Technical Advice on Discharge to Water Standards

Advice on Proposed Standards

Taumata Arowai

25 February 2025

Project name	Technical Advice on Discharge to Water Standards
Document title	Technical Advice on Discharge to Water Standards | Advice on Proposed Standards
Project number	12656252
File name	12656252_REP - Technical Advice on Discharge to Water Standards - REVC_Final Draft.docx
Status	FINAL (Rev 0)
Date of issue	25 February 2025
Acknowledgement is given to the contributing authors across the GHD, Beca and Stantec collaborative team, as well as their colleagues who provided technical input and advice to develop and refine the content presented in this report.	

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Executive summary

The Water Services Authority – Taumata Arowai is developing National Standards for wastewater treatment in line with the ministerial instruction to develop a 'single' national wastewater treatment Standard that will apply to new or renewed resource consents for publicly operated wastewater treatment plants (WWTPs) in New Zealand[1]. In line with this policy directive, Taumata Arowai engaged Ernst & Young Strategy and Transactions Limited (EY) and Tonkin & Taylor Ltd (T+T) in early 2024 to undertake a Performance Standards Options Assessment for wastewater discharges to water, and this work subsequently recommended initial environmental performance Standards for wastewater discharge to receiving waters.

As part of this process Taumata Arowai also engaged a Technical Review Group (TRG) to provide expert feedback on the draft Standards developed by EY and T+T. The TRG is made up of stakeholders including highly experienced technical practitioners, regional councils, network operators and te ao Māori experts. The TRG reviewed and considered the options for a discharge to water Standard and provided feedback on the preferred option presented. This feedback also highlighted areas that required further technical advice.

As such, GHD, Beca and Stantec have been engaged to respond to specific technical queries arising from the early work done by EY and T+T. This report documents the scope of the technical queries raised (as outlined in Section 1) and the respective technical responses to those queries (Section 2 onwards), including further development of the recommended numerical Standards and relevant rationale, assumptions and additional supporting material.

The content of this report is intended to assist Taumata Arowai in the preparation of the Discussion Document, which will be used to formally consult with a range of stakeholders in March 2025.

This scope of work is limited to responding to the specific technical queries and excludes consideration of Māori perspectives because Taumata Arowai has a separate process in place for this.

This report is subject to, and must be read in conjunction with, the limitations set out in section 1.2 and the assumptions and qualifications contained throughout the Report.

The inserted slide pack below provides an executive summary of the key outcomes and recommendations in response to the specific technical queries that comprise the scope of this project. The respective methodologies, rationale and assumptions are documented in more detail throughout the report. The slide pack summary therefore must be read in conjunction with the full report.

[1] As directed by the Local Water Done Well Legislation, detailed on the Department of Internal Affairs website, here: **Water Services Policy legislation and process - dia.govt.nz**

Discharge to Water Standards | Proposed Discharge Standards (Final Deliverable – Summary Slide Pack)

Building on the T&T/EY work and the Technical Review Group. This was the Task Breakdown for this stage of the work:

Part 1: Technical Limits for the Discharge to Water Standards:

1. Advice on categorisation of receiving environments

1. **How should we define open ocean and inshore water receiving environments**
2. **How should we define the high dilution and low dilution freshwater receiving environments**

2. Advice on categorisation of receiving environments

1. **Should we take a load or concentration approach to setting nutrient limits for freshwater environments. This should include consideration of setting an ammoniacal-nitrogen toxicity limit in conduction with mass load limits for total nitrogen and total phosphorus.**
2. **Nutrient limits for freshwater receiving environments that are already degraded (high in-stream load), versus receiving environments which are less degraded (low in-stream load).**
3. **Nutrient limits for high flow and low flow environments in freshwater, likely based on seasonal changes in flow.**
4. **Open ocean BOD limit**
5. **Open ocean TSS limit**
6. **All RE : Approach to UVT (UV transmissivity) as a proxy for spot sampling for pathogens. This should include consideration of UV dosing and whether it is appropriate to use UVT and dosing in place of pathogen sampling.**

Part 2: Assessment of coherence and effectiveness

3. Review treatment limits across all parameters and receiving environments to provide assurance that:

1. **Treatment limits are internally consistent and there is relativity across the limits**
2. **Treatment limits represent a cost-effective approach to consenting of wastewater treatment plants.**

Purpose of Discharge Standards

Standardisation and Simplification of Consenting for Wastewater Discharges

AND

Management of Effects in the Receiving Environment to maintain or improve outcomes

- The purpose of discharge standards is to protect against a variety of potential effects in the receiving water body and enable the maintenance or improvement of water quality (aka NPS FM)
- The parameters selected were developed to reflect most of the effects that could result from a treated wastewater discharge. These include:
  - o $cBOD_5$, reflects the potential for the discharge to reduce the oxygen in the receiving water
  - o Total suspended solids (TSS), relates to a number of potential effects; smothering of the river bed, visibility of plume
  - o Ammoniacal Nitrogen (Amm-N) is, typically, the primary cause of toxicity of the discharge
  - o Total Nitrogen (TN) and Total Phosphorus (TP) reflect the potential for the discharge to cause nutrient effects in the water body including:
    - ➢ Increased periphyton cover in hard bottom streams
    - ➢ Overgrowth of plants, algae and bacteria in the water body (i.e. : eutrophication)
    - ➢ Toxicity impacts on humans (from nitrates) if used as drinking water
  - \- E.coli & Enterococci, indicates the potential for risks to public health through exposure to pathogens from contact with the discharge in the water body, primarily from contact recreation and consumption of shellfish

Purpose of Discharge Standards

Aspects not addressed by the proposed standard:

- Some effects are not directly covered by the treated wastewater standards as proposed by Part 1 and will therefore remain covered by Regional Councils during consenting processes.
- These include:
  - Volume of discharge: relates to site specific effects such as scour, and also the scale of the discharge compared to the receiving water body, particularly with regard to cumulative effects of multiple discharges to the same water body
  - Cumulative effects of nutrient load which impacts the down-stream water bodies, i.e., later stages of the river, estuary, harbour or river mouth – currently tangentially addressed by the dilution ratio for rivers only
  - Other effects e.g.: odour, noise, location of discharge structures and bypasses, disturbance of stream bed/CMA, coastal occupation

Compliance with the proposed standards will, to an extent, reduce the risks of effects from non-specified contaminants as a result of co-regulation with those for which standards have been defined. These other risks and contaminants include:

- Toxicity of metals and other contaminants, such as pesticides, drugs, antibacterial agents, PFAS etc.
- Presence of artificial chemicals such as microplastics etc. with largely unknown effects
- Bioaccumulation of contaminants in organisms in the receiving water body, particularly mercury, PCBs.
- Bioaccumulation can also have a human health impact upon eating affected organisms, particularly filter feeders, such as molluscs. This is further to the pathogen risk which is explicitly covered in the discharge standards on the basis of faecal indicator organisms and the proposed QMRA process for shellfish.

Overall Rationale

- Clear definitions of discrete receiving environments
- A precautionary approach has been used for the development of these Proposed Standards, addressing both environmental and public health aspects.
- Categories of receiving environment types were defined based on existing NZ sources where they exist or amendments to them where required.
- An assessment of the impact of these “end of pipe” standards has incorporated consideration of assimilative capacity / reasonable mixing through the use of an assumed dilution ratio. This has enabled an assessment against relevant NZ receiving water guidelines.
- The Proposed Standards have been compared with international treated wastewater standards.
- An assessment has been made on available treatment technologies and relative scale of the discharge in determining the potential effects of the proposed Standards in terms of required treatment plant upgrades.
- A preliminary assessment of the current consent limits has been undertaken. This will be further advanced as part of the confirmation of the proposed treatment limits.
- High level consideration has been given to the existing and potential future legislative frameworks and implications of these Proposed Standards on new and existing consenting processes for WWTPs. This is anticipated to be addressed in more detail in the Regulatory Impact Statement.
- These Proposed Standards are intended to be applied irrespective of the degradation status of the receiving water body. It is anticipated that the application of these Standards will generally improve water quality.

Definition of receiving environment – Recommended categories

Proposed Category*	T&T Category	Definition	Definition Source
Lakes	Static freshwaters	Body of standing freshwater, which is entirely or nearly surrounded by land. It includes lakes and natura ponds but excludes any artificial ponds. Typically, low energy environment in which dispersion/dilution is limited by an absence of strong water currents.	RMA - amended.
Rivers and streams	Flowing freshwaters	A continually flowing body of fresh water, including streams and modified watercourses, but excludes any artificial watercourse (including an irrigation canal, water supply race, canal for the supply of water for electricity power generation, and farm drainage canal).	RMA - amended.
Estuaries	Inshore waters	A partially enclosed coastal body of water that is either permanently or periodically open to the sea in which the aquatic ecosystem is affected by the physical and chemical characteristics of both runoff from the land and inflow from the sea. It includes features variously named on the NZMS 1:50,000 topographic maps as estuary, creek, firth, inlet, gulf, cove, river mouth, bay, lagoon, stream, fjord, sound, haven, and basin**.	NIWA - amended
Low energy coastal		Area that is sheltered from large waves and long period waves. Occur in gulfs and behind islands and reefs on the open coast and includes recessed harbours and embayments.	NIWA - amended
Open ocean#	Open coast	Water that is remote from estuaries, fiords, inlets,sheltered harbours, and embayments, Typically >500m from a shoreline and relatively high energy for mixing.	RMA – amended

Notes:

***Excluded in Receiving Environment Categories :** Freshwater and Coastal natural or modified natural wetlands, salt marsh, groundwater, intermittent streams, seepage from the base of ponds or wetlands which may enter water, constructed wetlands (part of treatment process or land contact)

List of NZ estuaries are provided in the ***Assessment of the eutrophication susceptibility of New Zealand Estuaries* report by NIWA (See pg. 53 onwards)

Distance of >500m derived from information provided the Wastewater outfalls – International perspectives relative to New Zealand paper.

Risk Hierarchy Based on Dilution

- The degree of risk of each of adverse effects occurring depends on the nature of the water body into which the discharge occurs. The proposed discharge categories have been derived to reflect the variable degree of risks in each water body.
- Typically, the relative degree of risk of effects would follow this hierarchy, with highest risks at top and lowest at the bottom:
  - River or stream with dilution ratio <10 (very low)
  - River or stream with dilution ratio >10 and <50 (low)
  - River or stream with dilution ratio >50 and <250 (moderate)
  - Lakes and estuaries >50
  - Low energy coastal/inshore water >100
  - River or stream with dilution ratio >250 (high)
  - Open ocean >1000
- As the risk of effects decreases, then the treatment standard would be expected to be less stringent.
- We note that this hierarchy of effects can be affected by site specific considerations, which cannot be addressed by national standards.

Approach to Dilution Ratio – Freshwater

A dilution ratio approach has been adopted because it is simple, is understood by regulators/practitioners, and removes the need for detailed and complex dispersion modelling. Also used in other jurisdictions (Canada, US, Switzerland, EU). It is intended to be a proxy for mixing, assimilative capacity in the receiving environment and relative scale of the discharge in relation to waterbody volumes/flows. Approach adopted is

$$\mathrm{DR} = \frac{Q_{effluent+}\ Q_{upstream}}{Q_{effluent}}$$

$Q_{effluent}$ = Design annual median discharge volume in m^3/day

$Q_{upstream}$ = Mean Annual 7-Day Low Flow (MALF) in m^3/day

Assumption made include:

- Where there was a potential range, the lowest dilution ratio was used for each category. This gave a “worst case” concentration in the water body for each condition
- The dilution ratio is derived for “design annual median” discharge flow and the 7-day MALF which represents the lower flow in the river and hence is precautionary.
- Concentration in the water body upstream of the discharge is zero. Whilst this may be accurate for some parameters, it would not be true for TN and TP, however on balance with the points expressed above, the overall outcome is still considered precautionary.

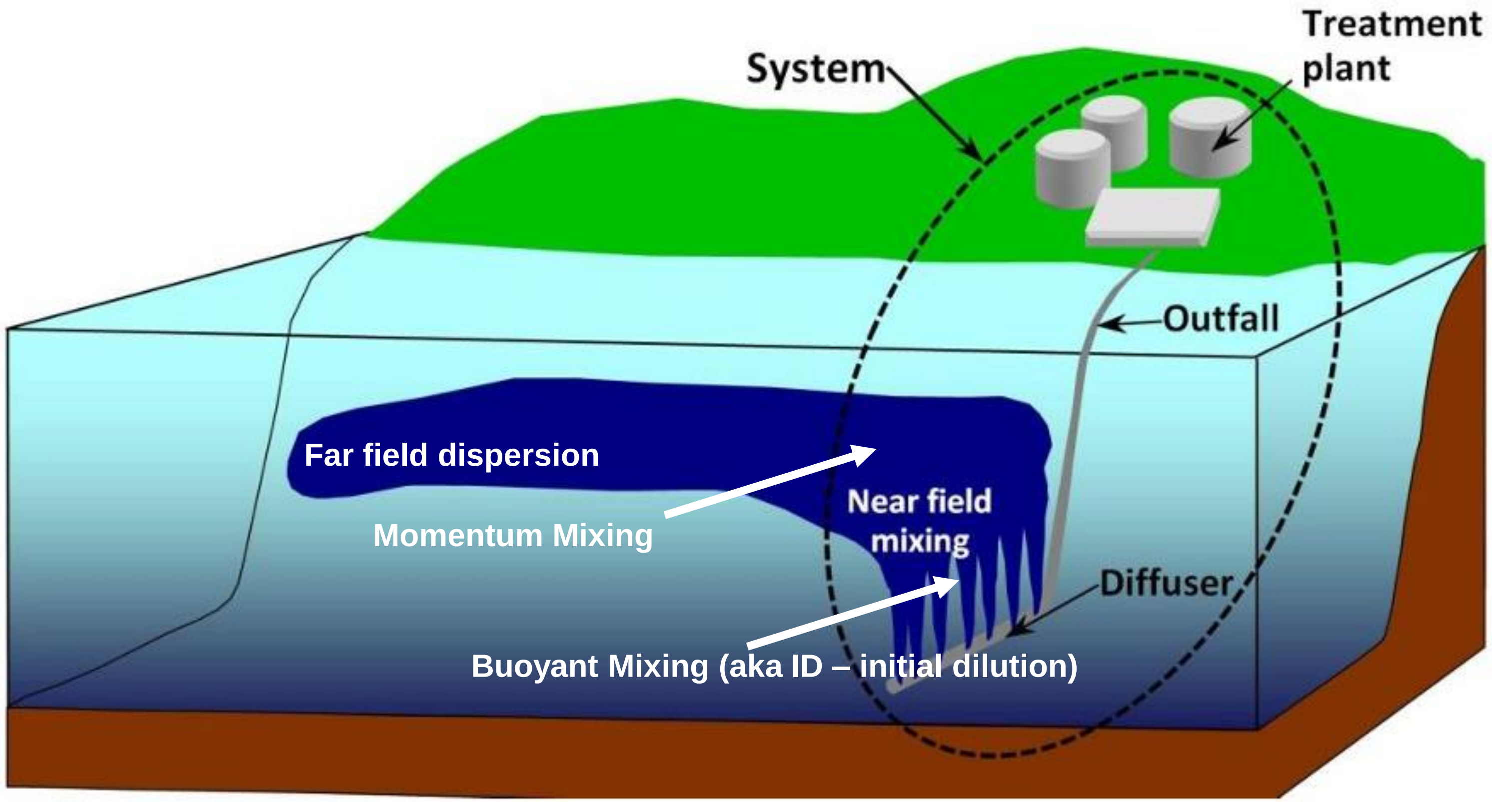
Approach to Dilution Ratio – Coastal

As freshwater effluent leaves a diffuser it initially mixes with the seawater as it rises to the surface = Buoyant Mixing

The diluted rising plume then moves away from above the diffuser, with further dilution occurring = Momentum Mixing

This combined mixing is termed Reasonable Mixing – assumed as the **"Dilution Ratio (DR)"** for the 3 Ocean + Coastal receiving water categories

Ocean/tidal currents and wind then move the plume away from the diffuser, with some further mixing with seawater – termed Far Field Dispersion



Adapted from: Philip J. W. Roberts, Henry J. Salas, Fred M. Reiff, Menahem Libhaber, Alejandro Labbe, James C. Thomson, *Marine Wastewater Outfalls and Treatment Systems,* IWA Publishing, 2010

Receiving Environment Categories and assumed dilution ratios

Receiving Environment	Category	Assumed Dilution ratio*
River or Stream	Very low dilution river	<10
	Low dilution river	>10 and <50
	Moderate dilution river	>50 and <250
	High dilution river	>250
Lakes	Lake	>50
Estuaries	Estuary	>50
Low Energy Coastal	Low Energy Coastal	>100
Open Ocean	Open Ocean	>1000

Notes:

* Intended to be achieved in the receiving environment after full or reasonable mixing

Minimum dilution ratios were used to inform development of treatment limits of Proposed Standards and is precautionary

Determination of Relevant Receiving Environment for Discharge

Receiving environment	Receiving Environment Selection Criteria	Category
River or Stream	The dilution ratio for the discharge is >250	High Dilution River
	The dilution ratio for the discharge is <250 but >50	Moderate Dilution River
	The dilution ratio for the discharge is <50 but >10	Low Dilution River
	The dilution ratio for the discharge is <10	Very Low Dilution River*
Lakes	- The discharge is located beyond the littoral zone of the lake, AND - Achieves a minimum centreline dilution of the plume of 20 at 100m from the diffuser as modelled by CORMIX at nominal low velocity conditions (nominated as depth averaged velocity of 0.01 m/s or the current velocity which is exceeded 90% of the time).#	Lake
Estuaries	- The discharge is within the spatial extent of the estuary as given by the Assessment of the eutrophication susceptibility of New Zealand Estuaries report by NIWA. - Is NOT into a stationary area of the estuary, AND - Achieves a minimum centreline dilution of the plume of 20 at 100m from the diffuser as modelled by CORMIX at nominal slack water conditions (nominated as depth averaged velocity of 0.02 m/s or the current velocity which is exceeded 90% of the time). #	Estuaries
Open Ocean	- The discharge is not within the spatial extent of an estuary, as defined above. - Further than 500m from mean high water spring (MHWS), OR covered by a minimum of 10m water depth through entire tidal cycle, AND - Achieves a minimum centreline dilution of the plume of 100 at 100m from the diffuser as modelled by CORMIX at nominal slack water conditions (nominated as depth averaged velocity of 0.02 m/s or the current velocity which is exceeded 90% of the time).#	Open Ocean
Low energy coastal	- The discharge is not into an estuary, or the open ocean as defined above, AND - Achieves a minimum centreline dilution of the plume of 20 at 100m from the diffuser as modelled by CORMIX at nominal slack water conditions (nominated as depth averaged velocity of 0.02 m/s or the current velocity which is exceeded 90% of the time).#	Low Energy Coastal

Notes

* Under this category the Proposed Standards do not apply (i.e., discharge consent should be applied for under the standard RMA process).

Dilution assessment undertaken for the Q_effluent as defined in the earlier slide.

If the discharge does not meet the Receiving Environment Criteria under any relevant receiving environment, it does not fall into a defined receiving environment under the Proposed Standards and the discharge consent should be applied for under the standard RMA process.

Basis of Standards

Standard	Supporting evidence / examples
5-day Biochemical Oxygen Demand ($cBOD_5$)	• No receiving water guidelines available for $cBOD_5$ in NZ, as effect is monitored through dissolved oxygen concentrations in the receiving environment. • International standards – Switzerland / EU, England, Canada • Refer to 5-day carbonaceous biochemical oxygen demand ($cBOD_5$) as this is an industry-accepted test method
Total Suspended Solids	• No receiving water guidelines available for TSS in NZ, as effect is monitored through visual clarity and deposited sediment measurements in the receiving environment. • International standards – Switzerland / EU, England, Canada
Total Nitrogen	• Only nationally derived nutrient guidance is from ANZECC 2000 (unchanged as ANZG 2018). All recent NZ guidance is for regional or place based limit setting. • Compared against default guideline values for general nutrient effects (physico-chemical stress) from ANZG 2018, using NZ Region for Rivers and South-eastern Australian region for other categories (e.g., coastal). For dilution ratios less than 10, there may be nitrogen-based issues in the water body. • Considered effects on Periphyton growth in rivers from MfE 2022 "Guidance on look-up tables for setting nutrient targets for periphyton". Only apply to hard-bottomed rivers. Considered the lowest and highest targets for unshaded sites (to achieve protection of 95% of sites) as precautionary approach. Current proposed Standards would not be sufficiently protective for periphyton. • International standards – England, Colorado (USA)
Total Phosphorus	• Only nationally derived nutrient guidance is from ANZECC 2000 (unchanged as ANZG 2018). All recent guidance is for regional or place based limit setting. • Compared against default guideline values for general nutrient effects (physico-chemical stress) from ANZG 2018, using NZ Region for Rivers and South-eastern Australian region for other categories (e.g., coastal). This indicates potential concerns at the lower half of the dilution ratio ranges for all rivers. • Considered effects on Periphyton growth as for total nitrogen. • International standards – Switzerland / EU, England, USA (Alabama, Colorado & Minnesota)
Total Ammoniacal Nitrogen	• Compared with default guideline values for toxicity for ammoniacal nitrogen in fresh and marine waters (ANZG 2018). Used 95^{th} and 99^{th} percentiles (conservative). General compliance, except for <dilution ratio of 10, with both guidelines provided that 100% of river flow or at edge of mixing zone available for mixing. • The international jurisdictions we reviewed did not have relevant/specific standards for ammonia.
Faecal Indicator Bacteria (public health)	• A standard was derived based on contact recreation in the receiving environment (MfE 2003, Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas), which was used to back-calculate the end-of-pipe standard (assuming the lowest dilution ratio from the ranges identified). • A, QMRA approach for shellfish consumption has been proposed.

Considerations for nutrients

Smaller WWTPs

- Total nitrogen and total phosphorus standards will not apply for existing WWTPs servicing population <1,000. This is on the basis that these WWTPs are expected to be have a low contribution of nutrients to a water body as compared to the wider catchment.
- Ammonia toxicity is considered for small plants.

Periphyton growth

- Periphyton growth is, primarily, a concern for hard bottom rivers and streams.
- The NZ Periphyton Guidelines were considered in the development of the proposed nutrient based Standards (TN and TP).
- Outcomes are that the Proposed Standards may not be sufficiently protective in all circumstances.
- The less sensitive ecosystems would comply for Bands B and C, but not A.
- The most sensitive ecosystems would not be sufficiently protected by the Proposed Standards.
- It is proposed that discharges to hard bottomed streams would undertake a site-specific assessment and approach to minimise adverse impacts

Considerations for nutrients

Nutrient Mass Loads

- Mass Load Standards (expressed in kg/day) have not been proposed for TN and TP. The mass load of these parameters may increase over time in response to increased influent flows to the WWTP and this may give rise to downstream effects.
- The mass load from a WWTP discharge contributes to the potential for cumulative adverse effects in the immediate receiving environment and beyond along side all other catchment contributors.
- The Proposed Standard will provide the required end of pipe concentrations and Regional Councils will consent the volume of treated wastewater discharged. Together these are used to calculate mass load.
- It is proposed that the TN and TP mass loads discharged from a WWTP are considered in the context of the wider catchment through a periodic review process by the relevant regional council and that a staged approach to asset upgrades can be undertaken to manage changes in load over the term of the consent.

Seasonality

- Seasonal variation of flows into and out of a wastewater treatment plant has the potential to affect the quality and volume of the treated wastewater that is discharged. Seasonal consideration include :
    - Lower receiving environment flows and potential for increased sensitivity to eutrophication in summer.
    - An increase in flow to a WWTP in winter and a reduction in nutrient removal efficiency in biological processes in colder temperatures.
- The Proposed Standard accommodates seasonal variations through the use of the precautionary approach used to establish receiving environment criteria and treatment limits and the management of the loading to the environment through the use of the Annual Median Design Flow. Further, potential seasonal impacts on treatment plant performance are addressed through engineering good practice in the treatment plant design process such that most biomechanical treatment plants are designed to deliver the required level of treatment at these lower temperatures.

Public Health Standards

- There is minimal international precedent for applying end-of-pipe standards for pathogens in treated wastewater (using faecal indicators, e.g., enterococci, E. coli, total faecal coliforms).
- Most international examples apply receiving environment standards (e.g., bathing water quality) directly to the discharge, which is considered to be unduly restrictive for these Proposed Standards because it does not take into account assimilative capacity and dispersion in the receiving waterbody.
- Criteria for public health adopted from MfE 2003 Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas - for contact recreation in fresh (E.coli) and marine (Enterococci) waters. The guidelines for a Microbiological Assessment Category (MAC) Grade of A were used to back-calculate the proposed Standard.
- Guidelines for shellfish gathering (faecal coliforms) are more restrictive. Shellfish gathering beds are typically further away from the discharge point and, hence, subject to more dilution. However, Quantitative Microbial Risk Assessments (QMRAs) have generally found that where shellfish beds are present, this mode of exposure has the highest risk of leading to illness.
- Adopted approach:
  - Identify the appropriate limit for contact recreation in the receiving environment, and back-calculate, using the lowest dilution ratio for each category of marine and freshwater environments, to determine end-of-pipe standard.
  - For coastal and estuarine discharges, a QMRA approach has been proposed for a discharge which could impact upon shellfish beds. This is based on relevant pathogens rather than indicator organisms.

Limiting Factors

- Potential inter-relationships between the Standards include:
  - E.coli standard may require that the treated wastewater be clearer than required to comply with the TSS standard
  - TP standard may require greater solids removal than that required to comply with the TSS standard
  - TN standard may require a higher level of biological treatment than required to comply with the $cBOD_5$ standard
  - If a high organic load is received (from trade waste), then the $cBOD_5$ standard may require a higher level of biological treatment which reduces the TN concentration to less than its standard

- There may be other inter-relationships depending upon the specifics of each WWTP.
- The potential for a single parameter to be the limiting factor in the design of a WWTP is normal and is not considered to be an issue for the standards.

Proposed Discharge Standards for >1,000 population

Category	$cBOD_5$ (mg/L)	Total Suspended Solids (mg/L)	Ammoniacal Nitrogen (toxicity) (mgN/L)	Total Nitrogen* (nutrient) (mgN/L)	Total Phosphorus* (nutrient) (mgP/L)	E.Coli (Public Health) (cfu/100mL)	Enterococci (Public Health)~ (cfu/100mL)
Statistic Used:	Annual median	Annual median	Annual 90%ile	Annual median	Annual median	Annual 90%ile	Annual 90%ile
Lakes#	15	15	3	10	3	6,500	N/R
Rivers and streams							
• Low Dilution Ratio	10	10	1	5	1	1,300	N/R
• Moderate Dilution Ratio	15	15	3	10	3	6,500	N/R
• High Dilution Ratio	20	30	25	35	10	32,500	N/R
Estuaries#	20	25	15	10	10	N/R	2,000
Low energy coastal	50	50	20	10	10	N/R	4,000
Open ocean	N/R	N/R^	50	N/R	N/R	N/R	40,000

Notes:

-This table must be read in conjunction with the defined receiving environment information and the selection criteria for the relevant receiving environment information.

- Standard to apply at end of discharge pipe direct from plant to receiving water OR piped discharge from constructed wetland to receiving water.

- Ammoniacal Nitrogen limit of 1mg/l as Annual 90%ile will be challenging and will require a fully nitrifying WWTP. This is achievable with current technology.

Lakes and estuaries, use same Standard for nutrients as moderate dilution ratio from Rivers and Streams.

* More restrictive Standards to control potential periphyton issues may apply for total nitrogen and phosphorus for discharges to hard bottom streams (Site specific assessment is required for discharge to hard bottom streams).

- N/R indicates that recommendation is for no Standard to be imposed for this parameter and receiving environment as not relevant to potential effects.

- N/R^ Control on TSS will result from achievement of the Enterococci standard for public health.

Proposed Discharge Standards Small Plants <1,000 population

Propose that a different set of Standards applies to existing treated wastewater discharges that serve a population equivalent less than 1,000, these exclude the TN/TP limits from the full set of standards.

These refined Standards are proposed to apply to existing discharges from smaller WWTP's, and the full Standards will apply to new discharges from all sizes of WWTP.

Definition of small WWTP's proposed to be based on influent $cBOD_5$ load of 85 kg/day to account for variability in flow and load factors when relying purely on a flow or population-based threshold.

Consideration was given to whether a specific allowance should be made for oxidation ponds, given the number of such sites across the country, particularly where they are operating well and are not causing significant environmental effects.

Further to the removal of the total nutrient limits, the following changes could be made for smaller plants, including those using oxidation ponds (seeking feedback), however it is noted that this would add a further layer of complexity to the Standard:

- End of pipe standards for E. coli or Enterococci could be made less stringent, particularly where limited human contact with receiving waters occurs.
- Limits could use dissolved $cBOD_5$ rather than total and the TSS limit could be reduced recognising that solids discharged from a well operated WWTP are likely to be algae solids (this may not regulate smaller plants that are not oxidation ponds).
- Operational requirements could be applied, such as regular desludging, appropriate loading rates.

Proposed Discharge Standards Small Plants <1,000 population

Category	$cBOD_5$ (mg/L)	Total Suspended Solids (mg/L)	Ammoniacal Nitrogen (toxicity) (mgN/L)	E.Coli (Public Health) (cfu/100mL)	Enterococci (Public Health)~ (cfu/100mL)
Statistic Used:	Annual median	Annual median	Annual 90%ile	Annual 90%ile	Annual 90%ile
Lakes#	15	15	3	6,500	N/R
Rivers and streams					
• Low Dilution Ratio	10	10	1	1,300	N/R
• Moderate Dilution Ratio	15	15	3	6,500	N/R
• High Dilution Ratio	20	30	25	32,500	N/R
Estuaries#	20	25	15	N/R	2,000
Low energy coastal	50	50	20	N/R	4,000
Open ocean	N/R	N/R^	50	N/R	40,000

Notes:

- This table must be read in conjunction with the defined receiving environment information and the selection criteria for the relevant receiving environment information.

- Standard to apply at end of discharge pipe direct from plant to receiving water OR piped discharge from constructed wetland to receiving water.

- Ammoniacal Nitrogen limit of 1mg/l as Annual 90%ile will be challenging and will require a fully nitrifying WWTP. This is achievable with current technology.

Lakes and estuaries, use same Standard for nutrients as moderate dilution ratio from Rivers and Streams.

- N/R indicates that recommendation is for no Standard to be imposed for this parameter and receiving environment as not relevant to potential effects

- N/R^ Control on TSS will result from achievement of the Enterococci Standard for public health.

UVT for Monitoring Microbial Contaminant Levels

- It has been concluded ultraviolet light transmissivity (UVT) alone is not appropriate as a proxy for spot sampling of Faecal Indicator Bacteria to indicate the presence of pathogens and is not recommended for use for this purpose.
- The use of UV dose measurement however is considered a suitable alternative approach for monitoring effluent quality in relation to pathogens where UV disinfection is installed.
  - The current technology is able to support this approach without significant cost increase from standard offerings
  - The continuous monitoring (& potential for automated) reporting provides the owner and regulator with greater certainty of continuous compliance and early warning of potential failures
  - Operationally, it is likely to be more cost effective than laboratory based sampling and testing of many grab samples
  - The threshold dose requirement would be particular to a WWTP. Its establishment could be included in a Particular Condition to the Consent
  - Guidance on the use of UV Dose based monitoring could be provided.
- The use of 'whole of plant' Log10 Reduction Values (LRV) is another possible alternative.
  - But the set-up process can be complex, site specific, and time consuming requiring a lot of time based data initially.
  - As such the adoption of LRV as part of the Proposed Standard is not recommended.

Implications for technological choice

- Proposed Standards are not testing limits of technology and technology to meet them is available in NZ.
- For pond based upgrades
  - Note many systems do not currently have power supply to the site
  - Lesser choice of reliable, available options
  - Membrane or DAF for removal of TSS, or treatment by UV for pathogen inactivation. Tertiary membranes may not require UV
  - Fixed film options if nitrification is required (e.g. MABR, MBBR))
  - Provide beneficial wet weather flow balancing to keep discharge rates down.
- For larger scale, bio-mechanical plants – significantly more choice of proven, reliable technologies. However, the biological choices for very low TN are reasonably limited.
- Some very small plants may need to be fully replaced if a very low TN, nearing limit of technology, is required.

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1. Introduction

The Water Services Authority – Taumata Arowai (herein referred to as Taumata Arowai), under its statutory authority conferred by the Water Services Act 2021, is developing National Wastewater Treatment Standards that will apply to new or renewed resource consents for publicly operated wastewater treatment plants (WWTPs). Consistent with the proposed legislation amendments announced by the Minister of Local Government in August 2024, principally revisions of the Water Services Act 2021, the Resource Management Act 1991, and the Local Government (Water Services) Bill, the proposed changes seek to implement “a single Standard rather than a minimum (or maximum), which would be implemented in resource consents”.

The government’s objectives for these amendments is the need to:

- Provide directive provisions that ensure regional councils implement a single standard approach in resource consents and cannot set additional or higher requirements than the standard in consenting conditions (apart from on an ‘exceptions’ basis).
- Allow Taumata Arowai to set infrastructure and operating requirements that, if implemented by a wastewater operator, will meet the treatment requirements in the Standard.
- Allow an easier resource consenting path or ’pre-consented option’ for lower-risk small-scale modular wastewater treatment plants that meet the wastewater environmental performance Standard.”

The proposed new approach intends to[2]:

- Reduce the regulatory burden by ensuring environmental regulation in water services legislation is proportionate to risk and benefit
- Deliver much greater standardisation of treatment systems and related infrastructure
- Enable material cost efficiencies in the design, build and operation of wastewater systems
- Provide councils with greater certainty of costs

In line with this policy directive, Taumata Arowai engaged Ernst & Young Strategy and Transactions Limited (EY) and Tonkin & Taylor Ltd (T+T) in early 2024 to undertake a Performance Standards Options Assessment for wastewater discharges to water. The initial environmental performance Standards recommended through this assessment for wastewater discharge to receiving waters are summarised in Table 1.

Table 1 Proposed wastewater discharge to water Standards for all WTTPs as proposed by T+T

Parameter	Open coast	Inshore waters	Static Freshwaters	Flowing Freshwater
BOD_5 (mg/L)	<25 (or a COD limit of <125)	<25 (or a COD limit of <125)	<10 (or a COD limit of <75)	<25 (or a COD limit of <125)
TSS (mg/L)	<35	<20	<20	<20
TN (mg/L)	<15	<10	<5	<10
TP (mg/L)	<10	<10	<1	<10
E. coli (cfu/100 mL)	-	<130	<130	<130
Enterococci (cfu/100 mL)	1,000	<40	-	-

Feedback received from the Technical Review Group convened by Taumata Arowai to review and comment on the draft Standards, highlighted the need for further technical advice on specific matters and a high-level check that the proposed discharge to water Standard is coherent and is a cost-effective approach to consenting of WWTPs.

To undertake this assessment and progress work on the discharge to water Standard, Taumata Arowai engaged GHD, and subconsultants Stantec and Beca, to provide technical advice on the following specific matters, as defined in the Consultancy Service Order (CSO):

[2] **Department of Internal Affairs (2024) Factsheet: Standards to help reduce water infrastructure costs**

Part 1: Technical limits for the discharge to water Standard

1. Advice on categorisation of receiving environments:
   1.1 How should Taumata Arowai define open ocean and inshore water receiving environments
   1.2 How should Taumata Arowai define the high dilution and low dilution freshwater receiving environments – definitions should include detailed methodologies, including how to calculate flow and dilution
2. Advice on treatment limits:
   2.1 Should Taumata Arowai take a load or concentration approach to setting nutrient limits for freshwater environments. This should include consideration of setting an ammoniacal-nitrogen toxicity limit in conduction with mass load limits for total nitrogen and total phosphorus.
   2.2 Nutrient limits for freshwater receiving environments that are already degraded (high in-stream load), versus receiving environments which are less degraded (low in-stream load).
   2.3 Nutrient limits for high flow and low flow environments in freshwater, likely based on seasonal changes in flow. *(note there should be four values for TN and TP in each of the discharge to freshwater columns – i.e. high load high flow, high load low flow, low load high flow, low load low flow)*
   2.4 Open ocean BOD limit
   2.5 Open ocean TSS limit
   2.6 Approach to UVT (UV transmissivity) as a proxy for spot sampling for pathogens. This should include consideration of UV dosing and whether it is appropriate to use UVT and dosing in place of pathogen sampling.

Part 2: Assessment of coherence and effectiveness

3. Review treatment limits across all parameters and receiving environments to provide assurance that:
   3.1 Treatment limits are internally consistent and there is relativity across the limits
   3.2 Treatment limits represent a cost-effective approach to consenting of wastewater treatment plants.

The scope therefore excludes consideration of Māori perspectives which is intentionally not addressed in this document since Taumata Arowai has a separate process in place for this.

