CAWTHRON

REPORT NO. 3873

ASSESSMENT OF CUMULATIVE EFFECTS ASSOCIATED WITH THE NELSON NORTH WASTEWATER TREATMENT PLANT DISCHARGE AND OTHER DISCHARGES IN THE NELSON CATCHMENT

ASSESSMENT OF CUMULATIVE EFFECTS ASSOCIATED WITH THE NELSON NORTH WASTEWATER TREATMENT PLANT DISCHARGE AND OTHER DISCHARGES IN THE NELSON CATCHMENT

CARLOS CAMPOS

Prepared for Nelson City Council

CAWTHRON INSTITUTE
98 Halifax Street East, Nelson 7010 | Private Bag 2, Nelson 7042 | New Zealand
Ph. +64 3 548 2319 | Fax. +64 3 546 9464
www.cawthron.org.nz

REVIEWED BY:
Calum MacNeil

APPROVED FOR RELEASE BY:
Grant Hopkins

ISSUE DATE: 29 August 2023

RECOMMENDED CITATION: Campos C. 2023. Assessment of cumulative effects associated with the Nelson North Wastewater Treatment Plant discharge and other discharges in the Nelson catchment. Nelson: Cawthron Institute. Cawthron Report 3873. Prepared for Nelson City Council.

EXECUTIVE SUMMARY

Nelson City Council (NCC) is seeking to renew its consent to discharge treated wastewater from the Nelson North Wastewater Treatment Plant (NWWTP) to Tasman Bay / Te Tai-o-Aorere (hereafter Tasman Bay). As part of the application process, NCC has contracted the Cawthron Institute (Cawthron) to assess the cumulative effects of contaminants present in the NWWTP discharge and other point-source and diffuse discharges in the Nelson catchment. This report is intended to be appended to the consent application, but it should also be interpreted in conjunction with other reports produced by Cawthron that support the assessment of environmental effects of the discharge. This current report is a cumulative effects assessment (CEA) comprising:

- a review of the available monitoring data for the NWWTP discharge and other catchment sources of physical and chemical contamination
- analysis of CLUES modelling outputs for riverine inputs to Tasman Bay.

The NWWTP discharge is one of many sources of nutrients, trace metals and other contaminants to Tasman Bay; other sources include private- and council-owned discharges, industrial discharges and inputs from rivers and streams. Monitoring to date has found no visible indication of accumulation of discharge constituents or discharge-related effects on benthic communities in the immediate vicinity of the outfall diffuser. Mean concentrations of total nitrogen (TN) and total phosphorus (TP) in the discharge have been typical of those found in tertiary-treated effluents during baseflow conditions. Concentrations of trace metals in the discharge have been below their respective consent limits.

Elevated levels / concentrations of physico-chemical parameters may be detectable near the sources – particularly during high-flows (during and shortly after rain events) – and have a cumulative water quality effect on the Nelson coastal marine area (CMA). However, given the distance of the NWWTP discharge from other urban sources (e.g. stormwater outfalls, pump station overflows) and the strong water movements in Tasman Bay, cumulative effects on the seabed and water column in the vicinity of the NWWTP discharge are unlikely. Based on previous studies, the Maitai River and its tributaries are clearly identified as the main contributors of TN and TP to the CMA. However, it should also be noted that a number of streams in the Hillwood / Todd Valley area (where the NWWTP is located) are associated with higher TN and TP loadings than some urban areas in the lower Nelson catchment. Water quality in the Maitai declines downstream as the river is affected by tributary contaminant loads. Previous mass balance studies have indicated that rivers and streams may contribute approximately 70% of the TN loading to Tasman Bay.

Using both New Zealand and overseas guidelines / standards, comparisons of measured TN and TP concentrations at sites in the inner Tasman Bay suggest that there is capacity for assimilation of additional nutrients without expression of adverse water quality effects in the discharge receiving environment.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

ABBREVIATIONS

ANZECC	Australian and New Zealand Environment and Conservation Council
BOD	Biochemical oxygen demand
CEA	Cumulative effects assessment
CLUES	Catchment Land Use for Environmental Sustainability
CMA	Coastal marine area
COD	Chemical oxygen demand
FMU	Freshwater management unit
LAWA	Land, Air, Water Aotearoa
LCDB	Land Cover Database
NCC	Nelson City Council
NOF	National Objectives Framework
NPS-FM 2020	National Policy Statement for Freshwater Management 2020
NWWTP	Nelson North Wastewater Treatment Plant
PS	Pump station
PSO	Pump station overflow
REC	River Environments Classification
TN	Total nitrogen
TP	Total phosphorus

GLOSSARY

CLUES	A steady-state, catchment-scale model developed by NIWA that provides information on the impacts of land-use changes and land management practices on stream water quality (as indicated by total nitrogen, total phosphorus and *E. coli*).
Cumulative effects	Any effects that arise over time or in combination with other effects regardless of the scale, intensity, duration, or frequency (as defined in the Resource Management Act 1991).
Freshwater Management Unit	A waterbody, multiple waterbodies or any part of a water body determined by the regional council as the appropriate spatial scale for setting freshwater objectives and limits and for freshwater accounting and management.

1. INTRODUCTION

1.1. Background

Nelson City Council (NCC) currently holds several resource consents associated with the operation of the Nelson North Wastewater Treatment Plant (NWWTP), including a coastal permit that authorises the discharge of treated wastewater to Tasman Bay / Te Tai-o-Aorere (hereafter Tasman Bay). This coastal permit was granted in 2004 for a duration of 20 years and expires in December 2024.

To support an application and assessment of environmental effects for the renewal of the coastal permit, NCC contracted the Cawthron Institute (Cawthron) to assess the cumulative effects of contaminants present in the NWWTP discharge and other point-source and diffuse discharges in the Nelson catchment. This cumulative effects assessment (CEA) covers physico-chemical contaminants (nutrients, trace metals / toxicants) and is based on:

- a review of the available monitoring data for the NWWTP discharge and other catchment sources of physico-chemical contamination
- analysis of CLUES[1] modelling outputs.

This report should be considered in conjunction with the assessment of effects of the discharge on the ecology of Tasman Bay (Morrisey and Campos 2023). Effects associated with microplastics are discussed in a companion report by Campos et al. (2023a). Effects associated with emerging organic contaminants (e.g. plasticisers, antimicrobials / preservatives, insect repellents, pharmaceuticals, oestrogens) are covered in the report by Campos et al. (2023b). Human health effects (most commonly gastroenteritis) from elevated microbiological contamination are covered by Hudson and Wood (2023).

1.2. Scope and approach

Section 3 of the Resource Management Act 1991 defines cumulative effects as any effects that arise 'over time or in combination with other effects regardless of the scale, intensity, duration, or frequency…' (Parliamentary Counsel Office 2020). In other words, cumulative effects can be defined as the product of an additive or interactive process that is triggered from a given activity over time or from multiple activities that can either be of a similar or different nature.

A CEA normally addresses multiple developments / activities, as well as their interactions over varying spatial and temporal scales, to determine an overall impact on a resource (MfE 2006). However, there is no standard method for undertaking a

[1] Catchment Land Use for Environmental Sustainability model. CLUES is a GIS-based system that predicts the effects of land-use change and farm practice scenarios on water quality indicators at the catchment scale.

CEA in Aotearoa New Zealand. The EIANZ Ecological Impact Assessment Guidelines recommend that 'cumulative effects should be described for direct and indirect effects over a larger area; a longer period of time; or due to interactions with other actions; and include other past, existing and future actions' (EIANZ 2018). Common elements in other CEAs published in the peer reviewed literature (Canter and Atkinson 2011; Hwang et al. 2019) include:

- a definition of the spatial and temporal boundaries for analysis
- use of environmental thresholds / limits and matrices, network diagrams or modelling to identify and consider possible additive effects.

