BEFORE THE CANTERBURY REGIONAL COUNCIL

UNDER THE	Resource Management Act 1991
AND	
IN THE MATTER	of application CRC190445 by the Christchurch City Council for a comprehensive resource consent to discharge stormwater from within the Christchurch City area on or into land, into water and into coastal environments

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STATEMENT OF EVIDENCE OF

PAUL CAMERON KENNEDY FOR CHRISTCHURCH CITY COUNCIL

Dated 15 October 2018

CHRISTCHURCH CITY COUNCIL
PO BOX 73015
Christchurch 8154
Solicitor Acting: Brent Pizzey
Tel 64-3-9415550
Brent.Pizzey@ccc.govt.nz

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INTRODUCTION

1. My full name is Paul Cameron Kennedy. I have been engaged by the Christchurch City Council (**CCC** or **Council**) to give evidence in relation to its application for a comprehensive stormwater network discharge consent (**Application**).

2. I hold the degrees of BSc and BSc. (Hons) in Botany and Zoology from Victoria University of Wellington and have been involved in environmental research and assessment since 1975.

3. I am a Principal Environmental Consultant with Kennedy Environmental Limited. Prior to December 2017 I was employed by Golder Associates (NZ) Limited (**Golder**), a global engineering and environmental consulting company as Principal Environmental Consultant. Prior to December 2006 I had been employed by Kingett Mitchell Ltd since 1985 and was a Principal of that Company. I am a member of the Society for Environmental Toxicology and Chemistry and the American Chemical Society.

4. I have been involved with a wide range of urban stormwater projects and research over the last 25 years. This work has included the items described in **Appendix A**.

5. I undertook a review of the Christchurch Contaminant Load Model (C-CLM) on behalf of Christchurch City Council.

6. I have read and referred to the following documents when preparing my evidence:

   6.1 The Stormwater Management Plans prepared by Christchurch City Council for the Ōtākaro/Avon, Huritini/Halswell, Ōpāwaho/Heathcote and Pūharakekenui/Styx River catchments as provided in the Application;

   6.2 Surface water quality monitoring and stormwater monitoring reports produced by Council and available on the Council website (https://www.ccc.govt.nz/environment/water/waterways/waterway-monitoring/)

6.3 The proposed resource consent conditions provided with the application and amendments to those conditions referred to in Ms West's evidence.

6.4 The Environment Canterbury Section42A report prepared by Nick Reuther, the Section 42 A report prepared by Michele Stevenson (effects of proposed discharges on surface water quality and aquatic ecosystems) and the Section 42A report prepared by Mr Rowan Freeman (effects of discharge of contaminants)

7. I have read and referred to the following draft evidence when preparing my evidence:

7.1 Dr Belinda Margetts on behalf of Council.

7.2 Mr Clint Cantrell on behalf of Council.

7.3 Mr Paul Dickson on behalf of Council.

7.4 Mr Eric van Nieuwkerk on behalf of Council.

8. I confirm that I have read and agreed to comply with the Code of Conduct for expert witnesses contained in the Environment Court Practice Note (dated 1 December 2014). I confirm that the issues addressed in the statement of evidence are within my area of expertise. I have not knowingly omitted to consider facts or information that might alter or detract from the opinions expressed.

9. This evidence covers:

9.1 An overview of the C-CLM including source information and load reduction factors.

9.2 Receiving environment attribute target levels (ATLs) and their use in relation to contaminant load reduction.

9.3 End of pipe monitoring.

9.4 Receiving environment monitoring.

9.5 Achieving environmental goals.

9.6 Contaminant source control.

9.7 Matters raised in submissions relevant to this evidence.

9.8 Matters raised in the s42A report relevant to my area of expertise.

9.9 All references identified in my evidence are listed in Appendix B attached to my evidence.

SUMMARY OF EVIDENCE

10. The effects of strategies to reduce contaminant loads in stormwater in Christchurch city catchments has been assessed using the C-CLM, a spreadsheet contaminant load model based on the Auckland CLM. In my opinion, the model is fit for its high-level use of looking at the implications of infrastructural efforts to reduce contaminant loads to waterways. The Auckland model was set up to look at four key contaminants of which three are included in the C-CLM. Council has committed through condition 37 to utilise other modelling tools to examine contaminant loads and concentrations.

11. The objectives of contaminant load reduction are targeted at the attribute targets in the Land and Water Regional Plan (LWRP). The LWRP targets are the default values in ANZECC (2000). The use of these targets provides a goal, but it must be recognised that the ecological state of waterways is driven by a wide range of physical and environmental factors some of which are not addressed using tools such as the C-CLM.

12. The Council will carry out a range of water quality monitoring in catchment waterways and this will be supplemented by wet and dry weather stormwater monitoring. This monitoring will provide an indication of environmental response to contaminant reduction strategies modelled using the C-CLM.

13. Urban waterways and stormwater transport a complex range of contaminants as a result of the nature of activities and materials used in urban catchments. Toxicity studies have shown that water borne toxicity is contributed by

contaminants such as zinc and insecticides. Due to the complexity and range of contaminants in urban environments, monitoring programmes look at key parameters. In my opinion the environmental monitoring programme being undertaken by Council covers key parameters. Other monitoring can be included as current information requires, during the life of the consent.

