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Baseline Ecological Report – Hihi Stream at Hihi Wastewater Treatment Plant

Far North District Council

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Prepared for

Far North District Council

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Limitations:

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Executive Summary

Far North District Council (FNDC) engaged Pattle Delamore Partners (PDP) to undertake ecological and water quality investigations to assess the effects of the Hihi Wastewater Treatment Plant (WWTP) discharge on the receiving environment (Hihi Stream). These investigations are required to support the renewal of the Northland Regional Council (NRC) resource consent CON20100739901, which authorises existing discharges from the WWTP.

PDP conducted ecological surveys on the 24th and 25th of January 2022 across six representative reaches of the Hihi Stream. Surveys included habitat assessments, macroinvertebrate samples and fish surveys. Three sites were selected upstream of the WWTP discharge location (50 m, 100 m and 150 m), to represent replicate control sites within the receiving environment and three sites were selected downstream of the WWTP discharge location (50 m, 100 m and 130 m), to represent impact sites. In addition, PDP collected a water sample at 50 m downstream in accordance with the Proposed Regional Plan – Northland definition for mixing zone, as the FNDC compliance monitoring site was calculated to be 40 m and therefore was within the mixing zone. Surface water samples were measured for a range of nutrients, *Escherichia coli* (*E. coli*) and Nocardia bacteria. Additional Nocardia bacteria samples were also collected from the effluent and wetland discharge for comparison.

Results of water quality sampling, habitat assessments and macroinvertebrate surveys show the current Hihi WWTP discharge has an impact on water quality and has contributed to poor stream health in the Hihi Stream. The water quality parameters that were most impacted by the WWTP discharge include ammoniacal nitrogen, dissolved reactive phosphorus, dissolved oxygen, and *E. coli* and are summarised below:

- Ammoniacal nitrogen concentrations exceeded the consent condition six times over the past 12 months. These exceedances ranged between 2.1 – 17 mg/L.
- Elevated DIN concentrations (likely due to the high ammoniacal nitrogen concentrations).
- Elevated nitrate concentrations exceeded the ANZG DGV but were below the PRPN and NPS-FM national bottom line guidelines.
- Low dissolved oxygen was likely caused by stream physical characteristics such as low hydraulic heterogeneity and not necessarily water quality. However slight decreases in dissolved oxygen due to the discharge could exacerbate conditions and contribute to poorer stream health.
- *E. coli* was potentially above the PRNP standards and the lowest NPS-FM attribute class. However, these results are indicative only as larger data sets are required.

- *E. coli* concentrations were higher in the impact reach compared to the control reach, indicating inputs from the discharge; however, dilution is occurring as concentration of *E. coli* does improve further downstream.

Macroinvertebrate community index (MCI) scores within the impact reach fall below the National Policy Statement – Freshwater Management (NPS-FM 2020) national bottom line and are lower than the control reach upstream of the WWTP discharge. This likely corresponds to the observed reduction of instream habitat quality below the discharge point and potential impacts from reduced water quality downstream of the discharge. Fish recorded at the site include banded kokopu (*Galaxias fasciatus),* and an unidentified eel (*Anguilla* sp). Freshwater shrimp were also recorded *(Paratya curvirostris*).

Nocardia bacteria filament numbers were lower (not present) in the Hihi Stream and the wetland discharge than measured in the effluent (moderate), indicating removal was occurring at the time of sampling between the effluent and the discharge point. The potential effects of Nocardia on people and animals at the measured levels discharging from the Hihi WWTP are considered to be minimal.

Overall, the results of this assessment demonstrate that there is an effect on the water quality and ecology of the Hihi Stream from the current WWTP discharge.

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1.0 Introduction

Far North District Council (FNDC) has engaged Pattle Delamore Partners (PDP) to undertake ecological and water quality investigations to assess the effects of the discharge from the Hihi Wastewater Treatment Plant (WWTP) on the receiving environment (Hihi Stream).

The Hihi WWTP is located on the southern side of the Hihi township and wastewater is pumped from the WWTP to a constructed wetland 800 m north of the site adjacent to Hihi Stream. Treated wastewater then flows through the constructed wetland to Hihi Stream. Discharge to Hihi Stream is currently authorised by Northland Regional Council (NRC) resource consent CON20100739901 (NRC discharge consent), issued in 2011, this consent is due to expire in November 2022. In preparation for the renewal of the resource consent, an assessment of the ecological effects of the discharge on the receiving environment is required.

1.1 Background

The site is located 500 m northeast of Hihi Beach which is a peninsular just north of Mangonui, Northland (Figure 1). The site is bounded by pastoral exotic grass and sections of native bush. Wastewater from the Hihi township is treated at the WWTP on the south end of the peninsular and piped north to the site which comprises of an artificial constructed wetland. Once the discharge passes through the wetland it discharges into the Hihi Stream.

FNDC conduct fortnightly water quality compliance sampling, as required by the NRC discharge consent, at the following locations:

- The effluent (NRC sampling site 100165 – UV treatment);
- The discharge from the constructed wetland (NRC sampling site 101874); and,
- Hihi Stream upstream (US) and downstream (DS) sampling sites (NRC sampling site 101130 and 108481 respectively).

Compliance monitoring requirements include pH, temperature, dissolved oxygen (DO), ammoniacal-nitrogen and *Escherichia coli (E. coli)* at the four locations listed above. After 2013, *E. coli* was dropped from the monitoring, as per consent condition 8.

FNDC has also commissioned WSP Opus to produce a performance assessment report, to identify WWTP upgrade options to achieve compliance with the new water quality treatment standards of the Proposed Regional Plan – Northland (PRPN) and to inform the renewal of the resource consent.

It is understood by PDP that the bacteria Nocardia has been present in the plant and caused issues throughout the year, particularly during the summer months. Excessive Nocardia presence can cause extra foaming and poor sludge settlement, which reduces effluent quality and produces strong odours and is required to be considered in this assessment (WSP Opus, 2022).

This report documents the findings of the ecological assessment and water quality investigations on the Hihi Stream to determine the effects of the WWTP discharge.

1.2 Project Scope

The scope of PDP's investigation to assess the effects of the WWTP discharge on the Hihi Stream is outlined below.

- **Effects of the wastewater discharge on the receiving environment**
  - A detailed assessment of the effects of the current discharge on the receiving environment (Hihi Stream).
  - Identification of strategies to avoid, remedy or mitigate any significant adverse effects on ecological values associated with the discharge.
  - Recommendations for on-going monitoring to establish any trends in respect of any potentially significant long-term effects of the discharge on the receiving environment.
  - An assessment of the effects of the discharge against the relevant objectives and policies of the Regional Policy Statement for Northland and the Proposed Regional Plan for Northland.
- **Effects of Nocardia**
  - An assessment of the effects of the discharge of nocardia to the receiving environment.
  - Identification of strategies to avoid, remedy or mitigate any significant adverse effects on ecological values associated with the discharge of nocardia.
  - Recommendations for on-going monitoring to establish any trends in respect of any potentially significant long-term effects of the discharge of nocardia on the receiving environment.
  - An assessment of the effects of the discharge against the relevant objectives and policies of the Regional Policy Statement for Northland and the Proposed Regional Plan for Northland.

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FIGURE
FIG 1: SAMPLING LOCATIONS

PROJECT
HIHI WWTP ECOLOGICAL SURVEY

2.0 Desktop Review

A desktop review of existing information was undertaken to provide background data on the current condition and ecological values of the Hihi Stream or nearby watercourses. This included a review of previous reports, WWTP compliance and NRC monitoring data, literature and database searches of water quality and ecological parameters. In particular, the following resources were reviewed for information:

- Land, Air and Water Aotearoa (LAWA) website;
- Northland Regional Council website (online maps, reports, data);
- Far North District Council website (online maps, reports, data);
- New Zealand Freshwater Fish Database (NZFFD); and,
- WSP Opus Hihi WWTP Process Review (WSP Opus, 2022).

2.1 Physical Environment and Water Quality

The Hihi Stream has a catchment of ~29 ha, including its headwaters just northeast of the discharge point (REC, 2010). Treated wastewater is discharged into a constructed wetland along the true left bank of Hihi Stream. The wetland is approximately 130 m in length and contains seven ponds/cells of varying size (~25 to 80 m^2). Once the discharge passes through the wetland it discharges into the Hihi Stream which then flows for ~800 m to the ocean at Hihi Beach. The surrounding land use is a mixture of native bush and pastoral exotic grasses. Where the Hihi stream drains into Hihi Beach, the land use is residential housing.

Currently there is a paucity of water quality and ecological data for the Hihi region. A web search showed no nearby long-term monitoring sites (either NRC or LAWA). The closest monitoring site is Oruaiti @ Windust Road, which is 5 km south of Hihi Beach with no connected water bodies. The NRC State of Environment (SoE) report (NRC, 2015) yielded no information regarding Hihi or immediately adjacent regions. Overall, the SoE reported the three main contaminants of concern in Northland were faecal bacteria, sediment and nutrients.

2.1.1 FNDC Compliance Water Quality Monitoring

FNDC is required to monitor the effects of the Hihi WWTP discharge on the Hihi Stream. Since 2010, FNDC has been monitoring wastewater discharges in the Hihi Stream and Hihi WWTP, as outlined in Section 1.1 or this report.

Condition 8 of the NRC discharge consent can be summarised as the following –

'the discharges of treated wastewater shall not cause the following effects on water quality downstream site 108481

a) Temperature shall not change more than 3 degrees when compared to upstream.

b) pH shall be within 6.5 – 9.0, unless the upstream also falls outside this range.

c) DO (daily minimum) shall not decrease by more than 20% compared to upstream.

d) No production of oil, grease films, scums or foams, floatable or suspended materials or emissions of objectionable odour.

e) No acute toxicity or significant adverse effects of chronic toxicity to natural aquatic life by reason of presence of toxic substances.

f) Hue of water shall not change more than 10 Munsell units when compared to upstream. Visual clarity shall not change more than 35% when compared to upstream.

g) Waters shall not be so tainted to make them unpalatable to farm animals.

h) Increase in median E.coli shall not exceed 50/100 ml when compared to upstream. This condition shall cease once the upgraded treatment system require by Condition 6 has been commissioned.

i) The concentration of ammoniacal nitrogen shall not exceed the following table:

pH of water at the time of sampling	Total Ammoniacal Nitrogen ($[NH_3 + NH_4]$-N) (grams per cubic metre)
6.0	2.57
6.1	2.56
6.2	2.54
6.3	2.52
6.4	2.49
6.5	2.46
6.6	2.43
6.7	2.38
6.8	2.33
6.9	2.26
7.0	2.18
7.1	2.09
7.2	1.99
7.3	1.88
7.4	1.75
7.5	1.61
7.6	1.47
7.7	1.32
7.8	1.18
7.9	1.03
8.0	0.90
8.1	0.78
8.2	0.66
8.3	0.56
8.4	0.48
8.5	0.40
8.6	0.34
8.7	0.29
8.8	0.24
8.9	0.21
9.0	0.18

j) If ammoniacal nitrogen exceeds the above values, then it should not exceed increase ammoniacal nitrogen more than 0.1 mg/L when compared to the upstream sample.'

Data from the past five years (February 2017 to January 2022) was supplied to PDP and analysed to assess the potential ecological effects of the discharge on Hihi Stream (see Section 4.2).

2.1.2 Historic Nocardia Monitoring

Nocardia presence has been noted as an ongoing problem at the Hihi WWTP facility (WSP Opus, 2022; pers comms Jessica Crawford). However, there is currently no historic data on the presence or concentrations of Nocardia bacteria filaments available for PDP to assess.

2.2 Ecology

There is a paucity of ecological data for Hihi and the immediate surrounding areas. There has been no known macroinvertebrate, macrophyte or periphyton surveys completed in the area.