In the context of wastewater discharge effects, cumulative environmental change can result from the build-up of contaminants in the immediate receiving environment of a discharge, as well as a wider environmental deterioration related to other point- or diffuse sources within the catchment (NZWERF 2002). To inform this CEA, I reviewed the available physico-chemical data for rivers and wastewater-related activities collected since 2008. This start date was chosen because the treatment process at NWWTP was upgraded in 2007 (NCC 2020). To assess nutrient loadings from rivers and streams in the Nelson catchment, I used outputs from the CLUES model developed by NIWA. I briefly consider the capacity of Tasman Bay to assimilate these contaminants within the context of relevant water quality standards for current and future discharge flows and contaminant loadings.

2. CATCHMENT DESCRIPTION

2.1. Freshwater management units

The spatial domain of this CEA is the Nelson catchment, which covers a total area of 13,014 ha and comprises the Maitai River and several other rivers and streams that discharge to the coastal marine area (CMA).[2] These freshwater courses and the adjacent land are sub-divided into 27 freshwater management units (FMUs) for the purposes of giving effect to the requirements of the National Policy Statement for Freshwater Management 2020 (NPS-FM 2020) (MfE 2023). A map of the principal land cover types within the study area is presented in Figure 1. The total area and percentage of individual land cover types within each FMU are listed in Appendix 1.

The largest area of native vegetation is in the upper catchment (6,097 ha). The Maitai and Brook Stream FMUs have relatively large areas of exotic forest, and together these comprise 2,835 ha of the Nelson catchment. Most of the urban areas are located in the lower catchment. FMUs with 100% urban areas are Akersten Street, Russel Street, Sealords, the Port, Vickerman Street, Victoria Road, Wakefield Quay, the Cliffs and the Wood. Fresh water in these FMUs flows directly into the Nelson Haven (a bar-built, fluvial erosion estuary) and the Boulder Bank through stormwater drains and small streams.

The Maitai River is the largest FMU (7,455 ha). The two main river branches in the upper catchment drain areas of conservation and water supply protection land and join in the Bryant Range just to the east of Nelson's city centre. The north branch is dammed just upstream of the confluence with the south branch to form the main Nelson water supply storage reservoir (LAWA 2023). The mid-catchment below the confluence of the headwater branches mainly comprises production forest, and the main valley bottom is mostly reserve with some limited areas of farming. The lower catchment runs through Nelson's city centre and water quality in rivers and streams are impacted by urban uses and surface water drainage systems (LAWA 2023).

The seaward boundary of the Nelson Haven is delineated by the Boulder Bank, a long and narrow strip of granodiorite pebbles, cobbles and boulders. The Nelson Haven opens to Port Nelson and Tasman Bay at its southwestern end and has numerous tidal flats and drainage channels that extend northeast from Port Nelson into an elongated intertidal embayment. Due to its shallow configuration and large tidal range, the upper estuary is almost completely drained on the ebb tide, which results in a short residence time of the waters within the Nelson Haven (Gillespie 2008).

[2] The Nelson regional policy statement defines a 'coastal marine area' as 'the foreshore, seabed, and coastal water, and the air space above the water: i) of which the seaward boundary is the outer limits of the territorial sea; ii) of which the landward boundary is the line of mean high water springs, except that where that line crosses a river, the landward boundary at that point shall be whichever is the lesser of: a) 1 km upstream from the mouth of the river; or b) the point upstream that is calculated by multiplying the width of the river mouth by 5' (NCC 1997).

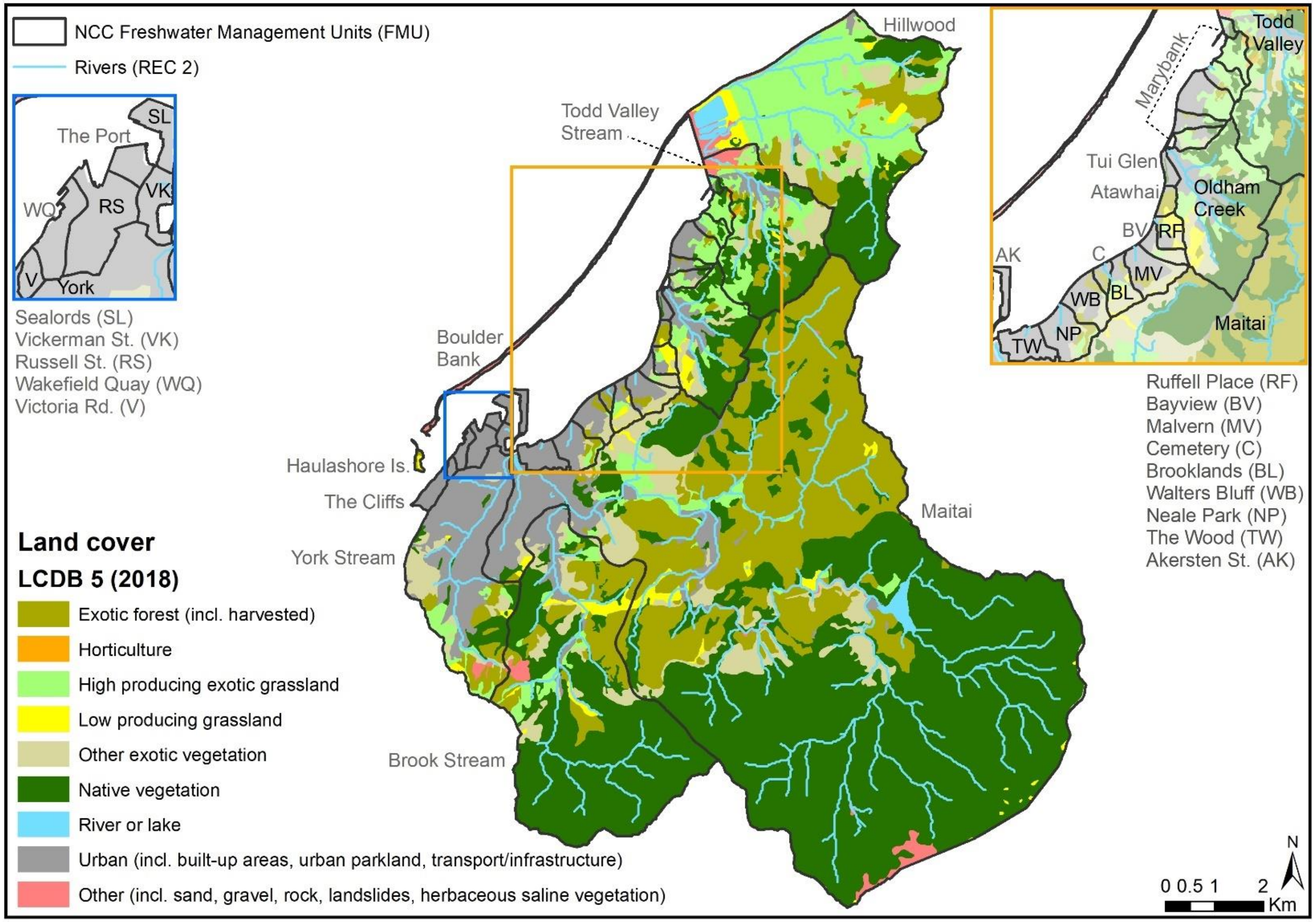

Figure 1. Land cover within freshwater management units in the Nelson catchment. Map derived from Land Information New Zealand 1:50,000 topographic database LCDB5 (LRIS 2018).

