LWP Ltd
145c Colombo Street
Christchurch 8023
03 3107420
021 495229

Greater Wellington Regional Council
PO Box 11646, Manners Street
Wellington 6142

Attention: Brent King

Project Ref: GW0138

18 March 2019 TAOP WIP Review.doc

Review of objectives and limits for the Te-Awarua-o-Porirua Whaitua Implementation Programme

LWP were commissioned by Greater Wellington Regional Council to provide review comments on the logic and basis used to establish water quality objectives, limits and targets in the Te-Awarua-o-Porirua Whaitua Implementation Programme (WIP).

Information for the review was provided in the form of a spreadsheet[1] containing attribute tables, outputs from water quality scenario modelling, assessments of current water quality state and workings utilised to establish objective state bands, numeric objectives and load reduction targets for inclusion in the WIP. A copy of the draft WIP[2] was also provided for reference. Specific tasks included a review of:

- The assessment of current state for each WMU on the basis of monitoring and modelling results;
- The conversion of the attribute state objectives and numeric objectives and their transposing to the WIP;
- Harbour-scale limits and their transposing to the draft WIP; and
- Development of the DIN and DRP nutrient concentration criteria.

Two key assumptions adopted for the review were that:

- Each modelling sub-component has been subject to internal per review processes so review of the modelling process itself was not required (i.e., model results were adopted on an 'as is' basis); and
- Model outputs and existing water quality are assumed to have been correctly populated in the spreadsheet provided.

---

[1] Review Version Scenario_Freshwater_Quality_2018-04-11 V2BKWorkings.xlsx

[2] Draft WIP Version 15 February 2019

1. Overview of water quality objective setting process

The Whaitua Committee-led process for establishing water quality objectives in the WIP included multiple considerations specific to individual water quality attributes. The Committee was provided with technical assessments of current water quality state for individual water quality attributes at numerous reporting points (that were ultimately grouped into 5 water management units (WMUs)) based on a combination of water quality monitoring results, baseline model results and expert assessment. The Committee selected water quality attribute state objectives (A, B,C band) for each WMU using the technical assessments combined with their own evaluation of environmental, social, cultural and economic implications of various options. Once the Committee had decided on their chosen attribute state objective, a technical process was undertaken to assign numerical water quality objectives appropriate to each objective state band using threshold figures from relevant attribute tables.

The technical process of assigning attribute state bands and numerical thresholds for the chosen objectives involved evaluation of a range of considerations including:

- The adequacy and/or representativeness of existing water quality data, particularly where data indicates variability in water quality state within a single WMU;
- The appropriateness of utilising existing water quality data or modelled water quality to assign water quality states to catchments with no data;
- Uncertainty inherent in water quality modelling results, particularly where model results appear to differ from actual water quality data (e.g., in terms of % exceedances at high flows)

1.1 Attribute tables

Tables outlining attribute state bands (A, B, C etc) along with accompanying narrative attribute states and numerical thresholds were developed for each freshwater attribute included in the WIP. Tables for a sub-set of attributes (E.coli, Ammonia, Nitrate and Periphyton) were adopted from the National Objectives Framework (NOF) contained in the NPS-FM. For attributes not included in the NOF, tables were developed based on a range of sources, each subject to expert input and/or review.

A review of the attribute tables contained in the AttributeTable tab of the review spreadsheet indicates that, where provided, attribute states and numerical thresholds were correctly transposed from the referenced sources. The single exception was the threshold for D band % exceedances over 260 cfu/100 ml in the E.coli table that listed an incorrect figure. However, a cross-check of attribute states assigned for E.coli does not indicate this error was carried through to the relevant state assessment tab.

Attribute tables for dissolved zinc and copper were noted as being developed based on advice from the modelling leadership group (MLG). No reference was provided, so it is assumed the numerical thresholds were appropriately transposed.

1.2 Current water quality state

Current water quality state attribute bands were assigned for each attribute across the 5 WMU's. This process involved consideration of existing water quality monitoring information, baseline water quality modelling results and expert assessment. The exact methodology adopted differed for individual attributes depending on the amount of monitoring information available, the applicability of modelled water quality results and a range of other factors specific to individual attributes. Tables 1 to 3 below provide summary comments on the current state assignment for individual freshwater, coastal water and harbour sedimentation attributes respectively.

