BEFORE THE INDEPENDENT HEARING COMMISSIONERS
FOR GISBORNE DISTRICT COUNCIL

IN THE MATTER: of the Resource Management Act 1991 (**RMA**)

AND

IN THE MATTER: of an application by Gisborne District Council for resource consent associated with wastewater overflows

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STATEMENT OF EVIDENCE OF DR MICHAEL STEWART
– ECOLOGY (EMERGING ORGANIC CONTAMINANTS)
22 June 2021

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INTRODUCTION

Qualifications and experience

1. My full name is Dr Michael Stewart. I am an environmental chemistry specialist and have been a Director of Streamlined Environmental Ltd since 2015.

2. Prior to this I was an environmental chemistry scientist at NIWA (2006-2014) and prior to that I was involved primarily in natural products research in the UK (pharmaceutical/biotech sector), Australia (academia) and New Zealand (NIWA).

3. I hold a PhD in Chemistry from the University of Canterbury (awarded 1997). I am a certified RMA Independent Commissioner, having initially qualified in 2017 and recertified in 2021.

4. My relevant expertise and experience includes:

   (a) Key researcher in a Ministry for Business Innovation and Employment (MBIE) funded programme (2017-2022) assessing environmental and economic risks to New Zealand from emerging organic contaminants;

   (b) Reviews and technical studies of water and sediment quality and/or emerging organic contaminants for RMA consenting purposes (Watercare – Omaha, Warkworth/Snells Beach, SW Manukau, Army Bay wastewater treatment plant (**WWTP**); Refining NZ; and private developers – Te Kauwhata; Whitford and Kingseat);

   (c) The design and implementation of monitoring programmes on legacy and/or emerging organic contaminants for Auckland, Bay of Plenty and Waikato Regional Councils and Meridian;

   (d) Critical reviews of state of the environment monitoring (**SOE**) programmes for Auckland and Waikato Regional Councils; and

   (e) Ecological and human health risk assessment of process chemicals in aquatic discharges for RMA consenting purposes (Refining NZ; Ravensdown; Contact Energy).

Code of Conduct

5. My qualifications as an expert are set out above. I confirm that I have read the Expert Witness Code of Conduct set out in the Environment Court's Practice Note 2014. I have complied with the Code of Conduct in preparing this evidence. Except where I state that I am relying on the evidence of another person, this evidence is within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed in this evidence.

SCOPE OF MY EVIDENCE

6. My evidence addresses the following aspects of the application:

   (a) My involvement in the Gisborne Wastewater Overflows Resource Consent Application (**Application**);

   (b) Ecological Risk Assessment of Emerging Organic Contaminants in Poverty Bay from wastewater overflows;

   (c) Response to issues raised in submissions;

   (d) Proposed consent conditions including monitoring plans;

   (e) Summary and conclusion.

MY INVOLVEMENT IN THE WASTEWATER OVERFLOW CONSENT PROJECT

7. I have been involved in this Project since February 2019.

8. I produced a Report for Gisborne District Council (**GDC or Council**) titled 'Ecological risk assessment of emerging organic contaminants in Poverty Bay from wastewater overflows' dated April 2020, which was included as Appendix N to the Application.

ECOLOGICAL RISK ASSESSMENT OF EMERGING ORGANIC CONTAMINANTS

Overview

9. Wastewater overflows may release untreated sewage into the receiving environment, leading to adverse ecological and/or human health effects caused by contaminants contained within the untreated sewage.

10. Contaminants of concern in untreated wastewater can be microbiological (e.g. bacteria, viruses, protozoa), physical (e.g. suspended sediment, pH, temperature) and chemical (e.g. metal and organic contaminants). My evidence covers a subset of organic contaminants, termed “emerging organic contaminants” (**EOCs**).

11. An EOC is any synthetic or naturally occurring organic chemical that is not commonly monitored in the environment but has the potential to enter the environment and cause known or suspected adverse ecological and/or human health effects.