14. The stormwater contaminant load reduction is targeted at reducing the concentrations of key contaminants in receiving waters within the city catchments to identified targets based on the ANZECC (2000) water quality guidelines. I have noted that Council is not in control of all sources of contaminants and successful reduction strategies to reduce loads will require alternative solutions. National source control management has been used previously to manage significant environmental and human health issues arising from specific contaminants with success and in my opinion is the most appropriate solution for reducing the copper load.

15. Council has in my opinion identified a substantial body of monitoring and technical investigations to support understanding of stormwater and environment quality and contaminant treatment system performance. I also consider that Council has been proactive in seeking source reduction at a national level.

16. Council has proposed a number of investigations in relation to the use of models and stormwater treatment which in my opinion will mitigate a range of concerns identified in the S42A reports.

CONTAMINANT LOAD MODELLING

17. As described in Mr Eric Van Nieuwkerk's (and others) evidence, Council is utilising a Contaminant Load Model referred to as the Christchurch CLM (**C-CLM**) to provide a basis for the assessment of the loads of contaminants (copper, zinc and sediment) generated in the Avon, Halswell, Heathcote and Styx catchments within Christchurch City (refer Evidence of Mr Nieuwkerk and Golder 2018).

18. The C-CLM was developed by the Auckland Council in 2006 and updated to Version 2.0 in 2010. The model is a spreadsheet tool used to estimate the annual loads of

total suspended solids (**TSS**), total zinc, total copper and total petroleum hydrocarbons (**TPH**) discharged from stormwater networks serving areas of mixed urban land use and rural land (ARC 2010 a,b, Timperley et al. 2011).

19. The C-CLM is a simple additive model, whose 'accuracy' is dependent on the contaminant source and the yield (treatment reduction) information entered into it. Some input values are fixed in the model but others allow user input. The latter include stormwater treatment efficiency. The model is not a design tool for devices, or a tool to select treatment devices. It is a tool for estimating 'relativity' between catchment contaminant loads over time for large urban areas which then assists in the prioritisation of specific investigations (in relation to contaminant sources, contaminant concentrations, receiving environment quality etc.).

20. The Council engaged me to review the development and results of the C-CLM and to express an opinion on any changes needed to be made to it in order to make it fit for purpose for this application. I completed that review and my review was attached to the application.

21. The current C-CLM has brought all the Christchurch City catchments together within the one model. The C-CLM is in my view fit for purpose and should provide useful information for Council when considering potential benefits of treatment at a catchment level.

22. Modelling tools such as the C-CLM are one of the few ways that changes in contaminant loads can be assessed for large urban catchments. The C-CLM allows catchment contaminant reduction assessments to be made at any point in time during the consent period as integrated contaminant reduction strategies are being implemented for catchments within the City. The modelling is undertaken by combining the information from all of the hydrological sub-catchments that make up the larger river catchments that then make up the Christchurch urban environment.

23. The scale at which the CLM is used is dependent upon a number of factors. In the context of the Application, the C-CLM is proposed to be used at a high level or larger scale, however the model is able to be used at a finer level, for example:

    23.1 Aggregating sub-catchments that have common downstream environments.

23.2 Using the model to assess contaminant load changes above waterway locations of known sensitivity or value.

23.3 Using the model to assess relative loads between sub-catchments with differing land-use and contaminant loads to maximise reduction strategies.

24. There has been criticism in the S42A report (Michelle Stevenson) that the CLM is an Auckland model and therefore is not appropriate for use in Christchurch. I have provided information in the following sections and also when responding to specific matters identified in the S42A report in Paragraphs 65 onward in my evidence. The two key model inputs are the contaminant load generated by a particular source and the treatment efficiency of any proposed treatment system.

25. The CLM supporting documents (ARC 2010 a,b), state that the CLM was developed for Auckland and this needs to be considered when adopting the model for use in other areas of New Zealand. In particular it is noted that allowance has to be made for local rainfall and region-specific differences in the physical characteristics of soils need to be considered (particle size and erosion characteristics). For key contaminants, the loading and treatment factors were considered transferable and I concur with that.

26. Source contaminant load is identified through using best available data. Although the data is Auckland sourced, the sources (roof types, road traffic etc.) are essentially the same in Auckland and Christchurch. Through stormwater quality research being undertaken in Christchurch, source quality data is becoming available. Although this data is valuable, at this stage the data generated does not fit the model in a manner that provides robust source data, as:

26.1 The model default source area fractions are for Auckland urban areas (these can be changed).

26.2 The roof material types are defined for land-use types based on roof type field work in different land-use areas in Auckland

26.3 Road vehicle numbers are set in categories (and these applied based on local data).

26.4 Roof material yields are based on Auckland research information.

26.5 Road contaminant loads (adjusted for catchpit removal) are based on vehicle emission rates and road area rather than road stormwater data.

27. The source input information at this stage is being used at a high level to assess the relative benefits of different treatment strategies. In due course the accuracy of the loads and treatment can be refined by improving the level of source information. This then improves the accuracy of the strategies as they might be applied to different areas of the city. This represents the most immediate improvement that could make the model more Christchurch specific. Overall, it should be recognised that the CLM was set up as a tool to assess contaminant load reduction strategies rather than providing absolute end of catchment contaminant concentration data. The model can be refined to assist in focusing load reduction at a limited subcatchment scale.

