Response To: Memorandum from Ella Boam (Pattle Delamore Partners) to Central Hawke's Bay District Council entitled Springhill Farm Holdings – WakaraRoad/SH50 Subdivision Cumulative effects assessment for wastewater discharge.

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1.0 Introduction

This is a response to Boam (2021) of the assessment of cumulative effects of wastewater discharge for the Springhill Farm Holdings development. The memorandum was written to review the cumulative effects of wastewater discharge for Springhill Farm Holdings development undertaken by Cook (2021b). This response will question many of the assumptions and assertions made by Boam (2021) which although stated as being conservative are unjustified.

In particular we question:

- The rate of wastewater discharge per person of 200 L/day
- The low stocking rate
- The low plant uptake rate of nitrogen and phosphorus
- No denitrification
- Assumptions of no attenuation of nutrients to groundwater
- No denitrification in soil or aquifer sediments is assumed
- No estimates of the dilution of the/any groundwater plume due to dispersion is considered or other nearby sources
- The assertions of effect on the Kahahakuri stream are tenuous at best
- Reduction in the application rate on the Mangatawai soil should be reduced to 2 mm/day.

2.0 Response

2.1 Rate of wastewater output

The hydraulic loading per person per day used in Cook (2021a,b) of 180 L/person/day is based on HBRRMP (2015, Section 6.1, p164) for households with on-site roof water tank supply. The rate used by Boam (2021, section 3) of 200 L/person/day is reticulated community/bore water supply. It has been clearly stated in Cook (2021a,b) that rain water tanks will be the water source for the households. Thus, increasing the flow to 200 L/person/day and the area of the disposal area from 270 to 300 m^2 is unjustified and will exaggerate the hydraulic loading to the site.

2.2 Stocking rate

The assumed stocking rate in Cook (2021b) was based on Nobel (1985, p27) who stated "The unit occurs on the Heretaunga Plains (5560 ha), Ongaonga-Waipukurau area (61 70 ha),…small areas are still used for intensive grazing with a present average stocking rate of 15 su/ha. The grazing potential is assessed as 32 su/ha.". Given this document is 36 years old and land management has improved a stocking rate of 8 cows or heifers per hectare does not seem unreasonable.

This would not be considered by the HBRC RRMP as a low intensity farming system is considered to be any where the " …farming enterprises that contain no more than 8 stock units per hectare…" which is erroneously claimed by Cook (2021b).

2.3 Plant uptake rate

Other authors of documents by Pattle Delamore Partners (PDP) have suggested nitrogen uptake rates for wastewater irrigated cut-and carry systems of 400-500 kgN/ ha/yr (Meares and Irvine, 2020; Craft and Irvine, 2021). I would have thought that these documents, which are for irrigation with wastewater would have formed the basis for assessing plant uptake rather that the document used (Pratap and Lough, 2020) which is for irrigated agriculture.

The uptake rate used in Boam (2021, Section 5) is 250 kgN/ha/yr for nitrogen and 20 kgP/ha/yr for phosphorous. These are low for wastewater irrigated grass which will bias the results towards increase leaching of nitrogen and phosphorus.

2.4 No denitrification

2.4.1 Soil

Boam (2021, Section 5) did not include denitrification in their analysis. Drip irrigation causes a saturate bulb around the dripper due to the nature of the axi-symmetric flow (Philip, 1984; Cook et al., 2003). This and the chemical and biological oxygen demand (COD, BOD) of the wastewater create conditions which result in denitrification (Beggs et al., 2011).

Cook (2021b) used an estimate of the denitrification based on Parfitt et al. (2008) for agriculture in Hawke's Bay. This will be an underestimation for subsurface drip irrigation (SDI) but is still better than an assumption of zero. Full modelling of an SDI wastewater system requires a lot more information than is presently available for the Springhill site, and is time consuming, computationally intensive and costly (Cook, 2019).

To ignore denitrification in the assessment of subsurface drip irrigation with wastewater will bias the results towards reduced losses of nitrogen and increased nitrogen concentration in the wastewater.

2.4.2 Groundwater

Again, in assessing the effect of nitrogen on groundwater no denitrification in the ground water is considered. Kroom (1992) reviewed the denitrification rate in aquifers and found the rate varied from 0.014 to 0.73 mgN/L/day. Due to a likely increase in dissolved organic carbon that will be in the leachate from the wastewater irrigated areas the denitrification rate is likely to be at the upper end of the measured rates. For 1 L of water travelling in the groundwater for 100 days we could expect a decrease of between 1.4 and 73 mgN/L in the concentration. By not considering denitrification in the groundwater Boam (2021) is again overestimating nitrogen concentration (in particular nitrate) in the groundwater.

2.5 Groundwater

The groundwater flow makes a number of assertions which after careful reading of Wilding and Waldron (2012) do not seem valid. The groundwater flow from the Waipawa River to the Kahahakuri stream is suggested in Wilding and Waldron as a way in which water is transferred from the Waipawa River to the Tukituki River. However, the losing section of the Waipawa River occurs below the region where the Springhill Development is sited (Figure 10, Wilding and Waldron, 2012).

