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# Whakatāne Comprehensive Stormwater Consent: Potential effects on ecology and water quality

Prepared for:

**Whakatāne District Council**

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# Contents

# 1 Introduction

## 1.1 Background

Whakatāne District Council (**WDC**) is responsible for the management of stormwater within the Whakatāne urban area and hold numerous resource consents and other authorisations enabling the discharge of stormwater. WDC is seeking to consolidate these consents into one Comprehensive Stormwater Consent (**CSC**). The consent will be supported by the Whakatāne Urban Stormwater Catchment Management Plan (**CMP**), this will be the key planning and management tool for stormwater management under the CSC. The CMP is expected to be regularly updated so as to adapt to changes in the network, new knowledge and tools.

River Lake Ltd was engaged to help inform the development of the CSC and CMP by:

- assessing the potential effects of the stormwater network management and discharges on the aquatic ecology and water quality of receiving waterbodies; and
- identifying issues and potential mitigation options to be incorporated in the CSC.

A description of the stormwater network, and issues relating to engineering, hydrology and cultural effects is addressed in other reports.

## 1.2 Information Sources

This report utilises existing monitoring data and information provided in other technical reports and monitoring related to stream water quality, stormwater quality, sediment quality, fish, and aquatic macroinvertebrates. In particular:

- Hamill KD 2019. Whakatane Comprehensive Stormwater Consent Monitoring Plan. Prepared by River Lake for Whakatāne District Council
- WSP Opus 2019. Stormwater monitoring report. Prepared for Whakatāne District Council by J. Gladwin, WSP Opus International Consultants, March 2019.
- Opus 2017. *Whakatāne stormwater catchment management plan Ecological Values Assessment*, *Hinemoa Stream and Apanui Stream*. Prepared for Whakatāne District Council.
- Opus 2016. Comprehensive Stormwater Monitoring Update. Memo to Inka Krawczyk, Whakatāne District Council from James Gladwin, 14 November 2016.
    - Sediment sampling occurred at: three locations in the Whakatāne River, Amber Grove Pump Station and Apanui Drain Pump Station. Stormwater sampling occurred at: Apanui Drain, Amber Grove, Te Tahi Street, The Hub and Wainui Te Whara.
- Opus 2016. Whakatāne Urban Catchment Management Plan (updated Issue No. 2 Draft). Prepared for Whakatāne District Council, October 2016.
- Hamill 2015. *Wainui Te Whara Stream survey 2015*. Prepared by River Lake for Whakatāne District Council
- Compliance monitoring data from stormwater systems

- Environmental monitoring information from Bay of Plenty Regional Council on the Whakatāne River, Wainui Te Whara Stream and Awatapu Lagoon.

The report builds on previous review of the draft Catchment Management Plans (CMPs) which identified information gaps and high-risk areas that might discharge to sensitive receiving environments and identifying linkages to appropriate management actions (Hamill 2017).

## 1.3 Whakatāne streams and stormwater network

The Whakatāne Urban Stormwater Catchment incorporates all the residential and commercial land in Whakatāne that drains indirectly or directly to the Whakatāne River. It includes the Whakatāne Township and central business district (**CBD**), the coastal development of Coastlands/Piripai and the commercial and industrial areas of the Hub and Gateway Drive (**Figure 1.1**).

There are three main Stormwater Zones: Apanui (271 ha), Hinemoa (139 ha) and Whakatāne South (203 ha) and six smaller Stormwater Zones: Wainui Te Whara (721 ha), Awatapu (45 ha), Wairaka (58 ha); Wairere (302 ha); Coastlands (127 ha); and Whakatāne West (85 ha).

The Whakatāne Urban Stormwater Catchment's natural waterbodies that receive stormwater discharges are as follows (with the number of stormwater discharge locations in brackets): Whakatāne River (19 downstream of Landing Road Bridge, 23 upstream of Landing Road Bridge), Wairere Stream (2), Waiewe Stream, Hinemoa Street drain, Wainui Te Whara Stream (11), Awatapu Lagoon (19), Sullivan's Lake and Orini Canal (**Figure 1.2**).

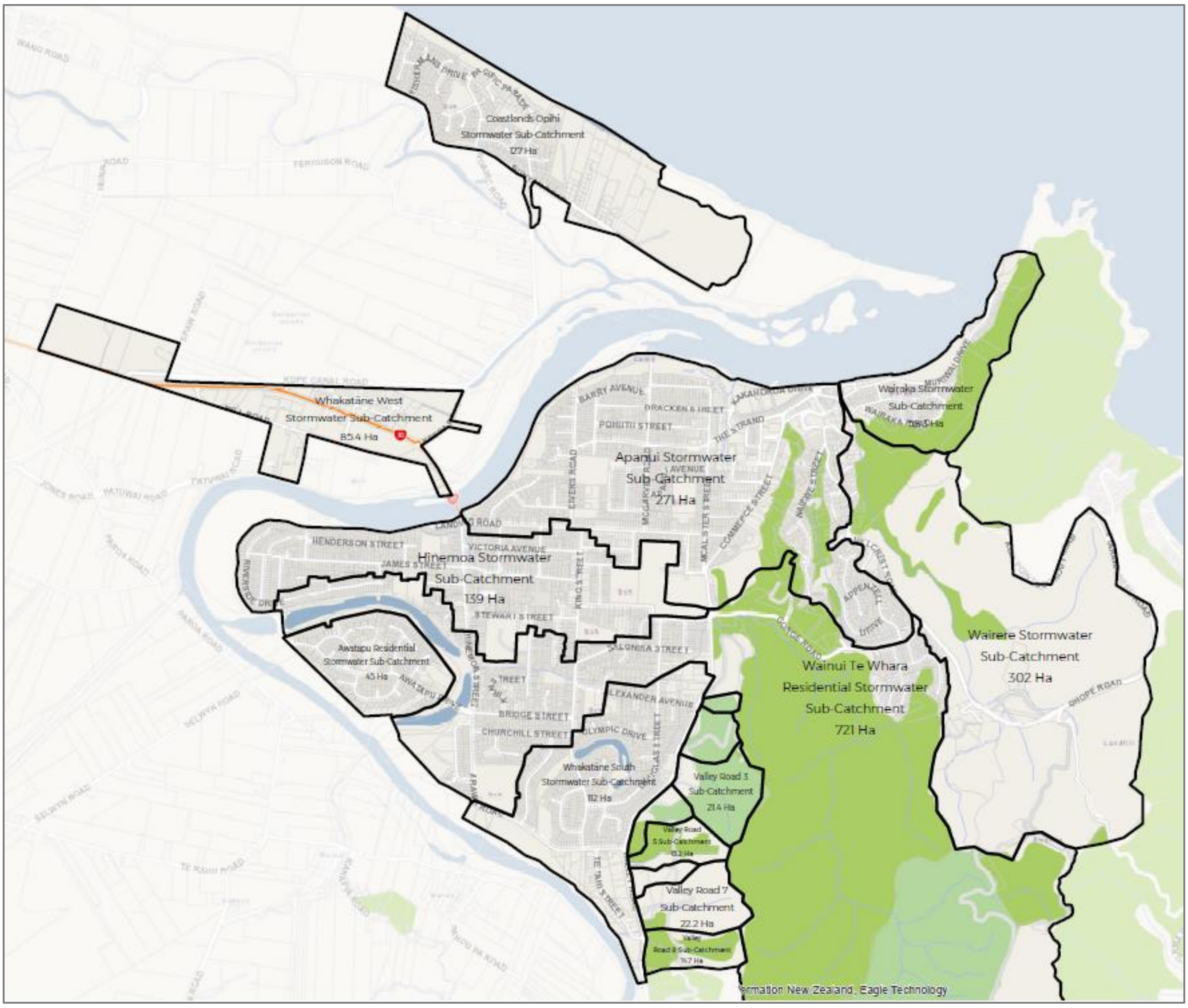


**Figure 1.1**: Whakatāne stormwater catchments. Overall Catchment Plan from WSP 2021

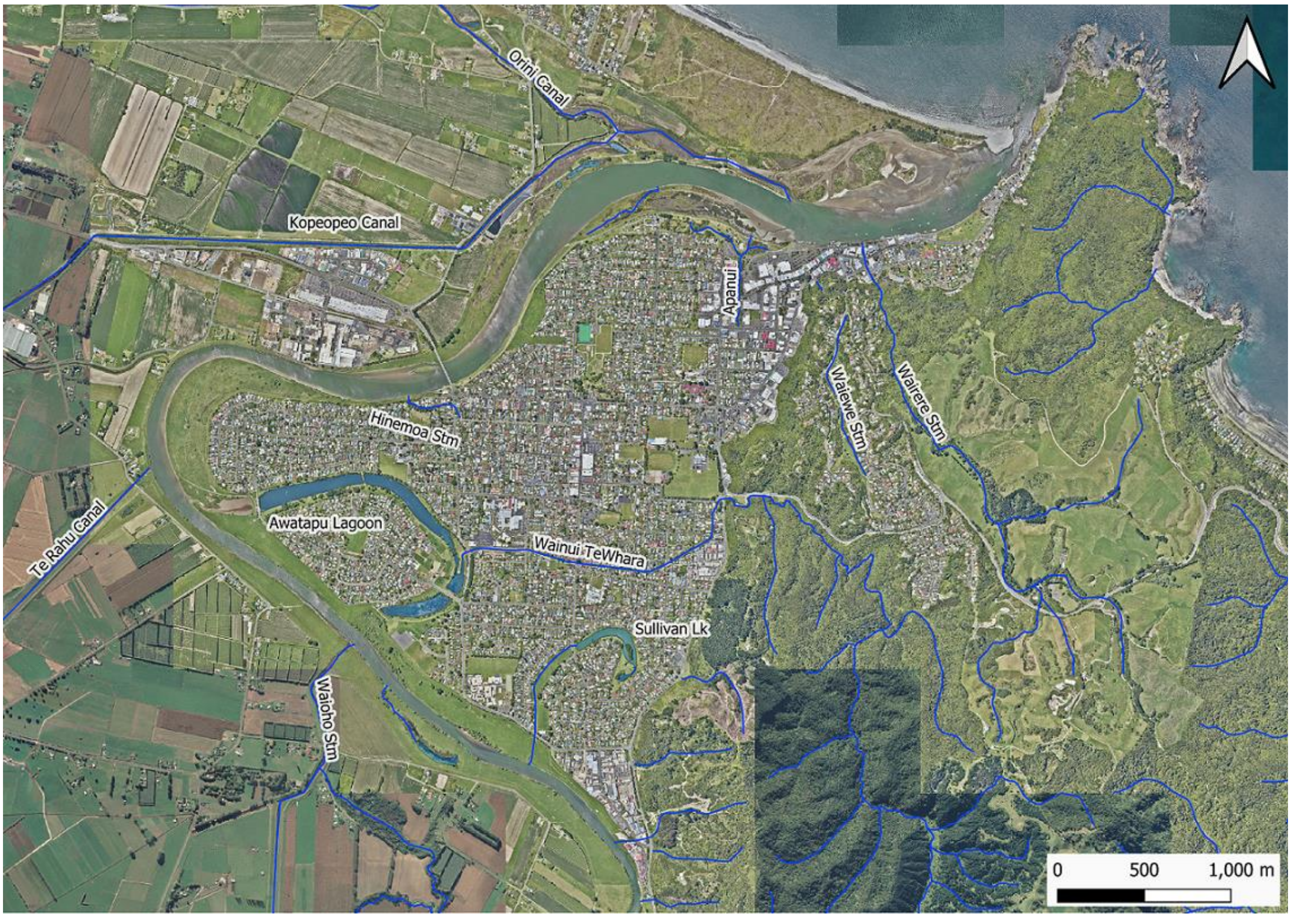


**Figure 1.2**: Waterbodies within the Whakatāne Urban area.

# 2 Method

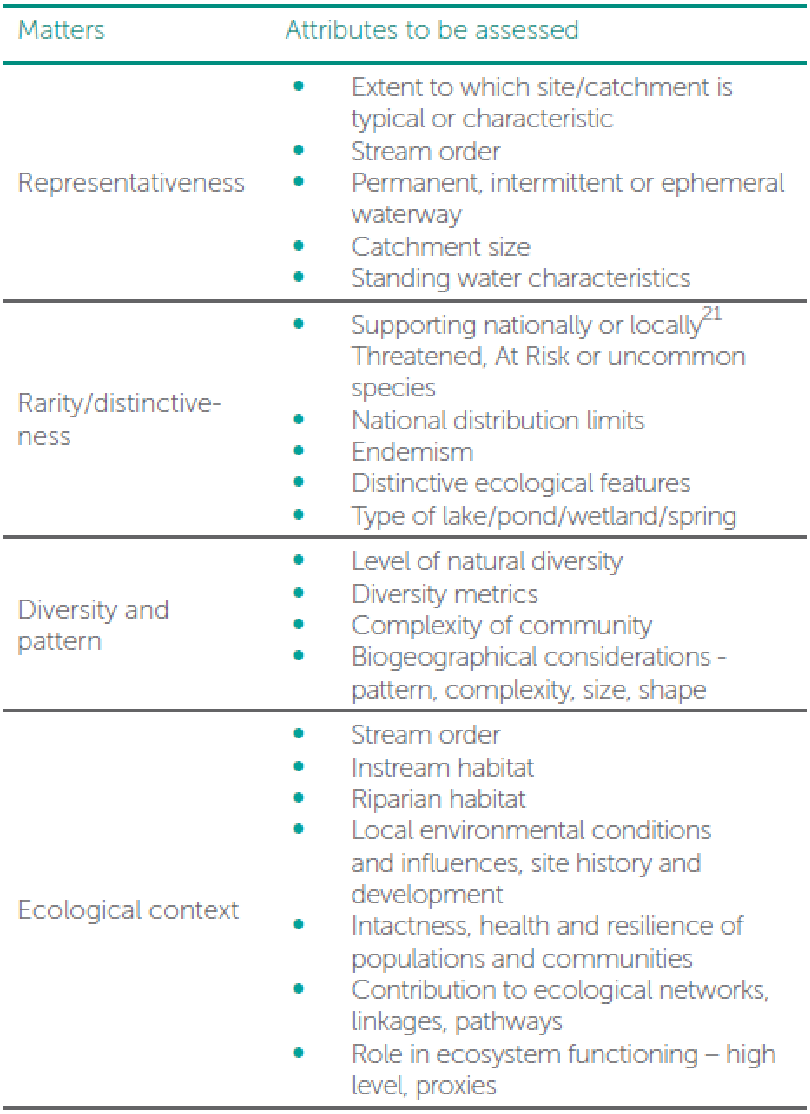
## 2.1 Ecological Impact Assessment Framework

The assessment of ecological effects used the Ecological Impact Assessment framework (**EcIA**) produced by the Environment Institute of Australia and New Zealand (EIANZ, 2015). The aim of using a standard framework and matrix approach is to provide a more consistent and transparent assessment of effects. It does not replace the need for sound ecological judgement.

### Step 1: Assess ecological values

In assigning ecological value to a habitat area, four key attributes were considered: representatives, rarity/distinctiveness, diversity and the ecological context. These are described in **Table 2.1**.

**Table 2.1**: Attributes considered when assigning ecological value to freshwater systems (from Roper-Lindsay et al 2018)



| Matters | Attributes to be assessed |
|---|---|
| Representativeness | • Extent to which site/catchment is typical or characteristic<br>• Stream order<br>• Permanent, intermittent or ephemeral waterway<br>• Catchment size<br>• Standing water characteristics |
| Rarity/distinctive-ness | • Supporting nationally or locally[21] Threatened, At Risk or uncommon species<br>• National distribution limits<br>• Endemism<br>• Distinctive ecological features<br>• Type of lake/pond/wetland/spring |
| Diversity and pattern | • Level of natural diversity<br>• Diversity metrics<br>• Complexity of community<br>• Biogeographical considerations - pattern, complexity, size, shape |
| Ecological context | • Stream order<br>• Instream habitat<br>• Riparian habitat<br>• Local environmental conditions and influences, site history and development<br>• Intactness, health and resilience of populations and communities<br>• Contribution to ecological networks, linkages, pathways<br>• Role in ecosystem functioning – high level, proxies |

Ecological values were assigned on a scale of ‘Low’ to ‘Very High’ based on species, communities, and habitats. In the case of species rarity/ distinctiveness, these were scored using criteria in the EcIA guidelines (see **Table 2.2**). Key habitat and taxa components used in assessing ecological values were:

- Fish communities and particularly the rarity of any fish present based on the classification in Dunn et al. (2018), nativeness and use of the Fish Index of Biological Integrity (**Fish IBI**) (Suren 2016).

- Aquatic macroinvertebrate communities determined using metrics of richness, the macroinvertebrate community index (MCI), and the Quantitative Macroinvertebrate Community Index (QMCI) (Stark 1985, Stark 1998m Collier 2008).

- Riparian and instream habitat quality, including naiveness, pristineness and resilience. In some streams the habitat quality has been quantified using protocols such as Clapcott (2015).

- Water quality pristineness as determined in the context guidelines (ANZG 2018) and expected natural conditions.

**Table 2.2**: Ecological values assigned to species and habitats (adapted from Roper-Lindsay et al. 2018)

| Value | Species Rarity/distinctiveness |
|---|---|
| Very High | Important for Nationally Threatened species |
| High | Important for Nationally At-Risk species and may provide less suitable habitat for Nationally Threatened species |
| Moderate | No Nationally Threatened or At-Risk species, but habitat for locally uncommon or rare species |
| Low | No nationally Threatened, At-Risk or locally uncommon or rare species |
| Negligible | Dominated by exotic or pest species with negligible rare species. |

Note: “rarity” rated higher if an unusual species assemblage or endemism

### Step 2: Assess magnitude of effect

The magnitude of effect is a measure of the extent or scale of the effect and the degree of change that it will cause. Effects were assessed in terms of confidence in predictions, intensity, spatial scale, duration, reversibility, and timing. Risk/uncertainty and confidence in predictions was also considered. Effect’s magnitude was scored on a scale of ‘No Effect’ to ‘Very High’ (**Table 2.3**). The assessment is made both with and without any mitigation.

The spatial scale for effects is important. Generally, it is appropriate to consider effects at the catchment or sub-catchment scale. In considering the magnitude of effect the timescale of potential effects was considered, with permanent effects (>25 years) given greater weight than long term (15-25 years), medium term (5-15 years), short term (<5 years), construction phase (e.g. months) or occasional.

**Table 2.3:** Summary of the criteria for describing the magnitude of effect (adapted from Roper-Lindsay et al. 2018).

| Magnitude of effect | Description |
|---|---|
| Very High | Total loss or major alteration of the existing baseline conditions;<br>Loss of high proportion of the known population or range of feature |
| High | Major loss or alteration of existing baseline conditions;<br>Loss of high proportion of the known population or range of feature |
| Moderate | Loss or alteration to existing baseline conditions;<br>Loss of a moderate proportion of the known population or range |
| Low | Minor shift away from existing baseline conditions;<br>Minor effect on the known population or range |
| Negligible | Very slight change from the existing baseline conditions;<br>Negligible effect on the known population or range |

### Step 3: Level of effects assessment

An overall level of effect was undertaken using a matrix approach that combine the 'ecological values' and the 'magnitude of effects' on these values. The matrix describes a level of ecological effect on a scale of 'No Effect' to 'Very High' (**Table 2.4**).

The level of effect can be used as a guide to the extent of response in terms of avoidance, mitigation and, if necessary, and biodiversity offsetting.

**Table 2.4**: Criteria for describing overall levels of ecological effects (from Roper-Lindsay et al. 2018, with colours added for clarity).

| | **Ecological Value** | | | | |
|---|---|---|---|---|---|
| **Effect Magnitude** | **Very High** | **High** | **Moderate** | **Low** | **Negligible** |
| **Very High** | Very high | Very high | High | Moderate | Low |
| **High** | Very high | Very high | Moderate | Low | Very Low |
| **Moderate** | High | High | Moderate | Low | Very Low |
| **Low** | Moderate | Low | Low | Very low | Very Low |
| **Negligible** | Low | Very low | Very low | Very low | Very Low |
| **Positive** | Net gain | Net gain | Net gain | Net gain | Net gain |

## 2.2 Aquatic macroinvertebrates

The structure and composition of aquatic macroinvertebrate communities can provide a useful indication of stream health. A range of metrics are used to summarise the aquatic macroinvertebrate community and water quality, including:

- Taxa Richness. This is a measure of the types of invertebrate taxa present in each sample.
- EPT richness and EPT abundance (Ephemeroptera-Plecoptera-Trichoptera). This measures the number of pollution sensitive mayfly, stonefly and caddisfly (EPT) taxa in a sample excluding *Oxyethira* and *Paroxyethira*.
- Macroinvertebrate Community Index (**MCI**). The MCI is an index for assessing the water quality and 'health' of a stream using the presence/absence of macroinvertebrates (Stark 1985).
- Quantitative MCI (**QMCI**). The QMCI is similar to the MCI but is based on the relative abundance of taxa within a community (Stark 1998).
- Average Score Per Metric (**ASPM**): ASPM is the average of three metrics standardised to a scale of 0 to 1 with the top of the scale representing reference conditions. The component metrics are: EPT taxa richness, %EPT taxa; and the MCI. When normalising scores for the ASPM, use the following minimums and maximums: %EPT-abundance (0-100), EPT-richness (0-29), MCI (0-200). (Collier2008).

Different indices are better at detecting different types of pollution. For example, the QMCI are effective at detecting organic pollution, but are not very effective at detecting the effects of heavy metals in streams. However, Hickey and Clements (1998) found that the abundance and species richness of mayflies, number of taxa in the orders Ephemeroptera, Plecoptera and Trichoptera (**EPT**), and total taxonomic richness were good indicators of heavy metals in New Zealand streams.

The MCI and QMCI reflect the sensitivity of the macroinvertebrate community to pollution and habitat change, with higher scores indicating higher water quality. Stark (1998) proposed quality thresholds for interpreting MCI and QMCI scores. The NPS-FM (2020) Appendix 2B identified MCI, QMCI and ASPM as river health attributes and applies slightly stricter thresholds to define quality bands (**Table 2.5**). Determining a band for the NPS-FM purposes should be based on the median of five years of annual samples.