28. The load reduction factors (LRF) (treatment efficiency) included in the Auckland CLM for devices were selected based on best knowledge at the time. The LRFs that were chosen in the Auckland CLM were defined as the highest load reductions likely to be achieved by a correctly designed, installed and managed treatment device or system. Treatment efficiency is complicated where the proportion of dissolved constituent is high. Two of the key urban stormwater contaminants – copper and zinc - have moderate to significant dissolved components and their dissolved chemistries differ requiring different treatment strategies to effectively remove the dissolved component. This can be considered in the input efficiencies for any given treatment option.

29. The treatment efficiency information used in the CLM is principally international data. Although there is data for treatment effectiveness for a range of New Zealand treatment devices, there is insufficient data to replace the input values used in the current model. Semadeni-Davies (2008), reviewed available international and New Zealand treatment effectiveness data.

30. When published treatment efficiency data is examined it is evident that there is considerable variability in the data (i.e., in the % contaminant removed). This variability results in there being a considerable range in the % efficiency used (for example a 50 % efficiency may be used but the 95 % confidence bounds may between 25 % and 75 % for example). Using single sampling results/studies with limited efficiency data has risks especially in relation to over-confidence in probable treatment. I discuss this further below in my evidence.

31. Overall, the C-CLM is a simple model that although developed for use in Auckland is useable in any urban area in New Zealand. The source and LRFs used in the C-CLM are able to be modified where suitable data is available. As described in Mr van Nieuwkerk's evidence, the model has been used to assess the relative benefits of contaminant load reduction strategies identified for Christchurch City urban catchments which is the primary purpose of the Council's use of the model.

CONTAMINANT LOAD MODELLING & WATERWAY CONCENTRATION TARGETS

32. Condition 20 of the proposed conditions requires that "*the consent holder shall use reasonable endeavours to mitigate the effects of the discharge of stormwater on surface water quality, instream sediment quality, aquatic ecology health and mana whenua values. The extent of mitigation of effects shall be measured by the Receiving Environment Objectives and Attribute Target Levels monitoring described in Schedules 4 and 5*."

33. Schedule 4 sets out "receiving environment objectives and attribute targets for waterways". These attribute targets are taken from the LWRP Table 1a and Schedule S5a. Table s5a refers to receiving water standards and identifies under toxicants that they, *'shall not exceed the concentration specified in the Table for the relevant level of protection*'.

34. ANZECC (2000) sets out the background for applying numeric values for toxicants as presented in Schedule 5 of the LWRP. ANZECC (2000) identifies that the numeric guidelines) can be accepted without change or they can be modified and refined. One of the key adjustments recommended by ANZECC (2000) that should be made is the adjustment of the hardness related trace elements to account for site specific hardness. This hardness adjustment has been made by Council (as described by Dr Margetts in her evidence and included in proposed consent condition 45 and Schedule 4.

35. Exceedance of any trigger value does not imply significant adverse effects. The trigger values, represent a concentration of the contaminant that should not result in degradation of the environment. In addition, ANZECC (2000) note in Section 3.4.3.1 "*It is important that toxicant guidelines are not interpreted in isolation from other ecosystem factors such as habitat, flow etc, as well as chemical fate*". The implications of exceedance of a trigger can only be assessed or confirmed through

the collection of appropriate receiving environmental ecological information (refer evidence of Dr Margetts and the Environmental Monitoring Programme provided in the application and in her evidence). In addition, not all effects identified in the receiving environment will arise due to urban stormwater contaminants but may be caused by other ecosystem factors as noted above.

36. The use of the word 'standard' in the LWRP implies that the numeric value is recognised as an enforceable control in a legal sense (e.g., drinking water standards) as compared to water quality criteria (e.g., USEPA) or, guidelines and water quality objectives (or targets). In summary, direct comparison of catchment waterway trace element concentrations with Schedule 5 of the LWRP can be conservative in my opinion.

END OF PIPE MONITORING

37. End of pipe monitoring does not assist directly in informing the long term understanding of the benefits of catchment stormwater quality management. Indirectly it provides information on the effectiveness of treatment devices where inflow quality data is also collected. Over time, data collected directly by Council or from research studies will inform the overall management programme. End of pipe treatment effectiveness data from indicative monitoring sampling will potentially be able to inform the input values to the C-CLM.

38. The Council currently undertakes end of pipe stormwater monitoring in accordance with the Interim Global Stormwater Consent (**IGSC**). That monitoring is reported by Council (e.g., Margetts & Marshall 2015) and is described in the evidence of Dr Margetts. End -off pipe monitoring between storm events will assist in understanding what non-storm related quality may be potentially affecting receiving environments.