At the time of writing, no fish species had been recorded in the Hihi Stream according to the New Zealand Freshwater Fish Database (NZFFD, Jan 2022). Nearby catchments in the immediate area were identified to have five native fish species present, details of these species and their conservation status are outlined in Table 1 below.

Table 1: Native fish and invertebrate species recorded in catchments adjacent to Hihi Stream (NZFFD) and conservation status

Common Name	Scientific Name	Conservation Status
Banded kokopu	*Galaxias fasciatus*	Not threatened
Redfin bully	*Gobiomorphus huttoni*	At Risk
Giant bully	*Gobiomorphus gobioides*	Naturally uncommon
Long fin eel	*Anguilla dieffenbachia*	At Risk
Freshwater shrimp	*Paratya curvirostris*	Not threatened

Notes:
Conservation status from Dunn et.al., 2017 and Grainger et.al., 2018.

2.3 National and Regional Guidelines

To gain a better understanding of the potential effects of the WWTP discharge on the receiving environment; relevant regionally-derived and national water quality guidelines and plans were reviewed. Specifically, this included the:

- Water Quality Standards for Ecosystem Health in Rivers - Proposed Regional Plan for Northland (PRPN);
- Australian and New Zealand Guidelines (2018) Default Guideline Values (ANZG (2018) DGV); and,

- National Policy Statement for Freshwater Management (2020) (NPS-FM).

Proposed Regional Plan for Northland

The Proposed Regional Plan for Northland (appeals version) (PRPN) regulates the discharge of treated wastewater from wastewater treatment plants and sets the water quality treatment standards for discharges. The standards are currently subject to appeals and not yet operative, however it is assumed by FNDC that appeals will be resolved and that these standards will be made operative soon and therefore will be used as a guideline document in this report.

The zone of reasonable mixing has been calculated to be 50 m downstream of the discharge point (the minimum distance required by the PRPN). The current downstream site is approximately 40 metres downstream of the discharge point, as such, this means that FNDC's current downstream monitoring location is within the mixing zone.

ANZG Default Guideline Values

The ANZG (2018) (formerly ANZECC 2000) default guideline values (DGV) provide a national framework for assessing water quality based on physical, chemical and biological characteristics. These characteristics are specific to river classification zones. The Hihi Stream is classified as a 'warm-wet low elevation stream' by the River Environment Classification (REC, 2010).

The main focus of the ANZG DGVs is on water quality within the context of broader ecosystem health management and comparison to natural 'reference conditions'. The ANZG physical and chemical stressor DGVs have been defined to indicate that there is a 'potential risk' of adverse effects at a site. Two percentiles have been calculated for the DGVs, based on the stressor: 80th percentile for stressors (indicators) that are harmful at high values and 20th percentile for stressors that are harmful at low values. Falling within these DGVs is in reference to conditions that can be expected in rivers and streams of that type (i.e. Warm wet low-elevation) with minimal or no anthropogenic influence. Falling outside the 80th or 20th percentile indicates anthropogenic effects.

National Policy Framework – Freshwater Management (NPS-FM)

The NPS-FM (2020) national objectives framework (NOF) allows some parameters to be assessed against nationally consistent standards with water quality and ecological attribute bands and 'national bottom lines' for grading waterways based on the level of degradation. In this report NPS-FM values have been applied where possible. It should be noted that many limits are designed to be calculated through monthly monitoring over a five-year timeframe and any comparisons to single discrete measurements are indicative only.

Relevant water quality guidelines and standards are summarised in Table 2.

Macroinvertebrate Guidelines and Interpretation

A variety of commonly used metrics were used to assess the relative health of the macroinvertebrate communities and thus the health of a stream. A description of the metrics commonly used is provided below:

- Taxa richness: the number of different taxonomic groups present in a sample. Streams supporting a high number of different taxa generally indicate healthy communities;
- The number of and percent abundance of Ephemeroptera, Plecoptera, Trichoptera (EPT abundance and %EPT taxa, respectively) EPT abundance measures the number of these pollution sensitive taxa in a sample, while %EPT taxa measures the proportion of EPT within the sample. Both metrics have been calculated with the pollution tolerant *Hydroptilidae sp.* removed;
- Macroinvertebrate Community Index (MCI): allocates macroinvertebrate taxa a score between 1 (pollution tolerant) and 10 (pollution intolerant) depending on each taxon's tolerance to organic enrichment and is based on presence/absence data; and
- Quantitative Macroinvertebrate Community Index (QMCI): utilizes the same macroinvertebrate taxa scores as MCI. The QMCI gives an average score per taxon and is more sensitive to changes in abundance or sample size.

Stream health can be inferred from MCI and QMCI (Table 3 in following pages).

Table 2: Threshold water quality values following relevant guidelines

Parameter	Water Quality Standards for Ecosystem Health in Rivers -Northland Proposed Regional Plan[1]	ANZG (2018) Default Guideline Values[2,3]	NPS-FM (2020) National Bottom Line
pH	6.0 < pH < 9.0 (Annual minimum and maximum)	7.3 - 7.7	-
Temperature (°C)	< 24[4]	-	-
Electrical Conductivity (µs/cm)	-	115	-
Dissolved Oxygen (mg/L)	≥ 4.0 (1-day min) ≥ 5.0 (7-day min)	-	4.0 (1-day min) 5.0 (7-day mean min)
Dissolved Oxygen (% saturation)	-	92 - 103	-
Turbidity (NTU)	-	5.2	-
Total Suspended Solids (mg/L)	-	8.8	-
Nitrate nitrogen (mg/L)	≤ 1.0 (Annual median) ≤ 1.5 (Annual 95th percentile)	0.065	2.4 (Annual median) 3.5 (Annual 95th percentile)
Total Ammoniacal nitrogen (mg/L)	≤ 0.24 (Annual median) ≤ 0.40 (Annual maximum)[5]	0.01	0.24 (Annual median) 0.40 (Annual maximum) [5]
Total Nitrogen (mg/L)	-	0.292	-
Dissolved Reactive Phosphorus (mg/L)	-	0.014	>0.018 (Annual median) >0.054 (Annual 95th percentile) [6]
Total Phosphorus (mg/L)	-	0.024	-
E. coli (number/100 mL)	≤ 130 (Median concentration/100 mL) ≤ 540 (95th percentile) [7]	-	540[8]
E. coli (%)	≤ 5 (% exceedances over 540) ≤ 20 (% exceedances over 260) [7]	-	-

Notes:

1. *Assumed water quality standards for discharges from Policy H.3.1 of the PRP: water quality standards from continually or intermittently flowing rivers ("Other Rivers" standards). Standards apply after reasonable mixing.*
2. *ANZG (2018) default guideline values are specific to the River Environment Classification (REC) for the study streams: Warm Wet Low-elevation.*
3. *ANZG (2018) default guideline values refer to the 80th percentile reference values, apart from pH and DO which refer to the 20th and 80th percentile.*
4. *Summer period measurement of the Cox-Rutherford Index (CRI), averaged over the five hottest days (from inspection of a continuous temperature record).*
5. *Based on pH 8 and temperature of 20 °C. Compliance with the water quality standard should be undertaken after pH adjustment.*
6. *DRP attribute band D under NPS-FM (2020) Appendix 2B – Attributes requiring action plans.*
7. *Equivalent to Attribute State Band A of the NPS-FM (2020).*
8. *National bottom-line value under NPS-FM (2020) Appendix 2B – Attributes requiring action plans.*

Table 3: Benthic Macroinvertebrate Indices and Guideline Limits				
	Classification	**Descriptions**	**MCI-sb**	**QMCI-sb**
Quality Class[1]	Excellent	Clean water	>119	>6.00
	Good	Doubtful quality/possible mild pollution	100-119	5.00-5.99
	Fair	Probable moderate pollution	80-99	4.00-4.99
	Poor	Probable severe enrichment	<80	<4.00
NPS-FM (2020)	National 'bottom-line'	Community largely composed of taxa insensitive to inorganic pollution/nutrient enrichment	<90	<4.5

Notes:

1. *Quality class interpretations derived from Stark and Maxted (2007). See Table 5.*
2. *NOF refers to the NPS-FM (2020) National Objectives Framework. Values are indicative as the guidelines refers to the annual median over 5 years.*

2.4 WSP Opus Performance Report

WSP Opus was engaged by FNDC to provide a performance report as part of the process review for reconsenting the Hihi WWTP (WSP, 2022). The report covers the identification of current plant issues, capacity and needs for water quality improvements.

WSP Opus has highlighted that the current effluent quality does not achieve consented performance for ammoniacal nitrogen, dissolved oxygen and pH.

To meet requirements for the current consent conditions and other national and regional guidelines (NPS-FM, ANZG and PRPN) the plant requires an improvement in the treatment of water and the consistency of that treatment – particularly the removal of ammoniacal nitrogen.

As noted by WSP Opus, water flows in the Hihi Stream are low, as such dilution cannot be relied on to meet consent conditions and water quality guidelines. In order to protect the local ecology, a high treatment standard of effluent is required. This includes lowering ammoniacal nitrogen, Soluble Inorganic Nitrogen (SIN, including Ammoniacal nitrogen and Nitrate) pH, and phosphate concentrations.

WSP Opus has suggested a range of recommendations both short and long term. The following recommendations have been proposed:

- Increase the process capacity for flow and load;
- Improve ammoniacal nitrogen removal including alkalinity levels;
- Improve treatment to control pH levels within the median consent range;
- Incorporate treatment techniques to increase discharge DO concentrations;
- Reduce solids carry over from the wetland to discharge point;
- Prevent wetland leakage to the stream;
- Put measures in place to ensure minimum recreational water standards are met; and,
- Prevent bypassing of the treatment plant.

Short-term solutions to improve the plant performance include the following:

- Assessment and potential refurbishment of the wetland ponds, including addition of pond lining;
- Install a temporary baffle within the main treatment tank to prevent flow short circuiting;
- Make permanent the alum dosing system to enhance settlement and removal of phosphorous;
- Perform daily manual alkalinity dosing to increase pH, and improve ammoniacal nitrogen removal;
- Improve wetland discharge sample point, and consider methods of increasing oxygenation of effluent before discharge; and,
- Carry out a network conditions assessment, to ascertain whether there are any leaks in the system.

Long-term solutions include:

- The replacement of the WW treatment system with an MBR treatment system which will allow for more consistent water quality compliance. Specifics of the replacement are detailed in the WSP-Opus report (2022).

PDP has incorporated these recommendations into this Hihi Stream Ecological Effects Assessment.

3.0 Methodology

Field assessments were carried out at Hihi Stream on the 23rd and 24th January 2022 during fine weather conditions, more than three weeks following the most recent significant high-flow event (i.e., >3-fold average flow). Assessments aimed to characterise the ecological condition of the Hihi Stream upstream and downstream of the consented wastewater discharge. Representative site photographs are provided in Appendix A.

A total of six assessment reaches were established in the Hihi Stream, each measuring 50 m long to sufficiently capture instream habitat variability. The assessment locations comprised of three control reaches upstream, and three impact reaches downstream of the discharge and wetland. Due to a piped inlet at the 130 m mark downstream, the last reach was shortened to 30 m to avoid any additional effects from flows from the pipe. Site locations are shown on Figure 1.

Water quality sampling was only conducted at some sites to avoid double ups with the FNDC fortnightly compliance monitoring. Due to *E. coli* being dropped in 2013 as per consent conditions, *E. coli* samples were taken at all six sites.

Details of monitoring sites and investigations undertaken at each site are included below (Table 4).