Overall, the methodology utilised to assign current state water quality attribute bands followed a relatively consistent process, with appropriate justification provided for the methodology and attribute state bands adopted. A review of the spreadsheet provided did not identify any instances of current state (measured or baseline modelled) being incorrectly assigned according to the relevant thresholds established in the attribute tables. Where monitoring and/or modelling data indicated some variance in current state, bands assigned appear 'reasonable' given the particular circumstances described in individual catchments.

General observations regarding the assignment of water quality state include:

- The spatial scale of the WMUs adopted results in a degree of variability in river types and water quality state within each management unit. As a consequence, assigning a single water quality state band to each individual WMU will inevitably result in localised departure for the assigned state at a sub-catchment scale. While this variability could be reduced by defining water quality state and objectives at a finer spatial scale, definition of a larger number of WMUs would significantly increase the scale and complexity of the objective setting process and subsequent regional planning and management;
- Given pressures associated with land use (particularly urban development), monitoring results from sites located in lower catchment areas may estimate poorer current water quality state than expected in headwater catchments of the same WMU;
- In catchments with no water quality monitoring data available, inferences regarding potential water quality state can reasonably be made on the basis of similarities in hydrology, land use and other pressures. However, care may be required when adopting attribute states or numerical objectives to un-monitored WMUs to avoid future inconsistencies arising should monitoring be undertaken in the future;
- For a number of attributes the current water quality state is significantly influenced by water quality occurring during high flow events (i.e., 95%ile concentrations rather than median concentrations);
- For attributes with limited monitoring data (e.g. dissolved zinc and copper), current water quality state is largely assigned based on modelled baseline water quality results. Given the lack of data for model calibration, this introduces significant uncertainty into the assignment of current state. Such uncertainty could be more explicitly noted in the WIP;
- For selected attributes (e.g. macroalgae), current state is assigned based on recent monitoring results which are assumed to supersede earlier expert assessment. This

assumption would appear reasonable as it is based on the most recent data available to characterise water quality state.

1.3 Assignment of attribute state objectives in the WIP

As noted previously, assignment of attribute state objectives (e.g., A, B or C band) in the WIP was informed by water quality scenario modelling and, where appropriate, modified to incorporate cultural and community considerations by the Whaitua committee. For the most part, the attribute state objectives are consistent with water quality outcomes technically assessed as being achievable under the various mitigation scenarios modelled. However, for some attributes (e.g., *E.coli*, dissolved copper and periphyton) modelling indicates that the attribute states identified in the WIP are unlikely to be achievable solely on the basis of modelled mitigations and will therefore require additional measures. Tables 1 to 3 below provide summary comments on the assignment of attribute state objectives for individual freshwater, coastal water and harbour sedimentation attributes respectively.

1.4 Assignment of numerical attributes in the WIP

For a majority of water quality objectives, a single numerical attribute was assigned to each WMU based on the threshold figures outlined in the corresponding attribute tables, rather than specific concentration estimates from monitoring or modelling. While this approach has a potential downside that it some circumstances it may provide for a limited reduction in water quality state within a given band (i.e., where current water quality state is higher than the threshold established for the relevant band), it offers several advantages including:

- It provides for simplicity and consistency of approach;
- The thresholds established in the attribute tables have an independent "effects-based" basis for their derivation;
- It reduces potential complexity associated with management based on a large number of (potentially arbitrary) attribute states;

Alternative approaches to establishing numerical objectives include the use of modelled or measured water quality. While results of water quality modelling could be utilised to establish objectives at a finer spatial scale, this approach has the potential to place unwarranted confidence in the ability of the model to accurately predict water quality at a sub-catchment scale and may result in un-necessary management actions to achieve a nominal water quality state.

Similarly, while monitoring data could be utilised to establish water quality objectives[3], the spatial distribution of monitoring sites is limited, with two WMUs having no current monitoring points (therefore requiring extrapolation of existing water quality state to un-monitored catchments). Some monitoring data is also limited in temporal extent so there is significant uncertainty with statistical estimates of current state (e.g., mean, median or other percentiles) that could result in incorrect

[3] For example, based on a nominal multiplier of existing (numerical) water quality state

assignment of current state and subsequent issues if future monitoring data is used to test compliance with objectives.

In addition, approaches using measured or modelled water quality data would effectively require arbitrary sub-divisions of the water quality attribute states outlined in the attribute tables, a majority of which are associated with a specific (narrative) water quality outcomes and all of which have an effects basis either from the NOF, technical literature or expert assessments. The other advantage of effects-based attribute tables from the NOF and/or technical literature is that a statistical basis for monitoring and assessing attainment of objectives has been developed and defined along with the thresholds in the tables.