To address the specific matters above the following process was followed:

- For each specific matter a technical team and challenge team of highly experienced technical practitioners was put together.
- The technical team worked together to provide a preliminary response to the specific matter.
- The preliminary response was then presented to the challenge team, and other project team members, in a workshop setting. In this setting the challenge team 'challenged' the preliminary outputs, and associated rationale and assumptions, and provided recommendations and technical advice regarding the outputs. Other team members were also welcomed to provide input where appropriate. Representatives from Taumata Arowai were also in attendance at the workshop, as observers, and provided early feedback, which was incorporated by the technical teams.
- Post workshops, a draft version of this document, rationale, assumptions and proposed approach for each specific matter was then presented to Taumata Arowai.
- Following feedback from Taumata Arowai, the content of this document was then refined by the technical team, reviewed by the technical leads again, and progressed to finalisation.

Acknowledgment is given to the various unnamed team members who contributed to this process and ultimately the delivery of the content presented in this document.

1.1 Purpose of this report

The purpose of this report is to provide specific technical advice to support Taumata Arowai in the development of National Wastewater Standards for discharges to water to propose a set of numerical standards and relevant additional material to assist Taumata Arowai in the preparation of the Discussion Document which will be used to formally consult with a range of stakeholders in March 2025.

This report documents the methodology, rationale, assumptions adopted and consideration of potential implications for implementation, and a review and update of the receiving environment categories and treatment limits proposed by T+T (Table 1). It summarises the revised recommendation for a Proposed Discharge to Water Standard (herein referred to as Proposed Standard) for wastewater discharges and it also outlines other additional matters, which were not within the original scope of works of this assignment but require further consideration in relation to the discharge to water Standards.

This report should be read in conjunction with the slide deck included in the executive summary of the report, and the list of estuaries in Appendix A.

1.2 Limitations

This report: has been prepared by GHD and subconsultants, Beca and Stantec, for Taumata Arowai and may only be used and relied on by Taumata Arowai for the purpose agreed between GHD and Taumata Arowai as set out in section 1.1 of this report.

GHD and its subconsultants otherwise disclaim responsibility to any person other than Taumata Arowai arising in connection with this report. GHD and its subconsultants also exclude implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD and subconsultants in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD and its subconsultants has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

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GHD and it subconsultants have not been involved in the preparation of the Taumata Arowai Discussion Document (which will be used for consultation) and have had no direct contribution to the Taumata Arowai Discussion Document other than in the development of this report for the purpose as stated in Section 1.1. GHD and its subconsultants exclude and disclaim all liability for all claims, expenses, losses, damages and costs, including indirect, incidental or consequential loss, arising directly or indirectly in connection with the Taumata Arowai Discussion Document.

GHD and its subconsultants have prepared this report on the basis of information provided by Taumata Arowai and others who provided information to GHD and its' subconsultants (including Government authorities), which GHD and its subconsultants have not independently verified or checked beyond the agreed scope of work. GHD and its subconsultants do not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

1.3 Assumptions

This report has been prepared on the basis of the following general assumptions:

- The information contained in the National Consents Database of wastewater consents, developed by Taumata Arowai, is a reflection of the number, location, type and discharge point of publicly operated wastewater treatment plants in New Zealand. This database has been updated by Taumata Arowai with the best available information, as part of this work, to inform the recommendations provided within this report. However, it requires verification and validation and as some information is known to be inaccurate. Information, values and analysis contained in this report which has leveraged the database is therefore subject to change following verification and validation of the database.
- National information on flow data from the Ministry for the Environment River Flows Geospatial data base (last updated 10 November 2021, and accessed on 29 November 2024), is a true and correct.
- In addition to the Government's objectives set out in the introduction of this report, GHD and its subconsultants have assumed that the intent of the discharge Standards is also to protect against a variety of potential effects in the receiving water body, to adequately protect public health and to enable the maintenance or improvement of receiving water quality.
- In 2024 the Government signalled that the National Policy Statement for Freshwater Management, 2020 (NPSFM) will be replaced in the near future. Hence, the numerical limits for the Proposed Standard have not relied on alignment or comparison with those set out in the NPSFM. The development of the Proposed Standard has, instead, referred to a range of specific technical documents which were commissioned to inform the development of the NPSFM.
- The Proposed Standard will not directly address potential effects beyond those parameters presented in the numerical limits. However, compliance with the Proposed Standard will reduce the risks of other related effects as a result of co-regulation of the relevant contaminants along with those for which standards have been defined.

- The Proposed Standard does not propose numerical limits for treatment plants with separate municipal and industrial treated wastewater streams, blended prior to discharge. These plants pose different risks to plants that are predominantly municipal in nature and therefore how these sites are consented in relation to the Proposed Standards needs to be established.
- Under current RMA requirements, consent renewals are considered “de novo” which means that the application for a renewal is considered as if it is a new consent application, and it has been assumed that this practice will continue. The assessments undertaken in this report have assumed that any consents issued for treated wastewater discharges will include treatment requirements or other conditions set out in the wastewater standards.
- There is a proposal that, where there is shellfish gathering near a discharge point in coastal waters, a QMRA process is required, which may determine revised treatment limits and appropriate upgrading and / or operating requirements (see Section 2.2.2.5).

More specific assumptions related to each task outlined in the Consultancy Services Order (CSO) are provided in the respective sections.

1.4 Precautionary Approach

A precautionary approach has been applied to this technical work and the development of the numerical standards proposed in this document, addressing both environmental and public health aspects. The precautionary approach applied recognises that, instead of treatment limits being set on a plant-specific basis as is currently the case, under the Proposed Standards treatment limits for some parameters will be set for multiple plants that fall within a category or class. For example, all plants that discharge to a particular receiving environment and dilution category will be subject to the same numerical limits. The intention being that the treatment limits that apply to all the plants in that class are set at a level that protects public health and the environment for all the plants in that class, notwithstanding there will be variation between plants in areas like the sensitivity of the receiving environment, or human contact in or near the receiving environment. We note that due to these local variations, the precautionary approach is applied “overall” and is not intended to achieve the most precautionary outcome for every factor and situation. A small number of exceptions to the Standard are also anticipated and will be identified in Taumata Arowai’s Discussion Document.

Key water quality parameters that reflect most of the potential for adverse effects in the receiving environment in relation to wastewater discharges were selected for inclusion in the numerical limits and dilution categories are proposed to be implemented based on low flow conditions and address the expected discharge volume that a plant is designed for across the consent term. The numerical limits have been proposed with reference to relevant guidelines and limits commonly used in New Zealand and where necessary have drawn on international references where a more local option is not available.

For some aspects, the Standards have been designed to enable a more tailored approach such as enabling the application of Quantitative Microbial Risk Assessment (QMRA) where shellfish beds may be affected or site-specific consideration of risk of excessive periphyton growth in hard bottomed streams. This approach minimises the need for exclusions to the Standard and enables) treatment limits and management of effects to be tailored to some specific site or plant-specific factors, notwithstanding the overall approach of standardisation.

Further specific detail on these elements is presented throughout Section 2 of this report.

1.5 Overview of WWTP

Outlined below is a snapshot of information obtained from the Taumata Arowai National Consents Database of wastewater consents. Table 2 summarises the number of wastewater treatment plants which discharge to the identified initial receiving environments. Table 3 categorises the size of the wastewater treatment plants, and Table 4 provides a summary of the different types of treatment provided. The tables indicate the number of treatment plants in each category.

New Zealand has a large number of small pond based treatment plants with the majority of the national population’s wastewater being treated in a few large, activated sludge based treatment plants.

As highlighted in Section 1.3, the national data base has not been verified at this time, therefore the intent of the tables below is to provide a relative indication of the receiving environments being discharged to, and the various size and configuration of wastewater treatment plants across the country.

It is acknowledged the values reported in the following tables do not align (and in some instance conflict) with values reported later in the report. For example, the Database currently identifies 3 wastewater treatment plants which discharge to lakes or natural wetlands in New Zealand, however as detailed in Section 2.1.1.3, it has been outlined that there is one wastewater treatment plant discharging to a lake and approximately 4 wastewater treatment plants that discharge to natural wetlands in New Zealand. This approximation has come from the knowledge of the subject matter experts involved in the production this report, and their track record of working with numerous wastewater treatment plants across New Zealand. The database on the other hand has been built only using information in the resource consents available at this time.

Table 2 ***Overview of the initial discharge environments (receiving environments) of WWTPs across New Zealand, based on the available information in the National WWTP Consents Database.***

Initial Discharge Environment	Number of WWTPs[3]
Lakes or natural wetlands	3
Rivers and Streams	120
Estuaries	10
Low Energy Coastal	14
Open Ocean	22
Land	161
Unknown	7

Table 3 ***Overview of WWTP sizes, based on the population size serviced.***

WWTP Size	Population Serviced	Number of WWTPs[3]
Small	< 1,000	160
Medium	1,001 - 20,000	130
Large	> 20,000	32
Unknown	Unknown	15

Table 4 ***Overview of WWTP sizes, based on the population size serviced.***

WWTP Treatment Type	Number Of Plants
Activated Sludge	57
Trickling Filters	26
Pond Based	202
Other*	33
* Other plants include recirculating filters, septic tanks among others.	

[3] These values are not verified and subject to change.

2. Technical Basis

2.1 Categorisation of receiving environments

2.1.1 Definition of receiving environment

2.1.1.1 Scope from CSO

> **1. Advice on categorisation of receiving environments**
>
> **1.1 How should we define open ocean and inshore water receiving environments**
>
> 2.2 How should we define the high dilution and low dilution freshwater receiving environments

It is noted that while the scope requires advice on the definition of open ocean and inshore receiving environment *only*, the freshwater categories were also reviewed, with proposed definitions provided.

2.1.1.2 Method

To refine the receiving environment categories, and associated definitions, consideration was given to the types of receiving environments that are subject to wastewater discharges in New Zealand. Within these environments, consideration was given to how they are discrete from one another and how physical characteristics or environmental values are differentiated one from another. Based on this assessment, the receiving environments were then grouped into 4 – 6 receiving environment categories, as preferred by Taumata Arowai.

The process of refining the categories and providing the proposed definitions included the review of the categories presented by T+T, as well as categories and definitions used in existing national legislation, policies, guidelines, and reports. Documents that were reviewed included:

- New Zealand Resource Management Act 1991 (RMA)
- NIWA Glossary of Coastal Terms
- National Policy Statement for Freshwater Management 2020 – Amended October 2024
- National Environmental Standards for Freshwater
- New Zealand Coastal Policy Statement 2021
- New Zealand Municipal Wastewater Monitoring Guidelines (NZWERF, 2022)
- Australian and New Zealand Guidelines (ANZG) for Fresh and Marine Water Quality (2018).
- Assessment of eutrophication susceptibility of New Zealand Estuaries (NIWA, 2018)
- A classification of New Zealand coastal hydrosystems (NIWA, 2016)

Based on the review of the above documents, the receiving environment categories proposed were generally aligned with the categories recommended by T+T, with some added specificity where required.

The definitions of receiving environment categories were drawn from the RMA, supplemented by definitions from NIWA's Coastal Terms Glossary, which was not available in the former T+T document. The purpose of using terms from existing national documents was to provide regulators, practitioners and WWTP operators with definitions that were already used and understood. However, these definitions were amended where they benefitted from further clarity.

2.1.1.3 Rationale

As outlined in Section 2.1.1.2, the categories and definitions proposed are closely aligned to those recommended by T+T, except inshore waters. Based on the review of definitions and the characteristics of the receiving environments that fall into the inshore waters category it was split into two categories, estuaries and low energy coastal (refer to Table 5 below, and Table 6 Section 2.1.1.5). Although the two have similar characteristics, there are also sufficient distinctions that warrant the separate categorisation of estuaries from other low coastal energy environments. These include the following:

- Estuaries are typically a low-energy depositional environment that can be sensitive to nutrients and other contaminants. Thus, they can be subject to eutrophication and over growth of mangroves due to sediment deposition. Sediments derived from land are often laden with urban or rural contaminants which negatively impact on estuarine ecosystems.
- Estuaries often support a diverse range of habitats, threatened native species and parts of aquatic lifecycles, such as īnanga spawning.
- The uses of estuaries differ from those of some other low-energy coastal areas. Many estuaries are used for food gathering and contact recreation, which warrants the need for a higher degree of treatment and therefore, standards, particularly in relation to microbial contamination.

A listing of estuaries in New Zealand is provided in Appendix A, obtained from the 2018 NIWA ***Assessment of the eutrophication susceptibility of New Zealand Estuaries***.

On the other hand, for low energy coastal environments, consideration was given to the number of offshore ocean outfalls there are in New Zealand and the length of these outfalls. Based on the paper by Jim Bradley, **Wastewater outfalls – International perspectives relative to New Zealand**, ocean outfalls in New Zealand are between 500m and 3000m metres in length. Therefore, the low energy coastal environment has been defined with a distance of less than 500m. Greater than 500m from mean high water springs falls into the Open Ocean categorisation.

This distinction was made because low energy coastal environments typically exist closer to the shoreline and are commonly used for bathing, other recreational activities and food gathering. Open ocean environments are typically higher energy locations with deeper water, faster dispersal of contaminants and less subject to bathing and other contact recreation activities.

Wetlands were considered for inclusion in the Proposed Standard.

Following discussions at the Challenge Workshop, dated 29 November 2024, Taumata Arowai clarified that they viewed wetlands as three types, some of which are relevant to the Discharge to Water Standard. A summary of the relevance of wetland types to the Proposed Standard is provided below:

- Constructed wetlands, usually considered part of the treatment process, with discrete outlet pipes into a receiving environment. These would be considered under the Discharge to Water Standards for the respective receiving environment.
- Constructed wetlands with slow diffuse release to receiving water - Standards would apply at point of discharge to the wetland because the flow from the wetland is difficult to measure and monitor.
- Wetlands that receive water at or near the surface which then, filters through to groundwater and to an ultimate surface water body: these are excluded from further consideration in the discharge to water Standard.
- It is understood, from a review of the current (December 2024) version of the Taumata Arowai National Consents Database, and the knowledge of the team involved in this work, that in the region of four[4] WWTPs across the country currently discharge to a natural wetland receiving environment.
- Natural or modified natural wetlands as a receiving water body should be an exception to Standard (see Section 2.1.1.6 for further explanation)

Based on this rationale, the categories and definitions initially proposed have been revised as provided in Table 5.

[4] May be subject to change as per assumption listed in Section 1.3.

Table 5 Proposed receiving environment categories

T+T Category	Category – Originally Proposed	Category – Updated
Static freshwaters	Lakes	Lakes
Flowing freshwaters	Rivers and streams	Rivers and streams
Inshore waters	Estuaries	Estuaries
	Low energy coast	Low energy *coastal*
Open Coast	Open Ocean	Open Ocean

2.1.1.4 Assumptions and potential implications

Based on the scope of works from the CSO and the type of receiving environments WWTPs discharge to in New Zealand, the following are not considered within the proposed receiving environment categories:

- Intermittent streams (NIWA defines them as stream reaches that cease to flow for some periods of the year because the bed can be above the water table at times). Therefore, dilution in the watercourse would be unavailable for portions of the year and when they do not support a flow of water, there would be a discharge to land. This type of receiving environment should perhaps be signalled as unsuitable to receive wastewater discharges under the Discharge to Water Standard.
- Natural or modified natural wetlands.
- Constructed wetlands that release water to groundwater that may eventually enter surface water.
- Groundwater.

In future, consent authorities would need to apply the definitions provided in the Standards so that consistency of application is achieved, and the National Consents Database and reporting is consistent and clear.

2.1.1.5 Recommended definitions

The refined receiving environment categories and definitions are detailed in the slide pack included in the Executive Summary and provided Table 6.

Table 6 Recommended definitions of receiving environments

Category*	T+T Category	Definition	Definition Source
Lakes	Static freshwaters	Body of standing freshwater, which is entirely or nearly surrounded by land. It includes lakes and natural ponds but excludes any artificial ponds. Typically, low energy environment in which dispersion/dilution is limited by an absence of strong water currents.	RMA - amended.
Rivers and streams	Flowing freshwaters	A continually flowing body of fresh water, including streams and modified watercourses, but excludes any artificial watercourse (including an irrigation canal, water supply race, canal for the supply of water for electricity power generation, and farm drainage canal).	RMA - amended
Estuaries	Inshore waters	A partially enclosed coastal body of water that is either permanently or periodically open to the sea in which the aquatic ecosystem is affected by the physical and chemical characteristics of both runoff from the land and inflow from the sea. It includes features variously named on the NZMS 1:50,000 topographic maps as estuary, creek, firth, inlet, gulf, cove, river mouth, bay, lagoon, , stream, fjord, sound, haven, and basin**.	NIWA - amended
Low energy coastal		Area that is sheltered from large waves and long period waves. Occur in gulfs and behind islands and reefs on the open coast and includes recessed harbours and embayments.	NIWA - amended

Category*	T+T Category	Definition	Definition Source
Open ocean#	Open coast	Water that is remote from estuaries, fiords, inlets, sheltered harbours, and embayments. Typically, >500m from a shoreline and relatively high energy for mixing.	RMA – amended
*****Excluded in Receiving Environment Categories: Freshwater and Coastal natural or modified natural wetlands, salt marsh, groundwater, intermittent streams, seepage from the base of ponds or wetlands which may enter water, constructed wetlands (part of treatment process or land contact). **List of NZ estuaries are provided in the ***Assessment of the eutrophication susceptibility of New Zealand Estuaries*** report by NIWA (See pg. 53 onwards) # Distance of >500m derived from information provided the **Wastewater outfalls – International perspectives relative to New Zealand** paper.			

2.1.1.6 Recommended exceptions to the Standards

Pristine waters are an important consideration for regional councils, particularly in relation to freshwater management plans. Hence, an exception to the Standards is recommended for WWTPs that discharge into waterbodies classified as 'pristine waters.'

Currently a standardised definition for the term "Pristine Waters" does not exist in New Zealand, hence, a definition is proposed based on the compulsory national values set out in the National Policy Statement (NPS) for Freshwater Management (2020 Amended Oct 2024). These compulsory values cover ecosystem health, human contact, threatened species and mahinga kai and must be assessed using attributes and numerical values expressed in Appendix 2A and 2B of the NPS:

- Appendix 2A: Attributes requiring limits on resource use for lakes and rivers
- Appendix 2B: Attributes requiring action plans (includes Macroinvertebrate Community Index (MCI), submerged plant communities, Dissolved Oxygen, E. coli and a numerical state value for dissolved reactive phosphorus (DRP) in rivers)

It is recommended that if a waterbody is demonstrated by the applicant and confirmed by the regional council to meet the requirements of Attribute Band A for all attributes, it will be considered a *pristine freshwater body* under the Proposed Standard and must revert to the standard RMA process. This will be applicable for both new and existing discharges.

It is noted that these compulsory attributes do not specifically include nutrients for the purpose of indicating ecosystem effects and that instead, regional councils are required to set limits for Dissolved Inorganic Nitrogen and Dissolved Reactive Phosphorous in their respective Freshwater Management Plans. However, as these are region-specific and vary across the country, reference to these management plans is not proposed for the purposes of this Proposed Standard.

However, a number of the other NPS attributes are influenced by nutrients, and will to some degree, collectively reflect nutrient status. For instance, dissolved oxygen, presence of submerged plants, fish species, macroinvertebrates and ecosystem metabolism, and ammoniacal nitrogen and nitrate are included with respect to toxicity.

It is noted that pristine waters generally occur higher up in the catchment, on lower order streams, and in areas with native bush or other substantive vegetative cover. On the other hand, WWTPs are located lower down in the catchment. However, it is expected that a few WWTPs currently discharge to pristine waters. In line with the precautionary approach the standard will not apply, and resource consent processes will set any treatment requirements for discharge to water body falling under this definition.

Natural or modified natural wetlands were considered for inclusion in the Proposed Standard. Wetlands are very low flow environments that are considered rare and declining categories of ecosystems in New Zealand (over 90% lost due to land management practices/ land use change) thus a precautionary and protective approach should be taken if wastewater is to be discharged to them.

Both natural or modified natural wetlands are considered highly sensitive ecosystems due to their low level of water movement and mixing energy, sensitivity to nutrients and other contaminants, high cultural values and unique communities of flora and fauna.

This current state of natural inland wetland ecosystems in New Zealand is widely acknowledged and the NPSFM specifically sets out to avoid the loss of extent of natural inland wetlands, protect their values and promote their restoration.

Thus, it is proposed that discharges to natural or modified natural wetlands are an exception to the Proposed Standards due to their high sensitivity, highly valued and rare ecosystems of low prevalence in New Zealand. Discharges to these receiving environments will undergo the standard RMA process.

2.1.2 Application of dilution categories

2.1.2.1 Scope from CSO

2. Advice on categorisation of receiving environments

2.1 How should we define open ocean and inshore water receiving environments

2.2 How should we define the high dilution and low dilution freshwater receiving environments

2.1.2.2 Method

As per the CSO scope, dilution has been defined for freshwater-receiving environments. In addition, dilution has also been defined for estuaries, low energy coastal and open ocean environments, with the rationale and assumptions associated with dilution in these environments detailed in Section 2.2.2. Furthermore, the approach to defining dilution for rivers and streams was different from the approach taken for lakes due to their distinct characteristics.

To define dilution for freshwater-receiving environments, the following guidelines, frameworks and regulations from New Zealand and other international jurisdictions were reviewed:

- New Zealand Municipal Wastewater Monitoring Guidelines (NZWERF, 2022)[5]
- European Union Water Directive Framework[6]
- British Colombia Municipal Wastewater Regulation 2012[7]
- Wastewater Systems Guidelines for Design, Operating and Monitoring (Alberta Government, 2013)[8]
- Regulatory Method (WAT-RM-03) Sewage Discharges to Surface Waters (Sottish Environmental Protection Agency, 2022)
- New Hampshire Medium Wastewater Treatment Facility General Permit (US EPA, 2024)[9].

Dilution categories were drawn from New Zealand guidelines (NZWERF, 2022) and supplemented by international standards and guidelines where these were not available. These proposed definitions and categories were also cross-checked with the dilution expected in the receiving environments of existing municipal WWTPs that discharge to fresh waterbodies across the country to assess applicability and relevance.

2.1.2.3 Rationale

River and Streams

Dilution Ratios are proposed to define dilution for rivers and streams. This approach is recommended for the following reasons:

- Includes simple calculations and removes the need for dispersion modelling which can be complex and expensive.
- Dilution ratios are clearly understood by regulators and practitioners.
- Using dilution ratios for wastewater treatment regulations is also common in other jurisdictions, including Canada, the US, Switzerland and the European Union.

[5] NZWERF (2022) New Zealand Municipal Wastewater Monitoring Guidelines
[6] European Commission (2000) Water Framework Directive
[7] British Columbia Municipal Wastewater Regulation 2012
[8] Alberta Government (2013) Wastewater Systems Guidelines for Design, Operating and Monitoring
[9] US EPA (2024) New Hampshire Medium Wastewater Treatment Facility General Permit

The proposed approach to calculating dilution ratio (DR) is provided by Eq.1.

$$\mathrm{DR} = \frac{Q_{effluent+}\, Q_{upstream}}{Q_{effluent}} \qquad \text{(Eq. 1)}$$

Where:

$Q_{effluent}$ = Design annual median discharge volume in m^3/day

$Q_{upstream}$ = Mean Annual 7-Day Low Flow (MALF) in m^3/day

The design annual median discharge volume is proposed for $Q_{effluent}$ because it is less likely to be skewed by peak flows and avoids the need to define "Peak Flow" which is highly variable. The use of the design median flow i.e.: the largest median flow predicted over the term of the consent means that the assigned limit is based on the highest potential for impact.

It is also considered that the use of the design median discharge volume enables plant design to accommodate both summer and winter treatment plant performance in a manner that enables it to meet the required numerical Standards.

Some WWTPs will experience significant growth over the term of the consent (currently anticipated as 35 years) such that the dilution ratio for the flows at the start of the period is more than at the end, assuming that the MALF value remains the same over this period. This may result in a more stringent treatment requirement being applied from the very start of the consent term. To balance the need for increased treatment capacity over time, related to growth and to spread out the timing of the associated investment, it is recommended that an applicant consider a staged approach to implementation of the Proposed Standard over the term of the consent. The benefit being that the asset owner would be able to optimise the timing of treatment plant upgrades in response to population growth whilst also meeting the appropriate treatment standard. This staged approach to WWTP upgrades is already common in existing consents and allows a cost effective response to development within the catchment.

$Q_{effluent}$ should be nominated by the consent applicant and included in the consent issued for the discharge. Linking it to the term of the consent enables the timing of upgrades and review of overall contaminant loadings to the receiving environment to be reviewed at renewal.

The 7-day MALF is recommended for $Q_{upstream}$ as it provides a precautionary dilution ratio estimate for rivers or streams that receive wastewater discharge. The MALF also accounts for low flow receiving environments and low flow conditions that arise due to seasonal variations.

In a "mix and match" scheme, the discharge occurs to both land and water with discharge to each receiving environment being limited to specific periods of the year. Typically, this will involve discharge to land during "summer" to avoid low flow periods in the river coupled with discharge to water in winter, or when river flows are higher. Other combinations are possible. In this instance, the plant would apply both the discharge to water Standard and the discharge to land Standard respectively, in the relevant portions of the year. When applying the discharge to water Standard, the flows which are used to determine the dilution ratio, should be limited to the period in which discharge is intended. It is proposed, therefore, that the median wastewater flow should be tailored to the discharge period not the full year and the relevant "low flow" in the river should be limited to the period for which discharge is intended, rather than the 7-day MALF.

This may mean that the discharge to water has a higher dilution ratio and hence is subject to less stringent limits for the period when discharge to water is occurring than would be the case for a year-round discharge to water. This could result in a more cost-effective scheme, particularly if an upgrade to the WWTP is not required to meet the adjusted discharge limits.

Flows into and from wastewater treatment plans can vary seasonally across the year and may also affect the dilution ratios and treated wastewater quality achieved. However, on balance it is considered that the application of the Proposed Standard is flexible enough to accommodate this variability. This is explained further in Section 2.2.1.5.3.

In the first instance, the MALF (or relevant stream flow in relation to mix and match scheme) should be derived from real time continuous measured flow data, if it is available for the immediate receiving environment. The data record should cover a minimum period of at least 5 years. Where MALF calculations are undertaken they should be based on full hydrological years (July to June) and MALF should be calculated by averaging the lowest seven-day rolling mean flow for each year on record. Where measured data is not available, it is recommended that the MALF is determined using the latest version of the Ministry for the Environment 'River Flow' geospatial data[10].

The dilution ratio categories to define dilution for rivers and streams have been adopted from the NZWERF Wastewater Monitoring Guidelines (2002). These guidelines grouped WWTPs in NZ based on 'poor', 'moderate', or 'excellent' dilution at 100 m from the outfall. The categories were defined according to the dilution ratio of the WWTPs and the visible characteristics of the discharge plume. Although Taumata Arowai initially proposed categorising freshwater-receiving environments into two dilution categories, four categories, aligned with the intent of the monitoring guidelines, are recommended and proposed to capture the dilution characteristics of low-flow receiving environments appropriately. These are very low, low, moderate and high (further detailed in Section 2.1.2.5).

The initially considered categories were assessed against categories defined by Canadian and Scottish guidelines and regulations to check for consistency, with Table 7 providing a comparison of this.

Table 7 Comparison of dilution categories

Source	Low	Moderate	High
New Zealand Municipal Wastewater Monitoring Guidelines	<50	50 – 250	>250
British Colombia Municipal Wastewater Regulation 2013	10 – 40 (< 10 is prohibited)	40 – 100	>100
Scottish EPA Regulatory Method (WAT-RM-03) Sewage Discharges to Surface Waters	<30 (<10 requires enhanced treatment or refusal of discharge)	30 – 400	>400

The proposed categories were refined based on the above to include a very low dilution ratio (< 10) and subsequently then also compared with the dilution ratios of existing WWTPs in New Zealand to assess their applicability[4]. This resulted in the development of Table 8 which indicates that within the very low dilution category, 16 treatment plants in New Zealand discharge into extremely low dilution environments of <5 and <2 times dilution. This is generally not a desirable outcome based on increased potential for adverse effects and international precedent where it would be either prohibited or require an elevated level of treatment to be applied.

[10] **River flows | MfE Data Service**

Table 8 Assessment of how WWTP in New Zealand, discharging to freshwater environments, would fall into the defined dilution categories. Note – Preliminary Assessment, not to be relied on as correct or validated at this time

Dilution Category	Plume expected 100m Downstream (amended from NZWERF, 2022)	Number of WWTP[11]	# of plants <1000 PE	# of plants >1000 PE
Very low (<10)	Conspicuous, persistent plume. Very slow to dissipate	22	8	14
Less than 5	*As above*	*12*	*4*	*8*
Less than 2	*As above*	*4*	*0*	*4*
Low (>10 and <50)	Conspicuous and persistent plume due to low flow/dilution. Slow to dissipate	21	9	12
Moderate (>50 and <250)	Noticeable but intermittent plume near the discharge which will dissipate.	32	18	14
High (>250)	No visible plume	73	43	30

Lakes

Based on the review of national and international approaches (US, Canada and Europe)[12] to defining dilution for lakes, it is proposed, that the standards for lakes are not differentiated based on level of dilution. Instead, a single precautionary standard, which is aligned with the moderate dilution category for rivers and streams, is applied for the following reasons:

- Due to the scale of the water body, static nature and often slow currents, mixing zone modelling has usually been undertaken.
- Lakes are sensitive environments and often subject to eutrophication, used for contact recreation, and considered to have high cultural value.
- Setting a single, precautionary standard would potentially disincentivise new or reconsenting applications for considering lakes as potential discharge locations and this is appropriate given the sensitivities referred to above.

A relatively precautionary standard would also likely incentivise other discharge options, such as land-based disposal or other innovative approaches.

Due to lakes' susceptibility to eutrophication and use for contact recreation, standards for nutrients and pathogens have been recommended as a priority.

The dilution requirements proposed for the Lakes receiving environment category are set out in Section 2.1.3.

Estuaries, Harbours, Low Energy Coastal and Open Ocean

The initial mixing dilution requirements for these environments is documented in Section 2.1.3 and the anticipated levels of dilution achieved beyond the initial mixing zone is indicated in Table 9 and outlined in Section 2.2.2.4.

2.1.2.4 Assumptions and potential implications

When assessing the standards relevant to a WWTP that discharges into river or stream, the following assumptions and implications related to use of dilution and dilution ratios should be considered:

- Dilution is proposed as a proxy for mixing, dispersion and assimilation capacity of the waterbody. It does not take into account the upstream concentrations of contaminants to enable a cumulative effect to be considered. It effectively assumes the existing concentration of contaminants from the upstream catchment is zero.

[11] The total number of plants listed here differs from the total number of plants discharging to lakes or wetland, and rivers and streams in Table 2. This is due to the changing nature of the information obtained from the National Consents Database (which is subject to further change as per the assumption detailed in Section 1.3) and the refinement of this information by the technical team based on industry knowledge and experience.

[12] **PSCI (n.d) Guidance for calculating dilution factors considering mixing zones**

- Dilution ratio for rivers and streams is expressed as if the discharge was fully mixed in receiving environment and assumes that the full flow of the river is available for mixing. The design and placement of the discharge pipe or diffuser should strive to meet this objective.
- Dilution is considered in immediate receiving environment, which may include a small or highly modified natural channel. This is on the basis of fish spawning and naturalisation observed in some of these small channels from recent consenting experience.

2.1.2.5 Recommended dilution categories

The assumed dilution ratios intended to be achieved in the receiving environment after full or reasonable mixing for each of the receiving environment categories are detailed in the slide pack provided in the Executive Summary and provided in Table 9.

Table 9 Receiving environment categories and assumed dilution ratios.

Receiving environment	Category	Assumed Dilution ratio
River or Stream	Very low dilution river	<10
	Low dilution river	>10 and <50
	Moderate dilution river	>50 and <250
	High dilution river	>250
Lakes	Lake	>50
Estuaries	Estuary	>50
Low energy coastal	Low Energy Coastal	>100
Open Ocean	Open Ocean	>1000
Notes: * Intended to be achieved in the receiving environment after full or reasonable mixing Minimum dilution ratios were used to inform development of treatment limits of Proposed Standards and is precautionary.		

2.1.2.6 Recommended exceptions to the Standards

Based on the National Consents Database, and refined dilution analysis in Section 2.1.2.3, it appears that 22 WWTPs discharge into very low (<10) dilution environments in rivers and streams. Fourteen of these are medium or large-size WWTPs.

Based on the relatively high risk of adverse environmental or public health outcomes, discharge into these environments, it is recommended that an exception to the Standards in relation to very low dilution ratios is included, requiring the applicant to revert to the existing RMA consenting process.

This would also apply to lakes, estuaries and low energy coastal environments unable to meet initial mixing criteria as set out in Section 2.1.3.

This would require the applicant to demonstrate how the adverse effects of the WWTP on the receiving environment would be mitigated and granting of consent would be at the discretion of the Regional Council.

2.1.3 Determination of Relevant Receiving Environment for Discharge

When determining which part of the Proposed Standard will apply to their discharge, an applicant will use the following criteria to determine which receiving environment and hence treatment limits apply. A precautionary approach has been adopted through the use of 7-MALF and close to slack water conditions for dilutions.

If the discharge does not comply with the relevant criteria, or if any of the exceptions specified to the Proposed Standards apply to the discharge or receiving environment, then the Proposed Standard does not apply to the discharge, and consenting will follow the standard RMA process.

In this situation, the applicant can either change the proposed discharge to comply with the criteria and avoid the exclusions or submit an application for the discharge which would be processed under the standard RMA process. Generally, these would be situations with low mixing and very low available dilution, but where minimal alternatives are available for the discharge.

In the Freshwater environment, (i.e. upstream of the boundary of the Coastal Marine Area), the method and criteria to determine the relevant category is:

- Discharge into a River or Stream:
  - Applicant to determine the dilution ratio (DR) for the discharge (according to Section 2.1.2.3)
    - If DR >250, then the high dilution river category will apply
    - If DR <250 but >50, then the medium dilution river category will apply
    - If DR <50 but >10, then the low dilution river category will apply
    - If DR <10, then the Standard does not apply to the discharge.
- Discharge into a lake:
  - Applicant to determine if the discharge point into the lake complies with the following:
    - Is located beyond the littoral zone of the lake, **AND**
    - Achieves a minimum centreline dilution of the plume of 20 at 100m from the diffuser as modelled by CORMIX using the $Q_{effluent}$ as defined in Section 2.1.2.3, Eq 1) at nominal low velocity conditions (nominated as depth averaged velocity of 0.01 m/s or the current velocity which is exceeded 90% of the time).
  - If the discharge complies with the criteria, then the lakes category applies.

In the Coastal environment (i.e., downstream of the boundary of the Coastal Marine Area), the method and criteria to determine the relevant category is:

- Discharge into an estuary:
  - Applicant to determine if the discharge is within the spatial extent of the estuary as given by the **Assessment of the eutrophication susceptibility of New Zealand Estuaries** report by NIWA (See pg. 53 onward)
  - Applicant to determine if the discharge section of the outfall into the estuary complies with the following:
    - Is NOT into a stationary area of the estuary, **AND**
    - Achieves a minimum centreline dilution of the plume of 20 at 100m from the diffuser as modelled by CORMIX using the $Q_{effluent}$ as defined in Section 2.1.2.3, Eq 1) at nominal slack water conditions (nominated as depth averaged velocity of 0.02 m/s or the current velocity which is exceeded 90% of the time).
  - If the discharge complies with these criteria, then the estuary category applies.
- Discharge into the open ocean:
  - Applicant to determine if the discharge section of the outfall is:
    - Not into an estuary, as defined above, **AND**
    - Further than 500m from mean high water spring (MHWS), OR covered by a minimum of 10m water depth through entire tidal cycle, **AND**

- Achieves a minimum centreline dilution of the plume of 100 at 100m from the diffuser as modelled by CORMIX using the $Q_{effluent}$ as defined in Section 2.1.2.3, Eq 1) at nominal slack water conditions (nominated as depth averaged velocity of 0.02 m/s or the current velocity which is exceeded 90% of the time).
  - If the discharge complies with these criteria, then the open ocean category applies.
- Discharge into a low energy coastal environment:
  - Applicant to determine if the discharge section of the outfall is:
    - Not into an estuary nor into the open ocean, **AND**
    - Achieves a minimum centreline dilution of the plume of 20 at 100m from the diffuser as modelled by CORMIX using the $Q_{effluent}$ as defined in Section 2.1.2.3, Eq 1) at nominal slack water conditions (nominated as depth averaged velocity of 0.02 m/s or the current velocity which is exceeded 90% of the time).
  - If discharge complies with these criteria, then the low energy coastal category applies.

