BEFORE THE INDEPENDENT HEARINGS PANELS APPOINTED TO HEAR AND MAKE RECOMMENDATIONS ON SUBMISSIONS AND FURTHER SUBMISSIONS ON PROPOSED PLAN CHANGE 1 TO THE NATURAL RESOURCES PLAN FOR THE WELLINGTON REGION

UNDER	the Resource Management Act 1991 (the Act)
AND	
IN THE MATTER	of Hearing of Submissions and Further Submissions on Proposed Plan Change 1 to the Natural Resources Plan for the Wellington Region under Schedule 1 of the Act

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STATEMENT OF EVIDENCE OF DR PETER STANLEY WILSON

ON BEHALF OF GREATER WELLINGTON REGIONAL COUNCIL

TECHNICAL EVIDENCE – MARINE ECOTOXICOLOGICAL RISK OF COPPER AND ZINC IN TE AWARUA-O-PORIRUA

HEARING STREAM 2 – OBJECTIVES, ECOSYSTEM HEALTH AND WATER QUALITY POLICIES

28 FEBRUARY 2025

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INTRODUCTION

1 My full name is Peter Stanley Wilson. I am a Principal Marine and Water Quality Scientist at SLR Consulting, where I have worked since February 2019. Prior to this role, I held the position of Coastal Water Quality Scientist at the Waikato Regional Council for four years. In these roles, my responsibilities have focused on marine science, research, and resource management with a focus on sediment and water quality.

2 I have prepared this statement of evidence on behalf of Greater Wellington Regional Council (**the Council**) in respect of technical matters arising from the submissions and further submissions Proposed Plan Change 1 to the Natural Resources Plan for the Wellington Region (**PC1**).

3 This statement of evidence relates to the matters in the Section 42A Report – Objectives and Section 42A Report – Ecosystem Health and Water Quality Policies and specifically what metal load reductions (Policy P.P4) are required to achieve the metals objectives in Objective P.O3.

QUALIFICATIONS AND EXPERIENCE

4 I hold a Bachelor of Science degree in chemistry and a Master of Science with Honours degree in chemistry, both from the University of Waikato. I also hold a PhD in marine biogeochemistry from Auckland University of Technology.

5 I have 12 years of experience in local government, consulting, and academia with a focus on resource management; ecological impact assessments; and designing, implementing, and reporting on monitoring programmes, including regional state of the environment programmes. I have provided technical advice and reported on a range of coastal and marine activities and discharges, including marine farms, stormwater, wastewater treatment plants, ports, and marinas. I routinely assess activities against the requirements of the Resource Management Act 1991, New Zealand Coastal Policy Statement 2010, National Environmental Standards, and regional coastal plans. I have also prepared and presented ecological evidence previously at Council hearings and the Environment Court.

6 I have been involved in this process since December 2024. My evidence builds on earlier work completed by Dr Claire Conwell, who prepared the initial tables and background information presented in this evidence.

CODE OF CONDUCT

7 I have read the Code of Conduct for Expert Witnesses set out in the Environment Court's Practice Note 2023 (Part 9). I have complied with the Code of Conduct in preparing this evidence. My experience and qualifications are set out above. Except where I state I rely on the evidence of another person, I confirm that the issues addressed in this evidence are within my area of expertise, and I have not omitted to consider material facts known to me that might alter or detract from my expressed opinions.

SCOPE OF EVIDENCE

8 My evidence addresses the ecotoxicological risks of metals copper (**Cu**) and zinc (**Zn**) in harbour sediments of Te Awarua-o-Porirua associated with modelled sediment load changes.

9 This evidence relies on the following information:

9.1 Technical evidence of John Oldman (DHI), providing the output of modelled scenarios;

9.2 Tabulations and summaries of the model outputs, prepared by Dr Claire Conwell (**Attachment 1** to this evidence);

9.3 Information in PC1, with specific reference to Objective P.O3 and Policy P.P4, Table 9.1 -Coastal water objectives, and Table 9.3 – Harbour arm catchment contaminant load reductions;

9.4 Information in Section 32 report: Part B Implementation of the National Objectives Framework for Whaitua Te Whanganui-a-Tara and Te Awarua-o-Porirua Whaitua for Proposed Plan Change 1 to the Natural Resources Plan for the Wellington Region, with specific reference to Section 3.18 Metal load reduction targets required to achieve the coastal water objectives in TAoP; and

9.5 Background information contained in: Greer, M.J.C., Blyth, J., Easton, S., Gadd, J., King, B., Nation, T., Oliver, M., Perrie, A. 2023. Technical assessments undertaken to inform the target attribute state framework of proposed Plan Change 1 to the Natural Resources Plan for the Wellington Region. Torlesse Environmental Limited, Christchurch, New Zealand.

BACKGROUND CONTEXT

10 PC1 focusses on giving effect to the National Policy Statement for Freshwater Management 2020 (NPS-FM), in two of the five whaitua of the Wellington region, Whaitua Te Whanganui-a-Tara (**TWT**) and Te Awarua-o-Porirua (**TAoP**) Whaitua.

