Technical Report associated with Te Awarua-o-Porirua Harbour Modelling Results and further quantitative information

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Contents

1. Introduction

The National Policy Statement for Freshwater Management (NPS-FM 2014) suggests adopting an integrated management approach through recognising the interactions, ki uta ki tai (from the mountains to the seas) between freshwater, land, associated ecosystems and the coastal environments. Te Awarua-o-Porirua Whaitua Committee have already set draft objectives for the freshwater environment, and have investigated some of the land management approaches that may achieve those objectives. Focus is now on the harbour waters into which the fresh water drains. Some preliminary harbour objectives (Appendix 1) were reached using expert assessment and will be reviewed using quantitative data recently received through the harbour scenario modelling.

This report provides more technical information regarding harbour objective setting around the recommendations from the harbour modelling undertaken by DHI. Key assumptions behind the recommendations, emerging messages and areas of uncertainty are included for consideration.

Recommendations are as follows:

- Sediment
  - Annual average sedimentation rate is less than 2mm per year [and no more than double the natural sedimentation rate] in the Pauatahanui Arm.
  - Annual average sedimentation rate is less than [1mm or 2mm] per year [and no more than double the natural sedimentation rate] in the Onepoto Arm.
- Muddiness
  - Sediment mud content does not exceed 20% in the intertidal sediments, and should not increase from current state
  - Spatial extent of soft mud shall not exceed 15% of the available intertidal area, with no increase in soft mud area from current state.
- Pathogens (Enterococci) – objectives set using a derivative of the NOF bands for *E. coli*
  - Onepoto Arm intertidal – C band
  - Onepoto Arm subtidal – A band
  - Pauatahanui intertidal – B band
  - Pauatahanui subtidal – B band
  - Potential to set objective/s for open coast
- Macroalgae
  - Ecological Quality Rating (EQR) is not less than 0.6 (B band), and does not worsen from current state in intertidal areas
- Metals (Zn, Cu)
  - Concentration of metals in sediment should be no more than 0.5 of Australian and New Zealand Environment and Conservation Council (ANZECC) guideline values (interim

sediment quality guidelines, ISQG) – low guidelines in intertidal areas, including reducing contamination in known intertidal hot spot areas
- Concentration of metals in subtidal area sediments reduced to below ANZECC guidelines

The harbour modelling looked at three scenarios; current state, business as usual (BAU) and water sensitive. The improved scenario was not modelled given the amount of data, such as catchment sediment loads, already available from the freshwater modelling, and that there is little difference in catchment inputs between the improved and water sensitive scenarios. It is reasonable to conclude that, in general, harbour outcomes for the improved scenario will be similar to the water sensitive scenario results.

2. Sediment

2.1 Sedimentation rate

Sedimentation rate is the rate at which sediment is deposited throughout the harbour. A single sedimentation rate is proposed for the intertidal and subtidal zones of each harbour arm because sediment moves back and forth between both zones depending on input sources, tidal movement, and wind and wave action. However, multiple sites would need to be monitored to generate an average for each arm to test against the objective.

2.1.1 Relationship to values

Elevated sedimentation rates can cause significant ecological changes such as alteration and degradation of habitat, change in flow and depth (infilling), smothering of invertebrates, shellfish and seagrass beds, and reduction in water clarity. These changes also impact on the values associated with the harbour such as the ecosystem health of the harbour, the ability to gather kiamoana/food, use of the harbour for various recreational purposes and mana whenua values.

2.1.2 Recommendations

The recommendations are:

- Annual average sedimentation rate is less than 2mm per year [and no more than double the natural sedimentation rate] in the Pauatahanui Arm.
- Annual average sedimentation rate is less than [1mm or 2mm] per year [and no more than double the natural sedimentation rate] in the Onepoto Arm.

2.1.3 Technical basis of recommendation

The Australian and New Zealand Environment and Conservation Council (ANZECC 2000) Guidelines for Fresh and Marine Water Quality state that greater than 2 mm/yr of sediment (above natural background levels) is the level at which significant changes to the macrofaunal community occur. A sedimentation rate less than 2mm/yr will protect the majority of animals living in the sediment from burial, including cockles and seagrass.

Reference to a natural sedimentation rate is given, which recognises that some estuaries have naturally high sedimentation rates, and that our ability to monitor and model sedimentation rates is constantly improving. A natural sedimentation rate is defined at the rate under a native-forested catchment.

In general, the typical natural background sedimentation rate for New Zealand estuaries is 0.1- 0.5 mm/yr (Townsend and Lohrer 2015). The modelling results indicate that current rates are likely to be > 2 mm/year above the estimated background rates in both arms of the harbour (Table 1). This current sedimentation rate may already be impacting on the ecological and recreational values of the harbour.