It is noted that the centreline dilution of the plume at 100m from the diffuser as modelled by CORMIX represents an initial phase of mixing, influenced to a large degree by the location of the outfall and design of the outfall diffuser. Thus, a range of discharge configuration options can be relatively easily, and cost effectively, assessed and evaluated against the required criteria.

The dilution ratio achieved after reasonable mixing as used to develop and assess the proposed Standards in other sections of this report will be significantly more than this initial value. This minimum centreline dilution is only relevant for this determination of the relevant receiving environment.

The criteria for determining the relevant receiving environment for the discharge is summarised in Table 10 below.

Table 10 Criteria for determining the relevant receiving environment, and therefore dilution category.

Receiving environment	Receiving Environment Selection Criteria	Category
River or Stream	The dilution ratio for the discharge is >250	High Dilution River
	The dilution ratio for the discharge is <250 but >50	Moderate Dilution River
	The dilution ratio for the discharge is <50 but >10	Low Dilution River
	The dilution ratio for the discharge is <10	Very Low Dilution River*
Lakes	– The discharge is located beyond the littoral zone of the lake, **AND** – Achieves a minimum centreline dilution of the plume of 20 at 100m from the diffuser as modelled by CORMIX at nominal low velocity conditions (nominated as depth averaged velocity of 0.01 m/s or the current velocity which is exceeded 90% of the time)[#]	Lake
Estuaries	– The discharge is within the spatial extent of the estuary as given by the Assessment of the eutrophication susceptibility of New Zealand Estuaries report by NIWA. – Is NOT into a stationary area of the estuary, **AND** – Achieves a minimum centreline dilution of the plume of 20 at 100m from the diffuser as modelled by CORMIX at nominal slack water conditions (nominated as depth averaged velocity of 0.02 m/s or the current velocity which is exceeded 90% of the time)[#]	Estuaries
Open Ocean	– The discharge is not within the spatial extent of an estuary, as defined above. – Further than 500m from mean high water spring (MHWS), OR covered by a minimum of 10m water depth through entire tidal cycle, **AND** – Achieves a minimum centreline dilution of the plume of 100 at 100m from the diffuser as modelled by CORMIX at nominal	Open Ocean

Receiving environment	Receiving Environment Selection Criteria	Category
	slack water conditions (nominated as depth averaged velocity of 0.02 m/s or the current velocity which is exceeded 90% of the time). #	
Low energy coastal	– The discharge is not into an estuary, or the open ocean as defined above, **AND** – Achieves a minimum centreline dilution of the plume of 20 at 100m from the diffuser as modelled by CORMIX at nominal slack water conditions (nominated as depth averaged velocity of 0.02 m/s or the current velocity which is exceeded 90% of the time)#	Low Energy Coastal

Notes:

* Under this category the Proposed Standards do not apply (i.e., discharge consent should be applied for under the standard RMA process).

Dilution assessment undertaken for the $Q_{effluent}$ as defined in Section 2.1.2.3, Eq 1

- If the discharge does not meet the Receiving Environment Criteria under any relevant receiving environment, it does not fall into a defined receiving environment under the Proposed Standards and the discharge consent should be applied for under the standard RMA process.

2.2 Proposed treatment limits

2.2.1 Freshwater treatment limits

2.2.1.1 Scope from CSO

2. **Advice on treatment limits:**
   - 2.1 **Should we take a load or concentration approach to setting nutrient limits for freshwater environments. This should include consideration of setting an ammoniacal-nitrogen toxicity limit in conduction with mass load limits for total nitrogen and total phosphorus.**
   - 2.2 **Nutrient limits for freshwater receiving environments that are already degraded (high in-stream load), versus receiving environments which are less degraded (low in-stream load).**
   - 2.3 **Nutrient limits for high flow and low flow environments in freshwater, likely based on seasonal changes in flow.**
   - 2.4 Open ocean BOD limit
   - 2.5 Open ocean TSS limit
   - 2.6 Approach to UVT (UV transmissivity) as a proxy for spot sampling for pathogens. This should include consideration of UV dosing and whether it is appropriate to use UVT and dosing in place of pathogen sampling.

2.2.1.2 Method

The method for developing these Proposed Standards for freshwater has followed the below general approach:

- Categories of receiving environments were developed as described in Section 2.1 of this Report, with four dilution ratio categories specified for freshwater (Section 2.1.2.5).

The Proposed Standards were developed based upon a combination of receiving environment factors and wastewater treatment process capabilities for each contaminant of concern. The parameters selected were developed to reflect most of the effects that could result from a treated wastewater discharge. These include:

- $cBOD_5$, reflects the potential for the discharge to reduce the oxygen in the receiving water.
- Total suspended solids (TSS), relates to a number of potential effects; smothering of the river bed, visibility of plume.
- Ammoniacal Nitrogen (Amm-N) is, typically, the primary cause of toxicity of the discharge.
- Total Nitrogen (TN) and Total Phosphorus (TP) reflect the potential for the discharge to cause nutrient effects in the water body including:
  - Increased periphyton cover in hard bottom streams.
  - Overgrowth of plants, algae and bacteria in the water body (i.e. eutrophication).
  - Toxicity impacts on humans (from nitrates) if used as drinking water.
  - E. coli & Enterococci, indicates the potential for risks to public health through exposure to pathogens from contact with the discharge in the water body, primarily from contact recreation and consumption of shellfish.

It is noted that some effects will not be directly covered by the treated wastewater Standards, whilst some will be co-regulated (refer to Section 2.3.2.3 (Co-regulation of Contaminants)).

The proposed numerical limits for the selected parameters were then reviewed and adjusted through the following method:

- Concentrations in the water body after mixing with the discharge were derived for each category and relevant parameters using the Proposed Standard divided by the dilution ratio and then compared to relevant guidelines. Assumptions made in this approach include:

- Where there was a potential range in dilution ratio, the lowest dilution ratio was used for each category. This gave a 'worst case' concentration in the water body for each condition.
- The dilution ratio is derived for the 'median' design discharge flow and the 7-day MALF which represents the lower flows in the river. Therefore, it will result in a calculated concentration in the water body which is at the higher end of predictions, hence is precautionary.
- For lakes, a dilution ratio in the receiving environment of >50 has been assumed to represent a minimum dilution ratio in a reasonably mixed scenario as context for the development of numerical treatment limits.
- Concentrations in the water body upstream of the discharge have been assumed to be zero. Whilst this may be accurate for some parameters, it would probably not be true for TN, TP and E. coli, and is not precautionary. However, at this level of assessment, it is the only way of providing an indication of potential effects and on balance the overall approach remains precautionary thus reducing the risk of adverse outcomes.

Receiving environment guidelines utilised in the development of these Proposed Standards included the following:

- Australian and New Zealand Guidelines for Freshwater and Marine Water Quality (ANZG, 2018). Default Guideline Values.
- Ministry for the Environment and Ministry of Health. Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas (2003).
- Ministry for the Environment (2022). Guidance on Look-up Tables for Setting Nutrient Targets for Periphyton: second edition.

2.2.1.3 Rationale

The overall rationale for the development of these Proposed Standards was as follows:

- A precautionary approach has been applied to the development of these Proposed Standards, addressing both environmental and public health aspects.
- Categories of receiving environment types were defined based on existing NZ sources where they exist or amendments to them where required.
- An assessment of the impact of these 'end of pipe' standards has incorporated consideration of the assimilative capacity of receiving water bodies / reasonable mixing through the use of a dilution ratio. This has enabled an assessment against relevant NZ receiving water guidelines.
- The Proposed Standards have been developed either as an annual median or an annual 90%ile concentration dependent upon the parameter. It is expected that further guidance from Taumata Arowai is developed on anticipated sampling frequencies and compliance periods to enable these Standards to be applied and monitored consistently throughout the country.
- Mass load Standards (expressed in kg/day) have not been proposed for TN and TP as these are site specific considerations relative to the proportional contribution of nutrients to the overall catchment load. These considerations cannot be expressed at the national level. The use of a mass load approach in conjunction with the concentration-based Standards to allow flexibility in asset upgrades to the asset managers has been posited and will be reviewed further in later drafts. It is proposed that the TN and TP mass loads discharged over a term of a consent should be checked through a review process undertaken on a periodic basis by the applicant and reviewed by the relevant regional council.
- The Proposed Standards have been compared with international treated wastewater Standards, where applicable.
- An assessment has been made on available treatment technologies and relative scale of the discharge in determining the potential implications of the Proposed Standards in terms of required treatment plant upgrades.
- A preliminary assessment of the current consent limits has been undertaken.
- High level consideration of the existing and potential future legislative frameworks and implications of these Proposed Standards on new and existing consenting processes for WWTPs has not been specifically assessed. This is anticipated to be addressed in more detail in the Regulatory Impact Statement.
- These Proposed Standards are intended to be applied irrespective of the degradation status of the receiving water body as no nationally adopted basis exists for the definition of a degraded water body and the rationale

for how this status would impact the Proposed Standards is unclear and unsupported. It is anticipated that the application of these Standards will generally improve water quality.

- Seasonal variation in discharge quality and potential for adverse effects is addressed through the use of the dilution ratio and median design flow which enables the plant design to accommodate both summer and winter plant performance with some variability over the year. Variation in treated wastewater quality is further accommodated through the proposed statistical basis for the numerical limits where they are expressed on an annual median basis. This is discussed in greater detail in Section 2.2.1.5.3.

2.2.1.4 Assumptions

The following assumptions have been made with respect to the below contaminants:

Carbonaceous 5-day Biochemical Oxygen Demand

- The Proposed Standard refers to 5-day carbonaceous biochemical oxygen demand ($cBOD_5$) as this is an industry-accepted test method.
- No receiving water guidelines are available for $cBOD_5$ in NZ, as the environmental effect is monitored through dissolved oxygen concentrations in the receiving environment and oxygen depletion effects in receiving waters. The National Policy Statement for Freshwater Management (NPS-FM) includes dissolved oxygen attribute states for 7-day mean minimum and 1-day minimum numeric attributes.
- International standards including $cBOD_5$ limits include Switzerland / EU, England and Canada.

Total Suspended Solids (TSS)

- No receiving water guidelines are available for TSS in NZ, as the environmental effect is monitored through visual clarity and deposited sediment measurements in the receiving environment.
- International standards including TSS limits include those from Switzerland / EU, England and Canada.

Total Ammoniacal Nitrogen

- The Proposed Standards have been compared to default guideline values for toxicity for ammoniacal nitrogen in fresh and marine waters (ANZG, 2018) at the 95%ile and 99%ile levels of species protection. Generally, compliance with the default guideline values is achieved with both guidelines provided that 100% of river flow or at edge of mixing zone available for mixing. This does not apply with scenarios with a dilution ratio of <10.
- The international jurisdictions we reviewed did not have relevant/specific standards for total ammoniacal nitrogen.

Total Nitrogen and Total Phosphorus

- The only nationally derived guidance available is from ANZG, 2018. All recent NZ guidance has been developed under regional plan change processes and this regional guidance has not been referred to in the development of these Proposed Standards.
- Proposed Standards have been compared against default guideline values for general nutrient effects (physico-chemical stress) from ANZG, 2018, using NZ region for rivers and South-Eastern Australian region for other categories (e.g. coastal).
- Potential effects on periphyton growth in rivers has been considered by comparing to the Ministry for the Environment document 'Guidance on look-up tables for setting nutrient targets for periphyton', 2022. These guidelines only apply to hard-bottomed rivers and streams which are relatively common in New Zealand.
- International standards including TN limits include England and Colorado (USA).
- International standards including TP limits include Switzerland / EU, England, USA (Alabama, Colorado and Minnesota).

Indicator Bacteria (Public Health)

- The Proposed Standards are based on contact recreation in the receiving environment where comparison was made to the Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas (MfE, 2003). The Proposed Standards were back calculated from the Microbiological Assessment Category (MAC) A based upon a sample 95%ile of less than or equal to 130 E. coli per 100mL (assuming the lowest dilution ratio).

- There is a proposal that, where there is shellfish gathering near a discharge point in coastal waters, a QMRA process is required, which may determine revised treatment limits, from those presented in Table 14, and appropriate upgrading and / or operating requirements (refer to Section 2.2.2.5).

2.2.1.5 Additional considerations for nutrients

2.2.1.5.1 Effects on Periphyton Growth and Algal Biomass

It is recognised that the effects of nitrogen and phosphorus are complex and vary throughout NZ with respect to river type, flow, bed substrate type, climate and hydrology (amongst other matters). The effects of discharged nutrients on receiving waters and associated ecological effects are generally more pronounced during lower flow / higher temperature conditions, however these 'seasonal' type effects vary throughout NZ and given this, the Proposed Standard does not contain seasonal limits, rather adopts an 'annual' approach where the Proposed Standards would apply year-round unless the plant discharges to water for only part of the year in which case a more tailored approach over the period the discharge is occurring has been suggested.

The relationship between nutrient limitation (whereby the absence of threshold concentrations of one nutrient limits the growth of algae / periphyton) and associated ecological responses also varies considerably throughout the country, and given the Proposed Standard applies an approach of considering that both TN and TP should be managed, rather than one or the other. This approach is considered precautionary.

When compared to default guideline values from ANZG, 2018, using NZ region for rivers, there may be nitrogen-based effects in the water body, especially for dilution ratios less than 10. However, the potential for this adverse effect is also dependent upon upstream nitrogen concentrations and the influence of background catchment sources. For phosphorus, there are potential concerns at the lower half of the dilution ranges for all rivers.

With respect to periphyton, consideration has been given to the Ministry for the Environment document 'Guidance on look-up tables for setting nutrient targets for periphyton', 2022. Comparisons were made to the lowest and highest targets for unshaded sites (to achieve protection of 95% of sites) as a precautionary approach. Based on this assessment, the current Proposed Standards would not be sufficiently protective for periphyton under all circumstances. However, some sites may be shaded and/or these effects could be mitigated through shading, noting that shading of waterways is reported to reduce the potential for periphyton growth, but does not affect in-stream nutrient concentrations.

We propose that where receiving environments comprise hard bottom streams where a risk of excess periphyton growth occurs, a site-specific assessment is undertaken to assess effects of the proposed discharge on periphyton growth. The site-specific assessment will consider potential for excess periphyton growth, where this exists then an approach for managing and minimising the risk should be proposed. For example, mitigative measures may include one or more measures such as improved treated wastewater quality, change of discharge location, provision of site shading and/or lower site specific TN and TP limits. These management provisions and any revision to treatment limits would need to be approved by the Regional Council and set out in resource consent conditions.

2.2.1.5.2 Nutrient mass load effects

In some larger river systems throughout NZ (such as the Waikato River), travel times are measured over longer periods of time and current wastewater resource consents are expressed in terms of the mass load of nutrients discharged (measured in kg/day), rather than the concentration limits that are included within the Proposed Standards.

Mass load effects are more concerned with the total quantity of nutrients discharged assuming that effects in the receiving environment are dominated by those effects that occur over longer timeframes (e.g. algal growth exertion effects in large river systems) or secondary receiving environments such as the Firth of Thames/Hauraki Gulf.

With the Proposed Standard only proposing nutrient concentration limits, there is the potential in some situations for mass loads from wastewater treatment plants to increase over time to the extent that the increased mass load would give rise to potential downstream eutrophication effects (e.g. in the case of WWTP's where flows would increase significantly over time and potentially results in consequential increases in the mass load of nutrients discharged). The use of the annual design median flow or the largest median flow predicted over the term of the consent means that the assigned limit is based on the highest potential impact.

These types of effects are more likely to occur in larger population areas where significant growth is projected to occur over time.

The approach proposed for the Proposed Standard includes the ability for regional councils to check for potential increases in nutrient load over the period of the consent and also for cumulative effects from a number of different sources into the same water body as part of the resource consenting process and subsequent management of the effects of the discharge. The primary control mechanism available to Regional Councils in the Proposed Standard is the discharge volume and these effects could be addressed based on the discharge volume expected at the end of the consent term.

An assessment could also consider staging over the lifetime of the consent to enable investment in infrastructure to be timed to align with changes in influent flows and subsequent increases in the mass loads of nutrients discharged. This staged approach is described further in section 2.1.2.3 of this Report.

2.2.1.5.3 Seasonality

Seasonal variation of flows into and out of a wastewater treatment plant has the potential to affect the quality and volume of the treated wastewater that is discharged. Assessing these seasonal implications is complex because changes occur both at the treatment plant and in the receiving environment i.e.:

- In the receiving environment flow varies and is typically low in summer and higher in winter. Further, sensitivity of the receiving environment, to nutrients in particular, also varies seasonally usually with a greater probability of eutrophication effects in warmer temperatures but acknowledging that recent consenting processes have concluded that this is less likely in areas of the North Island of New Zealand where temperature variation is much smaller.
- In summer the discharged nutrient loads pose a potentially heightened risk to the receiving environment because the waterbodies are in a low flow state. This risk is addressed through the use of the 7 Day MALF to establish the proposed dilution categories and management of the loading to the environment through the use of the Median Design Flow and proposed numerical limits. The median design flow is proposed as the basis for the discharge volume that will be consented.
- At the treatment plant, flows into the plant are often increased in the winter due to rainfall and the biological treatment processes are less effective at reducing nutrient concentrations at lower temperatures. This is managed through engineering good practice in the treatment plant design process such that most biomechanical treatment plants are designed to deliver the required level of treatment at these lower temperatures.
- Over the year, flows into and out of some treatment plants may increase due to significant increased visitor numbers relative to the usual population. This should be accommodated in the treatment plant design and through the use of the annual median statistical basis applied to the Proposed Standard which allows for some flexibility over the course of the year.

Overall, it is considered that the Proposed Standard provides sufficient flexibility to allow for seasonal variation to both freshwater and coastal waters whilst also maintaining an appropriate level of protection for freshwater environments under low flow conditions. This approach will mean that treatment plants are be effectively designed to achieve the required Proposed Standard across all seasons.

2.2.1.6 Comparison to current consent limits

A review of the Taumata Arowai National Consents Database (December 2024) was undertaken to indicate the potential for the Proposed Standard to require that WWTPs change their treatment level. Further to the general update of the Database, which is being undertaken, this included the following specific actions:

- The consents limits within each of the main discharge consents were reviewed and included into the Database. This included the parameters which are included in the Proposed Standards and a few additional related parameters.
- The dilution ratio for each WWTP was determined. This was based on the existing consented discharge rate rather than the potential future flows. For WWTPs whose flow will increase, their dilution ratio may reduce as their flows increase, which would lead to more restrictive Standards being applicable.

- The specific statistical function that was used in the consent to define the limit was also recorded for the equivalent to the "average", similar to a median limit, and equivalent to a higher end of the distribution of results, similar to a 90%ile limit.

Table 11 and Figure 1 summarises the results and potential implications of this assessment.

Table 11 Overview of comparison to current consent limits (as assessed December 2024).

Size of WWTP (as defined in Consents Database)	Comparison of Current Consent Limits to Proposed Standards	Potential for Change to WWTP when Standard is enacted	TP (average limit) (g/m^3)	TN (average limit) (g/m^3)	E. coli (%tile limit) (cfu/ 100ml)	Entero-cocci (%tile limit) (cfu/ 100 mL)
Large	consent less than standard	reduced treatment	0	6	7	5
Large	consent similar to standard (within 20%)	no change	0	1	0	0
Large	consent more than standard	increased treatment	0	5	0	1
Large	no consent limit	TBC	20	8	5	20
Medium	consent less than standard	reduced treatment	2	7	31	2
Medium	consent similar to standard (within 20%)	no change	6	3	0	0
Medium	consent more than standard	increased treatment	11	17	8	7
Medium	no consent limit	TBC	79	71	45	23
Small	consent less than standard	reduced treatment	0	2	16	0
Small	consent similar to standard (within 20%)	no change	0	1	1	0
Small	consent more than standard	increase treatment	6	7	10	0
Small	no consent limit	TBC	84	85	62	15
Size unknown	consent less than standard	reduce treatment	1	0	2	2
Size unknown	consent similar to standard (within 20%)	no change	4	0	0	0
Size unknown	consent more than standard	increase treatment	0	1	0	0
Size unknown	no consent limit	TBC	2	1	0	0
Consent not reviewed[13]			13	13	13	8
Total number WWTPs for which the proposed standard would apply	228[14]			228	200	83

[13] Consent conditions were not available to the project team at the time of writing in December 2024.
[14] It is acknowledged these numbers do not align with information reported earlier in this document. This is due to the changing nature of the information obtained from the National Consents Database (which is subject to further change as per the assumption detailed in Section 1.3) and the refinement of this information by the technical team based on industry knowledge and experience.

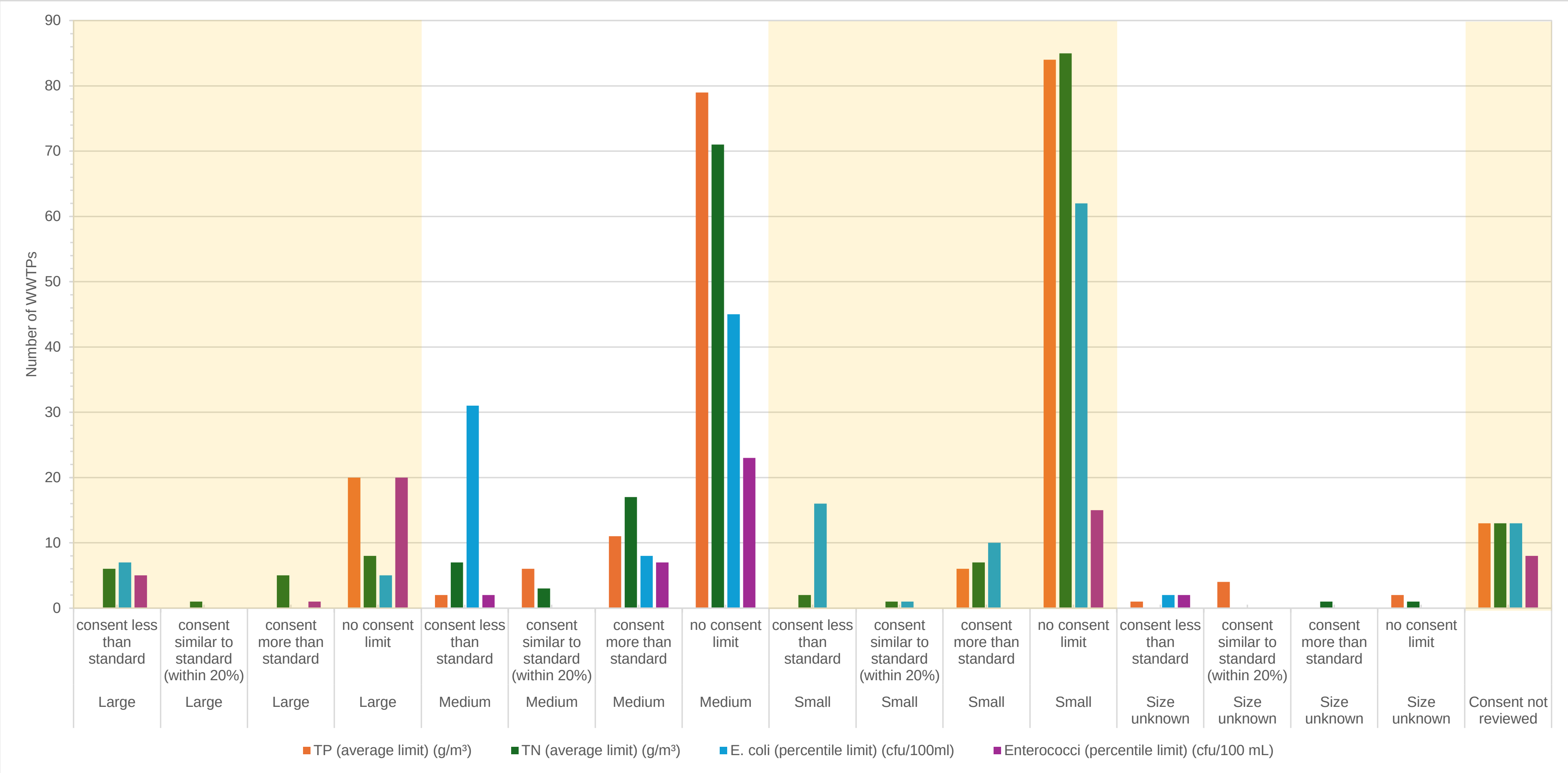


Figure 1 ***Graph of comparison to current consent limits.***

The range of terms used for the statistical definition of the BOD_5 limits in existing consents from the National Consents Database included:

Average statistical basis:

- 16 out of 26 samples
- 50th percentile
- 8 exceedances per month
- 8 out of 12 samples
- Annual average
- Annual mean
- Annual median
- Average
- Geometric mean
- Mean
- Median
- Rolling average
- Rolling geometric mean
- Rolling mean
- Rolling median
- Running average

Upper Percentile basis:

- 1 out of 10 samples
- 1 out of 12 samples
- 1 out of 20 samples
- 10 out of 12 samples
- 10% of samples
- 10% of the time
- 16 out of 26 samples
- 2 out of 12 samples
- 2 out of 20 samples
- 2 out of 3 samples
- 3 exceedances per quarter
- 3 out of 12 samples
- 4 out of 12 samples
- 4 out of 45 samples
- 4 out of 5 samples
- 8.3% of samples
- 80% of samples
- 80th percentile
- 9 out of 10 samples
- 9 out of 12 samples
- 90% of samples
- 90th percentile
- 92nd percentile
- 95% of samples
- 95th percentile
- Annual 90th percentile
- No more than 10% of samples
- No sample to exceed based on 95% UCL
- Rolling 80th percentile
- Rolling 90th percentile

A preliminary review of this information indicates that[4]:

- There are a large number of WWTPs which currently do not have consent limits for the parameters and statistics which are included in the Proposed Standards.
- A wide range of parameters and statistical terms are used to define the limits in existing consents, as demonstrated in the above example of BOD_5.This complicates comparison of performance across sites.
- Consents may include limits that relate to other related parameters. The other forms of nitrogen or phosphorus, or faecal coliforms instead of E. coli or enterococci have been added to the Database and have been reviewed. The outcome being that there a very limited number of consents that include limits for the other forms of nitrogen or phosphorus. Hence, it appears neither nitrogen nor phosphorus are being controlled in any of their forms in most consents as currently granted.
- The consents may include in-stream limits rather than end of pipe standards to control nutrients. This has not been assessed.
- The proposed limits represent a change to how treatment requirements apply to wastewater treatment plants and discharges from them. This includes standardised treatment limits being required or many WWTPs where no treatment limits are currently set at “end of pipe”.
- There is a lack of consistency in the current consenting regime with regard to the monitoring parameters set out in resource consents, Thus, the provision of a consistent set of parameters to be monitored in wastewater treatment plant discharges will enable greater insight across the sector into treatment plant performance.

2.2.1.7 Proposed Standards > 1,000 population equivalent

The Proposed Standards for WWTP's servicing populations greater than 1,000 PE are detailed in the slide pack provided in the Executive Summary and provided in Table 12.

Table 12 Proposed Standards for >1,000 population equivalent for lakes, and river and stream receiving environments[15].

Category	$cBOD_5$ (mg/L)	Total Suspended Solids (mg/L)	Ammoniacal Nitrogen (toxicity) (mg N/L)	Total Nitrogen* (mg N/L)	Total Phosphorus* (mg P/L)	E. coli (Public Health) (cfu/ 100mL)	Enterococci (Public Health)~ (cfu/100mL)
Statistic used:	Annual median	Annual median	Annual 90%ile	Annual median	Annual median	Annual 90%ile	Annual 90%ile
Lakes #	15	15	3	10	3	6,500	N/R
Rivers and streams							
– Low dilution ratio	10	10	1	5	1	1,300	N/R
– Moderate dilution ratio	15	15	3	10	3	6,500	N/R
– High dilution ratio	20	30	25	35	10	32,500	N/R

Notes:

- This table must be read in conjunction with Sections 2.1.1, 2.1.2 and 2.1.3, which define the receiving environment (summarised in Table 6), and the selection criteria for the relevant receiving environment (Table 10).
- Standard to apply at end of discharge pipe direct from plant to receiving water OR piped discharge from constructed wetland to receiving water.
- Ammoniacal Nitrogen limit of 1mg/l as Annual 90%ile will be challenging and will require a fully nitrifying WWTP. This is achievable with current technology.

  # Lakes use same Standard for nutrients as moderate dilution ratio from Rivers and Streams.

  * More restrictive Standards to control potential periphyton issues may apply for total nitrogen and phosphorus for discharges to hard bottom streams (Site specific assessment is required for discharge to hard bottom stream, refer to Section 2.2.1.5.1)
- N/R indicates that recommendation is for no Standard to be imposed for this parameter and receiving environment as not relevant to potential effects

[15] The determination for a 'small' treatment plant is defined in the Glossary (Section 4) and later in the report, as detailed in Section 2.2.1.8.1.

2.2.1.8 Proposed Standards < 1,000 population equivalent

Taumata Arowai proposes that a different set of Standards applies to existing treated wastewater discharges to surface water that serve a population equivalent less than 1,000 PE. These Standards do not apply to new treated wastewater discharges from small WWTP's, as the full Standards outlined in Table 12 (applicable to discharges greater than 1,000 PE) are proposed to apply to any new discharges. This section outlines the proposed approach to defining these discharges and the Proposed Standards.

2.2.1.8.1 Definition of Small Treatment Plants

It is proposed that the definition of a small WWTP be based on the influent $cBOD_5$ load to the WWTP to account for variability in flow and load factors when relying purely on a flow or population based threshold.

The translation to a $cBOD_5$ threshold was undertaken using a per capita load factor. There is no $cBOD_5$ load factor defined in current NZ standards and there can be significant variation between communities. A $cBOD_5$ load factor of 85 g/person/day has been used based on typical small town loads found in NZ. This results in a $cBOD_5$ threshold for small plants of 85 kg/day, including residential and commercial/industrial sources.

To determine whether WWTP's fall into the 'small' category, applicants should project the influent $cBOD_5$ load to the WWTP at the end of the consent duration using projected population and commercial/industrial growth projections (i.e. for a 35-year consent these projections should be undertaken for year 35).

Applicants can either use the default value of 85 g/person/day or could utilise actual measured influent wastewater quality and flow analysis to support the assessment for existing, and future projected, influent loads to the WWTP for the full duration of the consent applied for. The threshold for small plants is 85 kg/day as $cBOD_5$.

2.2.1.8.2 Proposed Standards for Small Treatment Plants

The limits that would apply to ***existing*** small plants (<1,000 PE) would be the same as the larger plants (> 1,000 PE) except that the TN and TP limit would be removed, given their relatively small contribution to the total catchment nutrient load. The toxicity related limit for ammoniacal nitrogen is retained. These proposed numerical limits are shown in Table 13.

Consideration was given to whether further specific allowance should be made for oxidation ponds, given the number of such sites across the country, particularly where they are operating well and are not causing significant effects. Some of these sites do not currently have a power supply, and there would be significant cost and difficulty of upgrading such sites.

Further to the removal of the total nutrient limits, the following changes could be further considered for small plants, including those using oxidation ponds:

- The numeric end of pipe Standards could be made less stringent, particularly the E. coli or Enterococci limits where limited human contact with the receiving water occurs.
- The limits could use dissolved $cBOD_5$ rather than total and the TSS limit could be removed to reflect that the solids discharged from a well operated oxidation pond are likely to be algae rather than wastewater solids. It is noted, however, that these algal solids can result in effects in the water body. This change is particularly relevant to oxidation ponds but may not sufficiently regulate small plants using treatment processes other than oxidation ponds.
- Operational requirements could be applied to maintain and manage plant treatment performance such as regular desludging, appropriate loading rates.

Optional recommendation for consideration: These less stringent standards could apply to all small plants, or just to the oxidation ponds serving small WWTPs, which would create three tiers of limits in the Standard. We consider that this may be appropriate and suggest seeking feedback through the consultation phase on these options.

2.2.1.9 Discharges in proximity to sources of human drinking water

Where discharges of treated wastewater to surface water occur in proximity to existing human drinking water supply abstraction points, a site-specific assessment will be required to assess the risk of discharged contaminants (including pathogens and other contaminants that may affect drinking water quality) adversely affecting the drinking water supply. The definition of 'drinking water supply' under the Water Services Act (2021) comes from the need to provide a risk assessment for any drinking water take that serves more than one household.

'In proximity' is suggested as discharges to rivers occurring 1,000m upstream / 100m downstream of the drinking water abstraction point and for lakes, within 500m radius from the source water intake and for rivers/streams that discharge to lakes within this 500m radius zone, 1,000m up any tributary waterways (with reference to the publication 'Delineating Source Water Risk Management Areas, Ministry for the Environment, 2023)[16]. Consultation with the water supplier and/or regulator will be required to determine that nature of the risk assessment and specific contaminants of concern.

[16] https://environment.govt.nz/assets/publications/Freshwater/Delineating-source-water-risk-mgmt-areas.pdf

Table 13 Proposed Standards for <1,000 population equivalent for lakes, and river and stream receiving environments (existing WWTP's[15])

Category	$cBOD_5$ (mg/L)	Total Suspended Solids (mg/L)	Ammoniacal Nitrogen (toxicity) (mg N/L)	E. coli (Public Health) (cfu/ 100mL)	Enterococci (Public Health) ~ (cfu/100mL)
Statistic used:	Annual median	Annual median	Annual 90%ile		Annual 90%ile
Lakes#	15	15	3	6,500	N/R
Rivers and streams*					
– Low dilution ratio	10	10	1	1,300	N/R
– Moderate dilution ratio	15	15	3	6,500	N/R
– High dilution ratio	20	30	25	32,500	N/R

Notes:

- This table must be read in conjunction with Sections 2.1.1, 2.1.2 and 2.1.3, which define the receiving environment (summarised in Table 6) and the selection criteria for the relevant receiving environment (Table 10).Standard to apply at end of discharge pipe direct from plant to receiving water OR piped discharge from constructed wetland to receiving water.
- Ammoniacal Nitrogen limit of 1mg/l as Annual 90%ile will be challenging and will require a fully nitrifying WWTP. This is achievable with current technology.

  * More restrictive Standards to control potential periphyton issues may apply for total nitrogen and phosphorus for discharges to hard bottom streams (Site specific assessment is required for discharge to hard bottom stream, refer to Section 2.2.1.5.1).

  # Lakes use same Standard for nutrients as moderate dilution ratio from Rivers and Streams.
- N/R indicates that recommendation is for no Standard to be imposed for this parameter and receiving environment as not relevant to potential effects.

2.2.2 Coastal treatment limits

2.2.2.1 Scope from CSO

2. Advice on treatment limits:

2.1 Should we take a load or concentration approach to setting nutrient limits for freshwater environments. This should include consideration of setting an ammoniacal-nitrogen toxicity limit in conduction with mass load limits for total nitrogen and total phosphorus.

2.2 Nutrient limits for freshwater receiving environments that are already degraded (high in-stream load), versus receiving environments which are less degraded (low in-stream load).

2.3 Nutrient limits for high flow and low flow environments in freshwater, likely based on seasonal changes in flow.

2.4 Open ocean BOD limit

2.5 Open ocean TSS limit

2.6 Approach to UVT (UV transmissivity) as a proxy for spot sampling for pathogens. This should include consideration of UV dosing and whether it is appropriate to use UVT and dosing in place of pathogen sampling.

2.2.2.2 Method

From review of the Taumata Arowai National Consent Database for discharge to water (December 2024), the following three categories of receiving waters on the coastal margin or the open ocean have been identified for the definition of treated wastewater Standards (refer to Section 2.1.1). There is a total of 61[4] consents with the numbers of consents considered to fall into each category shown in square brackets[14] (information obtained in December 2024):

1. Estuaries [15]
2. Low Energy Coastal [15]
3. Open Ocean (Outfalls > 500m long) [31]

Determination of the consents which apply to open ocean discharge was relatively straightforward, even though descriptions in the National Consents Database of the actual receiving environment are limited. Differentiating between the other consents, as to which were for discharges into estuaries and which were into rivers or streams close to their mouths (effectively indirectly into low energy coastal waters), was more difficult and relied heavily on knowledge held within the three consultancies. For now, these have been categorised as estuary discharges but are subject to further clarification to confirm this in the National Consents Database[4]. The proposed method for determining the relevant discharge receiving environment is detailed in Section 2.1.3

There is a wide range of discharge flows, some defined as average or maximum daily flowrates, with either maximum daily volumes or annual average daily flows. There is little consistency in how volumetric discharges or flowrates are stated in the consents. A similar comment applies to the parameters for which average/mean or "maximum" (i.e. 90 or 95 percentile) concentrations or loads are stated in the consents to be controlled and monitored and reported.

We note that whilst the scope expressed above only included BOD and TSS, this report also addresses total nitrogen, total phosphorus and faecal indicator bacteria for marine waters because some of these receiving environments are sensitive to these parameters and associated environmental and public health status. Conversely, where a parameter was not deemed to have a material impact for a given receiving environment, no numerical Standard has been proposed.