11 In 2016, the TAoP whaitua committee concluded that copper and zinc may be appropriate proxies for some of the other contaminants found in urban areas (para. 112 s32 Part B report). That is, managing copper and zinc will result in managing most other stormwater contaminants.

12 The TAoP WIP includes attribute state band tables for copper and zinc in sediment, which were developed to align with the attribute state tables in the NPS-FM (para. 113 s32 Part B report). These were modified by Greer *et al*. (2023), where the previous bands A and B were combined into a single Very Good or A band (less than 0.5 of the ANZG (2018) default guideline value (**DGV**) for toxicants in sediment). The previous C and D bands became B and C, respectively and a new band D was created (Table 1). The modified approach is considered to be a better reflection of the overall ecological state (Greer *et al*., 2023). Further reference of attribute states within my evidence uses the Greer *et al*. (2023) modified states.

Table 1: TAoP WIP and Greer et al., 2023 modified attribute states for copper and zinc in sediments.

Attribute State	**Attribute State Thresholds***	
	TAoP WIP	**Modified (Greer et al., 2023)**
A	≤ 20% DGV	≤ 50% DGV
B	≤ 50% DGV	≤ DGV
C	≤ DGV	≤ GV-high
D	> DGV	> GV-high

*** DGV = Default guideline value; GV-high = Guideline value high; ANZG (2018) default guideline values (DGVs) for toxicants in sediment.**

13 The TAoP WIP objectives for copper and zinc were intended to maintain the current levels in both the Onepoto Arm and Pāuatahanui Inlet (**the arms**) of Te Awarua-o-Porirua Harbour (TAoP WIP, 4.3.3). Taking into account the modified attribute states of Greer et al. (2023), this resulted in the current state and proposed attribute state for copper and zinc in sediments in TAoP shown in Table 2.

Table 2: Current (and future) attribute states for copper and zinc from the TAoP WIP using. The most recent (2020) annual mean concentration is shown in brackets (mg/kg).

Metal	**Onepoto**		**Pauatahanui**	
	Intertidal	**Subtidal**	**Intertidal**	**Subtidal**
Copper	A (3.9)	A (19.4)	A (3.7)	A (9.9)
Zinc	A (54)	B (195)	A (32)	A (74)

14 The TAoP WIP objectives for sediment copper and zinc were then translated into the Table 9.1 Coastal water objectives in PC1 as set out in my Table 3 below.

Table 3: Coastal water objectives in PC1.

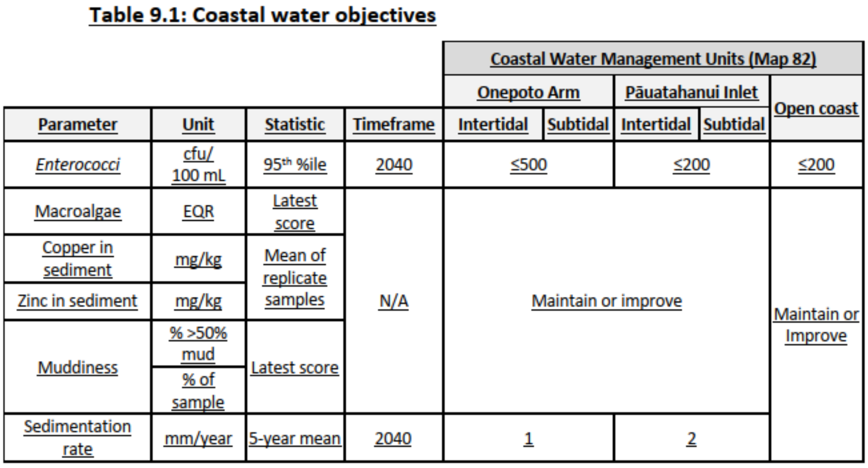

Table 9.1: Coastal water objectives

				Coastal Water Management Units (Map 82)				
				Onepoto Arm		Pāuatahanui Inlet		Open coast
Parameter	Unit	Statistic	Timeframe	Intertidal	Subtidal	Intertidal	Subtidal	
Enterococci	cfu/ 100 mL	95th %ile	2040	≤500		≤200		≤200
Macroalgae	EQR	Latest score	N/A	Maintain or improve				Maintain or Improve
Copper in sediment	mg/kg	Mean of replicate samples						
Zinc in sediment	mg/kg							
Muddiness	% >50% mud	Latest score						
	% of sample							
Sedimentation rate	mm/year	5-year mean	2040	1		2		

15 Thus, the mean of replicate sediment samples (as assessed across the intertidal and subtidal areas of both the Onepoto Arm and Pāuatahanui Inlet of the Harbour), are to be maintained at current levels, or improved over time (indefinite period, and beyond 2040). I note that without listing current baseline concentrations, an objective of "maintain or improve" is ambiguous.

ASSUMED LINK BETWEEN SEDIMENT METALS IN PC1

16 The Council undertook additional technical work[1] following the WIP process to support the development of the coastal water objectives (para. 161, s32 report).