39. The IGSC monitoring programme also provides information on a number of treatment devices (ponds, soil adsorption basins and retention basins). This monitoring provides valuable data but illustrates the difficulty in obtaining treatment effectiveness information when single grab samples are collected from the inlet and outlet. This type of water quality monitoring is relatively simple when assessing small treatment devices with small retention volumes (e.g., sand filters, cartridge filters, rain gardens etc.). The efficiency measured by comparing the inlet and outlet

concentrations is dependent upon when the samples were collected in the storm profile, how 'paired' the inlet and outlet samples are (in time), and what the retention volume is within the device if it is a pond. In some cases, if the outlet sample is collected too early, the outlet sample in a device that has a large volume may not be a paired sample. Ideally, multiple samples need to be taken of the inlet and outlet over the storm profile to allow the contaminant load removal profile to be identified and from this an event mean inlet and outlet concentration calculated. This then needs to be replicated to produce an average contaminant removal efficiency.

40. Overall, end of pipe monitoring (both storm event and between storm event sampling) assists in understanding likely environmental effects during storm events (and assessing sediment contaminant loads) and effects between stormwater events.

41. It can be difficult to identify end of pipe monitoring locations that represent the downstream end of a subcatchment where the effect of treatment systems and combined long term educational and structural changes can be monitored. However, where hydrologically contained subcatchments are able to be identified with a single combined downstream stormwater pipe, monitoring of loads does have potential to support the C-CLM (through comparison of actual and theoretical modelled loads). However due to the complexity of contaminant sources, a substantial number of storm events are required to be sampled to provide reasonable estimates of contaminant loads at different points in time (e.g., at 10-year intervals). The Auckland CLM was validated through catchment scale load assessment comparison with measured storm loads.

RECEIVING ENVIRONMENT MONITORING

42. Council undertakes receiving environment monitoring at 42 sites within the five city catchments (the Ōtākaro/ Avon, Ōpāwaho/ Heathcote, Huritini/ Halswell, Pūharakekenui/ Styx and Ōtūkaikino Rivers), the Linwood Canal and two sites in the Halswell retention basin (Margetts & Marshall 2018). The monitoring provides information on non-storm conditions in the waterways monitored which reflect, shallow groundwater drainage to the waterways, groundwater infiltration to the stormwater system and water entering the stormwater system that is not-storm related. The latter includes a variety of site-specific water uses on commercial,

industrial and residential sites. The baseflow water quality is the quality seen within the catchment waterways for more than 80-90 % of the year.

43. Dr Margetts describes the current and proposed monitoring programme in her evidence. A variety of water quality constituents are monitored in water and sediment. The key constituents monitored include the three parameters modelled in the C-CLM.

44. Monitoring programmes are developed to obtain the most relevant information in relation to understanding the environmental stressors that could adversely affect ecological resources or impact water way uses. Urban environments are extremely complex and the range of contaminants potentially influencing environmental quality is very large. Best judgement is used to identify the most appropriate parameters to include in monitoring programmes. This is based on evidence of contributions and effects.

45. Kennedy (2003) reviewed freshwater stormwater toxicity data available at that time. Work by Schiff et al. (2002) used toxicity characterisation finding that toxicity characteristics appeared to be associated with non-polar organic compounds (organophosphate insecticides such as diazinon and chlorpyrifos). Work in Rotorua and Auckland (Nipper et al. 1995, Hickey et al. 1997, Macaskill et al. 2003) identified a range of acute and chronic responses in baseflow and storm discharges. The Rotorua tests showed that residential catchment stormwater was least toxic compared to stormwater from commercial and industrial catchments.

46. Kennedy (2003) reviewed marine stormwater related toxicity information (stormwater and stormwater sediments) including work undertaken by Hickey et al. (1997) using marine species. Schiff et al. (2002) carried out toxicity characterisation to identify the constituents contributing the stormwater toxicity in discharges to marine waters and identified that trace metals (probably Cu and Zn) were responsible for the toxicity to sea urchins. Recently Boehler et al. (2017) examined the complex biological response to stormwater affected sediments from the Ahuriri and New river estuaries. They identified that sediment extracts had the potential to trigger a range of toxicity mechanism including endocrine activity, genotoxicity, and other responses. The authors concluded that “the results of our investigations strongly suggest urban stormwater is unlikely to be the sole source of the organic contaminants that produced the observed biological responses”.

47. In relation to what trace element contaminants to include in monitoring programmes Kennedy (2005) identified that the elements contributed to stormwater having the highest hazard scores were **copper, zinc, lead**, silver and antimony followed by chromium, nickel, cadmium and mercury. Not all elements need to be included in water quality monitoring and those not can be included in sediment monitoring where considered necessary. In addition, hot spot monitoring (e.g., industrial sub-catchment and site monitoring) can pick up specific contaminant related monitoring where required. Overall, there is a balance between what is included in routine on-going catchment monitoring and what is included in hot spot or targeted monitoring (e.g., for industrial properties). In the latter, the monitoring should reflect the contaminant profile for the site. It is my opinion that the proposed EMP focus on copper, lead and zinc is appropriate. Other non-routine checks can be made for other contaminants.

48. Finally, I would note that the CLM was set up to provide information about catchment changes in the three key elements. Other elements or organic compounds were not included in the original model development as there was insufficient information on sources and loads.

ACHIEVING ENVIRONMENTAL GOALS

49. The Council has proposed (in Table 2 of the proposed consent conditions) a series of contaminant reduction goals spread over the duration of the consent. These goals were developed based upon the contaminant management strategies set out in Golder (2018). The goals represent a target for contaminant reduction.

