the last ten years. I have preferred to apply the 10-year period as a more representative sample of the expected application volume, which has consistently

[2] Magesan, G. N., Wang, H., & Clinton, P. (Scion), February 2010. *Best Management Practices for Applying Biosolids to Forestry Plantations in New Zealand* (45869). Scion, New Zealand.
[3]New Zealand Water & Wastes Association, 2003. *Guidelines for the Safe Application of Biosolids to Land in New Zealand*. New Zealand Water & Wastes Association.

been around 32,900 m^3/year. This has resulted in an increase from the value of 22,500 m^3/year used in the original Groundwater Assessment[1].

Updated Groundwater Data

7.3 The original Groundwater Assessment included a review of groundwater level information and analysis of this information using contouring methods. This was undertaken on the assumption that the groundwater levels provided had been reduced to the same vertical datum. This was not the case, therefore the groundwater level analysis in the original report required revision. Analysis of groundwater levels and flow paths has now been revised based on reported monitoring well casing elevations and updated in this evidence.

7.4 The updated groundwater level analysis impacts the hydraulic gradients used to estimate potential peak contaminant concentrations in the coastal environment from biosolids application. The updated groundwater level analysis has been used to revise these estimated contaminant concentrations.

Summary of report and updated analysis and assessment

8 The site is located at Moturoa / Rabbit Island, which is located in Tasman Bay, approximately 3 km northwest of the Nelson airport at its closest point. The island is roughly elliptical in shape, oriented approximately northwest-southeast and is approximately 8.3 km long and 2 km wide. The island is low-lying, with a maximum elevation of around 6 m above sea level. The site is shown in Figure 1.

9 Moturoa / Rabbit Island is used for forestry as well as land- and water-based recreational activities. Recreational areas are located in the central portion of the northern coast of the island, as well as cycle and walking tracks in the north-western part of the island. Three toilet blocks are present in the west, centre and east of the coastal recreational area; treated effluent from these is discharged to land under consents held by the Tasman District Council.[4] A wastewater main and drinking water main traverse the north-western portion of the island.

10 Eleven groundwater monitoring bores have been installed across the island, including two transects of bores installed during preliminary hydrogeological investigations[5,6]: Transect 1 comprises Bores 1-5; Transect 2 comprises Bores 6-9 (Figure 1A).

[4] RM050777, RM060788.
[5] Thorpe, H. R., 1994. *Interim report on the ground water system at Rabbit Island, Richmond*. Appendix Two of: NZ Forestry Research Institute, September 1994. Biosolid application on Rabbit Island. Preliminary report prepared for Beca Steven.
[6] Thorpe, H. R., 1995. *The ground water system at Rabbit Island, Richmond.* Second report, prepared for Beca Steven. Appendix A of: Beca Steven, August 1995. *Biosolids disposal to Rabbit Island and draft resource consent conditions.*