17 This additional technical work determined '*A precautionary approach to maintaining zinc (Zn) and copper (Cu) concentrations in harbour sediments was found to be justified.*' (para. 161, s32 Part B report). It was for this reason that sediment metal load reductions were included in Policy P.P4 and Objective P.O3, despite the coastal objectives only requiring maintenance. The premise of this approach was an assumption through the Whaitua process that any reduction in catchment sediment loads is likely to result in a commensurate increase in sediment metal concentrations (i.e., in the absence of clean sediment to dilute incoming metal loads), even when metal loads remain unchanged.

18 Section 13 'Metal reductions to achieve metal-sediment targets' in Greer *et al*. (2023) discusses the validity of the assumption that a 40% reduction in metals is required to ensure coastal objectives are achieved. The memorandum recognises the modelled load reductions for sediment and metals are in line with published literature around the processes influencing metal deposition in estuaries, but it is noted that a 40% reduction in sediment loads will not achieve a 40% reduction in metal loads to either arm of the Porirua Harbour (due to different source and control measures to achieve reductions). For example, the majority of sediment reductions are anticipated from rural land use, but urban areas are typically the primary source of metals. As such, a 40% reduction of sediment load will not achieve a commensurate 40% load reduction in metals (Technical Memorandum 13 in Greer *et al*. 2023). Rather, for the Pāuatahanui Arm, it is likely that a reduction in metals from sediment mitigation would be 'much less than 20%'. For the Onepoto Arm, the maximum metal reduction from sediment reductions would be around 25%. Thus, additional mitigation for both harbour arms would be required to achieve an overall target of 40% catchment load reductions (Greer *et al.* 2023).

19 Objective P.O3 specifies the coastal water objectives for TAoP, and includes objectives for sediment and metal loads to be achieved by 2040, as follows:

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[1] https://www.gw.govt.nz/assets/Documents/2023/10/Greer-M.J.C.-Blyth-J.-Eason-S.-Gadd-J.-King-B.-Nation-T.-Oliver-M.-Perrie-A.-2023.-Technical-assessments-undertaken-to-inform-the-target-attribute-state-framework-of-proposed-Plan-Change-1-to-the-.pdf

(a) sediment and metal loads entering the harbour arm catchments either via freshwater bodies or directly are significantly reduced; and

(b) high contaminant concentrations, including around discharge points, are reduced.

20 The requirement for metal load reductions was based on the need for a precautionary approach discussed in Greer *et al.* (2023), and assumes a "worst-case" scenario where, in the absence of any change in catchment metal load, a reduction in catchment sediment load would result in a commensurate increase in harbour sediment metal concentrations (see Section 13 of Greer *et al*. (2023)).

21 The information and context for the derivation of the sediment loads and sediment load reduction 'targets' in TAoP WIP, and justification for the reduced targets are set out in Section 11 of Greer *et al*. (2023) and are discussed further in Mr John Oldman's Statement of Primary Evidence. Briefly, the sediment load reduction targets for TAoP were designed to reflect the reductions necessary to achieve the sedimentation rate objectives in TAoP (refer to Table 46, in Greer et al. 2023). A sediment reduction of 40% across both arms was identified as the necessary target. Thus, under the precautionary approach described in paragraph 17 above, the same load reduction target was set for copper and zinc and set out in Policy P.P4 to maintain sediment metal concentrations.

CURRENT UNDERSTANDING OF THE LINK BETWEEN SEDIMENT AND METALS

22 Since the publication of Greer *et al.* (2023) and the notification of PC1, Mr John Oldman has undertaken additional analysis of the relationship between sediment loads and metal accumulation in the bed substrate of Porirua harbour (see his statement of primary evidence). That work highlights that the precautionary approach taken in PC1 (i.e., sediment metal concentrations increase at the same rate as sediment load decreases) may require metal load reductions significantly higher than what is needed to meet the sediment metal concentrations in PC1.

23 To demonstrate, Mr Oldman has used the Porirua Harbour Coastal Receiving Environment Scenario Tool (**CREST**) to test the impact of various scenarios on:

- Sedimentation rate;
- Sediment zinc concentration; and
- Sediment copper concentration.

24 Briefly, CREST (described in Mr Oldman's evidence) allows a user to input subcatchment load reduction scenarios and compare model results to baseline (current land use) estimates.

25 For Porirua Harbour, these scenarios differed in the sediment and metal load reductions applied across the catchments (summarised in **Table 3** and described in the primary evidence of Mr John Oldman). On the basis of the descriptions provided, the last scenario (Metal 40/0 2040) represents the 'worst-case' scenario, where there is no reduction in catchment metal loads to the harbour; however, a reduction in sediment load will inherently reduce the metal load to some extent due to sediment-bound metals. As noted above (see paragraph 18), with a 40% sediment load reduction, metal loads are estimated to reduce no more than 20% in the Pāuatahanui arm and up to 25% for the Onepoto arm. Based on this, the 40/15 scenario (40% reduction in sediment and 15% reduction in metals) is a likely outcome if sediment is reduced by 40% and no other targeted actions are taken to further reduce metal loads.