**Table 2.5:** Values defining bands for MCI, QMCI and ASPM in the Appendix 2B of the NPS-FM (2020). Assessed as the median of five years of annual samples.

| Band | Description | MCI | QMCI | ASPM |
|---|---|---|---|---|
| A | High ecological integrity | > 130 | > 6.5 | >0.6 |
| B | Mild to moderate loss of ecological integrity | 110 – 130 | 5.5 - 6.5 | 0.4-0.6 |
| C | Moderate to-severe loss of ecological integrity | 90 – 110 | 4.5 – 5.5 | 0.3-0.4 |
| D | Severe loss of ecological integrity | < 90 | < 4.5 | <0.3 |

## 2.3 Relevant water quality guidelines

### 2.3.1 Trophic Level Index

Lake water quality is often expressed in terms of trophic state, which refers to the production of algae, epiphytes and macrophytes in a lake. The trophic state of each lake was assessed using the Trophic Level Index (**TLI**) (Burns et al. 2000).

The TLI integrates four key measures of lake trophic state - total nitrogen, total phosphorus, chlorophyll *a* and Secchi depth. The overall TLI score for a lake is the average of individual TLI scores for each variable. The overall score is categorised into seven trophic states indicative of accelerated eutrophication as evidence more nutrients, more algal productivity and reduced water clarity (**Table 2.6**).

Turbidity, total suspended solids, visual clarity and Secchi depth are strongly correlated with each other, but the specific correlation is often site-specific and flow specific because different types of sediments can have different optical properties. Nevertheless, where locally derived relationships are absent, then relationships from national datasets can provide helpful estimates (Franklin et al. 2019). Davies-Colley and Smith 2001). Davies-Colley and Smith (2001) found the following relationships using data from the National River Water Quality Monitoring Network (NRNMN): $TURB = 3.82\ y\mathrm{BD}^{-1.15}$; $TSS = {}^{TURB}/_{0.60}$; $y\mathrm{BD} = 2.63\ TURB^{-0.807}$. In Awatapu Lagoon the relationship between TSS and turbidity is closer to: $TSS = {}^{TURB}/_{0.93}$ (although this has high temporal variability). Secchi depth readings of water clarity used in the TLI are typically about 25% greater than black disc measurements of water clarity. Using these relationships, a Secchi depth of 1.0m corresponds to a black disc depth of about 0.75m, which corresponds to turbidity of about 5.3 NTU and total suspended solids of about 5.7 mg/L.

**Table 2.6:** Definition of Trophic Levels based on water quality measures (source Burns et al. 2000)

| Trophic State | TLI Score | Chl a (mg/m$^3$) | Secchi depth (m) | TP (mg/m$^3$) | TN (mg/m$^3$) |
|---|---|---|---|---|---|
| Ultra-microtrophic | <1 | < 0.33 | > 25 | < 1.8 | < 34 |
| Microtrophic | 1 - 2 | 0.33 – 0.82 | 15 - 25 | 1.8 – 4.1 | 34 - 73 |
| Oligotrophic | 2 - 3 | 0.82 - 2.0 | 15 - 7.0 | 4.1 – 9.0 | 73 - 157 |
| Mesotrophic | 3 - 4 | 2.0 - 5.0 | 7.0 - 2.8 | 9.0 - 20 | 157 - 337 |
| Eutrophic | 4 - 5 | 5.0 - 12 | 2.8 - 1.1 | 20 – 43 | 337 - 725 |
| Supertrophic | 5 - 6 | 12-31 | 1.1 - 0.4 | 43-96 | 725 - 1558 |
| Hypertrophic | >6 | >31 | <0.4 | >96 | >1558 |

### 2.3.2 National Policy Statement for Freshwater Management

The National Policy Statement for Freshwater Management (**NPS-FM** 2020) (MfE 2020) sets out objectives and policies that direct local government to manage water in an integrated and sustainable way. The NPS-FM includes a National Objectives Framework (**NOF**) which sets compulsory national values for freshwater including: ‘human health for recreation’ and ‘ecosystem health’. Appendix 2 of the NPS-FM sets water quality attributes that contribute to these values, and ranks attributes into bands to help communities make decision on water quality.  This includes setting minimum acceptable states called ‘national bottom lines’. For some attributes in the NPS-FM (e.g. river turbidity) the values assigned to bands differ depending on the REC classification.

Appendix 2A of the NPS-FM (2020) describes attributes that require limits on resource use; those relevant to rivers include: periphyton, total ammoniacal nitrogen (**NH4-N**) toxicity, nitrate (**NO3-N**) toxicity, dissolved oxygen (**DO**) below point sources, visual clarity and *E.coli* bacteria (human contact); while those specifically relevant to lakes include: total nitrogen (**TN**) total phosphorus (**TP**), phytoplankton and cyanobacteria (**Appendix 1**).

Appendix 2B of the NPS-FM (2020) describes attributes that require action plans; those relevant to rivers include: Fish IBI, macroinvertebrates (MCI and ASPM), deposited fine sediment (% fine sediment cover), dissolved oxygen, dissolved reactive phosphorus (**DRP**), ecosystem metabolism, and *E. coli* bacteria for primary contact sites (**Appendix 1**). The Whakatāne River and the Wainui Te Whara Stream fall into Suspended Sediment Class 1 and Deposited Sediment Class 2.

For lake ecosystem health, the Attribute State A corresponds to about Oligotrophic conditions or better, State B to Mesotrophic, State C to Eutrophic and State D to Supertrophic conditions or worse.[1]

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[1] It should be noted that Attribute States A for lake ecosystem health does not necessarily correspond to reference conditions or a realistic restoration outcome. The numeric values applied to TN, TP and chlorophyll-a for state A are much higher (too lenient) than reference conditions for many of New Zealand’s cleanest lakes and much lower (too strict) to reflect reference conditions for many of New Zealand’s small lowland lakes (e.g. Schallenberg 2014). A more accurate description of lake ecosystem health State A would be “Ecological communities are healthy and resilient”, and a more accurate description of State B would be “Ecological communities are slightly impacted by additional algal growth arising from nutrients levels that are elevated” as recommended by Hamill et al. (2014).

For designated bathing water sites the NPS-FM (2020) sets a national-bottom line of <540 *E.coli* /100mL expressed as a 95 percentile. This closely equates to the Action Mode trigger set in the Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas (MfE and MoH 2003).

### 2.3.3 ANZG water

ANZG (2018) guidelines set default guideline values (**DGVs**) to protect freshwater systems. The DGVs for toxicants generally correspond to the 95 percent protection level applied to '*moderately disturbed ecosystems*' , but stricter values can be applied to waterways with higher ecological values (**Table 2.7**). For metals, the ANZG (2018) DGVs equates to the ANZECC (2000) 95% protection level. Generally, these DGVs are compared with the 95-percentile statistic from the test waterbody of interest. These toxicant DGVs relate to chronic toxicity (i.e. long-term exposure[2]) and are suited to apply to baseflow monitoring or long-term average values. They should apply to dissolved metals in receiving waters after adjusting guideline values for the relevant hardness or dissolved organic carbon values in the receiving water (ANZG 2018, Gadd et al 2017).

The toxicity of metals to aquatic life is strongly dependent on the form and whether it is bound to other substances. Many metals are strongly adsorbed to suspended material and toxicity often decreases with increasing hardness and dissolved organic carbon. The ANZECC (2000) guidelines set default trigger values for cadmium, chromium, copper, lead nickel and zinc assuming water hardness of 30 mg/L as $CaCO_3$, and the value can be modified of actual water hardness using the appropriate formula. This results in higher trigger values being applied to harder water. [3]

Dissolved organic carbon (**DOC**) also has a strong influence on metal toxicity, particularly for copper. Revisions (not yet approved) to the ANZECC guidelines for copper propose adjusting the DGVs for copper according to DOC so that the modified DGV for copper approximately doubles as the concentration of DOC doubles. In waters with a DOC of 2 mg/L the DGV for copper would be 6.8 mg/m$^3$, and in waters with DOC of 10 the DGV for copper would be 36 mg/m$^3$, (Gadd et al 2017). [4]

Revisions (not yet approved) to the ANZECC guidelines for zinc propose adjusting the DGVs using both hardness and pH so that the modified DGV is higher with increasing hardness and lower with increasing pH (Gadd et al 2017).

Chronic toxicity guidelines are conservative when applied to stormwater discharges which tend to be short term and intermittent. Acute toxicity guidelines may be more appropriate to apply to short duration stormwater discharges. However, a decision on using acute toxicity guidelines depends on the frequency and duration of the discharge. For some contaminants, multiple short-term pulsed exposures, with short recovery time (e.g. <2 days) between exposures can cause adverse effects on some aquatic organism even when below acute guideline values (Gadd et al 2017, Bearr et al. 2006).

The ANZG (2018) DVG for TPH is calculated as 0.01 times the lowest 96-hour LC50 (a measure of chronic lethal effects). However, this value has 'low reliability' and is less than the detection limit of most laboratories.

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[2] Typically defined as between 4 to 21 days exposure depending on the organism being tested.

[3] The hardness of Awatapu lagoon outlet, Sullivan's Lake outlet, Hinemoa Stream and Apanui Canal was 28 mg/L, 34 mg/L, 70 mg/L and 152 mg/L respectively (measured in July 2018 in Opus 2018).

[4] The Dissolved Organic Carbon of Awatapu lagoon outlet, Sullivan's Lake outlet, Hinemoa Stream, Apanui Canal and Gateway Drive was 2.8 mg/L, 2.4 mg/L, 3.8 mg/L, 2.9 mg/L and 20 mg/L respectively (measured in July 2018 in Opus 2018).

**Table 2.7**: Water quality guideline values for dissolved metals to avoid chronic effects (ANZECC 2000 and ANZG 2018 DGVs) and acute effects (USEPA 2006). Assuming hardness of 30 mg/L and (for Cu) DOC of about 0.6 mg/L.

| **Metals** | **ANZECC Chronic (µg/L)** | | | **Acute (µg/L)** |
|---|---|---|---|---|
| | 95% DGV | 90% | 80% | USEPA CMC |
| Chromium (CrVI) | 1 | 6 | 40 | 16 |
| Copper | 1.4 | 1.8 | 2.5 | 4.3 |
| Copper (DOC of 2 mg/L) | 6.8 | 8.7 | 12.1 | |
| Lead | 3.4 | 5.6 | 9.4 | 17 |
| Zinc | 8 | 15 | 31 | 42.2 |
| TPH * | 7 | | | |

The ANZG (2018) DVG for physical-chemical stressors in freshwater have been developed for the second-level River Environment Classification (**REC**) classes (climate by typography), these were derived as the 80th percentile of values at sites in reference condition (McDowell et al. 2013). They are intended to be used as a trigger and indicate that the water quality deviates from typical reference conditions and that there is a 'potential risk' of adverse effects at a site. The physical-chemical DGVs are intended to be compared to median values. Small streams in the Whakatāne township have REC3 classifications of warm wet climate (WW), lowland source of flow (L) and volcanic geology (VA).[5] Whakatāne River has a REC3 classification of cold wet climate (CW), Hill source of flow (H) and volcanic geology (VA).[6] **Table 2.8** shows the relevant physical-chemical stressors for these classification types.

For microbiological contaminants ANZG (2018) refers to the microbiological water quality guidelines (MfE and MoH 2003) and the NPS-FM (MfE 2020).

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[5] The full REC classification for the Wainui Te Whara Stream is: WW/L/VA/IF/LO/MG; Wairere Stream is: WW/L/VA/P/LO/MG; and Waiewe Stream is: WW/L/VA/U/LO/HG. CW = cold wet climate, H = hill source of flow, L = lowland source of flow, VA = volcanic geology, P = pastural land cover, IF = indigenous forest landcover, LO = low order network position, MG = moderate gradient landform.

[6] Full REC classification for the Whakatāne River is: CW/H/VA/IF/HO/LG

**Table 2.8:** ANZG (2018) Default Guideline Values for physical-chemical stressors for water classifications relevant to waterways in Whakatāne (WW/L relevant to Wainui Te Whara, Waiewe Stream, and Wairere Stream; CW/H relevant to the Whakatāne River.

| Indicator | units | DGV WW/L | DGV CW/H |
|---|---|---|---|
| Clarity | m | 0.8 | 1.6 |
| COND | µS/cm | 115 | 95 |
| *E.coli* | cfu/100mL | 628 | 92 |
| NH4-N | mg/m$^3$ | 10 | 6 |
| NO3-N | mg/m$^3$ | 65 | 87 |
| TN | mg/m$^3$ | 292 | 238 |
| DRP | mg/m$^3$ | 14 | 8 |
| TP | mg/m$^3$ | 24 | 16 |
| TURB | NTU | 5.2 | 2.4 |
| TSS | mg/m$^3$ | 8.8 | 2.6 |
| pH | | 7.7 | 7.8 |
| TEMP | $^o$C | 16.2 | 13.9 |

### 2.3.4 ANZG (2018) metals in sediment

Metals associated with sediment can accumulate in the bottom sediments of depositional zones of receiving waters. Metals deposited with sediment can be released from the particulate form under low oxygen conditions and contribute to dissolved metal in overlying water.

ANZG (2018) has two guideline values for sediment - a default guideline value (DGV) and an upper guideline value (GV-high) (**Table 2.9**). The GV-high represents the median value of the effects ranking. As such the GV-high is more likely to be associated with biological effects than the DGV but the extent of that impact is not certain. The DGV represents the 10th percentile of the data and is recommended as the guideline trigger value for protection of ecosystems. If a DGV is exceeded then a multiple lines-of-evidence approach is recommended to better assess the risk to a sediment ecosystem.

Bioavailability and toxicity of contaminants is influenced by sediment grain size and finer sediment fractions tend to have a higher concentration of toxicants. Sediment samples should be filtered so that the ANZG sediment DGVs is applied to the fine sediment fraction. The <2 mm sediment particle size fraction should be used for chemical analyses for comparison with sediment quality guideline values The <65 micron (clay/silt) sediment fraction reflects what is mostly readily resuspended or potentially ingested by organism (ANZG 2018).

**Table 2.9**: Sediment trigger values receiving environments (ANZG 2018). Applicable to fine sediment fraction (<2mm) and PAH normalised to 1% organic carbon within the limits of 0.2 to 10%.

| **Variable** | **DGV (mg/kg dry wt)** | **GV-high (mg/kg dry wt)** |
|---|---|---|
| Total cadmium | 1.5 | 10 |
| Total chromium | 80 | 370 |
| Total copper | 65 | 270 |
| Total lead | 50 | 220 |
| Total nickel | 21 | 52 |
| Total zinc | 200 | 410 |
| Polycyclic Aromatic Hydrocarbons (PAHs) | 10 | 50 |
| TPHs | 280 | 550 |

# 3 Existing Environment

## 3.1 Location of streams and the stormwater network

Key waterways within the Whakatāne stormwater network area with reasonable ecological values or potential ecological values are: Whakatāne River, Wainui Te Whara Stream, Waiewe Stream, Wairere Stream, Awatapu Lagoon, Sullivan Lake, and to a less extent the lower section of Apanui canal and Hinemoa drain (**Figure 1.2**).

## 3.2 Whakatāne River

### 3.2.1 Ecology

All of Whakatāne township stormwater flows either directly or indirectly to the Whakatāne River. The Whakatāne River has a catchment area of about 1738 km$^2$, a median flow of 36.2 m$^3$/s and a mean annual low flow of 10.1 m$^3$/s. The catchment land cover is about 84% native forest, 4% exotic forest, 9% high producing pasture and less than 1% urban (BOPRC 2016).

The lower section of the Whakatāne River is an important recreational area and ecological habitat. The river and riverbanks throughout the urban zone are actively used for boating, swimming, fishing and white-baiting. The Whakatāne River Estuary salt marsh is one of the few estuarine wetlands remaining in the Te Teko Ecological District (Beadle et al. 1999). Although the wetland habitat has been reduced in size and heavily modified, there remain areas of high-quality salt marsh identified as Significant Indigenous Biodiversity Sites. Typical vegetation in the salt marsh is the ribbon wood (*Plagianthus divaricatus*) and sea rush tussockland (*Juncus kraussii*). The salt marsh is an important habitat for fish and birds, including three species classed as Threatened (Nationally Critical): white heron /kotuku, reef heron and Australasian bittern /matuku; one species classed as Threatened (Nationally Increasing): NZ dotterel /tūturiwhatu; and four species classed as At-Risk (Declining): banded rail (moho pererū), spotless crake (pūweto), north island fernbird (kōtātā). Other native birds commonly observed include hawks (karearea), grey ducks (pārera), kingfisher (kotare), and royal spoonbill (kōtuku-ngutupapa ) (OSNZ 2006, Robertson 2021).

Fourteen native fish species have been recorded in the Whakatāne River catchment and several introduced fish including brown trout and rainbow trout (**Table 3.1**). Most of these native fish either live in the lower river and tributary streams or are diadromous, so must migrate through the lower river to the sea for part of their life cycle. In addition to the freshwater fish the lower saline section of the Whakatāne River is used by marine fish including grey mullet, yellow mullet, parore and kahawai.

The Bay of Plenty Regional Council (**BOPRC**) has recently started restoring wetland habitat in sections of the lower Whakatāne River with the construction of inanga rearing habitat upstream of Landing Road Bridge in 2020. There is considerable potential for further wetland restoration within the stop bank section through the urban area including areas near the outlet and original inlet to Awatapu Lagoon.

The tidal influence and salt wedge extends about 11 km upstream from the Whakatāne River mouth. It is likely that all of the lower tributaries have some degree of saline influence near their confluence with the Whakatāne River during baseflow conditions.

### 3.2.2 Water Quality

Compared to ANZG DGVs, the water quality in the lower Whakatāne River has typical concentrations of nitrogen and *E.coli* bacteria, but slightly elevated concentrations of TSS and very high concentrations of phosphorus. The high phosphorus concentration is largely due to natural sources in the catchment headwaters (Hamill et al. 2020). TN, turbidity TSS and *E.coli* appear to increase slightly between upstream of Whakatāne township and Landing Road Bridge but a direct comparison between these sites is confounded by changes in salinity affecting fine sediment suspension and geochemistry. The river at Landing Road (SH30) Bridge is often turbid (**Table 3.2**).

Excessive periphyton growth is not a significant issue of the lower Whakatāne River where it flows through Whakatāne township because of the habitat conditions are not very suitable (i.e. incised banks, relatively deep water and mostly silty substrate). The dissolved nitrogen concentration (NOx-N + NH4-N) are sufficiently low to at least partially limit the rate of any periphyton growth, but the high DRP concentration is close to saturation threshold and is unlikely to significantly restrict periphyton growth (Hamill et al. 2020, Rier and Steven 2006).

Overall, the lower river does not meet microbial water quality guidelines for swimming with a grading of “poor”, although the site is generally acceptable for swimming during baseflow conditions (median *E. coli* of 105 cfu/100mL, 95 percentile of 2800 cuf/100mL) (Hamill et al. 2020)[7]. Further downstream at The Heads the river does meet microbial water quality guidelines for swimming with a grading of “good” - over the last three summers (2017/18 to 2019/20) had a 95-percentile *enterococci* concentration of 185 cfu/100mL (weekly sampling results from LAWA website).

The Whakatāne Paperboard Mill discharges to the Whakatāne River upstream of SH30 (Landing Road) Bridge. Scholes (2008) estimated that this discharge contributed about 7% of the average suspended solid load to the Whakatāne River but compliance monitoring has little observable water quality effects.

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[7] Based on approximately quarterly monitoring over the 10-year period 2009 – 2018.

**Table 3.1**: Freshwater fish recorded in the Whakatāne River catchment and waterbodies in the Whakatāne Urban area (source: NZ Fish Database, Hamill 2015, Opus 2017, Hicks et al 2015). Conservation Status from Dunn et al. (2018)

| Common name | Scientific name | Whakatāne River | Wairere | Waiewe | Apanui | Hinemoa | Wainui Te Whara | Awatapu | Sullivan Lk | Status |
|---|---|---|---|---|---|---|---|---|---|---|
| Shortfin eel | *Anguilla australis* | Y | Y | ? | Y | Y | Y | Y | Y | Not Threatened |
| Longfin eel | *Anguilla dieffenbachii* | Y | Y | | | | Y | | | At Risk Declining |
| Torrentfish | *Cheimarrichthys fosteri* | Y | | | | | | | | At Risk Declining |
| Koaro | *Galaxias brevipinnis* | Y | | | | | | | | At Risk Declining |
| Inanga | *Galaxias maculatus* | Y | Y ds | | Y | Y? | Y | Y | | At Risk Declining |
| Shortjaw kōkopu | *Galaxias postvectis* | Y | | | | | | | | Nationally Vulnerable |
| Banded kōkopu | *Galaxlas fasclatus* | Y | | | | | Y | | | Not Threatened |
| Common bully | *Gobiomorphus cotidianus* | Y | | | | | Y | Y | | Not Threatened |
| Giant bully | *Gobiomorphus gobioides* | Y | | | | | Y | Y | | At Risk Nationally Uncommon |
| Bluegill bully | *Gobiomorphus hubbsi* | Y | | | | | | | | At Risk Declining |
| Redfin bully | *Gobiomorphus huttoni* | Y | Y | | | | Y | | | Not Threatened |
| Koura | *Paranephrops spp.* | Y | | | | | | | | Not Threatened |
| Shrimp | *Paratya curvirostris* | Y | Y ds | | | | Y | | | Not Threatened |
| Common smelt | *Retropinna retropinna* | Y | Y ds | | | | Y | | | Not Threatened |
| Yelloweye mullet | *Aldrichetta forsteri* | Y | | | | | | | | Not Threatened |
| Grey mullet | *Mugil cephalus* | Y | | | | | | Y | | Not Threatened |
| Goldfish | *Carassius auratus* | Y | | | Y | | | Y | Y | Regional pest |
| Gambusia | *Gambusla affinis* | Y | | | Y | Y | | Y | | Unwanted organism |
| Rainbow trout | *Oncorhynchus mykiss* | Y | | | | | | | | Introduced |
| Brown trout | *Salmo trutta* | Y | Y ds | | | | Y | Y | | Introduced |

Note: ds = downstream of waterfalls. ? = species was not confirmed

**Table 3.2:** Median water quality in the Whakatāne River in Whakatāne township, 2015-2020 (source: BOPRC)

| Site name | TURB NTU | TSS mg/l | COND mS/cm | pH | TN mg/l | NNN mg/l | NH4-N mg/l | TP mg/l | DRP mg/l | *E.coli* cfu/100ml |
|---|---|---|---|---|---|---|---|---|---|---|
| ANZG 2018 DGV (CW/H) | 2.4 | 2.6 | 95.0 | 7.8 | 0.24 | 0.09 | 0.006 | 0.016 | 0.008 | 92 |
| Whakatāne opposite Trident | 3.5 | 9.7 | 10.2 | 7.1 | 0.19 | 0.12 | 0.008 | 0.048 | 0.03 | 53 |
| Whakatāne 300m d/s SH30 | 5.2 | 10 | 3.92 | 7.2 | 0.24 | 0.13 | 0.016 | 0.044 | 0.024 | 97 |

## 3.3 Wairere Stream

The Wairere Stream has its headwaters near Burma Road, it flows through predominantly farmland, with a small amount of the catchment in native forest and in residential urban landuse, before dropping over the Wairere Falls and flowing ca. 250m to the Whakatāne River at Quay Street. The now closed Burma Road Landfill is at the head of the catchment. The catchment area is about 302 ha and the estimated mean flow is about 47 L/s (REC estimate).