50. Catchment stream water quality is compared against receiving environment attributes as set out in Schedules 3 through 6 of the proposed resource consent conditions. The attributes were taken from the standards set out in Schedule 5 of the LWRP.

51. As described in Dr Margetts' evidence (and annual stream water quality reports), monitoring of catchment streams by Council shows that stream water quality does not meet the standards set in the LWRP schedule for some constituents at some locations. This information provides a very general indication of what constituents require reduction in concentration over time to meet the standards (as set out in the LWRP). The contaminant reduction targets (for the three key contaminants)

identified in Table 2 of the proposed consent conditions provide a means of, and demonstrates commitment to, gradual improvement to move stream water quality towards the standards in the LWRP

52. The LWRP sets the ANZECC (2000) aquatic biota protection trigger values as 'standards' on the basis that meeting those numeric values in the receiving environment will result in an accompanying improvement in the nature of the aquatic ecological community supported by the stream. In my opinion this may not be the case. As I identified earlier in evidence, the ANZECC (2000) trigger values are not a level which when reached will result in specific ecological goals being attained. Improving water quality concentrations of key contaminants to the levels of the LWRP water quality standards does not guarantee outcomes and goals may be achieved with less reduction than predicted. As such, I support the use of the LWRP ANZECC (2000) contaminant values (as ATLs) as set out in the conditions and Schedule 3 proposed by Council. Condition 46 allows for the updating of attribute values. In my opinion this is important as the review of environmental monitoring data should be able to be compared with current environmental guidance (e.g., National water quality guidelines such as MfE (2017) and updated ANZECC (2000) water quality trigger values and sediment quality values as identified through ANZECC (2018)).

53. Recent changes to the ANZECC (2000) sediment quality guidelines (ANZECC 2018) have been released (http://www.waterquality.gov.au/guidelines/anz-fresh-marine) based on Simpson et al. (2013). Default guideline values for coper and zinc did not change but concentration values for other key stormwater related contaminants such as polyaromatic hydrocarbons have. No new water quality trigger values have been released. However new trigger values for copper and zinc are expected to be released following consultation in late 2018. Council is aware of the changes.

CONTAMINANT SOURCE CONTROL

54. Achieving the environmental improvement goals sought by the LWRP and sought through the SMPs for the city waterways assumes the Council has the ability to manage the contaminant load (of contaminants that may be driving ecological effects) entering waterways. It can do that in two principal ways:

54.1 Source control reducing the contaminant load by preventing it entering the environment, or

54.2 treating stormwater to remove a proportion of contaminants.

55. The principal approach utilised to-date by the Council has been treatment. Even with a significant stormwater management and treatment strategy there are a variety of factors that are not under direct Council control but that influence the anticipated environmental outcomes. The Council does not control the source of all key contaminants that are emitted and enter stormwater. The Council has no current ability to manage all of the primary sources of copper and zinc but it can control some of the sources of sediment. Our society uses a range of potential contaminants and our urban environments have enormous ‘stocks’ of key metals such as copper and zinc as they form essential components of our modern infrastructure (like structural metals such as iron). For elements such as copper and iron a large proportion of the stock is hidden (underground, within building structures, in building contents, within cables etc.) and as a result does not contribute to day to day discharges to the environment (i.e., don’t normally contribute to stormwater). Many elements become more significant contaminants in our environment when technological innovation increases their use in our society. Initially they are typically seen as a benefit but can eventually result in environmental issues (good examples are historic use of lead in paints and the use of lead in antiknock compounds used in fuels).

56. Over time these uses change (e.g., the use of copper in wiring and its replacement by fibre-optic cabling) but in some cases the use ceases due to the identification of environmental issues that were not identified at the time. In New Zealand we have had several contaminants used for positive reasons but subsequently removed from use for environmental and human health reasons (these include lead in fuel, asbestos, Dichlorodiphenyltrichloroethane (DDT) for grass grub control and plastic micro-beads).

57. Council cannot control societal changes in the use of products and chemicals that change the flux of specific contaminants to our environment. I note below that herbicides and pesticides (potentially used on residential properties) have been implicated as causal factors of stormwater toxicity. These may be new

(e.g., some of the products and contaminants noted above) or may change due to significant changes in product use. Council itself can only control what it has legislative responsibility for. Controls at source are typically only effective where a known source or sources is a significant contributor to the emitted load (as in the case of copper or zinc).

58. We know that reduction in the mass of a contaminant discharged to our environment results in changes. Since the removal of lead in 1996 from fuels in New Zealand there have been reductions in the concentration of lead in in coastal sediments (e.g., in fine sediment within the lower Waitemata Harbour, sampling I have undertaken has shown that lead concentrations have declined by about 50 % from ~ 60 to ~30 mg/kg between 1988 and 2017). Lead is still present within urban environments as the stock of lead is large and there are still contributing lead sources in road environments (lead in wheel weights etc. refer Kennedy & Sutherland 2008). The reduction in copper emissions from motor vehicles (not elimination) would be expected to result in a proportional reduction in the contaminant load entering waterways. The response would depend upon the actual contribution brake pads make.