2.2.2.3 Rationale

Potential issues in the various receiving environments in relation to 'environmental' and 'public health' outcomes include:

- Estuaries:
  - potentially long flushing times,
  - potential for eutrophication,
  - deposited sediments and harbour bed smothering,
  - high public access for recreation and (shell) fishing,
  - stagnant/low velocity periods at high and low tide (4x per day),
  - Cultural values
- Low Energy Coastal:
  - shallower depths than open ocean – lower initial dilution,
  - lower currents, but high wave energy and mixing/dispersion,
  - potential for poor flushing of contaminants,
  - high public access for recreation and (shell) fishing,
  - less turbid waters generally than estuaries and harbours,
  - Cultural values
- Open Ocean
  - deeper waters – high initial mixing and dispersion,
  - benthic ecosystems subject to solids deposition,
  - high currents – tidal and wind-driven,
  - visibility of freshwater or coloured plume against clear seawater background,
  - low public accessibility in immediate discharge location, although plumes can reach recreational areas,
  - Cultural values

There are a range of possible controls to minimise the potential for issues arising in relation to the above matters, such as:

- Choosing a remote (from public access) location for discharge, including longer outfalls from sensitive coastal areas.
- Locating the discharge closer to estuary or harbour entrance to avoid long residence times.
- Applying an appropriate level of wastewater treatment to minimise the risk of adverse effects.
- Enhancing initial mixing of the discharge with purpose-designed diffusers.
- Requiring discharge only during stated tidal discharge windows or only above minimum low river flows.

The development of this Proposed Standard focuses only on managing the quality of the treated wastewater being discharged.

As a minimum, it is assumed that all discharges to ocean and coastal receiving waters should be milliscreened to remove gross solids, with treatment plants in New Zealand routinely screening to 1-3mm aperture. It is also assumed that Trade Waste and Council General Bylaws will control and manage the effects of the discharge of highly coloured waste streams and those containing compounds of known toxicity.

There are no internationally recognised standards applicable for end of pipe application for discharges to marine waters for Total Nitrogen and Total Phosphorus, therefore, the Proposed Standards for New Zealand's coastal waters have been developed against relevant national receiving water guidelines for the environment.

For environmental effects, a precautionary approach has been taken when considering the different parameters, but this has also incorporated consideration of the assimilative capacity and mixing which occurs in the three different receiving environments.

In respect of public health, there is minimal international precedent for applying end-of-pipe standards for pathogens in treated wastewater discharges, for example using faecal indicators such as enterococci, E. coli, or total faecal coliforms. Many international jurisdictions adopt bathing water (microbiological) quality guidelines as their end-of-pipe standards, but this is considered to be unduly restrictive as it does not take into account the mixing and dispersion of the treated wastewater plume in the receiving environment.

Currently the Proposed Standard is based on the MfE contact recreation standards (MAC of A) rather than the shellfish standards which are more restrictive. Given the importance and prevalence of shell fishing in New Zealand, and the well-known risks to humans of pathogen accumulation in shellfish, it is deemed desirable that the development of the Standard considers the role of site–specific Quantitative Microbial Risk Assessment (QMRA) where known shellfish areas are considered to be at risk of contamination from a wastewater outfall discharge. This reflects an important difference between New Zealand and other countries. This is presented in Section 2.2.2.5 (Consideration of a QMRA Requirement).

2.2.2.4 Assumptions and implications

The concept of a “Dilution Ratio” in the receiving environment was introduced in an earlier section (Section 2.1.2) for treated wastewater discharges to freshwater. For consistency, a Dilution Ratio (DR) has also been used in the development of the Proposed Standards for the ocean and coastal waters. The intention is that these dilution ratios, represent the reasonable mixing and dispersion which will occur beyond the immediate vicinity of discharge point and thus provide context for the setting of the numerical standards.

This DR is different from the minimum centreline dilution as determined by numerical modelling (e.g., CORMIX) at 100m from the diffuser in nominal slack water that is required to determine the relevant receiving environment category as given in Section 2.1.3.

The DR used to assess the potential impacts of the Standards is based on reasonable mixing as used in most previous consent applications. This goes beyond that achieved within the zone of ‘initial mixing’ which occurs due to the buoyancy of the discharge plume as it discharges from the diffuser or outfall. The DR used reflects mixing in the zone where reasonable mixing is expected to occur and is based on a typical range of dilutions that would be expected to be achieved by a properly designed and maintained diffuser section and its subsequent mixing in the water column.

Once the discharged water becomes part of the wider body of water, in terms of matching velocity, the discharge undergoes ‘far-field mixing’. Diffuser design can influence the near-field mixing to increase mixing that occurs in the near-field, but the far-field mixing is subject to ocean and tidal currents and wind. Many existing outfall consents in NZ have a near-field mixing zone defined in their consents, with monitoring on the boundary of this zone, see Figure 2 below (Adapted from: Philip J. W. Roberts, Henry J. Salas, Fred M. Reiff, Menahem Libhaber, Alejandro Labbe, James C. Thomson, *Marine Wastewater Outfalls and Treatment Systems,* IWA Publishing, 2010).

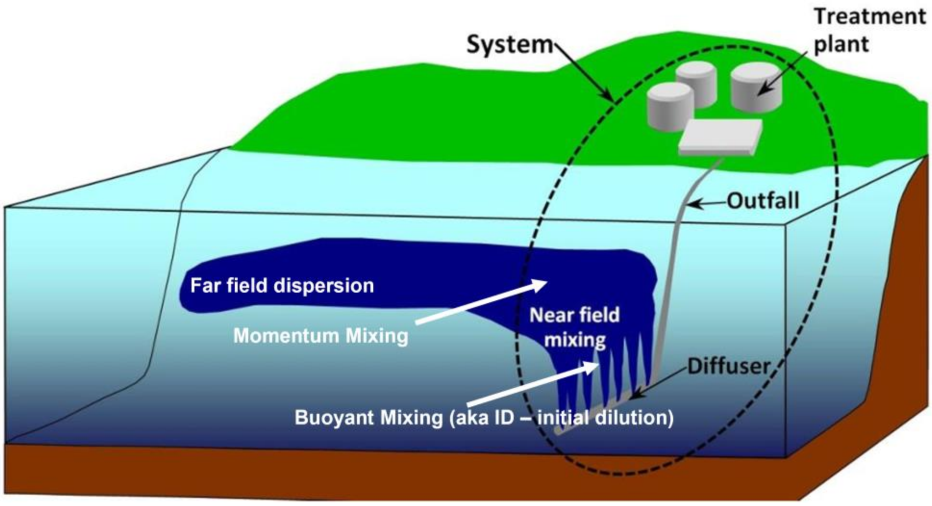


Figure 2 Schematic of a marine wastewater disposal system (Adapted from: Philip J. W. Roberts, Henry J. Salas, Fred M. Reiff, Menahem Libhaber, Alejandro Labbe, James C. Thomson, Marine Wastewater Outfalls and Treatment Systems, IWA Publishing, 2010).

The DR used in the development of the Standards are:

- Estuaries: DR >50 (most sensitive category)
- Low Energy Coastal: DR >100 (less sensitive category)
- Open Ocean: DR >1000 (least sensitive category)

The Dilution Ratio (DR) is different for each of the three categories of coastal receiving water. The DR has been used to back-calculate from receiving water quality guidelines to give end-of-pipe standards for Enterococci to achieve the MfE MAC of A in the contact recreation guidelines. The DR is considered to be a “minimum that would be expected to be achieved” in each of the three receiving environments after reasonable mixing and is cognisant of the relative environmental sensitivity of each category and the potential risks to public health.

The location, design and operation of the actual discharge pipe or diffuser can significantly influence the degree of initial mixing and should be designed to achieve (or exceed) the relevant selection criteria set out in section 2.1.3 for each receiving environment category. Based on experience, it is anticipated that when these initial mixing criteria are met then the assumed DR will also be met.

2.2.2.5 Recommended coastal treatment limits >1,000 PE

The Proposed Standards for wastewater treatment plants with populations of greater than 1000 PE are detailed in the slide pack provided in the Executive Summary and provided in Table 14. The Applicant would determine which receiving environment category and hence treatment limits in Table 14 applies to their discharge using the criteria given in Section 2.1.3.

Table 14 Proposed Standards >1,000 population equivalent for estuaries, low energy coastal and open ocean receiving environments.

Category	$cBOD_5$ (mg/L)	Total Suspended Solids (mg/L)	Ammoniacal Nitrogen (toxicity) (mg N/L)	Total Nitrogen (mg N/L)	Total Phosphorus (mg P/L)	E. coli (Public Health) (cfu/100mL)	Enterococci (Public Health) (cfu/100mL)
Statistic used:	Annual median	Annual median	Annual 90%ile	Annual median	Annual median	Annual 90%ile	Annual 90%ile
Estuaries#	20	25	15	10	10	N/R	2,000
Low energy coastal	50	50	20	10	10	N/R	4,000
Open ocean	N/R	N/R^	50	N/R	N/R	N/R	40,000

Notes:

– This table must be read in conjunction with Sections 2.1.1, 2.1.2 and 2.1.3, which define the receiving environment (summarised in Table 6), and the selection criteria for the relevant receiving environment (Table 10).

– Standard to apply at end of discharge pipe direct from plant to receiving water OR piped discharge from constructed wetland to receiving water.

Estuaries use same Standard for nutrients as moderate dilution ratio from Rivers and Streams.

– N/R indicates that recommendation is for no Standard to be imposed for this parameter and receiving environment as not relevant to potential effects

– N/R^ Control on TSS will result from achievement of the Enterococci Standard for public health.

To avoid any potential issues with low DO levels and/or discolouration/turbidity effects and smothering impacts from discharges to Estuaries and Low Energy Coastal receiving environments, treatment is recommended to reduce $cBOD_5$ and Total Suspended Solids (TSS) to the annual median concentrations proposed. It is possible TSS would need to be reduced to meet the Proposed enterococci Standard for public health.

With the higher DR of 1000 assumed after reasonable mixing in the receiving environment for open ocean outfalls, there is very low risk of reduced DO and of any turbidity issues, so it is not proposed to have $cBOD_5$ nor TSS Standards for this category. However, it is possible that TSS will need to be reduced to enable UV disinfection to meet the enterococci Standards (Table 14).

Estuaries and Low Energy Coastal use the same Standard of 10mg/L annual median for the nutrient TN as for the **moderate DR** for Rivers and Streams (refer Section 2.1.2) as the environmental risks are considered to be similar, however the Ammoniacal Nitrogen concentration is relaxed as toxicity in the brackish or saline waters is considered less of a risk. The recommended TP concentration is the same Standard as for the **High DR** for Rivers and Streams.

The criteria for public health and contact recreation in marine waters, as an annual 90%ile, is adopted from **MfE 2003 Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas**. Note that the MfE Standards differ slightly in being an annual 95%ile but this requires many more samples to be analysed and hence the 90%ile is proposed, which remains precautionary. The guidelines for a **Microbiological Assessment Category (MAC) of A** were used to back-calculate the Proposed Standard.

Consideration of a QMRA Requirement

This section outlines the rationale and a potential approach to QMRA for the ingestion of raw shellfish that is recommended as considered as part of the Proposed Standard.

The location of shellfish beds and other kai moana gathering areas are normally well-known by communities and Regional Councils, so choosing a location for a treated wastewater discharge remote from these waters and areas, would be the most precautionary approach. Applying the New Zealand microbiological guidelines for shellfish quality would likely result in a more restrictive outcome than applying a recreational standard to the discharge environment. Currently, QMRA is often used to assess the public health risk associated with treated wastewater discharges via a range of pathways that could result in adverse human health outcomes, including shellfish consumption (as mentioned earlier in Section 2.2.2.3).

Given that the Proposed Standard does not currently address risks associated with shellfish gathering and consumption of raw shellfish, we recommend that the Standard requires that a QMRA is used to assess the risk when existing shellfish gathering beds are in close proximity. Based on the QMRA results an applicant would then, develop an approach to manage/mitigate public health that is acceptable to the Regional Council and once accepted would result in a specific consent condition.

To ensure a nationally consistent approach to QMRAs, it is also recommended that a guideline is developed to support the Standard that outlines the proposed QMRA rationale, methodology, and assumptions. In developing the guideline, several key inputs to the QMRA will need to be considered including:

- Pathogens of concern
- Hydrodynamic modelling requirements of receiving waters
- Shellfish pathogen bioaccumulation
- Shellfish ingestion rates
- Infection and illness risk modelling
- Threshold for acceptable limit to risk of illness

New and existing outfalls would need to meet the relevant Standard for faecal indicator bacteria (which is based on recreational contact guidelines) ***and*** complete an appropriate QMRA if there is a shellfish bed within close proximity.

A proposed methodology for the use of QMRA in the context of implementation of the Standard is shown in Figure 5, in Section 2.3.2.3.

Recommendations for consideration:

- The methodology for setting and agreeing the appropriate "close proximity" distance. An initial suggestion of 4km is put forward based on experience with previous QMRA processes.
- Feedback on the proposed outline QMRA methodology and inputs as presented in this document

2.2.2.6 Recommended coastal treatment limits <1,000 PE (existing WWTP's)

As per the approach for the freshwater Proposed Standards, a separate set of standards are proposed for existing small WWTP's that discharge into coastal environments. These will apply to existing discharges only.

The threshold for defining 'small treatment plants' is proposed to be the same as freshwater, being a threshold of 85 kg/day influent $cBOD_5$ load, including residential and commercial/industrial sources (calculated at the end of the proposed consent period). As per the approach to freshwater it is proposed that the TN/TP limits do not apply to these small WWTP's.

A review of the National Consents Database has shown a small number of existing WWTP's fall into this category (approximately 7) and these are generally assumed to have minor contributions of TN/TP compared to wider catchment influences.

Options for further relaxation in relation to oxidation pond systems, as discussed earlier in Section 2.2.1.8.2, also apply in this situation.

The Proposed Standards for coastal discharges serving populations less than 1,000 PE are shown in Table 15.

Table 15 Proposed Standards for existing WWTPs <1,000 population equivalent for estuaries, low energy coastal and open ocean receiving environments.

Category	$cBOD_5$ (mg/L)	Total Suspended Solids (mg/L)	Ammoniacal Nitrogen (toxicity) (mg N/L)	E. coli (Public Health) (cfu/100mL)	Enterococci (Public Health) (cfu/100mL)
Statistic used:	Annual median	Annual median	Annual 90%ile	Annual 90%ile	Annual 90%ile
Estuaries#	20	25	15	N/R	2,000
Low energy coastal	50	50	20	N/R	4,000
Open ocean	N/R	N/R^	50	N/R	40,000

Notes:
- This table must be read in conjunction with Sections 2.1.1, 2.1.2 and 2.1.3, which define the receiving environment (summarised in Table 6), and the selection criteria for the relevant receiving environment (Table 10).
- Standard to apply at end of discharge pipe direct from plant to receiving water OR piped discharge from constructed wetland to receiving water.
- # Estuaries use same Standard for nutrients as moderate dilution ratio from Rivers and Streams.
- N/R indicates that recommendation is for no Standard to be imposed for this parameter and receiving environment as not relevant to potential effects
- N/R^ Control on TSS will result from achievement of the Enterococci Standard for public health.

2.2.3 UV transmissivity for monitoring microbial contaminant levels

2.2.3.1 Scope from CSO

2. Advice on treatment limits:

2.1 Should we take a load or concentration approach to setting nutrient limits for freshwater environments. This should include consideration of setting an ammoniacal-nitrogen toxicity limit in conduction with mass load limits for total nitrogen and total phosphorus.

2.2 Nutrient limits for freshwater receiving environments that are already degraded (high in-stream load), versus receiving environments which are less degraded (low in-stream load).

2.3 Nutrient limits for high flow and low flow environments in freshwater, likely based on seasonal changes in flow.

2.4 Open ocean BOD limit

2.5 Open ocean TSS limit

2.6 Approach to UVT (UV transmissivity) as a proxy for spot sampling for pathogens. This should include consideration of UV dosing and whether it is appropriate to use UVT and dosing in place of pathogen sampling.

Due to well-known difficulties in sampling and enumerating pathogen concentrations in treated wastewater, and the associated cost, an alternative - or proxy - method of assurance of the discharge meeting the numerical pathogen Standard is being sought by Taumata Arowai. The use of ultraviolet light transmissivity (UVT) has been suggested as one such proxy. This section addresses the suitability of that and suggests a more effective alternative.

It is considered that UVT alone is not suitable as a proxy for spot sampling of pathogens. However, it is considered that continuous monitoring would be appropriate and that continuous 'UV dose' measurement and reporting (telemetered), supported by regular but infrequent pathogen check testing probably *is* a suitable alternative monitoring method where UV disinfection is provided. Most modern UV systems are designed to be able to deliver this form of monitoring when appropriately set up.

2.2.3.2 Assessment of approach

To assess the approach to UVT for freshwater-receiving environments, the following guidelines, frameworks and reports were reviewed:

- Faecal coliforms, faecal *Enterococci*, *Salmonella Typhi* and *Acanthamoeba* spp. UV inactivation in three different biological effluents[17]
- Fluence (UV DOSE) Required to Achieve Incremental Log Inactivation of Bacteria, Protozoa, Viruses and Algae[18]
- Pathogen Specific UV System Sizing for Wastewater and Reuse – "Best Fit" Design Without the Pilot[19] (Meyer, K)
- US Environmental Protection Agency, 2006: UV Disinfection Guidance Manual[20]
- Design Manual: Municipal Wastewater Disinfection. United States Environmental Protection Agency[21]

[17] Beltran, NA; Jimenez, BE (2008); Faecal coliforms, faecal enterococci, Salmonella Typhi and Acanthamoeba spp. UV inactivation in three different biological effluents; Water SA, 34 (2), 261 - 269
[18] Malayeri, A.H., Mohseni, M., Cairns, B., Bolton, J.R. (2016); Fluence (UV Dose) Required to Achieve Incremental Log Inactivation of Bacteria, Protozoa, Viruses and Algae.
[19] Meyer, K. (2015). Pathogen Specific UV System Sizing for Wastewater and Reuse Disinfection – "Best Fit" Design Without the Pilot. Xylem Services
[20] **US Environmental Protection Agency UV Disinfection Guidance Manual**
[21] USEPA (1986); Design Manual: Municipal Wastewater Disinfection. United States Environmental Protection Agency. Manual EPA/625/1-86/021

- Using Statistical Methods for Water Quality Management Issues, Problems and Solutions. McBride, G.B (2005)

Pathogen source

Human sourced and other pathogens enter the wastewater stream from the community from which it serves. Some of the more common human pathogens we are concerned with include bacteria (e.g. staphylococcus aureus, streptococcus pneumoniae, salmonella), viruses (e.g. norovirus, hepatitis, adenovirus), and protozoa (e.g. giardia lamblia, cryptosporidium). They are typically present in large numbers in the incoming wastewater to the WWTP. The actual loading at any particular time is related to burden of a particular pathogen related disease in the community. In New Zealand, practitioners do not typically enumerate a wide range of influent pathogens but instead use faecal indicator bacteria such as E. coli and Enterococci to represent these organisms. Typical numbers of E. coli entering a wastewater treatment plant (WWTP) will be in the order of 5,000,000 cfu per 100ml of sewage.

Pathogen enumeration

The level of reduction, or disinfection required through the WWTP is such that we measure this in factors of 10, or Log10 reduction values (LRV). For example, if we take the above influent E. coli number and require a treated wastewater E. coli of less than 50, the minimum log10 reductions or LRV is 5 for E. coli.

If we have 50,000 norovirus replicates entering the WWTP per litre of sewage and require this to be reduced to less than 5/litre, then the LRV for norovirus is 4.

If we have 5,000,000cfu/100ml E. coli entering the WWTP and require this to be reduced to less than 130cfu/100ml then the LRV for E. coli is 4.6

Pathogen reduction in plant

Some pathogens will be removed or inactivated by the main treatment process. The balance needs to be inactivated by an appropriate disinfection means. For example, an activated sludge process, by itself, may provide 1 – 2 LRV for E. coli. Whereas an oxidation pond may provide 2.5 – 3.5 LRV because of the long exposure to micro-faunal predation and the naturally occurring UV light in sunlight.

Why consider continuous monitoring?

Monitoring of pathogen reduction compliance by sampling and testing of the indicator organisms has several drawbacks which make it attractive to adopt a better system. These drawbacks include:

- It is expensive. The combined sampling, chain of custody and testing procedure for faecal indicator bacteria is costly when undertaken frequently. It is not just a case of using part of the automatically collected composite sample from the site. And cost is amplified many times when virus enumeration is also required.
- Sampling must be via grab samples (unlike chemical analytes which are composited) because a 24-hr delay in sample collection and dispatch will result in sample deterioration. Therefore, the sampling is not representative of the day on which it was collected and even less representative of the week in which it was collected. E.g. for a weekly sampling regime, 2 seconds of plant treated wastewater flow is sampled and measured out of 604,800 seconds of elapsed time.
- Sample preparation and chilling must be just right. It is easy to slip up e.g. 'I forgot the ice packs'.
- Chain of custody can be delayed – courier broke down, plane was cancelled, courier pack misplaced, resulting in additional days being added before sample enumeration and potentially inadmissible samples due to the time bound nature of the standard testing procedure.
- Just as online instrumentation can give inaccurate results with poor maintenance, Lab based enumeration can also be inaccurate. From the 2 second sample, sub-samples are taken for enumeration purposes. The sample itself is not fully representative of the process flow at site, and similarly the tiny test subsamples may not be homogeneous. And so, when counting very large, or very small numbers, the count inaccuracies could be substantial.
- All the above lead to a significant probability of unrepresentative results, particularly when the target organism count level is low, as is currently proposed within the Standard.

Disinfection in New Zealand

In New Zealand we have largely adopted UV light irradiation (UV) for the disinfection of wastewater since the early 1990s. UV does not provide total disinfection, but it also does not produce harmful disinfection byproducts as chlorine-based disinfection can.

Many NZ WWTPs do not have a formal disinfection step and rely solely on sunlight irradiation and micro-faunal predation (other bugs eat them) of pathogens within the WWTP. NZ has one WWTP using chlorine (hypochlorite) as the primary source of disinfection.

Other jurisdictions (around the world) use various forms of chlorine, peracetic acid, ozone and UV, so in NZ we should be flexible and not prescribe UV as the only acceptable form of disinfection, which is another reason why UVT as a proxy for spot sampling may not be appropriate. For any of the disinfection methods listed above, applied 'dose' can be measured or estimated reasonably accurately.

UV Disinfection - How it works

UV Irradiation, as a water disinfection mechanism works by interrupting the replication of nucleic acids (RNA & DNA) making up or incorporated in the target organism/s and preventing them from replicating.

It is the dose (intensity x time) of UV light, in a germicidal wavelength range, that inactivates pathogens. The pathogens are not removed by the UV system.

Dose Response of organisms

The UV 'Dose Response', or 'Sensitivity' of all organisms varies. Thus, depending upon the indicator organism selected by the Regulator and the required LRV, the minimum dose needing to be administered by the UV system will vary from one situation to another.

The dose response of most key pathogenic organisms is reasonably well documented. The IUVA (International UV Association) provides tables of the fluence (Dose) requirements for various spores, bacteria, protozoa, viruses and algae (and other miscellaneous organisms). The last major update of this information was prepared by Malayeri et al in 2016[18].

Ultraviolet Transmissivity or UVT

UVT, is an indication of the ability of the liquid to transmit UV light at the specified wavelength. It is a function of the performance of the upstream process units. It is not a measure of the dose applied by the UV facility or the reduction in pathogen numbers. The actual dose applied to or received by individual organisms is affected by a wide range of operating conditions such as:

- flow rate,
- lamp power (some aftermarket lamps vary in power from the validated lamps)
- the number of banks and lamps actually turned on at any given time,
- for flow and dose paced systems, the actual power setting at any particular time,
- lamp age,
- cleanliness of quartz sleeves,
- distance from the bulb,
- UVT,
- presence of particulates.

Therefore, for a constant, or near constant UVT value, the applied dose can vary widely.

Effect of Particulates

The following figure (Figure 3) (Ratsey (2011)[22], derived from Beltran (2008)[17], and USEPA (1986)[21]) illustrates the likely effect of pathogen embedment (shielding) in secondary treated wastewater in tank-based systems.

[22] Ratsey, H. (2011): Opus internal document.

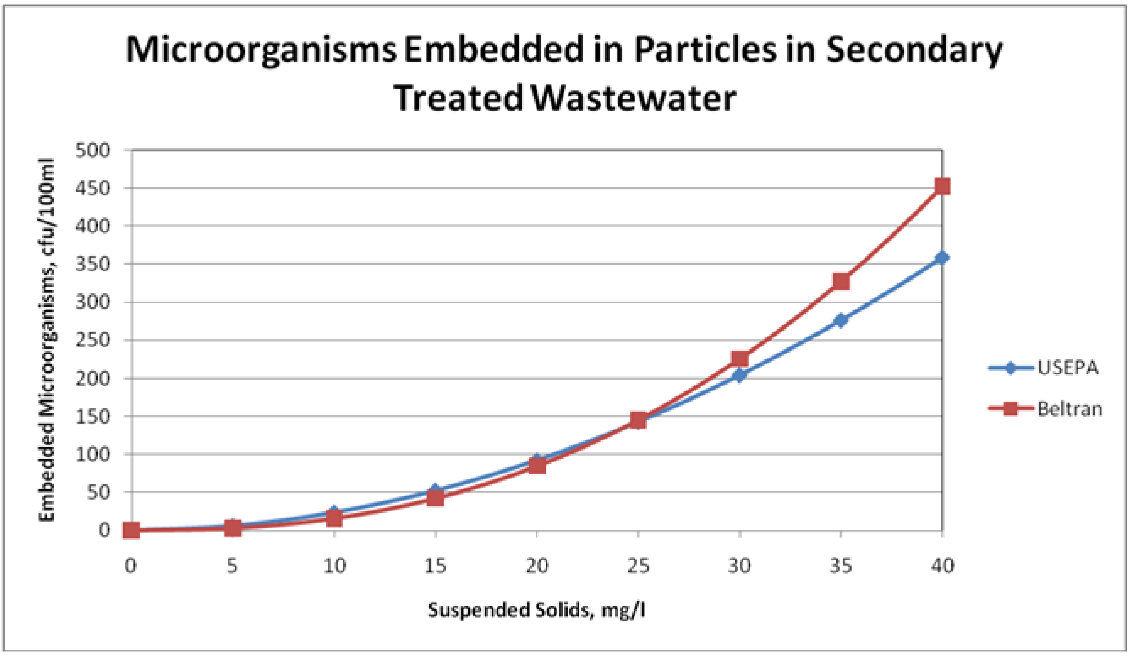


Figure 3 *Microorganisms embedded in particles in secondary wastewater.*

It suggests that, for a given treated wastewater TSS there will be a certain minimum number of target organisms that pass through untouched by the UV light no matter how high up the power level is turned. This effect will be particularly relevant for low final treated wastewater indicator target numbers.

This relationship between TSS and effective UV disinfection does not apply to oxidation pond treated wastewaters which behave differently due to the nature of the particles involved.

Continuous monitoring

Monitoring compliance through 'applied UV dose' is standard practice in the Drinking Water sector. The North American UVDGM (2006) 'Guideline'[20] (effectively an international standard) and German DVGW standard[23] are typically applied. However, its application is somewhat simplified in drinking water by the comparative (compared to wastewater) lack of particulate matter (water will have been through coagulation and/or media filtration and or membrane filtration, UVT typically >85% (cf 30-65%) and turbidity typically <1NTU).

Performance Validation

Thanks to adoption by the drinking water industry most of the modern UV disinfection systems have been through a 'validation' process. This is an independently verified process that certifies the performance of a particular UV system with verified inactivation of various challenge organisms. A number of these are shown in Figure 4. In New Zealand, the vast majority of WW disinfection is undertaken using Wedeco (Germany) and Trojan (Canada) UV systems. The Wedeco TAK55, Duron and LBX wastewater systems have been through validation processes. Trojan's UV3000, UVFit and UVSigna wastewater systems have all been validated.

[23] DVGW (2006). 'UV Devices for the Disinfection for Drinking water Supply – Parts 1, 2 and 3' Deutsche Vereinigung des Gas und Wassserfaches, Bonn, Germany.

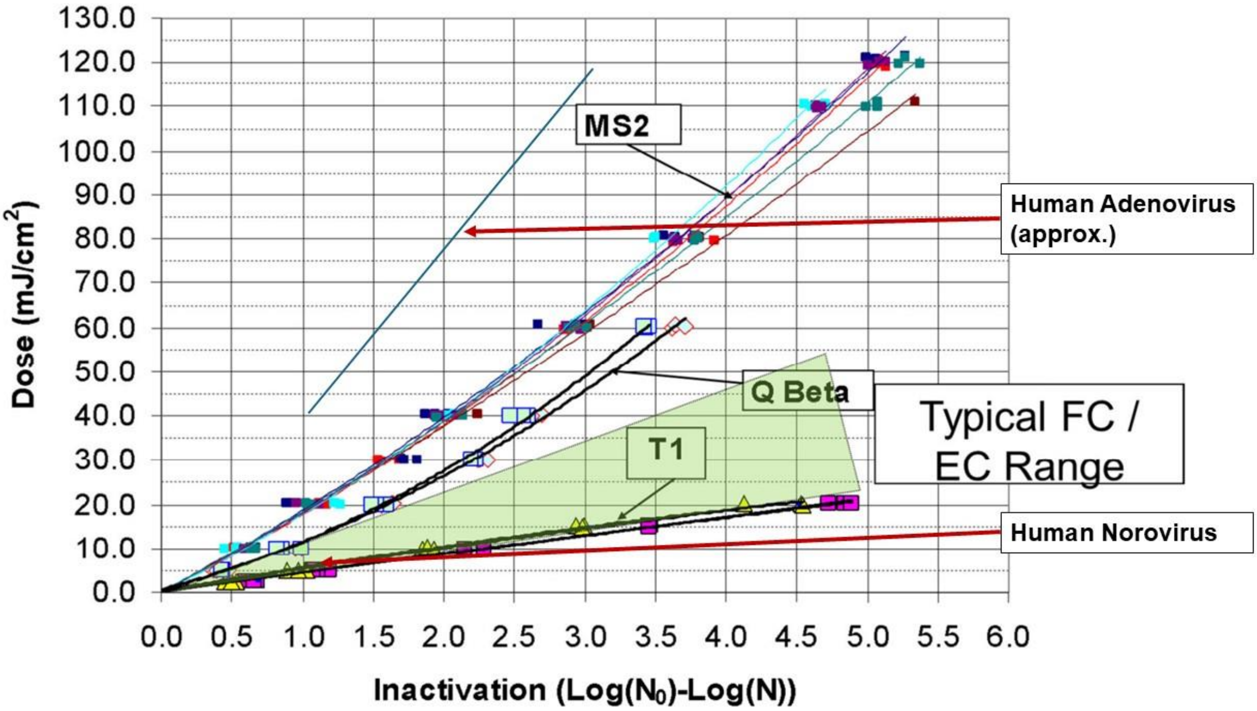


Figure 4 ***Range of UV Sensitivities (dose response) by type of surrogate (Meyer[19]).***

MS2 coliphage is a common (normally conservative) validation challenge organism. Therefore, if a system has been validated using MS2 only, the validated dose, for a particular situation needs to be adjusted / corrected for target organisms that are more sensitive (e.g. E. coli and norovirus) or less sensitive (e.g. Human adenovirus) than the validation challenge organism (Figure 4). Alternatively, collimated beam testing can be carried out, on the subject site, at the time of design to provide a dose response fitted to the site conditions. In this case, no adjustment is required.

Potential Methodology for evaluating UV disinfection

Rather than UVT, a possible methodology would be to use a field measured (continuous) average dose (time x intensity) corrected back to a validated dose and compared to the dose required for LRV of the target organism. Most modern UV systems are set up to be able to provide these calculations.

Calculation

A bespoke algorithm (based on a standard structure and standard parameters) would be established at design time for each installation then adjusted at commissioning time. This would provide, from the input parameters from the field and from the UV controller, a continuous measure of the validated dose being applied to the treated wastewater stream. Similar algorithms could be established for existing installations, particularly for those using UV systems that have now been through validation processes.

Field measurements would include:

- UVT: to check that the measured UVT in the treated wastewater is within the range over which the UV system was validated, or the validation adjusted at design time to account for treated wastewater that was known to be of higher (unlikely) or lower (more likely) UVT than that of the validation envelope. If not, a correction factor may have to be applied.
- UV intensity (UVi): to calculate the average intensity of applied UV light a set distances from lamp centre lines.
- Flow rate: through the UV system to calculate the average time a unit of flow is exposed to the UV light.
- Periodic treated wastewater TSS: To check that treated wastewater TSS is not such that other calculations are likely to be rendered inaccurate.

- Elapsed time: since UV bulb installation to verify that lamp life assumptions have not been contravened. However, the UVI could also be alarmed to provide a surrogate for this indication. The elapsed time would still be used as a flag to operators regarding lamp replacement.
- Check testing: Infrequent (Unless problems encountered), probably of both incident and treated wastewater enumeration of the target organism/s to verify that the dose-based monitoring is sufficiently accurate.

2.2.3.3 Should LRV be a requirement embedded in the Standards?

The concept of including treatment plant 'required LRVs' within the Proposed Standard has been considered. In such a system, the LRV would be specified for a plant such that it meets the 'end of pipe' (EoP) FIB standard.

However, not all influents are the same and not all treatment plants are the same. So, to meet any given EoP standard for FIB, the inlet conditions would have to be characterised, the pre-UV treatment performance would have to be characterised (as an LRV) and the required UV LRV (and consequently, design validated dose) then selected.

What could this look like?

The Standard 'could' require an E. Coli concentration of e.g. 1,300 cfu/100ml as 90^{th} %ile". The Consent then could say, or require to be reported / recorded at the outset:

- Based on the required Standard and influent characterisation, the whole of plant LRV requirement is 'X'.
- The plant non-UV LRV is 'Y'
- The required UV system LRV is therefore 'Z',
- Measured by monitoring the received UV dose
- The reporting parameter could be the 'achieved Plant LRV', or the achieved UV-LRV, or the received UV dose.
- The UV system actual LRV could back calculated using validated dose and FIB combination for that system.

There are two possible approaches to this: a) a simple, conservative, precautionary approach and b) a more mathematically rigorous, valid and less conservative approach. These are described in more detail in Appendix B.

Both of the approaches presented in Appendix B are a summary only of what would be required with or by each approach. However, there is a lot more data collection, data management and technical specification that would be required to ensure that each was implemented and maintained appropriately. As a result there would be a cost implication of this management and the potential for rework should the required LRV change if there are substantial changes in the catchment.

It is, therefore, concluded that this process requires a high degree of technical knowledge to conduct properly, would result in plant specific outcomes and is likely too complicated to include in the Standards.

2.2.3.4 Recommendation on UVT and LRV

The concept of continuous monitoring as a proxy for spot sampling for pathogens is an appropriate one.

UVT alone, is not appropriate and is not recommended for use for this purpose.

Continuous 'received dose' based monitoring and reporting is a valid monitoring tool and could be included in the conditions of the consent where UV disinfection is provided.

A continuously measured **UV Dose** based monitoring and reporting approach would be an acceptable, alternative (to grab sampling) form of FIB compliance monitoring. It uses technology and systems typically already included in modern UV disinfection systems. It would require more attention (than currently) to be applied to the establishment of the required dose and set up of calculation and reporting algorithms for each site. It would be validated by infrequent check sampling. It would give the regulator a higher degree of certainty that compliance is being achieved for a very high percentage of the time. The Dose itself would not appear as a numerical standard but the mechanism for calculating the target dose and reporting it would be built into the consent condition if the applicant and or regulator chose that particular approach. Continuous, dose-based monitoring would also provide early warning of potential system failures.

Adoption of '**Required Treatment Plant LRVs**' as 'Standards' has also been considered. It is not recommended because the process is complex and would result in plant specific requirements rather than a nationally appropriate Standard.

2.3 Assessment of coherence and effectiveness of Standards

2.3.1 Consistency and relativity of treatments

2.3.1.1 Scope from CSO

3. Review treatment limits across all parameters and receiving environments to provide assurance that:

3.1 **Treatment limits are internally consistent and there is relativity across the limits**

3.2 Treatment limits represent a cost-effective approach to consenting of wastewater treatment plants.

2.3.1.2 Method

As part of the challenge workshops an assessment of the consistency and relativity of the Proposed Standard, as it was drafted at that time, was undertaken as is presented in this section to express the assessment as undertaken as part of the "journey" for developing the Standard.

It is noted that a number of the points raised have undergone further consideration and the outcomes are presented in their most up to date form in the relevant sections of this report. Some points remain a work in progress and that is also signalled throughout the report.