Table 1. *Summary comments on assignment of freshwater current state and water quality objectives*

Attribute	WMU	Current State		Objective			
		Band	**Comment**	**Band**	**Numeric**	**Model Results**	**Comment**
E.coli	Taupo	**E**	*3 monitoring sites* ▪ *Northern Hills (Horokiri) - E band* ▪ *Eastern Hills (Pauatahanui) - E band* ▪ *Urban(Porirua) - E band* *Upper catchment areas likely to be in better condition than indicated by E band. Lower catchment areas likely to be impacted by residential/urban development* *Baseline model results indicate all nodes (except 2 in Northern Hills) = E band. 2 exceptions in D band (Northern Hills)*	**B**	*10% / 30% / 130 / 1,000*	*WSUD - 1 B, 2 C*	*Objectives set to meet suitability for contact recreation, statutory requirements and community aspirations.* *Model results indicate that even under the full range of modelled mitigations (i.e. WSUD), E.coli would not meet NOF bottom line, particularly in terms of 95%ile* *Achieving objectives will require measures over and above those considered in the WSUD scenario (with particular emphasis on reducing discharges during high flow events?)*
	Western Headwaters	**E**		**A**	*5% / 20% / 130 / 540*	*WSUD - 1 A, 1 C, 2 D, 1E*	
	Northern Hills	**E**		**B**	*10% / 30% / 130 / 1,000*	*WSUD - 1 A, 2 B, 2 C & 1D*	
	Eastern Hills	**E**		**C**	*20% / 30% / 130 1,200*	*WSUD - 1 B, 1 C, 2 D, 3 E*	
	Urban	**E**		**C**	*20% / 30% / 130 1,200*	*WSUD - 2 C, 4 D, 4 E*	
Ammonia	Taupo	**A**	*6 monitoring sites* ▪ *Northern Hills (Horokiri) - A Eastern Hills (Pauatahanui) - A* ▪ *Urban (4 sites Porirua & Kenepuru) - B or C band* *All modelled sites median in A band. 95%ile A band in Northern Hills and Eastern Hills WMU's, mixture of B and C in Taupo and Urban due to inputs in lower catchment.* *Median concentrations typically low (A) but elevated (B or C) in urban areas due to maximum concentrations associated with wastewater overflows. Upper urban catchment areas likely to be in better condition than indicated by C band.*	**A**	0.03 / 0.005	No improvement from BAU to WSUD	*Current state median generally meets A band except for urban WMU where exceedances are generally associated with wastewater overflows (i.e. annual maximum) rather than median concentrations.* *Objective to maintain current state in all WMUs except urban appropriate. Numerical objectives set at threshold for A band in attribute table* *Objective for Urban achievable under all scenarios with progressively reducing number of sites receiving B and C grades BAU to WSUD* *Measures implemented to achieve other objectives (e.g., E.coli) will also likely improve 95%ile NH_4 concentrations.*
	Western Headwaters	**A**		**A**	0.03 / 0.005	No improvement from BAU to WSUD	
	Northern Hills	**A**		**A**	0.03 / 0.005	All sites A	
	Eastern Hills	**A**		**A**	0.03 / 0.005	No improvement from Current State to WSUD	
	Urban	**C**		**A/C**	0.03 / 2.2	Median at A at current state - maintained in future scenarios Improvement in annual maximum from current state to BAU	