2.2. Public wastewater network

The wastewater system owned and managed by NCC comprises the NWWTP, reticulation pipes, associated trunk mains, manholes, pump stations and other assets (NCC 2021; Figure 2). The system collects wastewater from the northern part of the Nelson catchment. The wastewater then flows by gravity and pressure pipes to the Neale Park Pump Station (PS), and from here it is pumped to the treatment plant via an underground rising main that runs alongside State Highway 6. This rising main also collects wastewater from several Nelson suburbs (Atawhai, Marybank and Todds Valley). Wastewater from Glenduan is collected and transported to the NWWTP via a separate pipe (Figure 2).

2.2.1. Wastewater discharge consents

As mentioned in Section 1, NCC holds several resource consents related to wastewater activities (NCC 2021). The consents relevant to this CEA are:

- Coastal permit to discharge treated wastewater into Tasman Bay (SAR 05-61-01-06). As determined by this consent, the maximum volume of the discharge shall not exceed 38,000 m^3/day in a 2-year rainfall return period and a peak 28-day average flow of 21,000 m^3/day.
- Consent on accidental discharges from the network (RM 105388 V1) (discharge permit) and RM 105388A V1 (coastal permit). This consent prescribes overflow limits as follows:
    - From pump stations, during wet weather events: there shall be no more than 10 overflow events per 12-month period, reducing to five overflow events per 12-month period by 31/03/2032.
    - From pump stations, during dry weather: from 01/04/2023, there shall be no dry weather discharges from any pump stations.

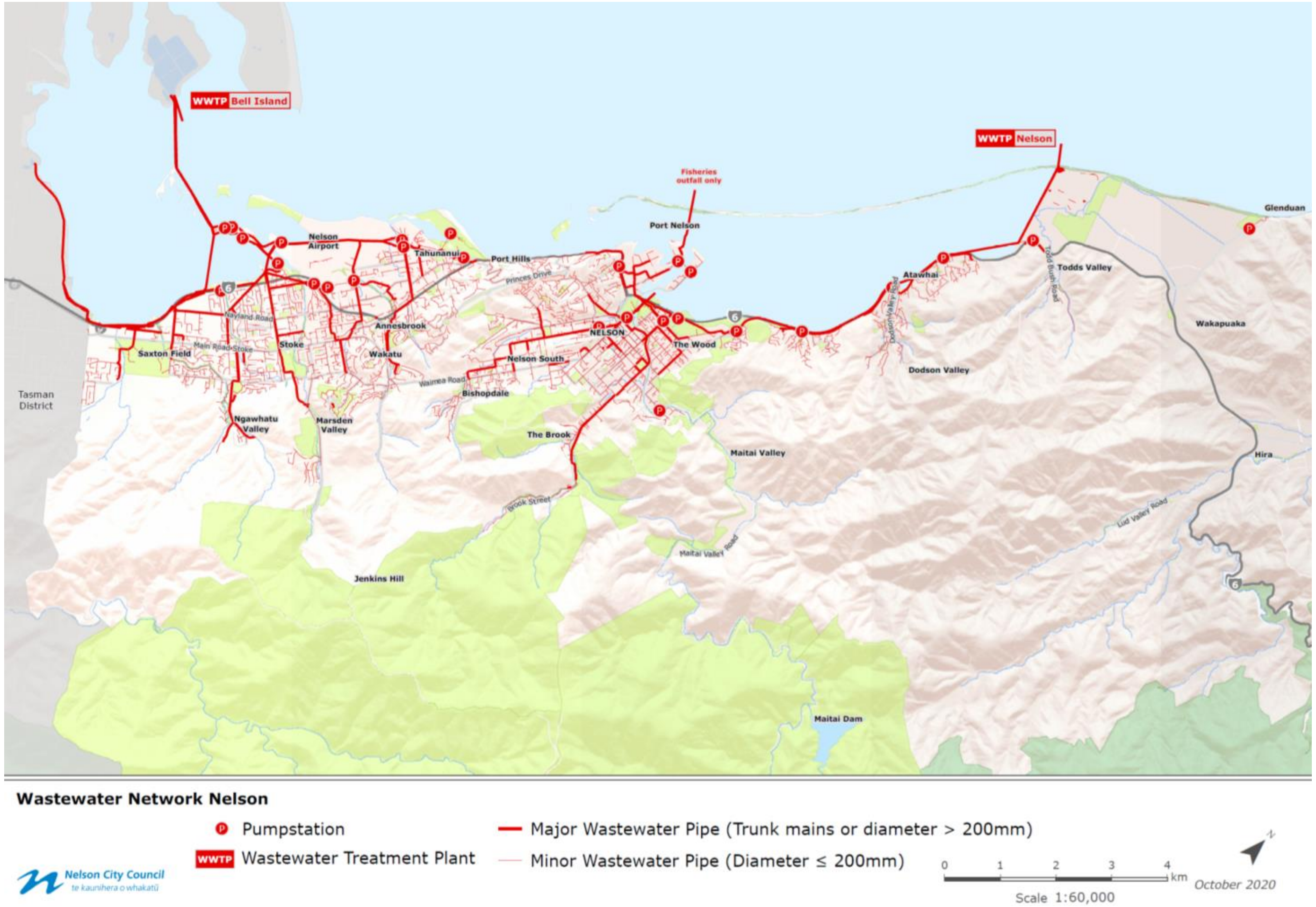

Figure 2. Public wastewater network managed by Nelson City Council (NCC). The sewerage catchment to the south of Nelson Airport (Saxton, Ngawhatu Valley, Stoke and Marsden Valley) is managed by Nelson Regional Sewerage Business Unit, a joint committee of NCC and Tasman District Council. This current assessment focuses on the wastewater network to the north, from Bishopdale to Todds Valley / Nelson North Wastewater Treatment Plant. Note that a proportion of the network is privately owned, but all sections operate as a single network. Map provided by Nelson City Council.

2.2.2. Nelson North Wastewater Treatment Plant discharge

The NWWTP lies on the seaward northwest corner of an area of low-lying land in the upper parts of Nelson Haven between Glen Road and what is now Boulder Bank Drive (Figure 2). The plant has been operational since 1979[3] and receives mainly domestic waste, as well as a small amount of trade waste, from the western part of Nelson City, which has a population of approximately 28,200.[4] The treatment process consists of removal of gross solids through the inlet works (screening), pretreatment of influent flows to reduce biochemical oxygen demand (BOD) and total suspended solids (trickling filter), ponds-based treatment (facultative and maturation) and final polishing through a wetland system, immediately prior to discharge into Tasman Bay.

The average daily wastewater inflow to the plant predicted for 2020 was 10,225 m^3 (75% of domestic flows) (Cordell and Setiawan 2007). Currently, the plant is operating at a daily average of 8,000 m^3 (NCC 2021). Wastewater inflows increase during wet weather and decline rapidly once rainfall events have ceased. Generally, daily rainfall totals < 20 mm do not cause flow volumes to exceed the average wet weather flow of 41,670 m^3/day (predicted for 2020) (Cordell and Setiawan 2007). Inflow volumes are also affected by the height of the tide and associated groundwater infiltration (NCC 2018).

2.2.3. Wastewater overflows

In addition to the NWWTP discharge, wastewater overflows (dry and wet weather) at pump stations and other components of the sewerage network (e.g. manhole sites) can contribute physico-chemical and microbiological contamination to rivers, streams and the CMA. In the Nelson catchment, there are at least 14 sites where pump station overflows (PSOs) have been recorded. Of these, Vanguard Street PS, Paru Paru Road PS and Russel Street PS have been identified as high priority for improvement and Marybank PS and Brooklands PS as medium priority for improvement because of their vulnerability to inflow and infiltration (Large 2021).