Only a small amount of urban stormwater enters the Wairere Stream from low density residential in Seaview Road, Hillcrest Road, and Carling Road. Below the Wairere Falls some (ca. 2ha) of the commercial landuse discharges to the Wairere Stream.

Wairere Stream is a Schedule 1 stream in the Bay of Plenty Natural Resources Plan. Native fish found in Wairere Stream include: common smelt, inanga, shortfin eel, longfin eel, redfin bully, and common bully (**Table 3.1**). The Wairere Falls (29m high) is a natural barrier to the upstream migration of some fish, but several fish species with good climbing ability (i.e. longfin eel, shortfin eel, redfin bully) are also found upstream of the Wairere Falls.

The baseflow sampling of the Wairere Stream by WSP (2019) found moderately high concentrations of nitrate (0.59 mg/L) and *E.coli* bacteria (210 cfu/100mL) (**Table 4.4**) . The median for four spot samples of *E.coli* bacteria below the waterfall in 2009 was 700 cfu/100ml - which exceeds the microbiological bathing guidelines.

## 3.4 Waiewe Stream

The Waiewe Stream flows in open sections along Waiewe Street for approximately 1km. The stream is piped down Hillcrest Road, flows as a waterfall and open stream besides the Hillcrest steps and is then piped under the Strand towards the paru flax dyeing wetland near McAlister Street. The stream joins the Apanui Canal and drains to the Whakatāne River via a fish-friendly flap gate at McAlister Street and pump stations at McAlister Street and the Rose Gardens. Waiewe Stream has a catchment area of about 48ha and an estimated mean flow of 8.6L/s (modelled in REC). About 30% of the catchment above the steps is in urban landuse but this is mostly low-density residential land with good ground soakage.

Fish migration up the Waiewe Stream is naturally restricted by the Hillcrest waterfall for non-climbing species. Migration is further restricted by the long, steep culvert down Hillcrest Road. Fish surveys have found shortfin eel (tuna hinahina), inanga and gambusia in the lower section of the Waiewe Stream near Apanui Canal (**Table 3.1**). Sampling in the upper Waiewe Stream during 2012 did not catch any fish, the author has observed large eels in the early 1980's. The natural waterfall and steep culvert down Hillcrest Road pose substantial barriers to fish migration.

There is potential for fish habitat and ecological enhancement in the paru flax dyeing wetland area (see also discussion below on Apanui Canal).

## 3.5 Apanui canal

Most of Apanui canal is a highly modified waterway with a primary function to effectively convey stormwater. Apanui canal enters the Whakatāne River via the Rose Garden Pump Station, the McAlister Street Pump Station and a gravity feed flap gate. The open stream channel starts near Pyne Street and runs for about 1km, including links to the Rose Garden Pump Station and the Paru flax dyeing wetland. Waiewe Stream enters the Apanui Stormwater Catchment at this point.

All of the catchment is within the Whakatāne urban area and is fed by a network of stormwater reticulation within the Apanui Stormwater Zone. The urban landuse in this catchment is a mix of residential and commercial.

The canal is about is about 2.5m wide at the lower end, is slow flowing and has a sandy/silt substrate. Periphyton growth can be prolific. Riparian vegetation consists mostly of mown grass to the water's edge, however there are sections of native wetland riparian plants near the pump stations and entrance to McAlister Street playground.

The aquatic macroinvertebrate community indicates poor water quality and habitat (i.e. no EPT taxa, MCI score = 45). However, low scores may also be due to a possible saline influence in the stream

(Opus 2017). Abundant growth of filamentous green algae is common in the lower section of Apanui channel and the flax dyeing wetland.

Fish observed in Apanui canal include shortfin eel, inanga, goldfish, and the pest fish gambusia (**Table 3.1**) (Opus 2017). A fish friendly flap-gate (**FFG**) was installed in 2017 that provides fish passage to the Whakatāne River; consequently, fish abundance in the canal may have improved since the 2017 survey. The FFG also allows brackish water from the Whakatāne River to enter the canal during high tide which improves water quality.

Dissolved oxygen concentration in Apanui Canal is often low. Diurnal minimum DO in early morning spot samples have been in the range of 1.1 mg/L to 5.0 mg/L, with worse (lower) DO further up the canal towards Peace Street (**Table 3.3**). This is less than the one-day minimum bottom-line limit of 4 mg/L as set in the NPS-FM, although it is noted that the Canal is not considered a stream for the purpose of the RMA.

Although Apanui Canal water quality is compromised by low DO, there is considerable potential to improve the ecology of the Apanui canal for fish by developing riparian wetlands along channel edge. Riparian wetland vegetation can help remove contaminants as well as providing habitat for fish and invertebrates when inundated at high tide or high flows. In addition, vegetation overhanging the channel provides cover and shading that helps control periphyton growth.

Sampling of fine sediment in the Apanui Canal has found elevated concentrations of copper, lead and zinc (see **Table 4.5** in next section).

**Table 3.3:** Dissolved oxygen, electrical conductivity and pH in Waiewe Stream under baseflow conditions.

| site name | date | time (NZST) | Temp. oC | %DO | DO (mg/L) | Spec EC uS/cm | pH | High tide entrance | Tide |
|---|---|---|---|---|---|---|---|---|---|
| Foot bdg 1 d/s | 15/11/2017 | 5:39 | 17.0 | 40 | 3.8 | 5,560 | 6.8 | 3:51 | high outgoing |
| Foot bdg 2 | 15/11/2017 | 5:43 | 17.5 | 37 | 3.5 | 7,000 | 7.0 | 3:51 | high outgoing |
| Bracken St bdg | 15/11/2017 | 5:46 | 16.5 | 23 | 2.3 | 366 | 7.2 | 3:51 | high outgoing |
| Peace S bdg. | 15/11/2017 | 5:49 | 16.8 | 42 | 4.0 | 302 | 7.0 | 3:51 | high outgoing |
| McAlistair St car park drain | 15/11/2017 | 5:57 | 17.5 | 24 | 2.3 | 4,116 | 6.9 | 3:51 | high outgoing |
| Foot bdg 1 d/s | 1/12/2017 | 4:38 | 19.8 | 59 | 5.0 | 24,755 | 7.1 | 4:52 | mid. incoming |
| Foot bdg 2 | 1/12/2017 | 4:39 | 19.4 | 51 | 4.5 | 14,212 | 7.0 | 4:52 | mid. incoming |
| Bracken St bdg | 1/12/2017 | 4:41 | 19.0 | 45 | 4.0 | 9,367 | 7.0 | 4:52 | mid. incoming |
| Peace S bdg. | 1/12/2017 | 4:45 | 17.8 | 12 | 1.1 | 688 | 7.0 | 4:52 | mid. incoming |
| Pyne St | 1/12/2017 | 4:49 | 17.7 | 27 | 2.6 | 274 | 6.8 | 4:52 | mid. incoming |
| McAlistair St car park drain | 1/12/2017 | 4:55 | 18.6 | 28 | 2.5 | 8,198 | 6.7 | 4:52 | mid. incoming |

## 3.6 Hinemoa Stream

Hinemoa Stream enters the Whakatāne River upstream of Landing Road Bridge, via a gravity flap gate and pump station. It has a completely urban catchment and only about 350m of open channel. Upstream of Hinemoa Street the stream open extends for about 60m from the piped network; this section has very little shade and the riparian edge is predominantly mown grass. Immediately downstream of Hinemoa Street the stream has about 40m of open channel, followed by 230m of channel shaded by mature trees and shrubs. Connection to the Whakatāne River is via flap gates. The stream is slow flowing, the upper reaches are shallow but deepens downstream near the stop bank. The substrate along the stream is dominated by sand and silt.

The water quality and ecological values of Hinemoa Stream are poor. Opus (2017) surveyed fish and aquatic macroinvertebrates in Hinemoa Stream in May 2017. The aquatic macroinvertebrate community composition indicated poor habitat and water quality conditions, no EPT taxa were present, the MCI-sb was 63, QMCI-sb was 3.2. Electric fishing found 60 shortfin eel and one unidentified galaxiid species. The majority (88%) of the shortfin eel caught were either elva (<100mm) or small eel. The ability of eel to migrate to sea will be limited by the flap gate.

The water quality in Hinemoa Stream is poor. Spot readings of dissolved oxygen during the day have found low DO concentrations of 5.3 mg/L (56%) (Opus 2017). Monitoring of Hinemoa Stream on four occasions during baseflow conditions found high concentrations of nitrate and *E. coli* bacteria. Total chromium, copper and zinc exceeded the ANZECC (2000) Default Guideline Values (DGV). Copper is within the DGVs after adjusting for dissolved organic carbon (measured at 3.8 mg/L), but zinc would likely still exceed the DGVs after adjusting for hardness (measured at 70 mg/L) (WSP-Opus 2019) (**Table 4.4**).

There is considerable potential to improve the ecology of the Hinemoa Stream including:

- Native riparian planting of the ca. 60m section between Victoria Street and Hinemoa Street. There is potential to reprofile this area to create potential wetland habitat in addition to more hydraulic storage during high water levels.
- Replacing the existing flap gates with FFGs to improve fish passage and use of the short section of existing open channel.

## 3.7 Wainui Te Whara Stream

The Wainui Te Whara Stream upstream of landing Road has a catchment size[8] of about 639 ha, and the median flow is about 54 L/s. It cascades steeply down Mokoroa gorge and at the base of the hill, downstream of Valley Road, the gradient flattens and the catchment becomes urban. From Valley Road bridge the stream flows about 1.75 km through Whakatāne urban area into the Awatapu Lagoon and the Whakatāne River. The upper catchment consists of steep hillside predominantly covered by indigenous forest (64%) and farmland (35%) in the headwaters. The lower catchment downstream of Valley Road is about 5% of the total catchment area and is predominantly residential and commercial landuse.

The urban catchment of the Wainui Te Whara Stream, below Valley Road, is a straightened and channelised urban stream confined within stop banks. The riparian margin is mown grass and there is little or no riparian cover. As the Wainui Te Whara flows through the town the stream substrate size reduces from large gravel to small gravel embedded in sand (Hamill 2015).

A number of actions have been taken to reduce flooding of the Wainui Te Whara Stream and maintain the flood storage capacity of the Awatapu Lagoon. These include:

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[8] Stream catchment to confluence with Awatapu Lagoon at Hinemoa Street.

- A coarse sediment trap and log deflector system located approximately 150m upstream of the Valley Rd bridge. This was formed in 2015 to capture sediment before it enters the urban reach of Wainui Te Whara and is periodically cleared about 3 – 4 times a year.
- A second silt trap at the Awatapu delta where the stream discharges into the lagoon.
- Widening of the Wainui Te Whara Stream channel downstream of Valley Road in 2016.

The aquatic macrophyte watercress (*Nasturtium officinale*) (naturalised) is common in the Wainui Te Whara Stream downstream of Valley Road and the parrots feather (*Myriophyllum aquaticum*) (a pest plant) is common in sections downstream of King Street. The abundance of macrophytes depends on recent flood conditions and whether they have been removed with spraying.

There is a reasonable diversity and abundance of fish in the Wainui Te Whara Stream including longfin eel, shortfin eel, inanga, common bully, giant bully, redfin bully, brown trout, and *Paratya* shrimp. Banded kōkopu and perhaps giant kōkopu occur in the upper catchment (Hamill 2015) (**Table 3.1**).

The spatial distribution and abundance of native fish in the Waiuni Te Whara Stream is strongly related to the amount of riparian cover available, such as undercut banks, woody debris and overhanging vegetation. Instream habitat features are also important but are less common in the lower stream due to its channelised nature. These features can be enhanced to improve habitat (Hamill 2016).

The quality of the aquatic macroinvertebrate community declines downstream from being high quality in the headwaters (median MCI score of 124), to “fair” condition in the downstream section near King Street (median MCI score of 90). The downstream site at King Street is boarderline on NOF Band C / D (**Table 3.4,** Hamill 2015). Periphyton growth can be prolific on stable substrate during summer.

Water quality information from the Wainui Te Whara is limited to short periods in 2021 (River Lake and BOPRC 2021) and during 2017-2018 by WSP-Opus (2019) (four winter baseflow samples 2018 and three rain-event samples). Compared to ANZG DGVs, the water quality in the Wainui Te Whara Stream appears to have reasonably good water clarity, but elevated TN and NNN, TP and DRP. The concentration nitrogen and phosphorus are at concentrations that may exert a partial control on periphyton growth. There is too little data to classify the microbial water quality in the stream in terms of recreational risk, but the median *E.coli* concentration suggest that the stream would not meet bathing water guidelines (**Table 3.5**).

During summer baseflow sampling the nutrient concentrations in the Wainui Te Whara Stream was typically slightly lower downstream at Hinemoa Street compared to at Valley Road. This probably reflects nutrient uptake by macrophyte growth in the stream itself. The opposite effect was observed on occasions when sampling occurred during a rain event.

A single spot sample of the Wainui Te Whara Stream by BOPRC on 20 November 2021 found an increase in the concentration of nitrogen, phosphorus and EC between the upper Toi Track Bridge and the bottom of Gorge Road (E.g. EC of 133 to 145 µS/cm, TN of 0.18 mg/L to 0.33 mg/L, DRP 0.013 to 0.024 mg/L).

There is considerable potential to improve the ecological values of the lower Wainui Te Whara Stream. This includes expanding the length and width of riparian planting downstream of King Street and installing instream habitat devices (Hamill 2015, and Hamill 2016). There is also potential to improve habitat conditions by changing the maintenance regime to minimise the use of herbicides, retain a reasonable cover of macrophytes and encourage natural regeneration of native plants. Under the current management regime, the macrophytes in the stream are occasionally sprayed and this is likely to have negative consequences for aquatic habitat and water quality.

**Table 3.4:** Aquatic macroinvertebrate metrics for the Wainui Te Whara Stream sites; 5-year median to 2020. Shaded cells indicate NOF band: green = B Band, yellow = C Band, orange = D Band. Source: BOPRC.

| Site | MCI | QMCI | ASPM | % EPT abundance | No. EPT taxa |
|---|---|---|---|---|---|
| Wainui Te Whara at upper Toi Track Bdg | 120 | 6.1 | 0.54 | 60 | 13 |
| Wainui Te Whara at Gorge Rd | 113 | 4.8 | 0.44 | 32 | 13 |
| Wainui Te Whara at King St | 92 | 2.4 | 0.31 | 2 | 13 |
| Wainui Te Whara at Hinemoa St | 61 | 3.3 | 0.1 | 0 | 0 |

**Table 3.5:** Median water quality in the Wainui Te Whara Stream and Awatapu Lagoon based on six samples February – June 2021 (sources: River Lake Ltd, BOPRC)[9]

| Site name | Black Disc m | TURB NTU | TSS mg/l | COND mS/cm | pH | TN mg/l | NNN mg/l | NH4-N mg/l | TP mg/l | DRP mg/l | *E.coli* cfu/100ml |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ANZG 2018 DGV (WW/L) | 0.8 | 5.2 | 8.8 | 115 | 7.7 | 0.292 | 0.065 | 0.01 | 0.024 | 0.014 | 628 |
| Wainui Te Whara at Valley Rd | 1.11 | 5.15 | 2.5 | 111 | 7.55 | 0.39 | 0.211 | 0.012 | 0.047 | 0.021 | 320 |
| Wainui Te Whara at Hinemoa St | 0.99 | 3.4 | 2.2 | 110 | 7 | 0.37 | 0.145 | 0.014 | 0.036 | 0.017 | 410 |
| Awatapu at Foot Bdg | 0.53 | 5.25 | 6.8 | 186 | 7.1 | 0.40 | 0.006 | 0.02 | 0.059 | 0.008 | 57 |
| Awatapu West at Causeway (2015-2017) |  | 11.5 | 14.5 | 212 | 7.2 | 0.47 | 0.008 | 0.006 | 0.125 | 0.022 | 130 |

## 3.8 Awatapu Lagoon

### 3.8.1 Morphology and Stormwater

Awatapu Lagoon is a 12.9 ha oxbow lake created when the Whakatāne River was straightened in 1970. The water depth in the lagoon is typically about 1.7m with the deepest areas of about 4.3m located on what would have been outside bends of the river. The catchment area is about 721 ha and most of the flow comes from within the Wainui Te Whara catchment.

The lagoon is divided into three sections by causeways at the foot bridge and Bridges Street:

- The western section (4.62 ha) connects the lagoon to the Whakatāne River via flag gate. A FFG was installed in 2012 that provides for fish passage and allows brackish water from the Whakatāne River to enter the lagoon during high tides. The water in this section is brackish.
- The eastern section (ca. 5.56 ha) receives water from the Wainui Te Whara Stream which enters the lagoon about midway along its length. Sand from the Wainui Te Whara Stream has formed a shallow delta where it enters the lagoon, part of this has been shaped by WDC to assist with sediment removal - done to minimise risk to upstream flooding.
- The southern section of the lagoon (2.75 ha) is the old entrance from the Whakatāne River which now only receives stormwater inflows. This area has very little flow.

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[9] Clarity tube readings >50cm were converted to Black disc using the equation: yBD = 7.28 x 10^(yCT/62.5) (Kilroy and Biggs 2002).

Stormwater directly enters the lagoon from the Hinemoa stormwater catchment and the Whakatāne South stormwater catchment, as well as entering via the Wainui Te Whara Stream.

### 3.8.2 Ecology

A narrow band of raupo (*Typha orientalis*) extends along parts of the lagoon margin. Aquatic macrophyte cover in the lagoon is dominated by the pest species of parrot's feather (*Myriophyllum aquaticum*) and hornwort (*Ceratophyllum demersum*). Exotic macrophyte cover is extensive in the southern lagoon (close to 100% cover). The macrophyte cover in the western lagoon is limited by the brackish water. The aquatic fern (*Azolla* sp.) can cover extensive areas of the lagoon in red mats. *Azolla* sp. has a symbiotic relationship with a cyanobacteria contained within it which fixes nitrogen from the atmosphere. Thus, *Azolla* can be a source of nitrogen to the lagoon water in same way as planktonic cyanobacteria.

Fish recorded in Awatapu Lagoon include: shortfin eel (*Anguilla australis*), inanga (*Galaxias maculatus*), common bully (*Gobiomorphus cotidianus*), giant bully (*Gobiomorphus gobioides*), common smelt (*Retropinna retrpinna*), goldfish, brown trout, and gamusia (*Gamgusia affinis*). Longfin eel (*Anguilla diefffenbachii*), Giant kōkopu (*Galaxias argenteus*) and redfin bully (*Gobiomorphus huttoni*) are present in the Wainui Te Whara Stream and would migrate through the Awatapu Lagoon (Hicks et al. 2015, Hamill 2015) (**Table 3.1**).

Awatapu Lagoon provides breeding and feeding habitat for a large number of water birds including: Royal spoonbill (*Platalea regia*), Australian coot (*Fulica atra*), pūkeko (*Porphyrio melanotus*), NZ kingfisher (*Todiramphus sanctus*), the New Zealand dabchick (weweia, *Poliocephalus rufopectus*), mallard ducks (*Anas platyrhynchos*) and occasional bittern (kotuku) and whitefaced heron. The presence of dabchick is notable because they are rare (about 2000 individual in NZ[10], Conservation Status of "recovering") and they have successfully bred and raised young on Awatapu Lagoon in recent years.

Bird life on Awatapu Lagoon has likely benefited from intensive rat trapping that has been undertaken by community groups around the lagoon (e.g. Halo).

### 3.8.3 Water quality

BOPRC has monitored water quality of Awatapu Lagoon at the Riverside Drive causeway from 2015 to 2020. During 2021 (February – June) water quality samples were collected from the Awatapu Lagoon South, Central and Western sections – including samples from the Footbridge and top/bottom samples from the lagoon and profiles of depth-temperature-DO and electrical conductivity (**EC**) (River Lake Ltd/ BOPRC 2021).

The Awatapu Lagoon would be classified as 'supertrophic' (NOF Band D), with an approximate TLI of 5.8. This is approximate because relatively few measurements are available for clarity or chlorophyll-a (n=8). The TN concentrations are moderately high (indicative of eutrophic conditions), but TP concentrations in the long-term data set are very high (indicative of supertrophic conditions) (**Table 3.6**). Awatapu West near the outlet had a period of high-water clarity and low chlorophyll-*a* concentrations during 2019 and 2020. Median water turbidity over this period was 3.4 NTU compared to a median of 8.7 NTU for the 2015-2020 period. A turbidity of 8.7 NTU would roughly equate to a black disc clarity of 0.4m.

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[10] http://nzbirdsonline.org.nz/species/new-zealand-dabchick

Cyanobacteria blooms are common during summer, resulting in low water clarity and large fluctuations in dissolved oxygen and pH. These are often associated with spikes in TN, which is likely partially due to the fixing of atmospheric nitrogen by cyanobacteria.

The microbial water quality of Awatapu Lagoon west is likely to be in NOF Band B for Human Contact. The median *E. coli* bacteria concentration is 86 cfu/100mL and the 95 percentile 322 cfu/100mL. Microbial water quality is good during stable conditions but elevated *E.coli* can occur during high flows into the lagoon.

The western lagoon generally has better water quality than the eastern lagoon or southern lagoon, due to more effective water exchange with the Whakatāne River. An interesting feature of the western lagoon is that during stable flow conditions during summer/autumn a halocline can form at a depth of about 1.5m with brackish water at the bottom and freshwater on the top. Consequently, although the lagoon is relatively shallow this section can still have strong summer stratification with consequential bottom-water deoxygenation and anoxia. The halocline weakens during winter and can be washed out with large flood events. Brackish water does not extend into the Central lagoon because the depth under the footbridge is only about 0.9m.