There are at least three centre pivot irrigators and an orchard within the same area as the proposed Springhill development (Figure 1). These will be applying more water than the 4 mm/day for the SDI wastewater system in the proposed Springhill Development yet no mention of these sources of leaching of water and nutrients to the groundwater is made in (Boam, 2021). These areas of agricultural irrigation are likely to contribute considerably more volume to the groundwater and with higher nutrient input.

Hence, it is unlikely that the contribution from the Springhill Development would even be measurable in the Waipawa River and attenuation of nutrient during travel through the aquifer will reduce the nutrient concentration considerably.

The analysis by Boam (2021) does not consider the dispersion (Dillon, 1989) that will occur of any plume, however unlikely, of nutrients from the Springhill Development into groundwater.

No attenuation of the leached nutrients is assumed to take place in the vadose zone between the soil (taken as 0.3 m depth) and the groundwater at 2.5 m depth. This will exaggerate the mass and concentration of nutrients entering the groundwater. This is further exacerbated by the incorrect assumption of application of 1200 L/day and an area of 300 m^2.

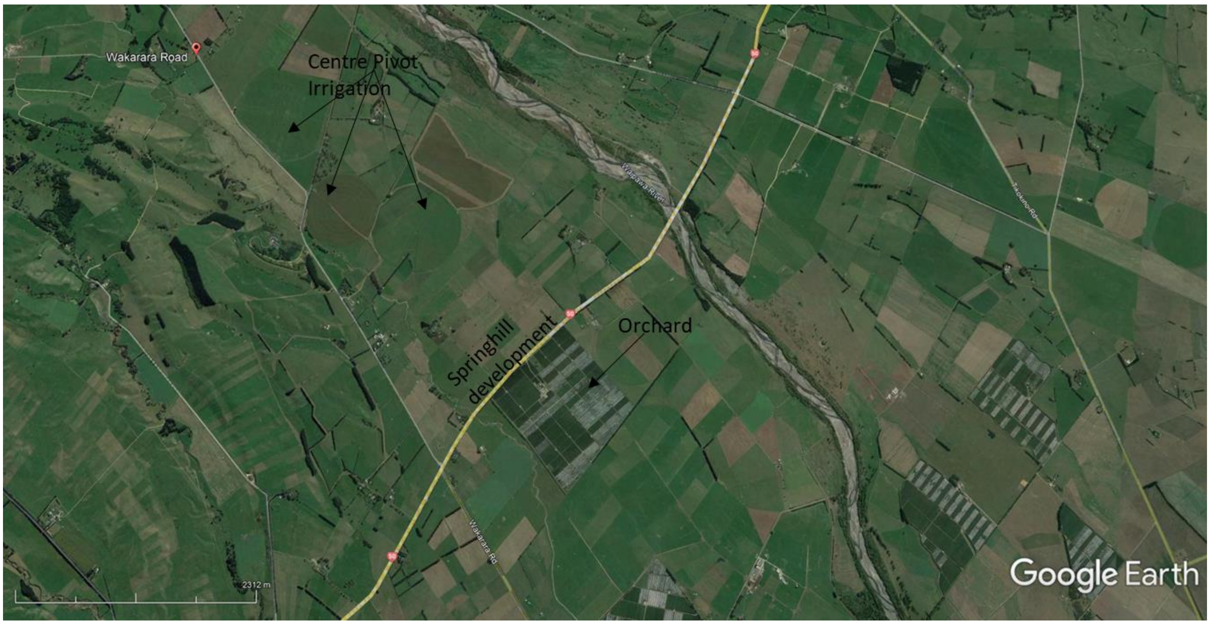

Figure 1. Google earth depiction of the area around the Springhill development showing centre pivot irrigation and orchard.

2.6 Surface water

Boam (2021) suggest that the surface water of the Kahahakuri stream will be affected mainly by runoff and groundwater discharge into it. With SDI the wastewater is applied to the soil at a depth below the soil surface. This means that during high rainfall periods the potential gradient of pressure is into the soil, so there will not be mixing of the wastewater with the runoff which will be mainly rainwater. By comparison the present land use and surrounding land will have urine and faeces deposited by livestock on the surface and can run off into the Kakahakuri stream. The SDI wastewater irrigation at the Springhill Development will result in a lower nutrient transport to the Kakahakuri stream than the present land use.

The likelihood of groundwater entering the Kakahakuri stream during low flow conditions would appear to be remote as the groundwater would have to travel at least 300 m downstream before the elevations are such that it might emerge in the stream. During this travel the nitrogen in particular is likely to reduce significantly due to denitrification. Approximately 2.4 km away from Chesterman's bridge the Kakahakuri stream passes through the middle of Mr Apple Pacific Orchard which is likely to be more of a threat to surface water quality than the proposed Springhill Development.

Boam (2021) does acknowledge that “the phosphorous scenario is very unrealistic”. To then suggest that the phosphorus load needs to be reduced is tenuous.