The frequency of wastewater overflows (combined dry and wet weather events) recorded by NCC during the period 2012–2019 is shown in Figure 3. The total annual number of events are shown, as well as those that entered the piped stormwater network and therefore had the potential to impact on a watercourse. Overflow frequency varied considerably between years, with lower numbers of overflows recorded in 2017 and 2018 relative to previous years. However, a decreasing trend in the number of overflows cannot be established given the limited timeframe of the dataset and the fact that the method for logging overflows was changed and improved in 2015. The average number of overflows for the 7-year period was 121. A national

[3] The oxidation pond was commissioned in 1979. A marine outfall existed to discharge untreated wastewater from Nelson City and satellite settlements at the northeastern end of the Boulder Bank from 1968.

[4] Population equivalent estimated for 2020. The plant is also designed to treat flows for a population equivalent of 33,750 in 2050 (Cordell and Setiawan 2007).

review of wastewater treatment performance carried out by Water New Zealand found an average of 2.3 wet weather overflows per 1,000 connections to the wastewater network in Nelson. This result is almost three times higher than the national average of 0.8 (Water New Zealand 2020).

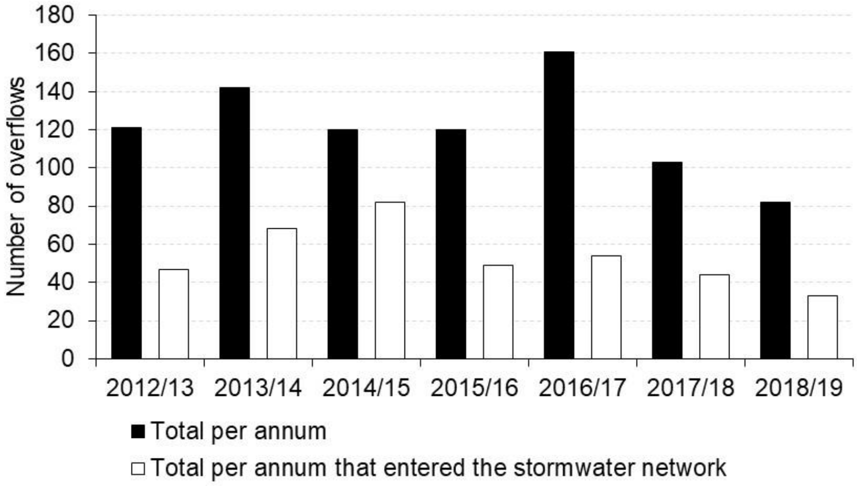

Figure 3. Total number of wastewater network overflows (dry weather and wet weather) in the Nelson catchment, 2012–2018. Note that overflow numbers include those at manholes, private property gully traps and inspection points. The method for logging overflows changed in 2015. Data provided by Nelson City Council.

Cracks / breakages of wastewater pipes due to intrusion of tree roots was the most common cause of overflows in the city (40%), followed by 'rags' (16%), fats (15%), other causes (15%) and gravel intrusion (13%). The category 'other causes' includes overflows caused by inflow, infiltration and wet weather events. The annual number of blockages per 100 km of sewer in Nelson reduced by one-third from 2006 (approximately 90 blockages) to 2015 (approximately 60 blockages) (NCC 2021). Most overflows discharged to the terrestrial environment and were some distance from rivers / streams.

2.2.4. Stormwater discharges

In addition to wastewater discharges, there are many other sources of 'background' physico-chemical contamination to rivers and the CMA, including run-off from urban and rural land and a large number of piped stormwater discharges. In a recent review of stormwater quality monitoring data obtained at six Nelson catchment types since 2012 (six grab samples taken during 'first-flush' conditions), Sneddon and MacNeil (2023) reported mean TN concentrations ranging from 1,300 mg/m^3 to 2,300 mg/m^3.

3. SUMMARY OF ECOLOGICAL EFFECTS OF WASTEWATER DISCHARGES

The main water quality issues associated with wastewater discharges to freshwater and marine environments that potentially impact upon ecological receptors are nutrient enrichment causing eutrophication and toxic effects on marine organisms from exposure to trace metals / toxicants.

Nutrients are essential to healthy aquatic ecosystems. In temperate coastal regions, nitrogen and, to a lesser extent, phosphorus limit biomass of algae and plants and are essential for microbial growth. However, when present in excessive concentrations, i.e. exceeding the assimilative capacity of the ecosystem, nutrients can cause detrimental effects, including increased phytoplankton biomass, reduction of water clarity and oxygen (hypoxia and anoxia), and changes in the trophic structure of planktonic and benthic organisms (National Research Council 2000). Eutrophication frequently leads to reduced biotic diversity of the ecosystem (Gold and Sims 2005). These changes can be subtle or dramatic and often cause degradation of submerged macrophytes[5] or fish kills. A symptom of eutrophication is the occurrence of harmful algal blooms[6] and their cascading effects on aquatic animal communities in higher trophic levels. Large open coast embayments such as Tasman Bay are less vulnerable to eutrophication than estuaries or coastal lagoons. Consequently, blooms of toxin-producing phytoplankton occur less frequently in well-flushed open coasts because the residence times of the waters are shorter than the generation time required for phytoplankton (approximately 1 day; Laws 2013).

Nutrient inputs to rivers and coastal waters originate from many sources, including atmospheric deposition, wastewater treatment plant discharges, agricultural run-off, urban run-off, groundwater seepage, and the release of accumulated nutrients from bottom sediments (National Research Council 1993). In wastewater, the main nutrients of interest are nitrogen and phosphorus. Nitrogen is found in untreated wastewater primarily in two forms: ammoniacal (NH_4^+ and NH_3) (about 60%) and organic (about 40%) (NZWERF 2002). This CEA focuses on measures of all organic and inorganic forms of nitrogen and phosphorus, reported here as total nitrogen (TN) and total phosphorus (TP).

A range of trace metals / chemical substances are commonly monitored in wastewater discharges, including chromium, zinc, nickel, cadmium, copper and mercury. In comparison to industrial discharges, discharges with a higher domestic component, such as the NWWTP discharge, usually contain lower levels of these chemicals and present a relatively low risk to marine organisms in environments with high (> 250:1)

[5] Macrophytes are plants that grow in or near water.
[6] Harmful algal blooms occur when colonies of algae grow out of control and produce toxic or harmful effects on people, fish, shellfish, marine mammals and birds.

dilution in the immediate recipient environment (NZWERF 2002). The toxic effects of these chemical contaminants on marine organisms are influenced by contaminant bioavailability and persistence, the ability of the organisms to accumulate and metabolise the chemicals, and the interference of contaminants with specific metabolic and ecological processes (Capuzzo et al. 1988). Assessing these contaminant transformations is outside the scope of this CEA.

4. SUMMARY INFORMATION ON PHYSICO-CHEMICAL CONTAMINANTS IN WASTEWATER DISCHARGES AND RIVERS

This section summarises the available data on the physical and chemical quality of wastewater discharges and rivers in the Nelson catchment. The data were obtained from recent monitoring undertaken to inform the NWWTP discharge consent application and information reported in previous studies.

4.1. Nelson North Wastewater Treatment Plant discharge

Results of monitoring for physico-chemical parameters undertaken at the NWWTP during the period August 2020–December 2021 are presented in Table 1. Concentrations of trace metals were below the respective consent limits.

Table 1. Concentrations of physico-chemical contaminants in the Nelson North Wastewater Treatment Plant discharge, August 2020–December 2021.