Questions explored in this assessment were:

- Are there any inter-relationships within the Proposed Standard and what are the implications of those?
- How do we address limiting factors e.g.: disinfection requirement might drive TSS?
- How close are we to existing New Zealand and other international standards?
- Does the approach stack up from a technical perspective?

Each question was addressed and workshopped in Challenge Workshop #2.

2.3.1.3 Summary of assessment of consistency and relativity

Internal inter-relationships - Comparison between discharge categories within each parameter

The degree of risk of each of adverse effects occurring depends on the nature of the water body into which the discharge occurs. The proposed discharge categories have been derived to reflect the variable degree of risks in each water body.

Typically, the relative degree of risk of environmental effects would follow this hierarchy, with highest risks at top and lowest at the bottom:

- River or stream with dilution ratio <10 (very low)
- River or stream with dilution ratio >10 and <50 (low)
- River or stream with dilution ratio >50 and <250 (moderate)
- Lakes, estuaries
- Low energy coastal
- River or stream with dilution ratio >250 (high)
- Open ocean

As the risk of environmental effects decreases, then the numeric Standard would be expected to increase. We note that this hierarchy of effects can be affected by site specific considerations, which cannot be specifically addressed by a national Standards approach.

The numerical difference between the Proposed Standards was found to mostly follow the risk hierarchy, except for:

- Low energy coastal water, which has less stringent Standards than those for the nominally “equivalent” estuaries in terms of assumed dilution. However, the estuaries have additional sensitivities relative to low energy coastal water which support more stringent treatment limits.
- The treatment limits for moderate dilution rivers and estuaries are different, despite the assumed dilution ratios being the same. This is because rivers can have additional sensitivities, but also a number of rivers will contribute to any given estuary. Also, the assumed dilution ratio for rivers is based on full mixing, which may not always be available. Collectively this requires a precautionary approach to treatment limits for rivers.

The Proposed Standard has subsequently been refined to address this.

Limiting factors – Comparison between parameters for each discharge categories

Potential inter-relationships between the standards include:

- E. coli standard may require that the treated wastewater be clearer than required to comply with the TSS standard.
- TP standard may require greater solids removal than that required to comply with the TSS standard.
- TN standard may require a higher level of biological treatment than required to comply with the $cBOD_5$ standard.
- If a high organic load is received (from trade waste), then the $cBOD_5$ standard may require a higher level of biological treatment which reduces the TN concentration to much less than its standard.
- There may be other inter-relationships depending upon the specifics of each WWTP.

The issue is whether this is a concern for the Proposed Standards, such that the Standards should be revised so that they reflect the typical relationships observed in treated wastewater concentrations. The Standards for different parameters are derived for different purposes, and hence consistency would not be expected or necessarily required. Typically, a single parameter will be the limiting factor which dictates the design of a WWTP.

Which parameter affects the design of the WWTP will depend upon:

- Nature of catchment and contributing sources.
- WWTP and discharge conditions (e.g. climate, area available, nature of soil/ground, sensitivity of neighbours, etc.).
- The one whose numerical value requirement comes closest to triggering a technology change.
- Council policies with regard to waste minimisation, greenhouse gas emissions, financial (debt and depreciation), etc.
- Preferred cost structure, (i.e. high capex/low opex, low capex/high opex etc.).

Therefore, the potential for a single parameter to be the limiting factor in the design of a WWTP is normal and is not considered to be an issue for the Standards.

Alignment with international standards

The Proposed Standard was compared against a range of international standards with the following outcome:

- For $cBOD_5$ and TSS the Proposed Standard is equivalent or more stringent than the reviewed international standards.
- For Total Nitrogen the Proposed Standard is equivalent or more stringent than the reviewed international standards, except for the high dilution ratio category of rivers and streams.
- For Total Phosphorus the Proposed Standard is less stringent than the reviewed international standards in all cases except moderate dilution rivers and streams where it was roughly equivalent to the Colorado, 12- month, 95 percentile standard.
- Few international standards for pathogens or faecal indicator bacteria were found that were relevant for application as end of pipe quality requirements.

Comparison to NZ Receiving Environment Guidelines

The assessment found that there are no relevant guidelines used in New Zealand available for $cBOD_5$ and TSS in receiving waters. So, no New Zealand based assessment was undertaken for these parameters. An assessment was made for the remaining parameters against the following guidelines, as outlined in Table 16, which uses the dilution ratios as discussed in earlier sections to assess concentrations in the receiving environment after reasonable mixing.

Table 16 Assessment against guidelines in New Zealand.

Parameter and guideline	Summary and Commentary
Where the dilution ratio is less than 10 (freshwater rivers and streams only), or for lakes or coastal waters that do not comply with nominated selection criteria	– No specific guidance on discharges to very low dilution environments in New Zealand – Apply for the discharge consent under the standard RMA process
Ammoniacal nitrogen in fresh and marine waters from ANZG.	– Derived concentrations from Discharge Standards comply with Toxicity guidelines.
Nitrogen and Phosphorous: ANZECC 2000 Guidelines, using NZ Region for Rivers and South-eastern Australian region for other categories.	– The minimum dilution ratio in each range was used to perform the assessment of potential nutrient effects. – Nitrogen - guidelines would be met for all categories except low dilution river and low energy coastal/inshore waters. – Phosphorus - guidelines would not be met for all categories. The discharges at the higher end of the dilution ratio range for each category would. – However, the Standards will impose nutrient limits which are not currently included in many existing consents.
Periphyton: MfE 2022 “Guidance on look-up tables for setting nutrient targets for periphyton	– The minimum dilution ratio in each range was used to perform the assessment of potential nutrient effects. – The periphyton guidelines would not be met in any of the river categories for any of the Bands when the most sensitive streams are considered given this “worst case” analysis. The least sensitive stream types would meet Bands B and C, but not A. – A site-specific assessment is required for hard bottom streams, which is the primary environment where periphyton is a concern.
Public health was assessed against the MoH 2003 Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas (MAC of A)	– End of pipe standards have been set based on the contact recreational guidelines and a minimum dilution factor. – Impact on shellfish gathering undertaken through a site specific QMRA. – Where shellfish gathering occurs, requirement is to achieve both the contact recreation Standard and satisfactory limit based on QMRA and approved by Regional Council

2.3.2 Cost effectiveness of treatment limits

2.3.2.1 Scope from CSO

3. Review treatment limits across all parameters and receiving environments to provide assurance that:

3.1 Treatment limits are internally consistent and there is relativity across the limits

3.2 Treatment limits represent a cost-effective approach to consenting of wastewater treatment

2.3.2.2 Method

The approach taken to assess the cost effectiveness of the limits included consideration of the Proposed Standard and the implications of implementation in the context of the current regulatory context and mooted amendments to it and considering the cost implications of the uplift of treatment capability at NZ WWTPs.

The content of this section is based solely on the experience of the technical team. The key questions posed were:

- Overall, do the treatment limits represent a cost-effective approach to consenting of wastewater treatment plants?
- Will the Standard achieve the consenting efficiencies envisaged?
- Is the proposed approach reasonably cost effective in terms of capex and opex?
- Any pinch points and implications?
- Are we will limiting technological choice?
- How confident are we in the optimisation choices made and that they will be seen as reasonable?

2.3.2.3 Consenting Rationale

Consenting Process

The Standards as proposed have a number of requirements which have been developed through this document. Figure 5 provides a flow chart example of the decision process that an asset owner would work through to determine how their discharge should comply with the Standards. This includes the specific steps which applies to the need for a QMRA to address public health (as given in Section 2.2.2.5), specific steps which applies to the need for a site-specific assessment for effects on periphyton growth (section 2.2.1.5.1). and steps for discharges in proximity to sources of human drinking water (Section 2.2.1.9).

The Standards propose that a wastewater discharge that complies with the Standard would be a controlled activity. This means that the asset owner would submit an application to the relevant Regional Council for a discharge permit. The application would need to demonstrate how the proposed discharge would comply with the various requirements within the Standard and identify which part of the Standards would apply to the discharge permit.

The Regional Council would process the application and determine if the evidence provided by the applicant confirms that the discharge as proposed does comply with the Standards and hence can be processed as a controlled activity. If this is confirmed, then the Regional Council must grant the consent for the discharge of wastewater.

Hence, Regional Councils would have the ability to impose conditions on the discharge consent over these matters only:

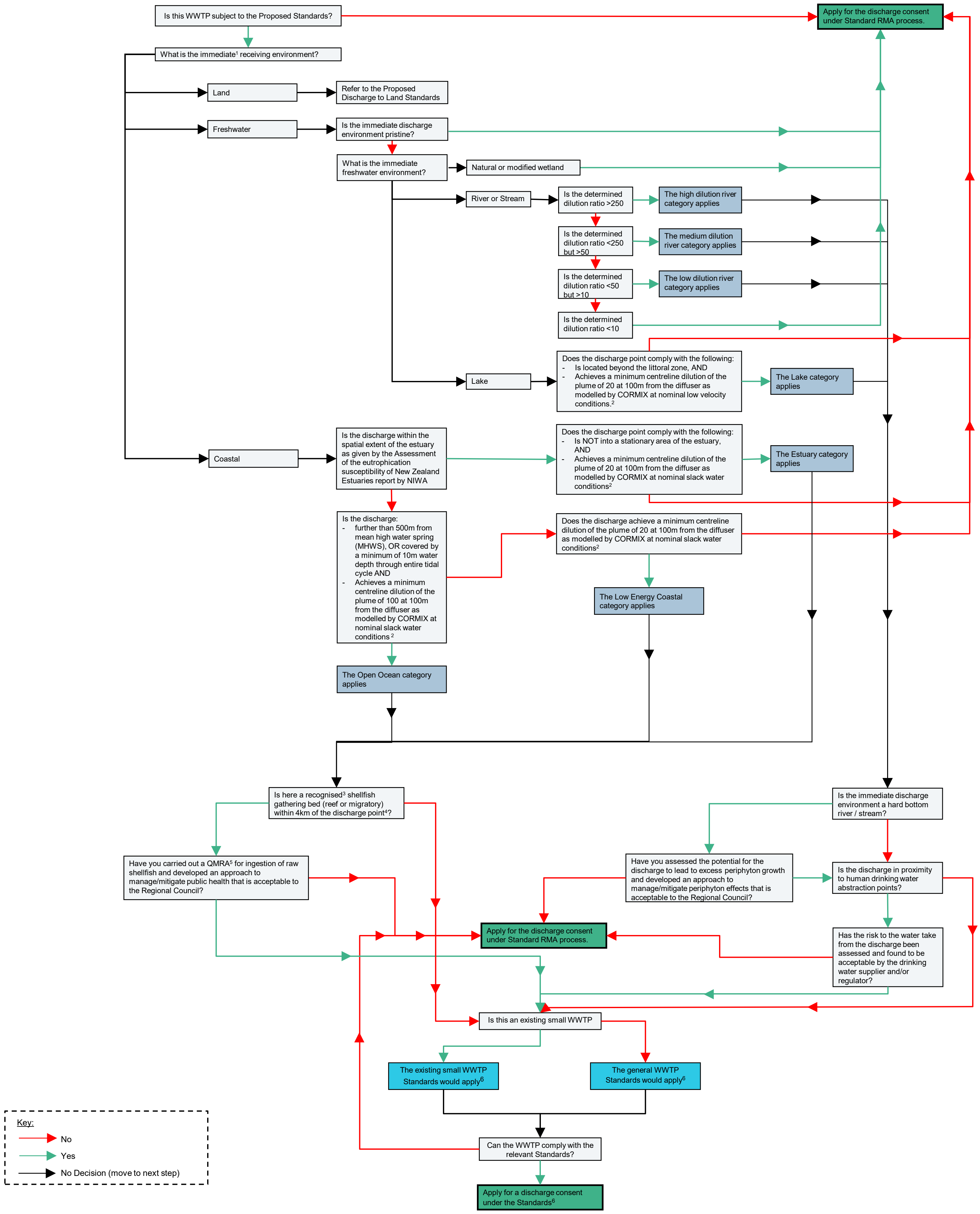
– Volume of discharge consented.

– monitoring, reporting, investigations into non-compliance or incidents, “other effects” etc. as presented in the T+T and EY work.

If the Regional Council determines that insufficient evidence has been provided to confirm that the Standards apply, under current RMA processes, the Regional Council could reject the application under Section 88 of the

RMA or seek further information under Section 92. If this information cannot be provided, then the application would be processed under the standard RMA process.

Example Process Flow Chart for Application of Discharge to Water Standard



Footnotes:
1. Immediate receiving environment being the environment at the point the applicant loses control of their discharge
2. Dilution assessment undertaken for the $Q_{effluent}$ as defined in Section 2.1.2.3, Eq 1
3. The mechanism for agreeing such presence is to be agreed. It could be unilateral, by Regional Council or may require other stakeholder involvement.
4. 4km has been suggested as this corresponds to far field (not extreme) reefs that have been investigated in existing QMRAs
5. Quantitative Microbial Risk Assessment
6. WWTP standards would apply, subject to any modifications as a result of any QMRA, periphyton or drinking water risk assessments required by the Standard

Figure 5 Process flow chart for application of Proposed discharge to water Standard.

Co-regulation of Contaminants

As discussed in Section 2.2, the Proposed Standards include numerical limits for specific parameters or contaminants. The proposed numeric limits control potential key environmental and public health effects from the discharge of treated wastewater associated with these specified parameters and also for other contaminants as follows:

- Carbonaceous 5-day Biochemical Oxygen Demand ($cBOD_5$) reflects the putrescible nature of the wastewater, which is reduced through the WWTP. It relates to the degree to which the treated wastewater contains “food” for micro-organisms, whose consumption reduces the oxygen in the water. This is indicated by a number of other parameters, including chemical oxygen demand (COD), total organic carbon (TOC). These other parameters will be co-regulated through the $cBOD_5$ Limit.
- Total Suspended Solids (TSS) indicates the amount of particulate matter is present in the treated wastewater. A number of contaminants in the wastewater will be associated with the solids. Hence, by reducing the amount of solids in the wastewater, these associated contaminants will also be reduced. This includes metals and organic compounds. Some of the synthetic or natural organic compounds in the Endocrine Disrupting Chemicals (EDC) or Pharmaceuticals and personal care products (PPCP) groups will be attached to solids and hence their concentrations will be reduced by complying with the TSS limit.
- Total Ammoniacal Nitrogen (Amm-N) is the main cause of toxicity in wastewater. Other toxicants, such as metals and organic compounds, would generally be removed through other processes and hence are not co-regulated through Amm-N control.
- Nutrients - Total Nitrogen and Total Phosphorus. There are many forms of nitrogen (i.e. Amm-N, nitrite, nitrate, organic nitrogen, oxidized nitrogen, total kjeldhal nitrogen) and similarly for phosphorus. The current consents that included limits for nutrients used a variety of forms in their conditions. As the stringency of the nutrient limits increases, this requires higher levels of treatment, typically including longer sludge ages, increasing chemical use and/or finer barriers (e.g. membranes). These increasing levels of treatment will also reduce other contaminants, either through increased removal of solids, similar to the TSS limit, or through enabling the breakdown of the contaminants in the system.
- Public Health - Faecal Indicator Bacteria (FIB) – E. coli and Enterococci. Many disinfection methods require the treated wastewater to be relatively clear and free of organic matter. Therefore, through implementing the treatment required to facilitate the disinfection process and comply with the FIB limits, the solids, organic matter and associated other contaminants will be reduced.

Therefore, regulation of the five specified parameters / contaminants will result in co-regulation as discussed above, of other contaminants in the treated wastewater. Hence, controls over contaminants not specifically regulated through the Standards would not be required for consents granted under the Standard.

This assumes that through regulating the specified parameters, other contaminants in the treated wastewater and their potential effects in the environment are also appropriately regulated. Co-regulation of contaminants is a common assumption which is typically implicit in most standards.

We note that this discussion is limited to the setting of numerical limits. Monitoring requirements are a separate issue. Monitoring for parameters other than the five specified ones, can and should be undertaken.

A review of the National Consents Database[4] has been undertaken which shows there are 7 plants that have limits for heavy metals and they all discharge to open ocean with a significant trade waste component. One plant has limits that appear to address diffuse source heavy metals (roofs and roads, presumably coming to the plant through I&I). There are a larger number of plants that have monitoring requirements for other parameters.

Numeric limits on other parameters could be added to the Standard over time, if identified as required, and where there is sufficient evidence to support a numerical limit.

Optional recommendation for consideration: Feedback could be sought on whether the co-regulation approach is considered to provide sufficient control or whether discretion should be allowed for Regional Council to consider the inclusion of limits on potential contaminants other than those currently specified.

Consenting efficiencies

The DIA fact sheet Local Water Done Well – Bill 3 fact sheet – **Wastewater and Stormwater Environmental Performance Standards** sets out a number of areas, related to consenting and regulation where they consider that there will be time and cost reductions due to the introduction of the Standards.

Taumata Arowai have indicated that they intend that a treated wastewater discharge would be required to:

- Comply with the relevant Discharge Standards which would then be included as conditions of consent without the current consultation and submissions process being required for those elements addressed by the Standard. This equates to a controlled activity under the current regulatory framework.
- Obtain and comply with a (probably) discretionary consent that would cover:
  - the "other effects" as listed below.
  - The location of the discharge.
  - Additional aspects such as odour, plant bypass limits.

Creating, operating and maintaining a discharge consent requires a suite of consents and approvals that happen or are obtained in a certain order and under a number of different regulatory 'instruments'. This effectively means that the consenting landscape for a particular discharge is a matrix structure. The numerical discharge Standards form one 'square' in the matrix. The rest of the matrix still needs to be addressed through other consenting processes. The extent of the matrix will obviously vary considerably depending upon the status of the discharge activity, with a new proposal being far more extensive than a simpler renewal process. However, under current RMA requirements, consent renewals are considered "de novo" which means that the application for a renewal is considered as if it is a new consent application.

It is intended that a consent (currently assumed to be Controlled Activity Consent)[24] would be obtained for a treated wastewater discharge compliant with the relevant Discharge Standards. This would bring about the following efficiencies:

- Reduction in the 'per consent renewal' monitoring, analysis and reporting of the likely ecological effects on the receiving water.
- Reduction in the professional and staff costs associated with developing, presenting, debating and defending the Proposed Standards in the Regional Council and stakeholder engagement fora.
- Reduction (proportion only) in legal costs associated with defending treated wastewater standard proposals.

However, under the current regime, it would remain necessary for the applicant to obtain and comply with a (probably) discretionary consent or bundle of consents that would cover:

- the "other effects" such as odour, noise, visual amenity, other contaminants that are not considered to be co-regulated by the Standards (e.g. emerging contaminants), ongoing environmental monitoring (likely to remain a Regional Council requirement).
- The location of the discharge – designations and land use obtained under a Notice of Requirement or District Planning consenting process.
- Additional aspects such as flow limits, plant bypass limits, building and maintaining structures in a water body.
- Cultural impacts, which are specifically outside the scope of this report.

Once the consent comes up for renewal, a number of these, such as designation of the land, would likely lose relevance in the context of a renewal. Although it does happen that long term, residual concerns of stakeholders are reintroduced and relitigated in subsequent consent renewals. Under the current regime it is difficult to prevent these being introduced as issues within peripheral consent renewal processes.

If the current practice of Regional Councils to bundle processing of consents with overlapping effects is to continue then it will likely result in the discharge consent being processed as a discretionary activity which would lose the efficiencies that the discharge Standards are designed to gain. This would be an unfortunate outcome, and the likelihood of this occurring needs to be assessed and could potentially be addressed in the Regulatory Impact Statement. If this risk does indeed raise uncertainty around the ability of the Standards to support a more efficient

[24] Note though that the RMA is also being replaced with new legislation **- Changes to resource management | Ministry for the Environment**.

consenting process, then safeguards to prevent consenting delays due to matters not directly addressed by the Standard will need to be developed.

The proposed RMA Amendment and the Local Government (Water Services) Bill (Bill 3) may provide opportunities to reduce and address this risk through the changes indicated to date.

2.3.2.4 Potential implications for Small Plants

The Proposed Standards are, for small plants, generally (although not exclusively) a step up in performance requirements from those currently existing. Consequently, most small plants are likely to require upgrades of one form or another to either meet tighter numerical standards or higher compliance (e.g. 90%ile rather than mean or median values).

Many small plants have nil or very limited power supply. So, adding process complexity will attract capital costs in obtaining a sufficient energy source (normally an electrical power source and transformer) that are in addition to the treatment upgrade costs itself. These normally incur a capital cost contribution to the electrical network company, as well as higher annual line charges, on top of the extra power consumed and higher supply capacity tariffs.

Treatment upgrade additions will incur increased operational costs as discussed below (under effects on operational cost).

There is a potential unintended consequence of the Standards, where these impose technologically more advanced and more intensive hardware processes on the site. Treatment process additions may result in increased greenhouse gas emissions through additional capital works and operational activities.

For a number of plants if may be more cost effective to abandon the site and pump away to amalgamate with other WWTPs on a subregional basis.

- This brings efficiencies from an operational sense: Less operator input, reduced consent renewal costs, fewer power supply tariffs, less managerial and reporting time, fewer instrument calibrations, lesser mechanical inventory to maintain and replace.
- Septicity and odour can become a problem because of the long conveyance pipelines involved, but this can be managed.
- Increased risk of pipe leaks and breakage.
- The capital cost of the additional pumping and pipeline assets needs to be weighed up carefully against the savings of decentralised upgrades and operations/maintenance.

A second potential outcome though is:

- More decentralised treatment is a possibility if new plant consents are significantly easier to obtain.
- If individual developers can easily get consent for small size WWTPs on an individual development basis, this has a serious implication for District Councils who may be forced to ‘vest’, own and manage these little, under resourced plants. Once vested in Council these plants then become publicly owned and operated and thus subject to the Standard.
- A direct implication of electro-mechanical upgrades of many pond based WWTPs and, indeed, additional WWTPs is the need for significantly more trained wastewater operators in the New Zealand market. There is already a very significant shortage of both trained and untrained operators for the systems we have now. This already leads to compliance outcomes that do not meet the potential of the existing systems, let alone the higher technological outcomes intended from higher tech electromechanical systems.

2.3.2.5 Assessment of cost effectiveness

2.3.2.5.1 Effects on Capex

Medium - Large Plants

Generally, apart from at the coast, the medium to larger WWTPs, in their upgrades, have been targeting reasonably high standards of treated wastewater quality already. Many of these plants have increased access to available funding mechanisms and hence will therefore be in a better position to be able to respond to the implementation of the Proposed Standard.

Further, significant portions of the cost of their upgrades are for Growth and Renewals as well as for increased levels of service (ILOS) that would be induced by a marginal increase in discharge Standards, and/or the statistical basis for compliance with the new Proposed Standards. Some of these, particularly on the lower Waikato River have or will incur higher costs than would be imposed by the Proposed Standards because those facility owners already have a memorandum of understanding with river iwi, for a higher river discharge standard in lieu of a land discharge requirement, giving effect to Te Ture Whaimana o te Awa o Waikato and the long term aspirational goal to return the River to the state it was in, in 1863.

There are a few large plants that are still based on pond systems and these could attract high upgrade or replacement costs. One scheme on the Eastern Seaboard of the South Island includes 4 small/medium sized, pond based, WWTPs which combined their treated wastewater (average quality) through an ocean outfall. This avoided upgrades to the plants and removed discharges from freshwater.

A small number of the larger coastal plants have biological treatment systems (lowly loaded trickling filters for BOD reduction only) but with no removal of solids or biomass. These also would likely attract substantial upgrade costs, primarily due to the proposed microbiological standards for ocean outfalls. If these plants are required to disinfect 'treated' wastewater, the costs will be substantial, in the tens of millions of dollars per plant for disinfection alone. If a clarification process to remove the solids/biomass was required, then substantial additional costs are added. In both these cases, the current biological treatment is focused on the municipal/domestic waste stream, with pre-treated (to meet Trade Waste Bylaws), high-strength industrial wastes collected separately and mixed with the WWTP treated wastewater for final discharge through the single outfall.

Other outfall treatment plants are already starting with a reasonable platform from which to accommodate some treated wastewater quality increases. For example, a medium sized coastal WWTP upgrade which moved the plant from a single pass, trickling filter to add a lamella clarifier, tertiary filtration and UV disinfection. The cost (2021, for a flow capacity of up to 450 L/s) was $40M, or approximately $46M inflation adjusted (2024). This is for a population of approximately 38,000. Major, high-strength, industrial flows bypass the treatment facility but share the outfall. An upgrade in any of these plants will be undertaken most cost effectively if permitted to be undertaken in conjunction with works associated with growth and renewals. That way:

- design, construction and project management overheads are shared across all categories of work,
- growth based staging is provided for,
- disruptive interventions are made only once,
- sizing related to Level of Service (LOS) is 'right sized' when implemented if it is done in conjunction with growth requirements.

This may mean that it is appropriate to build in some flexibility to LOS implementation (provision in regulations) to allow time to transition to the new Standard and enable it to coincide with works related to growth and renewal needs.

Small Plants & Pond based Plants

Many small WWTPs, to date, have not required major technological shifts with consent renewal where fairly 'easy to reach' FIB limits (about 1 log removal value (LRV) for E. coli through the UV system) have been addressed by direct addition of a UV system without other process enhancements.

A number of small treatment plants have already undertaken full, high tech rebuilds to address consenting issues.

While it is not possible to compare exact 'scope' between the upgrade projects (they all differ), the following figure (Figure 6Figure 6) provides an indication of the varying price 'trajectory' for those plants where a full, high-tech replacement has been procured (on the pond site) and those that have retained the ponds as a primary or significant component of the treatment train. Two medium sized plants (have been added to give a better perspective on the price trajectory. The one in orange has been a complete plant replacement in membrane bioreactor (MBR) based activated sludge technology, whereas the one in blue used a conventional activated sludge technology AND retained the pond system, undertaking 30% of the treatment load. Pond based process understanding and prediction as commonly practiced is somewhat random and the success of lower technology, pond-based upgrades has been less reliable in reducing ammonia levels than with the more exacting design and operational standards of activated sludge and the modern high-tech plants.

Those replacement treatment plants (orange in Figure 6Figure 6) have typically been targeting a TN of around 4mg/L as an annual mean or median while those in blue, if anything, have been closer to 15mg/L. It is also of note that all of these upgrades will have components of growth[25], renewals and increased LOS – so the entire cost would not be attributable to discharge quality requirements.

Some pond upgrade strategies have been beneficial for purposes other than ammonia reduction. For example:

- Additional aeration – improved BOD removal or increased BOD treatment capacity.
- DAF or Actiflo and coagulant dosing - Improved phosphorus and TSS removal and improved ultraviolet light transmissivity (UVT).
- UV systems – disinfection.

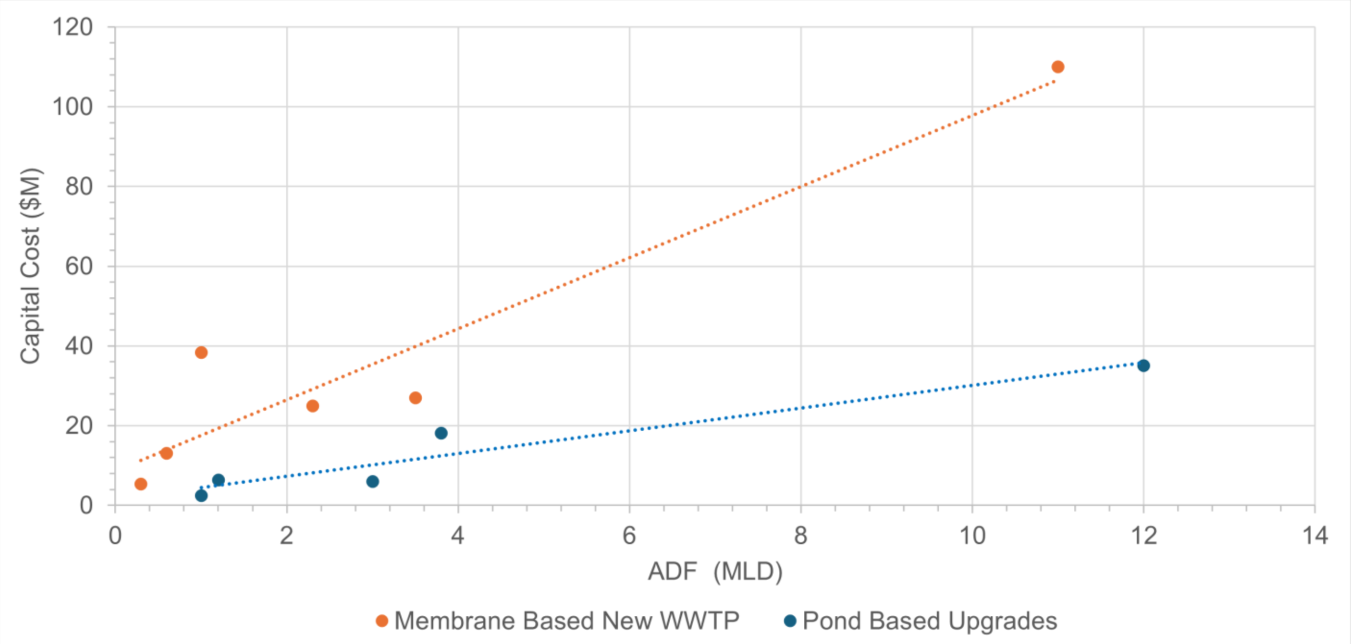


Figure 6 ***Upgrade vs Low TN Replacement cost trajectories (4 MLD (megalitres per day) ADF (average day flow) is approximately 16,000PE).***

By way of examples:

- For those pond systems required to achieve a low level of treated wastewater pathogens there is a significant cost increase (scope changes limited to unit process additions). The estimate for a 3 MLD (approx. 6000 population, but high flows) pond upgrade, currently in the design and procurement phase, is $6.5M for addition of a DAF[26] (dissolved air flotation) plus UV disinfection.
- For those pond systems required to achieve a significant level of ammonia-N reduction, (but not down to the low levels provided by activated sludge) there is a significant cost increase (scope changes limited to unit process additions). The tendered price (2024) for a current Moving Bed Bioreactor (MBBR) upgrade for 1.2MLD, as an Average Daily Flow, (or approximately 6,000PE) is $6.4M.
- An existing, small SBR style mechanical plant required an upgrade in 2021 for increased levels of service (BOD<3 mg/l, TSS<3, TN<4.5, ammonia-N<1.0, TP<3.4, E. coli < 50cfu/100ml) as medians. Stage 1 ADF is 0.6MLD or around 3,000PE. The discharge is to land in highly permeable soils in a catchment where nutrients are very strictly managed. The very high standard required for all key parameters led to the selection of an EBPR configured BNR AS plant with a membrane bioreactor (MBR) style solids separation process. EBPR is enhanced biological phosphorus removal. BNR is biological nutrient removal. Much of the existing civil / structural infrastructure was used (e.g. concrete tanks) and enlarged. All of the electro-

[25] Growth, because they were designed and built in the 1970s to 1980s. Renewals because electromechanical systems installed in the 1990s and early 2000s will be wearing out or obsolete. ILOS as a result in changes to treated wastewater quality expectations.
[26] Note that for pond systems with a reasonably relaxed disinfection limit and not subject to severe summer algal blooms, tertiary solids removal by DAF or membrane filter may not be required

mechanical systems had to be replaced. The inflation adjusted capital cost of this upgrade is approximately $15.5M

- A small Pond system was required to be upgraded to meet a TN<4mg/l median, very low TSS, very low E. coli standard in order to get agreement for a discharge to land requirement to be imposed. The ADF is 0.3MLD (700 population). The work was undertaken in 2020 consisting of a new MBR system. The pre-existing pond system was retained for wet weather balancing. Inflation adjusted capital cost for this upgrade is approximately $5.3M.

2.3.2.5.2 Effects on Operational Cost

Medium - Large Plants

Most medium to larger plants (except coastal) are targeting very low treated wastewater ammonia concentration now, requiring at least nitrification, and so a tightening of the TN limits is unlikely to cause very significant increases in energy costs.

The implication of a uniformly low phosphorus limit will result in a significant increase in the use of alum for chemically based precipitation. This has a direct cost (haulage and chemical cost) and often the added complication of disposing of residual sludge with a high aluminium content (refer to example under small plants below).

If the balance of coastal discharge plants are required to disinfect (A number do already) then there will be the added energy cost, lamp and ballast replacements, for running the disinfection system and potentially further chemicals associated with a sedimentation process.

As an example, a coastal city of, circa 38,000 PE, discharging 14.3 MLD has the following (Table 17) approximate UV system operating cost profile.

Table 17 Small Coastal city approximate UV system operating cost profile.

Consumable	Number	Units /year	Unit Cost	Annual Cost
Power	54 kW.hr/ML	5212 ML	$0.3/kW.hr	$84.4k
Lamps	140	70	$490	$34.3k
Ballast	140	14	$2095	$30.3k
Sleeves	140	20	$504	$10.1k
Operator		312 hr	$100	$31.2k
Technician		100hr	150	$15k
			Total	$205k/yr

For both large and small WWTPs, denitrification to low levels of TN is likely to require dosing of supplemental, readily biodegradable substrate.

Small Plants & Pond based Plants

For the small, simpler pond based WWTPs (typically less than 5 MLD but can apply to larger pond systems as well), upgrades to a common standard TN or TP standard will have more significant implications. The current version of National Consents Database (December 2024) indicates that there are some 170 pond based WWTPs remaining. The additional operational inputs are likely to include[4]:

- Operator time moving from, say 2 x 1hr visits/ week to 3-5 x 2hr visits per week. i.e. Plus 200-400% operator input.
- Instrumentation servicing (often currently only includes a flow meter, requiring servicing every 5 years or so). Analytical instruments (level, ammonia, nitrate, ORP, TSS, pH, Temperature, dissolved oxygen etc) require regular calibration and normally a significant annual overhaul).
- Plant and mechanical repairs and maintenance.
- Chemical consumption – particularly coagulant and polymer for DAF or for separate P removal.
- Energy consumption (Disinfection, aeration, additional pumping).
- Additional Monitoring requirements (sampling, transport and laboratory costs).

- 25-year renewal cycles for mechanical and electrical systems introduced.

As an example (Table 18) is based on a scenario of a 1MLD ADF (4,000 PE) single pond WWTP, removing phosphorus to meet a 1 mg/L consent limit (i.e. target is sub 1mg/L). This will likely require a 100mg/l alum dose rate, in a DAF, and a consequential 64mg/l TSS reduction (average). The aluminium contaminated sludge will need to be hauled to landfill.

Table 18 Example of cost for a small pond based plant.

Consumable	Number	Units /year	Unit Cost	Annual Cost
Power	10kW	87600	$0.3/kW.hr	$26.3k
Alum	100mg/l	36,500	$3.57/kg	$130.3k
Disposal of Sludge Cake 20% ex geobag to landfill	64mg/l + 100mg/l	354 T/yr	$150/wet.tonne	$53k
Haulage	40km round trip	14,000 wt.km/yr	$1.50	$21k
Operator		180	100	$18k
Technician		20hr	150	$3k
			Total	$252k/yr

2.3.2.5.3 Limitations on Technology

The Proposed Standards are generally not testing the limits of technology (LoT). Although a regulated limit of 5mg/L TN, end of pipe, will mean a design value of 3.5 – 4mg/L and this will come close to LoT.

For Pond based upgrades, there will be a lesser choice of reliable options available. Many potential solutions have failed, and some have only been partly successful. Ratsey (2016)[27] and Crawford et al (2023)[28] discuss a number of these technologies. The latter identifies those that have been most successful.

Pond systems, of their own accord, tend not to fully nitrify (convert ammonia – N to Nitrate) and it is generally regarded that this is the key problem related to the long term retained adoption of pond technology in New Zealand. The ammonia in treated wastewater has both acute and chronic environmental impacts in fresh and marine receiving waters due to:

- Acute ammonia toxicity to aquatic fauna, and
- The contribution to the Total Nitrogen load on the receiving water and the chronic effects of that nitrogen, seasonally, in respect to eutrophication of that receiving water.

Some technologies that have been found, across a number of pond-based plants, to provide reasonable reliability for reduction of one or a very limited range of analytes include:

- Tertiary Membrane Filters (not MBR) or Dissolved Air Flotation (DAF) for removal of TSS, followed by UV for pathogen inactivation. Tertiary membranes may not require UV. This intervention will remove a small amount of organic nitrogen, but will not reduce ammonia-N or nitrate-N. It removes a large proportion of the TSS and, consequently, also renders the treated wastewater significantly more suitable for UV based disinfection.
- In some circumstances, where the treated wastewater E. coli limit is reasonably relaxed and the pond does not suffer from extensive summer algal blooms, the required level of disinfection will be able to be achieved by a standalone UV system without the benefit of tertiary clarification or filtration.
- Aerated, fixed film options can be adopted if nitrification is required. The nitrification will not be as precise as it is in long SRT activated sludge plants. Therefore, low TN treated wastewater (say, below 15mg/L) is not likely to be readily achievable and supplementary dosing of readily degradable carbon products (8.6 grams readily biodegradable COD (rbCOD) per gram of nitrate –N to be denitrified) may also be required to enhance the denitrification process. The rbCOD can be sourced from products such as ethanol, sugar,

[27] Ratsey, H., Upgrading Waste Stabilization Ponds: reviewing the Options. Water New Zealand 2016
[28] Crawford, J., Bouman, R., Scrimgeour, C. Pond Upgrade or Plant Rebuild – A guide to Navigating the Pros and Cons. Water New Zealand 2023.

vinegar or molasses. The nitrogen removal process from pond-based plants will also be temperature dependent.