59. Studies undertaken in the San Francisco Bay catchments have shown that if sources of brake pad copper are eliminated, 90% of brake pad contributions to runoff will be eliminated in five years or less in many urbanised catchments and in some longer (11-20 years). CASQA (2016) estimated that brake pads manufactured in the US in 2021 are expected to contain 81-99 % less copper than they did in about 2010. That study predicted that the copper concentrations in urban stormwater will respond in a measurable way in the 2020s (in about 10 years). It was calculated that copper loads were expected to be 46 % to 57 % lower by 2024. Overall, with a nearly complete removal of copper from vehicle brake pads within a 10-year period, the copper load reduction was expected to be about 50 %, less than the 90 % noted above due to brake pads not making up 90 % of the total copper sources. I understand that monitoring is expected to show a response in relation to copper concentrations in sediment over that period. The responses seen are likely to be dependent upon the mass of residual copper that is still available for transport to stormwater. The proportional response in dissolved copper concentrations is dependent upon the proportional contribution of brake pad

copper to the in-water dissolved copper concentration. I am not aware of any technical studies that have as yet reported changes in receiving environment copper concentrations from the removal of copper from brake pads in the United States (**US**).

COMMENTS ON SUBMISSIONS

Department of Conservation

60. The Department of Conservation (DoC) notes in its relief sought (item 9) that *"the CLM is run based on the conditions of the different river catchments specific to each stormwater management plan*". I have not discussed with DoC what specific 'conditions' are being referred to. However, I note that each river catchment is dealt with independently within the CLM and specific model outputs can be derived for each as required.

61. DoC notes in its relief sought (item 11) that monitoring should include any other constituent required to be consistent with the National Policy Statement for Freshwater Management. I understand that the monitoring programme provides for the inclusion of all relevant constituents.

62. DoC comments in position point 14g that it acknowledges the model excludes other contaminants and *E. coli*. The model was set up to deal with four principal urban stormwater contaminants and is being used by Council for three (it is not used for total petroleum hydrocarbons). In most cases dealing with copper and zinc deals with the issues of the other particulate associated contaminants – including a range of organic compounds. As such where specific environmental concerns exist relating to particular contaminants, these need to be dealt with on a contaminant specific and or catchment specific basis. In my opinion this may or may not require specific modelling.

63. DoC notes in position point 14a that there is uncertainty as to whether the water quality standards will be met in the receiving environment by 2025. As discussed within my evidence, it is in my opinion an unreasonable objective to assume that receiving water 'standards' would be met by 2025 (in six years' time). DoC's relief sought (item 19) is that the C-CLM is run based on the

conditions of the different river catchments specific to each stormwater management plan. I have not discussed with DoC what specific ‘conditions’ are being referred to. However, each river catchment is dealt with independently within the model and specific model outputs can be derived for each as required. In my opinion the C-CLM model is able to provide information at a catchment and sub-catchment level as required by DoC.

The Ōpāwaho Heathcote River Network

64. The Ōpāwaho Heathcote River Network identified a concern that the C-CLM is based on Auckland sediments (in relation to suspended solids). The C-CLM does not differentiate between sediment particle size differences in sources. The model can be adjusted where required to account for higher loss rates under particular circumstances. In relation to all contaminants in the model, it is my opinion that the value of the model to Council can be increased by improving the “accuracy” of specific information within the model relating to current catchment contaminant sources (a query also raised in relation to Conditions 4 and 50 by the Network). The model still meets the purpose that it was developed for (assessing contaminant load reduction strategies).

65. In relation to a point made on proposed Conditions 49 and 50, the Ōpāwaho Heathcote River Network notes that it is unclear how much monitoring versus modelling will be used to assess targets. These targets will be assessed as treatment strategies are implemented. This occurs in the first instance using the C-CLM, but receiving environment monitoring will provide information identifying the current state of the environment.

66. Council has identified specific additional investigations and actions (Table 3 and Table 4 of proposed conditions) that in my opinion provide responses to a number of maters raised by the Network. In particular the investigation of in-water contaminant modelling and treatment effectiveness monitoring.

67. The Ōpāwaho Heathcote River Network notes that in relation to water quality standards that conditions must be worded in a manner that standards are measurable and enforceable. The consent conditions proposed by Council sets attribute targets that are equivalent to the standards set out in the LWRP. The individual attributes are measurable but also have to be seen as long-term

targets due to a variety of factors (as set out in my evidence above and in the evidence of Dr Margetts). Goals have been identified in relation to C-CLM calculated reductions (based on known changes in stormwater treatment or infrastructure changes within the catchment) on a time interval basis through the life of the consent.

COMMENTS ON S42a REPORT

68. I have read the Section 42A reports of Mr Nick Reuther, Mr Rowan Freeman and Michelle Stevenson.

Section 42 A report of Mr Reuther

69. In paragraph 65 of the report, it is noted that the applicant has described the key contaminants based on the Waterways Wetlands and Drainage Guide. The report follows in paragraph 66 with a note about the University of Canterbury Addington Brook study (Charters 2016) and its findings. It may be implied from the two adjunct paragraphs that the Addington study provides specific results that differ from other studies and our understanding of stormwater quality. The study provides useful data on stormwater quality from sources making up the overall quality of stormwater from an area of commercial/industrial landuse. In the Addington Brook catchment, carparks make up over 40 % of the impervious surfaces in the catchment and they are commercial, industrial carparks.