Table 4: Monitoring Sites and Investigations Undertaken		
Site code	**Location**	**Investigations**
US 50	50 m upstream of discharge point	Habitat assessment, water quality, macroinvertebrate survey, Periphyton/macrophyte assessment, continuous logger deployment
US 100	100 m upstream of discharge point	Habitat assessment, water quality, macroinvertebrate survey
US 150	150 m upstream of discharge point	Habitat assessment, water quality, macroinvertebrate survey, Periphyton/macrophyte assessment
DS 50	50 m downstream of discharge point, just beyond the end of the mixing zone.	Habitat assessment, water quality, macroinvertebrate survey, Periphyton/macrophyte assessment, continuous logger deployment, Nocardia sampling
DS 100	100 m downstream of discharge point beyond 50 m mixing zone	Habitat assessment, water quality, macroinvertebrate survey, Periphyton/macrophyte assessment
DS 130	130 m downstream of discharge point.	Habitat assessment, water quality, macroinvertebrate survey, Periphyton/macrophyte assessment
Wetland Discharge	From the wetland discharge pipe prior to mixing with stream	Nocardia sampling
WWT Effluent	From the wastewater treatment plant effluent	Nocardia sampling

3.1 Physical Habitat Assessment

At each site, rapid habitat assessment forms were used to conduct a semi-qualitative assessment of the stream based on instream, riparian, and bank features (Clapcott, 2015). This involved assessing the stream hydraulic conditions, channel and riparian features, stream-bottom substrata, instream plant cover and presence of organic material.

Rapid habitat assessment forms were used to assess the reach-scale habitat quality, by scoring the reach out of 10 on the following parameters: sediment deposition, diversity and abundance of habitat, fish cover diversity and abundance, hydraulic heterogeneity, bank erosion, riparian vegetation, width and shading (Appendix B).

3.2 Water Quality and Nocardia

Water quality monitoring was conducted while treated wastewater was being discharged into the Hihi Stream.

Grab samples were taken from within the Hihi Stream at three replicate sites upstream and downstream of the WWTP wetland discharge point. Samples were collected and analysed for *E. coli* to supplement fortnightly sampling conducted by FNDC. Samples were collected as per standard procedures in laboratory supplied sample bottles and were sent to Analytica Laboratories.

As the FNDC downstream monitoring site was within the mixing zone (according to the PRPN definition), a sample at 50 m was analysed for the full suite of nutrients in the consent.

To gain an understanding of Nocardia presence in Hihi Stream, samples were taken from the WWTP effluent discharge, the wetland discharge and 50 m downstream of the wetland discharge and sent to Watercare Laboratories for testing.

Spot measurements of water quality field parameters (temperature, electrical conductivity (EC), pH, dissolved oxygen (DO), and turbidity) were also taken at all six assessment sites to identify broadscale spatial variance in water quality. *In-situ* water quality measurements were collected using a calibrated water quality probe (YSI Pro DSS).

3.3 Sonde Installation

Two calibrated Zebra-tech D-Opto loggers were installed at representative reaches of the Hihi Stream, 20 metres upstream and 20 metres downstream of the discharge point. Loggers were used to gather continuous DO (concentration and saturation) and water temperature data from each reach, at 15-minute intervals over a period of a month (25th of January to 24th February 2022).

3.4 Benthic Macroinvertebrates

Benthic macroinvertebrate samples were collected using Protocol C2 for soft bottomed streams (Stark *et al*., 2001). A total of six macroinvertebrate samples were collected, comprising three replicate samples from both upstream and downstream of the discharge location. A D-net with a 500 µm mesh size was used to collect dislodged macroinvertebrates. Samples were preserved in a 70-80% ethanol solution and sent to Environmental Impact Assessments Ltd for sorting using the 200 fixed count with scan for rare taxa method (Protocol P2; Stark *et al*., 2001).

3.5 Periphyton and Macrophyte Assessments

Periphyton cover assessments were completed following the methodology described in the National Environmental Monitoring Standards – Periphyton (NEMS, 2020a). Four evenly spaced transects were established within each monitoring reach. Each transect was evenly partitioned into five points (total of 20 points). Using a bathyscope, the percent cover of each periphyton type based on form (film, mat, filament) and colour (e.g., green, brown, other). The percent cover of noxious and pest species (e.g., cyanobacteria) were also visually assessed at each point and noted.

For the macrophyte assessments, five transects were sampled at each of the four monitoring locations (i.e., a total of twenty transects for each monitoring round) at equally spaced intervals along a 50 m stretch of the stream (Collier, Kelly and Champion, 2007). At each transect, a one-metre wide belt upstream of the transect was observed, and the estimated percent cover recorded. Differentiation was made between emerged and submerged macrophytes, and the macrophyte and periphyton species present were identified.

3.6 Fishing

A fish survey was undertaken to understand what species are present in the area. Fish are highly mobile and transient which prevents comparable upstream downstream surveys; however, a fish survey can determine which fish species are residing in the area and assist with determining ecological values and potential effects of the discharge. To provide information on fish presence in the Hihi Stream, six Gee Minnow traps were placed in appropriate locations, baited and left overnight. The traps were retrieved the following morning. Captured fish and large macroinvertebrates (i.e., freshwater shrimp and crayfish) were identified to species level (where feasible in-field) and measured for length.

4.0 Results

4.1 Physical Habitat Assessment

Upstream

The riparian zone above the discharge point was dense native bush on both sides of Hihi Stream. The stream had high levels of shade and the vegetation generally consisted of tree ferns (*Dicksonia sp.*), Kanuka (*Kunzea ericoides*), and cabbage trees (*Cordyline australis*) for the overstory. The understorey was generally shrub ferns and *Coprosma tenuicaulis* (See Appendix A). The vegetation was generally the same between the three upstream replicate sites, except for just above the constructed wetland (near US 50) weeds were more prevalent where there were gaps in the canopy and less tree cover. Weed species observed on site included but are not limited to Kahili ginger (*Hedychium gardnerianum*) and Woolly nightshade (*Solanum mauritianum*).

The channel was approximately 0.3 - 1.2 m wide and 0.1 – 0.4 m deep. The channel was slightly straightened where it met the beginning of the wetland, however it had natural meanders throughout the rest of the upper stream reaches.

The streambed substate was predominantly silt-sand towards the US 50 reach. Further up the catchment gravels and small cobbles became more prevalent. Bank stability was poor; many sections of the bank had loose soil and appeared to have some evidence of erosion.

Habitat for instream fauna was moderate to high. Woody debris of various sizes, variety of substrate and organic material was present. Macrophytes were not observed except for a very small patch of starwort (*Callitriche stagnalis*) just upstream of the wetland before the dense native canopy cover commenced.

Upstream habitat quality on average scored 66 out of a possible 100, indicating moderate habitat quality (Appendix B). Limiting factors were the low bank stability and high sediment deposition throughout the upstream reaches. Hydraulic heterogeneity was also low with only slow runs and the occasional pools.

Downstream

The riparian zone below the discharge point was dense native bush with extensive woolly nightshade and grasses in the understorey on the true right side. On the left bank was a small strip of Kanuka and Woolly nightshade, a roading corridor (gravel driveway), and beyond this, a grazed pastoral paddock (See Appendix A).

The channel was approximately 0.2 – 0.5 m wide and between 0.1 and 0.3 m deep; slightly narrower and shallower than the upstream sites. The natural meanders were less prevalent through the downstream reach, as the channel was straightened and ran adjacent to the roading corridor.

Downstream habitat quality, on average, scored 26 out of 100, indicating poor stream habitat quality (Appendix B). The limiting factors of the downstream reaches were the lack of instream fauna habitat (woody debris, riffles, undercut banks etc.) and the modified shape of the channel. Fish cover availability was low and of poor quality.

4.2 Water Quality

Water quality was measured during the field survey with handheld meters (YSI ProDSS) and grab samples were analysed at the laboratory. There was some expected discrepancy between results from parameters analysed both in the field and in the laboratory, and lab results are preferentially reported on. A summary of water quality data is presented in Tables 5-8, full FNDC compliance results are provided in Appendix C.

Table 5: In Stream YSI Water Quality Parameters

Parameter	Hihi Stream - Upstream			Hihi Stream - Downstream			Average Upstream	Average Downstream	ANZG DGV	PRPN Water Quality Standards
	US150	US100	US50	DS50	DS80	DS120				
pH	**6.26**	**6.44**	**6.21**	**6.68**	**6.8**	**6.78**	**6.3**	**6.75**	**7.32 – 7.8**	6.0 – 9.0
Temperature (°C)	18.0	18.4	18.8	21.8	21.5	21.4	18.4	21.5	-	< 24
Dissolved Oxygen (% saturation)	**57.2**	**50.9**	**37.4**	**45.0**	**48.9**	**48.5**	**48.5**	**47.46**	**90 - 107**	-
Dissolved Oxygen (mg/L)	5.41	4.77	3.48	3.91	4.31	4.28	4.55	4.16	-	< 4
Conductivity (µS/cm)	**249.5**	**258.5**	**246.7**	**424.6**	**423.1**	**408.7**	**251.6**	**418.8**	**119**	-
Turbidity (FNU)	**5.4**	**7.5**	**16.6**	**10**	**8.3**	**17.1**	**9.8**	**11.8**	**4**	-

Notes:

1. *ANZG, 2018. ANZG Default Guideline Values*
2. *PRPN, 2022. Proposed Regional Plan – Northland Water Quality Standards*

Table 6: FNDC Compliance Monitoring Water Quality Results – Upstream vs Downstream

Analytes	Upstream			Downstream			Guidelines	
	5 year Average (SE)	12 month median	12 month Range	5 Year Average (SE)	12 month median	12 month Range	ANZG DGV [1]	PRPN Water Quality Standards [2]	NPS -FM [3]
pH	6.643 (0.04)	**6.6**	5.94 - 7.29	6.78 (0.03)	**6.85**	6.04 - 7.17	**7.32 – 7.8**	6.0 – 9.0	-
Temp (°C)	17.61 (0.29)	18.2	12.3 - 22.6	18.00 (0.13)	18.1	12. 7 - 22.7	-	< 24	-
DO (mg/L)	6.46 (0.14)	6.31	0.31 - 8.51	7.27 (0.18)	7.79	0.014 - 9.29	-	-	-
Ammoniacal nitrogen (mg/L)	0.05 (0.009)	0.03	0 - 0.1	1.48 (0.43)	0.845	0.01 – 17	**0.09**	-	0.24
DIN (mg/L)	0.560 (0.29)	0.216	0.09 - 25.02	3.58 (0.68)	4.668	1.15 - 53.4	-	-	-
DRP (mg/L)	0.15 (0.09)	0.011	0.006 - 7.38	0.86 (0.15)	0.069	0.027 - 7.69	-	-	0.018 [4]

Notes:

1. *ANZG, 2018. ANZG Default Guideline Values*
2. *PRPN, 2022. Proposed Regional Plan – Northland Water Quality Standards*
3. *NPS, 2020. National Policy Statement – Freshwater Management. National Bottom lines.*
4. *No bottom line value exists, value is the lowest possible attribute Class, Class D.*

Table 7: 50 m Downstream Site - Laboratory Water Quality Results				
Parameters	**DS 50**	**ANZG DGV**	**PRPN Water Quality Standards [1]**	**NPS -FM [1]**
Total Suspended Solids (mg/L)	**9**	**8.8**	-	-
Total Nitrogen (mg/L)	**2.0**	**0.292**	-	-
Ammoniacal nitrogen (mg/L)	**1.32**	**0.01**	0.2 [2]	**0.24** [3]
Nitrite-N (mg/L)	0.055	-	-	-
Nitrate-N (mg/L)	**0.414**	**0.065**	<1 [2]	2.4 [3]
Total Kjeldahl Nitrogen (mg/L)	1.49	-	-	-
Dissolved Reactive Phosphorus (mg/L)	**0.131**	**0.014**	-	0.018 [4]
Total Phosphorus (mg/L)	**0.36**	**0.024**	-	50 [3]
DIN	1.8	-	-	-

Notes:

1. *All guidelines are indicative guideline as the values does not apply to a single discrete measurement.*
2. *Value refers to the annual median.*
3. *Value is the national bottom line however refers to the annual median.*
4. *No bottom line value exists, value is the lowest possible attribute Class, Class D.*

Table 8: Laboratory Water Quality Results							
Parameters	**US 150**	**US 100**	**US 50**	**DS 50**	**DS 100**	**DS 130**	**NPS FM**
E. coli	18	36	45	260	240	180	**260** [1]

Notes:

1. *No bottom line value exists, value is the lowest possible attribute Class for the median across 60 samples, Class E.*

Instream field parameters

Instream field parameters were collected on the day of ecological sampling and assessment. Three replicates were completed upstream and downstream of the discharge.