			Current state assigned reasonable although modelling suggests that lower sites in Taupo and at Elden may be impacted by localised inputs in lower catchment.				
Nitrate (toxicity)	Taupo	**A**	*6 monitoring sites* ▪ *Northern Hills (Horokiri) – A* ▪ *Eastern Hills (Pauatahanui) - A* ▪ *Urban (4 sites Porirua & Kenepuru) - 2 A, 2 B* *Median concentrations typically low (A) in rural catchments (Taupo exception) but slightly elevated (B) in urban areas due to elevated 95%ile concentrations (associated with wastewater overflows?)* *Baseline model results indicate a mix of A's and B's across all WMU's (largely based on 95%ile concentrations). Two sites with C in Taupo and Urban WMU's* *Current state assigned based on monitoring results as considered model may be over-estimating 95%ile concentrations.* *Also assume current state assessments for Horokiri and Pauatahanui applicable to Taupo and Western WMU's. This assumption appears reasonable given similarities in physiography and development* *Current state assigned reasonable if assume that model over-predicts 95%ile concentrations*	**A**	1.0 / 1.5	Median A all scenarios, 96%ile A under WSUD, B others	*Current state median meets A band at all monitoring and model sites* *Modelled 95%ile results may be higher than measured (…at least based on existing monitoring and consideration of land use)* *Measures implemented to achieve other objectives in Urban WMU will also likely help achieve 95%ile A band. Also nutrient concentrations required to achieve periphyton objectives likely to limit toxicity effects.*
	Western Headwaters	**A**		**A**	1.0 / 1.5	Median A all scenarios, marginal improvement 95%ile B to A from BAU to WSUD	
	Northern Hills	**A**		**A**	1.0 / 1.5	Median A all scenarios, marginal improvement 95%ile B to A from BAU to WSUD	
	Eastern Hills	**A**		**A**	1.0 / 1.5	Median A all scenarios, marginal improvement 95%ile B to A from BAU to WSUD	
	Urban	**B**		**A**	1.0 / 1.5	Median A all scenarios, marginal improvement 95%ile B to A from BAU to WSUD	
Dissolved	Taupo	**C**	*Four monitoring sires all in Urban WMU (Porirua and Kenepuru) 1*	**A**	0.0024 / 0.0008	Progressive improvement current state to WSUD, A	*Largest impacts associated with urban*

Zinc			*D, 3 C*			achieved under latter	*development, roading or stormwater.*
	Western Headwaters	**D**	*Current state uncertain outside Urban WMU and largely assigned on the basis of baseline model results:* *Taupo C - reflecting SH1 + C&I activities in lower catchment* *Western Headwaters D - reflecting modelled result from Elsden but actual state much be higher depending on local stormwater management (and in upper parts of catchment)* *Northern and Western WMU - most sites modelled A and few risk activities in catchment* *Urban WMU D - reflecting monitoring result from lower Porirua. May be higher in upper catchment* *Current state assignment relatively uncertain particularly in rural catchments due to a lack of data. Assignment largely driven by model results, uncertainty in Taupo and Western where D assigned, may be localised or reflect conservatism in modelling. D current state in Urban may be applicable to lower reaches but upstream areas likely to be in better state*	**A**	0.0024 / 0.0008	Median A under current state, 95%ile shows progressive improvement current state to WSUD, A largely achieved under latter	*Current state median largely A in rural catchments (Taupo exception) but impacted in lower reaches at higher flows.* *Numeric objectives set using upper thresholds for band in attribute table* *Objectives can be largely achieved under improved scenario. Modelling also suggests that B could be achievable in Urban (under WSUD)*
	Northern Hills	**A**		**A**	0.0024 / 0.0008	Median A under current state, A achieved for 95%ile under improved	
	Eastern Hills	**A**		**A**	0.0024 / 0.0008	Median A under current state, 95%ile mix of A,B and C - limited change current state to improved but A achieved under WSUD	
	Urban	**D**		**C**	0.031 / 0.042	Significant improvement under WSUD, A largely achieved	
Copper	Taupo	**D**	*Four monitoring sires all in Urban WMU (Porirua and Kenepuru) 1 D, 2 C, 1 B. Progressive decline down catchment* *Current state uncertain outside Urban WMU and largely assigned on the basis of baseline model results:*	**B**	0.0014 / 0.0018	Median A all scenarios, 95%ile B/C under WSUD	*Largest impacts associated with urban development, roading or stormwater. Current state median A in rural catchments but impacted in lower reaches.* *Numeric objectives set using upper thresholds for Band in attribute table* *Relatively insensitive to mitigations under*
	Western Headwaters	**D**		**A**	0.001 / 0.0014	Median A except for Elsdon site under all scenarios, no change to overall band from current state to WSUD (mostly C & D) due to 95%ile exceedances	