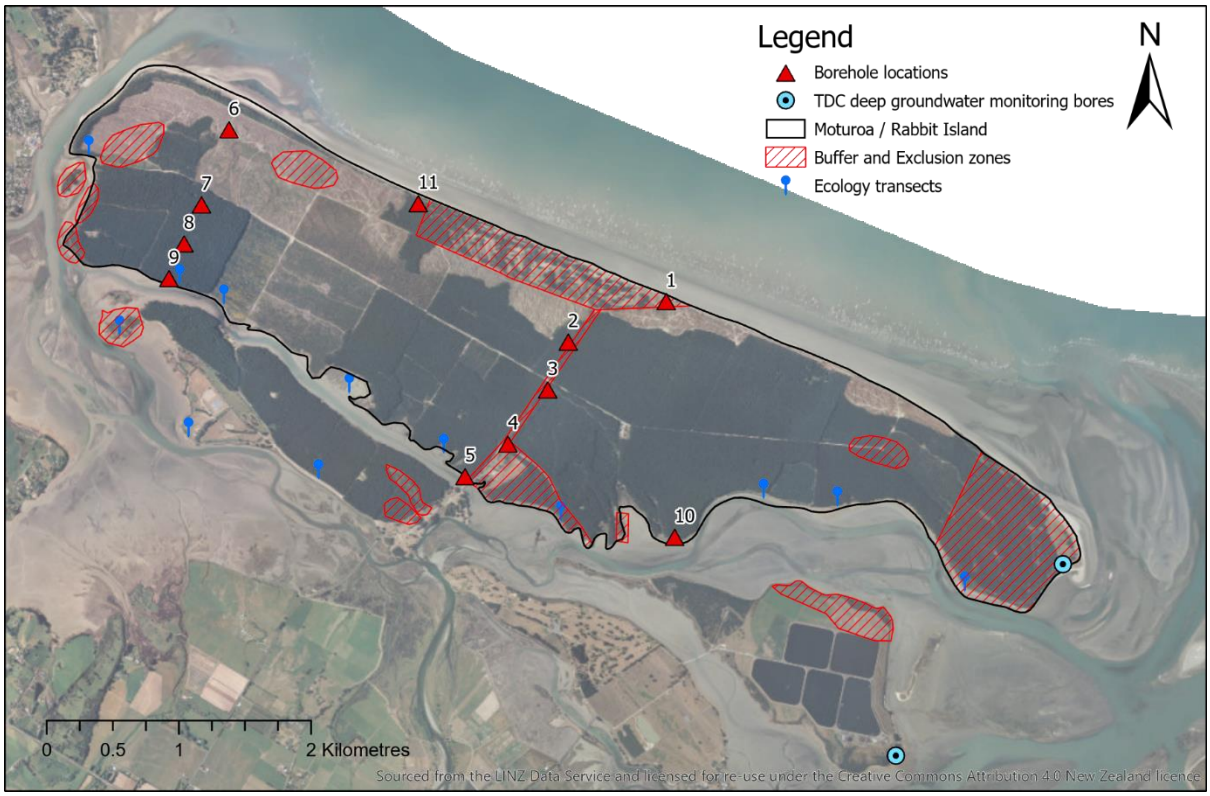

Figure 1A: Site and bore location plan. The buffer and exclusion zones depicted are from the existing resource consent and are subject to change.

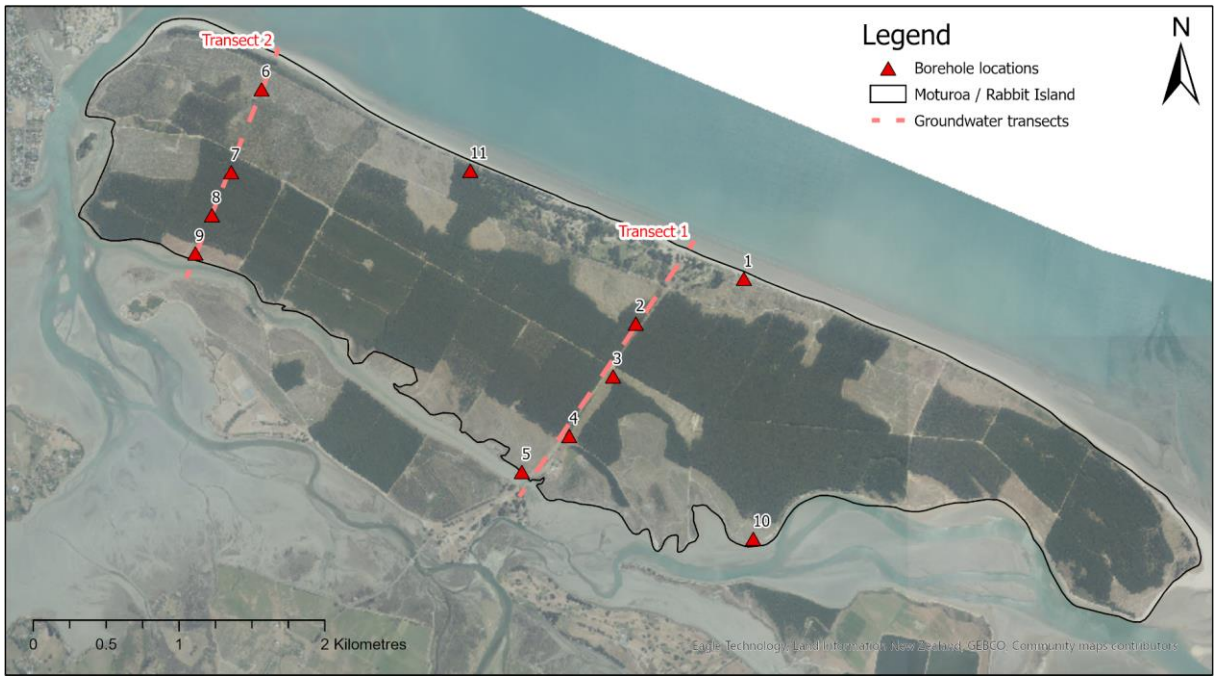

Figure 1B: Visual Representation of Transect 1 and 2.