12. EOCs encompass a large variety of chemicals. These include human and animal medicines (pharmaceuticals), antimicrobial disinfectants in soaps/shampoos, UV-filters in sunscreens, fragrances, pesticides, and those chemicals associated with industry (plasticisers, corrosion inhibitors, surfactants, flame retardants).

13. Major sources of EOCs include untreated wastewater overflows, treated wastewater discharges, stormwater and landfill leachate. There is considerable overlap of these sources and pathways to the environment.

14. It is not possible to measure all EOCs in wastewater. A more pragmatic approach in assessing ecological risk is to measure a sub-set of EOCs that are considered of the highest concern, commonly present, and representative of each class of chemical.

15. Many EOCs are suspected of affecting the endocrine (hormonal) system and these types are known as endocrine disrupting chemicals (**EDCs**). EDCs are implicated in affecting male and female reproduction, juvenile development and have been associated with certain cancers (WHO/UNEP, 2012). Antimicrobial resistance is an increasing threat to global public health, with overuse of antibiotics a suspected cause (WHO, 2015). Non-target effects (through multiple modes of action) and effects of mixtures (multiple stressors) are other complicating factors.

16. Current risk assessment approaches may not be suited to characterise the risk from many EOCs, particularly in relation to combined effects of very low levels of multiple contaminants with different modes of action. New methodologies are being developed, however until such time arrives when these are fully accepted and implemented, assessments of effects need to be made using current methods. Presently, these are based on toxicity endpoints such as No Effects Concentrations (**NOEC**), Lowest-Effects Concentrations (**LOEC**), or Predicted No Effects Concentrations (**PNECs**).

17. The receiving environment sites used for assessment are shown in Figure 1 later in my evidence. Human health effects, through ingestion of EOCs in drinking water, are not considered in this evidence, as the receiving environment sites are marine sites and not sources of human drinking water. A comment on human health risks associated with bioaccumulation of EOCs in biota is provided.

Assessment Methodology

Ecological risk of prioritised EOCs in untreated Gisborne wastewater

18. Concentrations of EOCs in untreated influent (after pre-screening) from the Gisborne wastewater treatment plant (WWTP) were reported by Northcott (2017). A total of 81 individual EOCs representing ten different classes were measured, from which 22 (Table 1) were identified by Northcott (2017) as priority EOCs.

Table 1. Priority EOCs identified by Northcott (2017).[1]

Priority EOC	Chemical class	CAS #
TCEP[1]	Alkylphosphate flame retardant	115-96-8
TCPP[2]	Alkylphosphate flame retardant	13674-84-5
TDCP[3]	Alkylphosphate flame retardant	13674-87-8
TBEP[4]	Alkylphosphate flame retardant	78-51-3
Triclosan	Anti-microbial	3380-34-5
Methyl-triclosan	Anti-microbial	4640-01-1
Technical nonylphenol	Alkyl phenol	84852-15-3
DEET	Insect repellent	134-62-3
Carbamazepine	Pharmaceutical	298-46-4
Diclofenac	Pharmaceutical	15307-86-5
Ibuprofen	Pharmaceutical	51146-56-6
Ketoprofen	Pharmaceutical	22071-15-4
Meclofenamic acid	Pharmaceutical	644-62-2
Naproxen	Pharmaceutical	22204-53-1
Monomethyl phthalate acid ester	Plasticiser metabolite	4376-18-5
Monobutyl phthalate acid ester	Plasticiser metabolite	131-70-4
Monoethylhexyl phthalate acid ester	Plasticiser metabolite	4376-20-9
Galaxolide	Polycyclic musk fragrance	1222-05-5
Tonalide	Polycyclic musk fragrance	21145-77-7
Estrone	Steroid hormone	53-16-7
Mestranol	Steroid hormone	72-33-3
17α-ethynylestradiol	Steroid hormone	57-63-6

[1] TCEP= Tris(2-chloroethyl) phosphate, [2] TCPP = Tris (1-chloro-2-propyl) phosphate, [3] TDCP = Tris[2-chloro-1-(chloromethyl)ethyl]phosphate, [4] TBEP = Tris-(2-butoxyethyl)-phosphate.