70. In paragraph 68c the report notes contaminants are also sourced from industrial or commercial premises and contaminated land. I would note that other contaminants are also derived from atmospheric deposition to impervious surfaces along with various activities on residential properties and recreational areas.

Section 42 A report of Mr Freeman

71. Mr Freeman summarises in paragraph 34 of his report that there are a wide range of contaminants of concern in urban environments and identifies that more emphasis on sediment removal at stormwater sources should occur. I

agree with this comment. as it is important for those contaminants that are present principally in the particulate phase (adsorbed to fine sediment or organic matter). Effective removal of sediment at source or bedload and suspended sediment will provide reductions in contaminant loads. Particulate removal is the key means of load reduction in most treatment systems proposed by Council.

72. In paragraph 42 of his report Mr Freeman discusses the need for monitoring that also includes atypical elements. As discussed in paragraph 46 of my evidence, I noted that monitoring related to high risk sites (potential hot spots within a catchment) should be tailored to the contaminant profile for the site.

Section 42 A report of Michelle Stevenson

73. In paragraph 13, the report notes that there is no relationship between the load reduction targets predicted by the C-CLM and the ATLs. In an ideal world a defined level of treatment would produce a specific reduction response in the downstream receiving water. Under these circumstances, a predicted decrease in a particular contaminant load by year 10 (e.g., 18 % total zinc reduction) would be reflected in corresponding reduction in that contaminant. That is the simplest linkage between the C-CLM and the ATLs. This was the approach described in Golder (2014) (Avon River contaminant load modelling assessment) where in-water contaminant concentrations were predicted. Golder (2014) noted that there are a range of limitations in generating surface water contaminant predictions from load data. I agree with the comments made in that report as this is a complex matter. However, it is the dissolved contaminant component that will influence water quality directly. Other factors will influence in-water concentrations and the contribution of these is unknown at this stage (i.e., influence of bed sediment contaminants on in-water concentrations). This linkage ideally only applies during storm events and is technically difficult to apply to between storm water quality in waterways (baseflow). Proposed condition 37 sets out in item 2, a proposal to develop an instream contaminant concentration model if it is considered feasible.

74. In Para 117a, Michelle Stevenson recommends that future modelling should use the best available modelling tools available at the time and this should be

recognised in the consent conditions. Condition 37 identifies stormwater quality investigations to be carried out by Council and in item 6 identifies an investigation into the application of modelling tools. I support this initiative. The C-CLM is the model that has been used to set the base for assessing load reduction strategies and should continue to do so. All models have their place in the assessment of stormwater generation and contaminant transport.

75. In paragraph 117b, Michelle Stevenson recommends that the contaminant load reduction goals should be presented for each catchment rather than as a single value for the entire combined catchment area. The C-CLM allows this information to be extracted.

76. In relation to Paragraph 117c, the proposed consent conditions allow for the potential application of other contaminant load reduction models. The work being undertaken by Council includes the assessment of contaminant reduction in stormwater treatment devices. It is my opinion that there is always benefit in revising both contaminant source loads and revising contaminant LRFs. I comment further on the latter in my evidence below.

77. I have read the review of the C-CLM carried out by Cochrane & Sullivan (Appendix A to the S42A report of Michelle Stevenson) and have set out below a number of comments on matters raised in the review.

78. In relation to contaminant load rates for landuse types, I agree with the reviewers that where sufficiently robust data is available on sediment loading rates for Christchurch specific conditions for the land-use types utilised in the C-CLM, that these are utilised in the model.

79. The authors discuss contaminant sources from roads and roofs being significantly differences in quality and load data between the two urban areas. At the scales that the modelling is being undertaken I do not consider this is a major concern. The points made in relation to types of models by the reviewers is relevant and the Council has already made this point in identifying that other models may be utilised in the future. Although the reviewers note that Medusa can predict hot spots, any model is only as good as its input data. The C-CLM is also able to identify hot spots through the use of detailed land use/source information much in the way that other GIS models can.

80. The authors note that the C-CLM utilises LRFs that are "largest load reductions that could be realistically be achieved". This can be considered as conservative (i.e., over predicting reductions). The C-CLM manual does note that the user can enter 'reduced' values to account for treatment systems being less effective. The factors used need to be the most robust that can be utilised. However, it should be recognised that the model is a relative tool for assessing reduction strategies. It is also my opinion that the larger errors sit with the identification of source yields due to the high variability within some source types (e.g., galvanised roofs) compared to errors associated with treatment estimates.

81. I recognise that there is a range of additional data on treatment effectiveness both internationally and in New Zealand and some post Semadeni-Davies et al. (2008). Examination of international data provides very large ranges of LRFs and typically median values are utilised. Prior to adopting any revisions to any of the LRFs used in C-CLM, any other published LRFs need to be scrutinised further (in relation to how the values were derived). If additional treatment system data is collected as part of Council monitoring programmes, it is always possible to adjust the LRF factors within the C-CLM. The C-CLM has to manage particulate and dissolved treatment efficiencies in a simple manner compared to other models by adjusting the LFR.

82. Source management controls as described in the review were considered. The strategies examined were limited but the value of the model is that assessing the potential reductions of any and multiple strategies is relatively simple. I also agree with the S42A report that copper brake pad source control is very important as a reduction tool as noted earlier in my evidence. Council has not omitted the issue as initial work in this area has already been undertaken and as such it was not included in source control conditions.

