Risk assessment of Kaeo WWTP discharges to the Kaeo River

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Kaeo WWTP re-consenting
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Executive summary

Jacobs Group New Zealand (Jacobs) were engaged by Far North District Council (FNDC) to undertake a qualitative risk assessment for the discharge of treated wastewater effluent from the Kaeo Wastewater Treatment Plant (WWTP) to the Kaeo River. This investigation forms part of the process of FNDC to re-consent discharges of treated effluent form the WWTP to the Kaeo River.

A weight-of-evidence approach to undertaking the qualitative risk assessment is set out. The lines of evidence include monitoring records for the discharges currently authorised under Consent CON20100720501, the long-term monitoring records from the Northland Regional Council's (NRC) state of the environment (SoE) monitoring programme upstream of the discharge location, and data sourced from NRC regarding faecal source tracking investigations, and historic monitoring records from the Whangaroa Harbour. Data were compared against receiving environment water quality objectives set out in the 'Proposed Regional Plan for Northland, Appeals Version' (NRC, November 2021) which are closely aligned with the attributes set out in the National Policy Statement for Freshwater Management (MfE 2020).

The lines of evidence demonstrate that, overall, the risk to the freshwater receiving environment is medium, driven largely by the acute and chronic toxicity risk of ammoniacal-nitrogen in effluent. This is regarded as precautionary, given the small subset of water quality parameters for which receiving environment monitoring data associated with the WWTP was available. In summary, risk assessment profiles indicated the following:

- There is medium risk of acute and chronic toxicity associated with elevated concentrations of ammoniacal-N in the effluent discharging to the Kaeo River. There is some indication of a source of contamination between the upper SoE site and the upstream consent monitoring site.
- There is a generally low risk posed by low dissolved oxygen in the effluent discharged to the Kaeo River. Effects are expected to be short, intermittent, and last for a period of days, rather than any long-term effects.
- Risks of *E. coli* is assessed as medium, given the poor microbiological water quality of the upper catchment it is apparent that any discharges from the WWTP will require faecal indicator bacteria to be at a level that will not exacerbate upper catchment issues. Poor water quality in the catchment is likely to be driven by upper catchment runoff during wet weather flushing flows.

Data were not available for other key water quality parameters (e.g. broader nutrient suite, metals/metalloids/organic toxicants). Historic monitoring records from targeted/one-off studies conducted in the Whangaroa Harbour suggest that these contaminants have not historically been recorded at concentrations of concern. Given the lack of significant land use change it is anticipated that any contaminant concentrations recorded in the Whangaroa Harbour are unchanged, and are most likely not influenced by the discharges from the Kaeo WWTP.

Important note about your report

The sole purpose of this Ecological Risk Assessment is to provide an analysis and interpretation of data and supporting information to determine any impacts to the Kaeo River receiving environment that could be confidently attributed to the activity of discharging treated wastewater effluent to the Kaeo River. This report is in accordance with the scope of services set out in the contract between Jacobs and Far North District Council (FNDC).

In preparing this report, Jacobs has relied upon, and presumed accurate, any information provided by FNDC and/or from other sources (e.g. monitoring data reports.). Unless otherwise stated, Jacobs has not verified the accuracy or completeness of any information provided by FNDC or contained in publicly available reports and databases. If the information is subsequently determined to be false, inaccurate or incomplete, then it may be possible that conclusions expressed in this report may be impacted. All data sources are referenced throughout the text and listed in the reference section at the end of this report.

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List of abbreviations

Abbreviation	Definition
Amm-N (NH4-N)	Ammoniacal-nitrogen
ANZG	Australia and New Zealand guidelines for fresh and marine water quality
CoC	Contaminants of concern
DGV	Default guideline value
DIN	Dissolved inorganic nitrogen
DRP	Dissolved reactive phosphorus
DO	Dissolved oxygen
DS	Downstream (consent monitoring site)
ERA	Ecological risk assessment
FIB	Faecal indicator bacteria
LAWA	Land, Air, Water Aotearoa
NO3	Nitrate
NPSFM	National Policy Statement for Freshwater Management
NRC	Northland Regional Council
PRP	Proposed Regional Plan (Appeals Version)
SoE	State of the Environment
TN	Total nitrogen
TON	Total organic nitrogen
TP	Total phosphorus
TSS	Total suspended solids
US	Upstream (consent monitoring site)
WQO	Water quality objective
WWTP	Wastewater treatment plant

1. Introduction

Far North District Council (FNDC) are applying for a new discharge consent for the Kaeo Wastewater Treatment Plant (WWTP). The WWTP is located west of Kaeo township and south of the Kaeo River. The current discharge consent (CON20100720501) authorises the discharge of treated wastewater into the Kaeo River which flows into the Whangaroa Harbour (Refer to Figure 1 for locations). The consent expires on the 31st of October 2022 (NRC, 2011).

FNDC have commenced investigations to support the application of a new consent. As part of the package of work to support the consenting process, a preliminary assessment of the WWTP performance has been set out in a detailed technical memorandum for FNDC (see Stumbles (2021) for full details). The 2021 assessment documented the key areas of the WWTP associated with potential or actual non-compliance, key performance issues, and determination of the quality of treated effluent that can be realistically achieved by the current design. The latter provided a foundation for the development of a basis of design for the WWTP and review of future treated wastewater discharge consent criteria dependent on the effluent disposal route.

Treated effluent is currently discharged directly to the Kaeo River after UV disinfection, bypassing the constructed wetland. The UV disinfection was installed in 2011, and the performance review has noted that the wetland planting is in poor condition and wetland treatment is not effective.

Discharge limits for a sub-set of indicator contaminants are currently required to be routinely monitored at a site 10 m upstream of the discharge point, and at 15 m downstream of the discharge point. Influent and effluent are also routinely assessed. Receiving environment monitoring records (2010-2021) indicate that for most of the time, treated effluent discharged to the Kaeo River has consistently complied with the NRC limits.

Since the commencement of the consent monitoring in 2011, there have been a number of key updates to science knowledge relevant for the management of discharges of treated effluent from the WWTP. These include, but not limited to:

- Updates to the compulsory attributes for surface water streams and rivers, set out in the National Policy for Freshwater Management (NPSFM 2020),
- Proposed Regional Plan for Northland (Appeals Version- November 2021),
- Australian and New Zealand Guidelines for Fresh and Marine and Water Quality (ANZG 2018) – these including the iterations of the Water Quality Management Framework,
- Various technical guidance publications (e.g. EIANZ 2018, EPA Victoria 2009[1]).

1.1 Objective of this study

This study provides an environmental risk assessment (ERA) for treated wastewater discharges from the Kaeo WWTP to the Kaeo River. A desktop performance analysis (Jacobs 2021) was recently undertaken for FNDC to assess the performance of the WWTP. This current study draws on section of information set out in that report, and focuses on effects to the receiving environment. This ERA considers the current monitoring data undertaken for the WWTP, the current state of the receiving environment (both in the upper catchment and below the WTWTP discharge to the Kaeo River), and the wider Whangaroa Harbour receiving environment.

[1] EPA Victoria publication No. 1287 sets out a comprehensive framework that is readily applied to assessment of risk to aquatic receiving waters. A comparable guide does not exist for New Zealand.

2. Environmental Risk Assessment Plan

This section outlines the risk assessment process which will be used to characterise the potential impact of the treated effluent discharge from the Kaeo WWTP on the values of the receiving environment of the Kaeo River and Whangaroa Harbour. This is a simplified process, focusing on the compliance monitoring for the upstream and downstream receiving environments. The adopted approach is consistent with the 'Guidelines for Risk Assessment of Wastewater Discharges to Waterways' (EPA Victoria, 2009).

2.1 Risk assessment approach

The process for the environmental risk assessment (ERA) comprised four main, sequential steps:

Step 1: Characterise the nature of the discharge. The origin and location of the discharge were defined.

Step 2: Characterise the receiving environment. At a high level, the values of the receiving environment were identified from the current proposed Natural Resources Plan (NRC 2021), NPSFM (MfE 2020), and ANZG (2018). Suitable endpoints for the assessment of risk identified (attribute state, default guideline values, DGVs).

Interim assessment : Assessment of discharge quantity and quality[2]. Available discharge quality from Kaeo WWTP interstage assessment were analysed to identify contaminants of concern (CoC) that could potentially be applied to the 'weight of evidence' approach for downstream risk assessment. This was included as an interim step, as data was considered at a high-level assessment only.

Step 3: Analysis of discharge quality and ambient monitoring data. Any CoC with concentrations greater than WQOs in the discharge were further examined by assessing whether there was evidence of any impacts to ambient water quality in the monitoring data. This includes comparison of discharge quality to any site-specific water quality objectives (WQOs, i.e. upper catchment attribute state assessments as set out on LAWA) if concentrations upstream of the discharge exceed DGVs.

Step 4: Environmental risk assessment. If, based on these steps, there was clear evidence that the discharge has led to an elevated concentration of contaminants in the receiving environment (with expected or actual environmental effects), the consequential environmental risk was assessed.

For the environmental risk assessment, sensitivity and exposure were combined in a risk assessment matrix to provide a rating of the residual risk that can be attributed to the discharge. The risk assessment matrix is shown in Table 2.1. The residual risk description is provided in Table 2.2.

Table 2-1 Risk assessment matrix incorporating assessments of sensitivity of the community value and the exposure duration

		Sensitivity of community value		
		Low	Moderate	High
Exposure	Short (days)	Low	Low	High
	Medium (weeks)	Low	Medium	High
	Long (months)	Low	Medium	High

[2] Discharge quality and quantity, as well as and discharge regime are also an important consideration if exceedances of COC are indicated in the receiving environment. The available effluent quality data set for the Kaeo WWTP is limited to 6 parameters in the receiving environment.