Field measurements of DO show an exceedance of the ANZG DGV values for all sites; however, there was no difference in the average DO upstream versus downstream. Two sites (upstream and downstream 50 m) exceeded the PRPN DO standard. See section 4.2.1 for further comment on DO in Hihi Stream.

Turbidity exceeded the ANZG DGV for all locations, average turbidity was 20% higher downstream of the discharge.

pH was measured below the ANZG DGV; however, it was within the PRPN water quality standards. Average pH was lower upstream than downstream.

Temperature downstream was higher than the upstream locations, with average temperature exceeding 3 degrees difference (3.1 °C) at the time of sampling. The temperature measured during the spot sampling are considered appropriate for aquatic life. See section 4.2.1 for further comment on temperature in Hihi Stream.

Conductivity was clearly higher at the downstream locations with a 49% increase in conductivity downstream of the discharge point.

Compliance water quality results

Water quality results for the past five years (Feb 2017 – January 2022) were analysed to understand the potential effect of the Hihi WWTP on the Hihi Stream.

There was no meaningful difference in pH or temperature measurements over the past five years, or within the past 12 months. Results did not exceed the PRPN water quality standards; however, both upstream and downstream pH did occasionally exceed the ANZG DGV.

Annual ammoniacal nitrogen concentrations were much higher downstream than upstream (252% higher). There were six recorded exceedances over the past 12 months, generally tended to be during the summer months.

Annual median concentrations of DIN were also higher downstream than upstream, as was the annual median concentration for DRP, which was measured as more than double the poorest NPS - FM attribute class (Class D), noting there is currently no national bottom line for DRP.

E. coli measurements show that there is an increase in *E. coli* numbers downstream of the wetland discharge; however, dilution does occur (concentrations almost halved) over 130 m. All *E. coli* results reported in the Hihi Stream below the discharge point exceed the RC consent compliance of no more than 50/100 ml increase downstream and the PRPN water quality standard of 130 mpn/100 (median

concentration) was also exceeded. The highest concentration was at DS 50 (260 MPN/100 ml) which is equivalent to the lowest attribute band (Class E – Red) for median concentration in the NPS-FM. It is noted that comparison is indicative only due to spot measurements and is not directly comparable to the guidelines, which require larger data sets and for all numeric attribute states to be met to assign an attribute state.

In addition to the samples collected by FNDC on a fortnightly basis, an extra downstream sample was collected by PDP to understand water quality conditions at the extent of the new mixing zone. The sample taken at DS 50 shows that there is potentially additional mixing that is not captured in the current resource consent downstream location (Table 7). Analytes measured at DS 50 were lower than concentrations measured at the consent location for the past month; however, analytes measured at the new measuring zone (DS 50) still display poor water quality. Concentrations of ammoniacal nitrogen and DRP still remain high and above the consent limit and relevant guidelines. TP, nitrate, TSS and TN were all above the ANZG DGV, indicating concentrations above reference conditions. No relevant NPS-FM national bottom lines were exceeded but TN and TP were still elevated compared to background concentrations and ammoniacal nitrogen was above the PRPN standards. TKN and nitrite do not have guidelines and concentrations appeared acceptable for these analytes.

4.2.1 Continuous Diurnal Water Quality Monitoring

Water Temperature

Water temperature upstream and downstream of the discharge site followed a diurnal cycle (i.e., peak daily temperatures were recorded in the afternoon and minimum temperatures recorded around sunrise) as shown in Figure 2.

The downstream site was consistently warmer than the upstream site throughout the monitoring and temperature spikes (the daily range from lowest temperature to highest temperature) showed higher peaks downstream than upstream indicating a direct effect of the discharge. The upstream location had a temperature range of 16.3 to 21.5, while downstream ranged between 17.3 and 24.7. There was generally a 2 °C difference between the two sites. The peak daily temperatures recorded from both reaches was generally below the PRPN standard (<24 degrees) for water temperature except for three days (9th – 11th February) at the downstream site. It is noted however, that direct comparison with the NPRP standard for temperature was not able to be achieved during the timeframe of this investigation, as this requires an assessment of summer temperature data, averaged over the five hottest days (from the inspection of a continuous temperature record). There were a number of occasions (12% of recordings) where the difference between the upstream and the downstream temperatures exceeded 3 degrees, thus exceeding the PRPN water quality standard for wastewater discharges to a stream (See section C6.6.2 of the PRPN) and the resource consent conditions.

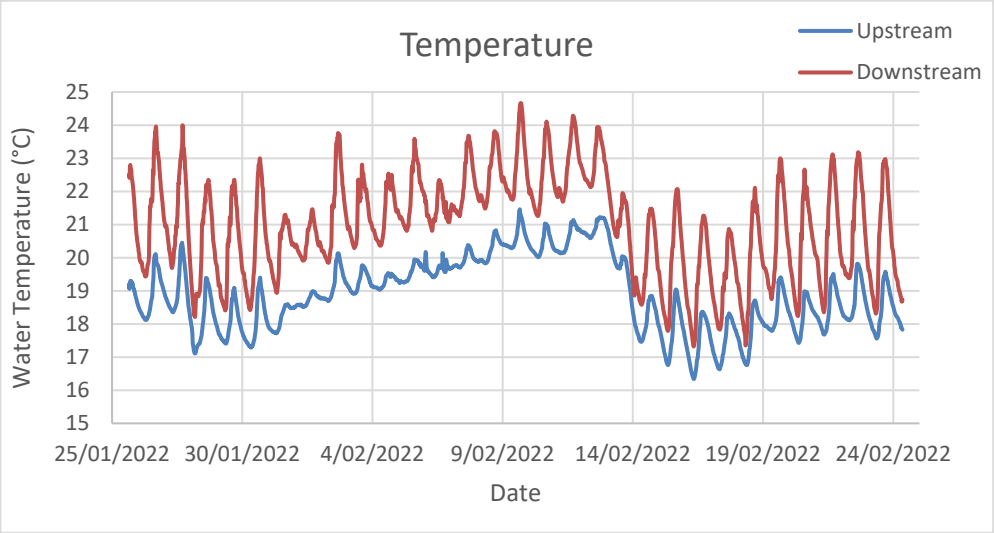

Figure 2: Hihi Stream continuous water temperature data

Dissolved Oxygen

Continuous DO concentration and saturation data are presented in Figures 3 and 4. A diurnal pattern was evident at both upstream and downstream reaches over the first 12 days, steadily cycling to peak in the afternoon and reaching a daily minimum soon before sunrise. Sensor fouling occurred on the downstream sensor after this point (12 days) therefore data after this point is not discussed.

Upstream DO % saturation was higher during the first few days of monitoring, both locations then fluctuated between <10% and 50% saturation for the first two weeks. Generally, upstream had slightly higher DO % saturation than downstream; however, both locations were considered to have poor DO levels. Results from both upstream and downstream sites were predominantly below the PRPN standard of 4.0 mg/L and the ANZG DGV of 90% saturation.

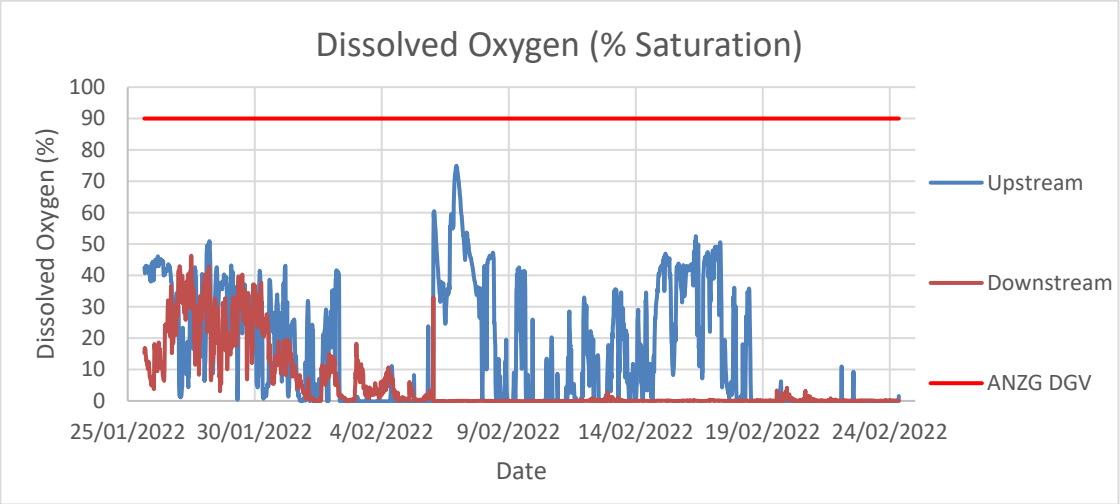

Figure 3: Hihi Stream continuous DO % saturation data

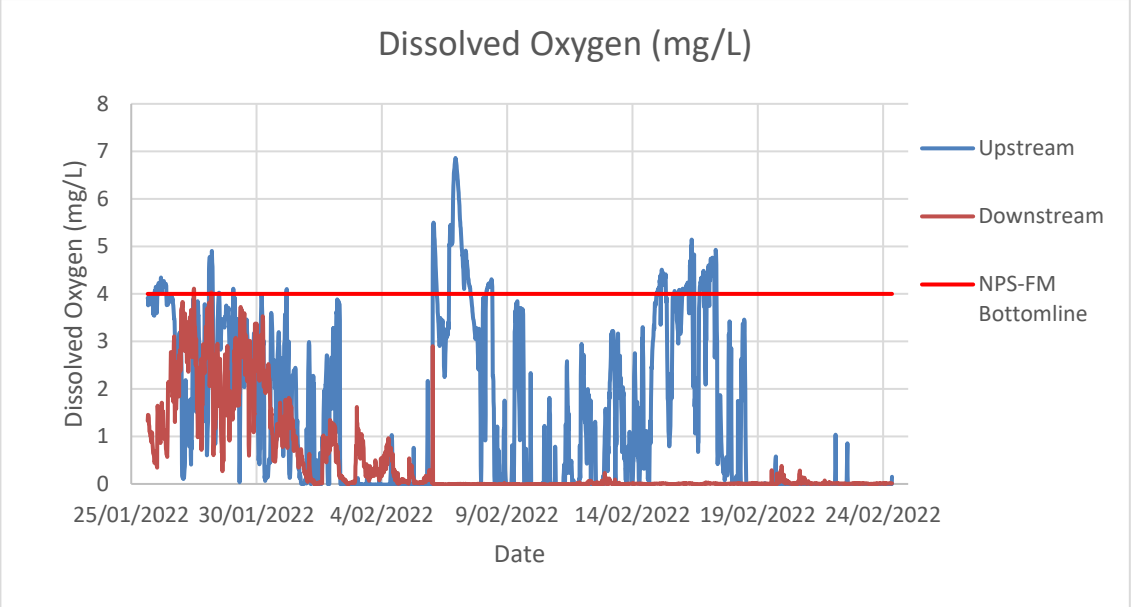

Figure 4: Hihi Stream continuous DO mg/L data

4.3 Nocardia

Samples were collected from the effluent discharge point, the wetland discharge point and 50 m downstream in the receiving environment (Hihi Stream). The results of the Nocardia analyses are presented in Table 9. The laboratory report can be found in Appendix D.