- A technology known as 'Bioshells' has been adopted full scale at pond based WWTPs servicing at least 4 communities However, the wider scale and longer-term success of this technology is, as yet, not cemented into WW process practice.
- Use of the pre-existing volumetric capacity of the ponds, as part of an upgrade process, to provide diurnal peak and wet weather flow balancing is beneficial in allowing the size (and cost) of the new electro-mechanical systems to be moderated.

Some small plants may need to be fully replaced) if a very low TN (5mg/L), nearing limit of technology, is required and/or where there is only a very low receiving water dilution ratio available.

For **larger scale, bio-mechanical plants**, there is significantly more choice of proven, reliable mechanical technologies available, retaining scope for competition in mechanical systems procurement. However, where the TN target is very low, say 4mg/L, the biological choices (accompanying the mechanical systems) are reasonably limited. Basically a 4 stage (alternating anoxic / aerobic) biological system is required. Internationally, 5 stage biological systems are also common, incorporating biological phosphorus as well. However, these are relatively uncommon in New Zealand with designers more commonly adopting chemical P removal systems.

Confidence in Optimisation of Discharge Quality vs Cost Implications

The intention is that, overall, the Standards strike a reasonable balance between cost outcomes and environmental/public health outcomes. Except at low dilutions, the Proposed Standards do not test the limits of technology.

The constrained time frame for this cost assessment has dictated that all work is done to date has been carried out at a relatively high-level, relying on comparison with international approaches, analysis of existing consents in New Zealand and the experience of and data available to the collective team members.

2.3.2.6 Outcome

Approximately 70% of WWTPs require reconsenting over the next 10 years, with approximately 30% operating on expired consents[29]. Reconsenting of these wastewater treatment plants is likely to result in a significant number of WWTPs being required to upgrade. The implementation of the proposed standards is intended to strike a reasonable balance between cost outcomes and environmental/public health outcomes. Large and medium plants are better placed to respond to the general standard proposed in this report. A small plant standard is proposed to ensure that proposals strike a balance between cost and environmental/public health outcomes for this smaller plant infrastructure

[29] **Local Water Done Well Fact Sheet: Wastewater and stormwater environmental performance standards.**

3. Abbreviations and acronyms

Term	Definition
ADF	Average Daily Flow
Amm-N	Ammoniacal Nitrogen
ANZG	Australia and New Zealand Guidelines
BOD	Biochemical Oxygen Demand
$cBOD_5$	5-Day Carbonaceous Biochemical Oxygen Demand
CMA	Coastal Marine Area
COD	Chemical Oxygen Demand
CSO	Consultancy Service Order
DO	Dissolved Oxygen
DAF	Dissolved Air Flotation
DR	Dilution Ratio
EBPR	Extended biological phosphorus reduction
EDC	Endocrine Disrupting Chemicals
EY	Ernst & Young Strategy and Transactions Limited
FIB	Faecal Indicator Bacteria
ILOS	Increased Level of Service
IUVA	International UV Association
LOS	Level of Service
LOT	Limits of Technology
LRV	Log10 Reduction Values
MAC	Microbiological Assessment Category
MBR	Membrane Bioreactor
MLD	Megalitres per day
7-day MALF	7-day Mean Annual Low Flow
NPS-FM	National Policy Statement for Freshwater Management
ORP	Oxidation Reduction Potential
PCBs	Polychlorinated Biphenyls
PE	Population Equivalent
PFAS	Per- and Polyfluoroalkyl Substances
PPCP	Pharmaceuticals and personal care products
QMRA	Quantitative Microbial Risk Assessment
rbCOD	Readily Biodegradable Chemical Oxygen Demand
RMA	New Zealand Resource Management Act 1991
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
T+T	Tonkin & Taylor Ltd
UVT	Ultraviolet Transmissivity

Term	Definition
WWTP	Wastewater Treatment Plant

4. Glossary

Term	Definition	Source
7-day Mean Annual Low Flow	Flows calculated by averaging the lowest seven-day rolling mean flow for each year on record. It is calculated based on full hydrological years (June to July) to avoid splitting a single drought event across years.	**LAWA Glossary**
Aerobic	Of organisms requiring oxygen for respiration or conditions where oxygen is available.	**LAWA Glossary**
Anoxic	Describes a condition without any oxygen, opposed to aerobic condition.	
Assimilative Capacity	The maximum loading rate of a particular pollutant that can be tolerated or processed by the receiving environment without causing significant degradation to the quality of the ecosystem and hence the community values it supports.	**ANZ Guidelines for Fresh & Marine Water Quality Glossary**
Ammoniacal Nitrogen	Covers two forms of nitrogen: ammonia and ammonium.	**LAWA Glossary**
Biochemical (or Biological) Oxygen Demand	The decrease in oxygen content in mg/L of a sample of water in the dark at a certain temperature over a certain of period of time which is brought about by the bacterial breakdown of organic matter. The oxygen demand is measured after 5 days (BOD5), at which time 70% of the final value has usually been reached.	**ANZ Guidelines for Fresh & Marine Water Quality Glossary**
Carbonaceous Biochemical Oxygen Demand	Oxygen demand resulting from decomposition of carbonaceous organic matter in a sample (excludes any effect from nitrification). Achieved by including a nitrification inhibitor in the test.	**New Zealand Municipal Wastewater Monitoring Guidelines**
Chemical Oxygen Demand	The amount of oxygen required to oxidise all organic matter that is susceptible to oxidation by a strong chemical oxidant.	**ANZ Guidelines for Fresh & Marine Water Quality Glossary**
Coastal Marine Area	Refers to the foreshore, seabed, and coastal water, and the air space above the water – – of which the seaward boundary is the outer limits of the territorial sea. – of which the landward boundary is the line of mean high water springs, except that where that line crosses a river, the landward boundary at that point shall be whichever is the lesser of 1 kilometre upstream from the mouth of the river; or the point upstream that is calculated by multiplying the width of the river mouth by 5.	**New Zealand Resource Management Act 1991**
Controlled Activity	Activities described by section 87A(2) of the RMA which require a resource consent from the Regional Council.	**New Zealand Resource Management Act 1991**
Dissolved Oxygen	Oxygen gas that is freely available in water to sustain the lives of fish and other aquatic organisms.	**New Zealand Municipal Wastewater Monitoring Guidelines**

Term	Definition	Source
Discharge	Volume of treated wastewater that is released from a wastewater treatment plant into the receiving environment.	Based on the context of this report.
Dilution Ratio	Ratio of receiving environment flowrate/volume to wastewater discharge flowrate/volume. A measure of extent of dilution that takes place within the receiving environment.	Based on the context of this report.
Eutrophication	Enrichment of waters with nutrients, primarily phosphorus, causing abundant aquatic plant growth and often leading to seasonal deficiencies in dissolved oxygen.	**ANZ Guidelines for Fresh & Marine Water Quality Glossary**
Faecal Indicator Bacteria	Faecal indicator bacteria (FIB) are bacteria that come from the gut of warm-blooded animals (including people). The presence of them in our waterways and groundwater indicates that other pathogens harmful to humans may also be present. Common FIBs include E. coli and Enterococci.	**LAWA Glossary**
Log10 Reduction Values	The level of microbial reduction, or disinfection required through the wastewater treatment plant measured in factors of 10.	From this report.
Microbiological Assessment Category	Categories from the New Zealand Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas for classifying marine recreational waters based on general water quality over an extended period. It is calculated on the basis of five years of historical data (at least 100 data points).	**New Zealand Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas**
Mixing zone	Zone in which mixing of the treated wastewater discharge takes place in the receiving environment.	**New Zealand Municipal Wastewater Monitoring Guidelines**
Nitrification	To oxidize (an ammonia compound) into nitric acid, nitrous acid, or any nitrate-nitrogen or nitrite-nitrogen, especially by the action of nitrobacteria.	**LAWA Glossary**
Near-field Mixing	Mixing and dispersion of the discharge with the water of the receiving environment that occurs immediately in the vicinity of discharge point. Occurs due to the buoyancy and momentum of the discharge plume as it discharges from the diffuser.	From this Report.
Periphyton	A group of organisms in aquatic environments specialised to live on and exploit much larger (usually inert) surfaces. Groups of organisms include fungi, bacteria, protozoa, and algae. The most conspicuous group is the algae and this group is usually the focus of most studies of periphyton.	**New Zealand Periphyton Guideline**
Quantitative Microbial Risk Assessment	A quantitative way of estimating the health risk to people who are swimming in and consuming raw shellfish harvested from waters which are near sources of microbial contamination such as river plumes and wastewater outfalls.	**NIWA. Microbial Modelling.**
Readily Biodegradable Chemical Oxygen Demand	Proportion of COD that that is directly available for biodegradation by heterotrophic microorganisms (volatile fatty acids, alcohols, amino-acids, simple sugars).	**Ohio Water Environment Association**

Term	Definition	Source
Receiving Environment	Any waterbody receiving discharge from a wastewater treatment plant.	**Adapted from NPSFM**
Small Treatment Plant	Plants with influent $cBOD_5$ threshold of 85 kg/day, or less, including residential and commercial/industrial sources	As described in Section 2.2.1.8.1
Total Nitrogen	A measure of all organic and inorganic forms of nitrogen in the water. Reflects the potential for the discharge to cause nutrient effects.	**LAWA Glossary**
Total Phosphorus	A measure of all forms of phosphorus in the water, including dissolved and particulate, organic and inorganic. Reflects the potential for the discharge to cause nutrient effects.	**LAWA Glossary**
Total Suspended Solids	The entire amount of organic and inorganic particles dispersed in water.	**US EPA**
Ultraviolet Transmissivity	An indication of the ability of a liquid to transmit UV light at the specified wavelength.	From this report.

Appendices

Appendix A

List of Estuaries

Taken from Appendix A of the 2018, NIWA Assessment of the eutrophication susceptibility of New Zealand Estuaries.

Appendix A Table of estuary results

Table A-1: Summary of estuary data and results. Estuary data were derived from the Coastal Explorer database, and information available through ETI tool 1 https://shiny.niwa.co.nz/Estuaries-Screening-Tool-1/.

Estuary	Regional Council	NZCHS code	ETI class	LAT (WGS84)	LON (WGS84)	Tidal prism spring tide (m^3)	Volume spring tide (m3)	Intertidal area (%)	Catchment Area (ha)	Mean freshwater inflow (m^3/s)	Flushing time (days)	Freshwater fraction (%)	TN load (T/yr)			Estuary TN Concentration (mg/m^3)			chl-a (µg/l)			Macroalgae Band			Phytoplankton Band			ETI Susceptibility Band		
													Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current
Tapotupotu Bay	NRC	7B	SSRTRE	-34.435	172.715	557185	797044	1	1341	0.20	8.0	18	1.231	2.683	2.723	61	102	103	3.4	7.9	8.0	A	B	B	A	B	C	A	B	C
Waitahora Stream	NRC	7B	C.LAKE	-34.456	172.795	0	206506	0	615	0.09	25.8	100	0.575	1.252	1.262	197	429	433	21.6	48.0	48.4	A	A	A	D	D	D	D	D	D
Parengarenga Harbour System	NRC	8	SIDE	-34.529	173.016	74683095	109524603	82	19596	2.87	13.7	3	35.361	77.040	94.581	53	67	73	4.3	6.0	6.7	A	A	A	B	B	B	A	A	A
Houhora Harbour	NRC	8	SIDE	-34.836	173.174	14648771	19560356	87	11633	1.62	10.9	8	18.197	39.645	59.998	62	95	126	4.8	8.5	12.0	A	B	B	B	C	D	A	B	B
Rangaunu Harbour	NRC	8	SIDE	-34.875	173.272	122167882	248188694	78	55150	11.47	17.0	7	115.589	251.834	559.314	57	83	141	5.3	8.2	14.7	A	B	B	B	C	D	A	B	B
Matai Bay	NRC	11	DSDE	-34.823	173.422	4217028	20270627	7	324	0.05	47.5	1	0.752	1.638	1.637	43	49	49	4.5	5.2	5.2	A	A	A	B	B	B	B	B	B
Awapoko River	NRC	6B	SIDE	-34.968	173.431	928354	1581009	47	9551	2.08	3.1	35	20.551	44.774	98.893	135	264	551	0.0	0.0	0.0	B	C	D	A	A	A	B	C	D
Taipa River	NRC	7A	SIDE	-34.982	173.475	2234740	3706197	52	12618	3.85	3.6	33	21.927	47.772	104.319	87	156	307	0.0	0.0	0.0	B	B	C	A	A	A	B	B	C
Mangonui Harbour	NRC	8	SIDE	-34.978	173.518	11218376	11929984	68	25644	7.37	4.4	24	44.665	97.312	189.116	77	130	223	0.0	0.0	9.6	A	B	C	A	A	C	A	B	C
Takerau Bay	NRC	11	DSDE	-34.926	173.546	456821	1490234	1	101	0.02	29.8	4	0.212	0.463	0.462	50	64	64	5.1	6.6	6.6	A	A	A	B	B	B	B	B	B
Taemaro Bay	NRC	11	DSDE	-34.930	173.584	1345496	3726052	3	432	0.10	24.1	6	0.773	1.684	1.733	52	68	68	5.0	6.9	7.0	A	A	A	B	B	B	B	B	B
Waimahana Bay	NRC	11	DSDE	-34.943	173.627	401044	1193351	8	729	0.17	15.5	19	1.175	2.561	2.749	74	124	130	7.0	12.6	13.4	A	B	B	B	C	D	B	C	D
Whangaihe Bay	NRC	11	DSDE	-34.984	173.818	389449	983997	3	207	0.06	19.4	10	0.425	0.927	1.047	58	85	91	5.5	8.6	9.3	A	B	B	B	C	C	B	C	C
Mahinepua Bay	NRC	11	DSDE	-35.001	173.869	947726	1596911	3	655	0.17	12.1	11	1.217	2.652	4.087	59	89	119	4.8	8.2	11.6	A	B	B	B	C	C	B	C	C
Takou River	NRC	7A	SIDE	-35.102	173.950	811887	1064981	57	7214	2.04	2.2	36	11.034	24.039	104.397	86	158	605	0.0	0.0	0.0	B	B	D	A	A	A	B	B	D
Tahoranui River	NRC	7A	SIDE	-35.118	173.967	429703	621026	25	2697	0.75	3.1	33	4.541	9.893	37.119	88	162	537	0.0	0.0	0.0	B	B	D	A	A	A	B	B	D
Tapuaetahi Creek	NRC	7A	SIDE	-35.118	173.982	425482	485568	84	1185	0.31	4.5	25	2.384	5.195	12.224	88	159	336	0.0	2.9	22.9	B	B	D	A	A	D	B	B	D
Te Puna /Kerikeri Inlet System	NRC	9	DSDE	-35.186	174.112	64786580	175541487	11	24430	7.92	21.6	8	42.680	92.986	464.814	49	66	192	4.7	6.6	20.8	A	A	B	B	B	D	B	B	D
Opua Inlet System	NRC	9	DSDE	-35.219	174.130	90004189	201871822	20	92633	23.16	14.5	14	170.507	371.484	954.476	66	106	220	6.0	10.5	23.5	A	B	C	B	C	D	B	C	D
Paroa Bay	NRC	11	DSDE	-35.244	174.146	2755026	4652984	27	359	0.09	16.0	3	0.792	1.726	2.144	45	54	58	3.8	4.8	5.2	A	A	A	B	B	B	B	B	B
Manawaora Bay	NRC	11	DSDE	-35.247	174.176	12159634	38744602	7	1044	0.27	30.8	2	1.819	3.963	7.242	42	47	54	4.2	4.7	5.5	A	A	A	B	B	B	B	B	B
Parekura Bay	NRC	11	SIDE	-35.241	174.213	5605251	14893034	37	2165	0.57	22.0	7	3.111	6.779	8.597	49	63	71	4.6	6.3	7.1	A	A	A	B	B	B	B	B	B
Oke Bay	NRC	11	DSDE	-35.224	174.272	1279573	6541153	1	73	0.02	50.2	1	0.085	0.185	0.185	40	42	42	4.2	4.4	4.4	A	A	A	B	B	B	B	B	B
Deep Water Cove	NRC	11	DSDE	-35.198	174.292	2453313	28637035	0	254	0.07	112	2	0.305	0.665	0.666	41	45	45	4.5	5.0	5.0	A	A	A	B	B	B	B	B	B
Whangamumu Harbour	NRC	11	DSDE	-35.242	174.329	4711274	41029541	1	138	0.04	86.9	1	0.228	0.498	0.526	40	42	42	4.4	4.5	4.6	A	A	A	B	B	B	B	B	B
Bland Bay	NRC	11	DSDE	-35.342	174.374	6415453	16993476	3	293	0.08	26.1	1	0.462	1.008	1.437	41	43	45	3.9	4.2	4.4	A	A	A	B	B	B	B	B	B
Whangaruru Harbour	NRC	9	SIDE	-35.360	174.346	19897380	44236086	26	6659	1.98	18.4	7	10.677	23.261	34.576	49	63	76	4.4	6.1	7.5	A	A	A	B	B	B	B	B	B
Helena Bay	NRC	11	DSDE	-35.423	174.387	5262636	12202396	3	2639	0.92	16.9	11	3.745	8.159	16.737	49	66	99	4.4	6.3	10.0	A	A	B	B	B	C	B	B	C
Mimiwhangata Bay	NRC	11	DSDE	-35.429	174.405	7386532	22294769	3	249	0.08	29.9	1	0.369	0.803	3.243	41	42	51	4.0	4.2	5.2	A	A	A	B	B	B	B	B	B
Whananaki Inlet	NRC	7A	SIDE	-35.523	174.470	2514250	3550490	75	5366	1.51	6.2	23	9.187	20.015	35.753	74	126	201	2.4	8.3	16.8	A	B	C	A	B	D	A	B	C
Whangaroa Harbour	NRC	9	SIDE	-34.995	173.774	41307851	109346708	32	24385	7.91	18.8	12	51.478	112.154	218.278	59	87	137	5.6	8.8	14.5	A	B	B	B	C	D	B	C	D

Estuary	Regional Council	NZCHS code	ETI class	LAT (WGS84)	LON (WGS84)	Tidal prism spring tide (m^3)	Volume spring tide (m3)	Intertidal area (%)	Catchment Area (ha)	Mean freshwater inflow (m^3/s)	Flushing time (days)	Freshwater fraction (%)	TN load (T/yr)			Estuary TN Concentration (mg/m^3)			chl-a (µg/l)			Macroalgae Band			Phytoplankton Band			ETI Susceptibility Band		
													Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current
Ngunguru River	NRC	7A	SIDE	-35.636	174.518	7228451	11875487	55	7988	2.24	9.9	16	14.268	31.085	54.003	65	103	155	4.7	9.1	15.0	A	B	B	A	B	D	A	B	B
Matapouri Bay System (MBS)	NRC	7A	SIDE	-35.558	174.518	1223426	1580950	61	1406	0.47	7.1	18	2.363	5.148	9.040	61	95	143	2.4	6.2	11.7	A	B	B	A	B	C	A	B	B
Matapouri Bay MBS	NRC	11	DSDE	-35.562	174.511	725674	2077939	19	1406	0.47	12.0	23	2.363	5.148	9.040	67	111	173	5.7	10.7	17.6	A	B	B	B	C	D	B	C	D
Matapouri Estuary MBS	NRC	7A	SIDE	-35.565	174.511	497713	517153	96	570	0.18	5.9	18	0.946	2.062	3.576	62	96	143	0.2	4.2	9.5	A	B	B	A	A	C	A	B	B
Tutukaka Harbour	NRC	9	DSDE	-35.617	174.543	1902412	4884170	4	377	0.10	23.3	4	0.603	1.313	2.206	45	54	66	4.2	5.3	6.6	A	A	A	B	B	B	B	B	B
Horahora River	NRC	7A	SIDE	-35.669	174.516	1862424	2309703	70	8573	2.08	3.7	29	14.603	31.817	81.433	91	166	383	0.0	0.0	0.0	B	B	D	A	A	A	B	B	D
Pataua River	NRC	7A	SIDE	-35.705	174.531	3152066	3584537	85	5043	1.07	6.6	17	8.370	18.237	35.045	73	123	207	3.1	8.7	18.3	A	B	C	A	B	D	A	B	C
Taiharuru River	NRC	7A	SIDE	-35.704	174.556	3949736	4425331	87	1301	0.26	9.9	5	2.360	5.142	13.780	50	67	120	3.1	5.0	11.1	A	A	B	B	B	C	A	A	B
Awahoa Bay	NRC	11	DSDE	-35.747	174.558	869832	1359689	10	63	0.01	15.4	1	0.078	0.170	0.417	39	42	50	3.0	3.4	4.2	A	A	A	B	B	B	B	B	B
Whangarei Harbour System	NRC	8	SIDE	-35.848	174.513	148225378	457556265	58	26787	5.28	29.0	3	47.070	102.551	259.778	44	53	80	4.3	5.4	8.5	A	A	B	B	B	C	A	A	B
Ruakaka River	NRC	7A	SIDE	-35.905	174.473	1250387	2070573	50	8993	1.58	4.5	30	17.929	39.063	130.426	132	259	806	0.7	15.1	77.3	B	C	D	A	C	D	B	C	D
Waipu River	NRC	7A	SIDE	-35.993	174.489	2499800	4339888	41	22087	4.68	3.6	33	38.186	83.197	251.583	109	211	590	0.0	0.0	0.0	B	C	D	A	A	A	B	C	D
Mangawhai Harbour	NRC	7A	SIDE	-36.089	174.609	6562592	9718917	67	6572	1.02	11.2	10	10.886	23.717	50.029	65	105	188	5.2	9.8	19.2	A	B	B	B	C	D	A	B	B
Pakiri River	ARC	7A	SSRTRE	-36.241	174.732	155329	213063	35	3434	0.79	1.3	42	5.833	12.708	24.221	117	233	427	0.0	0.0	0.0	B	C	D	A	A	A	B	C	D
Omaha Cove	ARC	11	DSDE	-36.293	174.821	624012	2256953	0	352	0.07	29.2	8	0.594	1.295	1.926	50	75	98	5.1	7.9	10.4	A	A	B	B	B	C	B	B	C
Whangateau Harbour	ARC	7A	SIDE	-36.329	174.793	9491105	11663589	85	3734	0.82	10.4	6	7.535	16.417	27.199	48	70	96	3.1	5.6	8.6	A	A	B	B	B	C	A	A	B
Millon Bay	ARC	11	DSDE	-36.400	174.764	1714237	1953712	62	493	0.10	10.2	4	1.013	2.208	4.554	44	61	95	2.6	4.5	8.4	A	A	B	A	B	C	A	A	B
Matakana River	ARC	8	SIDE	-36.403	174.743	6532060	8325191	76	4855	1.15	9.3	11	9.857	21.476	49.904	58	93	180	3.7	7.8	17.6	A	B	B	B	B	D	A	B	B
Mahurangi Harbour System	ARC	8	SIDE	-36.512	174.732	44892812	67261470	51	9954	3.05	13.2	5	19.469	42.416	101.984	39	52	84	2.7	4.1	7.8	A	A	B	A	B	B	A	A	B
Te Muri-O-Tarariki	ARC	7A	SIDE	-36.517	174.722	325629	325814	100	489	0.10	5.9	16	0.983	2.142	4.431	74	132	246	1.9	8.5	21.5	A	B	C	A	B	D	A	B	C
Puhoi River	ARC	7A	SIDE	-36.533	174.725	2697410	3693641	71	5304	1.17	7.1	19	9.993	21.772	38.370	77	139	226	4.2	11.2	21.1	A	B	C	A	C	D	A	B	C
Waiwera River	ARC	7A	SIDE	-36.548	174.717	1659432	2364498	64	3593	0.78	7.1	20	6.936	15.111	27.809	81	148	252	4.7	12.3	24.1	B	B	C	A	C	D	B	B	C
Orewa River	ARC	7A	SIDE	-36.595	174.709	1758642	1899475	89	2546	0.52	6.6	16	5.099	11.109	26.923	74	131	281	3.2	9.7	26.8	A	B	C	A	B	D	A	B	C
Okoromai Bay	ARC	11	DSDE	-36.621	174.812	2310461	2832822	27	190	0.03	12.1	1	0.359	0.782	1.166	34	39	43	1.9	2.4	3.0	A	A	A	A	A	A	A	A	A
Hobbs Bay (Gulf Harbour)	ARC	11	DSDE	-36.632	174.784	601267	1075639	0	447	0.07	14.4	8	0.688	1.499	2.446	53	83	117	4.5	7.9	11.8	A	B	B	B	B	C	B	B	C
Weiti River	ARC	6B	SIDE	-36.655	174.758	4937928	7032306	63	2783	0.52	11.7	8	5.375	11.711	26.924	52	81	150	3.9	7.1	15.0	A	B	B	B	B	D	A	B	B
Okura River	ARC	7A	SIDE	-36.657	174.752	2089152	2370942	79	2099	0.32	8.6	10	3.772	8.218	11.095	64	108	137	4.1	9.1	12.3	A	B	B	B	C	D	A	B	B
Waitemata Harbour System	ARC	8	SIDE	-36.836	174.824	177003695	341571865	36	39111	7.74	17.8	3	59.101	128.764	256.879	37	47	65	3.0	4.1	6.2	A	A	A	B	B	B	B	B	B
Tamaki River	ARC	8	SIDE	-36.842	174.887	37427602	49163825	40	8675	1.18	12.4	3	10.524	22.929	53.012	36	45	66	2.2	3.2	5.6	A	A	A	A	B	B	A	B	B
Whitford Embayment System (WES)	ARC	8	SIDE	-36.890	174.967	18516635	25549889	82	5334	0.75	12.8	3	8.701	18.958	28.626	41	55	68	2.8	4.4	5.9	A	A	A	A	B	B	A	A	A
Mangemangeroa Estuary WES	ARC	8	SIDE	-36.913	174.956	963637	1005437	87	674	0.09	8.7	7	1.133	2.469	3.416	54	86	109	3.0	6.6	9.2	A	B	B	B	B	C	A	B	B
Turanga Creek WES	ARC	8	SIDE	-36.915	174.962	2670640	3626616	74	2614	0.37	10.5	9	4.346	9.469	13.695	61	102	135	4.6	9.2	13.0	A	B	B	B	C	D	A	B	B
Waikopua Creek WES	ARC	8	SIDE	-36.904	174.981	2463504	2464243	100	1216	0.17	8.8	5	1.708	3.721	6.180	45	65	89	2.0	4.2	6.9	A	A	B	A	B	B	A	A	B
Wairoa River	ARC	8	SIDE	-36.938	175.096	5774004	8679788	42	27317	5.10	5.2	26	43.606	95.005	190.829	93	178	336	1.6	11.2	29.1	B	B	D	A	C	D	B	B	D
Firth of Thames System	EW/ARC	9	DSDE	-36.891	175.303	1924525011	6865962947	15	378239	90.37	32.7	4	632.150	1377.268	6882.549	36	46	118	3.5	4.6	12.8	A	A	B	B	B	D	B	B	D
Miranda Stream	EW	7A	SIDE	-37.187	175.337	126642	130134	95	1437	0.20	2.4	32	2.493	5.432	17.726	143	289	898	0.0	0.0	0.0	B	C	D	A	A	A	B	C	D

Estuary	Regional Council	NZCHS code	ETI class	LAT (WGS84)	LON (WGS84)	Tidal prism spring tide (m^3)	Volume spring tide (m3)	Intertidal area (%)	Catchment Area (ha)	Mean freshwater inflow (m^3/s)	Flushing time (days)	Freshwater fraction (%)	TN load (T/yr) Pristine	TN load (T/yr) Pre-human	TN load (T/yr) Current	Estuary TN Concentration (mg/m^3) Pristine	Estuary TN Concentration (mg/m^3) Pre-human	Estuary TN Concentration (mg/m^3) Current	chl-a (µg/l) Pristine	chl-a (µg/l) Pre-human	chl-a (µg/l) Current	Macroalgae Band Pristine	Macroalgae Band Pre-human	Macroalgae Band Current	Phytoplankton Band Pristine	Phytoplankton Band Pre-human	Phytoplankton Band Current	ETI Susceptibility Band Pristine	ETI Susceptibility Band Pre-human	ETI Susceptibility Band Current
Waitakaruru River	EW	6A	SIDE	-37.217	175.394	1092075	1442025	64	16594	2.93	2.1	36	39.908	86.948	273.637	175	359	1093	0.0	0.0	0.0	B	D	D	A	A	A	B	D	D
Piako River	EW	6A	SSRTRE	-37.191	175.493	4900022	7426156	26	148199	21.86	1.6	41	263.323	573.703	2772.465	172	356	1658	0.0	0.0	0.0	B	D	D	A	A	A	B	D	D
Waihou River	EW	6A	SSRTRE	-37.157	175.535	31594215	59347458	7	198287	58.82	3.9	33	302.372	658.779	3748.132	72	136	689	0.0	0.0	46.9	A	B	D	A	A	D	A	B	D
Kauranga River	EW	6A	SSRTRE	-37.151	175.538	612254	842741	55	13298	6.43	0.8	52	23.369	50.913	66.471	29	144	183	0.0	0.0	0.0	A	B	B	A	A	A	A	B	B
Kirita Bay	EW	11	DSDE	-36.873	175.409	928268	1065676	9	425	0.13	8.9	9	0.685	1.494	4.119	42	60	120	1.7	3.8	10.6	A	A	B	A	B	C	A	B	C
Manaia Harbour	EW	8	SIDE	-36.842	175.424	11080679	20538114	76	5914	2.31	12.8	12	10.012	21.813	28.523	43	63	74	3.0	5.3	6.7	A	A	A	B	B	B	A	A	A
Te Kouma Harbour	EW	8	SIDE	-36.828	175.426	5915819	10226151	46	427	0.13	16.7	2	0.889	1.936	4.209	33	37	48	2.4	3.0	4.1	A	A	A	A	A	B	A	A	A
Coromandel Harbour	EW	8	DSDE	-36.798	175.431	62796785	139671893	21	6955	2.67	20.6	3	15.232	33.186	51.316	35	42	49	2.9	3.8	4.6	A	A	A	A	B	B	A	B	B
Colville Bay	EW	8	DSDE	-36.620	175.425	11660466	13665726	5	4205	1.23	9.6	7	8.178	17.818	33.933	44	63	94	2.3	4.4	8.0	A	A	B	A	B	B	A	B	B
Waiaro Estuary	EW	7A	SSRTRE	-36.591	175.417	236567	328276	0	1150	0.33	3.6	31	1.652	3.600	5.465	71	129	184	0.0	0.0	0.0	A	B	B	A	A	A	A	A	A
Stony Bay	EW	11	DSDE	-36.496	175.434	2498637	9982717	1	1614	0.49	28.3	12	2.282	4.973	5.693	46	67	72	4.5	6.9	7.6	A	A	A	B	B	B	B	B	B
Port Charles	EW	11	DSDE	-36.506	175.459	10050641	46090872	2	3105	0.88	38.9	6	5.710	12.440	17.202	43	59	70	4.4	6.2	7.5	A	A	A	B	B	B	B	B	B
Waikawau Estuary	EW	7A	SIDE	-36.593	175.534	242475	254465	95	2767	0.79	1.4	38	5.583	12.163	20.517	104	204	331	0.0	0.0	0.0	B	C	D	A	A	A	B	C	D
Kennedy Bay System (KBS)	EW	11	DSDE	-36.675	175.579	8586637	29286184	15	5202	1.61	24.4	12	9.326	20.319	25.353	48	73	85	4.7	7.5	8.8	A	A	B	B	B	C	B	B	C
Kennedy Bay Estuary KBS	EW	7A	SIDE	-36.674	175.603	545200	593615	91	5202	1.61	1.6	37	9.326	20.319	25.353	87	168	204	0.0	0.0	0.0	B	B	C	A	A	A	B	B	C
Whangapoua Harbour	EW	7A	SIDE	-36.718	175.645	14902971	17164235	80	10122	3.43	7.7	13	21.267	46.334	85.525	52	83	132	2.1	5.6	11.1	A	B	B	A	B	C	A	B	B
Mercury Bay System (MBS)	EW	11	SIDE	-36.808	175.756	50508655	164248550	36	44399	20.86	17.2	19	85.370	185.997	431.404	48	77	148	4.3	7.6	15.6	A	A	B	A	B	D	A	B	D
Whitianga Harbour MBS	EW	7A	SIDE	-36.812	175.734	17110627	23675974	72	42442	20.21	4.0	29	82.223	179.140	400.749	58	103	204	0.0	0.0	0.0	A	B	C	A	A	A	A	B	C
Purangi River	EW	7A	SIDE	-36.827	175.752	1167979	1229451	95	1956	0.64	4.8	22	3.147	6.857	30.655	57	97	352	0.0	0.0	28.5	A	B	D	A	A	D	A	B	D
Tairua Harbour	EW	7A	SIDE	-37.009	175.886	7702351	7749027	51	27956	14.96	2.0	34	50.541	110.114	237.566	55	97	188	0.0	0.0	0.0	A	B	B	A	A	A	A	B	B
Wharekawa Harbour	EW	7A	SIDE	-37.118	175.894	1888011	2164594	86	9002	4.02	2.1	34	15.368	33.483	60.712	59	109	182	0.0	0.0	0.0	A	B	B	A	A	A	A	B	B
Whangamata Harbour	EW	7A	SIDE	-37.213	175.897	4552366	6488899	78	4874	2.12	7.1	20	7.531	16.407	30.744	44	70	113	0.5	3.5	8.4	A	A	B	A	A	C	A	A	B
Otahu River	EW	7A	SIDE	-37.237	175.897	1138659	1516965	60	7160	3.45	1.9	37	11.181	24.359	61.237	55	100	226	0.0	0.0	0.0	A	B	C	A	A	A	A	B	C
Tauranga Harbour System	EBOP	8	SIDE	-37.475	175.998	211514717	425300509	77	122234	36.40	14.7	11	158.530	345.390	1333.115	35	53	146	2.5	4.5	15.1	A	A	B	A	B	D	A	A	B
Maketu River	EBOP	6A	SSRTRE	-37.756	176.429	2638842	3548243	58	122892	44.75	0.6	62	117.889	256.844	1090.648	28	123	492	0.0	0.0	0.0	A	B	D	A	A	A	A	B	D
Waihi Estuary	EBOP	7A	SSRTRE	-37.754	176.484	3213142	4353159	57	33807	11.88	1.7	39	50.477	109.975	509.339	67	129	546	0.0	0.0	0.0	A	B	D	A	A	A	A	B	D
Whakatane River	EBOP	6B	SSRTRE	-37.939	177.007	2169092	6359039	31	178157	63.93	0.9	81	228.662	498.188	1131.151	26	205	459	0.0	0.0	0.0	A	C	D	A	A	A	A	C	D
Ohiwa Harbour	EBOP	9	SIDE	-37.984	177.152	26561008	44190150	84	16288	5.30	11.7	12	19.630	42.768	209.450	32	48	169	1.5	3.5	17.2	A	A	B	A	B	D	A	A	B
Waiotahi River	EBOP	7A	SIDE	-37.990	177.206	1114065	1744343	68	14660	5.48	1.5	42	19.160	41.743	113.218	58	112	285	0.0	0.0	0.0	A	B	C	A	A	A	A	B	C
Waioeka River	EBOP	7A	SSRTRE	-37.984	177.304	1481683	3093189	14	120369	56.27	0.6	100	176.710	384.998	697.091	100	217	393	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Waiaua River	EBOP	7A	SSRTRE	-37.978	177.387	215979	289650	59	10884	4.44	0.5	68	14.079	30.674	77.390	21	155	383	0.0	0.0	0.0	A	B	D	A	A	A	A	B	D
Whangaparaoa River	EBOP	6B	SSRTRE	-37.572	177.990	261264	418937	0	18152	13.78	0.4	100	36.724	80.011	191.396	84	184	440	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Wharekahika River	GDC	6D	SSRTRE	-37.576	178.297	66886	99537	34	16157	12.31	0.1	100	32.575	70.972	109.239	84	183	281	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Karakatuwhero River	GDC	3C	SSRTRE	-37.618	178.346	40895	66045	0	8403	7.31	0.1	100	19.465	42.409	58.201	84	184	253	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Uawa River (Tolaga Bay)	GDC	6B	SSRTRE	-38.374	178.314	1475920	3216449	23	55860	14.11	1.3	50	87.928	191.568	326.513	22	225	378	0.0	0.0	0.0	A	C	D	A	A	A	A	C	D
Pakarae River	GDC	6B	SSRTRE	-38.562	178.253	381278	645017	0	24437	5.12	0.8	57	38.620	84.143	182.108	20	303	648	0.0	0.0	0.0	A	C	D	A	A	A	A	A	A
Waiomoko River	GDC	6B	SSRTRE	-38.584	178.226	170479	288697	0	7199	1.37	1.2	48	10.190	22.201	58.199	18	254	651	0.0	0.0	0.0	A	C	D	A	A	A	A	A	A