Table 2-2 Residual risk description

Risk	Consequence
Low	Minor, short-term stress on the environment with rapid recovery.
Medium	Environment stress observed, short term disruption to breeding cycles and ecological processes; minor disruption to recreation and the aesthetics of the waterway.
High	Significant damage to the environment observed, including impact on threatened species, animal and public health risk and shift in underlying ecosystem processes.

For this assessment, the use of the term 'values' are intended to be representative of those commonly associated desired water quality contributing to ecosystem health (NPSFM 2020), primary contact recreation (NPSFM 2020, MfE 2003), and compulsory attribute benchmarking (NPSFM 2020). Where data is available for other CoC (e.g. metals, organic CoC), values are also considered in terms of the water management framework set out in the ANZG (2018). Cultural Health Indicators are not specifically addressed but warrant separate assessment. Community values that may be long term aspirations for water quality, are also not assessed and are outside the scope of this assessment.

3. Kaeo WWTP Discharges to the Kaeo River

This section summarises several key aspects of the WWTP performance assessment (Jacobs 2021) to provide context for step 1 of the ERA process set out in section 2.

3.1 Wastewater treatment and location of discharge

Jacobs (2021) summarises the key steps of the water treatment process. The discharge location and general flow path of the Kaeo River to the Whangaroa Catchment is shown in Figure 3-1.

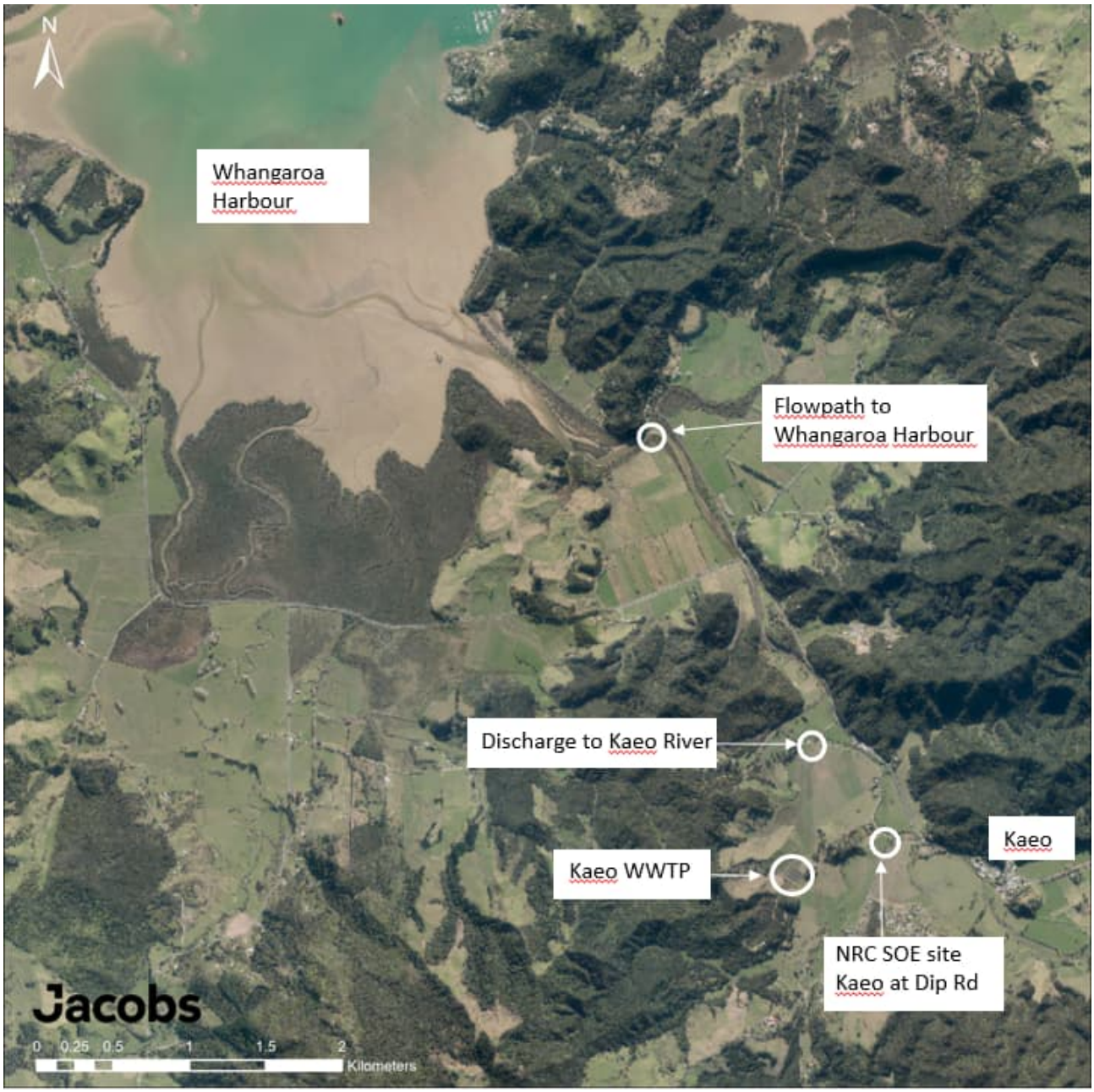

Figure 3-1 Kaeo WWTP Location and discharge location to the Kaeo River and flow to the Whangaroa Harbour. NRC long term monitoring site is shown as 'Kaeo at Dip Rd'

3.2 Northland Regional Council resource consent conditions

Current resource consent monitoring requirement for the Kaeo River receiving environment require samples to be collected from NRC monitoring locations 10 m upstream (US) and 15 m downstream (DS) of the WWTP discharge point within the Kaeo River. Sampling is also undertaken within the WWTP for influent and treated effluent discharges – this information is summarised in Jacobs (2021). Consent monitoring parameters are listed in Table 1.

Table 3-1 Summary of consent authorized monitoring parameters for the Kaeo WWTP

Parameter	Influent	Effluent	US	DS
Flow	✓	✓		
Temperature		✓	✓	✓
pH		✓	✓	✓
Dissolved Oxygen (DO)		✓	✓	✓
5-day Biological Oxygen Demand (BOD_5)		✓		
Total Suspended Solids (TSS)		✓		
Total Ammoniacal Nitrogen (NH_4-N)		✓	✓	✓
Faecal coliforms		✓	✓	✓
E. coli		✓	✓	✓
F-specific Bacteriophage	✓	✓		

US: upstream in the Kaeo River, DS: downstream in the Kaeo River

For the Kaeo River receiving environment, Condition 9 (a-e) (and repeated in Schedule 1), states:

9 Notwithstanding any other conditions, the exercise of these consents shall cause no significant adverse change to the following water quality parameters in the Kaeo River at NRC Sampling Site 100671, at or about 15 metres downstream of Kaeo Sewage discharge:

(a) Temperature;
(b) pH;
(c) Dissolved oxygen concentration;
(d) Faecal coliform concentration;
(e) Escherichia coli concentration.

For Ammoniacal-nitrogen (Amm-N), Condition 9(l) states the four-day average concentration of total ammoniacal nitrogen shall not exceed the following pH/temperature adjusted ammoniacal-N concentrations:

pH	10°C	15°C	20°C	25°C	30°C
6.5	1.81	1.81	1.22	0.86	0.6
6.75	1.81	1.81	1.22	0.86	0.6
7	1.81	1.81	1.22	0.86	0.61
7.25	1.81	1.81	1.23	0.86	0.61
7.5	1.81	1.81	1.23	0.86	0.61
7.75	1.73	1.64	1.15	0.81	0.58
8	1.13	1.09	0.76	0.54	0.39
8.25	0.64	0.62	0.44	0.32	0.23
8.5	0.37	0.36	0.26	0.19	0.14

Compliance is assessed by comparison of the downstream river water (15 m below the point of discharge in the Kaeo River) against the upstream river water quality (10 m above the point of effluent discharge). Jacobs (2021) has summarised the compliance as a ratio of the two monitoring data points of US:DS concentrations as per the limits listed in Table 3-2.

Table 3-2 Summary of water quality parameters and consent limits for receiving environment monitoring in the Kaeo River

Parameter	Limit	Frequency of sampling
Temp [deg C]	DS-US < 3.0 a,c	Monthly
pH [-]	DS: 6.5-9.0 a,c	Monthly
DO [g/m3]	DS/US > 0.80 a,c	Monthly
Fecal coliforms [c/100 mL]	log DS/US < 1.0 a,c	Monthly
E.coli [c/100 mL]	log DS/US < 1.0 a,c	Monthly
Amm-N (NH4-N) [g/m3]	b, c	Monthly
Amm-N (NH4-N) [g/m3] 4-day avg.	As per table for cond. 9(l)	Monthly

a. Limits shown here for US - DS sampling is a practical interpretation of the resource consent requirement, which states: "The discharge shall not cause a significant adverse effect on the downstream water quality, taking into account measuring variability."

b. NH4-N < 1.2 g/m3 valid for pH 7.5 and 20 deg.C. If receiving environment conditions vary considerably, the limit is adjusted according to the pH and temperature conditions (i.e. higher pH and temperature incurs a drop in Amm-N)

c. The receiving water samples shall only be taken between 3 and 7 hours after high tide occurred in the Whangaroa Harbour (to avoid any tidal mixing in the freshwater sample site)

4. Kaeo River Receiving Environment

This section describes the general condition of the Kaeo River in the vicinity of discharges from Kaeo WWTP, establishes the values of the Kaeo River and Whangaroa Harbour which require protection from the effects of threats or stressors and identifies suitable endpoints for the assessment of risk (i.e. step 2 of the ERA, outlined in section 2).

4.1 Whangaroa Catchment

The Kaeo River begins north of Waipapa and flows north into the Whangaroa Harbour. Approximately half of the catchment is native forest and scrub, with the remainder in pine forestry, lifestyle blocks or pastoral farming (Table 4-1). Only a small proportion is urban cover (<1%).