Hydrogeological setting

11 Moturoa / Rabbit Island is composed of late Quaternary clastic deposits, comprising the Rabbit Island Gravels overlain by the Tahunanui Sand[7]. The Rabbit Island Gravels comprise rounded gravels and cobbles and the deposit is up to 20 m thick. The Tahunanui Sand is a fine-grained sand that forms beach ridges and dunes that overlie or laterally grade into the Rabbit Island Gravels. The Tahunanui Sand is estimated to be 16 m thick at the site. The Rabbit Island gravels are underlain by the clay-bound Hope Gravels.

12 The surface hydrogeology of Moturoa / Rabbit Island comprises a shallow unconfined aquifer within the unconsolidated sediments of the Tahunanui Sands and Rabbit Island gravels. This unconfined aquifer is underlain by the clay-bound Hope Gravels. The shallow unconfined aquifer at the island is recharged through rainfall and it is likely that there is a lens of freshwater underlain by saline water intruding from Tasman Bay and the Waimea Inlet. Watercourses on the island are expected to be ephemeral only.

13 Major water-bearing features are found within the Hope Gravels, which extend throughout the Waimea Plains[7], in generally discrete aquifer units, known as the Upper and Lower Confined Aquifers and the Appleby Gravels Unconfined Aquifer[7]. The Upper Confined Aquifer is expected to merge into the Appleby Gravels Unconfined Aquifer[7]. Groundwater levels observed in the Upper Confined Aquifer and the Appleby Gravels Unconfined Aquifer south of Moturoa / Rabbit Island are at least 1 m above sea level. [8] Regional groundwater flow is, therefore, expected to be up towards the surface. The Upper Confined Aquifer has been observed to have a high salinity beneath Moturoa / Rabbit Island[7], indicating that a saline-freshwater interface is present beneath the island.

14 The Lower Confined Aquifer extends beneath the Waimea Inlet at least as far as the northeast coastline of Moturoa / Rabbit Island. Groundwater levels in bores screened in the Lower Confined Aquifer at the eastern tips of Rabbit Island and Bell Island are monitored via telemetry by the Tasman District Council[8]. The data from these bores indicate that the Lower Confined Aquifer is artesian and is influenced by tidal cycles.

15 Groundwater levels observed in the shallow unconfined aquifer show both short-term and long-term variation, which may be attributed to tidal effects and seasonal patterns, respectively.

15.1 In general, shallow groundwater levels are highest close to the north-eastern side of the island and lowest along the south-western side of the island. This indicates a horizontal hydraulic gradient that runs perpendicular to the island's long axis and is

[7] Dicker, M. J. I., Fenemor, A. D., & Johnston, M. R. (1992). *Geology and Groundwater Resources of the Waimea Plains, Nelson* (New Zealand Geological Bulletin No. 106). DSIR Geology and Geophysics, Lower Hutt.
[8] https://www.tasman.govt.nz/my-region/environment/environmental-data/groundwater-levels

inferred to be consistent along this axis. The horizonal groundwater flow direction is towards the Waimea Inlet[6] and the median horizontal hydraulic gradient along Transect 2 is calculated to be $\frac{dh}{dx} = 0.00035$; this is consistent with estimates from previous investigations[6].

15.2 My original assessment applied a horizonal groundwater flow gradient of 0.001[9]. As a result, I have also revised the peak concentration in groundwater available to discharge into the surrounding environment at paragraph 10.12 below.