The sample collected from the effluent discharge point indicated moderate amounts of Nocardia bacteria in the water; however, the samples at the wetland discharge point and the downstream Hihi Stream site indicated levels were in the 'Low' range, with an abundance rating of 0.0 (equates to no filaments were present).

Table 9: Nocardia Bacteria Results

Nocardia Parameters	Effluent Discharge	Wetland Discharge	Downstream 50 m
Filament presence	Moderate	Low[1]	Low
Filament Abundance Rating[2]	3.0	0.0	0.0

Notes

1. 'Low' is one of three descriptors for filament presence (Low, Moderate, High) which includes no-presence.
2. *No unit. Rating is out of 6.0.*

There are currently no guidelines for Nocardia abundance or presence available or historical results to compare to, therefore the results indicate that while there is Nocardia in the effluent discharge, it was not migrating through the constructed wetland system to the receiving environment at the time of sampling. This could be due to settlement of suspended solids via the wetland system, where bacteria have attached to flocculant.

4.4 Benthic Macroinvertebrates

A summary of calculated macroinvertebrate community metrics is presented in Table 10, full results are provided in Appendix E.

Table 10: Summary of Macroinvertebrate Community Metrics

Metric	Hihi Stream		NPS-FM (2020) National Bottom Line
	Upstream Average	Downstream Average	
Taxa richness	9.3	6.3	-
%EPT $_{taxa}$ [1]	28.0	0	-
MCI	96.05	**60.05**	**< 90**
QMCI	**3.33**	**3.36**	**< 4.5**
Classification[4]	Fair/Poor	Poor/Poor	-

Notes:

1. *EPT indices exclude the pollution sensitive Hydroptilidae sp.*
2. *Results for each site are an average of three replicates. See Appendix E for lab results.*
3. *NPS-FM (2020) National bottom line guidelines applies to 5 year median and is provided as an indicator only.*
4. *From (Stark & Matxed 2007), see Table 5.*

Macroinvertebrate community metrics were found to be lower in the downstream impact reach compared to the upstream control reach of the Hihi Stream, with the exception of QMCI (similar).

The upstream MCI score was ranked 'fair' in terms of some possible mild pollution. In contrast the downstream location had a 'poor' MCI score and no EPT taxa present. Despite these differences, the QMCI scores on average were the same. This is likely due to the high abundance of pollution tolerant taxa at both sites.

The top three taxa found in the Hihi Stream are Mollusc *Potamopyrgus*, true fly *Tanytarsini*, and Crustacea *Ostracoda*. These are all pollution tolerant taxa and were found both upstream and downstream. Pollution sensitive taxa were exclusively found in the upstream locations only.

4.5 Periphyton and Macrophyte Assessment

No periphyton was observed at any of the sampling locations (upstream or downstream). High periphyton cover can be an indicator of nutrient enrichment in streams; however, it requires instream hard substrates, macrophytes or root mats to adhere to. The lack of periphyton could be due to limited favourable substates to adhere to and the high shading present at the site (periphyton requires sunlight for growth).

Macrophytes, which can also be an indicator of nutrient enrichment in streams, were very limited in their cover. Macrophytes were only found immediately upstream and downstream of the wetland, where there was reduced canopy cover (reaches DS 50 and US 50). Even then, macrophyte cover was very low and consisted of very small sparse patches. There was no difference in cover between the upstream (<5%) and downstream locations (<5%). The species present were starwort (*Callitriche stagnalis*) and watercress (*Nasturtium officinale*). All other reaches surveyed had no macrophyte cover.

Overall, there was no changes in periphyton or macrophytes cover downstream of the WWTP wetland discharge point.

4.6 Fish Fauna

Sixteen native fish were captured, measured then released. All fish captured were banded kokopu ranging between 3.5 and 15 cm in length. Six freshwater shrimp were captured in the fish nets (approx. 3 cm in length). An unidentified eel was also visually observed downstream of the sampling locations, near the bridge. No obvious fish passage barriers were observed on site and a review of the Fish Passage Assessment Tool (NIWA, 2022) did not identify any barriers.

5.0 Assessment of Effects from Wastewater Discharge

5.1 Effects of Current WWTP Discharge

Results of water quality sampling, habitat assessment and macroinvertebrate surveys show the Hihi WWTP discharge has degraded water quality and contributed to poor stream health downstream of the discharge point in Hihi Stream. The water quality parameters that show the highest impact downstream of the discharge are ammoniacal nitrogen, DRP, DIN, DO and *E. coli*.

Ammoniacal nitrogen concentrations were higher downstream in the impact reach compared to upstream, and concentrations exceeded the consent condition requirements six times over the past 12 months. These exceedances ranged between 2.1 – 17 mg/L. Ammoniacal nitrogen can be toxic to aquatic life in high concentrations. When compared to the NPS-FM National Objective Framework (NOF), the annual median concentration of ammoniacal nitrogen falls within the attribute C band and the annual maximum concentration fell in the attribute D band. Attribute band C indicates an 80% species protection level, where impacts are starting to occur regularly on the 20% most sensitive species (NPS-FM 2020). Attribute band D indicates that acute impacts could be occurring at a level where there is risk of death for sensitive species (NPS-FM 2020). With exceedances occurring multiple times at a level >1.30 mg/L, there is likely an effect on species that may be living downstream of the discharge. Species are currently most at risk during the summer months, when the plant is operating at greater capacity due to an increase in population.

Downstream of the discharge DRP concentrations were measured higher than the poorest NPS - FM attribute band (Band D), noting that there is currently no national bottom line for DRP. This band indicates ecological communities are potentially being impacted by substantial DRP elevation above natural reference conditions (NPS-FM 2020). In combination with other conditions favouring eutrophication (sunlight, warm temperatures etc.), DRP enrichment can drive excessive primary production and significant changes in macroinvertebrate and fish communities, as taxa sensitive to hypoxia are lost.

DIN is a calculation of ammoniacal nitrogen, nitrate and nitrite, as such DIN concentrations are elevated due to the high ammoniacal nitrogen concentrations present. Nitrate was elevated above the ANZG DGV in the DS 50 sample; however, it was below the PRPN and NPS-FM guidelines. As such, it is considered that ammoniacal nitrogen is the driving factor behind high DIN in Hihi Stream.

DO in the Hihi Stream is consistently low, particularly below the discharge point. DO was below the NPS – FM bottom line, as such this can put stress on aquatic fauna. The Hihi stream is a low flow stream with little hydraulic heterogeneity. This has likely contributed to low DO both upstream and downstream of the site and could be factor of physical stream characteristics and not necessarily water quality. There is no clear evidence that discharge from the WWTP is causing low

DO as DO is also low upstream, however, conjoint with other factors slight decreases in DO due to the WWTP could exacerbate conditions and cause poorer stream health.

E. coli was potentially above the PRNP standards and poorest NPS-FM attribute band; however, these results are indicative only, as larger data sets are required to make comparisons with these guidelines. Measured *E. coli* concentrations do indicate that dilution is occurring, and concentration of *E. coli* does improve further downstream. As *E. coli* has been dropped from compliance sampling in 2013, as allowed by the consent conditions, a detailed assessment of effects on the receiving environment is not possible.

Macroinvertebrate MCI scores within the impact reach are below the NPS-FM national bottom line and are lower than the control reach, which is above the NPS-FM national bottom line. This likely corresponds to the concentrations of ammoniacal nitrogen discharged and the observed reduction in instream habitat quality below the discharge point.

Nocardia bacteria filament were lower (not present) in the Hihi Stream and the wetland discharge than measured in the effluent (moderate), indicating some removal was occurring at the time of sampling between the effluent and the discharge point. There are currently no Nocardia guidelines for comparison. The potential effects of Nocardia on people and animals at the current levels discharging from the Hihi WWTP are considered to be minimal; however additional sampling during differing conditions (i.e., seasonal sampling) could provide further certainty on wetland removal levels.

Overall, the results of this assessment demonstrate that there is an effect on the water quality and ecology of the Hihi Stream as a result of the current Hihi WWTP discharge. Water sampling conducted by PDP and FNDC show that there are times of non-compliance with the NRC discharge consent particularly during the summer months.

5.2 Potential Effects of Proposed Discharge

FNDC has engaged WSP Opus to conduct a performance review on the Hihi WWTP, the WSP Opus Process Review Report (WSP Opus, 2022) proposed a number of recommendations to improve effluent quality and consistency. Some of the short-term solutions include the following:

- Installation of a temporary baffle within the main treatment tank to prevent flow short circuiting;
- A permanent alum dosing system to enhance settlement and removal of phosphorous;
- Daily manual alkalinity dosing to increase pH, and improve ammoniacal nitrogen removal; and,

- Consideration of methods of increasing oxygenation of effluent before discharge.

FNDC are yet to decide which solution they will implement from the recommendations outlined in the WSP Opus Process Review Report (WSP Opus, 2022).

Given the assessment of effects from the current discharge, and assuming the discharge continues in the future to the Hihi Stream, it can be assumed that the WWTP upgrades will only improve the quality of the WWTP discharge into the Hihi Stream and that adverse effects on the receiving environment will be improved compared to current conditions. Table 11 and Section 9.2 of the WSP Opus report includes proposed practical quality parameters if a membrane bioreactor (MBR) and alum dosing were implemented. The intention of the WSP Opus recommended WWTP upgrades would be to remove greater concentrations of nutrients (ammoniacal nitrogen and phosphorous) and *E. coli*; minimising potential adverse effects on water quality and ecological values in the Hihi Stream. If the concentrations proposed in the WPS Opus report are achieved, an improvement in water quality, macroinvertebrate communities and overall stream health is considered likely.

5.3 Regional Objectives and Policies

Relevant objectives and policies were reviewed in relation to the Hihi WWTP discharge for both the Northland Policy Statement and the Proposed Regional Plan – Northland (PRPN). An assessment against relevant objectives and policies is presented in Appendix F and a summary is provided below.

As per Objective E 1.1 and Policy E.2 of the Northland Policy Statement, the suggested improvements outlined in the Hihi WWTP Process Review (WSP Opus, 2022) would result in an improvement to water quality and ecosystem health compared to the current discharge.

As per the relevant policies of the PRPN, water quality and ecosystem health in the receiving environment (HiHi Stream) are likely to improve as a result of the suggested WWTP improvements made by in the Hihi WWTP Process Review (WSP Opus, 2022). Effects of sedimentation in the catchment are expected to be minor. The immediate receiving environment is not used recreationally; however, microbiological effects occurring further down the catchment where there is recreational activity is possible, therefore additional *E. coli* sampling has been recommended.

5.4 Recommendations

It is recommended that improvements to effluent quality using some, if not all, of the short-term recommendations by WSP Opus are implemented as soon as practically possible.

To support the water quality monitoring currently being conducted by FNDC, it is recommended that in the short term, an extra sampling point is taken at the new location for mixing zones as defined by the PRPN (a minimum of 50 m below the discharge point). This will give an accurate measure of water quality in line with PRPN and NPS-FM guidelines. It is suggested that moving the downstream location to 50 m (to replace the current 40 m downstream site) is discussed with NRC during the consent renewal process so that sampling locations are updated in future consent conditions.

As *E. coli* sampling was removed in 2013, as per the consent condition, there is limited data available to compare conditions with relevant guideline and assess the effect of *E. coli*. The NPS-FM contract recreation guidelines require a minimum of 60 samples over five years. We recommend that monthly sampling is reinstated to provide a larger dataset to inform consent renewal assessments.