Table 4-1 Land use cover of the Whangaroa Catchment. Source: LCDB listed on LAWA

Land use cover type	%	Ha
Catchment Area	100.0	11409
Urban/bare/lightly vegetated surfaces	0.3	36
Cropland	0.0	2
Forest	50.0	5705
Grassland/other herbaceous vegetation	29.8	3403
Scrub/shrubland	19.7	2250
Water bodies	0.1	14

The Kaeo River is part of the wider Whangaroa Catchment. The catchment itself is highly erodible; the underlying geology of the Kaeo river is soft sediments, which is reflected in its elevated turbidity levels.

The river is a fifth order stream, draining the 11409 Ha Whangaroa Catchment before discharging to the Whangaroa Harbour. NRC has classified the river below the crossing with State Highway 10 as the general marine/coastal zone (i.e. tidally influenced). The WWTP discharges above this tidally influenced zone.

4.2 Freshwater state assessment

Northland Regional Council undertakes long term state of the environment (SoE) monitoring at a site approximately 200 m upstream of the WWTP discharge location – Kaeo River at Dip Rd (approx. 3.1 km upstream of the coastal marine area). The SoE monitoring site is located below the township of Kaeo, just before the influence of salt water.

The SoE data are listed on the Land, Air, Water Aotearoa (LAWA) website, and are summarised in Table 4.2 Along with key findings of state and trend analyses undertaken on an annual basis for regional council monitoring.

ANZG (2018) include the default guideline values (DGVs) for physical and chemical stressors (ammoniacal nitrogen, clarity, dissolved oxygen, electrical conductivity, filterable/dissolve reactive phosphorus, pH, nitrate, suspended solids, total nitrogen, total phosphorus and turbidity). The DGVs for these have been developed second-level River Environment Classification (REC) classes (climate by typography).

The Kaeo River is defined as REC(2) 'Warm Wet Low-elevation' (abbreviated to WWL in the ANZG 2018). Rec(2) DGVs are also listed in Table 4-2 for comparison.

LAWA summarises the current 5-, 10- and 15-year trend data for a sub-set of water quality parameters. The 5-year trends (where available) are listed in Table 4-2. It is noted here that data reported on LAWA did not

indicate any inclusion of metals or non-metallic organic contaminants. The data are listed for the physico-chemical (PC) parameters for nutrients, suspended sediment, faecal indicator bacteria, and macroinvertebrate community health / biomass (chlorophyll). Benchmarking for these is therefore analysed against NPSFM attribute bands (where indicated).

Table 4-2 Current state assessment of water quality parameters against NPSFM attributes. Data summary based on data collected between Jan 2015 and December 2019. Trends are reported for 5 -year trend analysis (Source: LAWA). Coloured vales correspond to NPSFM attribute states (no shading is for where no attribute bands are defined).

Parameter (statistical descriptor)	Numerical value and state (NRC, LAWA)	5 yr Trend (LAWA)	ANZG (2018) WWL (REC2) DGVs	NRC Policy H.3.1, Table 22
Nitrogen				
NH4 mg/L (annual median)	0.008	V.likely improving	0.01 (80th %)	≤0.24
NH4 mg/L (annual max)	0.051	V.likely improving		≤0.4
NO3 mg/L (annual median)	0.018	Indeterminate	0.065 (80th %)	<1.0
NO3 mg/L (95th percentile)	0.15			≤1.5
TON mg/L	0.02	Likely degrading		
TN mg/L	0.16	Indeterminate	0.292 (80th %)	
DIN mg/L (annual median)	0.028			
DIN mg/L (95th percentile)	0.166			
Phosphorus				
TP mg/L	0.015	V.likely improving	0.024 (80th %)	
DRP mg/L (annual median)	0.008	V.likely improving	0.014 (80th %)	
DRP mg/L (95th percentile)	0.017			
Suspended fine sediment				
Suspended Sediment Class (NPSFM Appendix 2C)	2			
Visual clarity (Black disk distance m)[1]	1.38	V.likely improving	0.8 (20th %)	≤30% Not more than 30% decrease in black disc or equivalent measurement
Faecal Indicator Bacteria				
E.coli % exceedance over 540 MPN/100 ml	36.7			≤ 20%
E.coli % exceedance over 260 MPN/100 ml	63.3			≤ 34%
E.coli MPN/100 ml (annual median)	403.5	V.likely improving		≤ 130

Parameter (statistical descriptor)	Numerical value and state (NRC, LAWA)	5 yr Trend (LAWA)	ANZG (2018) WWL (REC2) DGVs	NRC Policy H.3.1, Table 22
E.coli MPN/100 ml (95th percentile)	6571.8			≤ 1200
Biological indicators				
Chlorophyll a mg/m2 (92nd percentile)	26.8			≤200 Exceeded by no more than 8% of samples (default class rivers). Exceeded by no more than 17% of samples in productive class rivers. Based on monthly samples collected over three years
Macroinvertebrates (MCI)	93	V. likely degrading		
Macroinvertebrates (QMCI)	5	Indeterminate		
Macroinvertebrates (ASPM)	0.2	Indeterminate		
Other PCs not analysed above				
DO (%)			92 (20th %) 103 (80th %)	
Do (mg/L)				≥5.0 7-day minimum ≥4.0 1-day minimum
Conductivity (μ S/cm)			115 (80th %)	
pH			7.26 (20th %) 7.7 (80th %)	6.0 < pH > 9.0
SSC (mg/L)			8.8 (80th %)	
Deposited fine sediment- hard bottom wadable rivers (% cover, SAM2 protocol)				≤10% Not more than 10% increase in cover
Turbidity (NTU)[1]			5.2 (80th %)	
Temperature				≤24 deg.C

Parameter (statistical descriptor)	Numerical value and state (NRC, LAWA)	5 yr Trend (LAWA)	ANZG (2018) WWL (REC2) DGVs	NRC Policy H.3.1, Table 22
Metals/metalloids/inorganic and organic contaminants (excl. nitrate, Amm-N toxicity)	Not assessed			ANZG (2018) 95th% DGV

Table Notes:

Attribute Colour code

NPSFM band A	A
NPSFM band B	B
NPSFM band C	C
NPSFM band D & E	D

[1]Turbidity and clarity are closely and inversely related. The 80th percentile for turbidity is consistent with the 20th percentile for clarity and vice versa.

Current state assessment for the SoE site Kaeo at Dip Rd indicates for most PC stressors, NPSFM attribute band of A and B are being achieved. Benthic macroinvertebrate community health is benchmarked as degraded, (Band C and D), and trend analysis confirming as likely degrading.

Of note, microbiological water quality it currently impacted at the SoE site – upstream of the WWTP treated effluent discharge. Microbiological water quality is assessed as Band D – representing a poor state, and a significant risk to human health from primary contact recreation. Sources contributing to elevated faecal indicator bacteria (FIB) scores are cited as farm rain-fall runoff and livestock access to waterways (LAWA). Faecal source tracking investigations undertaken by NRC have confirmed the presence of ruminant faecal sources in the water ways of the Whangaroa catchment (Appendix A).

4.3 Whangaroa Harbour state assessment

NRC have undertaken a range of monitoring across Whangaroa Harbour, as part of one-off assessment related to aquaculture practices, and broader SoE monitoring. A list of historic monitoring undertaken by NRC across Whangaroa Harbour is included in Appendix A. As noted in the summary, the bulk of data sourced from NRC for the Whangaroa Harbour is considered old, with records only going up to 2011/12 for most programmes. Full assessment of catchment discharges to the Whangaroa Harbour would require the development of a hydrodynamic model. It is unknown that such a model exists for this harbour[3].

NRC Policy H.3.3 Coastal water quality standards Table 25): '*Water quality standards for ecosystem health in coastal waters, contact recreation and shellfish consumption'* apply to Northland's coastal waters, and they apply after allowing for reasonable mixing.

The standards for coastal water quality management units for tidal creeks and estuaries, as listed in Table 25 (NRC 2021) are applicable for the Whangaroa Harbour, listed in Table 4-3.

4.4 Environment values and water quality objectives

The term 'environmental values' is intended to be a broad term to encompass a range of values for the freshwater receiving environment, as identified in the regional plan, water quality management frameworks, and central government policy.

[3] It is understood that a Quantitative Microbial Risk Assessment has been undertaken, or is near completion. The QMRA typically includes hydrodynamic models to inform the QMRA process.

For freshwater, NRC Policy H.3.1 Water quality standards for continually or intermittently flowing rivers (Table 22) lists the standards applicable for rivers across the region. These are largely aligned with the NPSFM attribute bands, and the ANZG (2018) DGV for other toxicants at the 95th percentile for species protection. Microbiological FIB standards are derived from the MfE/MoH 2003 guidelines, and are also listed in the NPSFM 2020 attribute Table 5.

For the coastal marine area, NRC Policy H.3.3 Coastal water quality standards (Table 25) for tidal creeks and estuaries are applicable.

The derivation of these policies and standards encompasses a wide range of receiving environment values governing water quality management in the Northland region. These form the basis of the water quality objectives for assessing the risk posed by discharge from the Kaeo WWTP to the Kaeo River and Whangaroa Harbour. In summary:

Water quality objectives for freshwater aquatic ecosystem health are adopted from:

- NRC Policy H.3.1 Table 22: Water quality standards for ecosystem health in rivers
- Australian & New Zealand guidelines for Marine & Freshwater Quality (ANZG, 2018): REC(2) WWL DGVs
- Australian & New Zealand guidelines for Marine & Freshwater Quality (ANZG, 2018): 95% level of protection for slightly to moderately disturbed ecosystems (fresh waters) for toxicants.