[1] Dioxin like activity was also identified as a priority. However, dioxins are legacy organic contaminants and so an assessment of risk has not been covered in this evidence.

19. Northcott (2017) presented data for four sampling rounds. Importantly, EOCs were measured in both dissolved and particulate phases of the influent and the total concentration provided (as ng/L of influent).

20. My assessment involved calculating mean and maximum concentration statistics from the Northcott (2017) data for each priority EOC to represent "normal" and "worst-case" discharge scenarios, respectively.

21. The lowest available marine[2] Predicted No Effects Concentration (**PNEC**) for each of the priority EOCs was obtained from the NORMAN[3] Ecotoxicology Database.[4] Lowest PNECs are used primarily for prioritisation purposes. NORMAN states that most of the lowest PNECs have been derived for freshwater. Unless there is an experimental value for other matrices, the lowest PNEC for marine water is calculated by lowest PNEC for freshwater divided by 10. For the prioritised EOCs, the PNECs used were all predicted, with justification of marine PNEC derivation summarised in Table 2.

Table 2. Lowest Predicted No Effects Concentrations (PNEC) for priority EOCs.

Priority EOC	NORMAN Lowest Marine PNEC (ng/L)	Justification[1]
TCEP	400	FW/10
TCPP	3.9	FW/10
TDCP	110	FW/10
TBEP	14	FW/10
Triclosan	2.0	FW PNEC Chronic/10
Methyl-triclosan	6.8	FW/10
Technical nonylphenol	25	FW/10
DEET	8,800	FW/10
Carbamazepine	5.0	FW PNEC Chronic/10
Diclofenac	5.0	FW/10
Ibuprofen	100	FW/10
Ketoprofen	210	FW/10
Meclofenamic acid	9.7	FW/10
Naproxen	170	FW/10
Monoethyl phthalate acid ester	620	FW/10
Monobutyl phthalate acid ester	231	FW/10
Monoethylhexyl phthalate acid ester	19	FW/10
Galaxolide	700	FW/10
Tonalide	ND[2]	ND
Estrone	0.36	FW/10
Mestranol	0.170	FW/10

[2] Although discharges may be into a stream, the ultimate receiving environment sites are predominantly marine.
[3] NORMAN is a network of reference laboratories, research centres and related organisations for monitoring of emerging environmental substances. NORMAN has a membership of more than 70 leading laboratories and authorities across Europe and North America.
[4] https://www.norman-network.com/nds/ecotox/lowestPnecIndex.php

Priority EOC	NORMAN Lowest Marine PNEC (ng/L)	Justification[1]
17α-ethynylestradiol	0.0035	FW/10
Dioxin like activity (TCDD EQ)	0.90	FW/10

[1] FW = freshwater value. For triclosan and carbamazepine marine PNEC were based specifically on chronic FW PNEC (lowest presented).
[2] ND = No data.

22. Risk quotients (**RQs**) – the EOC influent concentration/PNEC – were calculated for the "normal" and "worst-case" scenarios in (20). An RQ value >1 indicates a potential ecological effect. In simplistic terms, the RQ is the dilution required to provide negligible ecological effects in the receiving environment.

23. The priority EOCs were ranked by RQ value from highest to lowest potential ecological risk from untreated wastewater overflows. These RQ values provided the potential ecological risk to the immediate receiving environment, i.e. due to undiluted wastewater.

Ecological risk of prioritised EOCs in untreated wastewater overflows to receiving environment sites

24. Currently the wastewater network overflows on average approximately 2.5 times per year and GDC is implementing a programme (DrainWise) that aims to reduce stormwater inflow and infiltration so that overflows occur on average less than once every two years, or less than 0.5 times per year (an approximate 5-fold reduction).