	Northern Hills	**A**	*Taupo C - reflecting SH1 + C&I activities in lower catchment* *Western Headwaters D - reflecting modelled result from Elsden but actual state much be higher depending on local stormwater management (and in upper parts of catchment)* *Northern and Western WMU - most sites modelled A and few risk activities in catchment* *Urban WMU D - reflecting monitoring result from lower Porirua. May be higher in upper catchment* *Current state assignment relatively uncertain, particularly in rural catchments due to a lack of data. Assignment largely driven by model results, uncertainty in Taupo and Western where D assigned, may be localised or reflect conservatism in modelling*	**A**	0.001 / 0.0014	Mostly A under current state, no change under other scenarios	*various model scenarios (some sites improve but not universal)* *Bands for 95%ile decrease under WSUD at Titahi at Titahi Bay and Kenepuru at Mouth.* *Some sites in Urban WMU do not meet C Objective under any scenario – may require additional measures to achieve. Some sites in other WMU's (e.g., Taupo, Elsden) do not meet Objectives under WSUD so may require additional measures?*
	Eastern Hills	**A**		**A**	0.001 / 0.0014	Mostly A under current state, no change under other scenarios	
	Urban	**D**		**C**	0.0014 / 0.0043	Mostly D under current state, some improvement under scenarios to WSUD	
Periphyton	Taupo	**C**	*Current state assigned based on expert assessment using monitoring points within each WMU*	**B**	120	Improve to B under improved & WSUD	*Objective set to generally reduce levels of periphyton.* *Achieving objective based on nutrient concentrations only would significant reductions in TN and DRP based on national guidelines (e.g., Snelder, 2019)* *Potentially difficult to achieve higher band based on assumed ~10% reduction in nutrient concentrations. Will require other measures to achieve objective (e.g. shading, riparian management)*
	Western Headwaters	**A**		**A**	50	Maintain current state	
	Northern Hills	**C**		**B**	120	Improve to B under improved & WSUD	
	Eastern Hills	**C**		**B**	120	Improve to B under improved & WSUD	
	Urban	**C/B**		**B**	120	Generally improve to B under improved & WSUD	
MCI	Taupo	**C**	*Current monitoring at two sites (Horokiri & Porirua). Both sites in B band*	**B**	105 / 100	Objective (B) met under Improved and WSUD	*Objectives set to improve MCI in all WMU's **except** Urban where Objective is to maintain current state*
	Western	**B**		**A**	130 / 120	Limited improvement under all scenarios remain	

	Headwaters		*Current state based on expert assessment at 10 sites (at least one in all WMU's)*			C or B/A	*Expert assessment indicates that A Objective in Western Headwaters and Northern Hills may not be achieved based on modelled scenarios.* *Achieving Objectives may therefore be reliant on a combination of alternative mitigation measures not modelled and improvements to achieve other Objectives (e.g., reduction in sediment load.)*
	Northern Hills	**C/B**		**A**	130 / 120	Improve to B under BUA	
	Eastern Hills	**C/B**		**B**	105 / 100	Improve to B under Improved and WSUD	
	Urban	**C**		**C**	80 / 80	Improve to higher C or B under Improved and WSUD	
Native Fish	Taupo	**C**	*Current state based on expert assessment for 10 sites* *Many streams have excellent diversity of fish species but B or C bands indicate populations under stress or in decline*	**B**		Improve to B under Improved and WSUD scenarios	*No numeric objectives set, narrative approach only* *Achieving objective will be assisted by factors also contributing to improved MCI (e.g. stream shading, reduced sediment loads). In Western Headwaters and Kenepuru may require additional measures to those considered under model scenarios (e.g. reconstructed habitat and fish passage)*
	Western Headwaters	**C**		**A**		Remain C under all scenarios	
	Northern Hills	**B/A**		**A**		Improve to A under Improved and WSUD	
	Eastern Hills	**B**		**A**		Improve to A under WSDC except for lower catchment (B)	
	Urban	**B/C**		**B**		Improve to A or B under Improved and WSDC except for Kenepuru at Mouth which degrades from B to B/C (possibly due to development assumptions?)	

Table 2. *Summary comments on assignment of coastal water current state and water quality objectives*

Attribute	**WMU**	**Current State**		**Objective**			
		Band	**Narrative**	**Band**	**Numeric**	**Model Results**	**Comment**
Enterococci	Onepoto intertidal	**D**	*Four monitoring sites (2 Porirua Harbour, 2 Pauatahanui) - C& D band in Porirua, A & C band Pauatahanui*	**C**	20% / 500	Some sites do not meet C Objective under any scenario due to 95%ile concentrations	*Achieving 95%ile objective may require improvements over and above those assumed in model scenarios (improvements may accrue with measures required to meet E.coli*
	Onepoto-						