Under the water sensitive scenario, sedimentation rates are reduced in both arms of the harbour, most notably in Onepoto Arm. This reduction should go a long way to diminishing, or avoiding, serious ecological impacts.

Table 1: Sediment budget illustrating modelled sediment loads to, percent change from current state for BAU and Water Sensitive scenarios, and sedimentation rates in, each arm of Te Awarua-o-Porirua.

PAUATAHANUI INLET								
	Catchment Inputs[1]		Export		Deposition		Sedimentation Rate	
	t/yr	% change	t/yr	% change	t/yr	% change	mm/yr	% change
Current State	5, 500		1, 500		4, 000		4.7	
BAU	5, 400	-2	1, 500	0	3, 900	-3	4.4	-6
Water Sensitive	3, 000	-45	1, 450	-3	1, 550	-61	2.0	-57
ONEPOTO ARM								
Current State	3, 300		750		2, 550		4.1	
BAU	2, 800	-15	750	0	2, 050	-20	2.5	-39
Water Sensitive	1, 400	-58	650	-8	710	-72	0.3	-93

2.1.4 Sediment sources and reductions

The modelling shows that significant reductions in sediment inputs are required to achieve harbour sedimentation rate objectives (Table 2). Looking at the relative contributions of sediment loads from different catchments and erosion processes helps build better understanding, and a guide to, priority areas for mitigation.

Pauatahanui sub-catchment contributes over half the sediment deposited in Pauatahanui Inlet, though the model may be underestimating the contribution of Horokiri when compared with the actual sediment monitoring results from these two catchments. Collectively, Pauatahanui, Horokiri, Duck Creek, Kakaho and Ration account for 98% of the deposition in Pauatahanui Inlet. Porirua Stream accounts for 93% of the deposition in Onepoto Arm, with the rest coming from the many small sub-catchments around the edge of the harbour.

The sediment model illustrates that there are multiple sediment sources in each sub-catchment (Table 2). Streambank erosion is a major sediment source in Pauatahanui and Horokiri sub-catchments, hillslope erosion is important in all sub-catchments and land sliding in most sub-catchments. Over 90% of the

[1] Improved scenario was not modelled for harbour outcomes. Catchment sediment input for improved scenario to Onepoto Arm were 1500 tonnes per year and for Pauatahanui inlet were 3200 tonnes per year. This suggests the improved scenario harbour outcomes are likely to be similar or have slightly higher deposition than the water sensitive scenario.

landslide erosion in the Porirua sub-catchment is estimated to come from the upper Kenepuru and Takapu sub-catchments, and most streambank erosion in the Porirua sub-catchment comes from the mid and lower reaches of the Porirua Stream.

Stabilising higher risk slopes is vital to reducing sediment from landslide sources, under both the improved and water sensitive scenarios. Stock exclusion and riparian planting stabilises stream banks and reduces erosion also. Increased residential water storage and reuse, as proposed under the water sensitive scenario, will likely reduce the volume of peak flows and associated erosion.

Table 2[2]: Modelled catchment sediment contribution to harbour, current state annual sediment loads from WMUs (including percentage contribution from different erosion processes) and modelled percentage reduction under three scenarios.

	Catchment contribution to harbour deposition (%)		Current State				BAU	Improved	Water sensitive
Catchment	Pauatahanui Inlet	Onepoto Arm	Annual average sediment load (T/yr)	% load from different erosion processes			Reduction in annual average sediment load		
				Hill slope	Land slide	Stream bank			
Pauatahanui Stream	56	1	3,214	41%	6%	53%	3%	-35%	-43%
Horokiri Stream	21	-	955	31%	36%	33%	-1%	-49%	-51%
Duck Creek	11	-	526	69%	26%	6%	-28%	-56%	-57%
Kakaho Stream	6	-	245	43%	41%	16%	-3%	-64%	-65%
Ration Creek	4	-	196	91%	0%	9%	3%	-12%	-13%
Porirua Stream	1	93	2,655	59%	32%	9%	-12%	-47%	-50%
Kenepuru	-		818	48%	50%	2%	-55%	-70%	-71%
Porirua Stream			1,705	66%	26%	7%	6%	-40%	-42%

The modelled scenario reductions are different in each sub-catchment and are strongly influenced by the sources of erosion and assumptions around types, and placement of treatments, in the scenario setup. For this reason, it is recommended against setting target reductions for each catchment, and to instead focus on harbour scale reductions at this point.

[2] Table 2 is similar to table 2 in memo – Recommended harbour objectives but has additional information thereby providing a fuller picture of sediment sources and contribution to harbor under the scenarios.

2.1.5 Sediment variability in the harbour

There is high variability, both temporally and spatially, in sedimentation rate throughout the harbour.