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													Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current
Pouawa River	GDC	6B	SSRTRE	-38.617	178.190	81407	135668	8	4254	0.67	1.1	48	6.070	13.225	25.935	18	308	596	0.0	0.0	0.0	A	C	D	A	A	A	A	C	D
Turanganui River	GDC	6B	SSRTRE	-38.676	178.022	869183	895593	0	32355	4.39	1.0	42	39.577	86.226	176.563	130	272	546	0.0	0.0	0.0	B	C	D	A	A	A	A	A	A
Waipaoa River	GDC	6B	SSRTRE	-38.716	177.945	1529244	4675430	2	218313	39.92	0.1	4	271.200	590.864	1229.427	25	35	57	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Wherowhero Lagoon	GDC	7A	SIDE	-38.748	177.952	655772	1052427	23	2478	0.18	10.1	15	2.512	5.473	12.785	80	158	350	6.5	15.4	37.2	A	B	D	B	C	D	B	C	D
Maraetaha River	GDC	6A	SSRTRE	-38.792	177.937	82547	139987	1	7841	1.88	0.6	71	11.982	26.104	54.215	17	319	658	0.0	0.0	0.0	A	C	D	A	A	A	A	A	A
Maungawhio Lagoon	GDC	7A	SIDE	-39.072	177.908	829969	1034215	79	7384	2.46	1.8	37	11.259	24.530	48.457	64	127	242	0.0	0.0	0.0	A	B	C	A	A	A	A	B	C
Nuhaka River	HBRC	4C	SSRTRE	-39.072	177.749	169469	283513	0	20640	7.60	0.4	100	31.269	68.127	168.447	130	284	703	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Tahaenui River	HBRC	4D	C.LAKE	-39.068	177.679	0	77718	0	5689	1.84	0.5	100	8.161	17.781	54.073	140	306	930	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Whakaki Lagoon	HBRC	2A	C.LAKE	-39.065	177.573	0	4749001	0	3332	0.75	72.8	100	1.677	3.654	10.144	70	153	426	7.8	17.2	48.2	A	A	A	B	D	D	B	D	D
Te Paeroa Lagoon	HBRC	2A	C.LAKE	-39.055	177.518	0	604566	0	90	0.02	368.9	100	0.315	0.686	0.738	526	1147	1234	59.8	130	140	A	A	A	D	D	D	D	D	D
Wairau Lagoon	HBRC	2A	C.LAKE	-39.056	177.500	0	185129	1	154	0.03	66.4	100	0.124	0.271	0.337	122	266	331	13.6	29.9	37.4	A	A	A	C	D	D	C	D	D
Ohuia Lagoon	HBRC	2A	C.LAKE	-39.067	177.474	0	551787	0	2824	0.56	11.4	100	3.722	8.110	25.320	211	459	1432	21.8	50.0	161	A	A	A	D	D	D	D	D	D
Wairoa River	HBRC	8	SIDE	-39.070	177.423	3409409	9734902	16	367359	125.10	0.9	100	480.551	1046.979	2191.545	122	265	556	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Waihua River	HBRC	3D	SSRTRE	-39.096	177.297	137315	230207	0	16164	3.42	0.6	75	18.396	40.080	93.920	16	281	654	0.0	0.0	0.0	A	C	D	A	A	A	A	A	A
Waikari River	HBRC	6C	SSRTRE	-39.172	177.099	202449	339576	0	32697	6.30	0.6	100	36.958	80.521	203.461	186	406	1025	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Aropaoanui River	HBRC	4C	C.LAKE	-39.286	177.005	0	63082	0	16831	3.77	0.2	100	19.852	43.251	115.639	167	364	974	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Ahuriri Estuary	HBRC	7A	SSRTRE	-39.476	176.896	3853629	6347333	9	13801	1.00	10.6	14	16.422	35.778	63.486	87	175	302	7.5	17.6	32.0	B	B	C	B	D	D	B	D	D
Ngaruroro River	HBRC	6B	SSRTRE	-39.568	176.936	1048044	2485690	0	336903	63.41	0.5	100	338.910	738.383	1407.965	169	369	704	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Mangakuri River	HBRC	6B	SSRTRE	-39.949	176.935	37602	64771	0	10495	1.81	0.4	100	14.713	32.055	69.356	257	561	1213	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Pourerere Stream	HBRC	4C	SSRTRE	-40.103	176.879	27797	47624	3	3714	0.54	0.7	66	4.209	9.169	24.586	14	362	964	0.0	0.0	0.0	A	D	D	A	A	A	A	A	A
Porangahau River	HBRC	7A	C.LAKE	-40.261	176.706	0	1667332	26	85544	9.88	2.0	100	77.828	169.565	438.796	250	544	1408	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Akitio River	MWRC	6B	SSRTRE	-40.612	176.429	354498	614967	0	58970	11.46	0.6	100	66.377	144.615	334.497	184	400	925	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Owahanga River	MWRC	6B	SSRTRE	-40.690	176.358	801529	1391322	0	40813	8.28	1.0	52	55.168	120.195	260.229	19	244	521	0.0	0.0	0.0	A	C	D	A	A	A	A	A	A
Whareama River	GWRC	6A	SSRTRE	-41.019	176.120	158714	276805	0	53246	8.41	0.4	100	61.071	133.056	276.278	230	502	1042	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Motuwaireka Stream	GWRC	4C	SSRTRE	-41.087	176.087	66593	112132	15	3319	0.61	1.1	50	4.224	9.203	17.438	16	246	459	0.0	0.0	0.0	A	C	D	A	A	A	A	C	D
Patanui Stream	GWRC	6D	SSRTRE	-41.160	176.030	35312	60854	7	3500	0.67	0.7	66	4.239	9.236	19.137	16	293	601	0.0	0.0	0.0	A	C	D	A	A	A	A	C	D
Pahaoa River	GWRC	6C	SSRTRE	-41.404	175.727	210195	370772	0	65066	12.65	0.3	100	76.371	166.390	306.712	191	417	769	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Oterei River	GWRC	6C	C.LAKE	-41.490	175.583	0	71782	0	6534	1.35	0.6	100	7.065	15.393	23.780	166	362	559	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Awhea River	GWRC	6C	C.LAKE	-41.510	175.529	0	56818	0	15194	3.39	0.2	100	18.984	41.361	83.607	178	387	783	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Lake Onoke/Turanganui River	GWRC	2A	SSRTRE	-41.413	175.136	7736470	20721539	2	343409	123.85	1.2	61	519.685	1132.240	2832.866	29	184	449	0.0	0.0	0.0	A	B	D	A	A	A	A	A	A
Wainuiomata River	GWRC	3C	C.LAKE	-41.427	174.875	0	40514	0	13382	3.96	0.1	100	22.881	49.852	56.029	183	399	448	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Lake Kohangatera	GWRC	2B	C.LAKE	-41.379	174.857	0	212559	0	2096	0.38	6.5	100	2.985	6.503	8.047	249	543	672	22.9	56.3	71.0	A	A	A	D	D	D	D	D	D
Lake Kohangapiripiri	GWRC	2B	C.LAKE	-41.370	174.848	0	107970	2	387	0.07	18.5	100	0.330	0.719	1.080	155	337	507	16.5	37.2	56.5	A	A	A	D	D	D	D	D	D
Wellington Harbour	GWRC	9	DSDE	-41.354	174.834	88321085	1369490185	0	71351	28.83	6.1	1	127.126	276.969	346.107	19	21	22	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Lyall Bay	GWRC	11	DSDE	-41.348	174.800	2472115	19926805	0	380	0.06	77.6	2	0.418	0.911	2.247	22	27	42	2.3	2.9	4.5	A	A	A	A	A	B	A	A	B
Te Ikaamaru Bay	GWRC	11	DSDE	-41.236	174.662	415484	4743860	0	550	0.09	79.2	12	0.579	1.262	1.484	41	73	83	4.5	8.0	9.2	A	A	B	B	C	C	B	C	C
Ohariu Bay	GWRC	11	DSDE	-41.214	174.704	290759	1424578	0	7985	1.16	5.6	40	10.097	21.999	39.333	120	249	437	6.3	20.9	42.3	B	C	D	B	D	D	B	D	D

Estuary	Regional Council	NZCHS code	ETI class	LAT (WGS84)	LON (WGS84)	Tidal prism spring tide (m^3)	Volume spring tide (m3)	Intertidal area (%)	Catchment Area (ha)	Mean freshwater inflow (m^3/s)	Flushing time (days)	Freshwater fraction (%)	TN load (T/yr)			Estuary TN Concentration (mg/m^3)			chl-a (µg/l)			Macroalgae Band			Phytoplankton Band			ETI Susceptibility Band		
													Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current
Titahi Bay	GWRC	11	DSDE	-41.104	174.822	385084	1264686	0	105	0.01	31.7	2	0.144	0.313	0.654	27	38	62	2.4	3.7	6.4	A	A	A	A	B	B	A	B	B
Okupe Lagoon	GWRC	1	C.LAKE	-40.829	174.962	0	78777	0	112	0.02	45.1	100	0.052	0.114	0.183	82	178	287	8.9	19.8	32.2	A	A	A	B	D	D	B	D	D
Te Awarua-o-Porirua Harbour	GWRC	8	SIDE	-41.077	174.831	7413661	9678790	11	17205	2.60	7.4	17	21.799	47.493	81.193	60	114	185	2.7	8.8	16.9	A	B	B	A	B	D	A	B	D
Waikanae River	GWRC	6B	SIDE	-40.862	174.994	451237	618297	50	15345	4.67	0.8	52	23.930	52.137	79.017	19	191	285	0.0	0.0	0.0	A	B	C	A	A	A	A	B	C
Waikawa Stream	GWRC	4D	SSRTRE	-40.695	175.131	170327	221858	54	7933	2.07	0.7	55	11.653	25.388	91.198	18	220	771	0.0	0.0	0.0	A	C	D	A	A	A	A	C	D
Ohau River	MWRC	4D	SSRTRE	-40.664	175.142	601043	883621	0	18822	7.84	0.7	56	32.174	70.098	221.418	18	166	510	0.0	0.0	0.0	A	B	D	A	A	A	A	A	A
Manawatu River	MWRC	6B	SSRTRE	-40.482	175.207	4869597	9050692	2	587649	133.22	0.6	78	797.317	1737.117	5991.202	31	327	1119	0.0	0.0	0.0	A	D	D	A	A	A	A	A	A
Rangitikei River	MWRC	6B	SSRTRE	-40.303	175.212	931087	1690595	4	392919	72.36	0.3	100	382.870	834.160	1620.377	168	366	710	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Turakina River	MWRC	6B	SSRTRE	-40.087	175.135	903827	1189344	34	96155	7.99	0.8	49	83.400	181.703	390.608	24	363	770	0.0	0.0	0.0	A	D	D	A	A	A	A	D	D
Whangaehu River	MWRC	6B	SSRTRE	-40.042	175.096	1109554	1978770	0	199151	41.59	0.6	100	226.604	493.703	1179.636	173	376	899	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Wanganui River	TRC	6C	SSRTRE	-39.954	174.981	8439492	9667230	0	713573	227.23	0.4	78	825.703	1798.962	3492.812	34	199	382	0.0	0.0	0.0	A	B	D	A	A	A	A	A	A
Waitotara River	TRC	6A	SSRTRE	-39.856	174.681	284040	387553	0	116194	22.17	0.2	100	119.021	259.311	363.774	170	371	520	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Whenuakura River	TRC	6B	SSRTRE	-39.786	174.506	309675	383403	47	46644	9.22	0.4	82	51.548	112.308	236.008	19	318	665	0.0	0.0	0.0	A	C	D	A	A	A	A	C	D
Patea River	TRC	6B	SSRTRE	-39.779	174.485	573063	1047793	32	104940	29.62	0.4	100	128.467	279.892	1280.652	138	300	1371	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Waiwakaiho River	TRC	6B	SSRTRE	-39.032	174.101	246678	319589	17	13633	10.16	0.4	100	37.176	80.995	435.577	116	253	1359	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Waiongana Stream	TRC	6B	SSRTRE	-38.984	174.185	234809	309331	5	16580	7.47	0.5	100	27.539	60.000	579.645	117	255	2459	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Waitara River	TRC	6B	SSRTRE	-38.978	174.225	1293504	2131199	0	113936	57.15	0.4	100	196.221	427.508	2158.854	109	237	1198	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Onaero River	TRC	6B	SSRTRE	-38.982	174.363	67645	86479	24	8842	3.32	0.3	100	12.645	27.549	79.318	121	263	758	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Urenui River	TRC	6B	SSRTRE	-38.979	174.388	343238	453746	0	13358	5.93	0.6	63	19.969	43.507	92.927	21	154	320	0.0	0.0	0.0	A	B	D	A	A	A	A	A	A
Mimi River	TRC	6B	SSRTRE	-38.955	174.418	369321	459278	39	13392	5.52	0.6	59	19.668	42.851	105.800	22	154	368	0.0	0.0	0.0	A	B	D	A	A	A	A	B	D
Tongaporutu River	TRC	6B	SSRTRE	-38.816	174.572	1203331	1870689	25	27216	12.35	0.9	52	38.799	84.531	131.297	23	122	184	0.0	0.0	0.0	A	B	B	A	A	A	A	B	B
Mohakatino River	TRC	6B	SSRTRE	-38.736	174.597	216433	355439	2	12654	5.35	0.6	74	18.585	40.492	50.035	22	184	226	0.0	0.0	0.0	A	B	C	A	A	A	A	A	A
Mokau River	EW/TRC	6B	SSRTRE	-38.707	174.602	3343698	5511303	0	144670	55.28	0.7	62	222.596	484.971	1855.152	27	180	666	0.0	0.0	0.0	A	B	D	A	A	A	A	A	A
Awakino River	EW	6B	SSRTRE	-38.666	174.610	997461	1646005	0	38339	20.15	0.6	68	83.218	181.308	451.444	24	200	487	0.0	0.0	0.0	A	B	D	A	A	A	A	A	A
Waikawau River	EW	4C	SSRTRE	-38.480	174.615	99715	132581	0	8179	3.99	0.4	100	15.334	33.409	55.440	122	266	441	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Marakopa River	EW	6B	SSRTRE	-38.309	174.699	1837757	2973975	14	36451	16.49	1.0	49	71.063	154.824	461.215	26	158	449	0.0	0.0	0.0	A	B	D	A	A	A	A	B	D
Waiharakeke Stream	EW	8	SIDE	-38.130	174.814	9782841	10520315	93	6272	2.42	7.0	14	11.814	25.740	55.720	42	68	123	0.2	3.1	9.4	A	A	B	A	A	C	A	A	B
Kaitawa Inlet KHS	EW	8	SIDE	-38.102	174.850	841197	849694	100	173	0.06	8.9	5	0.342	0.744	3.207	33	45	115	0.7	2.0	10.0	A	A	B	A	A	C	A	A	B
Rakaunui Inlet KHS	EW	8	SIDE	-38.101	174.862	3142104	3595496	87	3740	1.43	5.8	20	6.603	14.385	45.923	49	83	222	0.0	2.5	18.3	A	B	C	A	A	D	A	B	C
Awaroa River KHS	EW	8	SIDE	-38.082	174.895	4016263	4953457	81	10973	5.05	3.4	30	20.757	45.224	118.987	56	102	240	0.0	0.0	0.0	A	B	C	A	A	A	A	B	C
Oparau River KHS	EW	8	SIDE	-38.067	174.887	2793279	3271584	85	12402	5.65	2.3	34	22.023	47.981	149.655	58	108	301	0.0	0.0	0.0	A	B	C	A	A	A	A	B	C
Mangaora Inlet KHS	EW	8	SIDE	-38.059	174.856	830374	830706	100	980	0.31	5.5	18	1.636	3.563	6.669	50	85	142	0.0	1.9	8.4	A	B	B	A	A	C	A	B	B
Te Wharu Bay KHS	EW	8	SIDE	-38.061	174.835	2767234	2767511	100	412	0.13	9.2	4	0.464	1.011	2.928	28	33	50	0.3	0.8	2.8	A	A	A	A	A	A	A	A	A
Kawhia Inlet KHS	EW	8	SIDE	-38.086	174.778	102127938	148874545	69	45322	18.91	10.5	11	81.761	178.133	493.971	37	56	116	1.8	3.9	10.8	A	A	B	A	B	C	A	A	B
Kawhia Harbour System (KHS)	EW	8	SIDE	-38.089	174.745	126295622	162209696	74	45322	18.91	9.8	10	81.761	178.133	493.971	35	51	103	1.3	3.1	9.1	A	A	B	A	B	C	A	A	B
Aotea Harbour System	EW	8	SIDE	-38.018	174.783	59186968	100566459	74	16198	5.48	14.3	7	24.202	52.729	150.575	32	43	81	2.1	3.4	7.7	A	A	B	A	B	B	A	A	B

Estuary	Regional Council	NZCHS code	ETI class	LAT (WGS84)	LON (WGS84)	Tidal prism spring tide (m^3)	Volume spring tide (m3)	Intertidal area (%)	Catchment Area (ha)	Mean freshwater inflow (m^3/s)	Flushing time (days)	Freshwater fraction (%)	TN load (T/yr)			Estuary TN Concentration (mg/m^3)			chl-a (µg/l)			Macroalgae Band			Phytoplankton Band			ETI Susceptibility Band		
													Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current
Opotoru River RHS	EW	8	SIDE	-37.801	174.866	3078635	3670285	84	5538	1.41	6.0	20	6.106	13.304	53.127	48	80	259	0.0	2.8	23.1	A	B	C	A	A	D	A	B	C
Waitetuna Creek RHS	EW	8	SIDE	-37.793	174.924	9057971	11445503	79	17328	5.62	5.4	23	25.988	56.619	185.621	54	94	261	0.0	2.5	21.5	A	B	C	A	A	D	A	B	C
Kerikeri/Waingaro Arm	EW	8	SIDE	-37.790	174.909	26377784	34716747	76	16678	4.37	9.7	11	23.074	50.272	156.195	41	62	143	2.0	4.4	13.6	A	A	B	A	B	D	A	A	B
Ponganui/Paihere Creeks	EW	8	SIDE	-37.789	174.874	1434284	1439611	100	885	0.22	7.6	10	1.241	2.704	9.547	41	62	161	0.7	3.1	14.3	A	A	B	A	B	D	A	A	B
Raglan Inlet RHS	EW	8	SIDE	-37.801	174.842	20986083	45141069	46	50536	14.24	8.8	24	69.567	151.565	486.162	57	100	278	3.3	8.2	28.5	A	B	C	A	B	D	A	B	C
Raglan Harbour System (RHS)	EW	8	SIDE	-37.806	174.812	27652903	40076671	69	50536	14.24	6.9	21	69.567	151.565	486.162	53	91	249	1.2	5.6	23.5	A	B	C	A	B	D	A	B	C
Waikato River	EW	6B	SSRTRE	-37.374	174.684	49891290	116992603	8	1447309	355.48	1.8	46	1491.131	3248.732	14497.72	40	148	610	0.0	0.0	0.0	A	B	D	A	A	A	A	B	D
Manukau Harbour System (MHS)	ARC	8	SIDE	-37.072	174.503	710146881	2215803524	62	81877	14.33	30.3	2	105.387	229.607	705.504	31	36	54	2.9	3.4	5.5	A	A	A	A	B	B	A	A	A
Waitakere River (Bethells Beach)	ARC	4C	SIDE	-36.894	174.430	51824	55604	89	6648	1.57	0.3	82	7.009	15.272	24.265	29	259	409	0.0	0.0	0.0	A	C	D	A	A	A	A	C	D
Kaipara Harbour System	NRC/ARC	8	SIDE	-36.454	174.088	1615117448	3992734683	42	573964	125.97	21.3	6	1036.164	2257.494	5935.779	44	62	116	4.1	6.1	12.3	A	A	B	B	B	D	A	A	B
Waipoua River	NRC	6B	SSRTRE	-35.676	173.468	322823	428204	22	11237	3.62	0.7	53	19.383	42.230	47.599	37	213	238	0.0	0.0	0.0	A	C	C	A	A	A	A	C	C
Waimaukau River	NRC	6B	SSRTRE	-35.599	173.404	521306	678376	32	13309	4.02	0.9	47	21.329	46.469	116.351	37	192	451	0.0	0.0	0.0	A	B	D	A	A	A	A	B	D
Hokianga Harbour System	NRC	8	SIDE	-35.541	173.350	216172096	482972423	49	154045	41.87	15.8	12	285.427	621.861	1373.215	57	87	155	5.1	8.5	16.2	A	B	B	B	C	D	A	B	B
Whangapae Harbour System	NRC	8	SIDE	-35.383	173.204	17954810	24626719	67	29203	8.73	6.7	21	60.009	130.742	218.411	73	126	191	3.2	9.2	16.7	A	B	B	A	B	D	A	B	B
Herekino Harbour	NRC	8	SIDE	-35.297	173.148	7646102	8424765	84	8853	1.93	7.1	14	15.360	33.464	59.133	66	108	168	3.0	7.8	14.6	A	B	B	B	B	D	A	B	B
Waiatua Stream	NRC	4C	DSDE	-35.286	173.137	104253	142421	5	613	0.08	5.1	25	0.824	1.795	1.927	106	201	213	2.2	12.9	14.4	B	C	C	A	C	D	B	C	D
Tanutanu Stream	NRC	4C	SSRTRE	-35.235	173.083	452892	622605	1	1581	0.22	6.8	20	2.297	5.005	5.213	96	177	183	6.0	15.2	15.9	B	B	B	B	C	D	B	C	D
Pahurehure Inlet MHS	ARC	8	SIDE	-37.053	174.858	29153366	45795422	64	32630	6.21	10.8	13	48.770	106.255	353.069	57	94	253	4.2	8.4	26.5	A	B	C	B	C	D	A	B	C
Lucas Creek WHS	ARC	8	SIDE	-37.772	174.661	2321528	2672417	87	3325	0.58	7.5	14	5.362	11.682	17.893	63	111	159	3.0	8.6	14.0	A	B	B	A	B	D	A	B	B
Waitangi Stream	NRC	4C	C.LAKE	-34.428	172.962	0	58779	0	1097	0.15	4.4	100	1.247	2.718	2.741	255	556	561	12.9	47.2	47.7	A	A	A	C	D	D	C	D	D
Maketu Estuary	EBOP	7A	SIDE	-37.754	176.454	2639051	3548524	58	2398	0.81	8.1	16	4.796	10.449	56.707	50	85	374	2.1	6.1	38.9	A	B	D	A	B	D	A	B	D
Waitahanui Stream	EBOP	4	SSRTRE	-37.829	176.598	50020	79478	0	11900	4.35	0.2	100	15.853	34.540	96.460	116	252	703	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Otaki River	GWRC	6C	SSRTRE	-40.763	175.100	325037	487150	0	35764	30.97	0.2	100	106.195	231.367	290.894	109	237	298	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Ohau Bay	GWRC	11	DSDE	-41.237	174.651	212251	2038928	0	304	0.05	65.0	13	0.278	0.606	0.942	39	68	97	4.2	7.4	10.7	A	A	B	B	B	C	B	B	C
Mercury Bay MBS	EW	11	DSDE	-36.808	175.756	32298500	161474432	3	44332	20.83	21.0	23	85.212	185.651	430.787	53	89	176	5.0	9.1	19.0	A	B	B	B	B	D	B	B	D
Firth of Thames	EW/ARC	9	DSDE	-36.891	175.303	1891415910	16000000000	15	378239	90.37	77.5	4	632.150	1377.268	6882.549	36	46	119	3.9	5.0	13.3	A	A	B	B	B	D	B	B	D
Puhinui Creek MHS	ARC	8	SIDE	-37.031	174.852	904391	904934	100	2554	0.39	5.2	19	3.041	6.626	15.218	71	128	264	0.0	5.5	20.9	A	B	C	A	B	D	A	B	C
North Cove	ARC	11	DSDE	-36.412	174.823	1089925	1561974	37	119	0.02	14.0	2	0.181	0.394	0.395	35	40	40	2.4	3.0	3.0	A	A	A	A	A	A	A	A	A
Bon Accord Harbour	ARC	11	DSDE	-36.424	174.813	5424129	12417347	19	871	0.13	22.0	2	1.214	2.645	2.644	36	43	43	3.2	4.0	4.0	A	A	A	B	B	B	B	B	B
South Cove Harbour	ARC	11	DSDE	-36.444	174.826	511869	614853	31	115	0.02	11.3	3	0.224	0.488	0.488	41	54	54	2.5	4.0	4.0	A	A	A	A	B	B	A	B	B
Gardiner Gap	ARC	11	DSDE	-36.767	174.889	637554	1069541	60	132	0.03	15.5	3	0.131	0.285	0.725	34	40	57	2.4	3.1	5.1	A	A	A	A	B	B	A	A	A
Islington Bay	ARC	11	DSDE	-36.797	174.904	4754895	7859547	7	173	0.04	16.5	1	0.172	0.375	0.375	30	32	32	2.2	2.3	2.3	A	A	A	A	A	A	A	A	A
Matiatia Bay	ARC	11	DSDE	-36.781	174.983	988824	1743905	3	104	0.02	17.3	1	0.127	0.276	0.583	33	37	45	2.5	3.0	3.9	A	A	A	A	A	B	A	A	B
Owhanake Bay	ARC	11	DSDE	-36.769	174.991	746236	1417337	2	58	0.01	18.8	1	0.081	0.177	0.375	32	36	43	2.6	3.0	3.8	A	A	A	A	A	B	A	A	B
Oneroa Bay	ARC	11	DSDE	-36.775	175.021	4000498	12801343	1	90	0.01	32.2	0	0.147	0.320	0.452	31	32	33	2.9	3.0	3.1	A	A	A	A	B	B	A	B	B
Mawhitipana Bay	ARC	11	DSDE	-36.776	175.042	914388	2301964	9	110	0.02	24.5	2	0.180	0.392	0.638	35	41	48	3.1	3.8	4.6	A	A	A	B	B	B	B	B	B

Estuary	Regional Council	NZCHS code	ETI class	LAT (WGS84)	LON (WGS84)	Tidal prism spring tide (m^3)	Volume spring tide (m3)	Intertidal area (%)	Catchment Area (ha)	Mean freshwater inflow (m^3/s)	Flushing time (days)	Freshwater fraction (%)	TN load (T/yr)			Estuary TN Concentration (mg/m^3)			chl-a (µg/l)			Macroalgae Band			Phytoplankton Band			ETI Susceptibility Band		
													Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current
Te Matuku Bay	ARC	11	DSDE	-36.850	175.132	4350612	5733543	76	1135	0.17	12.3	3	1.450	3.159	4.280	37	47	54	2.3	3.4	4.2	A	A	A	A	B	B	A	A	A
Awaawaroa Bay	ARC	11	DSDE	-36.846	175.104	7014047	10223362	29	1307	0.19	13.9	2	1.662	3.621	5.996	35	42	51	2.4	3.2	4.2	A	A	A	A	B	B	A	B	B
Rocky Bay	ARC	11	DSDE	-36.831	175.055	3000404	4104300	30	409	0.06	13.3	2	0.605	1.318	1.579	35	41	43	2.2	2.9	3.2	A	A	A	A	A	B	A	A	B
Putiki Bay	ARC	11	DSDE	-36.818	175.025	7777440	9953530	35	1007	0.15	12.4	2	1.557	3.392	4.630	35	41	45	2.1	2.8	3.2	A	A	A	A	A	B	A	A	B
Huruhi Bay	ARC	11	DSDE	-36.814	175.004	12139148	26462932	12	224	0.03	22.0	0	0.355	0.774	1.270	30	31	33	2.5	2.7	2.8	A	A	A	A	A	A	A	A	A
Port Underwood	MDC	9	DSDE	-41.349	174.109	30943063	294283650	1	2780	0.98	90.1	3	3.316	7.224	7.510	21	25	25	2.2	2.6	2.6	A	A	A	A	A	A	A	A	A
Wairau River	MDC	6B	SSRTRE	-41.501	174.062	18842997	44539663	20	58515	6.06	14.0	16	51.756	112.762	226.812	61	114	212	5.4	11.3	22.5	A	B	C	B	C	D	B	C	D
Awatere River	MDC	3B	SSRTRE	-41.606	174.167	110648	187275	12	158979	23.12	0.1	100	128.380	279.702	299.660	176	384	411	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Lake Grassmere	MDC	2A	C.LAKE	-41.712	174.188	0	13675802	0	6295	0.40	397.3	100	0.501	1.091	1.783	40	87	142	4.5	9.8	16.1	A	A	A	A	B	D	A	B	D
Waiau River	ECAN	3B	SSRTRE	-42.771	173.380	696703	1175582	0	333260	114.38	0.1	100	424.703	925.301	1155.648	118	257	320	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Hurunui River	ECAN	3B	SSRTRE	-42.906	173.292	270542	449093	0	266996	73.53	0.1	100	274.735	598.566	893.458	118	258	385	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Waipara River	ECAN	3C	SSRTRE	-43.155	172.798	194307	305806	3	74060	5.58	0.5	80	46.246	100.757	209.309	37	465	960	0.0	0.0	0.0	A	D	D	A	A	A	A	A	A
Ashley River	ECAN	3D	SIDE	-43.271	172.727	1613564	2272805	78	129506	20.00	0.7	55	120.213	261.909	458.070	41	244	415	0.0	0.0	0.0	A	C	D	A	A	A	A	C	D
Waimakariri River	ECAN	6B	SSRTRE	-43.392	172.715	3733531	6746439	45	359020	144.14	0.5	100	485.775	1058.359	1666.250	107	233	367	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Avon-Heathcote River	ECAN	7A	SIDE	-43.559	172.759	8942222	13948201	66	29949	1.56	11.4	11	18.085	39.403	117.381	73	121	295	6.2	11.6	31.4	A	B	C	B	C	D	A	B	C
Lyttelton Harbour	ECAN	9	DSDE	-43.597	172.817	70438845	242920351	16	9512	0.82	34.1	1	8.853	19.287	31.685	40	44	49	4.0	4.5	5.0	A	A	A	B	B	B	B	B	B
Port Levy	ECAN	11	DSDE	-43.606	172.840	14590656	60344379	2	5373	0.48	39.1	3	5.931	12.922	15.891	47	59	64	4.8	6.2	6.8	A	A	A	B	B	B	B	B	B
Blind/Big Bay	ECAN	11	DSDE	-43.613	172.886	1926326	10379143	1	608	0.05	51.8	2	0.549	1.196	1.501	44	52	57	4.6	5.6	6.1	A	A	A	B	B	B	B	B	B
Little Pigeon Bay	ECAN	11	DSDE	-43.622	172.907	851828	3979252	0	396	0.02	44.7	2	0.321	0.700	0.491	46	58	51	4.8	6.1	5.4	A	A	A	B	B	B	B	B	B
Pigeon Bay	ECAN	11	DSDE	-43.625	172.922	15989724	84010556	0	5289	0.65	48.8	3	6.602	14.385	20.657	46	58	68	4.9	6.3	7.4	A	A	A	B	B	B	B	B	B
Scrubby Bay	ECAN	11	DSDE	-43.634	172.951	532413	1996237	4	294	0.03	34.3	4	0.307	0.669	0.278	50	67	48	5.1	7.0	4.9	A	A	A	B	B	B	B	B	B
Menzies Bay	ECAN	11	DSDE	-43.635	172.970	1812483	8854248	1	825	0.08	45.1	4	0.702	1.529	2.454	45	57	69	4.7	6.0	7.5	A	A	A	B	B	B	B	B	B
Decanter Bay	ECAN	11	DSDE	-43.649	173.002	1475602	5642346	0	745	0.08	34.6	4	0.687	1.497	2.224	46	60	72	4.7	6.3	7.7	A	A	A	B	B	B	B	B	B
Little Akaloa Bay	ECAN	11	DSDE	-43.651	173.012	3233941	11800533	4	1662	0.16	33.3	4	1.681	3.662	7.167	48	63	90	4.9	6.6	9.7	A	A	B	B	B	C	B	B	C
Okains Bay	ECAN	11	DSDE	-43.680	173.081	6419886	18315425	2	3279	0.50	24.6	6	3.574	7.786	18.033	47	63	100	4.6	6.3	10.6	A	A	B	B	B	C	B	B	C
Lavericks Bay	ECAN	11	DSDE	-43.718	173.110	746580	2719883	11	1003	0.15	25.6	12	1.164	2.536	3.700	62	97	127	6.2	10.3	13.7	A	B	B	B	C	D	B	C	D
Le Bons Bay	ECAN	11	DSDE	-43.734	173.122	3938326	14287266	6	2654	0.43	29.5	8	3.500	7.625	9.955	53	76	90	5.4	8.0	9.5	A	A	B	B	C	C	B	C	C
Otanerito Bay	ECAN	11	DSDE	-43.852	173.067	1149306	4377324	0	1095	0.21	27.3	11	1.115	2.430	3.034	52	74	85	5.2	7.7	8.9	A	A	B	B	B	C	B	B	C
Sleepy Bay	ECAN	11	DSDE	-43.854	173.060	311499	1171835	3	235	0.05	28.7	10	0.266	0.580	0.610	51	72	74	5.2	7.6	7.8	A	A	A	B	B	B	B	B	B
Stony Bay	ECAN	11	DSDE	-43.860	173.049	490309	1856834	2	754	0.15	23.0	16	0.785	1.710	2.116	58	89	103	5.7	9.3	10.8	A	B	B	B	B	C	B	B	C
Flea Bay	ECAN	11	DSDE	-43.880	173.020	1205445	6617243	1	859	0.17	42.2	10	0.872	1.900	2.405	49	67	76	5.1	7.2	8.2	A	A	A	B	B	C	B	B	C
Damons Bay	ECAN	11	DSDE	-43.889	172.992	1227804	10108813	0	362	0.07	73.6	5	0.382	0.832	1.270	43	52	61	4.7	5.7	6.7	A	A	A	B	B	B	B	B	B
Akaroa Harbour	ECAN	9	DSDE	-43.894	172.959	75076211	455980646	3	11505	2.29	57.7	3	16.478	35.901	62.766	43	49	59	4.5	5.3	6.3	A	A	A	B	B	B	B	B	B
Island Bay	ECAN	11	DSDE	-43.895	172.866	357393	1842196	0	439	0.08	34.4	13	0.519	1.131	1.666	60	91	119	6.3	9.8	12.9	A	B	B	B	B	D	B	B	D
Long Bay	ECAN	11	DSDE	-43.893	172.855	1480823	5739598	0	596	0.12	33.5	6	0.640	1.394	1.969	47	59	68	4.8	6.1	7.2	A	A	A	B	B	B	B	B	B
Horseshoe Bay	ECAN	11	DSDE	-43.882	172.226	1961739	11022650	0	712	0.14	49.3	5	0.803	1.749	2.118	79	91	95	8.6	9.9	10.4	A	B	B	C	C	C	C	C	C
Peraki Bay	ECAN	11	DSDE	-43.879	172.809	2088307	8392199	1	1760	0.36	29.5	11	1.738	3.788	4.479	52	71	78	5.2	7.5	8.2	A	A	A	B	B	C	B	B	C