Parameter	Range (mean)	*n*	Consent limit
Nutrient (g/m^3)			
Total nitrogen	8.0–37.0 (20)	36	
Total phosphorus	2.7–6.5 (4.6)	36	
Other physico-chemical			
Biochemical oxygen demand (g O_2/m^3)	4–101	36	
Total suspended solids (g/m^3)	5–220	36	
Trace metal / toxicant (g/m^3)			
Cadmium	< 0.000053–0.00011 (0.000057)	14	0.275
Copper	0.0023–0.005 (0.00348)	15	0.065
Nickel	0.0044–0.0076 (0.00533)	15	3.5
Zinc	0.0058–0.020 (0.10467)	15	0.75
Chromium	0.00149–0.00380 (0.002416)	15	1.37
Lead	0.00036–0.00119 (0.0007)	15	0.22
Cyanide	Not detected	15	0.2
Phenols	< 0.02	15	20
Mercury	< 0.00008	15	0.02

n – number of samples.

The mean concentrations of TN and TP in influent wastewater samples were typical of those found in untreated wastewater (Table 2). The nutrient removal rates at the

NWWTP were similar to those found in other treatment plants in Aotearoa New Zealand (NZWERF 2002). Indicative final effluent concentrations of TN and TP in well-performing wetland systems are 25 g/m^3 and 6 g/m^3, respectively (NZWERF 2002).

Table 2. Concentrations of nutrients and their removal efficiencies in the Nelson North Wastewater Treatment Plant (NWWTP).

Parameter	**Typical concentration in NZ untreated wastewater (NZWERF 2002)**	**Mean concentration in untreated wastewater at NWWTP**	**Mean concentration in the NWWTP discharge**	**Removal rate through the treatment process at NWWTP**
Total nitrogen	7–60 g/m^3	45 g/m^3	20 g/m^3	55%
Total phosphorus	3–13 g/m^3	5.9 g/m^3	4.6 g/m^3	22%

Concentrations of volatile and semi-volatile organic compounds and fats, oils and greases in the discharge (data not shown) were at or just over the limits of detection of the testing methods, except for a single high result of oil and grease detected at the wetland outlet (159 g/m^3) (Campos 2022).

4.2. Wastewater overflows

Results of wastewater sampling undertaken at Marybank PS, Paru Paru Road PS and Airport Storage PS reported in previous studies showed concentrations of TN, TP, BOD and total suspended solids within the ranges reported in the literature (Table 3). TN and TP concentrations were also typical of untreated wastewater in Aotearoa New Zealand (TN: 7–60 g/m^3;
TP: 3–13 g/m^3) (Hauber 1995). The elevated concentrations of COD, BOD, total suspended solids and some trace metals at Quarantine Road PS can be considered ‘typical’ of wastewater in industrial areas, i.e. areas with higher trade flows.

Table 3. Concentrations of physico-chemical contaminants measured in wastewater samples taken at four pump station wet wells and influent screening chamber at the Nelson North Wastewater Treatment Plant (NWWTP). Data compiled from Johnston (2011), Campos and Johnston (2021a, 2021b) and Campos (2022). n/r = not recorded.

Parameter	Marybank PS	Paru Paru Road PS	Quarantine PS	Airport Storage PS	NWWTP influent
Nutrient (mg/L)					
Total nitrogen[(a)]	29	49	380	30	45
Total phosphorus[(b)]	4.1	6.6	62	4.9	5.9
Other physico-chemical					
Biochemical oxygen demand[(c)] (g O_2/m^3)	130	310	3,200	n/r	n/r
Total suspended solids (g/m^3)	150	330	5,100	4,462	220
Trace metal / toxicant (g/m^3)					
Mercury	< 0.0002	0.0003	< 0.01	< 0.01	< 0.01
Arsenic	0.01	0.01	0.04	n/r	< 0.01
Cadmium	< 0.0005	< 0.005	0.0034	0.0003	< 0.01
Chromium	< 0.001	0.001	0.190	0.012	< 0.01
Copper	0.031	0.077	0.40	0.05	0.06
Lead	< 0.003	0.003	0.037	0.006	0.003
Nickel	0.0026	0.0035	0.047	0.008	0.006
Zinc	0.13	0.076	1.0	0.2	0.118

Typical concentrations in New Zealand wastewaters. Source: NZWERF (2002).

a) TN: 7–60 mg/L.

b) TP: 3–13 mg/L.

c) BOD: 150–450 mg/L.

4.3. Freshwater discharges

4.3.1. Main conclusions from State of the Environment monitoring

McArthur (2016) reviewed State of the Environment[7] water quality monitoring data from five FMUs in the Nelson catchment to inform the freshwater chapter of the Nelson Plan. McArthur reviewed data on habitat condition, water quality, sediment toxicity and biological communities. The Nelson catchment sampling sites considered in the review are represented in Figure 4. The main conclusions from the MacArthur study that are relevant to this CEA are:

[7] Under the Resource Management Act 1991, councils must undertake State of the Environment monitoring to 'effectively carry out their functions', i.e. to check if the desired environmental standards or guidelines are being met. These monitoring data are used to detect changes in environmental conditions and trends, including their significance and to detect changes in the state of the environment following the implementation of council plans and strategies.

- Water quality in the upper catchment is generally good but declines downstream as the river is affected by tributary contaminant loads, notably nitrogen contamination.
- The Sharland and Groom streams (at the confluence with the Maitai) had mean nitrogen concentrations above the ANZECC 'lowland' guideline value of 0.44 mg/L.
- Phosphorus concentrations were elevated in the Brook, York, Hillwood and Todd streams. Todds Valley had considerably elevated phosphorus concentrations when compared to other sites.
- The elevated phosphorus concentrations at some sites were probably from natural sources (soft sedimentary and volcanic acidic geology).
- The Groom and Sharland streams were found to be significant contributors of nutrients to the Maitai River.[8]