Water quality objectives for human contact recreation are adopted from:

- NRC Policy H.3.1 Table 23: Water quality standards for human contact in rivers

Water quality objectives for the coastal marine area are adopted from:

- NRC Policy H.3.3 Table 25: Water quality standards for ecosystem health in coastal waters, contact recreation and shellfish consumption
- Australian & New Zealand guidelines for Marine & Freshwater Quality (ANZG, 2018): 95% level of protection for slightly to moderately disturbed ecosystems (marine waters) for toxicants.

Specific values for each indicator and relevant WQO are provided in Table 5.3 for which data is routinely assessed for receiving environment compliance monitoring undertaken for the Kaeo WWTP discharges. It is noted here, given there are only six water quality parameters routinely monitored for the Kaeo WWTP receiving environment assessment, a large number of the range of WQOs listed above are not further assessed (given data is not available).

It is recommended, however, that if additional monitoring is undertaken, and as new data/analytical suites are potentially included, the same ERA framework set out in this report is applicable.

Table 4-3 Water quality objectives to assess risks to the receiving environment associated with the discharge for treated effluent from the Kaeo WWTP

Parameter	Consent Limit	NRC Policy H.3.1	REC(2) WWL DGV
NH4-N [g/m3]	<1.2	≤0.24 (annual median)[1] ≤0.40 (annual maximum)[1]	0.010 (80th % DGV)
Temp [deg C]	DS-US < 3.0 a,c	≤3 deg.C	
pH [-]	DS: 6.5-9.0 a,c	6.0 < pH <9.0	7.26 (20th % DGV) 7.7 (80th % DGV)
DO [g/m3]	DS/US > 0.80 a,c	≥5.0, 7-day mean minimum[1] ≥4.0, 1-day minimum[1]	
DO [%]	-		92 (20th % DGV) 103 (80th % DGV)
Fecal coliforms [c/100 mL]	log DS/US < 1.0 a,c		
E.coli [c/100 mL]	log DS/US < 1.0 a,c	% exceedance over 540 ≤20%[2] % exceedance over 260 ≤34%[2] Median conc. ≤130[2] 95th% ≤1200 [2]	

[1] NRC standard corresponds to NPSFM (2020) National bottom line for dissolved oxygen and Ammoniacal-N

[2] NRC standard corresponds to NPSFM (2020) D band threshold (noting there is no national bottom line for *E. coli*)

5. Discharge Quality Assessment

This section sets out an assessment of discharge quality of the treated effluent to the Kaeo River, addressing step 3 of the ERA . Discharge quality from both the effluent discharge from the WWTP and at the downstream monitoring location in the Kaeo River were compared against defined WQOs (NRC H.3.1, ANZG (2018) DGV for REC(2) WWL) to identify contaminants of concern (CoC) in the available data.

5.1 Kaeo WWTP discharge regime and discharge load assessment

The treated effluent discharge regime is summarized in detail in Jacobs (2021) and is not repeated here.

For assessment of effects to the receiving environment, including the downstream coastal marine area of the Whangaroa Harbour, it is acknowledged that discharges of total nutrients and suspended solids is of high interest for assessment of any potential adverse impacts to the CMA. Total nitrogen (TN) and total suspended solids (TSS) are not currently included in the routine receiving environment monitoring.

Interstage monitoring data undertaken for the Kaeo WWTP in 2021 is summarised in Table 5-1. The parameters assessed for each component process are included for comparison to the final effluent quality post-treatment.

Of interest for this assessment is the comparison of total nitrogen and total suspended solids, highlighted in the table below for ease of reading. Whilst TN and TSS are not monitored in the final effluent following UV treatment, the concentrations recorded in effluent discharged from the oxidation pond are considered representative of the final concentrations in the effluent (i.e. there is no significant change from post biofilter to post UV treatment).

Assessment for TN and TSS is included as a high-level assessment only based on interstage sampling[4], noting the full assessment of risk to the Whangaroa Harbour requires data that is not available with the current monitoring.

Comparing the 'combined effluent' and biofilter concentrations for TN and TSS, there is approximately three fold reduction in concentration following the treatment process.

Table 5-1 Summary of Kaeo WWTP Interstage monitoring undertaken 2021. Note: Water Quality of discharge from the biofilter (except for FIB) is considered indicative of final water quality in discharged effluent.

Whangaroa flow contribution: 4.05%				Influent	Post Oxidation Pond	Post Biofilter	
Parameter	**Units**	**Whangaroa Sewage**	**Kaeo Influent**	**Combined effluent**	**Kaeo - Pond 1 Effluent**	**Kaeo Biofilter**	**Kaeo Ex UV**
Biological Oxygen demand (BOD_5)	mg/L	236	139	143	24	14	
E. coli	cfu/100 mL	9.85×10^6	2.91×10^6	3.19×10^6		2.56×10^3	1.78×10^3

[4] Interstage monitoring for the WWTP treatment process has been undertaken in 2021, including analyses for TN, TSS. TP and DRP were not included in that monitoring.

Whangaroa flow contribution: 4.05%				Influent	Post Oxidation Pond	Post Biofilter	
Faecal Coliforms	cfu/100 mL		5.62×10^6	5.62×10^6		1.20×10^3	3.04×10^3
Ammoniacal Nitrogen (NH_4-N)	mg/L	19	25	25	8	5	
F-Specific Bacteriophage	pfu/L		10.04×10^6	10.04×10^6		12.5×10^3	10.2×10^3
TSS	mg/L	49	113	**110**	47	**36**	
Total Kjeldahl Nitrogen (TKN)	mg/L	38	41	41	14	10	
TN	mg/L	51	42	**43**	14	**13**	
UV Transmissivity	% transmittance						40
Temperature	°C	19	18	18	20	20	20
pH	pH unit	7	7	7	7	6	7
Dissolved Oxygen (DO)	mg/L	3	1	1	4	4	4

It is noted in the NRC Proposed Coastal Water Quality Objectives (Table 25) there are no objectives listed for TN or TSS, however there are WQOs listed for turbidity and TP. Turbidity and TSS are highly correlated, but require the derivation of a ratings curve to allow for conversion between the two parameters (typically undertaken across a series of wet weather events, and as per the National Environmental Monitoring Standards for Turbidity (NEMS 2017). This information is not currently available). Table 25 of Policy H.3.3 also lists WQOs for TP, but not for TN. TP was not assessed for any of the interstage or routine analyses.

5.2 Water quality analysis

Taking the WQOs listed in Table 4-4, summary statistics for monitoring data from the Kaeo WWTP are listed in Table 5-1. Data were summarised for the discharge effluent (CWL), receiving environment monitoring downstream of the discharge location (DS), and receiving environment monitoring data from the reference upstream of the discharge location. NRCs SoE data summary is included for comparison against the upper catchment background state.

For assessment of ammoniacal-N, the annual median and maximum for both the 2020 and 2021 monitoring years are included. It is noted that the available data set for 2021 appeared incomplete.

Data for the minimum record of DO across both 2021 and 2020 were also included; it is noted that monthly sampling does not strictly correspond to the intent behind the sampling regime in the WQO, but is included for comparison.

Data ranges for FIB were selected to include the most recent 5 years, corresponding to approximately 60 data points to summarise the FIB data, in accordance with the NPSFM (2020) procedures. For faecal coliforms,

neither the NRC, NPSFM nor ANZG (2018) list specific WQOs for this FIB. Five-year median and 95th percentiles are summarised for comparison.

For *E. coli*, data were summarised in accordance with the NPSFM (2020) process for including up to 60 data points. The percentage exceedances were calculated on the total number of monitoring samples for each location.

Table 5-2 Comparison of water quality monitoring from WWTP treated effluent (ex-UV) and downstream (DS) receiving environment against upstream (US, SoE) and WQOs. Data values in bold red indicate an exceedance of a WQO

Parameter	Kaeo Ex-UV	DS	US	SoE	NRC H.3.1	ANZG WWL Rec(2) DGV
NH_4-N [g/m3]	2021: **4.8** 2020: **7**	2021: **0.4** 2020: 0.18	2021: 0.035 2020: 0.02	0.008	≤0.24 (annual median)[1]	0.010 (80th % DGV)
	2021: **54** 2020: **28**	2021: **0.4** 2020: **1.8**	2021: 0.16 2020: **0.59**	2021: n/a 2020: 0.034 2019::	≤0.40 (annual maximum)[1]	
Temp [deg C]	Not assessed	Not assessed	Not assessed	n/a	≤3 deg.C	-
pH [-] (median)	2021: 6.55 2020: 6.85	2021: 6.93 2020: 6.85	2021: 6.95 2020: 6.84	n/a	6.0 < pH <9.0	7.26 (20th % DGV) 7.7 (80th % DGV)
DO [g/m^3]	2021: **2.9 (1d min)** 2020: **0.45 (1d min)**	2021: 6.3 (1d Min) 2020: 6.9 (1d min)	2021: **0.32 (1d min)** 2020: 6.0 (1d min)	n/a	≥5.0, 7-day mean minimum[1] ≥4.0, 1-day minimum[1]	
Fecal coliforms [cfu/100 mL]	120 (median) 9280 (95th %)	620 (median) 6760 (95th %)	575 (median) 4185 (95th %)	-	-	-
E.coli [cfu/100 mL] 60 samples	18.6 27.1 63 **19863**	**42.1** **71.9** **488** **3923**	**49.1** **76.4** **521** **2802**	**36.7** **63.3** **403** **6572**	% exceedance over 540 ≤20%[2] % exceedance over 260 ≤34%[2] Median conc. ≤130[2] 95th% ≤1200 [2]	-

Not assessed – data not assessed for the temperature WQO, as this requires continuous temperature record rather than single monthly records.

n/a – data not available

[1] NRC PRP Table 22 Water Quality Standards for ecosystem health in rivers (other rivers); [2] NRC PRP Table 23 Water quality standards for human contact in rivers (other rivers)

Comparison of monitoring data to WQOs indicates a number of exceedances in several parameters at both the upstream and downstream monitoring sites, as well as in the effluent itself.