Estuary	Regional Council	NZCHS code	ETI class	LAT (WGS84)	LON (WGS84)	Tidal prism spring tide (m^3)	Volume spring tide (m3)	Intertidal area (%)	Catchment Area (ha)	Mean freshwater inflow (m^3/s)	Flushing time (days)	Freshwater fraction (%)	TN load (T/yr)			Estuary TN Concentration (mg/m^3)			chl-a (µg/l)			Macroalgae Band			Phytoplankton Band			ETI Susceptibility Band		
													Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current
Te Oka Bay	ECAN	11	DSDE	-43.864	172.773	1346473	4347854	2	825	0.18	25.3	9	0.968	2.109	2.491	51	70	76	5.1	7.1	7.8	A	A	A	B	B	B	B	B	B
Tumbledown Bay	ECAN	11	DSDE	-43.860	172.766	298381	804808	6	462	0.09	16.1	16	0.569	1.240	1.016	64	101	89	6.0	10.2	8.8	A	B	B	B	C	C	B	C	C
Lake Forsyth (Te Roto o Wairewa)	ECAN	2B	C.LAKE	-43.829	172.710	0	5512392	1	11351	1.97	32.3	100	6.299	13.723	22.296	101	220	358	10.9	24.5	40.1	A	A	A	C	D	D	C	D	D
Lake Ellesmere (Te Waihora)	ECAN	2A	C.LAKE	-43.859	172.375	0	179138756	10	260018	19.00	109	100	227.733	496.162	1745.297	380	828	2913	43.0	93.9	331	A	A	A	D	D	D	D	D	D
Rakaia River	ECAN	3A	SSRTRE	-43.902	172.211	1072729	1670605	2	293275	175.55	0.1	100	456.563	994.715	1094.221	82	180	198	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Ashburton River	ECAN	3B	SSRTRE	-44.054	171.808	73445	114401	3	159696	32.63	0.0	100	152.701	332.691	871.906	148	323	847	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Rangitata River	ECAN	3B	SSRTRE	-44.184	171.521	137630	215935	1	181105	108.85	0.0	100	284.143	619.064	701.271	83	180	204	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Opihi River	ECAN	3C	SSRTRE	-44.281	171.355	278647	437747	1	237268	26.28	0.2	100	208.072	453.328	885.996	251	547	1069	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Washdyke Lagoon	ECAN	2A	C.LAKE	-44.369	171.264	0	230269	0	18170	1.13	2.4	100	6.117	13.328	34.434	172	374	966	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Saltwater Creek	ECAN	4D	C.LAKE	-44.427	171.257	0	109594	0	4774	0.26	4.9	100	1.681	3.662	9.053	207	452	1117	12.9	40.7	116	A	A	A	C	D	D	C	D	D
Wainono Lagoon	ECAN	2A	C.LAKE	-44.713	171.171	0	3792088	5	13725	0.56	79.0	100	2.514	5.477	12.006	143	313	685	16.1	35.3	77.6	A	A	A	D	D	D	D	D	D
Waihao River	ECAN	4D	C.LAKE	-44.774	171.174	0	358476	0	64849	4.28	1.0	100	42.510	92.616	168.768	315	686	1250	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Waitaki River	ECAN	3A	SSRTRE	-44.943	171.148	932411	1499963	3	1195472	410.37	0.0	100	1091.437	2377.917	2461.090	84	184	190	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Kakanui River	ORC	6B	SSRTRE	-45.191	170.901	246057	455441	21	89671	6.28	0.6	76	56.424	122.931	200.027	67	484	778	0.0	0.0	0.0	A	D	D	A	A	A	A	D	D
Orore Creek	ORC	4C	C.LAKE	-45.212	170.886	0	84727	0	1842	0.12	8.3	100	0.611	1.331	2.816	164	358	757	15.2	37.2	82.6	A	A	A	C	D	D	C	D	D
Shag River	ORC	7A	SIDE	-45.481	170.818	1117500	1352800	63	54236	3.09	1.9	37	33.131	72.183	109.058	164	310	448	0.0	0.0	0.0	B	C	D	A	A	A	B	C	D
Stony Creek	ORC	4C	SIDE	-45.511	170.784	140673	160907	87	901	0.06	5.9	20	0.242	0.527	1.270	75	103	178	1.8	5.0	13.5	A	B	B	A	B	D	A	B	B
Pleasant River	ORC	7A	SIDE	-45.571	170.732	971541	1443302	76	12848	0.98	4.7	28	5.318	11.586	17.109	94	150	200	0.0	4.8	10.5	B	B	C	A	A	C	B	B	C
Waikouaiti Lagoon	ORC	4B	C.LAKE	-45.613	170.683	0	24857	95	1681	0.04	7.6	100	0.141	0.307	0.546	119	259	460	9.5	25.4	48.3	A	A	A	B	D	D	A	A	A
Waikouaiti River	ORC	7A	SIDE	-45.643	170.662	1359584	2180631	68	42643	3.07	2.9	35	23.235	50.623	64.892	127	226	277	0.0	0.0	0.0	B	C	C	A	A	A	B	C	C
Blueskin Bay	ORC	7A	SIDE	-45.727	170.608	5787209	7559191	86	9277	0.78	10.2	9	8.625	18.792	25.512	94	132	156	8.2	12.5	15.3	B	B	B	C	D	D	B	B	B
Purakunui Inlet	ORC	7A	SIDE	-45.737	170.626	1027041	1294680	88	762	0.05	11.5	4	0.650	1.417	2.229	81	100	120	7.2	9.3	11.5	B	B	B	B	C	C	B	B	B
Otago Harbour	ORC	9	DSDE	-45.773	170.724	60304035	184773975	45	10407	1.31	29.6	2	9.619	20.956	39.707	70	74	83	7.3	7.8	8.8	A	A	B	B	B	C	A	A	B
Papanui Inlet	ORC	7A	SIDE	-45.842	170.738	3237684	3968608	90	1006	0.05	12.0	1	0.634	1.381	3.087	71	77	91	6.1	6.8	8.4	A	A	B	B	B	C	A	A	B
Hoopers Inlet	ORC	7A	SIDE	-45.882	170.679	3246593	3636671	95	928	0.07	10.9	2	0.676	1.473	3.246	73	79	94	6.0	6.8	8.4	A	A	B	B	B	C	A	A	B
Tomahawk Lagoon	ORC	4B	C.LAKE	-45.914	170.539	0	193787	2	441	0.06	36.3	100	0.201	0.439	1.172	103	225	602	11.2	25.1	67.9	A	A	A	C	D	D	C	D	D
Kaikorai Stream	ORC	6C	SSRTRE	-45.937	170.391	1001228	2100301	14	5477	0.50	10.1	21	5.962	12.990	22.058	136	228	347	12.9	23.4	37.0	B	C	D	C	D	D	C	D	D
Taieri River	ORC	6B	SSRTRE	-46.056	170.210	2511015	3915461	10	570631	45.46	0.6	64	382.568	833.501	1150.545	85	400	542	0.0	0.0	0.0	B	D	D	A	A	A	B	D	D
Akatore Creek	ORC	7A	SIDE	-46.116	170.193	462359	895893	70	6965	0.69	4.7	31	5.933	12.927	15.061	135	235	265	2.7	14.1	17.6	B	C	C	A	C	D	B	C	C
Tokomairiro River	ORC	7A	SSRTRE	-46.223	170.049	765229	1058980	51	39617	3.65	1.4	41	44.040	95.949	175.481	200	387	674	0.0	0.0	0.0	C	D	D	A	A	A	C	D	D
Clutha River	ORC	6B	SSRTRE	-46.333	169.839	10535431	16401711	5	2111146	617.00	0.3	100	2044.218	4453.745	5552.632	105	229	285	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Catlins River	ORC	7A	SIDE	-46.485	169.729	11763600	14156300	65	41805	6.96	5.3	23	38.165	83.151	168.539	95	142	229	2.2	7.4	17.4	B	B	C	A	B	D	B	B	C
Tahakopa River	ORC	7A	SSRTRE	-46.563	169.477	1345484	1939721	31	31147	7.17	1.3	43	44.458	96.860	124.359	128	226	278	0.0	0.0	0.0	B	C	C	A	A	A	B	C	C
Tautuku River	ORC	7A	SIDE	-46.601	169.430	838250	1338632	62	6235	1.32	3.7	32	8.313	18.112	18.845	115	190	195	0.0	0.0	0.0	B	B	B	A	A	A	B	B	B
Waipati Estuary	ORC	7A	SIDE	-46.624	169.361	722401	1330563	34	7269	1.64	3.3	35	10.373	22.601	26.647	119	201	229	0.0	0.0	0.0	B	C	C	A	A	A	B	C	C
Waikawa Harbour	ES	7A	SIDE	-46.648	169.133	7574506	9835149	82	23802	5.79	4.9	25	38.419	83.704	154.290	109	171	268	1.7	8.7	19.8	B	B	C	A	B	D	B	B	C
Haldane Estuary	ES	7A	SIDE	-46.668	169.032	2064020	2337221	93	6769	1.71	4.1	26	9.862	21.487	41.424	103	158	254	0.0	0.0	6.5	B	B	C	A	A	B	B	B	C

Estuary	Regional Council	NZCHS code	ETI class	LAT (WGS84)	LON (WGS84)	Tidal prism spring tide (m^3)	Volume spring tide (m3)	Intertidal area (%)	Catchment Area (ha)	Mean freshwater inflow (m^3/s)	Flushing time (days)	Freshwater fraction (%)	TN load (T/yr)			Estuary TN Concentration (mg/m^3)			chl-a (µg/l)			Macroalgae Band			Phytoplankton Band			ETI Susceptibility Band		
													Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current
Lake Brunton	ES	7B	C.LAKE	-46.658	168.894	0	258506	0	1467	0.33	9.1	100	1.903	4.145	10.190	184	402	988	18.0	42.7	109	A	A	A	D	D	D	D	D	D
Toetoes Harbour	ES	7A	SSRTRE	-46.585	168.796	8589338	11871604	31	563711	101.10	0.7	54	641.652	1397.969	3242.334	86	271	583	0.0	0.0	0.0	B	C	D	A	A	A	B	C	D
Waituna Lagoon	ES	2A	C.LAKE	-46.574	168.656	0	12588503	7	21316	2.90	50.2	100	11.428	24.899	53.748	125	272	587	13.8	30.5	66.4	A	A	A	C	D	D	C	D	D
Bluff Harbour	ES	8	SIDE	-46.605	168.360	89628434	121988796	52	7605	0.91	13.5	1	14.723	32.078	39.287	75	80	82	6.8	7.4	7.7	A	B	B	B	B	B	A	B	B
New River (Oreti) Estuary	ES	8	SIDE	-46.507	168.272	73102315	102935087	42	398458	65.10	4.9	27	480.820	1047.564	3951.101	114	187	563	1.8	10.1	52.8	B	B	D	A	C	D	B	B	D
Jacobs River (Riverton) Estuary	ES	7A	SIDE	-46.361	168.027	10151391	14697352	66	156864	29.32	2.1	37	191.723	417.707	1283.517	120	210	556	0.0	0.0	0.0	B	C	D	A	A	A	B	C	D
Waiau River	ES	3B	SSRTRE	-42.771	173.380	1092669	1839804	1	830279	489.42	0.0	100	452.702	986.304	1438.703	29	64	93	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Big River (Lake Hakapoua)	ES	9	DSDE	-46.220	166.925	10688413	38038249	0	15390	12.16	10.4	29	41.392	90.181	76.585	69	106	95	5.4	9.6	8.4	A	B	B	B	B	C	B	B	C
Preservation Inlet	ES	10	DSDE	-46.142	166.609	180913302	7298729976	1	44126	43.60	17.1	1	165.904	361.455	291.807	52	53	53	4.7	4.8	4.8	A	A	A	B	B	B	B	B	B
Chalky Inlet	ES	10	DSDE	-46.030	166.489	208778230	12729611785	0	38176	39.77	20.0	1	147.555	321.478	273.450	49	50	50	4.6	4.7	4.7	A	A	A	A	A	B	A	A	B
Breaksea/Dusky Sound	ES	10	DSDE	-45.616	166.569	515651976	30389041529	1	103572	134.26	20.6	1	554.359	1207.783	1006.493	44	45	45	4.0	4.2	4.1	A	A	A	B	B	B	B	B	B
Coal River	ES	11	DSDE	-45.494	166.704	5814735	44113235	2	6522	6.62	22.3	29	22.146	48.249	46.418	59	95	93	5.8	9.9	9.6	A	B	B	B	B	C	B	B	C
Dagg Sound	ES	10	DSDE	-45.391	166.764	28394024	778194350	1	9216	9.72	9.9	1	36.597	79.734	74.604	38	40	39	1.7	1.9	1.9	A	A	A	A	A	A	A	A	A
Thompson/Doubtful sound	ES	10	DSDE	-45.147	166.961	254867548	18978270538	1	82591	109.86	19.1	1	447.077	974.049	774.416	32	34	33	2.6	2.7	2.7	A	A	A	A	A	A	A	A	A
Nancy Sound	ES	10	DSDE	-45.102	167.019	27117750	1440801049	0	7009	8.88	10.8	1	43.460	94.687	85.935	31	32	32	1.3	1.4	1.4	A	A	A	A	A	A	A	A	A
Charles Sound	ES	10	DSDE	-45.046	167.086	30317543	990184689	4	14182	22.91	5.9	1	115.599	251.857	209.806	31	33	33	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Caswell Sound	ES	10	DSDE	-45.000	167.130	33290705	2491218702	0	24724	46.99	8.9	1	228.907	498.721	400.452	31	33	32	0.4	0.7	0.6	A	A	A	A	A	A	A	A	A
Two Thumb Bay	ES	11	DSDE	-44.953	167.178	2280973	8435863	2	3304	4.97	6.8	35	18.071	39.371	36.478	58	105	99	1.7	7.0	6.3	A	B	B	A	B	B	A	B	B
Looking Glass Bay	ES	11	DSDE	-44.918	167.212	2666036	17270010	3	1278	1.96	25.2	25	7.832	17.063	16.640	52	89	87	5.1	9.3	9.1	A	B	B	B	B	C	B	B	C
George Sound	ES	10	DSDE	-44.844	167.348	58967636	3304945089	0	25074	47.63	11.7	1	224.365	488.826	423.161	28	30	30	1.1	1.4	1.3	A	A	A	A	A	A	A	A	A
Catseye Bay	ES	11	DSDE	-44.806	167.382	1594832	5013355	5	3446	5.55	4.0	39	23.099	50.325	49.885	66	126	125	0.0	0.0	0.0	A	B	B	A	A	A	A	A	A
Bligh Sound	ES	10	DSDE	-44.765	167.483	39994109	1462615962	2	17665	33.25	8.0	2	178.960	389.900	311.806	27	30	29	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Sutherland Sound	ES	10	DSDE	-44.725	167.546	20562346	114358227	2	15559	29.39	13.9	31	164.212	357.768	267.974	71	136	106	6.5	13.8	10.4	A	B	B	B	C	C	B	C	C
Poison Bay	ES	11	DSDE	-44.653	167.623	16135457	321672860	0	6313	10.77	3.3	1	45.430	98.979	82.266	24	26	25	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Milford Sound	ES	10	DSDE	-44.564	167.802	54781767	3579420379	1	52406	99.88	9.1	2	517.932	1128.419	758.152	27	31	28	0.0	0.5	0.2	A	A	A	A	A	A	A	A	A
Hollyford River	ES	6B	SSRTRE	-44.338	168.001	3103811	4667024	2	113477	213.11	0.3	100	855.557	1864.006	1452.362	127	277	216	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Awarua River	ES	3C	SSRTRE	-44.291	168.114	228836	459797	0	5510	9.75	0.5	100	35.798	77.994	76.308	116	254	248	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Cascade River	WCRC	6B	SSRTRE	-44.025	168.349	1931803	2873150	1	43879	94.70	0.4	100	353.381	769.912	592.216	118	258	198	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Waiatoto River	WCRC	6B	SSRTRE	-43.969	168.788	2732735	3946666	12	54117	125.56	0.4	100	392.101	854.271	671.894	99	216	170	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Okuru River	WCRC	6B	SSRTRE	-43.909	168.885	3128239	4386557	25	51463	107.14	0.5	100	363.361	791.656	657.024	108	234	194	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Waita River	WCRC	6D	SSRTRE	-43.796	169.092	445784	627421	21	13127	25.03	0.3	100	53.043	115.565	114.202	67	146	145	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Moeraki (Blue) River	WCRC	4C	SSRTRE	-43.699	169.255	136992	199244	1	10658	24.56	0.1	100	63.181	137.652	117.498	82	178	152	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Paringa River	WCRC	5C	SSRTRE	-43.627	169.433	972465	1395896	6	36625	84.15	0.2	100	222.291	484.307	422.882	84	182	159	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Ohinemaka River	WCRC	6D	SSRTRE	-43.627	169.496	219375	316944	0	7112	12.90	0.3	100	32.030	69.783	69.732	79	172	171	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Mahitahi River	WCRC	6B	SSRTRE	-43.596	169.586	828911	1184195	5	20137	49.75	0.3	100	142.000	309.377	258.810	91	197	165	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Makawhio River (Jacobs River)	WCRC	6B	SSRTRE	-43.566	169.632	1285453	1791819	18	17081	39.38	0.4	83	99.717	217.254	176.161	15	147	119	0.0	0.0	0.0	A	B	B	A	A	A	A	B	B
Manakaiaua River	WCRC	6D	SSRTRE	-43.541	169.675	525427	751847	3	5915	11.89	0.5	71	22.698	49.452	56.091	13	97	110	0.0	0.0	0.0	A	B	B	A	A	A	A	A	A

Estuary	Regional Council	NZCHS code	ETI class	LAT (WGS84)	LON (WGS84)	Tidal prism spring tide (m^3)	Volume spring tide (m3)	Intertidal area (%)	Catchment Area (ha)	Mean freshwater inflow (m^3/s)	Flushing time (days)	Freshwater fraction (%)	TN load (T/yr)			Estuary TN Concentration (mg/m^3)			chl-a (µg/l)			Macroalgae Band			Phytoplankton Band			ETI Susceptibility Band		
													Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current
Ohinetamatatea River (Saltwater Creek)	WCRC	6E	SSRTRE	-43.457	169.761	283366	404773	3	9610	17.24	0.3	100	39.303	85.629	105.947	72	157	195	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Three Mile Lagoon	WCRC	7B	C.LAKE	-43.241	170.125	0	351518	58	2584	4.62	0.9	100	5.923	12.905	12.888	41	89	88	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Okarito Lagoon	WCRC	7B	C.LAKE	-43.221	170.158	0	18664663	14	30243	60.07	3.6	100	96.035	209.231	226.899	51	110	120	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Saltwater Lagoon	WCRC	7B	C.LAKE	-43.099	170.330	0	7538565	4	2066	2.87	30.4	100	5.745	12.516	12.451	63	138	138	6.6	15.1	15.0	A	A	A	B	C	D	B	C	D
Poerua River (Hikimutu Lagoon)	WCRC	6C	SSRTRE	-43.047	170.404	847270	1195083	0	25834	47.29	0.3	100	90.365	196.879	297.877	61	132	200	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Duffers Creek/Te Rahotaiepa River	WCRC	6D	C.LAKE	-42.992	170.583	0	192306	0	6576	9.50	0.2	100	14.649	31.915	34.726	49	106	116	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Waitaha River	WCRC	6C	SSRTRE	-42.957	170.659	576737	778394	22	33749	81.94	0.1	100	184.068	401.030	499.217	71	155	193	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Mikonui River	WCRC	6C	SSRTRE	-42.901	170.765	145017	196813	18	15741	41.11	0.1	100	92.728	202.026	188.770	72	156	146	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Totara River	WCRC	6D	SSRTRE	-41.861	171.452	2577812	4445826	1	13544	23.88	1.1	50	37.412	81.509	132.698	11	59	93	0.0	0.0	0.0	A	A	B	A	A	A	A	A	A
Taramakau River	WCRC	6C	SSRTRE	-42.565	171.123	2136444	2873440	22	100592	157.96	0.2	100	423.577	922.849	901.560	85	185	181	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Saltwater Creek/New River	WCRC	6D	SSRTRE	-42.527	171.153	540852	963955	0	14605	15.12	0.6	79	36.963	80.532	110.848	10	135	185	0.0	0.0	0.0	A	B	B	A	A	A	A	A	A
Grey River	WCRC	6C	SSRTRE	-42.441	171.191	2040072	2040072	0	394696	343.37	0.1	100	844.728	1840.412	3164.845	78	170	292	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Deverys Creek	WCRC	4B	C.LAKE	-42.195	171.311	0	142735	0	710	0.81	2.0	100	1.574	3.430	12.042	62	135	473	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Punakaiki River	WCRC	4C	SSRTRE	-42.124	171.324	143197	250711	0	6301	7.76	0.4	100	16.004	34.868	36.041	65	142	147	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Pororari River	WCRC	6B	SSRTRE	-42.100	171.333	295821	403921	5	10409	12.07	0.4	100	30.982	67.500	74.418	81	177	195	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Waitakere River (Nile River)	WCRC	5C	SSRTRE	-41.897	171.443	175064	238869	0	12729	18.18	0.2	100	49.790	108.478	114.374	87	189	199	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Totara River	WCRC	6D	SSRTRE	-41.861	171.452	272601	367356	8	10888	12.94	0.3	100	43.542	94.866	105.753	107	233	259	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Okari Lagoon	WCRC	7A	SIDE	-41.812	171.454	2568110	3398574	71	7581	5.51	2.5	34	24.475	53.324	147.126	54	111	297	0.0	0.0	0.0	A	B	C	A	A	A	A	B	C
Buller River	WCRC	6B	SSRTRE	-41.729	171.588	5126165	5126165	11	642680	435.35	0.1	100	1141.070	2486.053	3160.198	83	181	230	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Orowaiti Lagoon	WCRC	7A	SIDE	-41.741	171.660	3453038	4519994	71	4736	3.73	4.0	28	8.183	17.829	110.743	27	50	274	0.0	0.0	4.6	A	A	C	A	A	B	A	A	C
Jones Creek	WCRC	4E	C.LAKE	-41.681	171.771	0	59875	6	2041	2.73	0.3	100	6.308	13.744	34.754	73	160	404	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Mokihinui River	WCRC	6B	SSRTRE	-41.522	171.933	1160869	1526954	14	75138	89.70	0.2	100	240.724	524.466	525.979	85	185	186	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Ngakawau River	WCRC	6B	SSRTRE	-41.606	171.873	293982	387127	14	19730	28.24	0.2	100	102.165	222.587	214.590	115	250	241	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Little Wanganui River	WCRC	6B	SSRTRE	-41.390	172.056	976400	1248904	29	20992	14.30	0.6	59	48.095	104.784	142.262	13	141	190	0.0	0.0	0.0	A	B	B	A	A	A	A	B	B
Karamea River	WCRC	7A	SSRTRE	-41.262	172.088	7809114	10378445	68	130750	124.57	0.6	61	380.240	828.430	864.486	18	132	137	0.0	0.0	0.0	A	B	B	A	A	A	A	B	B
Oparara River	WCRC	7A	SSRTRE	-41.212	172.094	1701331	2468446	50	14441	13.62	1.0	48	35.382	77.086	113.409	10	90	130	0.0	0.0	0.0	A	B	B	A	A	A	A	B	B
Heaphy River	WCRC	5A	SSRTRE	-40.988	172.102	298221	396497	3	29819	28.61	0.2	100	97.380	212.162	197.712	108	235	219	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Big River	TDC	5C	SSRTRE	-40.764	172.255	565975	810541	51	10971	13.13	0.5	72	59.790	130.264	100.870	10	229	178	0.0	0.0	0.0	A	C	B	A	A	A	A	C	B
Anaweka River	TDC	5C	SIDE	-40.750	172.285	995741	1282105	72	2958	2.87	1.9	37	10.278	22.392	21.621	46	96	93	0.0	0.0	0.0	A	B	B	A	A	A	A	B	B
Turimawiwi River	TDC	3B	SSRTRE	-40.729	172.310	119681	148683	41	5701	5.37	0.3	100	19.369	42.200	45.676	114	249	270	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Anatori River	TDC	3B	SSRTRE	-40.701	172.363	253436	324039	25	7587	6.16	0.4	74	20.018	43.614	43.735	9	168	168	0.0	0.0	0.0	A	B	B	A	A	A	A	B	B
Paturau River	TDC	6B	SSRTRE	-40.639	172.428	129184	170602	2	8931	5.97	0.3	100	20.509	44.684	45.349	109	237	241	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Whanganui Inlet	TDC	8	SIDE	-40.574	172.539	47196180	59628780	79	6915	2.81	11.3	5	15.321	33.380	36.388	15	25	26	0.0	0.7	0.9	A	A	A	A	A	A	A	A	A
Green Hills Stream	TDC	3C	DSDE	-40.504	172.650	465232	1168618	9	805	0.15	14.9	16	1.248	2.719	3.121	50	102	116	4.2	10.1	11.7	A	B	B	A	C	C	A	C	C
Port Puponga	TDC	7A	SIDE	-40.527	172.737	751378	993507	58	519	0.09	10.5	9	0.773	1.685	2.273	30	57	74	1.1	4.1	6.0	A	A	A	A	B	B	A	A	A
Pakawau Inlet	TDC	7A	SIDE	-40.586	172.686	1365591	1379385	100	943	0.24	7.4	11	1.648	3.590	4.752	32	61	78	0.0	2.7	4.6	A	A	A	A	A	B	A	A	A
Waikato Estuary	TDC	7A	SIDE	-40.630	172.679	378435	382257	100	237	0.08	6.8	13	0.501	1.091	1.291	33	62	72	0.0	2.2	3.3	A	A	A	A	A	B	A	A	A

Estuary	Regional Council	NZCHS code	ETI class	LAT (WGS84)	LON (WGS84)	Tidal prism spring tide (m^3)	Volume spring tide (m3)	Intertidal area (%)	Catchment Area (ha)	Mean freshwater inflow (m^3/s)	Flushing time (days)	Freshwater fraction (%)	TN load (T/yr)			Estuary TN Concentration (mg/m^3)			chl-a (µg/l)			Macroalgae Band			Phytoplankton Band			ETI Susceptibility Band		
													Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current
Ruataniwha Inlet	TDC	7A	SIDE	-40.670	172.684	13502253	15028893	88	71518	73.39	1.0	43	258.065	562.247	721.178	53	110	139	0.0	0.0	0.0	A	B	B	A	A	A	A	B	B
Parapara Inlet	TDC	7A	SIDE	-40.715	172.690	3603422	3899560	92	4336	2.25	4.6	23	8.931	19.458	20.297	37	71	74	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Onahau River	TDC	7A	SIDE	-40.798	172.773	660161	685996	96	2167	0.56	3.7	26	3.634	7.917	31.959	63	126	483	0.0	0.0	10.0	A	B	D	A	A	C	A	B	D
Takaka River	TDC	5B	SSRTRE	-40.816	172.800	858318	1089762	5	87206	53.35	0.2	100	201.064	438.058	583.925	120	260	347	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Takaka Estuary	TDC	7A	SIDE	-40.821	172.812	1838124	2421804	60	410	0.10	11.9	4	0.553	1.205	9.604	19	28	142	0.2	1.2	14.1	A	A	B	A	A	D	A	A	B
Motupipi River	TDC	7A	SIDE	-40.833	172.848	2565294	2988676	82	4080	1.03	6.3	19	5.895	12.843	43.450	44	84	260	0.0	3.7	23.7	A	B	C	A	A	D	A	B	C
Ligar Bay	TDC	7A	SIDE	-40.819	172.903	943945	1280300	53	407	0.09	11.4	7	0.517	1.126	1.248	25	40	43	0.7	2.4	2.8	A	A	A	A	A	A	A	A	A
Wainui Inlet	TDC	7A	SIDE	-40.812	172.942	3819984	4444235	83	4099	1.20	6.9	16	6.506	14.175	17.265	39	72	85	0.0	3.4	5.0	A	A	B	A	A	B	A	A	B
Totaranui Stream	TDC	7A	SIDE	-40.822	173.016	232247	232910	100	884	0.23	3.3	27	1.307	2.847	2.992	60	119	125	0.0	0.0	0.0	A	B	B	A	A	A	A	B	B
Awaroa Inlet	TDC	7A	SIDE	-40.852	173.033	4175182	4258318	98	6666	2.11	4.9	21	9.263	20.182	20.356	40	75	75	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Bark Bay	TDC	7A	SIDE	-40.920	173.059	1567546	1988990	26	692	0.21	9.9	9	0.991	2.158	2.158	27	43	43	0.5	2.3	2.3	A	A	A	A	A	A	A	A	A
Sandfly Bay	TDC	7A	SIDE	-40.928	173.057	147098	169163	85	2146	0.70	1.2	41	2.817	6.138	6.138	62	124	124	0.0	0.0	0.0	A	B	B	A	A	A	A	B	B
Frenchman Bay	TDC	7A	SIDE	-40.937	173.058	99022	108745	91	130	0.04	5.8	19	0.157	0.341	0.341	35	62	62	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Torrent Bay	TDC	7A	SIDE	-40.945	173.063	4999772	7062550	28	1510	0.49	11.8	7	1.794	3.909	3.899	22	32	32	0.5	1.6	1.6	A	A	A	A	A	A	A	A	A
Marahau River	TDC	7A	SIDE	-40.995	173.012	347155	350662	100	2749	0.95	1.6	36	3.629	7.907	9.599	54	106	126	0.0	0.0	0.0	A	B	B	A	A	A	A	B	B
Otuwhero Inlet	TDC	7A	SIDE	-41.011	173.013	2016584	2479236	74	5800	2.10	3.8	28	9.040	19.695	18.037	49	94	87	0.0	0.0	0.0	A	B	B	A	A	A	A	B	B
Kaiteretere Estuary	TDC	7A	SIDE	-41.041	173.020	347700	388111	88	379	0.09	7.1	15	0.417	0.908	1.174	34	59	72	0.0	2.1	3.6	A	A	A	A	A	B	A	A	A
Ferrer Creek	TDC	6C	SIDE	-41.070	173.007	390236	413107	94	1435	0.40	3.3	28	1.570	3.422	26.427	46	87	597	0.0	0.0	0.0	A	B	D	A	A	A	A	B	D
Motueka River	TDC	5B	SSRTRE	-41.082	173.023	1075640	1372982	1	206082	63.09	0.3	100	262.345	571.573	747.414	132	287	376	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Motueka Estuary North	TDC	7A	SIDE	-41.104	173.032	955470	1108643	83	112	0.02	11.1	2	0.124	0.270	1.017	19	23	43	0.0	0.4	2.8	A	A	A	A	A	A	A	A	A
Motueka Estuary South	TDC	7A	SIDE	-41.129	173.029	3363777	3971053	80	163	0.03	11.7	1	0.159	0.347	2.370	17	19	35	0.0	0.1	1.9	A	A	A	A	A	A	A	A	A
Moutere Inlet	TDC	8	SIDE	-41.157	173.040	17558583	23218843	59	18622	2.20	10.5	9	20.759	45.227	156.118	40	71	208	2.2	5.6	21.2	A	A	C	A	B	D	A	A	C
Waimea Inlet	TDC	8	SIDE	-41.287	173.197	75693684	99818432	59	91549	21.66	8.2	15	105.603	230.078	368.272	38	66	97	0.8	3.9	7.5	A	A	B	A	A	B	A	A	B
Tahunanui Estuary	NCC	7A	SIDE	-41.284	173.222	563047	777752	47	326	0.06	11.4	7	0.380	0.828	2.073	31	49	99	1.4	3.4	9.1	A	A	B	A	B	C	A	A	B
Nelson Haven	NCC	7A	SIDE	-41.267	173.258	30800259	37895215	66	10627	3.18	10.1	7	12.749	27.776	31.790	25	36	39	0.3	1.6	1.9	A	A	A	A	A	A	A	A	A
Delaware Estuary	NCC	7A	SIDE	-41.161	173.441	5835251	6270285	93	8029	2.28	5.8	18	9.055	19.728	19.264	37	64	63	0.0	0.5	0.4	A	A	A	A	A	A	A	A	A
Whangamoa River	NCC	7A	SIDE	-41.101	173.529	902338	1102327	76	9467	2.79	1.7	37	11.071	24.121	24.012	58	114	113	0.0	0.0	0.0	A	B	B	A	A	A	A	B	B
Croisilles Harbour	MDC	9	DSDE	-41.044	173.633	148516116	542110837	4	6820	1.95	36.0	1	8.136	17.727	17.845	18	20	20	1.6	1.8	1.8	A	A	A	A	A	A	A	A	A
Manuhakapakapa Bay	MDC	11	DSDE	-40.904	173.779	11199557	38963827	1	1013	0.29	33.3	2	1.076	2.344	2.669	18	21	22	1.5	1.8	1.9	A	A	A	A	A	A	A	A	A
Greville Harbour	MDC	11	DSDE	-40.825	173.789	37948037	128671344	1	4361	1.11	32.3	2	4.400	9.586	10.729	18	21	22	1.4	1.8	1.9	A	A	A	A	A	A	A	A	A
Otu Bay	MDC	11	DSDE	-40.755	173.836	3383235	9254589	1	1152	0.28	23.4	6	1.147	2.498	2.550	22	31	31	1.6	2.7	2.7	A	A	A	A	A	A	A	A	A
Port Hardy	MDC	9	DSDE	-40.730	173.903	78258581	493577463	0	3017	0.77	62.6	1	3.152	6.867	6.619	15	17	17	1.5	1.6	1.6	A	A	A	A	A	A	A	A	A
Catherine Cove	MDC	11	DSDE	-40.878	173.887	9603071	97906969	0	720	0.18	99.2	2	0.728	1.586	1.584	18	20	20	1.8	2.1	2.1	A	A	A	A	A	A	A	A	A
Admiralty Bay	MDC	11	DSDE	-40.945	173.869	39831357	603705437	0	859	0.27	14.9	0	1.027	2.238	2.708	17	17	17	0.4	0.4	0.4	A	A	A	A	A	A	A	A	A
Pelorous/Kenepuru Sound	MDC	9	DSDE	-40.945	174.086	932042778	11325992741	3	159073	65.44	107	5	215.995	470.590	572.708	21	28	30	2.2	3.0	3.3	A	A	A	A	A	B	A	A	B
Port Gore	MDC	11	DSDE	-40.992	174.272	98899835	1428727491	0	2168	0.84	13.3	0	2.632	5.734	6.363	16	16	16	0.1	0.1	0.1	A	A	A	A	A	A	A	A	A
Queen Charlotte Sound (Totaranui)	MDC	9	DSDE	-41.047	174.353	455510181	9614466079	1	25741	10.18	15.3	0	31.408	68.429	75.732	16	16	16	0.4	0.4	0.4	A	A	A	A	A	A	A	A	A

Estuary	Regional Council	NZCHS code	ETI class	LAT (WGS84)	LON (WGS84)	Tidal prism spring tide (m^3)	Volume spring tide (m3)	Intertidal area (%)	Catchment Area (ha)	Mean freshwater inflow (m^3/s)	Flushing time (days)	Freshwater fraction (%)	TN load (T/yr)			Estuary TN Concentration (mg/m^3)			chl-a (µg/l)			Macroalgae Band			Phytoplankton Band			ETI Susceptibility Band		
													Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current
Onekaka Inlet	TDC	7A	SIDE	-40.747	172.712	365553	401345	90	1734	0.77	2.1	34	2.766	6.026	12.660	46	92	186	0.0	0.0	0.0	A	B	B	A	A	A	A	B	B

Appendix B

Potential approaches for determination of LRV

A) Simple and Conservative approach

- A conservative value is standardised for influent FIB. For example, 10,000,000 cfu/100ml E. coli
- The appropriate EoP E. coli value selected from the Standard. E.g. 130 cfu/100ml
- A conservatively low (precautionary) LRV could be assigned, by the Standard, to particular unit processes in the treatment plant. E.g. Primary sedimentation - 0.5, clarified activated sludge – 1.5, MBR – 3 etc
- Whole of plant 'required LRV calculated log10(10,000,000/130) = 4.9
- If this is a simple MLE plant, then the non-UV LRV would simply be 1.5 (from above), and the UV-LRV, 4.9 - 1.5 =3.4.
- If the validated UV dose for E. coli is 5mJ/cm2 (approx. From IUVA Data 2016), then
- The validated UV dose to be designed for and delivered is 17mJ/cm^2.

But the assignment of LRVs to unit processes is not simple because not all unit processes of the same generic type will have similar performance. For example, the LRV performance of a 'Contact Stabilization' process will be quite different to that of an extended aeration process. A heavily loaded BTF will perform differently to a lightly loaded one.

B) Rigorous, less conservative approach

A more complex and rigorous, and less conservative but acceptable methodology would be something like the following (this may suit more highly resourced WWTPs where the implication of a very conservative (but unnecessarily high) UV_LRV requirement is extreme):

- An influent data characterisation set is collected and maintained by the applicant. This is added to over time. It could be FIBs and other choices of priority pathogen such as norovirus.
- Statistical analysis is used to derive a statistically valid distribution for the influent FIBs / pathogens for that treatment plant. In early years, a 'hockey stick' type top end extension may be required until the extreme values are better understood.
- Enumeration of relevant species immediately pre-UV would be used to derive a statistically valid distribution for the FIB/Pathogen LRV across the plant pre-UV. Again, this would have to be undertaken over a sufficient period of time to make sure that a statistically valid performance distribution is developed.
- A 95th %ile Pre-UV FIB / pathogen number would be derived using a Monte Carlo or equivalent numerical simulation process.
- The required UV-LRV to reduce 95th%ile pre-UV FIB/Pathogen number to the EoP Standard would then be calculated.
- Using IUVA published data, or actual on-site collimated beam test data, the validated dose required to achieve the required UV-LRV would be calculated.
- The received dose would be continually monitored and regularly reported.
- The achieved result is the statistical 95th%ile of the calculated received doses. An agreed 'rolling' reporting period would be required to be set. This could be converted back to an LRV.
- Periodic check sampling would be undertaken to verify that the method remains valid.

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