2.7 Reduction in application rate on Mangatawai soil

Boam (2021) suggests that a reduction in the application rate of wastewater to the Mangatawai soil to 2 mm/day should be a condition to reduce runoff and lateral flow. This is recommended on the basis that the groundwater will ultimately discharge into the Kakahakuri stream. This is not justified as the wastewater is discharged below ground level and during runoff there is a potential gradient downward into the soil so the discharged wastewater will not mix with the surface water.

The low permeability of the Mangatawai soil means that the saturated zone around the dripper will be larger and persist for longer. This will result in more denitrification of the nitrogen and lower concentration in any drainage water leached to the groundwater.

I find no merit in the suggestion of reducing the irrigation rate on the Mangatawai soil and would strongly suggest that this recommendation not be implemented.

3.0 Conclusion

The following conclusions can be drawn from an assessment of the Boam (2021) report:

- Even with assumptions that decrease nutrient losses, the conclusion is that the wastewater disposal for the Springhill Development will be less polluting than the present land use.
- The suggestions that the Springhill Development could have an effect on groundwater quality are only arrived at by making some dubious assumptions that no attenuation in the vadose zone and aquifer of nutrients occurs.
- The suggestions that the Springhill Development could have an effect on surface water quality require an assumption that the groundwater during low flows will enter the Kahahakuri stream and/or the groundwater will flow back from the Waipawa River. Neither of these assumptions hold weight as the Waipawa River loses water to the groundwater a distance downstream from the Springhill Development and attenuation of the nutrients will occur in transit through the groundwater.
- The recommendation to lower the application rate on the Mangatawai soils is without merit and should not be implemented.
- I agree with the conclusion that bacteriological risk is less than minor.
- The report by Cook (2021) was at the level of the whole Development and recommendation of individual systems is not appropriate. However, some of the systems will have lower nutrient concentrations in the wastewater which mean the both the reports of Boam (2021) and Cook (2021) will overestimate offsite effects of the Springhill Development for such systems.

4.0 References

Beggs, R. A., Hills, D. J., Tchobanoglous, G. and Hopmans, J. W. (2011). Fate of nitrogen for subsurface drip dispersal of effluent from small wastewater systems. *Journal of Contaminant Hydrology* **126**: 19-28.

Boam E. (2021). Memorandum. Springhill Farm Holdings - Wakarara Road/SH50 Subdivision: Cumulative effects assessment for wastewater discharge. Prepared for Hawke’s Bay District Council, 11 November 2021.

Craft, L. and Irvine, D. (2021). Raglan wastewater treatment plant discharge options: Assessment of land irrigation. Prepared for Watercare Services by Pattle Delamore Partners, 14 January 2021. In Raglan WWTP optioneering – Short list design and costing. BECA, 5 February, 2021, 144p.

Cook, F. J. (2019). Modelling nitrogen leaching from subsurface drip irrigation for the Te Anau waste water upgrade. Freeman Cook and Associates Pty Ltd, for Southland District Council, April 2019, 33p.

Cook, F. J. (2021a). Preliminary on-site wastewater management site evaluation report. Freeman Cook and Associates Pty Ltd, 24p.

Cook, F. J. (2021b). Loading from on-site wastewater management and cumulative effects Springhill Subdivision evaluation report. Freeman Cook and Associates Pty Ltd, 41p.

Cook, F.J. Thorburn, P.J., Fitch, P. and Bristow, K.L. (2003). WetUp: A software tool to display approximate wetting patterns from drippers. *Irrigation Science* **22(3-4)**: 129-134.

Dillon, P. J. (1989). An analytical model of contaminant transport from diffuse sources in saturated porous media. *Water Resources Research* **25(6)**: 1208-1218.

HBRRMP (2015). Chapter 6 Regional Rules. Hawke's Bay Regional Resource Management Plan. 86p.

Kroom, S.F. 1992. Natural denitrification in the saturated zone: A review. *Water Resources Research*, **28**: 1657-1668.

Meares, B. and Irvine, D. (2020a). Raglan wastewater discharge consenting: Reuse of wastewater through supplementary irrigation – Potential land use suitability assessment. Prepared for Watercare Services by Pattle Delamore Partners 17 September 2020, 69p. Reference number A03532200.

Noble K. E. (1985). Land use capability classification of the Southern Hawke's Bay-Wairarapa region: a bulletin to accompany New Zealand land resource inventory worksheets. Water & Soil Miscellaneous Publication no. 74, 128p.

Parfitt R. L., Baisden, W. T., Schipper, L. A. and Mackay, A. D. (2008). Nitrogen inputs and outputs for New Zealand at national and regional scales: Past, present and future scenarios. *Journal of the Royal Society of New Zealand* **38(2)**: 71-87.

Philip, J. R. (2003). Travel times from buried and surface infiltration point sources. *Water Resources Research* **30(7)**: 990-994.

Pratap N. and Lough, N. PDP (2020). Irrigation nutrient balance model summary. Prepared by Pattle Delamore Partners for Silver Fern Farms Limited June 2020. Reference number A02164500.

Wilding, T. and Waldron, R. (2012) Hydrology of the Tukituki catchment flow metrics for 17 sub-catchments. Hawke's Bay Regional Council, September 2012, HBRC Plan No. 4405, 74p.