Ammoniacal-N exceeded the annual median for the 2021 monitoring year at the downstream monitoring site, and maximum concentrations exceeded WQO across both 2020 and 2021 assessment periods. The upstream site recorded an exceedance of the annual maximum in 2021.

Ammoniacal-N was high in the treated effluent (prior to discharge), recording a maximum concentration of 28 and 54 mg/L ammoniacal-N in 2020 and 2021, respectively. These concentrations represent highly acute toxicity for any biota. Acute toxicity resulting from ammoniacal-N is expected where concentrations start to exceed 2.2 mg/L (NPSFM 2020).

For DO, the breach of the WQO for the downstream site occurred during a summer sampling round (January 2021). Subsequent monitoring data indicates dissolved oxygen was within the acceptable range (>4 mg/L for a 1-day minimum level).

Faecal indicator bacteria are demonstrably elevated in the upstream reach of the Kaeo River; exceedances across all four assessment criteria were recorded for both the SoE site as well as the upstream compliance monitoring site.

6. Environmental Risk Assessment

This section provides a summary of the data screening steps listed in Section 5. A qualitative risk assessment for indicators not assigned as a negligible risk during these earlier assessments, is set out. This is step 4 of the ERA process outlined in Section 2. This is to confirm that the following criteria are satisfied:

- The concentration of the indicators monitored downstream of the discharge location are below the water quality objectives (i.e. NRC 2021. ANZG 2018).
- The concentration of the indicators monitored downstream of the discharge location do not exceed the upstream ambient conditions (upstream consent site and the SOE site)
- The contaminant concentration in the effluent is not adversely impacting downstream WQOs.

The assessments set out here focus on the concentration of Ammoniacal-N, physico-chemical stressors, and FIB in the effluent discharged to the Kaeo River. A summary of potential threats to environmental values is listed in Table 6-1.

Table 6-1 Summary of stressors, risks and other factors influencing risk.

Value/Stressors	Threat	Other factors influencing the threat
A. Protection of Aquatic Ecosystems		
Ammoniacal-N	Direct toxicity to aquatic organisms (e.g., algae, macroinvertebrates, and fish) Secondary poisoning to aquatic organisms	pH, temperature
Physico-chemical stressors	Physical stressors and reduction in life supporting capacity of the receiving environment (reduced oxygen, increased temperature, pH fluctuation)	Duration of discharge, reduced upstream flow, seasonal vulnerability
B. Recreation and Aesthetics		
FIB	Bioaccumulation in shellfish/fish Risk to human health	Duration of discharge, reduced upstream flow, seasonal vulnerability

6.1 Weight-of-evidence

Weight-of-evidence describes the process to evaluate a combination of different qualitative, semi-quantitative or quantitative lines of evidence to make an overall assessment of water quality and its associated management. It is the central platform for water/sediment quality assessments in the ANZG (2018). This sets out judgements about the quality, quantity, relevance and alignment of the data contained in the different lines of evidence.

A high-level summary of the lines-of-evidence described in Section 5 is listed in Table 6-2.

For the effluent or downstream receiving environment monitoring, where there has been evidence of an exceedance, or probable exceedance of a WQO, or where the concentrations are markedly higher compared with background data, the endpoint indicator is highlighted. Indicators that are elevated across both the upstream and downstream sites, the overall risk is listed as ‘possible’.

Any water quality parameters highlighted as overall possible risk to receiving environment WQOs are discussed

Table 6-2 Summary of potential exceedances of WQO and indication of potential risk to environmental values of the Kaeo River

Parameter	Effluent conc > WQO	DS > WQO	DS > US/SOE	Potential risk
Ammoniacal-N	Y	Y	Y	Yes
pH	N	N	N	N
Dissolved oxygen	Y	N	N	Possible
Fecal coliforms	n/a	n/a	Y	Yes
E.coli	Y	Y	Y	Yes

n/a – not applicable

As summarized in Section 2, the Kaeo WWTP is located in the lower reaches of the Whangaroa Catchment. General water quality in the lower reaches is impacted by the wider catchment land use, consisting of agriculture/pastoral use, forestry and lifestyle sections.

Current state assessment of available monitoring data records indicates that for the 18 water quality parameters assessed, ten are ranked in attribute band B or A. Microbiological indicators, and macroinvertebrate community health are classed as D and C bands, respectively. On the basis of the available land use information, current state assessment, and the proximity to the Whangaroa Harbour, the overall sensitivity of the receiving environment is regarded as 'Moderate'. This recognises that the receiving environment is modified, but is not representative of a degraded or highly disturbed environment. Nor is it considered highly sensitive, as would be applied to a pristine or outstanding water body.

Given the limited data set for other water quality variables associated with WWTP effluent (e.g. metal/metalloid, other inorganic and organic toxicants), a precautionary approach is taken for the assessment of risk.

The period of likely exposure to CoC concentrations above background levels in the immediate receiving environment is understood to be predominantly continuous, with some periods of intermittent flow during drier months. The exposure of the Kaeo River receiving environment is therefore rated as "Long" (continuous months).

Specific CoC descriptions, as taken from the Table 6-2 summary, are set out in the following sections.

6.2 Risk to environmental values from ammoniacal-nitrogen

The risk of adverse effects, acute toxicity as well as longer term chronic toxicity due to the elevated concentrations of ammoniacal-nitrogen are apparent for the downstream receiving environment. Concentrations of ammoniacal-N downstream of the effluent discharge location are up to an order of magnitude higher than the corresponding upstream consent monitoring location, and two orders of magnitude higher than the SoE median state further upstream. There is a strong indication that elevated effluent concentrations contribute to the risk of acute toxicity in the Kaeo River receiving environment.

Concentrations of ammoniacal-N in the effluent are up to two orders of magnitude higher than the WQO for acute toxicity for this contaminant, and an order of magnitude higher than the WQO for long term chronic toxicity.

The median concentration of ammoniacal-N in the upstream consent monitoring site is an order of magnitude higher that the upstream SoE site, suggesting a contaminating source(s) in close proximity to the upstream site that may exacerbate the elevated concentrations further downstream. Despite this apparent elevation in median Amm-N from the SoE site to the US consent site, it is emphasized that both meet the WQO for Amm-N in NRC's PRP Policy H.3.1 Table 22 (see Table 5-2).

For annual maximum of Amm-N, however, both the US and DS consent sites are in breach of H.3.1 Table 22 for Amm-N (Table 5-2) for the 2020 monitoring periods, and the DS site was in breach for the 2021 monitoring period. There were no breaches of the annual maximum reported for the SoE site for the monitoring years 2019 to 2020 (2021 data was not available). These occasional breaches at the US consent site again suggests a contaminating source downstream of the SoE site, but upstream of the WWTP discharge location.

Policy D.4.1 (5) states when considering overall water quality, discharges will not cause an acute toxic adverse effect within the zone of reasonable mixing. For the discharges to the Kaeo River, the defined zone of reasonable mixing has not been explicitly defined. A common default mixing zone is to use the point that is three times the width of the width of the river. The downstream consent monitoring site, at 15 m downstream of the effluent discharge, may be just outside the mixing zone, or near to the edge.

Acute toxicity due to Amm-N, as per the attribute definitions in the NPSFM, could be expected if in-stream concentrations exceed 2.2 mg/L. This is the concentration associated with acute impact levels (mortality) for sensitive species. Concentrations between 0.4 to 2.2 mg/L Amm-N pose a risk to more sensitive species, associated with reduced survival. Thus for the annual maximum concentration of Amm-N recorded at the DS site in 2020 to 2021, this poses a probably risk of survival to more sensitive species. Close to the point of discharge, given the annual Amm-N maximums have been reported as 28 and 58 mg/L for 2020 and 2021, this represents an acutely toxic concentration for biota in the immediate receiving environment of the Kaeo River at the point of discharge to the DS monitoring site. Of the 19 monitoring samples for treated effluent (Ex-UV) for the 2020/21 period, only two were at or below the acute toxicity threshold of 2.2 mg/L.

Site specific toxicity of ammoniacal-N is influenced by temperature and pH variation. Given the significant exceedance of the WQO (by orders of magnitude), any resulting influence of pH and/or temperature fluctuations on Amm-N toxicity is considered marginal.

Given the sensitivity of the receiving environment is assessed as moderate, overall, the risk of toxicity due to elevated concentrations of Amm--N in the effluent discharged to the Kaeo River is assessed as medium (Table 6-3).

Table 6-3 Qualitative risk assessment for the discharge of elevated Ammoniacal-N to the Kaeo River

		Sensitivity of receiving environment value		
		Low	**Moderate**	**High**
Exposure	**Short (days)**	Low	Low	High
	Medium (weeks)	Low	Medium	High
	Long (months)	Low	Medium	High

6.3 Risk to environmental values from low in-stream dissolved oxygen concentrations

The risk to receiving environment health due to reduced dissolved oxygen concentrations is mitigated by the infrequent occurrence of low DO, likely mitigation in the receiving environment of any effluent discharges that has low DO, and the immediate return to ambient DO in subsequent sampling rounds. This suggests the risk is short-lived, most likely for a number of days, rather than for an extended period of time.

Overall, the risk posed by low DO in effluent discharged to the Kaeo River is assessed as low (Table 6-4).

Table 6-4 Qualitative risk assessment for the discharge of reduce dissolve oxygen to the Kaeo River

	Sensitivity of receiving environment value

		Low	Moderate	High
Exposure	Short (days)	Low	Low	High
	Medium (weeks)	Low	Medium	High
	Long (months)	Low	Medium	High

6.4 Risk to environmental values from *E. coli*

Given the poor microbiological water quality upstream of the Kaeo WWTP, there is little ability for the receiving environment to mitigate any residual risk of discharges of potentially elevated FIB to the Kaeo River. It would be expected that any period of high flow in the Kaeo River would also be associated with a sharp increase in the instream concentration of FIB flushing into the surface water channels and into the harbour.