Temporal variability in sedimentation rates are observed, with significant amounts of sediment entering the freshwater and marine environments in pulses during wet weather events. This occurred most recently during the storm events in May 2015 and November 2016 (Fig 1). It is worth noting that the modelling reflects a period of relatively low levels of sediment input. This potentially under-estimates the magnitude of reduction required, and warrants some caution around setting a target of annual average sedimentation rate of 2 mm/yr.

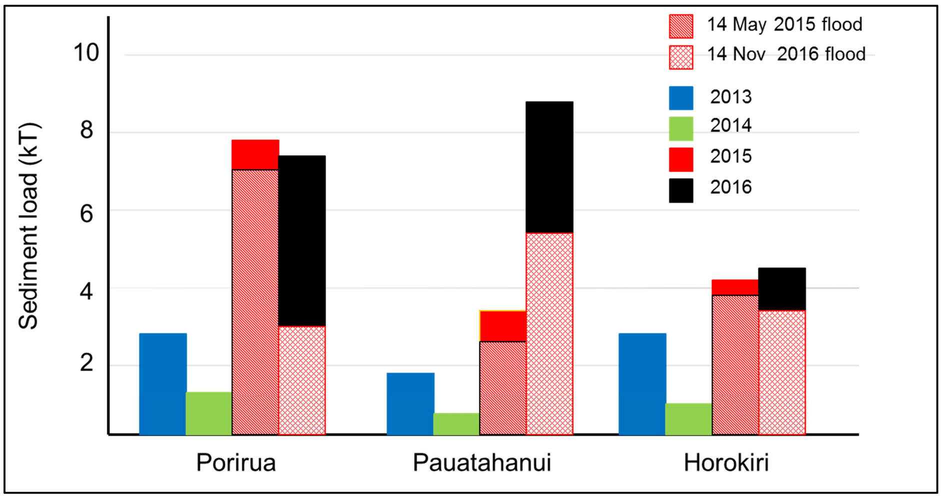

Figure 1: Monitored sediment loads since 2013, including the two storm events in 2015 and 2016, for the three largest catchments in Te Awarua-o-Porirua.

The longer term simulations show a general reduction in sediment deposition throughout the harbour. However event simulations highlight pulses of widespread deposition, caused primarily from wet weather, will continue with gradual erosion of these deposits following events. The objective/s therefore needs to recognise, and make allowance for, this highly variable nature of sediment deposition.

High spatial variability is also observed across both arms of the harbour as well as between the intertidal and subtidal zones, with some areas eroding and others accumulating sediment. As mentioned, there is currently greater accumulation than erosion which may be having an effect on the ecology of the harbour. The spatial variability between accumulation and erosion will continue even where there are significant reductions in sediment inputs under a water sensitive scenario. For this reason, site-specific sediment objectives cannot be set as there would be no provision for the described variability.

Under the modelled sediment reductions, three spatial patterns of sedimentation are possible (Fig 2):

- Some areas that are currently accumulating are likely to continue accumulating. Those areas include:
  - The mid-eastern side of Onepoto Arm (Aotea and Papakowhai)
  - Bradey's Bay, Pauatahanui Stream mouth and the central basin of Pauatahanui Inlet.

- Some areas that are currently accumulating may begin to erode with the reduced inputs. These areas include:
  - The Porirua Stream and Duck Creek sub-estuaries

- Areas that are currently eroding may erode at a faster rate, including:
  - The neck and mouth of both harbour arms
  - The intertidal areas on the north side of Pauatahanui Inlet