Table 3: CREST sediment modelling scenarios assessed in this evidence

Description	Sediment load reduction	Metal load reduction
Metal Current Present Day	Present day – baseline state	Present day – baseline state
Metal Current Present 2040	2040 modelled state (no change from current loads)	2040 modelled state (no change from current loads)
Metal 40/40 2040	40%	40%
Metal 40/15 2040	40%	15%
Metal 40/0 2040	40%	0%

26 The purpose of this evidence is to describe the relative and absolute ecological risk associated with the modelled sediment copper and zinc concentrations under these scenarios. This will inform ecologically relevant metal load reduction targets for Porirua Harbour that do not allow for an increase in risk from current, but also do not require reductions beyond what is necessary to achieve the PC1 coastal objectives.

APPROACH TO ASSESS THE ECOTOXICOLOGY OF COPPER AND ZINC

27 The environmental concerns of elevated levels of copper and zinc are widely described and are not repeated here. Further detailed descriptions and justifications for inclusion into the TAoP WIP and PC1 are set out in both the TAoP WIP and Technical Memorandums 12 and 13 (in Greer *et al*. 2023), respectively.

28 Assessment of the risks of ecotoxicology of the modelled sediment metal concentrations for each scenario was assessed by comparison of the modelled values against the NOF-style 4 band attribute framework (**Table 4**).

Table 4: Harbour sediment attribute states for copper and zinc

Parameter	**ANZG**		**Attribute State**			
	DGV	GV-high	**A: Very Good**	**B: Good**	**C: Fair**	**D: Poor**
			<50% DGV	50% DGV to <DGV	DGV to <GV-H	≥GV-H
Copper (mg/kg)	65	270	<32.5	32.5 to <65	65 to <270	≥270
Zinc (mg/kg)	200	410	<100	100 to <200	200 to <410	≥410

29 The context of the sediment guideline value (**GV**) was considered an important aspect in the ecotoxicological assessment, given this is the basis for the attribute framework applied.

30 Recommended Default Guideline Values (**DGV**) and Guideline Values-high (**GV-high**)[2] are listed in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (referred to as ANZG, 2018). As noted in the ANZG (2018), derivation of sediment quality guidelines is considered somewhat more limited than the DGV for water contaminants because of the lack of available data for deriving the sediment quality guideline thresholds. In terms of ecotoxicological-effects, the DGV represents the 10th percentile of the range of effects in the available data and the GV-high represented the 50th percentile.

31 The sediment DGVs indicate the concentrations below which there is a low risk of unacceptable effects occurring (i.e., A and B states). Where concentrations exceed the DGV (C state), toxicity-related adverse effects are possible, and where the GV-high is exceeded (D state), toxicity-related adverse effects may be observed.

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[2] https://www.waterquality.gov.au/anz-guidelines/guideline-values/default/sediment-quality-toxicants

32 The bioavailability and toxicity of contaminants in sediments is influenced by a range of factors, including (but not limited to) grain size, sediment organic content, the presence of other contaminants, presence of overlying water and porewater, oxygenation of porewater, and presence of other factors such as acid volatile sulphides.

33 For example, zinc toxicity in sediments may be mitigated by the presence of acid volatile sulphides (**AVS**) and organic carbon. The adsorption of zinc to suspended particles and the subsequent deposition of these particles is a major removal route for zinc in water. Under chemically reducing conditions (e.g. in anoxic sediments), zinc can desorb from particles and dissociate from iron and manganese inorganic complexes and organic complexes (ECHA online, Zn Brief). Thus, when deriving toxicity for guideline or threshold determination, the data obtained under conditions of low organic carbon concentrations and low-to-median AVS concentrations in the sediment may be of interest.

34 The ANZG framework recognises the paucity of applicable sediment toxicity data in the derivation of the DGV and GV-high thresholds. In this, the guidelines recommend a 'weight of evidence' approach is applied to the overall assessment of potential ecotoxicity and risk. Such an approach may often include the assessment of co-factors (e.g. organic content, co-contaminants, pore water chemistry, and ecological endpoint assessments).

35 Additional ecotoxicological data are available, which can supplement the ANZG (2018) values when interpreting results. Ecotoxicological databases available on the European Union's European Chemical Agency (**ECHA**) database[3], and the United States Environmental Protection Agency's (ECOTOX database[4] provide extensive information about chemical toxicity and various assessed endpoints (i.e., an organism's response to a toxicant).

36 Biological endpoints across available data have been compiled into endpoint effects summaries and provide data such as No Observed Effect Concentration (**NOEC**) (the concentration of a substance that does not produce any observable effects on a species under specific test conditions).