Analysis of the 5-year median for the effluent, however, indicates that the effluent discharge will not exacerbate the already impacted state of microbiological water quality; only the 95th percentile was elevated, and in the long-term, concentrations are below those currently recorded for the main river stem (across the upstream consent site as well as the SoE site). Faecal source tracking records have confirmed the dominance of ruminants as contributing to poor microbiological water quality. This is echoed in the statements of the LAWA SoE analysis that poor water quality is associated with cattle and stock access to water courses.

Overall, the risk of toxicity due to elevated concentrations of *E. coli* in the effluent discharged to the Kaeo River is assessed as medium (Table 6-5).

Table 6-5 Qualitative risk assessment for the discharge of elevated *E. coli* to the Kaeo River

		Sensitivity of receiving environment value		
		Low	Moderate	High
Exposure	Short (days)	Low	Low	High
	Medium (weeks)	Low	Medium	High
	Long (months)	Low	Medium	High

7. Conclusion

The qualitative risk assessment for the discharge of treated effluent to the Kaeo River is based on several lines of evidence, albeit with a fairly limited suite of parameters included in the monitoring data set from which to draw the conclusions. On the basis of available monitoring data, the following evidence across the WQO assessed:

- There is medium risk of acute and chronic toxicity associated with elevated concentrations of ammoniacal-N in the effluent discharging to the Kaeo River. There is some indication of a source of contamination between the upper SOE site and the upstream consent monitoring site.
- There is a generally low risk posed by low DO in the effluent discharged to the Kaeo River. Effects are expected to be short, intermittent, and last for a period of days, rather than any long-term effects.
- Risks of FIB are assessed as medium, given the poor microbiological water quality of the upper catchment it is apparent that any discharges from the WWTP will require FIB to be at a level that will not exacerbate upper catchment issues. FIB data from the effluent monitoring suggests that despite high 95th percentiles for FIB, annual average loads are not significantly exacerbating the poor state of the currently impacted microbiological water quality. Poor water quality is likely to be driven by upper catchment runoff during wet weather flushing flows.

Ideally, it would be appropriate to assess the effluent quality in the final discharge to the downstream receiving environment.

A snap shot of available comparisons is listed in Table 7-1. This demonstrates for the most up to date available data, there are several gaps in the line of knowledge about current key water quality parameters.

Table 7-1 Summary of monitoring and information gaps for key water quality parameters

Parameter	WQO available, Table 22 (H.1.3)	Treated effluent monitoring	DS monitoring	US monitoring	SOE monitoring	Gap
Ammoniacal-N	✓	✓	✓	✓		No
pH	✓					No
DO	✓	✓	✓	✓	✓	No
Fecal coliforms	✓	✓	✓	✓		No
E.coli	✓	✓	✓	✓	✓	No
Toxicants	✓					Yes
TN	✓ (marine)				DIN	Yes
TP	✓ (marine)				DRP	Yes
Temperature	✓	✓	✓	✓	✓	No
Nitrate	✓					Yes
Clarity	✓				✓	Yes
TSS (or SSC)		✓				Partial*

*Not considered necessary for assessment against WQOs, but is recognised as inversely correlated with visual clarity

This qualitative risk assessment was constrained to an assessment of a small but important sub-set of water quality indicators that contribute to overall health of the receiving environment. It was not possible to directly assess other aspects of likely interest, such as impacts of other key nutrients, or other toxicants such as metals/metalloids/organic toxicants as this monitoring data are not available. Historic monitoring records from targeted/one-off studies conducted in the Whangaroa Harbour suggest that these contaminants have not historically been recorded at concentrations of concern.

For complete assessment against the WQOs listed in the Proposed Regional Plan, it is recommended that a targeted monitoring campaign be introduced to fill the knowledge gaps about the status of the contribution of several water quality parameters to the receiving environment. These include:

- assessment of visual clarity upstream/downstream during routine monitoring of the WWTP discharge,
- an assessment of the contribution of toxicants (metals/metalloids/non-metallic organic contaminants) to the receiving environment (as a one-off assessment only to determine the current status),
- assessment of potential contribution of nutrients (TN, TP) to the downstream receiving catchment of the Whangaroa Harbour,
- assessment of the zone of reasonable mixing for discharges to the Kaeo River

Given the lack of significant land use change it is anticipated that any contaminant concentrations recorded in the Whangaroa Harbour are unchanged, and are most likely not influenced by the discharges from the Kaeo WWTP.

8. References

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Jacobs 2021. Kaeo WWTP Performance Review. Technical memorandum prepared for Far North District Council, Project No. IA266600. 13 Dec 2021

MfE 2003. Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas. Ministry for the Environment No. 474. June 2003.

NRC 2021. Northland Regional Council Proposed Regional Plan for Northland - Appeals Version November 2021.

NPSFM 2020. National Policy Statement for Freshwater Management. Ministry for the Environment, September 2020.

Appendix A. Information Stocktake

This section includes a stocktake of information relevant to the Whangaroa Catchment, and Kaeo River.

Water quality monitoring data was sourced from current consent related monitoring records for the Kaeo WWTP, as well as wider catchment monitoring undertaken by Northland Regional Council.

A summary of the main water quality objectives, as specified in the Northland Regional Council Proposed Regional Plan for Northland (Appeals Version, November 2021) is also listed. This is used to identify and key information gaps

Northland Regional Council recent and current monitoring

NRC published recent and current environmental data via the online Environmental Data Hub[5], as well as on Land, Air, Water, Aotearoa. A summary of the key long term monitoring programmes that were cross referenced for this assessment are listed in Table 9-1.

Table 9-1 NRC Long term monitoring programmes

Programme	Whangaroa Catchment Location	Purpose	Parameters
River Water Quality (36 sites across Northland Region, sampled monthly)	Kaeo River at Dip Rd[1]	Long term state of the environment monitoring Relevance to Kaeo WWTP: provides an upstream reference location for comparison of general background water quality	Range of nutrients, physico-chemical parameters, macroinvertebrate community health. Does not include toxicants (metals, metalloids, organic contaminants)
Recreational Water Quality 'Can I swim here?'[2]	No current site in the Whangaroa Catchment (fresh or marine waters)	Surveillance and grading of popular contact recreation sites Relevance to Kaeo WWTP: No direct link can be drawn with results of other monitoring sites outside Whangaroa Harbour	*E. coli* (freshwater) Enterococci (marine waters)
Coastal Water Quality	Water level – Whangaroa HArbour at Game Fish Club No discrete water quality No Continuous water quality	Long term tide levels Relevance to Kaeo WWTP: No direct link	Level (stage) , tidal range monitoring
Coastal Sediment Quality	Whangaroa at KAH and KAE sites (historic only)	Marine farm Relevance to Kaeo WWTP: No direct link, data is generally sparse, historic, and without any long term context	AFDW, TN. Last sampled 2019 at KAE

[1] Land, Air, Water Aotearoa (LAWA) - Kaeo at Dip Road
[2] Land, Air, Water Aotearoa (LAWA) - Can I swim here?

[5] Environmental data - Northland Regional Council (nrc.govt.nz)

In addition to the long-term programmes, NRC have also undertaken one-off studies for assessment of specific environmental / water quality issues.

A Faecal Source Tracking (FST) study was undertaken by NRC in 2018/19 at the SOE site Kaeo River at Dip Road. Results of the three rounds of sampling and FST analysis concluded:

- Round one (Sept 2018) sampling contained ruminant dominated faecal contaminant sources,
- Round two (Nov 2018) contained ruminant and avian sources,
- Round three (Feb 2019) contained possible avian sources (Source: NRC unpublished FST data).

Northland Regional Council historic monitoring

A compilation of data held by Northland Regional Council is summarised in Table 9-2 and 9-3 below. The sites listed in Table 9-2 correspond to the sites displayed in Figure 9-1 for ease of reference.

Sixteen monitoring programmes are listed, covering up to 35 monitoring sites. Dates ranges for sampling indicate the data is old, ranging from1989 to around 2011 across most sites, with more recent data for the site linked to the WWTP discharges. Given the age of the data across most of the catchment and harbour sites, it was not considered current for the purpose of this current risk assessment.