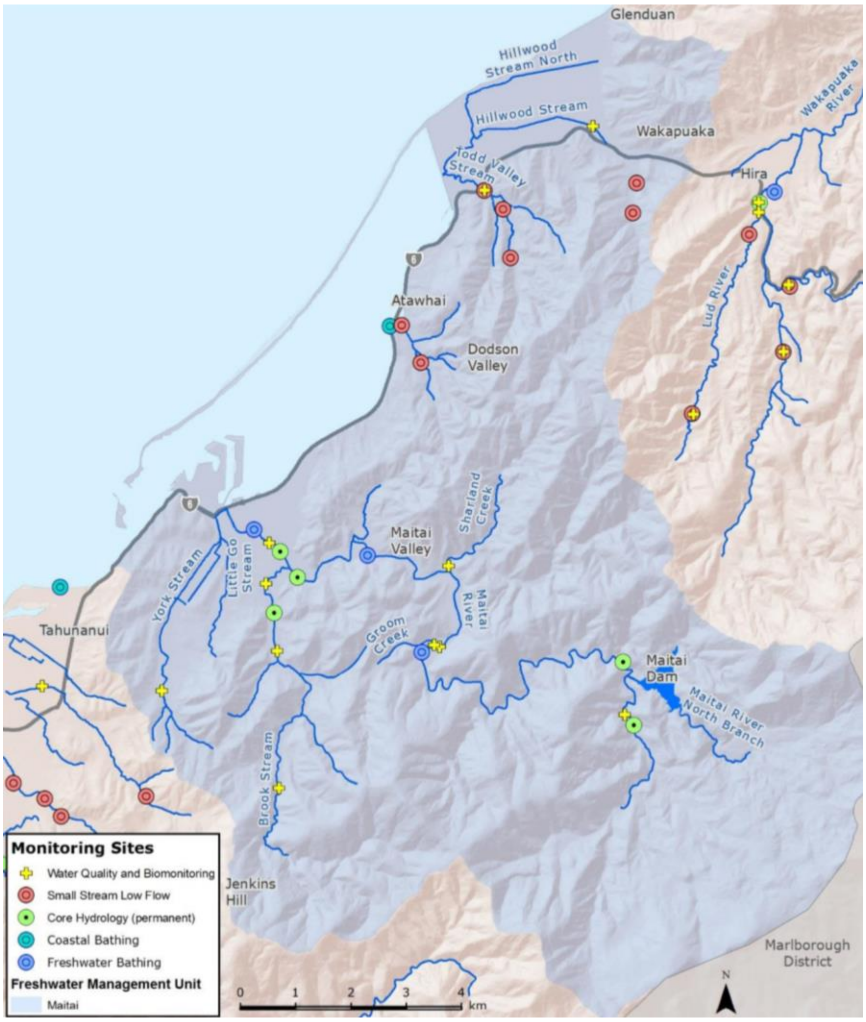

Figure 4. Monitoring sites in the Nelson catchment considered in the McArthur (2016) study.

[8] Results from Project Maitai, which aims to improve the environmental health of the Maitai River and all its tributaries.

4.3.2. Summary of nutrient concentrations in rivers

Concentrations of TN and TP in freshwater samples taken from 11 sites in the Nelson catchment over the period January 2017–December 2019 were downloaded from the Land, Air, Water Aotearoa (LAWA) website: https://www.lawa.org.nz. The dataset used contains 254 valid results.[9] The downloaded results were compared with historic river flow data and classified as 'baseflow' or 'high-flow' for further analysis. The statistical summaries of concentrations of TN and TP at the 11 sites are presented in Tables 4–5.

Mean concentrations of TN were higher under high-flow than under baseflow conditions at all sites. Elevations in high-flow concentrations at Hillwood (Glen Road), Brook (Manuka Street), Todd Valley (State Highway 6; SH6), Groom (Maitai Confluence), Brook (Burn Place), Maitai (Riverside) and Maitai (Groom Road) were statistically significant at 95% confidence levels.

During baseflow conditions, mean TN concentrations ranged from 0.696 mg/L at York (Waimea Road) down to 0.057 mg/L at Maitai South Branch (Intake). During high-flows, mean TN ranged from 0.857 mg/L at York (Waimea Road) down to 0.082 mg/L at Maitai South Branch (Intake). The highest maxima were found at Sharland (Maitai Confluence) (3.700 mg/L) during baseflows and at Todd Valley (SH6) (3.100 mg/L) during high-flows.

Mean concentrations of TP were higher under high-flow than under baseflow conditions at all sites. Elevations in high-flow concentrations at Groom (Maitai Confluence), Brook (Manuka Street), Brook (Burn Place) and Sharland (Maitai Confluence) were statistically significant at 95% confidence levels.

Mean concentrations of TP ranged from 0.034 mg/L at Hillwood (Glen Road) down to 0.006 mg/L at Maitai (Groom Road) during baseflows. During high-flows, TP concentrations ranged from 0.036 mg/L at Hillwood (Glen Road) down to 0.007 mg/L at Maitai South Branch (Intake) and at Maitai (Groom Road).

[9] In the dataset, results reported below the limit of quantification of the methods were substituted by values determined by regression on order statistics (Helsel 2012). This method derives probability plotting positions for individual results (censored and non-censored) based on the ordering of the non-censored data. A relationship between the observations and the non-censored probability plotting positions is then fitted by least squares regression, and this relationship is used to predict the concentrations for the censored results based on their plotting positions (Helsel 2012).

Table 4. Summary statistics of total nitrogen concentrations (mg/L) in freshwater samples from 11 sites in the Nelson catchment, 2017–2019.

Site name	Baseflow							High-flow						
	n	Min.	Max.	Mean	SD	Lower 95% CI	Upper 95% CI	*n*	Min.	Max.	Mean	SD	Lower 95% CI	Upper 95% CI
York at Waimea Road	18	0.450	2.200	0.696	0.379	0.596	0.812	17	0.540	1.300	0.853	0.172	0.777	0.936
Sharland at Maitai Confluence	19	0.117	3.700	0.483	0.810	0.324	0.720	16	0.380	1.510	0.787	0.326	0.646	0.960
Hillwood at Glen Road	21	0.180	1.350	0.430	0.323	0.335	0.553	14	0.210	1.880	0.721*	0.428	0.536	0.969
Brook at Manuka Street	18	0.190	0.640	0.335	0.123	0.287	0.391	17	0.260	0.830	0.476*	0.176	0.402	0.565
Todd Valley at SH6	20	0.160	1.460	0.330	0.355	0.248	0.438	15	0.157	3.100	0.687*	0.709	0.466	1.013
Groom at Maitai Confluence	7	0.150	0.800	0.310	0.255	0.186	0.516	8	0.450	1.800	0.813*	0.446	0.586	1.129
Brook at Burn Place	18	0.091	0.510	0.205	0.137	0.158	0.267	17	0.129	0.830	0.405*	0.178	0.327	0.502
Maitai at Riverside	19	0.113	0.570	0.204	0.126	0.164	0.253	16	0.119	0.640	0.324*	0.157	0.251	0.418
Brook at Motor Camp	18	0.066	0.167	0.109	0.032	0.095	0.125	17	0.073	0.240	0.126	0.046	0.108	0.147
Maitai at Groom Road	18	0.068	0.220	0.103	0.035	0.090	0.117	17	0.069	0.280	0.130*	0.048	0.111	0.152
Maitai South Branch at Intake	19	0.022	0.172	0.057	0.043	0.044	0.075	15	0.047	0.160	0.082	0.029	0.069	0.097

Sites ranked by base flow geometric mean. *n* – number of samples; Min. – minimum; Max. – maximum; SD – standard deviation of $\log_{10}$-transformed results; lower 95% CI – lower 95% confidence level; upper 95% CI – upper 95% confidence level. * Statistically significant elevation in the mean concentration at high-flow compared with that at baseflow (t-test; $P < 0.05$).

Table 5. Summary statistics of total phosphorus concentrations (mg/L) in freshwater samples from 11 sites in the Nelson catchment, 2017–2019.

Site name	Baseflow							High-flow						
	n	**Min.**	**Max.**	**Mean**	**SD**	**Lower 95% CI**	**Upper 95% CI**	***n***	**Min.**	**Max.**	**Mean**	**SD**	**Lower 95% CI**	**Upper 95% CI**
Hillwood at Glen Road	21	0.018	0.165	0.034	0.036	0.027	0.043	14	0.016	0.210	0.036	0.052	0.025	0.053
Todd Valley at SH6	20	0.015	0.143	0.026	0.027	0.022	0.032	15	0.014	0.200	0.035	0.046	0.025	0.049
Brook at Motor Camp	18	0.014	0.039	0.018	0.006	0.016	0.021	17	0.014	0.035	0.020	0.005	0.018	0.022
York at Waimea Road	18	0.006	0.091	0.016	0.019	0.012	0.020	17	0.010	0.150	0.024	0.032	0.018	0.033
Groom at Maitai Confluence	7	0.011	0.024	0.016	0.005	0.012	0.020	8	0.017	0.041	0.024*	0.008	0.019	0.029
Brook at Manuka Street	18	0.010	0.021	0.014	0.003	0.013	0.015	17	0.008	0.047	0.018*	0.009	0.015	0.022
Brook at Burn Place	18	0.006	0.035	0.013	0.006	0.011	0.015	17	0.010	0.035	0.019*	0.006	0.016	0.022
Sharland at Maitai Confluence	19	0.004	0.020	0.010	0.005	0.008	0.012	16	0.007	0.030	0.016*	0.007	0.013	0.019
Maitai at Riverside	19	0.004	0.028	0.008	0.005	0.007	0.010	16	0.004	0.018	0.011	0.005	0.009	0.014
Maitai South Branch at Intake	19	0.004	0.013	0.006	0.003	0.005	0.008	15	0.004	0.011	0.007	0.002	0.006	0.009
Maitai at Groom Road	18	0.004	0.010	0.006	0.002	0.005	0.007	17	0.004	0.014	0.007	0.003	0.006	0.009

Sites ranked by baseflow geometric mean. *n* – number of samples; Min. – minimum; Max. – maximum; SD – standard deviation of log_{10}-transformed results; lower 95% CI – lower 95% confidence level; upper 95% CI – upper 95% confidence level. * Statistically significant elevation in the mean concentration at high-flow compared with that at baseflow (t-test; $P < 0.05$).