Thermal stratification is uncommon and short-lived in the Central and Southern sections of Awatapu Lagoon because of its shallow depth. However, deoxygenation and hypoxic conditions can occur below macrophyte beds when these become extensive. The southern lagoon often has extensive cover of surface reaching macrophytes (e.g. the pest plant hornwort) and when this occurs the surface water DO is consistently low i.e. in 2021 the spot readings of percent DO saturation ranged from 3.5% to 57%. During 2021, floating rafts of hornwort (about 400mm thick) covered large areas of the Central Lagoon, the DO concentration underneath these rafts were about 4% (0.37mg/L). Dead goldfish were observed in the lagoon on these occasions. Overall, Awatapu Lagoon does not meet dissolved oxygen bottom-line criteria set in the NPS-FM (**Appendix 1**).

Compared to water quality entering from the Wainui Te Whara Stream the Awatapu Lagoon has similar concentrations of TN, higher concentrations of TP and lower concentrations of *E.coli* bacteria. Most nutrients in the lagoon water are bound within algal cells so dissolved nutrient concentration in the lagoon are generally low. However, on occasions when the lagoon stratifies and the bottom waters turn anoxic there is release of phosphorus and total ammonia from the sediments that is available for phytoplankton growth when the top and bottom waters eventually mix.

**Table 3.6:** Median water quality in the Awatapu Lagoon West (2015-2020, *n*=58) and Awatapu Central (2021, *n*=6) (sources: River Lake Ltd, BOPRC)

| **Site name** | **Black Disc m** | **TURB NTU** | **TSS mg/l** | **COND µS/cm** | **pH** | **TN mg/l** | **NNN mg/l** | **NH4-N mg/l** | **TP mg/l** | **DRP mg/l** | **Chl-a $mg/m^3$** | ***E.coli* cfu/100ml** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Eutrophic /Supertrophic | 0.7* | | | | | 0.73 | | | 0.043 | | 12 | |
| Awatapu at Foot Bdg (2021) median | 0.53 | 5.25 | 6.8 | 186 | 7.1 | 0.40 | 0.006 | 0.02 | 0.059 | 0.008 | 17.75 | 57 |
| Awatapu West at Causeway (2015-2020) median | *1.2 *** | 8.69 | 11.8 | 201 | 7.29 | 0.47 | 0.007 | 0.01 | 0.114 | 0.024 | *4.3*** | 86 |
| Awatapu West at Causeway (2015-2020) 95%ile | | 26.6 | 23.6 | 2543 | 8.9 | 1.10 | 0.231 | 0.31 | 0.213 | 0.059 | | 322 |

* The Eutrophic/Supertrophic threshold for Secchi depth of 1.1m was roughly equates to a BD of 0.7m.

** For Awatapu at Causeway n=58, except for Chl-a (n=7) and clarity (n=8) with measurements only for 2020.

### 3.8.4 Restoration potential

Awatapu Lagoon is in a degraded conditions but has high potential for creation of wetlands, riparian habitat, and improving water quality. Improving the water quality in Awatapu Lagoon will require multiple restoration actions over the long-term. Priority actions over the short-term include creation of wetland areas to provide water quality treatment and habitat and harvesting of aquatic macrophytes. These actions would improve habitat, improve the dissolved oxygen regime, reduced sediment anoxia, and remove nutrients.

In early 2019 WDC trialled the use of macrophyte harvesting in Awatapu Lagoon South rather than using herbicides to control macrophytes. The harvesting cut and removed the macrophytes (hornwort and parrots feather) to a depth of about 1.5m, it was very effective at clearing the macrophytes and removing nutrients. A high macrophyte biomass had re-established within about two years.

## 3.9 Sullivan Lake

### 3.9.1 Morphology and Stormwater

Sullivan Lake is shallow, sheltered, is rich in nutrients and generally has poor water quality and clarity. The lake area is about 2.7 ha and has a median water depth about 1.2m (Hamill 2017). Several small streams from the escarpment east of Valley Road enter Sullivan Lake via the stormwater system. During the summer WDC often pumps Whakatāne River water into the lake to help improve the water quality and provide some flushing. The water levels are controlled by a weir with water flowing under King Street with a gravity discharge to the Whakatane River.

The inlet to the lake at the south end incorporates a sediment trap in the form of a low bund. Four of the six main stormwater pipes feeding into the lake discharge upstream of the bund.

In 2019 part of Sullivan Lake was suction dredged to remove fine sediment. Prior to dredging the depth of fine sediment (silt and clays) in the lake was typically about 0.65m deep (range 0.1m to 0.9m) (Hamill 2017).

In the past there were anecdotal reports of sewage overflows on Douglas Street during heavy rain events. This could have contributed considerable nutrient and organic load to the lake. However, any potential for such overflow was addressed in 2012 by improving the waste water system inflow (new 300mm sewer pipe) and outflow by doubling the capacity of the pumping station at Douglas Street. There have been no reports of sewage overflows since this improvement.

### 3.9.2 Ecology

Sullivan Lake provides a small urban habitat for waterfowl including: pūkeko (*Porphyrio melanotus*); australian coot (*Fulica atra australis*), australasian shoveler (*Spatula rhynchotis*), spoonbill (*Platalea regia*), gulls (*Larus* spp.), mallard ducks (*Anas platyrhynchos*), muscovy ducks (*Cairina moschata*), and mute swan (*Cygnus olor*). Occasionally outbreaks of Botulism has occurred in wildfowl during extended dry summers.

Fish recorded in the lake include shortfin eel, common bully, *Gambusia* and goldfish (**Table 2.1**). There are anecdotal reports of elva in Sullivan Lake indicating passage from the Whakatāne River outlet. However, there are substantial barriers to fish passage to Sullivan Lake in the form of the lake outlet weir and flap gate for the gravity flow to the Whakatāne River.

Most of Sullivan Lake is devoid of macrophytes except for water lily (*Nymphaea sp.*) which covers a large section of the western part of the lake near King Street. Patches of floating sweet grass (*Glyceria fluitans*) and *Egeria densa* can occur on the lake margins. Other species that have been recorded in the past include *Azolla* spp., *Potamageton crispus,* and pest plants of *Egeria densa*, *Elodea* spp. and hornwort (*Ceratophyllum demersum)*. The macrophytes are historically managed by use of herbicide sprays.

### 3.9.3 Water quality

The lake is classed as hypertrophic and commonly has algae blooms dominated by potentially toxic cyanobacteria (Scholes 2005). Water clarity is typically about 0.64m (black disc) (**Table 3.7**). Cyanobacteria blooms occasionally occur in the lake during summer. *Anabaena* spp. generally the predominant cyanobacteria genus, with *Planktothix* sp. and *Pseudanabaena limnetica* occurring in lower abundance (Scholes 2008).

BOPRC undertook trial to assess the potential of different products for treating the water quality in Sullivan Lake during 2005 (Scholes 2005). Two products were futher trial in the lake from December 2006 to March 2008, these were PAP-5 Melter slag (a by-product of the iron making process) and Pond Treat PT-450 (anon-pathogenic microbial enzyme treatment) (Scholes 2008). The product Pond Treat PT-450 appeared to be effective at reducing algae biomass, reducing nutrients and improving water clarity. The effectiveness of the product PAP-5 Melter Slag was not as obvious. Waterlily cover also increased over the trial period which may have influenced the trial results..

Stormwater enters Sullivan Lake from the Whakatāne South Stormwater catchment; this includes stormwater from the industrial area around Te Tahi Street. Hamill (2017) found that the lake water itself is well within ANZG DGV values for all metals, however the lake sediment was moderately high in zinc i.e. between the ISQG-low and ISQG-high values. This is probably primarily due to stormwater inputs over many years. Other heavy metals (i.e. copper, lead) had sediment concentrations less than the ISQG-low.

The section of the lake receiving stormwater from Te Tahi Street has high concentrations of dissolved zinc in the pore water. The concentration of zinc in the pore water of sediment from most of the lake would require about 1.8 times dilution to achieve ANZECC 80%ile guideline values while the pore water of sediment from the southern embayment near the Te Tahi Street culvert would require about 20 times dilution to achieve ANZEC 80%ile guideline values.

**Table 3.7:** Median water quality in the Sullivan Lake outlet for period 2001 to 2018 (n=110) (source: BOPRC)

| Site name | Black Disc m | TURB NTU | TSS mg/l | COND µS/cm | pH | TN mg/l | NNN mg/l | NH4-N mg/l | TP mg/l | DRP mg/l | Chl-a mg/m$^3$ | *E.coli* cfu/100ml |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Eutrophic /Supertrophic | 0.7* | | | | | 0.73 | | | 0.043 | | 12 | |
| Sullivan Lake outlet 2001-2008 | 0.64 | 17 | 8 | 122 | 8.4 | 0.82 | 0.004 | 0.01 | 0.138 | 0.015 | 46.2 | |

* The Eutrophic/Supertrophic threshold for Secchi depth of 1.1m was roughly equates to a BD of 0.7m.

### 3.9.4 Restoration potential

The Sullivan Lake Reserve Management Plan was updated in 2015; and this includes goals to manage and enhance the conservation values, and to manage and improve the water quality of the lagoon. There is potential for undertaking additional actions to provide higher certainty of achieving better water quality outcomes in the lake. In particular, improvement of water quality in the lake over the long term will require efforts to reduce both the external and internal supply of nutrients. In addition, it will require maintaining an appropriate balance of aquatic macrophyte cover whilst taking into account the biosecurity risk of the plant.

The retaining and filtering of nutrients from stormwater inputs to Sullivan Lake can be improved by establishing wetlands in association with the current sediment trap near the southern end of Sullivan Lake. Recommendations for treatment wetlands were made in Hamill (2017).

Fish passage to Sullivan Lake could be improved with instillation of a FFG at the Whakatāne River outlet and a retrofitting a ramp and /or spat rope over the outlet weir.

## 3.10 Orini Canal and Kopeopeo Canal

Orini Canal is the original channel of the Rangitāiki River to the Whakatāne River prior to diversion. It now forms part of a drainage network on the Rangitāiki Plains, under the management of the BoPRC Rivers and Drainage group. It has a catchment area of about 1680ha and estimated mean flow of 0.27 m$^3$/s (REC). The Kopeopeo Canal is a drain that enters the Orini Canal downstream of Keepa Road; it has a catchment area of about 2091 ha and estimated mean flow of 0.48 m$^3$/s (REC). It also has a connection to the Rangitāiki River via Reed Central Canal.

The catchments of the Orini Canal and Kopeopeo Canal are dominated by high producing pasture and horticulture land use. A small amount of urban stormwater enters the Kopeopeo Canal from the Gateway Drive Commercial area, and a small amount of urban stormwater enters the Orini Canal from Coastlands via stormwater pond at Keepa Road.

The riparian habitat of the Orini Canal and Kopeopeo Canal is poor but the inter-tidal riparian vegetation along the lower section of the Orini Canal and Kopeopeo Canal has sections of high-quality habitat that is representative of an originally rare ecosystem type (Wildlands 2013). The area is classified in the BOPRC Regional Policy Statement as having High Natural Character.

Minimal water quality data is available for the Orini Stream or Kopeopeo Canal.

Sections of land along both the Orini Stream and Kopeopeo Canal are recognised as contaminated with wood waste containing dioxins. BOPRC has recently completed dredging of Kopeopeo Canal to remove and treat sediments contaminated with dioxins, however a residual amount of dioxin contamination remains in the sediments and shortfin eel resident in the canal are considered unsafe to eat.

## 3.11 Wetlands

The NPS-FM has policies relating to wetlands including: "*Policy 6: There is no further loss of extent of natural inland wetlands, their values are protected, and their restoration is promoted*". Also, the National Environmental Standards for Freshwater Regulations 2020 (**NES-FW**) includes specific provision relating to effects of activities on wetlands.

"Wetland" is defined in the Resource Management Act (1991) (**RMA**) as:

> "*Wetland includes permanently or intermittently wet areas, shallow water, and land water margins that support a natural ecosystem of plants and animals that are adapted to wet conditions*."

Natural wetlands are defined in the NES and NPS-FM as:

> *"**natural wetland** means a wetland (as defined in the [RMA]) that is not:*
>
> *(a) a wetland constructed by artificial means (unless it was constructed to offset impacts on, or restore, an existing or former natural wetland); or*
>
> *(b) a geothermal wetland; or*
>
> *(c) any area of improved pasture that, at the commencement date, is dominated by (that is more than 50% of) exotic pasture species and is subject to temporary rain-derived water pooling".*
>
> A **natural inland wetland** means a natural wetland that is not in the coastal marine area

Wetlands that have been constructed to offset impacts on/ or restore an existing or former natural wetland, and induced wetlands, are treated as natural inland wetlands. MfE (2021) notes that: *"'Induced wetlands' are wetlands that have resulted from any human activity, except the deliberate construction of a wetland or waterbody by artificial means. They are considered 'natural wetlands'."*.

Waterways receiving Whakatāne stormwater that are can be clearly characterised as "Natural Wetlands" are:

- The Whakatāne River Salt Marsh on the true right of the river (receiving water from Apanui canal system via the pump station and gravity outlets at McAlister Street and the Rose Gardens)
- The Whakatāne River Salt Marsh on the true left of the river including the riparian area adjacent to Orini Canal. The stormwater discharges to the Orini Canal and Kopeopeo Canal are more than 200m from these wetland areas (**Figure 3.1**).

There is a small wetland associated with the Waiewe Stream in the Waiewe Street Drainage Reserve. The area is used for flood detention and the wetland has developed in the wet ground resulting from the flood detention system (i.e. a bund with a c. 300mm culvert outlet and scruffy dome high level outlet). This does not meet the definition of "natural wetland" as the impoundment appears to be constructed for the purpose of flood detention. The contours and historical (1981) aerial photographs suggest that the are was not originally a wetland.

The Puru Wetland near the confluence of the Waiewe Stream and the Apanui Canal is in a location that appears to have been estuarine mudflats prior to the establishment of the stop banks (see aerial photos in the CMP). The area appears to have been deliberately created and restored for use as a wetland, it does not appear to be a remnant wetland habitat and is thus likely classed as ‘created’ rather than an ‘induced’ or ‘natural’ wetland.

BOPRC has also undertaken some recent ecological enhancement along sections of the Whakatāne River upstream of the Landing Road Bridge creating ponds for inanga rearing habitat and planting riparian vegetation. This area does not strictly meet the definition of natural wetland and has no stormwater discharges within 100m of it.

There is a potential natural wetland along the channel connecting the Awatapu lagoon outlet to the Whakatāne River. This wetland is dominated by raupo (*Typha orientalis*) and *Schenoplectus* sp., it is located on the true right bank and starts about 100m from the outlet culvert. There are no direct stormwater outlets within 100m of the wetland. There is also an area of wetland vegetation on the river side of the stop bank near the original inlet to Awatapu Lagoon, but no stormwater discharges nearby to it (**Figure 3.1**).

The Awatapu Lagoon has a narrow fringe of raupo along much of its edge and some recent riparian planting; this raupo fringe is likely to be classified as a wetland feature that formed after the oxbow, but would need additional assessment to confirm. However, Awatapu Lagoon was formed/constructed with the diversion of the Whakatane River in 1970 and the waterbody is used as an important part of the flood management system, so the raupo margins probably do not meet the definition of “natural” wetlands because they are incidental to the creation and operation of the oxbow (see MfE 2021).

There are no natural or induced wetlands associated with Sullivan’s Lake, but there has been some recent riparian planning, including native wetland species, along small sections of Sullivan Lake.

Although there are only limited areas of natural wetlands in the Whakatāne stormwater area, there is considerable potential for creating wetlands for habitat and water quality treatment. This includes sections near Amber Grove, Apanui Canal, Awatapu Lagoon, and Sullivan’s Lake. Potential for using wetland creation as a mitigation tool is further discussed in the following sections.

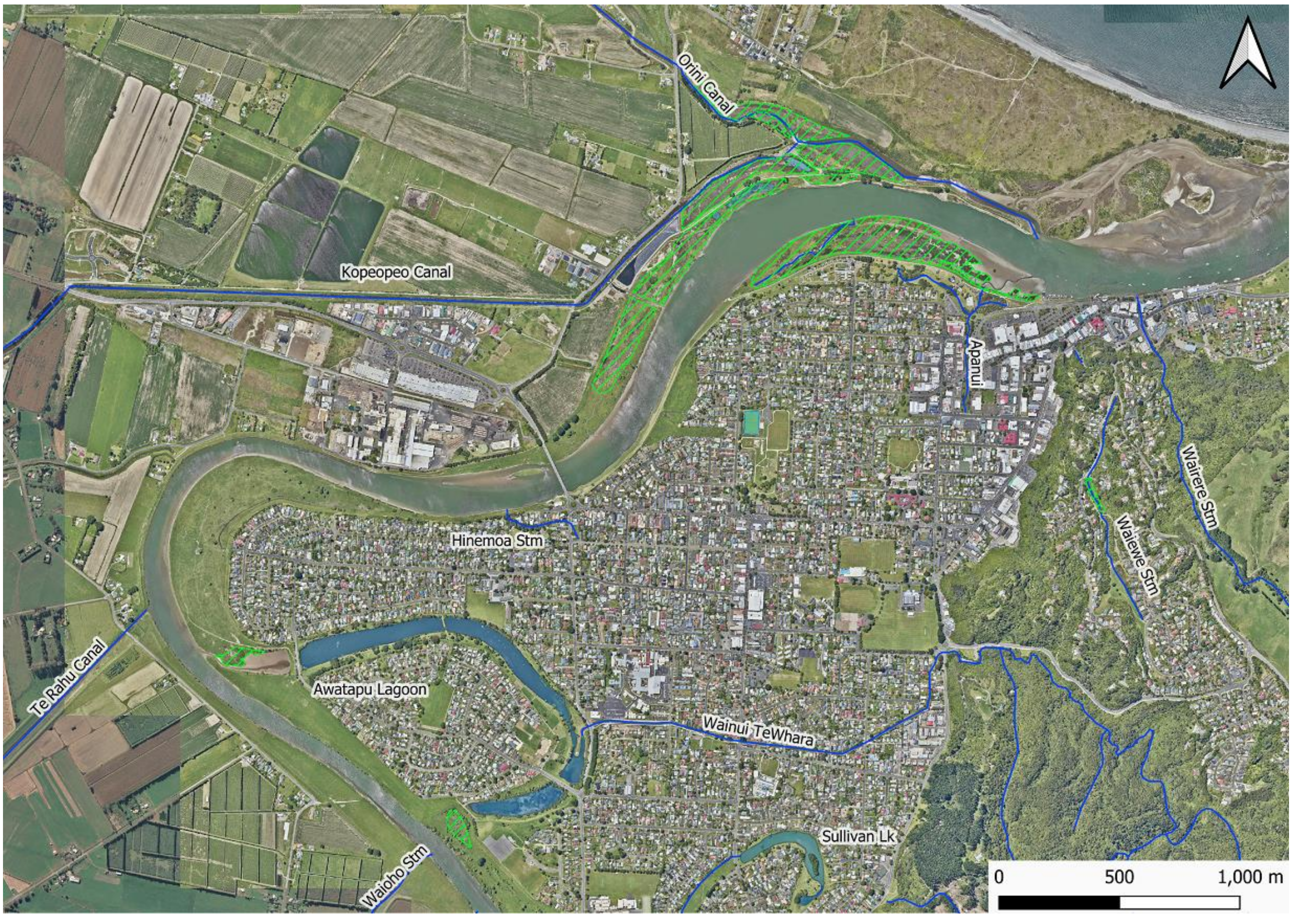

**Figure 3.1**: Location of potential natural or induced wetlands (green hashed area). Stormwater discharges from the Apanui Canal system via McAlister Street and Rose Gardens are within 100m of a salt marsh.

## 3.12 Summary

The overall ecological values of each waterbody receiving stormwater from Whakatāne township are summarised in **Table 3.8**. The values were assessed using the EcIA approach described in Section 2.

**Table 3.8**: Summary of overall ecological values for waterways receiving stormwater from the Whakatāne township.

| Waterway | Ecological value | Reason for ecological value |
|---|---|---|
| Whakatāne River | High | Important habitat for At-risk fish species (inanga), shellfish gathering, recreation and swimming. Wetland fragments near Awatapu Lagoon and salt marsh wetland near McAlister Street. |
| Wairere Stream | High | High quality habitat, macroinvertebrate community likely 'good', longfin eel upstream of waterfall. |
| Waiewe Stream | Moderate-Low | Moderate quality habitat, highly modified, largely urban catchment, waterfall and culverts a substantial fish barrier. A constructed wetland in the Waiewe Street reserve and Puru wetland near the McAlister Street. |
| Apanui Canal | Low | Poor habitat, low MCI, poor WQ, no At-Risk fish |
| Hinemoa Stream | Low | Poor habitat, low MCI, poor WQ, no At-Risk fish. Good riparian shade at d/s section. |
| Amber Grove drains | Negligible | Poor habitat, poor WQ, no fish passage. Not a natural waterway but has restoration potential. |
| Wainui Te Whara Stream u/s Valley Road | High | Highly modified lower catchment but good macroinvertebrate community and At-risk fish species common. |
| Wainui Te Whara Stream d/s Valley Road | Moderate | Poor quality riparian zone, "fair" quality macroinvertebrate community, At-risk fish species present but limited habitat. Passage to high quality habitat u/s. Deteriorating trend in MCI values. |
| Awatapu Lagoon | Moderate | Poor WQ, limited riparian habitat, migration route for At-Risk fish. NZ dabchick breeding on the lagoon. |
| Sullivan Lake | Low* | Poor WQ, poor aquatic habitat, urbanised margins. Shortfin eel present but no At-Risk fish. Poor fish passage to the Whakatāne River. |
| Orini Canal | Moderate | Past contamination, poor WQ, poor riparian and instream habitat. Shortfin eel present, likely has smilar fish as the lower Whakatāne River. High quality salt marsh habitat in the lower sections. |
| Kopeopeo Canal | Low | Past contamination, poor WQ, poor riparian and instream habitat. Shortfin eel present. Salt marsh adjacent to lower section of canal. |

# 4 Assessment of effects

## 4.1 Introduction

Stormwater discharges can have multiple levels of effects on streams by affecting stream hydrology and morphology, water quality and the water temperature regime (Storey et al. 2013, Walsh et al. 2005). The magnitude of these effects is generally a function of the percentage of impervious surface in the catchment, type of landuse, type of stormwater is treated and sensitivity of the receiving waterbody.