To date there is insufficient information to accurately assess the effects of Nocardia on the receiving environment. It is recommended that FNDC continue to take monthly samples during the warmer months of the year as this when Nocardia has been noted to be problematic. Monthly sampling should be taken between the months of Nov – April at the effluent discharge location, the wetland discharge and the downstream 50 m site. This will provide further data to determine if there are any potential effects to the receiving environment.

6.0 Conclusions

PDP conducted an ecological and water quality survey in January 2022 to characterise impacts to the Hihi Stream from the Hihi WWTP.

Results of surveys at impact sites below the WWTP discharge show degraded water quality and stream health in the receiving environment, particularly for concentrations of ammoniacal nitrogen, DRP, DIN, DO and *E. coli*, which are not compliant with PRPN and NPS-FM guidelines. Results downstream of the constructed wetland discharge show elevated nutrient and *E. coli* concentrations and reductions in macroinvertebrate community metric, indicative of nutrient enrichment from effluent discharge. Water quality compliance monitoring indicates that effects are particularly evident during the summer months, when Hihi's population increases beyond the WWTP capacity.

The potential effects of Nocardia on people and animals at the current levels discharging from the Hihi WWTP are considered to be minimal.

PDP also reviewed the WSP Opus Process Review Report (WSP Opus 2022), to determine what performance improvements have been recommended for the Hihi WWTP. It is likely that with the WWTP performance improvement recommendations made, water quality of the receiving environment will improve over time, which will likely result in an improvement in stream health and macroinvertebrate communities, in line with objectives and policies in the Northland Policy Statement and the Proposed Regional Plan – Northland.

7.0 References

ANZG. 2022. Australian & New Zealand Guidelines for Fresh and Marine Water Quality. Accessed 02/02/2022. Retrieved from https://www.waterquality.gov.au/anz-guidelines/your-location/new-zealand

Clapcott, J. 2015. National Rapid Habitat Assessment Protocol Development for Streams and Rivers. Prepared for Northland Regional Council. Prepared by Cawthron Institute.

Dunn, N., Allibone, R., Closs, G., Crow, S., David, B., Goodman, J., Griffiths, M., Jack, D., Ling, N., Waters, J., and Rolfe, J. Conservation Status of New Zealand Freshwater Fishes, 2017. New Zealand Threat Classification Series 24. New Zealand Government and Department of Conservation.\

Collier, K. Kelly, J. and Champion, P. 2007. Regional Guidelines for Ecological Assessments of Freshwater Environments: Aquatic Cover in Wadeable Streams. Environment Waikato Technical Report 2006/47.

Grainger, N., Harding, J., Drinan, T., Collier, K., Smith, B., Death, R., Makan, T., and Rolfe, J. Conservation Status of New Zealand Freshwater Invertebrates, 2018. New Zealand Threat Classification Series 28. New Zealand Government and Department of Conservation.

LAWA. 2021. Land Air Water Aotearoa. Accessed 01/02/2022 via https://www.lawa.org.nz/explore-data/northland-region/river-quality).

REC. 2010. River Environment Classification New Zealand. Ministry for the Environment. Accessed 1/6/2021. https://data.mfe.govt.nz/layer/51845-river-environment-classification-new-zealand-2010-deprecated/.

NIWA, 2022. Fish Passage Assessment Tool. Accessed at https://niwa.co.nz/freshwater/management-tools/fish-passage-assessment-tool

NPS. (2020). National Policy Statement for Freshwater Management (2020). Accessed from https://environment.govt.nz/acts-and-regulations/national-policy-statements/national-policy-statement-freshwater-management/

NRC. (2015). State of Environment Report 2015. Northland Regional Council. Accessed on 1/02/2022 via https://www.nrc.govt.nz/media/opbpljxu/stateoftheenvironmentreport2015website.pdf.

PRPN, 2022. *Proposed Regional Plan for Northland Appeals Version - March 2022*. Prepared by Northland Regional Council.

Stark, J.D., Boothroyd, I.K.G., Harding, J.S., Maxted, J.R. and Scarsbrook, M.R. (2001) *Protocols for sampling macroinvertebrates in wadeable streams*. New Zealand Macroinvertebrate Working Group Report No. 1. Prepared for the Ministry for the Environment.

Stark J.D. and Maxted J.R. 2007: A biotic index for New Zealand's soft-bottomed streams. *New Zealand Journal of Marine and Freshwater Research* 41: 43-61.

WSP Opus, 2022. *Hihi WWTP Consenting: Hihi WWTP Process Review.* Prepared by WSP Opus for Far North District Council. Rev02. May 2022.

Appendix A: Site Photographs

Photograph 1: Upstream reach. US 50

Photograph 2: Close up on upstream substrate, soft bottomed with a mixture of gravels.

Photograph 3: Upstream reach, US 100. Slightly more gravels and cobbles.

Photograph 4: Example of deeper pools.

Photograph 5: Upstream Reach, US 150.

Photograph 6: Example of upstream vegetation

Photograph 7: Straightened channel adjacent to wetland.

Photograph 8: Downstream reach, DS 50

Photograph 9: Example of low macrophyte cover in DS 50 reach.

Photograph 10: Downstream reach, DS 100

Photograph 11: Downstream reach, DS 150

Appendix B: Habitat Assessment

Table B1: Habitat Assessment - reach-scale habitat quality

Parameter	Upstream			Downstream			US Average	DS Average
	US 150	US 100	US 50	DS 50	DS 100	DS 130		
1. Sediment Deposition	4	4	3	1	2	1		
2. Diversity of Habitat	8	8	6	2	3	2		
3. Abundance of Habitat	8	7	6	2	2	2		
4. Fish Cover Diversity	6	6	3	1	1	1		
5. Fish Cover Abundance	7	6	5	1	1	1		
6. Hydraulic Heterogeneity	5	4	3	1	1	1		
7. Bank erosion	6	5	3	4	4	5		
8. Bank Vegetation	10	9	8	3	3	3		
9. Riparian Width	10	10	8	4	4	4		
10. Riparian Shade	10	10	9	6	6	7		
Total out of 100	**74**	**69**	**54**	**25**	**27**	**27**	**66**	**26**

Appendix C: Water Quality Results

Water Quality

Hihi STP		US - NRC #101130						DS - NRC #108481					
Month	Date	pH [-]	Temp [deg C]	DO [g/m3]	NH4-N [g/m3]	DIN [g/m3]	DRP [g/m3]	pH [-]	Temp [deg C]	DO [g/m3]	NH4-N [g/m3]	DIN [g/m3]	DRP [g/m3]
Feb 17	13/02/17	6.89	20	6.14	0.4	0.55	0.016	6.99	20.7	6.16	0.79	3.49	1.4
Feb 17	21/02/17	6.5	17.8	5.2	0.078	0.24	0.017	6.7	19.1	6	0.12	1.1	1.9
Feb 17	27/02/17	7.16	19	6.72	0.04	0.23	0.013	7.2	19.5	8.46	0.05	0.65	0.98
Mar 17	14/03/17	6.68	19.1	5.78	< 0.01	0.15	0.012	6.83	19.5	7.73	0.06	1.06	1.5
Mar 17	28/03/17	6.78	19.3	6.16	0.02	0.17	0.015	7.04	19.8	8.35	0.44	2.54	1.1
Apr 17	03/04/17	6.7	18.6	5.8	0.059	0.22	0.019	6.8	20.3	6.3	0.33	2.4	1.5
Apr 17	10/04/17	6.73	20.1	6.92	0.02	0.13	0.012	6.89	20	8.23	< 0.01	1.6	1.3
May 17	09/05/17	6.94	16.6	7.56	0.04	0.23	0.011	5.89	16.2	8.07	1	4.8	1.1
Jun 17	06/06/17	6.6	14.5	7.8	0.01	0.2	0.01	6.73	13.4	9.6	< 0.01	3.1	0.43
Jul 17	04/07/17	6.4	13.7	8.2	0.02	0.2	0.01	6.59	13.7	8.19	0.66	5.36	0.5
Aug 17	14/08/17	6.5	14.2	7.7	0.056	0.24	0.013	6.6	14.1	7.9	0.037	1.6	0.29
Aug 17	15/08/17	6.37	15.1	7.89	0.01	0.18	0.017	6.74	15.1	8.34	< 0.01	3.5	0.35
Sep 17	25/09/17	6.59	16.9	7.47	0.01	0.22	0.017	6.62	16.4	7.32	< 0.01	1.4	0.23
Oct 17	17/10/17	7.33	16.2	6.11	0.01	0.2	0.006	6.8	15.7	9.98	< 0.01	1.3	0.25
Nov 17	13/11/17	6.72	17.1	7.6	0.02	0.22	0.014	6.9	16.7	8.74	0.01	1.51	0.5
Nov 17	27/11/17	6.8			0.044	0.25	0.01	6.9			0.03	0.23	1
Dec 17	04/12/17	6.48	20.5	7.26	0.04	0.65	0.018	6.86	21.7	8.85	0.03	0.116	1.9
Dec 17	18/12/17	6.72	21.5	6.9	0.02	0.154	4.3	6.72	23.6	7.74	0.03	0.056	0.87
Jan 18	15/01/18	7.09	20.3	5.97	0.01	0.165	0.013	7.11	23.3	6.62	0.01	0.227	0.79
Jan 18	30/01/18	6.61	22.4	6.16	0.13	0.286	0.011	6.89	22.4	7.14	1	1.34	0.96
Feb 18	12/02/18	6.08	24.4	5.96	0.13	0.256	0.01	6.3	23.3	6.17	0.11	0.132	1.3
Mar 18	05/03/18	6.58	21.7	5.5	0.05	0.174	0.013	6.79	22.8	7.83	1.9	3.09	1.2
Mar 18	12/03/18	5.78	20.9	7.44	0.02	0.654	0.011	5.87	18.6	7.54	0.6	2.42	0.38
Mar 18	22/03/18	6.5	16.6	7.2	0.062	0.25	0.015	6.7	17.2	7.8	0.28		
Mar 18	26/03/18	6.45	18.5	6.34	0.04	0.198	0.013	6.36	20.3	7.33	0.9	7.38	1.5
Apr 18	16/04/18	6.93	19.8	6.72	0.01	0.222	0.014	6.61	19.7	8.21	0.05	2.26	0.75
May 18	07/05/18	6.66	16.6	7.15	0	0.19	0.014	6.5	16.2	8.35	< 0.01	4	0.7
Jun 18	04/06/18	4.99	15.7	7.89	0.03	0.266	0.016	6.03	15.9	8.02	1.4	3.28	0.35
Jun 18	13/06/18	6.5	12.9	8.5	0.051	0.23	0.007	6.7	12.3	9.5	0.96	2.6	0.33
Jul 18	02/07/18	5.8	15.5	7.55	0.01	0.202	0.012	6.38	14.1	9	0.01	2.512	0.27
Aug 18	13/08/18	6.33	14	7.71	0.01	0.212	0.01	6.79	14.1	8.12	< 0.01	3.8	0.28
Sep 18	24/09/18	6.57	15.4	7.71	0.01	0.202	0.016	6.75	16.1	8.86	0.01	1.512	0.25
Oct 18	01/10/18	6.95	15.9	7.57	0.01	0.202	0.019	7.07	16.2	9.48	0	2.5	0.27
Nov 18	12/11/18	6.76	17.2	6.99	0.02	0.086	0.01	6.98	20.7	8.23	0.01	7.8	0.33
Nov 18	29/11/18												
Dec 18	03/12/18	6.75	17.7	7.28	0.02	0.184	0.009	6.89	18.1	6.1	0.02	0.814	0.6
Dec 18	17/12/18	6.94	19.6	6.94	0.03	0.186	0.017	7.15	20.1	7.79	0.02	0.634	0.61
Jan 19	14/01/19	7.15	18.3	6.5	0.01	0.132	0.015	7.34	19.2	4.23	3.9	5.66	2.4
Jan 19	29/01/19	7.21	20	5.01	0.01	0.22	0.018	7.41	22.8	4.69	0.14	1.348	8.5
Feb 19	11/02/19	7.25	18	4.93	0.03	0.106	0.014	7.45	18.8	4.86	0.04	0.578	2.6
Feb 19	25/02/19	7.33	16.2	5.99	0.04	0.168	0.02	7.57	16.9	5.79	0.13	0.316	1.2
Feb 19	28/02/19	6.9	15.6	2.1	0.09	0.23	0.022	7	16.5	5.6	0.12	0.22	0.84
Mar 19	11/03/19	7.99	17.2	5.85	< 0.01	0.14	0.016	7.59	19.2	6.37	< 0.01	0.02	0.51