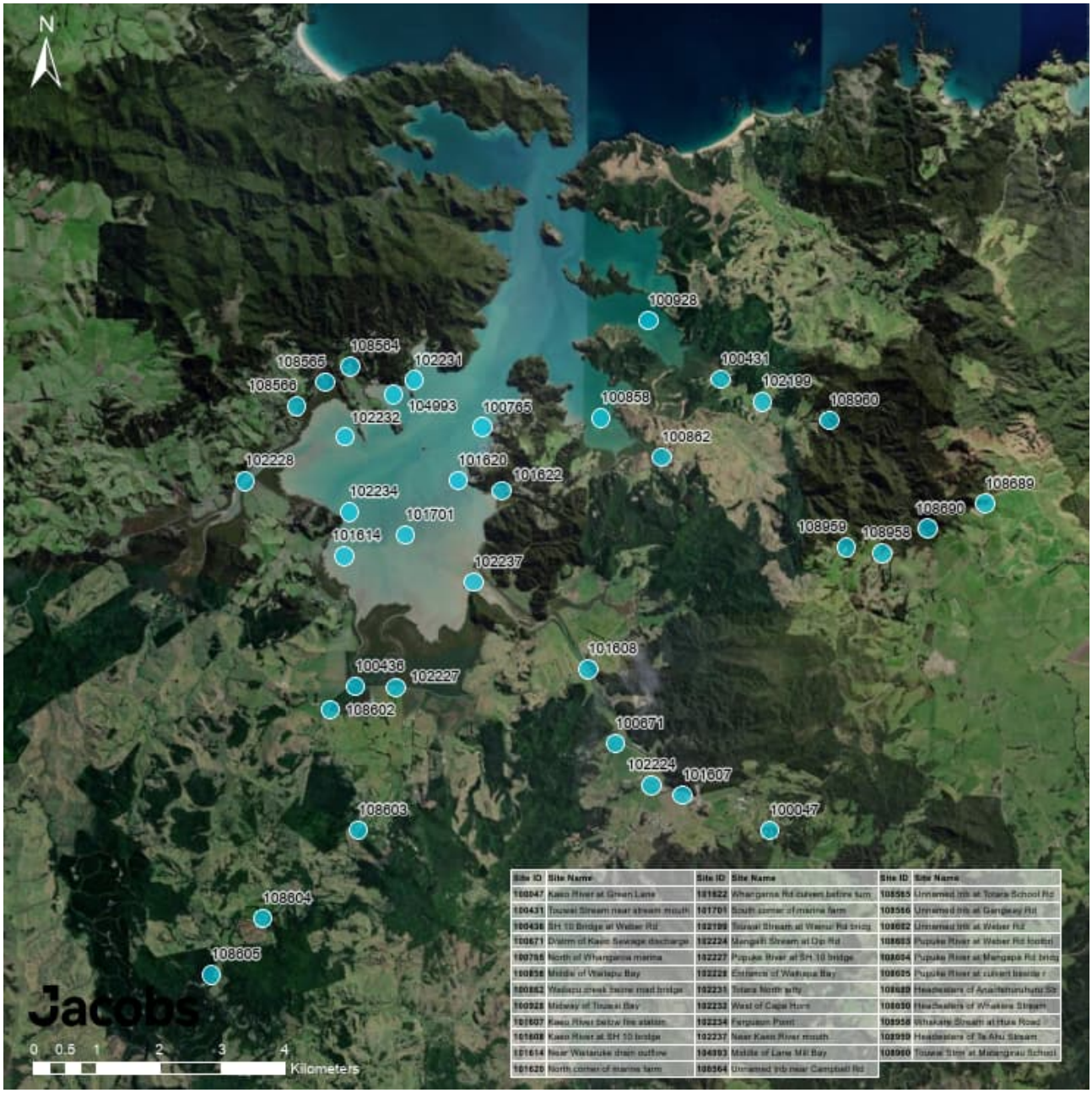
Table 9-2 Northland Regional Council historic monitoring across the Whangaroa Catchment. Summarised from NRC supplied data

Programme	Site Name	Year(s) sampled	Parameters
720501	D/strm of Kaeo Sewage discharge	2006 - 19	Amm-N, DO, E. Coli, FC, TC, Temp, pH
864728	Kaeo River at SH 10 bridge	2015-16	Ent, E. Coli, FST
	Middle of Lane Mill Bay	2016	E. coli, TC, FST Sal, Turb
1318701	Headwaters of Anaotehuruhuru Strm	2005-06	Metals (Cu, Cd, Cr, Pb. Hg, Ni, Zn) Sulphate, Sulphide Clar, Cond, DO, TSS, Turb, pH
	Headwaters of Whakare Stream	2005-06	
FNDC KAEO SEWAGE DISPOSAL SYSTEM	D/strm of Kaeo Sewage discharge	2002-06	Amm-N, DO, E. Coli, FC, TC, Temp, pH, Turb
Freshwater Whangaroa SOE	Entrance of Waihapa Bay	2011	DO, Sal, Temp, Turb E. coli
	Kaeo River at SH 10 bridge	2011	
	Pupuke River at SH 10 bridge	2011	
	SH 10 Bridge at Weber Rd	2011	
	Touwai Stream near stream mouth	2011	
	Unnamed trib at Gangway Rd	2011	
	Unnamed trib at Totara School Rd	2011	
	Unnamed trib near Campbell Rd	2011	
	Whangaroa Rd culvert before turnoff	2011	
MACROINVERTEBRATES-RESOURCE CONSENT SITES	D/strm of Kaeo Sewage discharge	1998 - 2003	MCI,QMCI,, Semi Q MCI, Taxa, EPT, Abundance

Programme	Site Name	Year(s) sampled	Parameters
MICROBIAL SOURCE TRACKING	Near Kaeo River mouth	2009	DO, Sal, Temp, Turb E.coli, Ent, FC, TC
MNC 801403	Near Kaeo River mouth	2013	Amm-N, DRP, Nitrate-N, Nitrite-N, NNN, TN, TP, TKN Chl-a, DO, Sal, Turb, TSS, Temp, Sal, SecchiD Ent, FC, AFDW, PSD,
	South corner of marine farm	2013	
REG.007205.01 FNDC Kaeo WWTP	D/strm of Kaeo Sewage discharge	2020-2021	Amm-N, DO, E. Coli, FC, Temp, pH
SOE - FAR NORTH HARBOURS (WHANGAROA)	Near Kaeo River mouth	2004	Amm-N, AFDW, DRP, E. coli, Ent, FC, TN (sediment),Nitrate - N (sediment), Nitrite-N, DRP, TP Sal, Temp, TC, DO, Turb, TSS
	South corner of marine farm	2004	
SOE WHANGAROA HARBOUR CONTRIBUTING STREAMS	D/strm of Kaeo Sewage discharge	2003-2004	DO, Sal, Temp, Turb E. coli, TC
	Entrance of Waihapa Bay	2002 - 2011	
	Kaeo River at Green Lane	2002 - 2005	
	Kaeo River at SH 10 bridge	2002-05, 2010-11	
	Kaeo River below fire station	2002- 2005	
	Mangaiti Stream at Dip Rd	2003 - 2005	
	Near Kaeo River mouth	2004	
	Pupuke River at culvert beside road	2005 - 2008	
	Pupuke River at Mangapa Rd bridge	2005 - 2008	
	Pupuke River at SH 10 bridge	2002 - 2011	
	Pupuke River at Weber Rd footbridge	2005 - 2008	
	SH 10 Bridge at Weber Rd	2002 - 2011	
	Touwai Stream near stream mouth	2003 - 2011	
	Unnamed trib at Gangway Rd	2005 - 2011	
	Unnamed trib at Totara School Rd	2005 - 2011	
	Unnamed trib at Weber Rd	2005 - 2008	
	Unnamed trib near Campbell Rd	2005 - 2011	
	Waitapu creek below road bridge	2003 - 2011	
	Whangaroa Rd culvert before turnoff	2004, 2007-2011	
SOE WHANGAROA HARBOUR STUDY	Ferguson Point	2003 - 2008	DO, Temp, Turb E. coli, FC, TC
	Middle of Lane Mill Bay	2003 - 2008	
	Middle of Waitapu Bay	2003 - 2008	
	Midway of Touwai Bay	2003 - 2008	
	Near Kaeo River mouth	2003, 2005, 2007	

Programme	Site Name	Year(s) sampled	Parameters
	Near Waitaruke drain outflow	2003 - 2008	
	North corner of marine farm	2003 - 2008	
	North of Whangaroa marina	2003 - 2008	
	South corner of marine farm	2003 - 2008	
	Totara North jetty	2003 - 2007	
	West of Cape Horn	2003 - 2008	
	Whangaroa Rd culvert before turnoff	2003, 2005-2007	
SOE WHANGAROA SANFORDS	Ferguson Point	2008 - 2009	Turb E. coli, FC, TC,
	Middle of Lane Mill Bay	2008 - 2009	
	Middle of Waitapu Bay	2007 - 2010	
	Midway of Touwai Bay	2007 - 2010	
	Near Waitaruke drain outflow	2007 - 2010	
	North corner of marine farm	2007 - 2010	
	North of Whangaroa marina	2008 - 2010	
	South corner of marine farm	2007 - 2010	
	West of Cape Horn	2007 - 2011	
	Whangaroa Rd culvert before turnoff	2007	
WHANGAROA HBR OYSTER RUN	South corner of marine farm	2003	DO, Temp, Sal E. coli, FC, TC
WHANGAROA SOE	Headwaters of Anaotehuruhuru Strm	2006-2007	Cond, DO, Sal, Temp, Turb E.coli, FC, TC
	Headwaters of Te Ahu Stream	2006-2007	
	Headwaters of Whakare Stream	2006-2007	
	Touwai Stream at Wainui Rd bridge	2006-2007	
	Touwai Stream near stream mouth	2006-2007	
	Touwai Strm at Matangirau School Rd	2006-2007	
	Whakare Stream at Huia Road	2006-2007	
Un-named 1	Near Kaeo River mouth	2010	DO, Sal, Temp, Turb Ent, E. coli, FC, TC
	Pupuke River at SH 10 bridge	2010	
	West of Cape Horn	2011	
	Whangaroa Rd culvert before turnoff	2011	
Un-named 2	D/strm of Kaeo Sewage discharge	1989 - 2002	DO, Sal, Temp, Turb, pH E.coli, FC, TC
	Entrance of Waihapa Bay	1991-92, 1998	
	Ferguson Point	1991-92, 1998	
	Kaeo River at Green Lane	2001	
	Kaeo River at SH 10 bridge	1990-1992	
	Kaeo River below fire station	1990-1993, 1995, 2001	
	Mangaiti Stream at Dip Rd	1991-1992	
	Middle of Lane Mill Bay	1998	
	Middle of Waitapu Bay	1989, 1998, 2004	
	Midway of Touwai Bay	1989, 1998	

Programme	Site Name	Year(s) sampled	Parameters
	Near Kaeo River mouth	1990-1992, 1998, 2003	
	Near Waitaruke drain outflow	1990, 1998	
	North corner of marine farm	1990-1992	
	North of Whangaroa marina	1989, 1992, 1998, 2004	
	Pupuke River at SH 10 bridge	1991-1992	
	South corner of marine farm	1990	
	Totara North jetty	1991-92, 1995, 1997, 2003	
	Touwai Stream at Wainui Rd bridge	1991, 1993	
	Touwai Stream near stream mouth	2002	
	Waitapu creek below road bridge	1989, 1998	
	West of Cape Horn	1991 - 1992	
	Whangaroa Rd culvert before turnoff	1990, 1992, 2003-04	
	Unnamed site	1989	