25. Once the DrainWise programme is implemented, overflow volume in a 10-year Annual Recurrence Interval (ARI) event is predicted to reduce from 17,849 m^3 to 1,545 m^3 (12-fold reduction) and 25,782 m^3 to 8,010 m^3 (3-fold reduction) for the major Wainui and Peel Street overflows, respectively.

26. Risk assessments were undertaken on the "current" wastewater situation (i.e., before implementation of the DrainWise programme) and the "future" wastewater situation (i.e., after implementation of the DrainWise programme).

27. MetOcean Solutions (2019) undertook hydrodynamic modelling of the expected discharge characteristics from different overflow discharge locations (Figure 1) for both

the current wastewater situation (2-year and 10-year ARI events) and future wastewater situation (10-year ARI event only).[5]

28. Using conservative principles, a worst-case scenario was investigated with the following methodology:

(a) Minimum, median and maximum dilutions at each site were calculated from data provided by MetOcean Solutions (2019) for "current" and "future" scenarios and 6 hours, 24 hours and 48 hours after wastewater overflow discharge;

(b) Minimum dilutions at each site, irrespective of scenario or time (hours) after wastewater discharge, were used to estimate a worst-case scenario of EOC receiving environment concentrations;

(c) RQs were calculated at 14 pre-defined sites (see Figure 1) within streams close to overflow discharge locations (sites 4, 6, 7, 8 and 14) and in Poverty Bay (sites 1, 2, 3, 5, and 9 to 13). RQs for each priority EOC were calculated for the "current" and "future" situations.

Figure 1. Fourteen receiving environment sites used for assessment (numbered and yellow) with 4 discharge locations (red spheres).

[5] No overflows are predicted to occur in a 2-year ARI event following improvements implemented through GDC's Drainwise programme, hence this scenario was not modelled.

Assessment of effects – "current" untreated and undiluted Gisborne wastewater

29. The majority (18) of the prioritised EOCs exhibit a potential ecological risk from untreated wastewater overflows (i.e. RQ >1). RQs of up to 2,460 (17α-ethynylestradiol, maximum concentration) were calculated. The top 10 highest risk EOCs have RQs >100 (based on maximum concentration). Mean and median risk quotients of 229 and 58 were calculated, based on the maximum concentration (Table 3).

Table 3. Summary of mean and maximum (undiluted) wastewater overflow concentrations and associated risk quotient (RQ).

Priority EOC	Mean Concentration (ng/L)	Maximum Concentration (ng/L)	RQ (Mean)	RQ (Maximum)	Rank[1]
17α-ethynylestradiol	5.5	8.6	1,562	2,460	1
Triclosan	649	993	324	497	2
Estrone	51	135	142	375	3
Monoethylhexyl phthalate acid ester	3,279	5,832	173	307	4
Technical nonylphenol	4,330	6,921	173	277	5
TCPP	919	1,071	236	275	6
Diclofenac	1,071	1,157	214	231	7
Ibuprofen	12,677	16,882	127	169	8
Carbamazepine	666	794	133	159	9
TBEP	1,352	1,963	97	140	10
Naproxen	8,908	11,824	52	70	11
Mestranol	4.3	7.7	25	46	12
Galaxolide	4,996	6,433	7.1	9.2	13
TDCP	330	468	3.0	4.3	15
Methyl-triclosan	12.5	27.1	1.8	4.0	16
Monobutyl phthalate acid ester	677	881	2.9	3.8	17
Meclofenamic acid	15.7	18.5	1.6	1.9	18
Monomethyl phthalate acid ester	390	513	0.6	0.8	19
Ketoprofen	123	168	0.6	0.8	20
TCEP	183	214	0.5	0.5	21
DEET	1,224	1,697	0.1	0.2	22
Tonalide	279	353	NA[2]	NA	NA
Mean			**149**	**229**	
Median			**39**	**58**	

[1] Rank based on maximum concentration risk quotient.
[2] Not applicable as PNEC could not be sourced.