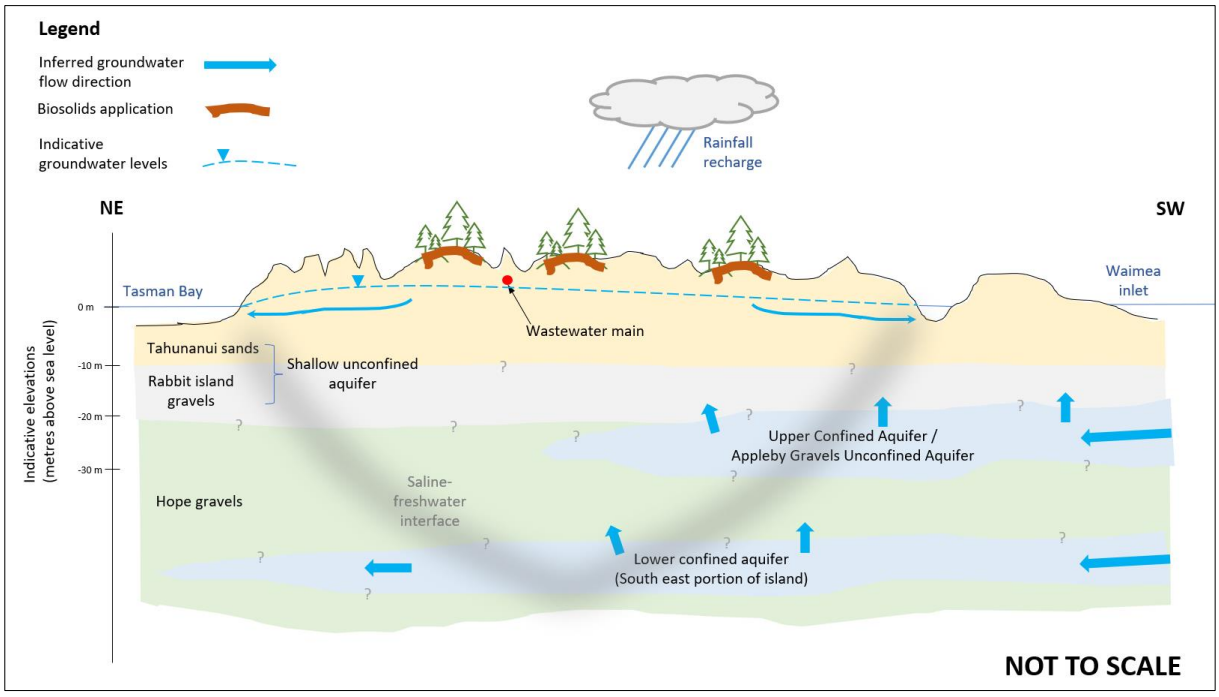

Figure 2: Hydrogeological conceptual model, approximately along Transect 2. Not to scale, indicative only.

Source characterisation

16 Source contaminants in biosolids can be categorised into the following groups according to the relevant guidelines[10]: Metals, nutrients, organic contaminants and microbiological contaminants. NRSBU regularly monitors concentrations of metals in biosolids, treated soils and groundwater.

16.1 Laboratory analysis of sub soils below biosolids application areas at Moturoa / Rabbit Island indicate that metals are generally below maximum allowable concentrations for Grade 'A' treated soils under the NZ biosolids guidelines**Error! Bookmark not**

[9] Application as filed, Part 2, page 273 of 379
[10] New Zealand Water & Wastes Association, 2003. *Guidelines for the Safe Application of Biosolids to Land in New Zealand*. New Zealand Water & Wastes Association.

defined..[11] Reported exceedances of the maximum allowable concentrations for arsenic and nickel may be attributed to naturally elevated metals concentrations from background influences[12,11].

16.2 Reviewed literature indicates that metal contaminants from the application of biosolids are predominantly retained in the forest litter layer[13]. The literature indicates that heavy metals observed in underlying soils were mostly residual and unlikely to be mobile[13]. This is consistent with partition coefficient values between 29-150 L/kg for metals encountered at Moturoa / Rabbit Island with elevated concentrations[14].

16.3 Groundwater chemistry data from monitoring bores at the site indicate that median concentrations of metals are below the ANZG guideline concentrations for slightly to moderately disturbed marine ecosystems[15]. 95th percentile concentrations of some contaminants (chromium, copper, lead, mercury, nickel and zinc) are above ANZG guideline concentrations. Metals concentrations in shallow groundwater at the site sampled prior to the commencement of biosolids application indicate that metals concentrations are occasionally above ANZG guideline concentrations[6], suggesting that background metals concentrations are naturally elevated, possibly due to interaction of brackish and fresh water in the coastal margin. This is especially likely for Bore 5 (located approximately 10 m from the coast), for which elevated metals concentrations are often reported, both before and after the commencement of biosolids application at Moturoa / Rabbit Island. No long-term trends were observed for metals concentrations in groundwater.