The LAWA database also contains predominant land-use classifications for individual FMUs (classified as forest, rural or urban). Figures 5–6 show boxplots[10] of the TN and TP data grouped by land-use class and flow condition.

Median TN concentrations in rural and urban FMUs were higher than those in forest FMUs. Differences in mean concentrations by flow condition and land-use class were statistically significant (MANOVA; $P < 0.001$). The boxplots also show outlier results that represent occasional peak TN and TP concentrations that are well above the median, particularly in forest FMUs during baseflow conditions.

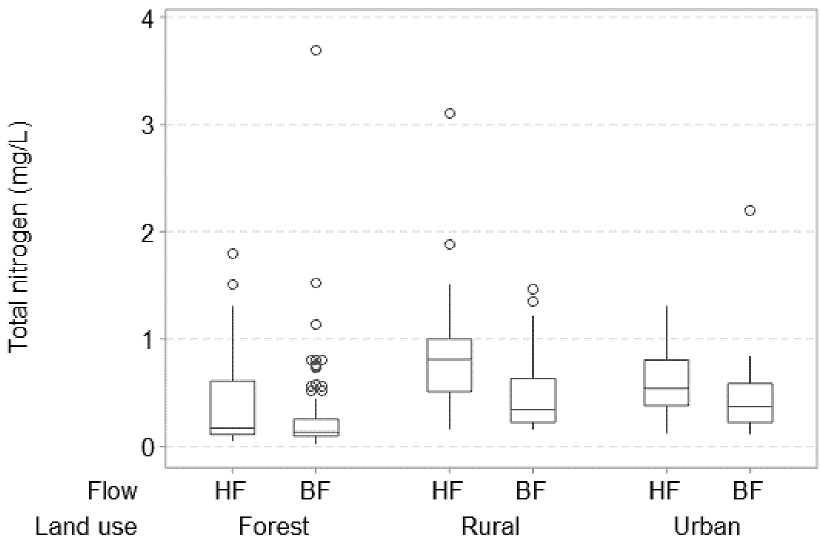

Figure 5. Boxplots of total nitrogen at freshwater management units grouped by land-use category in the Nelson catchment during high-flow (HF) and baseflow (BF) conditions, 2017–2019.

The data distributions for TP were similar to those for TN. Median TP concentrations between land-use class were statistically significant (MANOVA; $P < 0.001$) but those between flow conditions were not, suggesting that the differences in flow regimes in the rivers do not account for the differences in TP concentrations between FMUs with different land uses.

[10] A boxplot is a standardised way of displaying the distribution of data based on a five number summary (minimum, first quartile, median, third quartile and maximum).

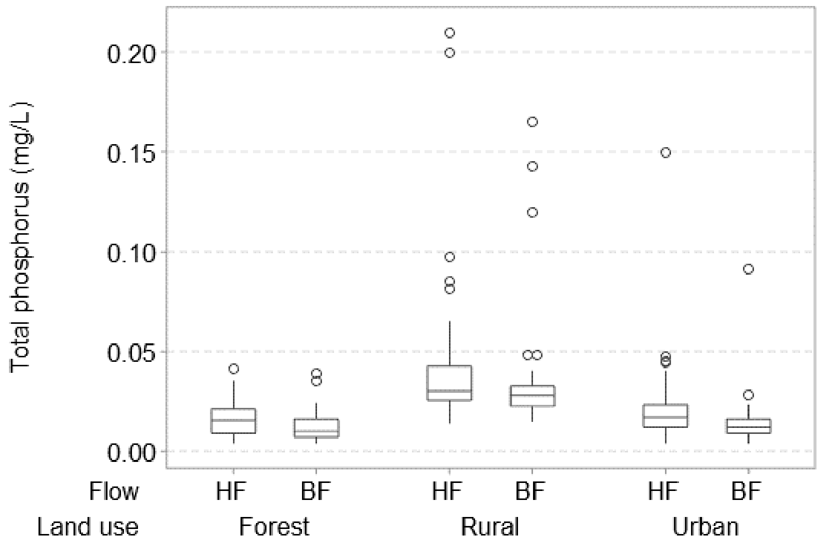

Figure 6. Boxplots of total phosphorus at freshwater management units grouped by land-use category in the Nelson catchment during high-flow (HF) and baseflow (BF) conditions, 2017–2019.

4.4. Associations between nutrients and land uses

Grant and Le Cren (2017) studied the causes of water quality deterioration and the associations between water quality and land uses in rural parts of the Nelson catchment. The main conclusions from this study relevant to nutrient loading were:

- Many streams draining pastoral land in the Todd Valley and lower Maitai River are riparian fenced and / or have livestock exclusion structures, and therefore there is little opportunity for cattle and sheep to access these watercourses.
- Concentrations of ammoniacal nitrogen and nitrate-nitrogen were low across the Maitai FMU. However, soluble inorganic nitrogen at both baseflow and high-flow conditions exceeded the ANZECC lowland guideline in the Sharland, Groom and York sites. Because of the low livestock density in these FMUs, it was considered unlikely that pastoral farming contributed substantially to these results.
- Concentrations of dissolved reactive phosphorus were high at the Brook, York, Hillwood, and Todd Valley (SH6). Contamination was unlikely to originate from livestock at the Brook and York sites.

4.5. Estimated contributions of total nitrogen inputs from wastewater discharges and rivers

Previous studies have reported estimates of TN loadings from various land-based sources into Tasman Bay. The NWWTP discharge has been estimated to contribute only 4% of the total loading to the bay (Table 6). Most land-derived nitrogen inputs to the bay are from rivers and streams. The Motueka River alone has been estimated to contribute 60–70% of the input of 'new' (i.e. not generated by recycling within the bay) dissolved inorganic nitrogen from freshwater inputs to Tasman Bay (MacKenzie et al. 2003). The estimates presented in Table 6 should be considered with caution because the studies used different methods (either mass balance calculations using field data or modelling studies) and were reported over a long timeframe (20+ years). Consequently, the estimates only provide an indication of the nitrogen loading from individual sources.

Table 6. Estimated contributions from different point and diffuse sources to inputs of total nitrogen (TN) to Tasman Bay.