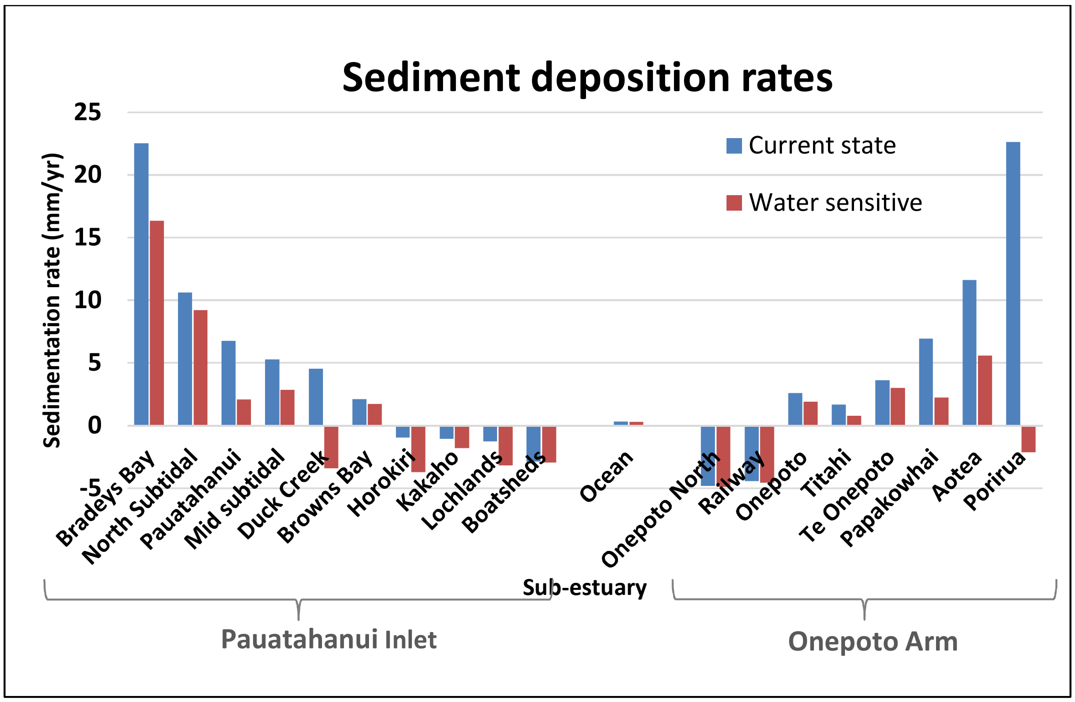

Figure 2: Sub-estuary sediment rates showing erosion and accumulation for both current state and water sensitive scenarios. Negative rates are erosion, positive rates are accumulation.

2.2 Mud Content

Mud (defined as grain size between 3.4 and 62.3 µm) is very fine sediment that feels smooth or "slimy" when you work it between your fingers or toes. The amount of mud in the harbour is intricately linked with the amount of sediment reaching it from the freshwater and terrestrial environments.

2.2.1 Relationship to values

Increasing mud content in estuaries can cause detrimental and often irreversible changes to the ecology and community composition (Robertson 2013). Significant impacts in the intertidal such as smothering of infauna (including taonga species) and seagrass occur at around 20% mud content, sensitive species are at risk at 25%, and if mud content exceeds 30% considerably more marine species are impacted.

Muddy sediment covering more than 15% of the intertidal area can cause stress and loss of sensitive species from the harbour, impacting further up the food chain on those fish and bird species that feed on them. It can also have a negative impact on the aesthetics and recreational values of the harbour.

2.2.2 Recommendations

To give a more thorough framework for managing the impacts of sediment on the harbour it is recommended that, alongside objectives for sedimentation rates, objectives for mud content and spatial extent are set.

The recommendations are:

- Sediment mud content does not exceed 20% in the intertidal sediments, and should not increase from current state.
- Spatial extent of soft mud shall not exceed 15% of the available intertidal area, and no increase in soft mud area from current state.

2.2.3 Technical basis for recommendations

Although muddiness of the harbour has not been modelled, monitoring results dating back to 2004, show a consistent trend of increasing mean sediment mud content at intertidal and subtidal sites in both arms. This highlights ongoing issues with fine sediment in the estuary (Stevens 2017). Current levels of mud content in the harbour are around 20% for the intertidal and 80% for the subtidal areas. There is also evidence that the spatial extent of muddy sediment in the intertidal is increasing both shoreward and toward the subtidal basins (Stevens 2017).

It is recognised that while mud is of concern in both intertidal and subtidal areas, focussing objectives on maintaining or improving the intertidal areas will help to preserve the diversity and resilience of these vulnerable zones. Setting objectives that maintain current, or reach the recommended levels, is expected to reduce or avoid significant ecological effects from mud content in the intertidal area. Further, setting objectives in the intertidal areas will also benefit subtidal areas; however subtidal areas of a shallow estuary will always be muddier. It is also acknowledged that there is a significant legacy of existing mud within Te Awarua-o-Porirua Harbour.

It is expected that reductions in sedimentation rate, as shown by the modelling, will maintain or reduce the amount of mud within the sediment. Additionally, the mud content objectives are likely to be achieved with the sediment reductions required to achieve sedimentation rate objectives.

2.3 Water column sediment

Suspended sediments are very fine particles that remain in suspension in water, due to turbulence, currents and/or wind, for a considerable period of time. Suspended sediment has been looked at through the harbour modelling, which could give some indications about how some of the water column and visual characteristics of the harbour might change with the sediment reductions modelled in the scenarios.

2.3.1 Relationship to values

Fine sediment suspended in the water column can have a variety of effects on values around water, particularly the compulsory value under the NPS-FM of ecosystem health and also contact recreation (safety as well as aesthetics). Suspended sediment primarily reduces visual clarity and light penetration, directly impacts seagrass and macroalgal growth and dilutes food sources for filter-feeders.

2.3.2 Recommendations

It is recommended that water column sediment objectives are not set in the harbour.

2.3.3 Technical basis for recommendations

The modelling indicates that suspended sediments are largely driven by resuspension of sediments through wind and waves, rather than the delivery of new sediment, and the scenarios modelled showed very little difference in suspended sediment concentrations. This means that even with the large reductions in incoming sediment modelled in the water sensitive scenario, changes in the visual characteristics of the harbour waters are unlikely to be seen.