16.4 Nutrient concentrations are monitored in the biosolids, soil, groundwater and the coastal marine environment at Moturoa / Rabbit Island. Groundwater monitoring indicates low concentrations of ammoniacal nitrogen, nitrite and nitrate that are generally within expected background ranges[16]. However, time-series data indicate occasional periods of elevated concentrations of ammoniacal nitrogen or nitrate within individual bores, with no concurrent peaks observed in those bores for other analytes (i.e., metals or other nutrients). The cause of these elevated concentrations is not

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[11] Evidence of Dr Xue (Soil), dated 11 May 2022 at [28]
[12] Landcare Research, June 2015. *Background concentrations of trace elements and options for managing soil quality in the Tasman and Nelson Districts*. Report prepared for Tasman District Council.
[13] Su, J., Wang, H., Kimberley, M. O., Beecroft, K., Magesan, G. N., & Hu, C. (2008). Distribution of heavy metals in a sandy forest soil repeatedly amended with biosolids. *Soil Research*, 46(7), 502.
[14] US EPA, November 2019. *Regional Screening Levels – Generic Tables.* https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables
[15] ANZG, 2018. *Australian and New Zealand Guidelines for Fresh and Marine Water Quality.* Australian and New Zealand Governments and Australian state and territory governments, Canberra ACT, Australia. Available at www.waterquality.gov.au/anz-guidelines.
[16] World Health Organisation, 2011. *Nitrate and nitrite in drinking-water*. https://www.who.int/water_sanitation_health/dwq/chemicals/nitratenitrite2ndadd.pdf

clear but is likely to be associated with biosolids application and/or wastewater infrastructure (i.e., collection networks, septic tanks). No long-term increasing trends were observed for nutrients in the groundwater monitoring data.

16.5 Phosphorus concentrations measured in soils beneath biosolids application areas are within background ranges reported elsewhere in New Zealand[17].

Availability and likely quantity of contaminants to enter groundwater and migrate to the coastal environment

17 Groundwater chemistry data indicates that median concentrations of metals are below the ANZG guideline values. Elevated metals concentrations in groundwater beneath the site are considered indicative of background concentrations for the region. The introduction of additional metals through biosolids application is unlikely to pose a risk to environmental or human health due to the immobilisation of metals within the forest litter layer and underlying soils, and attenuation of metals concentrations in groundwater through partitioning to the aquifer matrix and mixing with ambient groundwater.

18 Concentrations of organochlorine, organonitrogen and organophosphorous pesticides reported in biosolids from the Bell Island WWTP in 2013 and 2018 are all below limits of detection. Given this, and the primary exposure pathway of these contaminants being via grazing animals[10], I consider any potential effects of such contaminants on the coastal environment to be negligible.

19 Concentrations of microbiological contaminants in the biosolids are generally very low or below the limit of detection. Given this, any microbiological contaminants present in the applied biosolids are likely to be attenuated in the subsurface such that concentrations at receptors are negligible.

20 Concentrations of nutrients reported in the biosolids are generally high, with nitrogen present predominantly in organic and ammoniacal forms. Therefore, a conservative mass-balance approach was used to predict the annual loading of nitrogen into the coastal environment based on mean concentrations of Total Kjeldahl Nitrogen (organic + ammoniacal nitrogen) and ammoniacal nitrogen reported for the biosolids, as well as mean annual biosolids application volumes and rates. The prediction is subject to the following assumptions:

20.1 The median concentrations of Total Kjeldahl Nitrogen (as nitrogen) and ammoniacal nitrogen (as nitrogen) in the biosolids are 1,800 mg/L and 895 mg/L, respectively.

[17] Auckland Regional Council, 2001. *Background concentrations of inorganic elements in soils from the Auckland Region,* Technical Publication 153.

20.2 The average annual biosolids application volume at Moturoa / Rabbit Island is 32,900 m^3 applied over an average area of 166 hectares.

20.3 Approximately 55% of ammoniacal nitrogen is lost to the atmosphere through volatilisation[18]. The remainder is mineralised to nitrate.

20.4 Approximately 50% of the organic nitrogen applied in a soil will be converted to inorganic nitrogen[19]. This inorganic nitrogen is mineralised to nitrate.

20.5 The average annual uptake of mineralised nitrogen by pine forest is expected to be approximately 40 kg/ha/year[20].

20.6 All application rates, volumes and processes are constant and based on average values.

20.7 Denitrification does not occur in the unsaturated zone or groundwater.

21 Using the assumptions outlined above, the potential quantity of nitrogen available to discharge into the surrounding environment is estimated to be approximately 21.5 tonnes per year. This mass would represent 4.8% and 1.2% of the reported mean annual cumulative nitrogen loads for the Waimea Inlet and Tasman Bay catchments, respectively[21]. While this estimate is subject to some uncertainty, the conservative choices made in the assumptions mean that even with this uncertainty, a greater discharge than the predicted value would be unexpected.