Assessment of effects – "current" untreated and diluted Gisborne wastewater

30. For the "current" wastewater situation, the lowest receiving environment dilution was 3,170 at site 4, 24-hours after discharge, which is therefore the most at-risk site. This

dilution factor was used as the “worst-case scenario” for the “current” wastewater situation.

31. For the “current” wastewater situation, RQs in the marine receiving environment for the most at-risk site (i.e., with minimum dilution of wastewater – in this case site 4) ranged from 0.0001 (DEET) to 0.8 (EE2) (Table 4).

32. An RQ <1 suggests negligible ecological effects from each individual EOC.

33. Most sites had minimum dilution of the wastewater plume after 6 hours >10,000, which was greater dilution than site 4 (the most at-risk site) and therefore presented lower risk (lower RQ).

34. Generally, 24 and 48 hours after discharge, the minimum dilution at all sites is either similar to that for 6 hours after discharge or significantly increased. Therefore, risks from wastewater overflows to the receiving environment sites for the “current” wastewater situation would generally be further reduced 24 to 48 hours after discharge.

Table 4. Summary of worst-case scenario risk quotient (RQ) for EOCs from wastewater overflows into the marine receiving environment for the current wastewater situation (pre-DrainWise).

Priority EOC	Worst-case RQ in the marine receiving environment
17α-ethynylestradiol (EE2)	0.8
Triclosan	0.2
Estrone	0.12
Monoethylhexyl phthalate acid ester	0.10
Technical nonylphenol	0.09
TCPP	0.09
Diclofenac	0.07
Ibuprofen	0.05
Carbamazepine	0.05
TBEP	0.04
Naproxen	0.02
Mestranol	0.01
Galaxolide	0.003
TDCP	0.001
Methyl-triclosan	0.001
Monobutyl phthalate acid ester	0.001
Meclofenamic acid	0.001
Monomethyl phthalate acid ester	0.0003
Ketoprofen	0.0003
TCEP	0.0002
DEET	0.0001

Assessment of effects – "future" untreated and diluted Gisborne wastewater

35. For the "future" wastewater situation, the lowest dilution was 7,920, at site 4, 6-hours after discharge and is therefore the most at-risk site. This dilution factor was used as the "worst-case scenario" for the "future" wastewater situation.

36. For the "future" wastewater situation, RQs in the marine receiving environment for the most at-risk site (i.e., with minimum dilution of wastewater – in this case site 4) ranged from 0.00002 (DEET) to 0.3 (EE2) (Table 5).

37. All other sites had minimum dilutions 6 hours after discharge at least 2-fold higher than site 4 with risks from wastewater overflows to these sites further reduced by a factor of 2.

38. Generally, 24 and 48 hours after discharge, the minimum dilution at all sites is either similar to that for 6 hours after discharge or significantly increased. Therefore, risks from wastewater overflows to the receiving environment sites for the "future" wastewater situation would generally be further reduced 24 to 48 hours after discharge.

39. Furthermore, as stated earlier in my evidence, implementation of the DrainWise programme will lead to an approximate 5-fold reduction in the frequency of wastewater overflows and a 12-fold and 3-fold reduction in volumes of wastewater overflows for the major Wainui and Peel Street overflows, respectively.

40. Therefore, upon implementation of the DrainWise programme the reduced frequency of wastewater overflows and the higher dilutions (though lower volumes of wastewater discharged) will lead to an overall significantly reduced risk from EOCs as compared to the "current" wastewater situation.

Table 5. Summary of worst-case scenario risk quotients for EOCs from wastewater overflows into the marine receiving environment for the future wastewater situation (post-Drainwise).