2.4 Model confidence

The freshwater and harbour sediment models calibrate reasonably well to actual sediment monitoring results in both environments, although the freshwater model estimates of sediment inputs are slightly lower than observed. The period of modelling reflects a relatively low level of sediment input compared with longer term modelled catchment inputs and sedimentation rates. Freshwater modelling reflects the period 2005-14 and the harbour modelling has used 2010 as representative of that period. The current harbour modelling also looked at sediment inputs during large storm events. Should catchment sediment rates return towards longer term averages, as has been seen in recent years and may be likely with climate change, the reductions in sediment inputs required may be greater than modelled in order to achieve the target sedimentation rates in the harbour.

3. Pathogens

Pathogens (bacteria, viruses, protozoa) are found in the faecal material of mammals and birds, and are capable of causing infection/sickness in other mammals such as humans. Enterococci are distinguished by their ability to survive in salt water and are typically more human-specific and are therefore used as an indicator of pathogens in salt water.

3.1.1 Relationship to values

Waterborne pathogens affect how safe the water is for recreation and food/kaimoana gathering. There are strong community expectations for Te Awarua-o-Porirua Harbour to be safer for these activities.

3.1.2 Recommendations

The recommended objectives for pathogens in the harbour are:

- Onepoto Arm intertidal – C band
- Onepoto Arm subtidal – A band
- Pauatahanui intertidal – B band
- Pauatahanui subtidal – B band
- Potential objectives for open coast to be discussed

3.1.3 Technical basis for recommendations

Setting pathogen objectives for contact recreation is not compulsory in coastal water, there is no defined attribute table and no bottom line that must be met (to date). However, a band framework similar to the *E. coli* NOF framework has been developed for enterococci (Table 3). The 2003 Microbiological Guideline thresholds have been used to give expression of the different levels of risk of getting sick and amounts of time that Enterococci in the water might be low or high risk to humans.

Table 3: Framework developed for Enterococci

Attribute state	Description	95th percentile: Enterococci per 100 ml	Percentage of exceedances over 500 Enterococci per 100 ml
A	Estimated GI risk is <1% and AFRI risk is <0.3% from a single exposure. The estimated GI risk is >10% and AFRI risk is >4% less than 5% of the time.	<=40	<5%
B	Estimated GI risk is 1-5% and AFRI risk is 0.3-2% from a single exposure. The estimated GI risk is >10% and AFRI risk is >4% between 5 and 10% of the time.	<=200	5-10%
C	Estimated GI risk is 5-10% and AFRI risk is 2-4% from a single exposure. The estimated GI risk is >10% and AFRI risk is >4% between 10 and 20% of the time.	<=500	10-20%
D	Estimated GI risk is >10% and AFRI risk is >4% from a single exposure. The estimated GI risk is >10% and AFRI risk is >4% more than 20% of the time.	>500	>500

* GI is gastrointestinal illness and AFRI is acute febrile respiratory illness

Given this attribute does not have a conscious bottom line or 'unacceptable' threshold given, unlike the NPS-FM attributes, the Te Awarua-o-Porirua Whaitua Committee has the freedom to consider all the bands, their associated risks and to set objectives in any band that they find "acceptable". There is also the option to not set objectives, or to set objectives that apply all year or for only certain periods of the year.

The harbour model results have been mapped and extracted from 13 points in the harbour (Fig 3) to give an indication of the patterns of risk and changes observed through the scenarios (Table 4). Results in these places can also help to understand connections between freshwater inputs and changes in conditions around the harbour.