	subtidal						*objectives?)*
	Pauatahanui intertidal	**D**		**B**	10% / 200	Some sites do not meet B Objective under any scenario due to 95%ile concentrations	
	Pauatahanui intertidal						
Total Zinc in Sediment	Onepoto intertidal	**B**	*Current state assessment based on monitoring data. Consistency in monitoring sites during baseline period and within replicates at each site* *Current state (B) Onepoto intertidal lower that assigned by expert assessment (A).* *Current state Pauatahanui intertidal (A) differs from expert assessment A/B*	**B**	100		*Objective to maintain current state but will require a commensurate reduction in loading to match reduction in sediment load (i.e., to maintain overall sediment concentrations)* *Noted potential transposition error of current state and objectives for Onepoto and Pauatahanui intertidal?*
	Onepoto-subtidal	**C**		**C**	200		
	Pauatahanui intertidal	**A**		**A**	40	Expert assessment indicates B/C BAU or A/B under Improved and WSUD	
	Pauatahanui subtidal	**B**		**B**	100		
Total Copper in Sediment	Onepoto intertidal	**A**	*Current state assessment based on monitoring data. Consistency in monitoring sites during baseline period and within replicates at each site*	**A**	32		*Objective to maintain current state but will require a commensurate reduction in loading to match reduction in sediment load (i.e., to maintain overall sediment concentrations)*
	Onepoto-subtidal	**B**		**B**	65		
	Pauatahanui intertidal	**A**		**A**	13		
	Pauatahanui subtidal	**A**		**A**	32		
Macro Algae	Onepoto intertidal	**B**	*Monitoring results show 2016 EQR for Onepoto and Pauatahanui = 'Good'. Current state assigned on basis of theses monitoring results.* *Earlier expert assessment*	**B**	6	Expert assessment indicates C band under all scenarios (higher C under WSUD)	*Objective to maintain current state. Likely achievable due to measures required to meet stream dissolved nutrient concentrations and harbour-scale total nutrient loads*
	Pauatahanui	**B**		**B**	6	Expert assessment indicates C band under	

	intertidal		*which assigned C current state for both assumed to be superseded by later monitoring results*			all scenarios	

Table 3. *Summary comments on assignment of harbour sediment current state and water quality objectives*

Attribute	**WMU**	**Current State**	**Comment**	**Objective**	**Comment**
Sedimentation rate	Onepoto Arm	4.1 mm/year	*Sedimentation rate based on harbour model assessment using inputs from catchment water quality model. Harbour sedimentation modelling limited to a single 'representative' year (2010) while catchment model included multi-year variability*	1.0 mm/year	*Only BAU and WSUD scenarios modelled with harbour model (due to time constraints). Numerical objective based on Committee discussions and included consideration of interpolated change in sedimentation rate between various modelled water quality scenarios*
	Pauatahanui Arm	4.7 mm/year	*Sedimentation rate based on harbour model assessment using inputs from catchment water quality model. Harbour sedimentation modelling limited to a single 'representative' year (2010) while catchment model included multi-year variability*	2.0 mm/year	*Based on harbour model reduction in sedimentation rate under WSUD scenario and results from catchment water quality model showing a majority of reductions occurred under Improved scenario, with only marginal reductions under WSUD.* *Based on modelling results alone, adoption of the Improved scenario may get close, but not quite achieve sedimentation rate objective.*

2. Harbour-scale load limits

The WIP establishes harbour-scale limits for Total Nitrogen (TN), Total Phosphorus (TP), Zinc, Copper and sediment which form part of a package for achieving water quality objectives.

2.1.1 Limits and targets for sediment

Harbour-scale sediment load limits were calculated by modelling in-harbour sedimentation rates using catchment sediment losses calculated under the various water quality scenarios. Due to time constraints, modelling of harbour sedimentation rates was undertaken for a single 'representative' year (2010) and limited to the baseline, BAU and WSUD water quality scenarios.

Harbour modelling for the Pauatahanui Arm indicated that a catchment sediment load reduction of approximately 45% would result in a sedimentation rate of 2 mm/year (i.e., the objective identified in the WIP). Based on consideration of outputs from the catchment water quality model it was identified that a majority of sediment reduction (approximately 40%) occurred under the improved scenario, with a relatively small marginal benefit (in terms of reduced sediment loss) associated with significantly increased costs under the WSUD scenario. Based on this analysis a sediment reduction target of 40% from current was adopted in the WIP.