37 Another measure is the Predicted No Effect Concentration (**PNEC**) (a measure of the concentration of a substance that is not expected to produce an adverse effect on an organism or ecosystem at any exposure time). The PNEC are calculated based on available

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[3] https://echa.europa.eu/

[4] https://cfpub.epa.gov/ecotox/

NOEC or similar data (e.g. Lowest Observed Effect Concentration, or Effective Concentration Data), and have an Assessment Factor (**AF**) built in, e.g. that may be a higher toxicity threshold.

38 I note that the ANZG DGV are based on published substance NOEC and other Effective Concentration data. The compilation and assessment of data to generate the sediment DGV, however, is limited due to the smaller number of available effects range data. As such, percentile levels of species protection (e.g. 95th percentile, 80th percentile etc.) are not able to be calculated as they are for many toxicants in water.

39 The ECHA and USEPA databases are weighted towards water-borne phase exposures, rather than sediment phase exposure routes (notably the case for the USEPA ECOTOX database).

40 A summary of the available ecotoxicology thresholds for copper and zinc from the ECHA used in the assessment tin this evidence is listed in Table 5.

Table 5: Summary of ecotoxicological thresholds for zinc and copper. All values are in mg/kg. Thresholds used to assess ecotoxicity throughout this evidence are highlighted and underlined in blue.

Metal	ANZG DGV/GV-high	PNEC	NOEC	Median NOEC[1]
Zinc	DGV: 200 GV-high: 410	146.9 (FW) 162.2 (Mar)	776 (1.055 years)	Lower median: 364 Upper Median: 776 Overall Median: 510
			292.9 (7 months)	
			850 (56 days)	
			510 – 1170 (42 days)	
			218 – 369 (35 days)	
Copper	DGV: 65 GV-high: 270	87 (FW) 676 (Mar)	30.6 – 97.4 (35 days)	Lower median: 23.4 Upper Median: 97.4 Overall Median: 37.75
			18.3 – 580.9 (28 days)	
			23.4 – 44.9 (21 days)	

[1] Median based on NOEC values (lower and upper ranges) provided on ECHA Scientific Properties summary

41 The notable feature of the ecotoxicological thresholds in Table 5 is the wide range of values. This is due to the limited range of appropriate studies, the methods applied to derive different toxicological thresholds, and the differences in the calculations to derive the numbers themselves.

42 The ANZG DGV and GV-high values are based on the 10th and 50th percentile of ranked distribution of available data and combine available freshwater and marine data (noting

there are no separate freshwater and marine thresholds for sediment DGVs listed in the ANZG).

43 Separate marine and freshwater PNEC values are reported by ECHA, but they are heavily weighted towards freshwater effects studies. NOEC ranges do not distinguish between freshwater and marine thresholds.

44 On the basis of the available published NOEC data, the median of these values was calculated to provide an indicative overall NOEC value (as listed in **Table 5**). In the following section, I assess the ecotoxicity risk based on outputs of the CREST modelled scenarios against ANZG, PNEC, and lower median NOEC thresholds.

ASSESSMENT OF MODELLED SCENARIOS FOR COPPER AND ZINC IN TE AWARUA-O-PORIRUA

45 A tabulated summary of the average modelled concentrations of sediment copper and zinc for each scenario is shown in **Table 6** at the end of this section. Additional tables including 95th percentile model outputs and breakdowns by sub-estuary are presented in **Attachment 1**. I discuss the average model outputs in this section as I consider this to be similar to the results from the type of sampling that would be conducted for broad-scale state of the environment monitoring (e.g., average of replicate samples to take into account heterogeneity). The 95th percentile of the model outputs, for example, I consider to be more representative of localised hot spots.

46 The modelling outputs show that based on the current sediment and metal loads (i.e., no change to current state), concentrations of copper and zinc will continue to accumulate (increase) in the sediment. This is shown in the ‘Current 2040’ scenario, where all values are higher than the ‘Current Present Day’. In this scenario, sediment copper and zinc concentrations are predicted to increase from present day concentrations by about 7% in the Onepoto arm and about 10% in the Pāuatahanui arm by 2040.

47 Copper concentrations under all scenarios and in all areas were within the A band (<50% DGV). This indicates a low level of toxicological risk to marine fauna due to sediment copper.

48 Although copper and zinc concentrations are predicted to increase in all areas under the ‘Current 2040’ scenario, only the subtidal area of Onepoto is predicted to shift to a worse band (B to C); this shift happens under all scenarios. This is because the ‘Present Day’ concentration of zinc in Onepoto subtidal is 0.2 mg/kg from the edge of the B/C attribute

state boundary and so even a small increase will result in an attribute state change. Consequently, subtidal sediment zinc concentrations in Onepoto will exceed the DGV in all scenarios (and likely within the next few years), which means there is likely to be a greater than low risk of unacceptable effects occurring (but well below the GV-high, where toxicity-related adverse effects are likely to be observed). In addition, the average modelled zinc concentrations in Onepoto subtidal sediments exceeds the PNEC threshold, including the present-day concentration. Exceeding both these thresholds (DGV and PNEC) could mean that sublethal effects may be occurring in sensitive benthic fauna; however, they are still well below the lower median NOEC and GV-high thresholds above which adverse effects are likely to be observed.