The management of the stormwater network can have additional effects, either positive or negative, by physical disturbance, use of herbicides and changing the riparian and instream habitat conditions.

## 4.2 Hydrology and Thermal Effects

### 4.2.1 Potential effects on hydrology

Stormwater discharges can alter stream hydrology. An increase in impervious surfaces from roads and urbanisation can increase flood peaks and volume causing them to be more ‘flashy’ than natural streams. As a result, urban streams often have increased erosion and become deeper and wider than natural streams, become simpler and uniform, and have more fine sediment on the beds. This can result in less diversity and abundance of macroinvertebrates and fish in the stream. Significant ecological degradation of streams can occur when the total impervious area in the catchment is as low as 5% to 10% (Storey et al. 2013). These hydrological effects are much less evident in waterways influenced by diurnal tides or ponding.

Stormwater hydrological effects can be avoided by using dispersed stormwater retention measures (e.g. soakage) to reduce the effective imperiousness of the catchment (Storey et al. 2013, Walsh et al. 2005). Stormwater detention ponds or wetlands are commonly used to reduce peak flows from stormwater systems. These systems have benefits, but do not mitigate the overall higher runoff volume and reduced baseflow that can result from urbanisation of a catchment. To comprehensively address these hydrological effects requires reducing the amount of impermeable area, and /or using treatment devices that enhance infiltration as well as flow detention to reduce the ‘effective’ impervious area. It is more ecologically beneficial to increase infiltration rather than rely solely on detention of collected stormwater (Storey et al. 2013).

### 4.2.2 Potential effects on thermal pollution

Water temperature has a strong influence on the distribution of aquatic biota. It directly affects metabolism and indirectly affects biota by influencing pH, dissolved oxygen and algae growth. Olsen et al (2012) recommended maximum water temperatures to protect the most sensitive native species of 20$^{o}$C for upland stream and 25$^{o}$C for lowland streams, although some fish have higher temperature preferences (e.g. shortfin eel prefer warm water of 26. 9$^{o}$C (Richardson et al. 1994). Temperature tolerance of fish is affected by the acclimatisation temperature, and a rapid increase in temperature can cause thermal shock (Herb et al. 2007).

Thermal pollution from stormwater can be reduced by reducing the amount of impermeable area, maximising infiltration (e.g. grass swales, vegetated swales and infiltration trenches), using vegetated treatment wetlands and increasing shading (of the stream or treatment devices). Swale vegetation cools the first flush of stormwater. Vegetated treatment wetlands can mitigate thermal pollution by providing shading, evapotranspiration and infiltration. Wetlands also mitigate the thermal load by capturing small rain events (Young et al. 2013).

### 4.2.3 Potential effects from Whakatāne stormwater

The hydrological and thermal effects of stormwater on natural waterways are largely a function of the relative area of the hard surface catchment relative to the receiving water and the treatment applied to the stormwater in the form of stormwater detention, retention and soakage.

The likely effects of the Whakatāne township stormwater on the hydrology and temperature regime in receiving waters are summarised in **Table 4.1**. The potential hydrological and thermal effects of stormwater is expected to be negligible or low for the Whakatane River, Wainui Te Whara Stream and Wairere Stream due to the small urban catchment relative to the overall catchment (<1%, 5% and <4%

respectively). The urban catchment of Wairere Stream is mostly low density residential with a large proportion of on-site soakage and the catchment area through the commercial urban zone is relatively small.

Extra flow from stormwater is a potential positive benefit to Sullivan Lake and Awatapu Lagoon by providing additional flushing, but this does not negate the need to manage potential water quality effects.

**Table 4.1**: Likely magnitude of effects of the current Whakatāne township stormwater (SW) on the hydrology and temperature regime of receiving waterbodies.

| Waterway | Hydrology | Temperature | Reason |
|---|---|---|---|
| Whakatāne River | Negligible | Negligible | SW a very small fraction of catchment (<1%). |
| Wairere Stream | Negligible | Negligible | SW a very small fraction of catchment, good soakage. |
| Waiewe Stream | Low | Low | Urban area a small fraction of catchment (<5%), good soakage. |
| Apanui canal | Low | High | High percentage urban catchment. Negligible hydrology effect due to widened channel, low gradient and tidal influence. |
| Hinemoa Stream | Low | High | High percentage urban catchment. Low hydrology effect due to widened channel, low gradient and tidal influence. |
| Amber Grove drains | Low | Moderate | High percentage urban catchment including large parks. Low hydrology effect due to widened channel. |
| Wainui Te Whara Stream u/s Valley Road | Negligible | Negligible | SW a very small fraction of catchment. Stormwater ponds at Whitehorse Drive mitigate flow peak. |
| Wainui Te Whara Stream d/s Valley Road | Low | Low | SW a small fraction of catchment (<5%). |
| Awatapu Lagoon | Positive | Low | Thermal buffering by lagoon volume. Extra stormwater flow potentially positive for flushing. |
| Sullivan Lake | Positive | Low | Thermal buffering by lagoon volume. Extra stormwater flow potentially positive for flushing. |
| Orini Canal | Negligible | Negligible | SW a very small fraction of catchment. Most SW to soakage |
| Kopeopeo Canal | Negligible | Negligible | SW a very small fraction of catchment |

## 4.3 Water quality

### 4.3.1 Urban stormwater quality

Stormwater runoff from residential developments can contain a wide range of contaminants, but those of particular concern in residential stormwater include sediments, metals (especially copper (Cu) and zinc (Zn) from building materials and traffic) faecal bacteria and the nutrients nitrogen and phosphorus.

#### 4.3.1.1 Metals and hydrocarbons

The heavy metals of copper and zinc can enter urban stormwater as a result of road use (i.e., brake linings and tyres) and leachate from building materials. Braking and tyre wear results in the emission of brake pad and tyre debris, containing these metals, to the road surface. New sub-divisions typically have lower concentrations of lead, zinc and copper compared to older subdivisions (e.g., pre-2000) due to the use of different building materials, e.g., replacing galvanised zinc roofing with 'coloursteel' roofing and removal of lead-based paint[11]. Borough et al. (2012) found median concentrations of total zinc in untreated stormwater from old and new subdivision was 0.253 mg/L and 0.041 mg/L respectively. Similarly, median concentrations of total lead in old and new subdivision was 0.0053 mg/L and 0.0019 mg/L respectively.

Hydrocarbon compounds (e.g., PAH or measured as TPH) are emitted to the road surface from oil, grease and fuel leakages and spills, and from exhaust emissions. Metals and hydrocarbons are strongly associated with sediment fractions, but some are also in a dissolved form (NZTA 2010, Fernandes and Barbosa 2018).

#### 4.3.1.2 Microbial

Generally, microbial contamination of stormwater can occur from runoff of animal faecal matter, waterfowl and occasional[12] cross-contamination from sewage overflows entering the stormwater system. A significant proportion of microbial contaminants that enter streams from discharges survive and persist within stream /lake sediments. Microbes in the sediments re-suspend in the water column with floods, or from wave action or physical disturbance (e.g., Pachepsky and Sheldon 2011). This legacy effect is a major reason why streams have higher faecal coliform concentrations during flood events (e.g., Nagels et al. 2002). It is an ongoing effect that intermittent discharges of runoff and stormwater have on the environment.

#### 4.3.1.3 Nutrients

Urban stormwater runoff can carry high loads of the plant nutrients nitrogen (**N**) and particularly phosphorus (**P**). These can derive from roads, lawns, fertilisers, mobilisation of P stored in soils, and occasionally wastewater cross-contamination (Lewis et al 2007). Often the nutrients are in particulate form. A study in Rotorua estimated that urban road sweeping removed N and P equivalent to 38% and 36% of the urban stormwater load respectively (Depree 2013).

#### 4.3.1.4 Sediment

Sediment contamination effects water clarity and substrate. In terms of ecology the primary concern regarding sediment in discharges is the deposition of sediment on the stream beds. Fish are tolerant of high levels of suspended sediment, and most native fish, with the exception of very sensitive species such as banded kōkopu[13], show little change in behaviour with increased turbidity. However, many taxa are affected by a combination of other environmental changes associated with high loadings of suspended solids (Richardson et al. 2001, Rowe et al.2002). The effects of deposited sediment persist long after a rain event has stopped (Wood and Armitage 1997). Sediments can also be contaminated with metals, hydrocarbons and microbes. These contaminants can be resuspended into the water column during high flow events.

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[11] Also unleaded petrol became mandatory in New Zealand in 1996 which drastically reduced lead in stormwater.

[12] Rare in Whakatāne.

[13] Banded kōkopu reduce feeding and show avoidance behaviour when water turbidity is over 25 NTU.

#### 4.3.1.5 Gross pollutants

Gross pollutants include litter coarse sediment, vegetation that can be carried by runoff into the stormwater system. Many gross pollutants can be effectively managed at source by provision of rubbish disposal systems, education and urban road sweeping. There are a variety of gross pollutant traps available to capture litter once it is entrained in stormwater. Gross pollutant traps are often constructed as cages, filters or wells and they require regular maintenance to clean them.

### 4.3.2 Source of storm water

Commercial and industrial areas typically have higher loads of metals and hydrocarbon compounds (e.g., from exhausts). This is as the results of industrial practices and activities, combined with large impermeable areas as is generally the case for industrial estates. On the other hand, stormwater from lifestyle blocks often has relatively higher concentrations of suspended solids. Hydrocarbon compounds are generally in low concentration in stormwater from residential areas due to low traffic volumes, few other sources exist compared to industrial or heavy traffic areas. Residential areas do however contribute washdown water runoff as a result of house, car and boat washing.

The concentration of contaminants in urban runoff varies widely between events and depending on the catchment characteristics. In urban catchments the highest concentration of contaminants generally occur as a ‘first-flush’ after initial rainfall, but with some contaminants (e.g. TSS, *E.coli* bacteria) a second peak can occur with very high rainfall volumes. Borough et al. (2012) sampled urban stormwater through rain events and found highest concentrations of that after the first flush (1mm rain), with subsequent samples of rain on average one third of the first flush concentration for TSS, Zn and Cu; one quarter of the first flush concentration for TP and TN and about 40% of the first flush concentration for *E. coli*.

### 4.3.3 Typical urban storm water quality

NIWA has compiled contaminant concentrations in stormwater monitoring from around New Zealand in the Urban Runoff Quality Information System (**URQIS**). **Table 4.2**. shows the median and mean concentration of contaminants in untreated stormwater from different catchment types. It shows that relative to ANZG DGVs, typical residential stormwater can be particularly high in sediment, total nitrogen, nitrate, zinc, copper and *E. coli* bacteria. When compared to median-density residential, the stormwater from Commercial Business District (**CBD**) typically have lower TSS and nitrate, while stormwater from light industrial areas typically have lower TSS and nitrate but higher DRP, *E.coli* bacteria, zinc and lead.

Hickey et al. (2001) estimated concentrations and specific yields of sediment, nutrients and *E. coli* in stormwater from the Flagstaff catchment, Hamilton. Annual average stormwater concentrations for TSS, TP, TN and *E.coli* were 48.1 mg/L, 0.11 mg/L, 0.43 mg/L and 760 cfu/100mL respectively. The specific yield for TSS, TP, TN and *E.coli* were 360 kg/ha/yr, 0.79 kg/ha/yr, 3.2 kg/ha/yr and 5.71x$10^{10}$ cfu/100mL respectively.

**Table 4.2**: Typical stormwater water quality in reported in NIWA Urban Runoff Quality Information System (URQIS) (https://urqis.niwa.co.nz), compared to guideline values. This summary data filters for untreated stormwater under all flow conditions. Whakatāne River sampling results from opposite Trident High School (BOPRC).

| Variable mg/L; (cfu/100mL) | All landuse NIWA URQIS | | Median density residential NIWA URQIS | | CBD NIWA URQIS | | Light industrial NIWA URQIS | | ANZG DGV WW/L | NPS-FM Lake Band-C | Whakatāne Rv opp. Trident |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | median | mean | median | mean | median | mean | median | mean | | median | median |
| TSS | 30 | 88 | 59 | 155 | 32 | 66 | 20 | 57 | 8.8 | | 9.7 |
| TN | 1.8 | 2.6 | 0.85 | 1.5 | | | *2* | *3* | 0.292 | 0.8 | 0.19 |
| NO3-N | 0.68 | 1.9 | 0.81 | 1.3 | 0.64 | 0.92 | 0.65 | 3.4 | 0.065 | | 0.12 |
| NH4-N | 0.088 | 4.6 | 0.016 | 0.14 | 0.077 | 0.14 | 0.13 | 9.5 | 0.01 | 0.24 | 0.008 |
| TP | 0.15 | 8.7 | 0.028 | 0.13 | | | 0.64 | 21 | 0.024 | 0.05 | 0.048 |
| DRP | 0.035 | 2.1 | 0.022 | 0.033 | 0.025 | 0.034 | 0.043 | 4.8 | 0.014 | | 0.03 |
| *E.coli* bacteria | 2000 | 20000 | 590 | 1900 | | | 2000 | 31000 | 628 | 130 | 53 |
| Zn total | 0.14 | 0.34 | 0.21 | 0.28 | 0.29 | 0.44 | 0.67 | 0.93 | | | 0.0014 |
| Zn dissolved | 0.05 | 0.18 | 0.1 | 0.16 | 0.22 | 0.24 | 0.42 | 0.66 | 0.008 | | |
| Cu total | 0.014 | 0.025 | 0.016 | 0.022 | 0.02 | 0.037 | 0.015 | 0.032 | | | 0.0006 |
| Cu dissolved | 0.0061 | 0.0096 | 0.0052 | 0.0071 | 0.0081 | 0.011 | 0.0058 | 0.013 | 0.0014 | | |
| Pb total | 0.0049 | 0.016 | *0.0007* | *0.011* | *0.035* | *0.07* | 0.0037 | 0.0058 | | | 0.00023 |
| Pb dissolved | 0.0003 | 0.0008 | *0.0005* | *0.0035* | | | *0.0005* | *0.0012* | 0.0034 | | |
| Cr total | 0.0024 | 0.021 | *0.003* | *0.021* | | | 0.0023 | 0.025 | | | 0.0005 |
| Cr dissolved | 0.0003 | 0.0027 | *0.0003* | *0.0006* | | | *0.0009* | *0.0012* | 0.001 | | |

Values in italics are based on a small (n<50) sample size.

## 4.3.4 Whakatāne stormwater quality

WDC currently has three resource consents that require monitoring of the stormwater first-flush, these are: The Hub to Kopeopeo Canal (Consent 63352), The Hub Stormwater to Whakatāne River (Consent 62713 and Consent 65604), and Keepa Road Settling Pond which discharges to the Orini Canal (Consent 66383). The monitoring results (**Table 4.3**) indicate the stormwater was within guideline values and the concentrations were relatively low concentrations of all variables relative to typical stormwater.

**Table 4.3**: Summary results of Whakatāne stormwater consent monitoring (dataset for Keepa Road was missing data for 2017 and 2018). Some lab results had unusually high detection limits of total metals.

| Site | Statistic | n | pH | TSS | TPH | Dioxin WHO TEQ upper (pg/L) | PAH (mg/L) | COD (mg/L) | TP (mg/L) | TN (mg/L) | Total Lead | Total Zinc | Total Copper |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Guideline** | | | | **150** | **15** | **30** | | | | | **0.012** | **0.043** | **0.008** |
| Keepa Rd to Oreni, 66383 | Median | 6 | 6.6 | 6.3 | 0.7 | 4.69 | | | 0.0885 | 0.49 | 0.0009 | 0.006 | 0.0021 |
| Keepa Rd to Oreni, 66383 | Max. | 6 | 6.8 | 11 | 0.7 | 6.93 | | | 0.22 | 1.09 | <0.0011 | <0.021 | <0.053 |
| Hub to Kopeopeo Canal, 63352 | Median | 18 | | 28 | | | <0.00004 | 34 | | | | | |
| Hub to Kopeopeo Canal, 63352 | Max. | 18 | | 91 | | | 0.00047 | 200 | | | | | |
| Hub to Whak. PS, 62713 | Median | 28 | | 33.5 | | | 0.000018 | 25 | | | | | |
| Hub to Whak. PS, 62713 | Max. | 28 | | 179 | | | <0.01 | 230 | | | | | |

Guidelines: TSS in discharge of <150 mg/L (BOPRC). TPH <15 mg/L (MfE Environmental Guidelines for Water Discharges from Petroleum Industry Sites in NZ). Dioxin < 30 pg I-TEQ /L (USEPA). Total metal guidelines are ANZECC trigger for 80% protection in marine waters.

An investigation of baseflow and stormwater quality of Whakatāne stormwater discharges and receiving water was undertaken during 2017-2018 by WSP-Opus (2019). Water samples were collected from 17 sites during baseflow conditions and four sites during rain events. In addition, sediment samples were collected on two occasions from eight sites. The sampling results and are shown in **Table 4.4** and **Table 4.5**. The key features of these results are:

- *E. coli* bacteria concentrations were high during storm events. Faecal source tracking of samples from Amber Grove, Apanui Canal and Te Tahi Street found that the bacteria were not from a human source, instead the results indicated a wildfowl source and, at some sites, a possible ruminant source.

- Baseflow *E. coli* bacteria were above recreational bathing guidelines at Sullivan Lake and Hinemoa Stream.

- The water quality results for metal are conservative because they are based on total metals rather than the dissolved fractions. Nevertheless, total cadmium and mercury were within ANZECC DGV at all sites.

- Median total copper was within the ANZG DGV with adjustment for dissolve organic carbon (i.e., 6.8 mg/m$^3$) at all sites during baseflow conditions. However, for rain event sampling the copper DGV was exceeded at Apanui Canal and Te Tahi Street.

- Median total zinc exceeded the ANZECC 80% protection level in baseflow stormwater discharges from Gateway Drive, and also at Amber Grove, Apanui canal and Te Tahi Street during rain events. The median zinc concentration at Gateway Drive was very high compared to other sites. In natural water bodies, total zinc exceeded that 90% species protection limit at Hinemoa Street and Apanui Stream.

- Median total chromium (III and IV) was within ANZECC 80% protection level at all sites (baseflow and rain event monitoring). The 90th protection level was exceeded at Te Tahi Street, and the 95th percentile protection limit was exceeded at Gateway Drive, The Hub the Wainui Te Whara and the mid-section of the Whakatāne River – with all sites recording reasonably high TSS at the time of sampling. These results are particularly conservative because the guideline value used was for Cr (IV) but much of the Cr would be in the form of Cr (III) which has a less stringent DGV of 0.0033 mg/L.

- Median total lead was within the ANZG DGV at all sites during baseflow conditions. However, the ANZG DGVs were exceeded in stormwater during rain events at Te Tahi Street, Apanui Canal and Amber Grove.

- There were five (marginal) exceedances of the BOPRC 150 mg/L TSS trigger level. In the Wainui Te Whara Stream this was associated with dredging work occurring in the stream at the time.

- All hydrocarbons were below laboratory detection limits.

- High concentrations of total copper or zinc were often associated with high concentrations of suspended solids at the time of sampling.

- The Gateway Drive stormwater was not sampled during rain-events, but results from baseflow sampling were higher than at Te Tahi Street for TSS, Cr, Cu, Pb, Zn and *E.coli* bacteria. Some additional rain-event monitoring at this site may be warranted.

- Sediment sampled from Apanui canal indicated Cu, Pb and Zn were above the ANZECC DGV, with Zn also above the ANZECC DV-high. Sediment sampled from Amber Grove had Zn above the ANZECC DGV (**Table 1.5**).

- Metals within sediment samples from the Whakatāne River, Wainui Te Whara and Waiewe Stream were all within the ANZG DVGs. Metal concentrations in the fine sediment fraction were very similar at all Whakatāne River sites.

- The median stormwater quality results from all sites were similar to or less than typical stormwater for comparable catchments recorded in URQIS (**Table 4.1**), with the exception of lead from Te Tahi Street which had a median total Pb concentrations higher than stormwater from Light Industrial sites recorded in the URQIS.

- The priority sites for focusing further investigations of potential stormwater contamination are: Te Tahi Street (Pb, Zn, Cu, Cr, *E.coli*), Apanui Canal (Zn, Cu, *E.coli*), Amber Grove (Zn, *E.coli*) and Gateway Drive (rain event sampling). Additional work is also required to better understand external nutrient inputs to Sullivan Lake and Awatapu Lagoon. The elevated *E.coli* levels recorded in Sullivan Lake are likely from waterfowl or animal sources, and this could be confirmed with faecal source tracking methods.