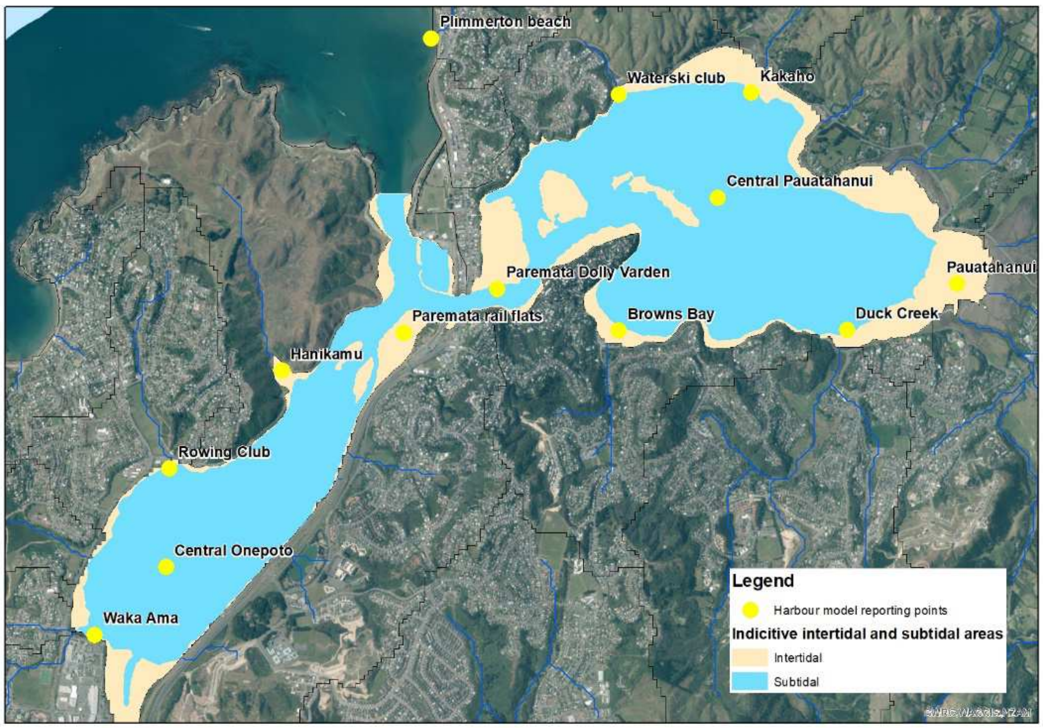

Figure 3: Map showing the 13 points used to model the risk and changes in Enterococci from the scenarios.

Table 4: Attribute state, and grade using developed framework (Table 3), for Enterococci at 13 locations in Te Awarua-o-Porirua harbour.

	Current State	BAU	Water Sensitive
Waka Ama	D	D	D ↑↑
Rowing Club	D	D	C
Central Onepoto	B	B	A
Hanikamu	C*	B	B*
Paremata Rail flats	B	B	A
Paremata Bridge	B	B	A
Water Ski	C*	B	B
Kakaho	D*	C	B
Pauatahanui	D	D ↑	C
Duck Creek	D	D ↑	C*
Browns Bay	B	B	A
Central Pauatahanui	B	B ↑	A
Plimmerton	B	B	A

* grade may be one better than indicated as model prediction for 95%tile is within 20% of the threshold.

↑ Numeric result is between 15 and 50% better than current state

↑↑ Numeric result is more than 50% better than current state

Enterococci conditions are higher risk at the upper ends and around the edges of both arms of the harbour, and lower risk in the central parts of the harbour (Fig 4). Sources are mixed at most sites, though are often dominated by the closest catchment.

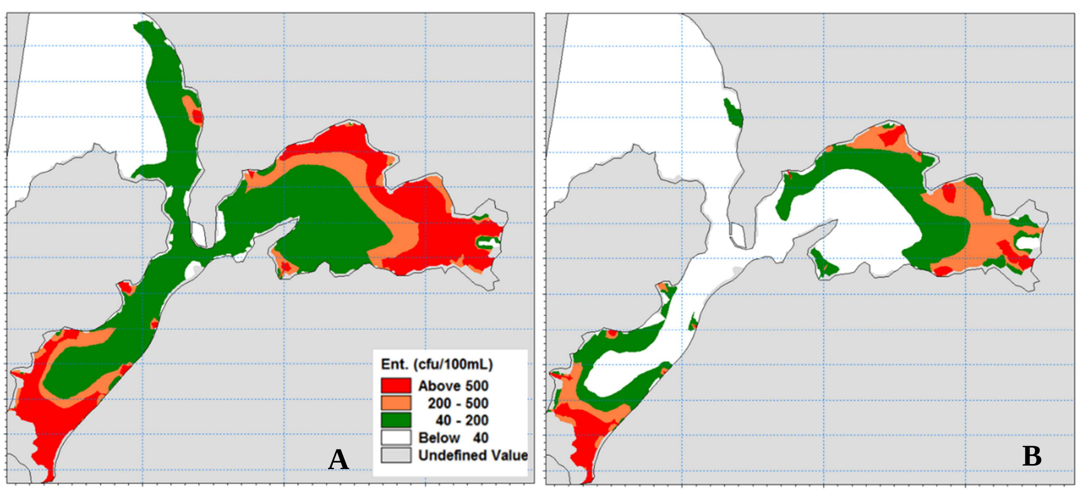

Figure 4: Estimated 95% percentile for current state (A) and Water sensitive (B) scenarios.

In general, the modelling of the water sensitive scenario suggests a band change improvement in enterococci levels, and the associated health risk, should be seen across most places in the harbour. However, the health risks will continue to be highest near the inner harbour areas, where concentrations of pathogens are greatest.

3.1.4 Link to freshwater objectives

The freshwater *E. coli* objectives in the Porirua Stream are seeking greater reductions than the water sensitive scenario modelled estimates for enterococci. Achieving those *E. coli* objectives in freshwater will likely produce further harbour reductions beyond the model results, although it is unknown if it would be enough to change a further band in the higher risk places.