49 In all scenarios where sediment loads are decreased by 40% into the harbour, copper and zinc concentrations are predicted to increase by 2040. This is true even with an equivalent 40% reduction in metals; however, the concentration increases are generally similar or less than the ‘Current 2040’ scenario.

50 If sediment loads are reduced into the harbour by 40% but metal concentrations are not reduced, sediment metal concentrations are predicted to increase by 2040 by about 20-22% in all areas (subtidal and intertidal in both arms). As noted earlier (paragraph 24), this scenario is highly unlikely as a 40% reduction in sediment load will inherently result in a metal load reduction (albeit unquantified) due to a fraction of the total metal pool being sediment-bound.

51 The 40/15 scenario (40% sediment load reduction, 15% metal load reduction) is a likely outcome if no additional targeted mitigation of metal loads is implemented. The 15% reduction is likely to occur due to sediment-bound metals associated with the sediment load reductions. In this scenario, the predicted increase in sediment metal concentrations relative to the ‘Current 2040’ scenario is about double in Onepoto arm (from ~7% to ~15%) but a smaller difference for Pāuatahanui arm (from ~10% to 16%).

52 Overall, copper and zinc concentrations are predicted to increase in TAoP sediments by 2040 in all scenarios. The increase is greatest in the 40/0 scenario and least in the 40/40 scenario. There is a small increase in ecotoxicological risk with increasing metal concentration; however, no additional ecotoxicological thresholds are exceeded under any scenario, other than the transition in Onepoto subtidal from attribute state B to C, which this area is very close to exceeding in its current state.

Table 6: Summary of the average CREST modelled scenario results for sediment copper and zinc in the subtidal and intertidal areas of Onepoto and Pāuatahanui arms. The percentage increase from the Present-Day concentrations is shown in brackets. Values in bold and underline exceed the PNEC or median NOEC value. Cells are coloured based on the attribute state bands in Table 2.

Scenario	**Onepoto Arm**		**Pāuatahanui Inlet**	
	Intertidal	**Subtidal**	**Intertidal**	**Subtidal**
Zinc				
Zn Current Present Day	105.7	**199.8**	17.6	45
Zn Current 2040	112.5 (6)	**216.1** (8)	19.2 (8)	50.3 (11)
Zn 40/40 2040	107.4 (2)	**210.9** (5)	19.3 (9)	50.8 (11)
Zn 40/15 2040	122.6 (14)	**237.6** (15)	19.3 (9)	52.4 (14)
Zn 40/0 2040	135.2 (22)	**256** (22)	21.7 (19)	56.2 (20)
Copper				
Cu Current Present Day	9.7	18.3	1.6	4.3
Cu Current 2040	10.3 (6)	19.8 (8)	1.8 (11)	4.8 (10)
Cu 40/40 2040	9.9 (2)	19.4 (6)	1.8 (11)	4.8 (10)
Cu 40/15 2040	11.4 (15)	21.8 (16)	1.9 (16)	5.1 (16)
Cu 40/0 2040	12.3 (21)	23.4 (22)	2 (20)	5.4 (20)

ONEPOTO SUBTIDAL SEDIMENT ZINC

53 In TAoP, sediment zinc concentrations are highest in subtidal sediments in the Onepoto arm. The current mean zinc concentration (199.8 mg/kg) is very close to the DGV (200 mg/kg), which is also the boundary of attribute bands B and C.

54 As noted in paragraph 46, sediment metal concentrations are predicted to increase by 2040 under all modelled scenarios, including the current loads. This is visualised in Figure 1 for Onepoto subtidal, showing the varying rate of sediment zinc increase from present day to 2040 based on the various modelled scenarios (i.e., all lines have a positive slope).

55 Present day concentrations are approximately at the DGV threshold, and all scenarios are predicted to have concentrations in 2040 that exceed the DGV but do not exceed any

further ecotoxicological thresholds (e.g., NOEC or GV-high). As such, this indicates that some sub-lethal effects may occur in sensitive species, but adverse toxicity-related effects are unlikely to be observed. This is the same for each scenario and, overall, indicates only a marginally increased ecotoxicological risk to marine fauna under any scenario from its current state.

56 If zinc concentrations in Onepoto subtidal sediments continued to increase at a constant rate as predicted in the worst-case (40/0) scenario, concentrations would exceed the lower median NEOC threshold in 2089 and the GV-high in 2108.