Estimated peak contaminant concentrations

22 In addition to estimating the potential annual quantity of nitrogen available to discharge into the surrounding environment, I have predicted peak nitrate concentrations in the groundwater and the coastal environment. This was accomplished using the Domenico analytical solution for a non-continuous contaminant source[22] and a mass balance approach for mixing in the coastal environment. Parameters for the analytical solution have been estimated by matching a breakthrough curve of nitrate-N observed in Bore 7 between 2006-2012.

22.1 Fitting of the analytical solution to these concentrations suggests biosolids application is a plausible explanation for locally elevated concentrations of nitrate-N, but that that nitrate is rapidly attenuated in the subsurface with distance from the source.

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[18] Robinson, M. B., & Röper, H., 2003. Volatilisation of nitrogen from land applied biosolids. *Soil Research*, 41(4), 711.
[19] Wang, H. et al., 2003. Biosolids-Derived Nitrogen Mineralization and Transformation in Forest Soils. *Journal of Environmental Quality 32*(5), 1851–1856.
[20] Beets, P. N., & Pollock, D. S., 1987. Uptake and accumulation of nitrogen in pinus radiata stands as related to age and thinning. *New Zealand Journal of Forestry Science*, 17(2/3), 353–371.
[21] Evidence of P Gillespie (Coastal Effects), dated 11 May 2022 at [34]-[37].
[22] Domenico P.A., 1987. An analytical model for multidimensional transport of decaying contaminant species. *Journal of Hydrology 91*, 49-58.

22.2 I have modelled the effects of biosolids application at a distance to the coast of 50 m, based on the buffer zones in the current consent. The approach models the cumulative effects of multiple pulses of nitrate-N, consistent with the multiple applications of biosolids undertaken at each plot location at Moturoa / Rabbit Island.

22.3 The maximum nitrate-N concentration predicted in groundwater at 50 m from the source is approximately 3 mg/L, with the peak concentration expected to occur between twelve and sixteen years after the release. I note that this is a reduction from the 18mg/L predicted within my original assessment.[23] This estimate is subject to some uncertainty. However, as with the annual discharge predictions, conservative choices made in the assumptions mean that even with the uncertainty, higher peak discharge concentrations would be unexpected.

22.4 Mixing of affected groundwater with marine water in the Waimea Inlet will reduce the peak nitrate-N concentrations significantly. Based on estimates of groundwater mixing with estuary flow adjacent to Rabbit Island, I estimate that the nitrate-N concentrations would be approximately 0.00002 mg/L in the Waimea Inlet. Again, the revised figures demonstrate a reduction in estimated nitrate-N concentrations within the Waimea Inlet (compared to 0.00035 mg/L).[24]

Response to Officer's report and Submitters

23 As part of my evidence I have reviewed the Council Officer's report. I agree with the Council Officer's summation, subject to my revisions outlined above. For clarity, the revisions to my assessment above only support these conclusions.

24 I acknowledge that submitters have raised concerns that relate to groundwater. Specifically, Waimea Inlet Forum and Te Atiawa o Te Waka-a-Maui.[25] I am satisfied that, based on my earlier technical report and my revisions as outlined above, the groundwater monitoring condition proposed by NRSBU at [27] is appropriate to ensure that biosolids application on Moturoa/ Rabbit Island will be adequately monitored to avoid potential adverse effects on groundwater over the life of the new consent.

25 While I do not oppose the insertion of [27A] as a condition of consent, I do not consider this to be necessary as the biosolids activity is a discharge to land as opposed to water, and my assessments (and that of Cawthron) conclude that the activity has demonstrated that the effects listed within are not being exhibited in the receiving environment.

[23] Application as lodged, Part 2, page 282 of 379
[24] Application as lodged, Part 2, page 282 of 379
[25] Submissions also identified within 42A Report (in particular, Waimea Inlet Forum at [5.8.b]; Te Atiawa o Te Waka-a-Maui Trust at [5.16.a].

26 Further, I consider that the annual report and MTRR conditions provide a requirement for NRSBU to analyse the monitoring data collected, identify any trends, report any non-compliances and consider changes to monitoring regimes as required to respond to any issues that may be identified over time.

Jeremy Paul Bennett

11 May 2022