Harbour modelling for the Onepoto Arm indicated a significant reduction in sedimentation rate from the baseline to BAU and WSUD scenarios (4.1, 2.5 and 0.3 mm/year respectively). Again water quality modelling indicated the bulk of the reduction in sediment load occurred under the improved scenario. Based on a linear relationship between modelled sedimentation rates under the various water quality scenarios it was calculated that a sedimentation rate of 1 mm/year (i.e., the objective for the Onepoto Arm) could be achieved with a 40 percent reduction in current sediment load. This figure was adopted as the sediment reduction target for the Onepoto Arm, and is also consistent with the figure adopted for the Pauatahanui Arm.

Comments on the methodology, assumptions and data used to establish sediment loads and reduction targets for inclusion in the WIP include:

- Calculation of loads and reduction targets at a harbour arm scale provides an appropriate spatial scale. Given limited monitoring data, specification of load limits at a catchment or sub-catchment scale would be reliant on model results that have uncertain accuracy at a sub-catchment scale and which are influenced by the assumed spatial distribution of mitigations in the water quality scenarios (which were nominal assumptions in many cases). As acknowledged in the WIP this approach "*does not preclude prioritising and identifying specific catchments based on their relative contribution to the total sediment load, or addressing particular erosion processes*";
- While heavily reliant on interpolation of model results, the overall approach utilised to develop sediment loads and targets follows a logical process which appropriately recognises limitations of the available data;
- Due to model uncertainties, greater emphasis in terms of policy development should be placed on the sediment load percentage reduction target rather than the absolute sediment

load estimate. Future modelling may update or change calculated sediment load estimates creating potential issues meeting absolute numerical load limits. However, the numeric percentage reduction target will ensure progress toward achieving nominated water quality objectives; and

- It is noted that modelling indicates differing sensitivity to the modelled water quality scenarios. A greater percentage reduction in sedimentation rate was observed for a given water quality scenario in the Onepoto Arm compared to the Pauatahanui Arm.

2.1.2 Limits and targets for zinc and copper

The WIP establishes an objective of maintaining the current level of copper and zinc concentrations in sediments in the Onepoto Arm and Pahuatahanui Arm. However, given the target for a 40% reduction in catchment sediment load coming into each arm of the harbour, the WIP identifies a commensurate (i.e., 40%) reduction in total zinc and copper load is required to match the reduction in sediment load.

The proposed approach to managing total zinc and copper loads is a logical measure to avoid an increase in harbour sediment concentrations due to the reduced dilution associated with lower sediment loads.

As with sediment loads, it is suggested that greater emphasis in terms of policy development should be placed on the sediment load percentage reduction target, rather than the absolute load estimates of total zinc and copper. Future modelling may update or change calculated metal load estimates creating potential issues meeting absolute numerical load limits. However, the numeric percentage reduction target will ensure progress toward achieving nominated water quality objectives.

2.1.3 Limits and Targets for Total Nitrogen and Total Phosphorus

The WIP establishes an objective of maintaining the current macroalgae state in the Onepoto Arm and Pauatahanui Arm. To support this objective the WIP establishes a target of maintaining current loads of Total Nitrogen (TN) and Total Phosphorus (TP).

The proposed approach to managing total TN and TP appears reasonable given the water quality objective established. Again, due to inherent uncertainty in model predictions, it is recommended that emphasis is placed on maintaining existing loads rather than absolute numerical load limits for policy development. It is also noted that co-benefits from measures adopted to meet other water quality objectives (e.g. reduced wastewater overflow and stormwater discharges to meet *E.coli*, enterococci and metal objectives, and improved land erosion, stormwater and urban development management to meet sedimentation objectives) may also result in lower TN and TP concentrations to the coastal environment.

3. DIN and DRP nutrient concentration criteria

Periphyton is typically in the C band at the current time across much of the Whaitua (except Western Headwaters WMU which has a current state in the A band). Periphyton objectives in the WIP require maintenance of the existing A band in the Western Headwaters WMU, and a general improvement to the B band across the remaining WMUs.

To assist with achieving these objectives criteria for dissolved inorganic nitrogen (DIN) and dissolved reactive phosphorus (DRP) have been included in the WIP[4]. Numerical values DIN were derived from existing monitoring data, allowing for a 10% reduction in median concentration and a 20% reduction in the 95%ile concentration under the improved water quality scenario. Numerical values for DRP were derived using a similar approach assuming a 30% reduction in median concentrations and a 35% reduction in 95%ile concentrations. Selection of the % reductions to establish the nutrient criteria noted that a majority of reductions in DIN and DRP concentrations occurred under the improved scenario, with limited further improvement under the WSUD scenario. This assumption is consistent with expert assessment which similarly indicated a majority of improvements in periphyton levels occurred under the improved scenario.