Priority EOC	RQ marine receiving environment
17α-ethynylestradiol	0.3
Triclosan	0.1
Estrone	0.05
Monoethylhexyl phthalate acid ester	0.04
Technical nonylphenol	0.03
TCPP	0.03
Diclofenac	0.03
Ibuprofen	0.02
Carbamazepine	0.02

Priority EOC	RQ marine receiving environment
TBEP	0.02
Naproxen	0.01
Mestranol	0.01
Galaxolide	0.001
TDCP	0.001
Methyl-triclosan	0.001
Monobutyl phthalate acid ester	0.0005
Meclofenamic acid	0.0002
Monomethyl phthalate acid ester	0.0001
Ketoprofen	0.0001
TCEP	0.0001
DEET	0.00002

Assessment of effects – potential for bioaccumulation

41. There is the potential for bioaccumulation of some EOCs in marine species. Bioaccumulation concentration factors (**BCF**) may be used to estimate potential bioaccumulation of EOCs in biota, with a value >1,000 indicative of potential for bioaccumulation.[6]

42. Six priority EOCs have a BCF value above 1,000 and so are expected to bioaccumulate: technical nonylphenol (26,580); galaxolide (19,002); tonalide (13,834); methyl-triclosan (9,161); triclosan (4,270); and mestranol (1,059). The other sixteen priority EOCs are not expected to bioaccumulate, with BCF < 1,000.

43. Once the DrainWise programme is implemented, the frequency and volume of wastewater overflows will reduce substantially, leading to a significant reduction in loads of EOCs discharged and a reduction in bioaccumulation rates.

44. However, for most EOCs there are not established analytical methods to measure them in biota and therefore it is not possible to determine whether bioaccumulation (in this instance) has occurred. Furthermore, there is a large knowledge gap of potential human health effects of EOCs in biota from which to establish whether there is a risk from consumption of these species.

[6] US EPA Sustainable Futures / P2 Framework Manual 2012 EPA-748-B12-001 Chapter 5. Estimating Physical / Chemical and Environmental Fate Properties with EPI Suite™.

PROPOSED CONSENT CONDITIONS INCLUDING MONITORING PLANS

45. The list of appropriate priority EOCs from wastewater discharges will change in the future, due to new scientific information becoming available on effects. This in turn may further drive regulatory processes that prohibit or restrict the use of certain high risk EOCs. In effect, the priority EOC list will need to be relevant to the specific time. Furthermore, bioaccumulation potential in marine species has been flagged by this evidence as a potential issue, but there is currently not the analytical capability to measure these EOCs in biota or the human health effects data necessary to properly assess the risks.

46. GDC are seeking a 20-year consent term for wastewater overflows. Based on this timeframe it is highly likely that the current priority list will not be valid over the length of the consent.

47. Therefore, I recommend that within 10 years of the consent commencing:

    (a) a literature review is undertaken to provide a report that incorporates current knowledge and sets an appropriate priority list of EOCs for measurement in Gisborne wastewater. This review will need to incorporate current knowledge on human health consumptive risk from EOCs in marine species.

    (b) the EOCs on the updated priority list are measured in the influent of the Gisborne WWTP. Consistent with Northcott (2017), the monitoring plan will include four sampling rounds and the measurement of EOCs in both <u>dissolved</u> and <u>particulate</u> phases of the influent.

    (c) if the literature review concludes that there is appropriate methodology to assess human health consumptive risk from EOCs in marine species, a human health monitoring programme should be developed and implemented.

RESPONSE TO ISSUES RAISED IN SUBMISSIONS

48. There were no issues identified in the s42A Officer's Report that needed to be addressed.

SUMMARY AND CONCLUSIONS

49. Untreated and undiluted wastewater overflows in Gisborne contain EOCs at concentrations that have the <u>potential</u> to lead to adverse ecological effects.

50. Dilution in the receiving environment reduces the potential for adverse ecological effects and the current risk from EOCs is low.

51. Reduction in the volume and frequency of stormwater and wastewater overflows (once the DrainWise programme is implemented) will further reduce the ecological risks from EOCs.

52. A potential for bioaccumulation in marine species has been identified for 6 of the priority EOCs measured, however this will be significantly reduced once the DrainWise programme is implemented.

53. Future monitoring should include a review of the literature and incorporation of this into a modified monitoring programme for ecological risk and human health consumptive risk.

Dr Michael Stewart

22 June 2021

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