Water Quality

Hihi STP		US - NRC #101130						DS - NRC #108481					
Month	Date	pH [-]	Temp [deg C]	DO [g/m3]	NH4-N [g/m3]	DIN [g/m3]	DRP [g/m3]	pH [-]	Temp [deg C]	DO [g/m3]	NH4-N [g/m3]	DIN [g/m3]	DRP [g/m3]
Mar 19	25/03/19	6.77	19.4	5.42	0.01	0.172	0.017	7.01	19.5	6.51	0.01	0.102	1.1
Apr 19	15/04/19	6.56	17.6	6.11	0.01	0.192	0.019	6.98	16.9	7.42	0.03	0.226	1.1
May 19	13/05/19	6.64	17	5.86	0.01	0.162	0.013	6.87	16.6	6.12	0.49	2.088	1.1
Jun 19	25/06/19	6.43	12.5	7.4	0.02	0.204	0.01	6.48	12.4	8.84	0.01	1.712	0.5
Jul 19	15/07/19	6.55	13.5	7.42	0.04	0.248	0.013	6.11	13.9	8.45	0.26	7.612	0.93
Aug 19	12/08/19	6.67	14.8	6.98	0.01	0.202	0.009	7.01	14.6	8.87	0.01	2.712	0.58
Aug 19	29/08/19	6.9	11	7.9	0.069	0.26	0.008	6.9	11.1	9.5	0.04	1.4	0.3
Sep 19	23/09/19	6.88	15.2	7.6	0.01	0.202	0.015	7.17	15.6	9.68	< 0.01	0.98	0.33
Sep 19	30/09/19	6.54	15.9	8.17	0.04	0.438	0.016	6.23	16.9	8.74	1.5	9.5	1.2
Nov 19	11/11/19	6.8	15.5	6.95	< 0.01			7.16	16	7.11	1.2		
Nov 19	18/11/19												
Nov 19	27/11/19	6.6	15.5	6.4	0.078	0.22	0.011	6.6	17.6	3.5	19	19	6.1
Dec 19	02/12/19	6.74	19.7	5.7	0.01	0.132	0.008	6.82	20.8	3.18	0.5	1.41	0.66
Dec 19	16/12/19				< 0.4	< 0.4	0.014				< 0.4	< 0.4	0.012
Jan 20	06/01/20												
Jan 20	13/01/20	6.96		9.1	0.02			7		9.49	5.9		
Jan 20	29/01/20	7.41	20.9	5.49	< 0.01			7.17	22.8	5.33	0.16		
Feb 20	17/02/20	6.97	21.3	4.4	0.01	0.082	0.006	7.11	23.6	5.18	0.05	0.21	0.66
Mar 20	02/03/20	6.94	20.2	3.82	0.04	0.078	0.012	7.12	21.3	5.05	0.05	0.14	0.064
Mar 20	17/03/20	6.82	17.5	5.02	< 0.01	0.032	0.011	7.03	18.2	6.44	0.17	3.6	0.6
Mar 20	30/03/20 n/a				< 0.4	0.11	0.011 n/a				< 0.4	1.7	0.47
Apr 20	20/04/20	6.74	16.7	6.04	< 0.4	0.12	0.013	6.93	17.2	7.81	< 0.4	1.7	0.34
May 20	18/05/20	6.03	16.4	5.74	< 0.4	0.19	0.016	6.55	15.7	7.69	0.8	9.98	0.46
Jun 20	29/06/20	6.66	14.7	7.14	0.02	0.294	0.011	6.58	14.9	7.09	0.2	5.04	0.47
Jul 20	20/07/20	6.02	16.1	6.12	< 0.01	0.34	0.014	6.77	15.9	6.89	0.04	3.1	0.46
Aug 20	17/08/20	6.82	14.8	7.26	< 0.01	0.22	0.008	7.02	14.2	8.8	< 0.01	2.2	0.25
Aug 20	12/08/20	5.77	13.9	6.77	0.032	0.81	0.007	6.03	14.6	7.75	0.023	3.6	0.25
Sep 20	28/09/20	6.69	17	6.7	0.02	0.23	0.006	6.79	16.9	8.21	1	2.8	0.22
Oct 20	12/10/20	5.24	17.3	6.46	0.01	0.2	0.007	5.99	17.3	8.92	0.01	0.63	0.12
Nov 20	16/11/20	6.02	21.1	6.55	0.04	0.228	0.008	6.28	19.5	8.03	0.8	1.38	0.16
Dec 20	08/12/20	5.86	19.7	6.12	0.035	0.19	0.006	7.01	21.5	5.92	0.179	1.8	0.121
Dec 20	09/12/20	6.47	19.8	5.6	0.04	0.198	0.008	6.31	21.6	5.61	0.3	0.456	
Dec 20	21/12/20	6.52	19.2	5.85	0.06	0.212	0.006	6.49	18.9	5.55	0.9	2.38	0.079
Jan 21	06/01/21	6.62	20.2	5.85	0.03			6.57	21.5	4.39	30		
Jan 21	18/01/21	7.4	25	5.38	0.01	0.012	0.01	6.98	22	5.59	2.9	3.6	0.206

Water Quality

Hihi STP		US - NRC #101130						DS - NRC #108481					
Month	Date	pH [-]	Temp [deg C]	DO [g/m3]	NH4-N [g/m3]	DIN [g/m3]	DRP [g/m3]	pH [-]	Temp [deg C]	DO [g/m3]	NH4-N [g/m3]	DIN [g/m3]	DRP [g/m3]
Feb 21	09/02/21	6.8	20.7	4.31	0.03	0.09	0.01	6.56	21.5	5.05	0.89	3.9	0.095
Feb 21	22/02/21	7.12	22.6	4.35	0.05	0.142	0.015	7.16	22.7	5.41	0.89	1.15	0.122
Mar 21	08/03/21	6.51	19.5	5.79	0.06	0.182	0.011	6.28	19.1	7.79	2.1	3.52	0.05
Mar 21	22/03/21	7.29	20.7	6.2	0.03	0.156	0.011	6.91	19	7.9	0.8	4.86	0.051
Apr 21	19/04/21	6.95	20.1	6.3	0	0.13	0.024	6.76	17.8	8.55	6.9	8.92	0.126
May 21	13/05/21	6.75	15.8	0.31	0.055			6.69	15.7	0.14	0.994		
May 21	17/05/21	6.8	18.2	6.31	0.01	0.192	0.009	6.92	18.1	8.52	0.65	4.78	0.069
Jun 21	28/06/21	7.12	15.8	7.59	0.02	0.216	0.006	7.02	16	7.8	0.09	4.668	0.056
Jul 21	19/07/21				0.1	0.54	0.013				0.8	3.16	0.082
Jul 21	21/07/21	6.15	13.9	8.51	0.04			7.08	14.1	8.61	0.01		
Aug 21	16/08/21	6.57	12.3	7.84	0.01	0.192	0.006	6.69	12.7	9.29	0.2	4.54	0.035
Sep 21	27/09/21	6.23	14.2	7.41	0.02	0.72	0.019	6.43	14.7	7.78	0.52	8.17	0.042
Oct 21	04/10/21	5.94	15.9	8.45	0.03	0.546	0.057	6.04	15.8	8.23	0.8	4.06	0.048
Nov 21	15/11/21					0.24	0.008					1.336	0.027
Nov 21	17/11/21	6.41	17.6	6.32	0.05 .			6.67	17.7	7.73	0.68		
Dec 21	06/12/21	6.58	20.3	6.79	0.02	25.024	7.38	6.85	19.8	7.77	17	53.4	7.69
Dec 21	20/12/21	6.39	18.2	7.13	0.05	0.22	0.009	6.85	19.1	9.06	4	5.07	0.07
Jan 22	17/01/22	6.6	19.7	5.68	0.04	6.902	0.008	7.12	21.2	6.75	9	10.95	0.398
Jan 22	24/01/22	6.68	14.4	4.66	0.03			7.17	19.9	3.75	7.9		
	5 year Median	6.64	17.61	6.47	0.05	0.60	0.15	6.78	18.01	7.27	1.48	3.58	0.86
	5 yr std of error	0.05	0.30	0.14	0.01	0.30	0.10	0.04	0.32	0.18	0.44	0.68	0.15
	12 month media	6.6	18.2	6.31	0.03	0.216	0.011	6.85	18.1	7.79	0.845	4.668	0.069
	12 month max	7.29	22.6	8.51	0.1	25.02	7.38	7.17	22.7	9.29	17	53.4	7.69
	12 month min	5.94	12.3	0.31	0	0.09	0.006	6.04	12.7	0.14	0.01	1.15	0.027

Appendix D: Nocardia Lab Report

Watercare Services Limited
52 Aintree Ave, Mangere, Auckland, 2022
PO Box 107028, Auckland, 2150
T: (09) 539 7600
clientsupport@water.co.nz
www.watercarelabs.co.nz

Certificate of Analysis
Laboratory Reference:220126-169

Attention:	Lab Samples	*Final Report:*	**444765-0**
Client:	**PATTLE DELAMORE PARTNERS**	*Report Issue Date:*	**28-Jan-2022**
Address:	**PO Box 9528, Newmarket, 1149**	*Received Date:*	**26-Jan-2022**
Client Reference:	**Filamentious Nocardia**	*Laboratory Activity Dates:*	**27-Jan-2022 - 27-Jan-2022**
Purchase Order:	**Not Available**	*Quote Reference :*	**13921**

Sample Details	WATERS	WATERS	WATERS
Lab Sample ID:	**220126-169-1**	**220126-169-2**	**220126-169-3**
Client Sample ID:			
Sample Date/Time	26/01/2022 08:00	26/01/2022 08:00	26/01/2022 08:00
Description:	WWT Outlet	Wetland	DS 50
Microbiology Special Report			
Activated sludge biota by Microscopy			
See detailed report below	Y	Y	Y