**Table 4.4**: Median water quality from baseflow and rain-event sampling by WSP Opus (2019). Shaded cells indicated exceedance of ANZECC guideline values as follows: blue = >DGV; green = > ANZG 90% level; yellow = >ANZG 80% level. Site names in bold are natural waterbodies. Copper DGV adjusted for DOC of 2ppm.

| Site Name | n | TSS (g/m3) | Total Cadmium (g/m3) | Total Chromium (g/m3) | Total Copper (g/m3) | Total Lead (g/m3) | Total Mercury (g/m3) | Total Zinc (g/m3) | NH4-N (g/m3) | NO3-N (g/m3) | *E. coli* cfu/100ml |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Baseflow** | | | | | | | | | | | |
| Amber Grove | 4 | 13 | 0.00005 | 0.0006 | 0.0008 | 0.0006 | 0.00008 | 0.0117 | 0.18 | 0.12 | 34 |
| Apanui Canal | 4 | 5.5 | 0.00005 | 0.0006 | 0.0008 | 0.0003 | 0.00008 | 0.0186 | 0.27 | 0.21 | 27 |
| **Awatapu Outlet** | 4 | 19 | 0.00005 | 0.0006 | 0.0012 | 0.0007 | 0.00008 | 0.0032 | 0.06 | 0.21 | 95 |
| Coastlands | 4 | 4 | 0.00005 | 0.0006 | 0.0037 | 0.0007 | 0.00008 | 0.0063 | 0.03 | 0.01 | 60 |
| Gateway Drive | 4 | 17.5 | 0.00005 | 0.0021 | 0.0043 | 0.0012 | 0.00008 | 0.3435 | 0.07 | 0.30 | 55 |
| **Hinemoa Stream** | 4 | 3 | 0.00005 | 0.0005 | 0.0024 | 0.0007 | 0.00008 | 0.0465 | 0.21 | 1.08 | 685 |
| Sullivan Lake Inlet | 4 | 13 | 0.00005 | 0.0008 | 0.0015 | 0.0006 | 0.00008 | 0.0146 | 0.05 | 0.23 | 780 |
| **Sullivan Lake Outlet** | 4 | 10.5 | 0.00005 | 0.0005 | 0.0013 | 0.0006 | 0.00008 | 0.0111 | 0.010 | 0.05 | 225 |
| Te Tahi Street | 4 | 3 | 0.00005 | 0.0005 | 0.0009 | 0.0003 | 0.00008 | 0.0166 | 0.04 | 0.30 | 40 |
| The Hub | 3 | 33 | 0.00011 | 0.0011 | 0.0011 | 0.0002 | 0.00008 | 0.0094 | 0.12 | 0.15 | 10 |
| **Wairere Stream** | 4 | 3 | 0.00005 | 0.0005 | 0.0005 | 0.0001 | 0.00008 | 0.0015 | 0.014 | 0.59 | 210 |
| **Wainui Te Whara Downstream** | 4 | 59 | 0.00005 | 0.0013 | 0.0018 | 0.0018 | 0.00008 | 0.0069 | 0.014 | 0.40 | 75 |
| **Wainui Te Whara Upstream** | 4 | 3 | 0.00005 | 0.0005 | 0.0005 | 0.0001 | 0.00008 | 0.0011 | 0.010 | 0.41 | 52 |
| **Whakatane River Downstream** | 4 | 12.5 | 0.00021 | 0.0019 | 0.0019 | 0.0011 | 0.00008 | 0.0049 | 0.021 | 0.20 | 50 |
| **Whakatane River Bridge** | 4 | 17.5 | 0.00008 | 0.0011 | 0.0011 | 0.0008 | 0.00008 | 0.0033 | 0.020 | 0.20 | 55 |
| **Whakatane River Midway** | 4 | 52 | 0.00005 | 0.0010 | 0.0015 | 0.0011 | 0.00008 | 0.0048 | 0.012 | 0.21 | 55 |
| **Whakatane River Upstream** | 4 | 17 | 0.00005 | 0.0005 | 0.0006 | 0.0002 | 0.00008 | 0.0014 | 0.010 | 0.19 | 41 |
| **Rain Event** | | | | | | | | | | | |
| Amber Grove | 4 | 17.5 | 0.00005 | 0.0015 | 0.0031 | 0.0036 | 0.00008 | 0.1095 | 0.07 | 0.14 | 3100 |
| Apanui Canal | 4 | 23 | 0.00008 | 0.0024 | 0.0102 | 0.0054 | 0.00008 | 0.1435 | 0.07 | 0.09 | 3100 |
| Te Tahi Street | 4 | 83 | 0.00014 | 0.0079 | 0.0119 | 0.0084 | 0.00008 | 0.3070 | 0.01 | 0.09 | 2850 |
| **Wainui Te Whara Downstream** | 3 | 17 | 0.00005 | 0.0008 | 0.0015 | 0.0007 | 0.00008 | 0.0127 | 0.01 | 0.09 | 500 |

**Table 4.5**: Sediment results from WSP-Opus (2019). Bolded values are above the ANZG Default Guideline Value (DGV) of copper 65 mg/kg, lead of 50 mg/kg and zinc of 200 mg/kg.

| Date | Site | Sediment fraction | Total Copper (mg/kg dw) | Total Lead (mg/kg dw) | Total Zinc (mg/kg dw) |
|---|---|---|---|---|---|
| 10/08/16 | Amber Grove | <2mm | 27 | 37 | **350** |
| 20/11/17 | Amber Grove | <63µm | 22 | 23 | 177 |
| 10/08/16 | Apanui Canal | <2mm | 42 | **62** | **400** |
| 20/11/17 | Apanui Canal | <63µm | **121** | **181** | **1180** |
| 20/11/17 | Waiewe Stream | <63µm | 15.2 | 25 | 164 |
| 20/11/17 | Wairere Stream | <63µm | 6.4 | 9.5 | 47 |
| 20/11/17 | Wainui Te Whara Downstream | <63µm | 10.2 | 12.3 | 76 |
| 10/08/16 | Whakatāne River Downstream | <2mm | 16.3 | 12 | 62 |
| 20/11/17 | Whakatāne River Downstream | <63µm | 15.1 | 9.9 | 61 |
| 10/08/16 | Whakatāne River Midway | <2mm | 11.6 | 8.3 | 44 |
| 20/11/17 | Whakatāne River Midway | <63µm | 16.2 | 11.5 | 63 |
| 10/08/16 | Whakatāne River Upstream | <2mm | 7.6 | 4.7 | 29 |
| 20/11/17 | Whakatāne River Upstream | <63µm | 15.7 | 10.3 | 60 |

BOPRC assessed contamination of zinc and copper in the Wainui Te Whara Stream during 2020 by sampling sediments and installing Diffuse Gradient Thin-film (**DGT**) sampling devices. DGTs are passive sampling devices that measure the dissolved fraction relevant to biota, averaged over a period of time (often weeks). The results from DGTs can be compared to ANZG DGV without adjusting for hardness or DOC.

The sediment sampling found Zn and Cu less than the DGV (although Zn at Hinemoa Street was very close to the sediment DGV of 200 mg/kg). The DGT sampling found the average dissolved metals in the water at most sites was within the ANZG (2018) DGV values; the exception was King Street where Cu was within but close to the DGV (1.4 mg/m$^3$) and Zn exceeded the DGV (8 mg/m$^3$) and the ANZECC 80th percentile protection limit (31 mg/m$^3$) (**Table 4.6**). The results are consistent with that of WSP-Opus which found acceptable levels of Cu and Zn in the sediment of the lower Wainui Te Whara, but indications of elevated Zn in the water during rain events.

**Table 4.6**: Copper and zinc in sediment and water at sites along the Wainui Te Whara Stream during 2020 (Source: A. Suren, BOPRC).

| | Water DGT (mg/m$^3$) | | Sediment (mg/kg) | |
|---|---|---|---|---|
| **Site** | **Cu** | **Zn** | **Cu** | **Zn** |
| Wainui Te Whara at upper Toi Track Bdg | 0.003 | -0.01 | 2.8 | 19 |
| Wainui Te Whara at Gorge Rd | | | 3.8 | 32 |
| Wainui Te Whara at King St | 1.01 | 36.6 | 4.5 | 50 |
| Wainui Te Whara at Hinemoa St | 0.02 | 1.30 | 11.5 | 194 |

DGT Zn had negative value because high Zn was found in the blank.

### 4.3.5 Potential effects from Whakatāne stormwater

The likely effects of the Whakatāne township stormwater on the water quality in receiving waters are summarised in **Table 4.7**. The concentration of Cu, Pb and Zn in water and sediment provides markers of potential stormwater effects on a waterbody. There has been limited monitoring of nutrients (N and P) in Whakatāne's urban stormwater to understand concentrations and loads, however urban stormwater often carries high concentrations of nutrients, and this can contribute to eutrophication – particularly in lakes (i.e., Awatapu Lagoon and Sullivan Lake). Even if the concentration of nutrients in stormwater to Awatapu Lagoon and Sullivan Lake is less than in the lake itself (e.g., due to high internal loading from sediments of cyanobacteria) there is still a strong case for reducing nutrient loads as a fair contribution to the waterbodies to achieve targets set in the NPS-FM as a national bottom-lines (e.g. for TN, TP and Chlorophyll-*a*).

Stormwater can have high concentration of *E. coli* bacteria, which in Whakatāne is usually derived from animal sources (e.g., dogs, wildfowl). For the Whakatāne River and Wainui Te Whara Stream the instream sampling indicates that stormwater being discharged to the river from the urban area has similar *E. coli* concentrations to the water that comes down the river from upstream sources during high flow events. On a mass load basis, the influence of the Whakatāne Stormwater on the Whakatāne River is very small due to its much smaller catchment area. I have previously noted that the lower Whakatāne River does not meet microbial water quality guidelines for swimming at Landing Road Bridge (grade as "poor" due to high *E.coli* concentrations at high flow events), but does at the Heads where there is more saline influence. Similarly, the Whakatāne River at Landing Road exceeds stock drinking water standards (1000 cfu/100mL) about 7% of the occasions predominantly during high flow events. During rain events the stormwater discharges contribute to this exceedance – although in a very small way.

There is potential for recreational shellfish gathering at the mouth of the Whakatāne River beyond the entrance to the sea. Shellfish in this are not regularly monitoring for microbial suitability. Water quality at The Heads, although graded suitable for recreation bathing is unlikely to meet the stricter standard set for shellfish gathering[14]. However, however, most shellfish suitable for harvest are located further towards the sea than the monitoring site. It will have better microbial water quality due to being closer to the sea than the water quality monitoring site, but, in my view, would likely to be unsafe for shellfish gathering for several days after high river flows. As discussed above, the effect of the Whakatāne stormwater on microbial water quality in the shellfish gathering areas would be very small due to its small due to the small catchment area compared to the river, but incremental.

In the past there has likely been occasional, rare, sewage leaks to Sullivan Lake and to the Wainui Te Whara Stream and consequently Awatapu Lagoon. The causal issues have been addressed but it is difficult to quantify any legacy effect of these on the concentration of nutrients in sediments.

There are some other direct sources of contaminants to Sullivan Lake and Awatapu Lagoon in addition to urban stormwater or stream inputs. These include wildfowl (*E.coli*, nutrients), and an old landfill near Awatapu lagoon (Bridge Street).

Production of odour from stormwater assets is rare. Occasional odour complaints have occurred in the past associated with water from Sullivan Lake but these are generally be associated with decomposition of material after spraying of aquatic weeds.

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[14] A median faecal coliform value of 14 MPN/100ml and not more than 10% of samples exceeding 43 /100mL (MfE and MoH 2003).

**Table 4.7**: Likely magnitude of effects of the current Whakatāne township stormwater (SW) on the water quality of receiving waterbodies.

| Waterway | Water Quality | Reason |
|---|---|---|
| Whakatāne River | Low | SW a very small fraction of catchment (<1%). Metals in fine sediment within DGVs and similar u/s and d/s of town. Possible small scale localised effects at outlets. |
| Wairere Stream | Negligible | SW a very small fraction of catchment. Metals in sediment low and within DGVs. |
| Waiewe Stream | Low | Zn slightly elevated in sediment but still within DGVs. SW a small fraction of overall catchment. |
| Apanui Canal | High | Urban catchment. Sediments have elevated Cu, Zn and Pb above DGVs. Metals and *E.coli* in water elevated during rain events. Low DO. Oily film can be present on water after rain. Litter. |
| Hinemoa Stream | Moderate - High | Urban catchment. Indication of elevated Zn and *E.coli* in water at baseflow. Uncertainty with no sediment sampling or rain-event sampling. High nitrate. |
| Amber Grove drains | High | Urban catchment. Sediments have elevated Zn above DGV. Zn and *E.coli* in water elevated during rain events (likely from animals) |
| Wainui Te Whara Stream u/s Valley Road | Low | Macroinvertebrate scores are generally good. Dissolved Cu and Zn increase down Gorge Road but still low. TN and TP above DGVs but TP likely naturally elevated. |
| Wainui Te Whara Stream d/s Valley Road | Moderate | Macroinvertebrate scores decline to poor downstream. Zn and Cu elevated d/s but within DGV. DGT sampling found dissolved Zn elevated above DGVs at King Street. |
| Awatapu Lagoon | Moderate | Very high nutrient status. Low metal concentration in outlet water. Concentration of TN similar to WTW inflow but TP is higher, suggesting internal load or a SW source. Historical sewage leaks. N & P may be elevated in inflows (based on URQIS) but not confirmed. Litter in lagoon. |
| Sullivan Lake | Moderate | Very high nutrient status. Elevated Zn in sediment and inflows. Inflows also elevated in *E.coli*. Historical sewage leaks. N & P may be elevated in inflows (based on URQIS) but not confirmed. Fine sediment observed in inflows. |
| Orini Canal | Negligible - Low | Urban SW a small fraction of catchment. Low concentration of Zn, Cu, Pb and dioxins in SW. Very low nitrogen in SW. |
| Kopeopeo Canal | Low | Urban SW a small fraction of catchment. Indication of elevated Zn in stormwater from Gateway Drive. |

## 4.4 Operation and Maintenance effects on waterways

### 4.4.1 Introduction

The physical management of urban streams and waterbodies can have potential positive or negative effects on its overall health. Management activities related to stormwater might include mowing or spraying of riparian vegetation, widening or deepening of waterways (e.g., Wainui Te Whara in 2016), sediment traps (e.g., on the Wainui Te Whara), removal of sediment accumulations (e.g., at inlet to Awatapu Lagoon), maintaining flap gates, planting of riparian vegetation, or creating wetlands. The effect of instream and riparian management are often hard to disentangle from that of the stormwater discharges. Consequently, the way waterways are managed can either exacerbate or mitigate the direct effects of stormwater. For example, establishing riparian vegetation provides multiple ecosystem functions including shading, stream bank stabilisation, filtering of water, improving instream habitat conditions, providing coarse organic matter that acts as food for invertebrates and helps bind heavy metals.

Often these activities are only indirectly related to stormwater. This report has focused on the regular operation and management activities and how these can be modified to mitigate potential stormwater effects and potentially provide benefits to particular waterways. In practice, the operations and practice need to reflect the multiple aims of the stormwater system including conveying water, minimising flooding, maintaining water quality and, in the case of natural waterways, maintaining or improving habitat values.

### 4.4.2 Potential effects from Whakatāne stormwater

The likely effects on waterways of the stormwater related operation and maintenance activities are summarised in **Table 4.8.** The effects identified generally related to maintenance of the riparian margin or the presence of a flap gate restricting fish passage. For many water bodies there is high potential to turn these activities from causing an adverse ecological effect to a positive effect by installing fish friendly flap gates and by planting native riparian margins (Wainui Te Whara), riparian wetlands (Apanui Canal, Amber Grove, Awatapu), or in-lake filter wetlands (Awatapu, Sullivan Lake).

Fundamental to ensuring operation and maintenance activities turn from a negative to a positive is to recognise enhancing ecological values and maintaining water quality as high-level objectives of the stormwater network alongside conveyance of water and avoiding flooding. High ecological aspirations then need to cascade through to policies, local plans and on the ground practices.

**Table 4.8**: Likely magnitude of effects of the operation and maintenance activities related to Whakatāne township stormwater.

| Waterway | O & M Effect | Reason |
|---|---|---|
| Whakatāne River | Negligible | Little SW O&M activity in the Whakatāne River |
| Wairere Stream | Negligible | Little SW O&M activity in Wairere Stream |
| Waiewe Stream | Low | Drain maintenance in upper catchment mown grass. Potential for riparian filter strips. |
| Apanui Canal | Moderate | Riparian margin mostly mown grass, occasional herbicide use. Limited riparian planting lost to mowing. Lack of shade = algae growth. Good potential for establishing riparian wetlands to provide habitat, filtering and shade. |
| Hinemoa Stream | Moderate | Flap gate restricts fish passage; replacement with FFG would improve fish passage and WQ.<br>Riparian margin mostly mown grass. Potential for riparian wetlands d/s James Street. |
| Amber Grove drains | Moderate | Occasional drain clearing. Potential for riparian planting along drain system for shade and habitat. |
| Wainui Te Whara Stream u/s Valley Road | Low | Sediment trap has localised effects when cleared. |
| Wainui Te Whara Stream d/s Valley Road | Moderate | Sediment trap reduces supply of large gravel and cobbles to stream relative to sand.<br>Herbicide spraying restricts regeneration of instream and riparian vegetation.<br>High potential for improved habitat and WQ functions through extensive riparian planting d/s King Street. |
| Awatapu Lagoon | Moderate | Herbicide spray to waters edge. Localise impact from sediment removal to maintain storage capacity.<br>High potential for developing wetlands and native riparian margins to provide filtering and habitat. |
| Sullivan Lake | Moderate | Very limited natural wetland margins.<br>Spraying of aquatic plants can cause too much loss and negatively effect WQ.<br>Flap gate restricts fish passage; replacement with FFG would improve fish passage and WQ.<br>High potential for developing wetlands to provide filtering and habitat. |
| Orini Canal | Negligible | Little SW O&M activity in Orini Canal |
| Kopeopeo Canal | Negligible | Little SW O&M activity in this Kopeopeo Canal |

## 4.5 Overall stormwater effects and potential mitigation

The overall ecological effects resulting from stormwater discharges from Whakatāne township are summarised in **Table 4.9**. Most of the stormwater discharges have “Low” or “Very Low” overall effects because of either the small amount of stormwater input to the water way, or the currently poor ecological values of the waterway, or both.

The lower Wainui Te Whara Stream and Awatapu Lagoon had overall “moderate” ecological effects. Sullivan Lake had “low” overall ecological effects in part because of its current “low” ecological values. However, Sullivan Lake has amenity values (moderate) and actions to improve water quality would improve these. For these systems the historic and current stormwater directly and indirectly effects the ecological conditions, particularly through inputs of metals, nutrients, possible microbial contamination, litter and in the case of the Wainui Te Whara, operational management practices that restrict establishment of native riparian plant communities at the water’s edge.

This assessment considers the current effects of stormwater discharges and does not account for proposed future mitigations that may occur as part of the Catchment Management Plan (**CMP**). **Table 4.9** provides some potential mitigation options to address the effects contributed to by the stormwater system. The stormwater system is one of multiple pressures on these waterbodies and the implementing mitigations could result in a general improvement in ecological values. This is not a comprehensive list of mitigation options to improve ecological values, instead it is a selection of practical options which have a high certainty of being able to be successfully implemented and have positive influences on ecological value. It includes street sweeping, installing sediment traps and litter traps, fish friendly flap gates, macrophyte harvesting, constructing wetlands and planting riparian margins. There may be opportunities in the management of drainage reserves to allow longer grass to improve their filtering as swales.

There are other interventions may also be appropriate, for example, the potential adverse water quality effects of road runoff can be mitigated by treating at source and using treatment devices (e.g., swales, ponds and treatment wetlands), reducing contamination at source through the use of suitable building materials, ensuring industrial contamination stays on-site.

The potential stormwater effects of new housing and new subdivisions can be effectively managed by ensuring a water sensitive design approach to land development and stormwater treatment. Useful guidance on treatment devices to assist with water sensitive design is available in Cunningham et al. (2017) and Farrant et al. (2019).

Marina hard-stand activities such as boat-washing, scraping and repainting are not common in Whakatāne, but should they occur as part of future developments, then consideration should be given to capturing and treating stormwater to reduce contamination by copper that is contained in anti-fowling paints[15].

### 4.5.1 Lakes

The water quality in Awatapu Lagoon and Sullivan Lake is poor with low water clarity, high nutrient concentrations and high phytoplankton growth indicative of supertrophic and hypertrophic conditions respectively. It is likely that both lakes have significant internal loading of nutrients from the sediment either by sediment suspension or in the case of Awatapu Lagoon via occasional bottom water anoxia. There is also internal nitrogen loading via cyanobacteria blooms and Azolla.

If water quality in these lakes is to improve to achieve ‘eutrophic’ conditions of NPS-FM Band C, then multiple interventions will likely be required, including reducing the external nutrient load, reducing sediment resuspension and the internal loading of nutrients from the sediment, enhancing natural processes that attenuate and remove nutrients, and weed macrophyte harvesting. Consideration may also need to be given to the potential for increasing flows through Awatapu Lagoon.

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[15] Work by NIWA in 2013 found that as much copper exported from the four marinas in the Waitemata Harbour as from inputs of stormwater for the whole Waitemata Harbour catchment, due to leaching from anti-fowling paints.

It is unrealistic[16] to expect a significant improvement in water quality of either Awatapu Lagoon or Sullivan Lake without improved riparian and in-lake wetlands and appropriate management of the aquatic plant community. Firstly, the lakes need plants. It is rare for shallow lakes to have reasonable water quality without substantial macrophyte cover. Drake et al (2010) found that for shallow NZ lakes, 30% macrophyte cover corresponded to a TN concentration of 800 mg/m$^3$ – the threshold for the NPS-FM C / D band. Norton et al. (2014) found lakes dominated by aquatic macrophytes had a TN concentration of <1000 mg/m$^3$. A similar finding is found internationally where shallow lakes with a TN concentration of >1000 mg/m$^3$ almost always have less than 50% macrophyte cover (Jeppesen et al. 2007; Kelly et al. 2013). Overseas studies of natural lakes have shown that submerged aquatic plant cover needs to be consistently between 30% and 60% to ensure a clear water state (e.g., Jeppesen et al. 1994; Tatrai et al. 2009; Blindow et al. 2002).

Secondly, excessive pest macrophyte cover as occurs in Awatapu Lagoon can cause its own water quality and biodiversity problems in the form of low dissolved oxygen, adding carbon to the sediment and displacing native plants. In this case, macrophyte harvesting can provide multiple benefits by removing pest weeds, improving recreational use, improving the dissolved oxygen regime, permanently removing nutrients from the system and reducing the extent of summer algae blooms as plants regrow.

Harvesting of the aquatic pest plant hornwort from Awatapu Lagoon and creating wetlands to provide treatment are both realistic and relatively cost-effective approaches to removing N and P from Awatapu Lagoon. For example, in 2019 WDC harvested hornwort and parrots feather from Awatapu South, about 200 tonnes wet weight of plant material was removed from the lagoon, which equates to the removal of about 240kg of nitrogen and 32 kg of phosphorus[17].

A list of ecological issues facing Awatapu Lagoon and potential mitigation options are summarised in **Appendix 2**. These take a wholistic approach that extends beyond just the effects associated with stormwater. Apparent in the table is that some mitigations (e.g. macrophyte harvesting) have benefits in addressing multiple issues.

The 2021 Long Term Plan approved funding to creation of wetland areas in Awatapu lagoon (south and central) including diverting baseflow of the Wainui Te Whara into Awatapu south. This project will improve water quality, ecological values, flow conditions and the oxygen regime (mostly in the southern lagoon), but the extent of benefits will depend on the detailed design. Furthermore, other actions will still be required to address issues in the lagoon for example, wetlands will not prevent the accumulation of excessive macrophyte growth in the remaining open water or the benefits of macrophyte harvesting.

### 4.5.2 Wetlands

The National Environment Standard – Freshwater (NES-FW) includes specific provision relating to effects of activities on wetlands (Part 3). These include general conditions relating to water quality and movement (Regulation 55). With respect to water quality, [*Activities] must not result in the discharge of a contaminant if the receiving environment includes any natural wetland in which the contaminant, after reasonable mixing, causes, or may cause, 1 or more of the following effects:*

> *(i) the production of conspicuous oil or grease films, scums or foams, or floatable or suspended materials;*

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[16] Assuming funding is not unlimited.