Site ID	Site Name	Site ID	Site Name	Site ID	Site Name
100047	Kaeo River at Green Lane	101622	Whangarna Rd culvert before farm	108565	Unnamed trib at Totara School Rd
100431	Touwai Stream near stream mouth	101701	South corner of marina farm	108566	Unnamed trib at Gengaway Rd
100436	SH 10 Bridge at Weber Rd	102199	Touwai Stream at Wainui Rd brdg	108602	Unnamed trib at Weber Rd
100671	Distrm of Kaeo Sewage discharge	102224	Mangahi Stream at Dip Rd	108603	Pupuke River at Weber Rd footbd
100765	North of Whangaroa marina	102227	Pupuke River at SH 10 bridge	108604	Pupuke River at Mangapa Rd brdg
100858	Middle of Waitapu Bay	102228	Entrance of Waitapu Bay	108605	Pupuke River at culvert beside r
100862	Waitapu creek below road bridge	102231	Totara North jetty	108689	Headwaters of Ayaitanuhuhu Str
100928	Midway of Touwai Bay	102232	West of Cape Horn	108690	Headwaters of Whakara Stream
101607	Kaeo River below fire station	102234	Ferguson Point	108958	Whakara Stream at Hura Road
101608	Kaeo River at SH 10 bridge	102237	Near Kaeo River mouth	108959	Headwaters of Te Ahu Stream
101614	Near Waitaruke drain outfow	104993	Middle of Lane Mill Bay	108960	Touwai Strm at Matangirau School
101620	North corner of marina farm	108564	Unnamed trib near Campbell Rd		

Figure 9-1 Northland Regional Council historic monitoring across the Whangaroa Catchment.

Table 9-3 Northland Regional Council historic monitoring across the Whangaroa Catchment – site names and site identification numbers

Site ID	Site Name	Latitude	Longitude
100047	Kaeo River at Green Lane	-35.105	173.793
100431	Touwai Stream near stream mouth	-35.040	173.784
100436	SH 10 Bridge at Weber Rd	-35.085	173.720
100671	D/strm of Kaeo Sewage discharge	-35.093	173.766
100765	North of Whangaroa marina	-35.047	173.742
100858	Middle of Waitapu Bay	-35.046	173.763
100862	Waitapu creek below road bridge	-35.051	173.774
100928	Midway of Touwai Bay	-35.032	173.771
101607	Kaeo River below fire station	-35.100	173.778
101608	Kaeo River at SH 10 bridge	-35.082	173.761
101614	Near Waitaruke drain outflow	-35.066	173.718
101620	North corner of marine farm	-35.055	173.738
101622	Whangaroa Rd culvert before turnoff	-35.056	173.746
101701	South corner of marine farm	-35.063	173.729
102199	Touwai Stream at Wainui Rd bridge	-35.043	173.791
102224	Mangaiti Stream at Dip Rd	-35.098	173.772
102227	Pupuke River at SH 10 bridge	-35.085	173.728
102228	Entrance of Waihapa Bay	-35.055	173.701
102231	Totara North jetty	-35.041	173.730
102232	West of Cape Horn	-35.049	173.718
102234	Ferguson Point	-35.060	173.719
102237	Near Kaeo River mouth	-35.070	173.741
104993	Middle of Lane Mill Bay	-35.043	173.727
108564	Unnamed trib near Campbell Rd	-35.039	173.719
108565	Unnamed trib at Totara School Rd	-35.041	173.715
108566	Unnamed trib at Gangway Rd	-35.044	173.710
108602	Unnamed trib at Weber Rd	-35.088	173.716
108603	Pupuke River at Weber Rd footbridge	-35.105	173.721
108604	Pupuke River at Mangapa Rd bridge	-35.118	173.705
108605	Pupuke River at culvert beside road	-35.126	173.696
108689	Headwaters of Anaotehuruhuru Strm	-35.058	173.830
108690	Headwaters of Whakare Stream	-35.061	173.820
108958	Whakare Stream at Huia Road	-35.065	173.812
108959	Headwaters of Te Ahu Stream	-35.064	173.806
108960	Touwai Strm at Matangirau School Rd	-35.046	173.803

Northland Regional Council Proposed Regional Plan for Northland (Appeals Version, November 2021), relevant objectives, policies for the assessment of risk to the Kaeo River

Table 9-3 Northland Regional Council objectives, information status and recommendations to address information gaps

Policy/Objective/WQ Standard	Relevance to Kaeo WWTP discharges	Status of current information	Gap in knowledge
D.4.1 Maintaining overall water quality	When considering an application for a resource consent to discharge a contaminant into water or onto or into land where it may enter water or onto land where it may enter water: 1) ensure that the quality of fresh and coastal water is at least maintained, and 2) where a water quality standard in Appendix H.3 is currently met: a. ensure that the quality of water in a river, lake or the coastal marine area will continue to meet the standards in Appendix H.3; and b. consider whether any improvements to water quality are required in order to achieve Objective F.1.2 3) where a water quality standard in Appendix H.3 is currently exceeded, ensure that any resource consent for a new discharge will not, or is not likely to, cause or contribute to a further exceedance of a water quality standard in Appendix H.3; 4) where a water quality standard in Appendix H.3 is currently exceeded and the exceedance of the water quality standard is caused or contributed to by an existing activity for which a replacement resource consent is being considered, ensure any replacement resource consent	Detailed knowledge about the immediate downstream and upstream receiving environment for ht parameters that are routinely monitored. Several parameters in H.3 are not included in routine monitoring. The spatial extent of effects to water quality are not well understood. This is in part due to the zone of mixing not being clear, thus assessment against D.4.1(5) is not clear (indicative only based on available data). For the available parameters, the data quality is considered complete and robust. A precautionary approach is still considered appropriate, and consistent with the WQO in H.3	Partial. Recommend the inclusion of upstream and downstream parameters to address knowledge gaps specifically in regard to H.3 Recommend the definition of the zone of reasonable mixing, to assess compliance with D.4.1 (5), and as per D.4.4 (below) Available data for the assessment of D.4.1 (6) is not current. However if an assessment of the discharge to complete knowledge gaps for H.3 are undertaken, then potential downstream effects to the CMA can be inferred. Other potential catchment contributing sources should also be considered for this assessment, given this will be the results of cumulative discharges, over time.

Policy/Objective/WQ Standard	Relevance to Kaeo WWTP discharges	Status of current information	Gap in knowledge
	granted for the existing discharge includes a condition(s) that: a. requires the quality of the discharge to be improved over the term of the consent to reduce the contribution of the discharge to the exceedance of the water quality standard in Appendix H.3; and b. sets out a series of time bound steps, demonstrating how the activity will be managed to achieve the water quality improvements required by (4) (a). 5) ensure that the discharge will not cause an acute toxic adverse effect within the zone of reasonable mixing 6) where a discharge will, or is likely to, cause or contribute to: a. an exceedance of the coastal sediment quality guidelines in Appendix H.3.4, or b. a transitory exceedance of the toxicants… 7) where existing water quality is unknown, or the effect of a discharge on water quality is unknown, the activity must be managed using a precautionary approach, which may include adaptive management.		
D.4.4 Zone of reasonable mixing	Specific regard to 1) using the smallest zone necessary to achieve the required water quality in the receiving waters as determined under Policy D.4.1, and 2) ensuring that within the mixing zone contaminant concentrations and levels of dissolved oxygen will not cause acute toxicity effects on aquatic ecosystems.	Generally assessed on a site-specific basis, for freshwater streams, rivers this is by default 3 times the wetted width.	Yes Recommend the zone of reasonable mixing for the effluent discharge to the Kaeo River to be defined

Policy/Objective/WQ Standard	Relevance to Kaeo WWTP discharges	Status of current information	Gap in knowledge
F.1.2 Water quality	Manage the use of land and discharges of contaminants to land and water so that: 1) existing water quality is at least maintained, and improved where it has been degraded below the river, lake or coastal water quality standards set out in H.3 Water quality standards and guidelines, and 2) the sedimentation of continually or intermittently flowing rivers, lakes and coastal water is minimised, and 3) the life-supporting capacity, ecosystem processes and indigenous species, including their associated ecosystems, of fresh and coastal water are safeguarded, and the health of freshwater ecosystems is maintained, and 4) the health of people and communities, as affected by contact with fresh and coastal water, is safeguarded	Data for the downstream receiving environment is well described and comprehensive in terms of temporal scale. There is very limited current knowledge about the water quality further downstream, and any assessment with regard to cumulative effects. Upper catchment contaminant sources are acknowledged as contributing significantly to FIB contamination. A small subset of relevant water quality parameters are available on which to assess risks of sedimentation, life supporting capacity, and comparison to upstream SOE water quality.	Several key water quality parameters are not readily available, including TN, TP, SSC, metals. Recommend a short-term targeted investigation to be undertaken to assess the current status of these in the effluent as well as downstream receiving environment that can be then related directly to WQOs in Table 22 (H.1.3), and the upstream SoE long term monitoring site.
H.3.1 Table 22	The water quality standards in Table 22: *Water quality standards for ecosystem health in rivers* apply to Northland's continually or intermittently flowing rivers, and they apply after allowing for reasonable mixing.	A subset of water quality parameters is available.	Partial gap. Recommend a short-term targeted investigation to be undertaken to assess the current status of these in the effluent as well as downstream receiving environment that can be then related directly to WQOs in Table 22 (H.1.3), and the upstream SoE long term monitoring site.