Microbiology - Extended Details

Activated sludge biota by Microscopy	Sample : 220126-169-1 WWT Outlet Sample Date : 26/01/2022 08:00
SAMPLE CHARACTERISTICS	
Colour/Texture	Brown*
Settling characteristics	Fair*
FLOC SHAPE	
Round shaped flocs	20.0%*
Irregular shaped flocs	80.0%*
FLOC SIZE	
Flocs <150µm in size	10.0%*
Flocs between 150-500µm	60.0%*
Flocs >500µm in size	30.0%*
FLOC STRUCTURE	
Compact Structure	20.0%*
Open Structure	80.0%*
FLOC MORPHOLOGY	
Floc Morphology	Firm*
Floc Morphology	Irregular*
Floc Morphology	Diffuse*
FLOC QUALITY	
Floc Density	Medium*
FILAMENTOUS CHARACTERISTICS	
Filament Abundance	Moderate*
Filament Characteristics	Mixture*
Filament Abundance Rating	3.0*
MISCELLANEOUS	
Inorganic/organic particles	incidental*
Spirochaetes	absent*
Free cells in suspension	absent*
PROTOZOA	
Amoebae	incidental*
Filamentous bacteria	
Filamentous bacteria	Present*
TYPE 0092	10.0%*
Nostocoida limicola II.I.III	15.0%*
Sphaerotilus natans	15.0%*
TYPE 0675 & 0041	50.0%*
TYPE 021N	5.0%*
Beggiatoa	5.0%*
Ciliates	
Free-swimming ciliates	incidental*
Stalked ciliates	10-100/prep.*
Crawling ciliates	5-10/prep*
Total ciliates	10-100/prep.*
Crawling	
Aspidisca	5-10/prep*
Free-Swimming	
Litonotus	incidental*
Stalked	
Vorticella	5-10/prep*
Carchesium	10-100/prep.*
Flagellates	
Flagellates	absent*

Metazoa	
Metazoa	incidental*
Nematodes	incidental*
NON-FILAMENTOUS BACTERIA	
Non Filamentous bacteria	Absent*

Activated sludge biota by Microscopy	**Sample : 220126-169-2 Wetland** **Sample Date : 26/01/2022 08:00**
SAMPLE CHARACTERISTICS	
Colour/Texture	Brown*
Settling characteristics	Good*
FLOC SHAPE	
Round shaped flocs	100.0%*
Irregular shaped flocs	0.0%*
FLOC SIZE	
Flocs <150µm in size	100.0%*
Flocs between 150-500µm	0.0%*
Flocs >500µm in size	0.0%*
FLOC STRUCTURE	
Compact Structure	100.0%*
Open Structure	0.0%*
FLOC MORPHOLOGY	
Floc Morphology	Firm*
Floc Morphology	Round*
Floc Morphology	Compact*
FLOC QUALITY	
Floc Density	Medium*
FILAMENTOUS CHARACTERISTICS	
Filament Abundance	Low*
Filament Characteristics	Contained*
Filament Abundance Rating	0.0*
MISCELLANEOUS	
Inorganic/organic particles	absent*
Spirochaetes	absent*
Free cells in suspension	absent*
PROTOZOA	
Amoebae	absent*
Filamentous bacteria	
Filamentous bacteria	Absent*
Ciliates	
Free-swimming ciliates	absent*
Stalked ciliates	absent*
Crawling ciliates	absent*
Total ciliates	absent*
Flagellates	
Flagellates	absent*
Metazoa	
Metazoa	absent*
NON-FILAMENTOUS BACTERIA	
Non Filamentous bacteria	Absent*

Activated sludge biota by Microscopy	**Sample : 220126-169-3 DS 50** **Sample Date : 26/01/2022 08:00**

SAMPLE CHARACTERISTICS	
Colour/Texture	Brown*
Settling characteristics	Good*
FLOC SHAPE	
Round shaped flocs	100.0%*
Irregular shaped flocs	0.0%*
FLOC SIZE	
Flocs <150µm in size	100.0%*
Flocs between 150-500µm	0.0%*
Flocs >500µm in size	0.0%*
FLOC STRUCTURE	
Compact Structure	100.0%*
Open Structure	0.0%*
FLOC MORPHOLOGY	
Floc Morphology	Firm*
Floc Morphology	Round*
Floc Morphology	Compact*
FLOC QUALITY	
Floc Density	Medium*
FILAMENTOUS CHARACTERISTICS	
Filament Abundance	Low*
Filament Characteristics	Contained*
Filament Abundance Rating	0.0*
MISCELLANEOUS	
Inorganic/organic particles	absent*
Spirochaetes	absent*
Free cells in suspension	absent*
PROTOZOA	
Amoebae	absent*
Filamentous bacteria	
Filamentous bacteria	Absent*
Ciliates	
Free-swimming ciliates	absent*
Stalked ciliates	absent*
Crawling ciliates	absent*
Total ciliates	absent*
Flagellates	
Flagellates	absent*
Metazoa	
Metazoa	absent*
NON-FILAMENTOUS BACTERIA	
Non Filamentous bacteria	Absent*

Where samples have been supplied by the client, they are tested as received.
The results of analysis contained in this report relate only to the sample(s) tested. Where sample collection was performed by the laboratory, the results of analysis contained in this report relate only to the sample(s) collected.

Reference Methods

The sample(s) referred to in this report were analysed by the following method(s)

Analyte	Method Reference	MDL	Samples	Location
Microbiology Special Report				
Activated sludge biota by Microscopy				
Amoebae	Microscopy		All	Auckland

Microbiology Special Report

Activated sludge biota by Microscopy

Colour/Texture	Microscopy	All	Auckland
Compact Structure	Microscopy	All	Auckland
Filament Abundance Rating	Microscopy	All	Auckland
Filament Abundance	Microscopy	All	Auckland
Filament Characteristics	Microscopy	All	Auckland
Floc Density	Microscopy	All	Auckland
Floc Morphology	Microscopy	All	Auckland
Flocs <150µm in size	Microscopy	All	Auckland
Flocs >500µm in size	Microscopy	All	Auckland
Flocs between 150-500µm	Microscopy	All	Auckland
Free cells in suspension	Microscopy	All	Auckland
Inorganic/organic particles	Microscopy	All	Auckland
Irregular shaped flocs	Microscopy	All	Auckland
Metazoa	Microscopy	All	Auckland
Open Structure	Microscopy	All	Auckland
Round shaped flocs	Microscopy	All	Auckland
Settling characteristics	Microscopy	All	Auckland
Spirochaetes	Microscopy	All	Auckland

The method detection limit (MDL) listed is the limit attainable in a relatively clean matrix. If dilutions are required for analysis the detection limit may be higher.

For more information please contact the Compliance and Projects Manager.

Samples, with suitable preservation and stability of analytes, will be held by the laboratory for a period of two weeks after results have been reported, unless otherwise advised by the submitter.

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Appendix E: Macroinvertebrate Result

Table E1. Macroinvertebrate Results

Bottle No. / Taxa	MCI Score	MCI Score	US 50	US 100	US 150	DS 50	DS 100	DS 130		
Caddisfly Aoteapsyche	4	6			1					
Caddisfly Polyplectropus	8	8.1	5	5	4					
Caddisfly Psilochorema	8	7.8			1					
Caddisfly Triplectides	5	5.7	2	21	7					
Beetle Rhantus	5	1				1				
True Fly Muscidae	3	1.6				3				
True Fly Orthocladiinae	2	3.2	6	1	35		3	2		
True Fly Paralimnophila	6	7.4	2		7					
True Fly Tanytarsini	3	4.5	1		15	34	50	19		
True Fly Zelandotipula	6	3.6	3							
Crustacea Ostracoda	3	1.9	2	7		164	5	1		
Crustacea Paratya	5	3.6			1			1		
Crustacea Talitridae	5	5		2						
SPIDERS Dolomedes	5	6.2	4	2	1		1	1		
Mollusc Lymnaeidae	3	1.2				2				
Mollusc Physella (Physa)	3	0.1				1				
Mollusc Potamopyrgus	4	2.1	23	62	116	14	8	7		
Mollusc Sphaeriidae	3	2.9	1	10		1			Average US	Average DS
Number of Taxa			10	8	10	8	5	6	9	6
EPT Value			2	2	4	0	0	0	3	0
Number of Individuals			49	110	188	220	67	31	116	106
% EPT (taxa number)			20	25	40	0	0	0	28.3	0.0
Sum of recorded scores			45.6	35.1	54.6	15.3	17.9	21.5	45.1	18.2
SBMCI Value			91.2	87.75	109.2	38.25	71.6	71.67	96.1	60.5
Sum of abundance load			181	358.3	570.8	505.2	267.1	118.3	370.0	296.9
QMCI-sb Value			3.69	3.26	3.04	2.30	3.99	3.82	3.33	3.37

Appendix F: Objectives and Policy Assessment

Table 1: Assessment against relevant objectives and policies		
Objective/ Policy	**Description**	**Assessment**
Proposed Regional Plan – Northland		
E.1 Objective E.1.1 Catchment-specific (Doubtless Sound)	1) cultural and recreational uses associated with fresh and coastal waters	Not applicable for the immediate receiving environment. However, HiHi Stream flows to Hihi Beach, as such there is potential for cumulative effects. Cultural effects not assessed as part of this project scope.
	2) the ability to gather mahinga kai	Receiving environment not a known mahinga kai site, cultural effects not assessed as part of this project scope.
	3) the natural character of waterbodies and their margins	With WSP-Opus (2022) suggestions implemented, natural character of the receiving environment should be improved.
	4) the quality of habitat for aquatic native species	With WSP-Opus (2022) suggestions implemented water quality should be improved.
	5) access to freshwater for productive uses	Not applicable.
Policy E2.1	1) reducing the amount of sediment entering waterways from hill slope and stream-bank erosion	Not applicable, discharge is from a constructed wetland.
	2) improving the quality of fresh and coastal water for cultural and recreational uses, particularly contact recreation and the ability to gather mahinga kai	With WSP-Opus (2022) suggestions implemented, water quality of the receiving environment is expected to improve for cultural and recreational uses.
	3) protecting the ecosystem health and natural character of freshwater bodies, particularly outstanding lakes	With WSP-Opus (2022) suggestions implemented, water quality and ecosystem health should be improved.
	4) enabling the extraction and use of freshwater where this will not compromise other values or exceed a minimum flow or level, or an allocation limit.	Not applicable.

Table 1: Assessment against relevant objectives and policies		
Objective/ Policy	**Description**	**Assessment**
Northland Policy Statement		
3.2 Region-wide water quality	a) Reducing the overall Trophic Level Index status of the region's lakes	Not applicable.
	b) Increasing the overall Macroinvertebrate Community Index status of the region's rivers and streams	With WSP-Opus (2022) suggestions implemented, MCI scores should improve over time.
	(c) Reducing sedimentation rates in the region's estuaries and harbours	Minor effect. Currently some minor increase in turbidity downstream of discharge. With WSP-Opus (2022) suggestions implemented TSS concentration of <5 mg/L is expected.
	(d) Improving microbiological water quality at popular contact recreation sites, recreational and cultural shellfish gathering sites, and commercial shellfish growing areas to minimise risk to human health	Potential microbiological effects from the current discharge. Increased *E. coli* monitoring has been recommended to further understand effects. With WSP-Opus (2022) suggestions implemented *E. coli* concentration of <10 cfu/100ml is expected.
	(e) Protecting the quality of registered drinking water supplies and the potable quality of other drinking water sources	Not applicable. There are no known surface water takes downstream of the discharge.
3.3 Ecological flows and water levels	Maintain flows, flow variability and water levels necessary to safeguard the life supporting capacity, ecosystem processes, indigenous species and the associated ecosystems of freshwater.	Not applicable, the HiHi WWTP discharge provides additional flow to HiHi Stream.
3.4 Indigenous ecosystems and biodiversity	a) Protecting areas of significant indigenous vegetation and significant habitats of indigenous fauna	Not applicable. No significant ecological areas (SEAs) nearby on NRC maps.
	b) Maintaining the extent and diversity of indigenous ecosystems and habitats in the region	With WSP-Opus (2022) suggestions implemented, instream habitat will be maintained, and water quality downstream of the discharge is expected to improve.

Table 1: Assessment against relevant objectives and policies		
Objective/ Policy	**Description**	**Assessment**
	c) Where practicable, enhancing indigenous ecosystems and habitats, particularly where this contributes to the reduction in the overall threat status of regionally and nationally threatened species.	c) No threatened species were identified/recorded within Hihi Stream. Water quality improvements should assist in providing better quality environment for threatened fish to migrate to.