[17] Based on data from Lake Rotoehu in Gibbs (2015).

*(ii) a conspicuous change in colour or visual clarity:*
*(iii) an emission of objectionable odour;*
*(iv) the contamination of freshwater to the extent that it is not suitable for farm animals to drink;*
*(v) adverse effects on aquatic life that are more than minor.*

Potential stormwater discharges that may influence natural wetlands identified in this report are:

- Discharges from the pump station and gravity outlets at McAlister Street and the Rose Gardens to the salt marsh edge of the Whakatāne River

- Discharges to the Kopeopeo Canal and to the Oreni Canal which flow adjacent to the Whakatane River salt marsh wetland. Direct stormwater discharges to these water ways are more than 100m from the salt marsh.

- The outflow from Awatapu Lagoon is about 100m from a potential natural wetland along the channel connecting the Awatapu lagoon outlet to the Whakatāne River. This is not a direct stormwater discharge but is addressed in this section because it is a stormwater structure.

Stormwater discharges from the outlets at McAlister Street and the Rose Gardens have low risk of adversely affecting the salt marsh ecology. There are small, localised direct effects from the outlet and dissipation structures; and stormwater does impact on the water quality of Apanui Canal. However, the potential effects on the salt marsh is reduced by the influence of the Whakatāne River. Consequently, sediment sampling from the Whakatāne River just downstream of the outlets found low concentrations of stormwater contaminants (copper, lead, zinc). The operation of the gravity outlet at McAlister Street allows tidal flows through the Apanui Canal, allowing a more natural hydraulic regime in the channel running through the salt marsh and minimising the risk of any changes in clarity or colour. When the pumps are running the turbulent water can result in a small amount of foam, but the effects are minor and similar to what is observed in many turbulent natural waters. There is no indication of the discharges causing sedimentation.

Urban stormwater discharged to the Kopeopeo Canal and to the Oreni Canal have low risk of causing adverse effects on the downstream salt marsh because the stormwater is a very small fraction of the overall catchment. There have been indications of elevated zinc from Gateway drive, but stormwater entering Oreni Canal has low concentration or zinc, copper, lead and nitrogen.

The discharge from Awatapu Lagoon has low risk of influencing the wetland area in the downstream channel. The water quality of Awatapu lagoon tends to have TN and TP twice as high as in the Whakatane River, but similar concentrations of TSS and *E.coli* and lower concentrations of dissolved nutrients (**Tables 3.2 and 3.6**). However, little water from Awatapu Lagoon interacts with the wetland area and when it does it is highly diluted by water from the Whakatāne River. At low tide, the water discharged from Awatapu Lagoon flows in a channel that bypasses the wetland. Only at mid-tide to high-tide does water enter the wetland area (>0.5m RL contour) and at these times there is either a net inflow of water into Awatapu Lagoon or the tide gates are shut. The vast majority of the water interacting with the wetland will be from the Whakatane River, which is closer, and connected by a much larger open channel compared to the culvert outlet from the lagoon.

**Table 4.9**: Summary of overall ecological effects of current stormwater on waterways in Whakatāne township, and potential mitigation actions to reduce these effects and potentially ensure a net benefit.

| Waterway | Ecological value | Magnitude of effect | Overall Effect | Potential mitigation |
|---|---|---|---|---|
| Whakatāne River | High | Low | Low | |
| Wairere Stream | High | Low | Low | |
| Waiewe Stream | Moderate-Low | Low | Low | |
| Apanui Canal | Low | High | Low | Riparian restoration for shading and habitat.<br>FFG was installed in 2017. |
| Hinemoa Stream | Low | High | Low | Install a FFG.<br>Riparian /wetland planting between James St and Hinemoa St. |
| Amber Grove drains | Negligible | High | Very Low | Riparian wetland planting on one side of drains for shade and habitat.<br>Fence stock away from drains. |
| Wainui Te Whara Stream u/s Valley Road | High | Low | Low | Sediment detention bunds in upper catchment. |
| Wainui Te Whara Stream d/s Valley Road | Moderate | Moderate | Moderate | Riparian and instream restoration d/s King Street.<br>Allow plants in the stream.<br>Change management to avoid spray near stream edge. |
| Awatapu Lagoon | Moderate | Moderate | Moderate | Create wetlands for WQ treatment and wildlife.<br>Regular weed harvesting of south and central lagoon to improve habitat, oxygen conditions and remove nutrients.<br>Azolla harvesting to remove nutrients.<br>Improve litter management e.g. litter traps. |
| Sullivan Lake | Low* | Moderate | Low* | Create banded wetlands for treatment near southern end of lake. Ensure sections of lake retain aquatic plants.<br>Focus SW management on Te Tahi Steet industrial area.<br>Investigate sediment inputs.<br>Encourage low fertiliser use in catchment.<br>Improve fish passage at outlet weir and install a FFG at Whakatane River outlet. |
| Orini Canal | Moderate | Low | Low | |
| Kopeopeo Canal | Low | Low | Very Low | Potential for riparian restoration |

## 4.6 Monitoring and investigations

This assessment of water quality effects from stormwater has used a combination of local stormwater monitoring data, typical stormwater quality from the URQIS national monitoring database and literature. For most stormwater discharges in Whakatāne the monitoring data set is small and the list of variables monitored is incomplete. Additional monitoring would improve the certainty of this assessment including:

- Monitoring for dissolved metals at sites where total metals were found to exceeded DGVs, i.e., Zn Cu, Cr and Pb at the sites: Amber Grove, Apanui Canal, Gateway Drive, Hinemoa Stream, Sullivan Lake Inlet (including a new site sampling the inflow from the Te Tahi Street catchment), Te Tahi Street, The Hub, Wainui Te Whara Stream at Hinemoa Street, Wainui Te Whara Stream at Landing Road. This should include analysis of dissolved organic carbon and hardness. The additional sampling would need to occur during baseflow conditions and during rain events. Note that rain-event sampling is currently lacking for Gateway Drive, inlets to Sullivan Lake.

- An alternative or complimentary approach to repeating the grab samples for metals would be to install DGTs (diffusive gradients in thin films). DGTs are small, simple passive sampling devices that accumulate dissolved substances and provide a time-weighted average concentration over the deployment period. They should be deployed in duplicate and water temperature data should be collected during their deployment. The period of deployment should cover a rain-event.

- Analysis of metals (Zn, Cu, Pb) in sediment is particularly helpful in assessing effects of stormwater; this would be worth repeating in the Whakatāne River, Wainui Te Whara (Valley Road and Hinemoa Street), Apanui Canal and Hinemoa Stream.

- There is limited data on nutrients and dissolved organic carbon (DOC) data from any site. This gap should be filled by additional sampling. Particularly important to collected this data for the more natural waterways (and especially Wainui Te Whara) during baseflow and rain events.

The waterbodies identified with highest overall effects from stormwater were Wainui Te Whara Stream, Awatapu Lagoon and Sullivan Lake. These lagoons are particularly sensitive to nutrient inputs but there is insufficient data available to accurately estimate nutrient loads. Additional monitoring that would assist in managing these waterbodies is described below, but given limited budgets, priority should be given first to initiating the management and mitigation actions:

- Regular monitoring of the Wainui Te Whara Stream for water quality suite (TSS, *E. coli*, TN, NNN, NH4, TP, DRP, hardness, pH, EC, temperature) to develop a dataset suitable for estimating loads.

- Monitoring of the main stormwater inflows to Sullivan Lake and Awatapu Lagoon for water quality variables to better characterise the contribution of stormwater to the lakes. Lake water quality should be monitored at the same time.

- Estimate total hydraulic load and nutrient load to Awatapu Lagoon and Sullivan Lake. Initially this can be done at a broad scale using catchment data and rainfall records alongside monitoring data.

- Investigate the potential increase in nutrients observed in the Wainui Te Whara Stream between the Toi's track Upper Bridge and Lower Bridge. Initially this should consist of some additional monitoring and consecutive flow gaugings at the two sites.
- Calculate dissolved oxygen depletion rate in Awatapu Lagoon by monitoring dissolved oxygen-temperature-depth profiles during a period of summer stratification. Top and bottom water samples should be collected at the same time.
- The monitoring data collected by BOPRC from Awatapu Lagoon west has been valuable for characterising the water quality.
- Most stormwater from the Awatapu stormwater catchment is currently pumped directly to the Whakatāne River. There have been suggestions of potentially diverting this to the Awatapu Lagoon South as a way of augmenting the flow. One risk of this proposal is the potential to add contaminants to the Awatapu Lagoon. In this context it would be valuable to have water quality monitoring data for this pumped outfall.

# 5 Conclusions

This report has described the values of waterways receiving stormwater from the Whakatāne township and the potential effects of the stormwater on these waterways using the Ecological Impact Assessment framework. The stormwater effects considered in this assessment related hydrology, temperature, water quality and effects arising from operation and maintenance activities.

The analysis found that most of the stormwater discharges currently have “Low” or “Very Low” overall effects because of either the small amount of stormwater input to the waterway, or the currently poor ecological values of the waterway, or both. The lower Wainui Te Whara Stream and Awatapu Lagoon had overall “moderate” ecological effects, but there is considerable potential to mitigate these effects and possibly achieve net benefits.

The assessment considers the current effects of stormwater discharges and does not account for mitigations that may occur as part of the proposed Catchment Management Plan. There are many mitigation actions that can be undertaken to reduce the effects of the stormwater network on waterways, in addition to addressing other, non-stormwater related pressures. Some of these could change the effects of the stormwater network management from a negative to a positive. A fundamental method to ensure both improved water quality and ecological outcomes are achieved is to include ‘the enhancement of ecological values’ as a high-level objective of the stormwater network alongside conveyance of water.

# References

ANZG 2018. *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. Australian and New Zealand Governments and Australian state and territory governments, Canberra ACT, Australia. Available at www.waterquality.gov.au/anz-guidelines

ANZECC 2000. *Australian and New Zealand Guidelines for Fresh and Marine Water Quality Vol. 1.* Australian and New Zealand Environment and Conservation Council.

Beadel S.M., Shaw W.B. and Gosling D.S 1999: Taneatua Ecological District. Survey report for the Protected Natural Areas Programme. Department of Conservation, Rotorua. 265 pp.

Bearr JS, Diamond J, Latimer H, Bowersox M. 2006. Effects of pulsed copper exposures on early life-stage *Pimephales promelas*. *Environmental Toxicology and Chemistry 25*(5), 1376-1382.

Blindow I., Hargeby A. & Andersson G. 2002. Seasonal changes of mechanisms maintaining clear water in a shallow lake with abundant Chara vegetation. *Aquatic Botany* 72:315–334.

Brough A., Brunton R., England M. & Eastman R. 2012. *Stormwater quality – an analysis of runoff from modern subdivisions and the implications for stormwater treatment*. Water New Zealand Storm-water Conference, Amora Hotel Wellington, 10-11 May 2012. 14 pp.

Burns N., Bryers G., Bowman E. 2000. Protocol for monitoring trophic levels of New Zealand lakes and reservoirs. Prepared for Ministry of the Environment by Lakes Consulting, March 2000. Web: http://www.mfe.govt.nz/publications/water/protocol-monitoring-trophic-levelsmar-2000/index.html

Clapcott J 2015. *National rapid habitat assessment protocol development for streams and rivers*. Prepared for Northland Regional Council. Cawthron Report No. 2649. 29 p. plus appendices.

Collier KJ 2008. Average score per metric: An alternative metric aggregation method for assessing wadeable stream health. *New Zealand Journal of Marine and Freshwater Research* 42:4, 367-378, DOI: 10.1080/00288330809509965

Cunningham, A., Colibaba, A., Hellberg, B., Silyn Roberts, G., Simcock, R., S. Speed, Vigar, N and Woortman, W 2017. Stormwater management devices in the Auckland region. Auckland Council guideline document, GD2017/001

Davies-Colley R., Franklin P., Wilcock B., Clearwater S., Hickey C. 2013. *National Objectives Framework - Temperature, Dissolved Oxygen & pH Proposed thresholds for discussion*. Prepared for Ministry for the Environment by NIWA. NIWA Client Report No: HAM2013-056.

Davies-Colley RJ, Smith DG 2001. Turbidity, suspended sediment, and water clarity: A review. *Journal of the American Water Resources Association 37* (5): 1085-1101.

Depree C 2013. Analysis of Rotorua’s street sweeping programme and options to improve environmental outcomes. NIWA Client Report HAM2013-055.

Drake D.C., Kelly D. & Schallenberg M. 2010. Shallow coastal lakes in New Zealand: current conditions, catchment-scale human disturbance, and determination of ecological integrity. *Hydrobiologia* 658: 87-101.

Dunn, NR, Allibone, RM, Closs, GP, Crow, SK, David, BO, Goodman, JM, Griffiths M, Jack DC, Ling N, Waters JM, Rolfe, JR (2018). *Conservation status of New Zealand freshwater fishes, 2017*. New Zealand Threat Classification Series 24. Wellington.

Farrant S, Leniston F, Greenberg E, Dodson L, Wilson D., Ira S 2019. Water Sensitive Design for Stormwater: Treatment Device Design Guideline version 1.1. Wellington Water

Franklin P, Stoffels R, Clapcott J, Brooker D, Wagenhoff A, Hickey C 2019. *Deriving potential fine sediment attribute thresholds for the National Objectives Framework*. Prepared for Ministry for the Environment, by NIWA, June 2019

Gadd J, Milne J, Hickey C 2017. Copper and zinc aquatic toxicity. Frequently asked questions. Prepared for Environment Canterbury. NIWA Client Report 2017129AK.

Gibbs M. 2015. Assessing lake actions, risks and other actions. NIWA Client Report No. NIWA 2015-102. Prepared for Bay of Plenty Regional Council, Whakatane.

Hamill KD, Dare J, Gladwin J 2020. River water quality state and trends in the Bay of Plenty to 2018: Part A. Prepared by River Lake Ltd for Bay of Plenty Regional Council.

Hamill KD, Dare J, Gladwin J 2020b. River water quality state and trends in the Bay of Plenty to 2018: Part B. Prepared by River Lake Ltd for Bay of Plenty Regional Council.

Hamill KD, Kelly D, Hamilton D, Howard-Williams C, Robertson B, Schallenberg M, Vant B, Ward N. 2014. Attributes for Intermittently Open and Closed Lakes and Lagoons (ICOLLs) applicable to the National Objectives Framework for Fresh Water. Prepared for Ministry for the Environment.

Hamill, KD 2015. *Wainui Te Whara Stream survey 2015*. Prepared by River Lake Ltd for Whakatāne District Council. *(A549385).*

Hamill KD 2016. *Wainui Te Whara Stream morphology survey and design options 2016*. Prepared by River Lake Ltd for Whakatāne District Council. *(A1085380).*

Hamill KD 2017. *Sullivan Lake sediment zinc*.  Prepared by River Lake Ltd for Whakatane District Council. *(A1185226)*.

Hamill KD 2017. *Aquatic plant filters for improving water quality and ecology of Sullivan Lake*. Memo prepared for Nicholas Woodley, Whakatāne District Council by River Lake Ltd, 13 November 2017. *(A1278194)*.

Hamill KD 2017. *Whakatāne Comprehensive Stormwater Consent: Review of information for assessing effects on ecology and water quality*. Prepared by River Lake Ltd for Whakatāne District Council

Hickey C., Clements W. 1998. Effects of heavy metals on benthic macroinvertebrate communities in New Zealand streams. *Environmental Toxicology and Chemistry 17*(11): 2338-2346

Hickey, C.W.; Macaskill, J.B.; Martin, M.L.; Scarsbrook, M.R.; Williamson, R.B. 2001. Hamilton City stormwater: assessment of contaminant loads and impacts on the Waikato River. No. HCC00210. NIWA, Hamilton. pp. 70p.

Hicks, B.J., D.G. Bell, and W. Powrie. 2015. *Boat electrofishing survey of the Awatapu Lagoon and lower Tarawera River*. Environmental Research Institute Report No. 58. Client report prepared for

Department of Conservation and Bay of Plenty Regional Council. The University of Waikato, Hamilton. 18 pp. ISSN 2350-3432

Jeppesen E., Søndergaard M., Kanstrup E., Petersen B., Henriksen R.B., Hammershøj M., Mortensen E., Jensen J.P., & Have A. 1994. Does the impact of nutrients on biological structure and function of brackish and freshwater lakes differ? Hydrobiologia 275/276: 15–30.

Jeppesen E., Søndergaard M., Meerhoff M., Lauridsen T., Jensen J. 2007. Shallow lake restoration by nutrient loading reduction-some recent findings and challenges ahead. Hydrobiologia 584: 239-252.

Kelly D., Shearer K., Schallenberg M. 2013. Nutrient loading to shallow coastal lakes in Southland for sustaining ecological integrity values. Prepared for Environment Southland by Cawthron Institute. Report No. 2375

Kennedy P., Allen G and Wilson, N 2016. The management of hydrocarbons in stormwater runoff: a literature review. Prepared by Golder Associates (NZ) Limited for Auckland Council. Auckland Council technical report, TR 2016/010

Kilroy C; Biggs B 2002. Use of the SHMAK clarity tube for measuring water clarity: Comparison with the black disk method, *New Zealand Journal of Marine and Freshwater Research, 36*:3, 519-527, DOI: 10.1080/00288330.2002.9517107

Lewis G P, Mitchell J D, Andersen C B, Haney D C, Liao M K, Sargent K A 2007. Urban influences on stream chemistry and biology in the Big Brushy Creek watershed, South Carolina. *Water Air and Soil Pollution*, 182: 303-323

McDowell RW, Snelder TH, Cox N 2013. Establishment of reference conditions and trigger values for chemical, physical and micro-biological indicators in New Zealand streams and rivers. AgResearch Client Report. Prepared for the Ministry for the Environment.

Ministry for the Environment and Ministry of Health 2003. Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas. Ministry for the Environment

Ministry for the Environment. 2021. Defining 'natural wetlands' and 'natural inland wetlands'. Wellington: Ministry for the Environment.

Moores J, Pattinson P, Hyde C 2009. *Enhancing the control of contaminants from New Zealand's roads: results of a road runoff sampling programme*. New Zealand Transport Agency research report 395. 161p.

Nagels J.W.; Davies Colley R.J.; Donnison A.M; Muirhead R.W. 2002. Faecal contamination over flood events in a pastoral agricultural stream in New Zealand. *Water Science and Technology 45*(12): 45–52.

New Zealand Government 2020. National Policy Statement for Freshwater Management (amended 2020).

Olsen DA, Tremblay L, Clapcott J, Holmes R 2012. *Water temperature criteria for native aquatic biota*. Prepared for Auckland Council, Environment Waikato and Hawkes Bay Regional Council. Cawthron Report No. 2024. Auckland Council Technical Report 2012/036.

Opus 2017. Whakatāne Stormwater Catchment Management Plan. *Ecological values assessment Hinemoa Stream and Apanui Stream*. Prepared for Whakatāne District Council by P Deegan, Opus International Consultants.

OSNZ 2006. Classified, summarised notes, BOP/Volcanic Plateau, 1 July 2003 – 30 June 2006. Ornithological Society of New Zealand (OSNZ).

Pachepsky Y., Shelton D. 2011. Escherichia Coli and Faecal Coliforms in Freshwater and Estuarine Sediments. *Critical Reviews in Environmental Science and Technology 41*(12):1067-1110

Rowe D.K., A. M. Suren, M. Martin, J. P. Smith, B. Smith, E. Williams 2002. *Lethal turbidity levels for common freshwater fish and invertebrates in Auckland streams*. Auckland Regional Council Technical Publication Number 337. 37 p.

Richardson J, Boubee JAT, West D 1994. Thermal tolerance and preference of some native New Zealand freshwater fish. *New Zealand Journal of Marine and Freshwater Research 28*: 399-407.

Rier S.T., Stevenson R.J. 2006. Response of periphytic algae to gradients in nitrogen and phosphorus in streamside mesocosms. *Hydrobiologia 561*:131–147.

Robertson H.A., Baird K.A., Elliott G.P., Hitchmough R.A., McArthur N.J., Makan T., Miskelly C.M., O'Donnell C.J., Sagar P.M., Scofield R.P., Taylor G.A. and Michel P. 2001. Conservation status of birds in Aotearoa New Zealand, 2021. *New Zealand Threat Classification Series 36*. Department of Conservation, Wellington. 43 p.

Roper-Lindsay J., Fuller S.A., Hooson, S., Sanders, M.D., Ussher, G.T. 2018. Ecological impact assessment. EIANZ guidelines for use in New Zealand: terrestrial and freshwater ecosystems. 2nd edition. Prepared for the Environment Institute of Australia and New Zealand (EIANZ).

Schallenberg M. 2014. Determining the reference condition of New Zealand lakes. Science for Conservation Series. Prepared for Department of Conservation by Hydrosphere Research Ltd.

Scholes P. 2005. *Water Treatment Trial Sullivan Lake*. Environment Bay of Plenty Environmental. Environmental Publication 2005/27.

Scholes P. 2008. *Water Treatment Trial Sullivan Lake DRAFT*. Environment Bay of Plenty Environmental. Environmental Publication.

Scholes P. 2008. Effluent discharge receiving water impact report 2008. Bay of Plenty Regional Council Environmental Publication 2008/10

Stark J. D. 1985: A macroinvertebrate community index of water quality for stony streams. *Water and Soil Miscellaneous Publication 87*.

Stark J.D. 1998. SQMCI: A biotic index for freshwater macroinvertebrate coded abundance data. *New Zealand Journal of Marine and Freshwater Research 32*: 55-66.

Storey R, Brierley G, Clapcott J, Collier K, Kilroy C, Franklin P, Moorhouse C and Wells R 2013. *Ecological responses to urban stormwater hydrology*. Prepared by NIWA for Auckland Council. Auckland Council technical report TR2013/033.

Suren A. 2016. *Development of a Fish Index of Biotic Integrity for the Bay of Plenty*. Bay of Plenty Regional Council

Tatrai I., Boros G., Gyorgy A., Matyas K., Korponai J., Pomogyi P., Havasi M. & Kucserka T. 2009. Abrupt shift from clear to turbid state in a shallow eutrophic, biomanipulated lake. *Hydrobiologia. 620*: 149–161.