The reductions in *E. coli* to reach the freshwater objectives in rural catchments will most likely fall somewhere between the amounts estimated for the improved and water sensitive scenarios. This means the harbour outcomes from achieving *E. coli* objectives in freshwater may not be as high in harbour waters as indicated in these maps and tables.

3.2 Model confidence

The model has been calibrated based on existing forecasting models that DHI developed for Te Awarua-o-Porirua Harbour over the past several years, which match observed data well. The same cautions already mentioned for sediment objectives apply to the pathogen modelling; the modelled outcomes for the harbour are only as good as the estimated inputs from the freshwater catchments

Another important distinction to note when interpreting the pathogen results is the period these results represent. Due to the computational complexity and associated runtime of the harbour model, one ‘typical’ year within the 10 year period of freshwater modelling has been modelled for the harbour. The bathing water quality monitoring to date makes assessments of the summer time conditions over several years. This means consideration is required on how the model results might represent particular variations in two ways:

- The inter-annual variation that can be expected between different years
- The seasonal variation that can be expected within a year

However, 2010 (chosen as the annual sediment load was close to the average annual sediment load for the 10-yr period) appears to be a year of extremes. Five months were particularly dry with low rainfall, *E. coli* concentrations and flows; and two months that were particularly wet. This suggests:

- median enterococci concentrations may be underestimated, and conditions might be somewhat worse than reported by the model

- estimates of the percentage of time certain thresholds are exceeded may be underestimated, and conditions might be somewhat worse than reported by the model
- 95^{th} percentile concentrations may be overestimated, and conditions might be somewhat better than reported by the model.

It is difficult to evaluate how these results might reflect seasonal differences therefore caution is warranted when making statements about summer only conditions. GWRC's recreational water quality monitoring programme can give us information about the current conditions and risks over summer periods.

Caution is also advised when looking at enterococci levels at the following locations:

- The results at Hanikamu may not be as high as indicated by the modelling. The stream appears to be highly influenced by the local catchment, which is an example of a small catchment where the freshwater modelling may not be representing conditions well. There are likely to be some urban influences that impact the stream and it may require more localised investigation to confirm the level of reductions required to meet any objective set here. Tidal flushing in the bay may be limited by a bar crossing the mouth of the bay, which may detain the freshwater locally and reduce mixing. Increased flushing and mixing with may also help improve conditions in this bay.

- The influence and level of reductions sought in the Kakaho catchment may also warrant closer evaluation. The Kakaho modelling point in the harbour may be over-estimating the amount of enterococci because *E.coli* estimates in the Kakaho catchment may have been over-estimated by the freshwater model. Caution is advised about the estimates of enterococci in this catchment due to the stream size and low flows.

4. Macroalgae

Macroalgae is used here as a proxy for nutrients (especially nitrogen), primarily using the two most common macroalgae species; the green alga *Ulva* and the red alga *Gracilaria*. Nutrients were modelled within the harbour, however, the freshwater objectives are expected to resolve the issue of excess nutrients entering the harbour. That is, nutrients are not currently a problem in the harbour and, as the freshwater objectives will limit nitrogen inputs further, this is expected to maintain or improve nutrient concentration in harbour sediments.

4.1.1 Relationship to values

Long-lasting, persistent blooms of macroalgae can have negative impacts on both ecological and aesthetic values, and can be indicative of excessive nutrients and/or deteriorating sediment conditions.

4.1.2 Recommendations

The draft objective from expert assessment was to maintain current state in intertidal areas. This is based on percent cover and biomass of macroalgae, and the degree of entrainment of the macroalgae within the intertidal sediment. This recommendation remains largely unchanged but is now expressed using the Ecological Quality Ratio (EQR). The EQR is an index of macroalgal condition and can be used to provide early warning of excess nutrients. EQR ranges between 0 and 1, and is converted into the following bands (Table 5).

	High (A)	Good (B)	Moderate (C)	Poor (D)	Bad (E)
EQR	≥0.8 – 1	≥0.6 - <0.8	≥0.4 - <0.6	≥0.2 - <0.4	<0.2

Table 5: Ecological Quality Ratio (EQR) scores and associated bands (Stevens & O'Neill-Stevens, 2017).

The recommendation is that the:

- EQR is not less than 0.6 (B band) and does not worsen from current state in intertidal areas.

4.1.3 Technical basis for recommendations

Macroalgae is persistent in the harbour but is not a nuisance. Current assessments indicate there is moderate macroalgae cover and low biomass implying no problematic nuisance conditions (as caused by high nutrients levels).