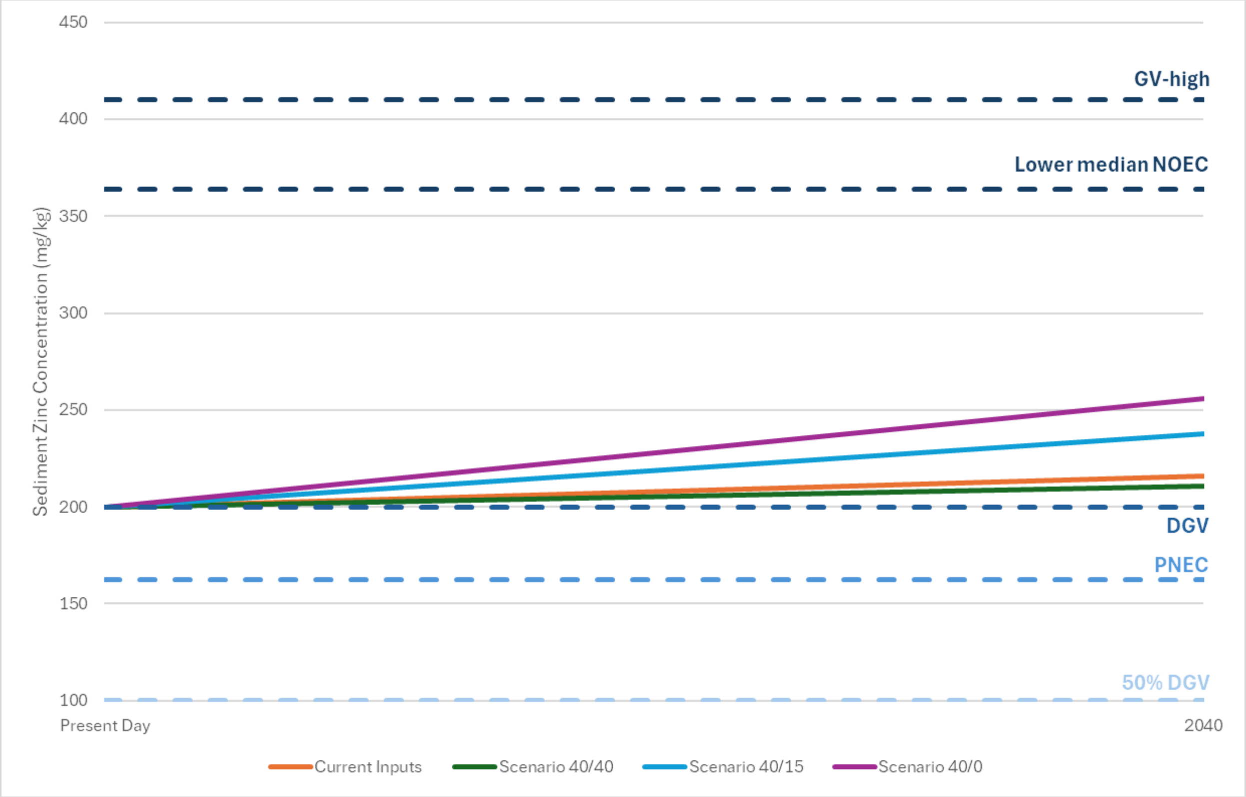

Figure 1: Summary of zinc concentrations now and in 2040 under a range of modelled scenarios for Onepoto subtidal sediments. Relevant ecotoxicological thresholds are shown as dashed horizontal lines.

REVISED SEDIMENT LOAD REDUCTIONS

57 The sediment load reductions of 40% that have been used to inform my assessment were based on what was required to achieve sedimentation rate objectives from the WIP of 1 and 2 mm/year for the Onepoto and Pāuatahanui arms (see Mr Oldman’s evidence). I understand that revised sedimentation rates are being proposed (i.e., less stringent than the WIP objectives), which will subsequently require less of a sediment load reduction to achieve (i.e., <40%) (see Dr Melidonis’ evidence).

58 The extent of change to metal concentrations in 2040 will decrease with a lower sediment reduction load. As such, the effects I have assessed here will be less for lower sediment load reductions (i.e., <40% sediment load reduction).

CONCLUSIONS

59 My evidence addresses the ecotoxicological risks of metals copper and zinc in harbour sediments of Te Awarua-o-Porirua associated with modelled sediment load changes to achieve sedimentation rates of 1 and 2 mm/year for the Onepoto and Pāuatahanui arms, respectively. The modelled scenarios include the current state, future state based on the current sediment and metal loads, and the future state based on a sediment load reduction of 40% with metal load reductions of 40, 15, and 0%.

60 Sediment copper and zinc concentrations are predicted to increase under all modelled scenarios, including based on current sediment and metal loads (i.e., no reduction in sediment load). Logically, sediment metals increase at higher rates in scenarios with lower sediment load reductions.

61 Overall, sediment copper concentrations are currently low (attribute state A; < 50% DGV; Table 1). Modelled scenarios show slightly increased sediment copper concentrations in 2040 but there is no change in attribute state or an exceedance of any ecotoxicological thresholds under all scenarios. As such, the ecotoxicological risk to marine fauna from sediment copper is low in all modelled scenarios.

62 Sediment zinc concentrations are notably lower in the Pāuatahanui arm then in the Onepoto arm. Similar to copper, zinc concentrations in the Pāuatahanui arm (intertidal and subtidal) did not change attribute state (remain in attribute state A) or exceed any ecotoxicological thresholds under all scenarios. As such, the ecotoxicological risk to marine fauna from sediment zinc in the Pāuatahanui arm is low in all modelled scenarios.