USEPA 2006. National recommended water quality criteria for toxic pollutants. United States Environmental Protection Agency.

Young D, Afoa E, Meijer K, Wagenhoff A, Utech C 2013. *Temperature as a contaminant in streams in the Auckland region, stormwater issues and management options*. Prepared by Morphum Environment Ltd for Auckland Council. Auckland Council technical report, TR2013/044

Walsh CJ, Roy AH, Feminella JW, Cottongham PD, Groffman PM, Morgan II RP 2005. The urban stream syndrome: current knowledge and the search for a cure. *Journal of the North American Benthological Society, 24*(3): 706-723.

Whakatāne District Council 2015. *Sullivan Lake Reserve Management Plan*. Whakatāne District Council. *(A1122146).*

Wood P. J.; Armitage P. D. 1997. Biological effects of fine sediment in the lotic environment. *Environmental Management 21*: 203-217.

WSP Opus 2019. *Stormwater monitoring report*. Prepared for Whakatāne District Council by J. Gladwin, SWP Opus International Consultants, March 2019.

WSP 2021. Whakatāne Urban Area Stormwater Catchment Description. Prepared for Whakatāne District Council by James Gladwin, WSP. *(A1339422)*.

# Appendix 1: NPS-FM Attributes

## Summary of NPS-FM Appendix 2A: Attributes requiring limits on resource consents

| River/Lake | Attribute | Statistic | Units | Band A | Band B | Band C | Band D | Band E |
|---|---|---|---|---|---|---|---|---|
| River, Lake | NH4-N | Median | mg/L | ≤0.03 | **≤0.24** | ≤1.3 | >1.3 | |
| River, Lake | NH4-N | Maximum | mg/L | ≤0.05 | **≤0.4** | ≤2.2 | >2.2 | |
| River | NO3-N | Median | mg/L | ≤1 | **≤2.4** | ≤6.9 | >6.9 | |
| River | NO3-N | 95%ile | mg/L | ≤1.5 | **≤3.5** | ≤9.8 | >9.8 | |
| River, Lake | *E.coli* bacteria | % samples >260 cfu/100ml | % | ≤20% | ≤30% | ≤34% | ≤50% | >50% |
| River, Lake | *E.coli* bacteria | % samples >540 cfu/100 ml | % | ≤5% | ≤10% | ≤20% | ≤30% | >30% |
| River, Lake | *E.coli* bacteria | Median | *E.coli* / 100mL | ≤130 | ≤130 | ≤130 | ≤260 | >260 |
| River, Lake | *E.coli* bacteria | 95%ile | *E.coli* / 100mL | ≤540 | ≤1000 | ≤1200 | ≤1200 | >1200 |
| River/Lake | Periphyton default class | Exceeded <8% of samples | mg *chl-a* /m$^2$ | ≤50 | ≤120 | **≤200** | >200 | |
| River point source | DO (point source) | 7-day min. summer | mg/L | ≥8 | ≥7 | **≥5** | <5 | |
| River point source | DO (point source) | 1-day min. summer | mg/L | ≥7.5 | ≥5 | **≥4** | <4 | |
| River | Visual clarity (Class 2) | Median | m | ≥0.93 | ≥0.76 | **≥0.61** | <0.61 | |
| River | Visual clarity (Class 3) | Median | m | ≥2.95 | ≥2.57 | **≥2.22** | <2.22 | |
| Lake | Phytoplankton | Median | mg *chl-a* /m$^3$ | ≤2 | ≤5 | **≤12** | >12 | |
| Lake | Phytoplankton | Maximum | mg *chl-a* /m$^3$ | ≤10 | ≤25 | **≤60** | >60 | |
| Lake | TN (stratified) | Median | mg/m$^3$ | ≤160 | ≤350 | **≤750** | >750 | |
| Lake | TN (polymictic) | Median | mg/m$^3$ | ≤300 | ≤500 | **≤800** | >800 | |
| Lake | TP | Median | mg/m$^3$ | ≤10 | ≤20 | **≤50** | >50 | |
| Lake | Cyanobacteria biovolume | 80%ile of potentially toxic cyanobacteria | mm$^3$/L | ≤0.5 | ≤1.0 | **≤1.8** | >1.8 | |

## Table 1 – Phytoplankton (trophic state)

| | | |
|---|---|---|
| **Value (and component)** | **Ecosystem health (Aquatic Life)** | |
| **Freshwater body type** | **Lakes** | |
| **Attribute unit** | **mg chl-*a*/ m$^3$ (milligrams chlorophyll-*a* per cubic metre)** | |
| **Attribute band and description** | **Numeric attribute state** | |
| | **Annual median** | **Annual maximum** |
| **A**<br>Lake ecological communities are healthy and resilient, similar to natural reference conditions. | ≤2 | ≤10 |
| **B**<br>Lake ecological communities are slightly impacted by additional algal and/or plant growth arising from nutrient levels that are elevated above natural reference conditions. | >2 and ≤5 | >10 and ≤25 |
| **C**<br>Lake ecological communities are moderately impacted by additional algal and plant growth arising from nutrient levels that are elevated well above natural reference conditions. Reduced water clarity is likely to affect habitat available for native macrophytes. | >5 and ≤12 | >25 and ≤60 |
| **National bottom line** | **12** | **60** |
| **D**<br>Lake ecological communities have undergone or are at high risk of a regime shift to a persistent, degraded state (without native macrophyte/seagrass cover), due to impacts of elevated nutrients leading to excessive algal and/or plant growth, as well as from losing oxygen in bottom waters of deep lakes. | >12 | >60 |
| For lakes and lagoons that are intermittently open to the sea, monitoring data should be analysed separately for closed periods and open periods. | | |

## Table 3 – Total nitrogen (trophic state)

| | | |
|---|---|---|
| **Value (and component)** | Ecosystem health (Water quality) | |
| **Freshwater body type** | Lakes | |
| **Attribute unit** | mg/m$^3$ (milligrams per cubic metre) | |
| **Attribute band and description** | **Numeric attribute state** | |
| | **Annual median** | **Annual median** |
| | Seasonally stratified and brackish | Polymictic |
| A<br>Lake ecological communities are healthy and resilient, similar to natural reference conditions. | ≤160 | ≤300 |
| B<br>Lake ecological communities are slightly impacted by additional algal and/or plant growth arising from nutrient levels that are elevated above natural reference conditions. | >160 and ≤350 | >300 and ≤500 |
| C<br>Lake ecological communities are moderately impacted by additional algal and plant growth arising from nutrient levels that are elevated well above natural reference conditions. | >350 and ≤750 | >500 and ≤800 |
| **National bottom line** | **750** | **800** |
| D<br>Lake ecological communities have undergone or are at high risk of a regime shift to a persistent, degraded state (without native macrophyte/seagrass cover), due to impacts of elevated nutrients leading to excessive algal and/or plant growth, as well as from losing oxygen in bottom waters of deep lakes. | >750 | >800 |
| For lakes and lagoons that are intermittently open to the sea, monitoring data should be analysed separately for closed periods and open periods. | | |

## Table 4 – Total phosphorus (trophic state)

| **Value (and component)** | Ecosystem health (Water quality) |
|---|---|
| **Freshwater body type** | Lakes |
| **Attribute unit** | mg/m³ (milligrams per cubic metre) |
| **Attribute band and description** | **Numeric attribute state** |
| | Annual median |
| **A**<br>Lake ecological communities are healthy and resilient, similar to natural reference conditions. | ≤10 |
| **B**<br>Lake ecological communities are slightly impacted by additional algal and plant growth arising from nutrient levels that are elevated above natural reference conditions. | >10 and ≤20 |
| **C**<br>Lake ecological communities are moderately impacted by additional algal and plant growth arising from nutrient levels that are elevated well above natural reference conditions. | >20 and ≤50 |
| **National bottom line** | **50** |
| **D**<br>Lake ecological communities have undergone or are at high risk of a regime shift to a persistent, degraded state (without native macrophyte/seagrass cover), due to impacts of elevated nutrients leading to excessive algal and/or plant growth, as well as from losing oxygen in bottom waters of deep lakes. | >50 |
| For lakes and lagoons that are intermittently open to the sea, monitoring data should be analysed separately for closed periods and open periods. | |

| | | |
|---|---|---|
| **Value (and component)** | Ecosystem health (Water quality) | |
| **Freshwater body type** | Rivers and lakes | |
| **Attribute unit** | mg $NH_4$-N/L (milligrams ammoniacal-nitrogen per litre) | |
| **Attribute band and description** | **Numeric attribute state** | |
| | Annual median | Annual maximum |
| **A**<br>99% species protection level: No observed effect on any species tested. | ≤0.03 | ≤0.05 |
| **B**<br>95% species protection level: Starts impacting occasionally on the 5% most sensitive species. | >0.03 and ≤0.24 | >0.05 and ≤0.40 |
| **National bottom line** | **0.24** | **0.40** |
| **C**<br>80% species protection level: Starts impacting regularly on the 20% most sensitive species (reduced survival of most sensitive species). | >0.24 and ≤1.30 | >0.40 and ≤2.20 |
| **D**<br>Starts approaching acute impact level (that is, risk of death) for sensitive species. | >1.30 | >2.20 |
| Numeric attribute state is based on pH 8 and temperature of 20°C. Compliance with the numeric attribute states should be undertaken after pH adjustment. | | |

| | | |
|---|---|---|
| **Value (and component)** | Ecosystem health (Water quality) | |
| **Freshwater body type** | Rivers | |
| **Attribute unit** | mg $NO_3$ – N/L (milligrams nitrate-nitrogen per litre) | |
| **Attribute band and description** | **Numeric attribute state** | |
| | Annual median | Annual 95th percentile |
| **A**<br>High conservation value system. Unlikely to be effects even on sensitive species. | ≤1.0 | ≤1.5 |
| **B**<br>Some growth effect on up to 5% of species. | >1.0 and ≤2.4 | >1.5 and ≤3.5 |
| **National bottom line** | **2.4** | **3.5** |
| **C**<br>Growth effects on up to 20% of species (mainly sensitive species such as fish). No acute effects. | >2.4 and ≤6.9 | >3.5 and ≤9.8 |
| **D**<br>Impacts on growth of multiple species, and starts approaching acute impact level (that is, risk of death) for sensitive species at higher concentrations (>20 mg/L). | >6.9 | >9.8 |
| This attribute measures the toxic effects of nitrate, not the trophic state. Where other attributes measure trophic state, for example periphyton, freshwater objectives, limits and/or methods for those attributes may be more stringent. | | |

## Table 7 – Dissolved oxygen

| Value (and component) | Ecosystem health (Water quality) | |
|---|---|---|
| Freshwater body type | Rivers (below point sources only) | |
| Attribute unit | mg/L (milligrams per litre) | |
| **Attribute band and description** | **Numeric attribute state** | |
| | 7-day mean minimum (summer period: 1 November to 30th April) | 1-day minimum (summer period: 1 November to 30th April) |
| A<br>No stress caused by low dissolved oxygen on any aquatic organisms that are present at matched reference (near-pristine) sites. | ≥8.0 | ≥7.5 |
| B<br>Occasional minor stress on sensitive organisms caused by short periods (a few hours each day) of lower dissolved oxygen. Risk of reduced abundance of sensitive fish and macroinvertebrate species. | ≥7.0 and <8.0 | ≥5.0 and <7.5 |
| C<br>Moderate stress on a number of aquatic organisms caused by dissolved oxygen levels exceeding preference levels for periods of several hours each day. Risk of sensitive fish and macroinvertebrate species being lost. | ≥5.0 and <7.0 | ≥4.0 and <5.0 |
| **National bottom line** | **5.0** | **4.0** |
| D<br>Significant, persistent stress on a range of aquatic organisms caused by dissolved oxygen exceeding tolerance levels. Likelihood of local extinctions of keystone species and loss of ecological integrity. | <5.0 | <4.0 |

The 7-day mean minimum is the mean value of seven consecutive daily minimum values.

The 1-day minimum is the lowest daily minimum across the whole summer period.

## Table 8 – Suspended fine sediment

| | | | | |
|---|---|---|---|---|
| **Value (and component)** | Ecosystem health (Water quality) | | | |
| **Freshwater body type** | Rivers | | | |
| **Attribute unit** | Visual clarity (metres) | | | |
| **Attribute band and description** | **Numeric attribute state by suspended sediment class** | | | |
| | **1** | **2** | **3** | **4** |
| **A**<br>Minimal impact of suspended sediment on instream biota. Ecological communities are similar to those observed in natural reference conditions. | ≥1.78 | ≥0.93 | ≥2.95 | ≥1.38 |
| **B**<br>Low to moderate impact of suspended sediment on instream biota. Abundance of sensitive fish species may be reduced. | <1.78 and ≥1.55 | <0.93 and ≥0.76 | <2.95 and ≥2.57 | <1.38 and ≥1.17 |
| **C**<br>Moderate to high impact of suspended sediment on instream biota. Sensitive fish species may be lost. | <1.55 and >1.34 | <0.76 and >0.61 | <2.57 and >2.22 | <1.17 and >0.98 |
| **National bottom line** | **1.34** | **0.61** | **2.22** | **0.98** |
| **D**<br>High impact of suspended sediment on instream biota. Ecological communities are significantly altered and sensitive fish and macroinvertebrate species are lost or at high risk of being lost. | <1.34 | <0.61 | <2.22 | <0.98 |

The minimum record length for grading a site is the median of 5 years of at least monthly samples (at least 60 samples).

Councils may monitor turbidity and convert the measures to visual clarity.

See Appendix 2C Tables 23 and 26 for the definition of suspended sediment classes and their composition.

The following are examples of naturally occurring processes relevant for suspended sediment:

- naturally highly coloured brown-water streams
- glacial flour affected streams and rivers
- selected lake-fed REC classes (particularly warm climate classes) where low visual clarity may reflect autochthonous phytoplankton production.

## Table 9 – *Escherichia coli* (*E. coli*)

| | | | | |
|---|---|---|---|---|
| **Value** | Human contact | | | |
| **Freshwater body type** | Lakes and rivers | | | |
| **Attribute unit** | *E. coli*/100 mL (number of *E. coli* per hundred millilitres) | | | |
| **Attribute band and description** | **Numeric attribute state** | | | |
| Description of risk of *Campylobacter* infection (based on *E. coli* indicator) | % exceedances over 540/100 mL | % exceedances over 260/100 mL | Median concentration /100 mL) | 95th percentile of *E. coli*/100 mL |
| A (Blue)<br>For at least half the time, the estimated risk is <1 in 1,000 (0.1% risk).<br>The predicted average infection risk is 1%. | <5% | <20% | ≤130 | ≤540 |
| B (Green)<br>For at least half the time, the estimated risk is <1 in 1,000 (0.1% risk).<br>The predicted average infection risk is 2%. | 5-10% | 20-30% | ≤130 | ≤1000 |
| C (Yellow)<br>For at least half the time, the estimated risk is <1 in 1,000 (0.1% risk).<br>The predicted average infection risk is 3%. | 10-20% | 20-34% | ≤130 | ≤1200 |
| D (Orange)<br>20-30% of the time the estimated risk is ≥50 in 1,000 (>5% risk).<br>The predicted average infection risk is >3%. | 20-30% | >34% | >130 | >1200 |
| E (Red)<br>For more than 30% of the time the estimated risk is ≥50 in 1,000 (>5% risk).<br>The predicted average infection risk is >7%. | >30% | >50% | >260 | >1200 |

Attribute state should be determined by using a minimum of 60 samples over a maximum of 5 years, collected on a regular basis regardless of weather and flow conditions. However, where a sample has been missed due to adverse weather or error, attribute state may be determined using samples over a longer timeframe.

Attribute state must be determined by satisfying all numeric attribute states.

The predicted average infection risk is the overall average infection to swimmers based on a random exposure on a random day, ignoring any possibility of not swimming during high flows or when a surveillance advisory is in place (assuming that the *E. coli* concentration follows a lognormal distribution). Actual risk will generally be less if a person does not swim during high flows.

## Table 10 – Cyanobacteria (planktonic)

| **Value** | Human contact |
|---|---|
| **Freshwater body type** | Lakes and lake fed rivers |
| **Attribute unit** | Biovolume mm³/L (cubic millimetres per litre) |
| **Attribute band and description** | **Numeric attribute state** |
| | 80th percentile |
| **A (Blue)**<br>Risk exposure from cyanobacteria is no different to that in natural conditions (from any contact with freshwater). | ≤0.5 mm³/L biovolume equivalent for the combined total of all cyanobacteria |
| **B (Green)**<br>Low risk of health effects from exposure to cyanobacteria (from any contact with freshwater). | >0.5 and ≤1.0 mm³/L biovolume equivalent for the combined total of all cyanobacteria |
| **C (Yellow)**<br>Moderate risk of health effects from exposure to cyanobacteria (from any contact with freshwater). | >1.0 and ≤1.8 mm³/L biovolume equivalent of potentially toxic cyanobacteria OR<br>>1.0 and ≤10 mm³/L total biovolume of all cyanobacteria |
| **National bottom line** | **1.8 mm³/L biovolume equivalent of potentially toxic cyanobacteria**<br>**OR**<br>**10 mm³/L total biovolume of all cyanobacteria** |
| **D (Orange/Red)**<br>High health risks (for example, respiratory, irritation and allergy symptoms) exist from exposure to cyanobacteria (from any contact with freshwater). | >1.8 mm³/L biovolume equivalent of potentially toxic cyanobacteria<br>OR<br>>10 mm³/L total biovolume of all cyanobacteria |
| The 80th percentile must be calculated using a minimum of 12 samples collected over 3 years. Thirty samples collected over 3 years is recommended. | |

## Summary of NPS-FM Appendix 2A: Attributes requiring Action Plans

| River/Lake | Attribute | Statistic | units | Band A | Band B | Band C | Band D | Band E |
|---|---|---|---|---|---|---|---|---|
| Lake | Cyanobacteria biovolume | 80%ile of potentially toxic cyanobacteria | mm$^3$/L | ≤0.5 | ≤1.0 | **≤1.8** | >1.8 | |
| Lake | Submerged Plants Native Condition Index) | | % | >75 | >50 | **≥20** | <20 | |
| Lake | Submerged Plants Invasive Condition Index) | | % | ≤1 | ≤25 | **≤90** | >90 | |
| River | Fish IBI | Mean | | ≥34 | ≥28 | ≥18 | <18 | |
| River | Macroinvertebrates QMCI | Median | | ≥6.5 | ≥5.5 | **≥4.5** | <4.5 | |
| River | Macroinvertebrates MCI | Median | | ≥130 | ≥110 | **≥90** | <90 | |
| River | Macroinvertebrates ASPM | Median | | ≥0.6 | ≥0.4 | **≥0.3** | <0.3 | |
| River | Deposited fine sediment (Class 1) | Median | % | ≤7 | ≤14 | **≤21** | >21 | |
| River | Deposited fine sediment (Class 2) | Median | % | ≤10 | ≤19 | **≤29** | >29 | |
| River | Deposited fine sediment (Class 3) | Median | % | ≤9 | ≤18 | **≤27** | >27 | |
| River | Deposited fine sediment (Class 4) | Median | % | ≤13 | ≤19 | **≤27** | >27 | |
| River | DO | 7-day min | mg/L | ≥8 | ≥7 | **≥5** | <5 | |
| River | DO | 1-day min | mg/L | ≥7.5 | ≥5 | **≥4** | <4 | |
| Lake | Lake-bottom DO | annual minimum | mg/L | ≥7.5 | ≥2 | **≥0.5** | <0.5 | |
| Lake | Mid-hypolimnetic depth | annual minimum | mg/L | ≥7.5 | ≥5 | **≥4** | <4 | |
| River | DRP | Median | mg/L | ≤0.006 | ≤0.01 | ≤0.018 | >0.018 | |
| River | DRP | 95%ile | mg/L | ≤0.021 | ≤0.03 | ≤0.054 | >0.054 | |
| River, Lake | *E.coli* bacteria Primary Contact sites | 95%ile | *E.coli* / 100mL | ≤130 | ≤260 | **≤540** | >540 | |
| River | Ecosystem metabolism | | g O$_2$/m/d | | | | | |

# Appendix 2: Ecological issues and potential mitigation option for Awatapu Lagoon

These ecological issues and potential mitigation options take a wholistic approach that extends beyond just the effects associated with stormwater.

| Ecological issues Awatapu | Causes | Potential mitigation options |
|---|---|---|
| Supertrophic high concentration of nutrients, algae, poor clarity. Cyanobacteria blooms. | External nutrient load | ○ Sediment & nutrient control devices in catchment<br>○ Sediment detention bunds in upper catchment<br>○ Avoid any sewage overflows<br>○ Encourage macrophyte growth in WTW Stream to takeup dissolved nutrients.<br>○ Remove fine sediment from WTW Stream delta<br>○ Floating wetlands for N removal and habitat.<br>○ Create treatment wetlands in-lake.<br>○ Harvest aquatic macrophytes and remove from catchment. |
| | Internal nutrient load via sediment resuspension or anoxia | ○ Harvest Azolla sp.<br>○ Dredging of fine sediment<br>○ Sediment capping. Needs careful attention to material used. |
| | Bottom water anoxia | ○ Harvest aquatic macrophytes to reduce BOD load during decomposition |
| Poor oxygen conditions | Floating macrophyte mats | ○ Harvest aquatic macrophytes |
| | Halocline stratification in Western lagoon | ○ Naturally occuring and may have limited impact if brocken only during high flow events. |
| | Negligible flow in South lagoon | Divert WTW Stream into South Lagoon by building penisulars and a culvert under Bridge Street.<br>Create a piped connection to Whakatāne River (contingent on sufficient hydraulic head) |
| Excessive aquatic plant cover affecting biodiversity and aesthetics | Pest plants of hornwort and parrots feather as floating rafts and rooted in shallow areas. | ○ Harvest aquatic macrophytes<br>○ Herbicide spray of aquatic macrophytes (has risk of aggrevating issues of low DO and high nutrients). |
| Pest plants on riparian zone | Glyceria maxima near the foot bridge | ○ Targeted herbicide spray |
| Litter | Rubbish directly and via stormwater | ○ Street sweeping<br>○ Litter traps<br>○ Regular "pick-ups" |
| Riparian management resticting development of marginal wetlands | | ○ Plant native riparian vegetaion to optimise habitat values.<br>○ Create shallow sloping banks into water and plant with wetlands. |
| Poor access to the water | Lack of structures in water | ○ Construct jetties and boat launcing areas. |