The greater the macroalgal coverage, biomass, persistence and extent of entrainment within sediments, the greater the subsequent adverse impacts on underlying sediment and fauna, fish, birds, seagrass and saltmarsh. Decaying macroalgae can also accumulate on shorelines, and in subtidal areas, causing oxygen depletion, nuisance odours and other detrimental conditions.

It is important to acknowledge that the EQR and underlying metrics are still under development and may be refined in the future, but is based on best available information for NZ estuaries.

5. Metals

Trace metals, such as zinc and copper, occur naturally in the environment, but high concentrations suggest contamination from another source. This attribute refers to levels of metals (zinc and copper) bound to the sediment in the harbour. High concentrations of zinc and copper are localised, and are generally known to originate from certain stormwater-borne sources, such as roads (tyres and brake pads) and zinc roofing/cladding.

5.1 Relationship to values

Metals bind to sediment and are transported along waterways from urban environments, accumulating in estuarine and coastal sediments with potentially negative impacts on flora and fauna.

5.2 Recommendations

The Australian and New Zealand Environment and Conservation Council (ANZECC 2000) Interim Sediment Quality Guidelines (ISQG) provides a set of default trigger values for metals. These have been used to assess the potential ecological effects of metals in the streambed sediments.

The recommendations for metals are:

- Concentrations of metals in intertidal sediments should be no more than 0.5 times ANZECC guideline values (ISQG–Low), including reducing contamination in known intertidal hot spot areas, such as in front of the Porirua CBD area

- Concentrations of metals in subtidal sediments are to reduce below ANZECC (ISQG-Low) guidelines

5.3 Technical basis for recommendations

To create greater resolution within these guidelines, we propose to apply the estuary condition ratings used elsewhere in GWRC reporting, where the Low band is half the ANZECC ISQG-Low guideline value (Robertson & Stevens, 2015). For example, the ANZECC ISQG-Low guideline value for Zinc is 200 mg/kg, so the limit for intertidal areas of Porirua Harbour would be 100 mg/kg.

The ANZECC guidelines are considered to be reasonably robust, and conservative (i.e., they err on the side of environmental protection). They are not ‘pass’ or ‘fail’ numbers, and the developers of the guidelines emphasise that they are best used as one part of a ‘weight of evidence’ approach to evaluating potential effects of contaminants on benthic biota.

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Appendix 1

Te Awarua-o-Porirua information on six harbour attributes and scenario results using expert assessment

Grouping	Annual ave. sedimentation rate				% area with soft mud				Copper				Zinc				Macroalgae (intertidal only)				Invertebrates			
	Current state	BAU	Improved	Water sensitive	Current state	BAU	Improved	Water sensitive	Current state	BAU	Improved	Water sensitive	Current state	BAU	Improved	Water sensitive	Current state	BAU	Improved	Water sensitive	Current state	BAU	Improved	Water sensitive
Pauatahanui intertidal	C	C	C↑	C↑	C	C	B	B	A	A	A	A	A/B	B/C↓	A/B	A/B	C	C	C	C	B	B	B↑	B↑
Pauatahanui subtidal					D	D	D↑	D↑↑	A	A	A	A	B	B	B	B↑	N/A				C	C	C	C
Onepoto intertidal	B	B	A	A	B	B	B	B	A	A	A	A	A	A	A	A	C	C	C	C↑	B	B	B↑	B↑
Onepoto subtidal					D	D	D↑	D↑↑	B	B	B	B↑	C	C	C	C↑	N/A				C	C	C	C↑

Te Awarua-o-Porirua draft objectives for harbour attributes

Grouping	Annual avg. sedimentation rate			% area with soft mud			Copper			Zinc			Macroalgae (intertidal only)			Invertebrates		
	Current state	Objective	Minimum scenario to achieve objective	Current state	Objective	Minimum scenario to achieve objective	Current state	Objective	Minimum scenario to achieve objective	Current state	Objective	Minimum scenario to achieve objective	Current state	Objective	Minimum scenario to achieve objective	Current state	Objective	Minimum scenario to achieve objective
Pauatahanui Intertidal	C	**C↑**	Imp	C	**B**	Imp	A	**A**	Imp	A/B	**A/B**	Imp	C	**C**	Imp	B	**B↑**	Imp
Pauatahanui subtidal				D	**D↑↑**	WS	A	**A**	Imp	B	**B↑**	WS	N/A			C	**C**	Imp
Onepoto intertidal	B	**A**	Imp	B	**B**	Imp	A	**A**	Imp	A/B	**A/B**	Imp	C	**C↑**	WS	B	**B↑**	Imp
Onepoto subtidal				D	**D↑↑**	WS	B	**B↑**	WS	C	**C↑**	WS	N/A			C	**C↑**	WS

Band	Description
A	Reflects relatively natural levels
B	Minor stress
C	Moderate stress and risk of losing sensitive species
D	Significant, persistent stress with likely loss of expected species
↑ or ↑↑	Relative improvement with band