83. In section 4a of the review, the review discusses the potential issues associated with contaminants in stream bed and transformation of contaminants. These are not considerations in terms of the direct use of the C-CLM. I have not been able to ascertain what changes in the stormwater network itself will have any significant affect on the contaminant load entering waterways.

84. Section 4b notes that the C-CLM does not support individual property owners on optimal source control. Although that is correct, the C-CLM can be used to assess particular controls (e.g., in relation to roof runoff) which can then be fed back to 'property owners' in the wider sense to provide recommendations on relevant control methods through education.

85. Section 4c mentions a number of factors that affect the identification of LRFs. These are recognised (by Council) and in particular that different treatment devices (especially biological versus non-biological system or inert media versus amended filter media).

86. The ability to management of hot spots of contaminants is mentioned a number of times in both the main body of the S42A report and in the Appendix 2 review. In relation to contaminants other than sediment, hot spots arise due to two factors. First, site specific commercial and or industrial landuse or roading (with high vehicle numbers) that creates a contaminant load hot spot relative to other sections of the catchment. The C-CLM is able to handle this type of hot spot. The second are unique contaminant generating activities. This typically takes the form of industrial emissions that increase local deposition of a contaminant, changing the normal source contaminant load (for example roofs near industrial emissions can have a copper or zinc contaminant profile that differs to the contaminant profile generated by the roof type, refer Kingett Mitchell 2008). The second is the generation of other site specific/industry specific contaminants. The latter cannot be dealt with through the C-CLM or any other model and are typically dealt with through site specific stormwater management plans for industrial sites.

Paul Kennedy

15 October 2018

APPENDIX A

Paul Kennedy Urban Stormwater Experience

Contaminants in stormwater

1. An assessment of stormwater quality and implications for the treatment of stormwater in the Auckland region. Included information on contaminants in stormwater and urban gutter dusts (including a range of persistent organic contaminants). Produced by ARC as ARC Technical publication TP5.

2. A study of roof runoff quality in the Auckland region to improve the understanding of the contribution made by buildings to contaminant loads and quality. Study included suspended solids, key trace elements, polyaromatic hydrocarbons. The study was undertaken for Auckland Regional Council.

3. A study assessing the sources of copper, lead and zinc in different land uses contributing to the quality of stormwater in urban areas. Identification of load contribution profiles for key sources and the key elements copper, lead and zinc. This was carried out for Auckland Regional Council and published as Council TR 2008/23.

4. I undertook a study of the concentrations of contaminants associated with particulate material on road surfaces across Waitakere City. This work was undertaken for Ministry of Transport. This report and others noted below are available at https://www.transport.govt.nz/assets/Import/Documents.

5. I prepared a literature review of trace elements in road surface particulate material for Ministry of Transport.

6. I undertook an investigation of trace elements and organic compounds concentrations in tyres, brake pads and bitumen in New Zealand (for Ministry of Transport);

7. I prepared a review of emission factors for contaminants released by motor vehicles for Ministry of Transport and Auckland Infrastructure.

8. I have carried out a study of contaminants in surface particulate materials associated with road surfaces and adjacent industrial properties in Auckland.

Stormwater quality and catchment reviews

9. I carried out a review of regional urban stormwater data collected by Greater Wellington Regional Council, assessment of suspended sediment quality, stormwater quality (metals, organic compounds) and implications of stormwater quality data to receiving environment discharge.

10. I was involved in preparing overviews of subcatchment environments in Waitakere City for the then Waitakere City Council. That work included overviews of water quality and sediment quality.

11. I prepared sub-catchment overviews of all subcatchments in North Shore City for the North Shore City Council. That work included reviews of all state of the environment information for freshwater and coastal environments.

12. I contributed to the preparation of stormwater catchment plans for the Patumahoe and Pukekoe catchments for Franklin District Council and Hingaia for Manukau City Council. Those studies included the use of the Auckland Council Contaminant Load Model.

13. I have been involved in various Christchurch City stormwater catchment studies, mainly in a review capacity. Those studies included the use of the Auckland Council Contaminant Load Model.

14. I have also been involved in a number of Industrial Site stormwater quality assessments in the Auckland region. These have included heavy industrial facilities and complexes and commercial properties.

Stormwater and water quality effects related studies and reviews

15. I was the principal author of a review of hydrocarbons in urban environments for Auckland Council. The review was published as Auckland Council TR 2016/010.

16. I undertook a review of the effects of contaminants associated with roads on freshwater and coastal aquatic environments. This was prepared for the Ministry of Transport.

17. I undertook a review of contaminants and rail transport in the rail corridor for Ministry of Transport.

18. I have undertaken catchment faecal source tracking (FST) in a review capacity and implemented a FST study in the Laingolme catchment on the northern shore of the Manukau Harbour for Auckland Council, one of a significant number of FST studies undertaken by that Council.

19. I undertook a review of the effectiveness of catchpit management and street cleaning practices (for North Shore City Council).

20. I undertook a review of catchpit sediments and contaminants for Auckland Regional Council. Published as Auckland Council TP 2009/122.

APPENDIX B

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