63 The current zinc concentrations of **intertidal** sediment in the Onepoto arm sediments place it in attribute state B (<DGV). All modelled scenarios resulted in increases in sediment zinc in intertidal Onepoto sediments, but they remained in a B attribute state and no ecotoxicological thresholds were exceeded. As concentrations are below the DGV, there is a low likelihood of unacceptable effects to fauna occurring in all modelled scenarios.

64 The current state of zinc in **subtidal** sediment in the Onepoto arm is very close to the boundary of attribute states B and C (current concentration: 199.8 mg/kg; boundary

between B/C states: 200 mg/kg). Current zinc concentrations in subtidal Onepoto sediments exceed the predicted no effect concentration (**PNEC**); this is the predicted threshold below which adverse effects are unlikely to occur. Since all scenarios predict an increase in zinc concentrations, all scenarios resulted in a shift from attribute state B to attribute state C. This results in the exceedance of the DGV, which means there is a greater than low likelihood of unacceptable effects to fauna occurring (i.e., there could be some non-lethal effects to sensitive fauna). However, predicted concentrations in all scenarios are still well below the lower median no observable effects concentration (NOEC) and GV-high and so it is unlikely that there would be observable adverse effects on the fauna that are present in all scenarios.

65 Based on the outputs of the modelled scenarios, there are three potential future states for sediment copper and zinc in TAoP sediments that would each require different management approaches. The decision on which scenario or approach is most appropriate is a policy matter and, therefore, outside the scope of my evidence. However, I note that Scenario 1 (paragraph 65.1) is most consistent with achieving the "maintain or improve" sediment objective in Table 9.1, but Scenario 3 (paragraph 65.3) is sufficient to maintain the current risk of adverse ecotoxicological effects on aquatic life.

65.1 **Maintain current harbour sediment metal concentrations.** In all scenarios, the sediment metal concentrations are predicted to increase by 2040. To maintain the current concentrations, a reduction in metal load that is greater than the reduction in sediment load is required. For example, a sediment load reduction of 40% would require a metal load reduction greater than 40% to maintain or reduce the current sediment metal concentrations. Even if there is no reduction in sediment loads, a reduced metal load would still be required to maintain the current sediment metal concentrations. The exact metal reduction required to maintain current sediment metal concentrations is not known at this stage.

65.2 **Maintain the current trajectory (increase) of harbour sediment metals.** Based on the 'current' scenario, metal concentrations are predicted to increase in 2040 by about 5% in the Onepoto arm and 10% in the Pāuatahanui arm from the current state. To maintain this general rate of increase, a 40% reduction in sediment load should be accompanied by a 40% reduction in metal load.

65.3 **Maintain the current ecotoxicological risk to marine fauna from harbour sediment metals.** For all scenarios in areas other than Onepoto subtidal, there is no change to the attribute state. For all areas, including Onepoto subtidal, there is no change to ecotoxicological thresholds that are met or exceeded, even though concentrations are predicted to increase. As such, no targeted metal reductions would likely be necessary to maintain the current ecotoxicological risk to marine fauna, even if sediment loads were reduced by 40%. As noted, this is likely similar to the 40/15 scenario (40% reduction in sediment, 15% reduction in metals).

66 The attribute state (**Table 4**) for predicted sediment metal concentrations (**Table 6**) in each of the three scenarios above are the same, with the exception of zinc in Onepoto subtidal sediment, which for the present day scenario is very close to the boundary of the B and C attribute state. That is, copper concentrations at all sites in all scenarios are within the A attribute state; zinc concentrations in Pāuatahanui Inlet are also within the A attribute state; zinc concentrations in the Onepoto Arm are within the B attribute for intertidal sediment and the B/C attribute state for subtidal sediment. These can be translated into coastal water objectives suitable for use in PC1, Table 9.1 using the upper concentration of each band (**Table 7**). Regarding Onepoto Arm subtidal, the upper value of the C band is the GV-high guideline (as noted earlier in this evidence, this is a threshold at which you might already expect to observe toxicity-related adverse effects) and the future predicted concentrations are at the lower end of the band. Allowing such large degradation within the band may not be appropriate and could allow for significant adverse effects to occur. As such, I recommend that, if this approach is adopted, an objective halfway between the lower and upper end of the C band is used (i.e., halfway between 200 and 410 mg/kg = 305 mg/kg) to accommodate some level of natural variability, while limiting ecotoxicological risk.

Table 7: Recommended coastal objectives for sediment metals in TAoP based on future modelled states. The colours represent the corresponding attribute state in Table 4 (green = A, yellow = B, orange = C).

Scenario	**Onepoto Arm**		**Pāuatahanui Inlet**	
	Intertidal	**Subtidal**	**Intertidal**	**Subtidal**
Copper in sediment (mg/kg)	🟩 <32.5	🟩 <32.5	🟩 <32.5	🟩 <32.5
Zinc in sediment (mg/kg)	🟨 <200	🟧 <305	🟩 <100	🟩 <100

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