The approach outlined for determining DIN and DRP criteria based on monitoring data and modelled water quality improvements under the water quality modelling scenarios is logical and transparent. However, one drawback of this approach is that it relies on a limited number of monitoring sites which may not be fully representative of all sub-catchments within WMUs, and requires assumptions regarding water quality state in WMU's with no existing monitoring.

An alternative approach to utilising actual data would be to establish DIN and DRP using literature figures for nutrient concentrations to achieve periphyton targets. It is understood that application of the approach outlined in Larnard *et al.* (2015)[5] was investigated but ultimately discounted due to:

i) Apparent over-prediction of current periphyton biomass at existing monitoring sites (which may be distinctly different from the sites included in the national dataset used in Larnard *et al.* (2015)), and

ii) The resulting derived nutrient-limiting criteria being substantially lower than existing concentrations in the Porirua Whaitua. While a more recent update of this method (Snelder, 2019[6]) improves the predictive ability of this method, it is understood that application of this modified approach would still result in derivation of DIN and DRP criteria that would, in order to meet WIP periphyton objectives by nutrient limitation alone, be significantly (up to an order of magnitude) lower than those included in the WIP. Such low concentrations appear to be unachievable under the mitigation scenarios modelled.

Overall comments on the DIN and DRP criteria specified in the WIP include:

[4] This is consistent with requirements of the NPS-FM (2017) which states "*To achieve a freshwater objective for periphyton within a freshwater management unit, regional councils must at least set appropriate instream concentrations and exceedance criteria for dissolved inorganic nitrogen (DIN) and dissolved reactive phosphorus (DRP).*"

[5] Larnard, S.T., T Snelder and M Unwin. 2015; *Water Quality in New Zealand Rivers; Modelled Water Quality State*. NIWA Client Report, NIWA, Christchurch, New Zealand.

[6] Snelder, T., 2018 [minor revisions March 2019]; *Nutrient concentration targets to achieve periphyton biomass objectives incorporating uncertainties.* Lower Hutt (NZ): GNS Science. 42p. (GNS Science report; 2018/38).

- The methodology utilised to derive the proposed DIN and DRP criteria based on monitoring data and assumed improvements under the water quality modelling scenarios is simple and transparent. It does however have the drawback of requiring assumptions regarding the representativeness of existing monitoring, and requires existing monitoring data to be extrapolated to WMUs with no data;
- Based on literature values, achieving periphyton objectives on the basis of creating nutrient limiting concentrations alone would likely require reductions in DIN and DRP concentrations significantly greater than criteria listed in the WIP, and which appear to be unachievable under the water quality scenarios modelled;
- While the DIN and DRP criteria listed in the WIP are likely to be sufficient to maintain or slightly improve periphyton state across the Whaitua, they are unlikely to be sufficient on their own to limit periphyton growth to the defined periphyton objective biomass. Achieving the listed objectives is therefore likely to be heavily reliant on additional measures (such as stream shading and riparian management). This appears to be appropriately acknowledged in the WIP; and
- It is noted that the DIN and DRP criteria are specified in the draft WIP as both median and 95 percentile concentrations. I understand that for the purpose of achieving periphyton objectives it is the median criteria that are usually considered most relevant. The use of upper percentile (e.g., 95 percentile) criteria is usually relevant to attributes for toxicity (e.g., nitrate), health risk exposure (e.g., *E.coli*) or other attributes where short-term high concentrations are important for achieving water quality objectives. It may therefore be worth considering specifying only median criteria for DIN and DRP in the WIP for assisting with periphyton management. This approach would be consistent, for example, with the NPS-FM NOF table criteria for TN and TP concentrations in lakes to achieve trophic state objectives. Under the suggested approach, data medians from future monitoring would be tested against the median DIN and DRP criteria.

4. Summary

The Te-Awarua-o-Porirua Whaitua Implementation Programme (WIP) establishes objectives, limits and targets for a range of water quality attributes that are intended to achieve water quality outcomes identified by the Whaitua Committee. Based on a review of the methodologies utilised, I consider the objectives, limits and targets for individual water quality attributes have been derived on a clear and logical basis, which provides appropriate acknowledgement of uncertainties in the available data and modelling.

Yours Sincerely

Brydon Hughes