Source	**Total nitrogen (tonnes/year)**	**Percentage of total nitrogen inputs**
Bells Island Wastewater Treatment Plant discharge(a)	97	4
Nelson North Wastewater Treatment Plant discharge(a)	120	4
Motueka Wastewater Treatment Plant discharge(b)	37	1
Nelson fisheries processing discharge(a)	80	3
Motueka food processing (Talley's)(c)	45	2
All river and stream discharges(d)	1,803	71
Wastewater overflows to the Waimea Estuary(e)	342	14
Biosolids application to Moturoa / Rabbit Island(f)	14	1
Total inputs from land	2,520	
Denitrification in Tasman Bay sediments(g)	-2,900	

a) Gillespie et al. (2001) reported an input of 102 tonnes/year, based on data in Barter and Forrest (1998). However, converting the daily TN loads in Barter and Forrest gives an average TN loading of 89 tonnes/year and a maximum loading of 120 tonnes/year.
b) Sneddon et al. (2014).
c) Cawthron unpublished data.
d) Gillespie and Berthelsen (2017) (based on CLUES modelling).
e) Derived from estimates in Johnston (2011) and Johnston (2017).
f) Morrisey et al. (2020).
g) Christensen et al. (2003), Gillespie et al. (2011).

Using a mass balance modelling approach, Zeldis and Swaney (2018) estimated the following dissolved inorganic nitrogen loadings (as annual average) to Tasman Bay:

- 63 x 10^6 mol/year from rivers
- 12 x 10^6 mol/year from atmospheric deposition
- 5 x 10^6 mol/year from submarine groundwater
- 7 x 10^6 mol/year from wastewater discharges

The Zeldis and Swaney estimates indicate an 8% contribution from continuous wastewater discharges, which is consistent with the estimates in the table above.

4.6. Modelled concentrations and loadings of nutrients in rivers

To complement the data summarised in Section 4.5, mean concentrations and loadings of TN and TP in the Nelson catchment rivers were obtained from the CLUES model, a steady-state, spatially distributed and integrated modelling system that predicts contaminant concentrations and loadings with a spatial resolution of 0.5 km^2. CLUES couples three water quality models, and its spatial unit is the River Environments Classification (REC) reach and surrounding sub-catchment (Elliott et al. 2016). The spatial data are grouped within each REC sub-catchment. Catchment characteristics, such as soil and slope, are aggregated by the average value for each FMU in the Nelson catchment. The CLUES model represents land use in each REC FMU by the percentage of the FMU area covered by each of 19 land-use classes. The mean cumulative (instream) loadings (expressed as tonnes per year) are calculated for the terminal node of each river reach, following procedures described by Semadeni-Davies et al. (2016).[11] Further details on CLUES can be found in Elliott et al. (2016).

The model outputs obtained for this CEA include all streams and rivers draining to the Nelson CMA. The highest TN and TP loadings are associated with the Maitai River and associated tributaries (Figure 7). The maximum instream TN and TP loadings predicted by the model are 44 mg/m^3 and 5 mg/m^3, respectively. Other streams in the Hillwood FMU are associated with relatively high nutrient loadings.

The CLUES model outputs represent annual average data for nutrients and therefore provide a high-level indication of contamination 'hotspots' in the catchment.

[11] The CLUES calculations were performed in version 10.3 using the default settings based on Land Cover Database version 3 (LCDB3) 2008/09 land use and the 2010 REC2 stream network database.

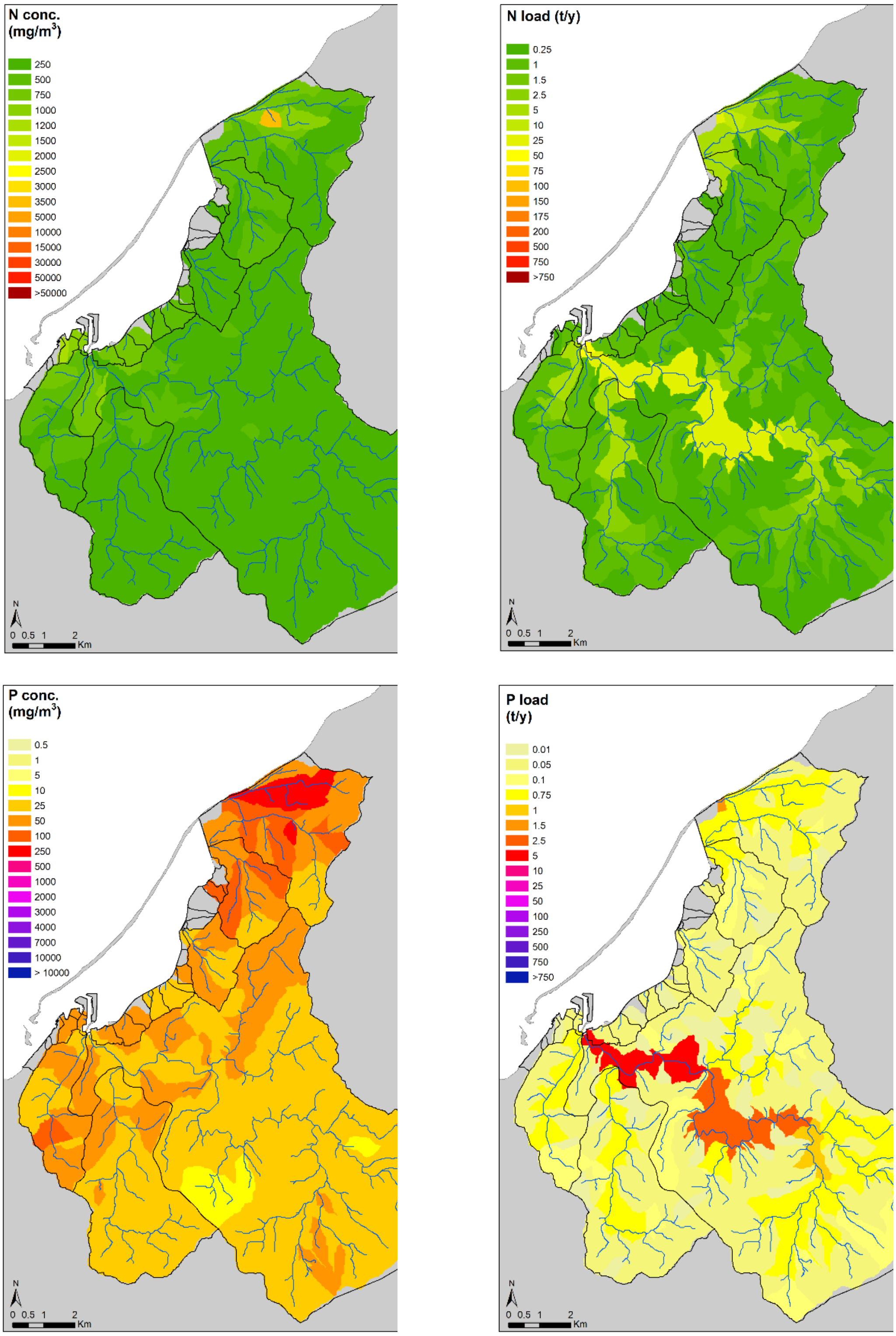

Figure 7. Predicted total nitrogen (N) and total phosphorus (P) instream reaches in the Nelson catchment, represented as median concentrations (left) and mean annual loads (right). Source: CLUES model.

5. DISCUSSION ON THE CAPACITY OF TASMAN BAY TO ASSIMILATE NUTRIENTS

In this section, nutrient limits / thresholds implemented in Aotearoa New Zealand and overseas are presented with the available monitoring data for the NWWTP discharge and other sources in the Nelson catchment to discuss the potential for Tasman Bay to assimilate these contaminants. When discussing this potential, consideration is also given to current (2022) and future (2059) discharge scenarios. It should be stressed that long-term water quality monitoring data from source-representative sites in Tasman Bay would be required to increase the confidence of any assessment of the potential for contaminant inputs to trigger adverse ecological impacts in the bay.

5.1. Comment on nitrogen cycling

As mentioned in Section 3, nitrogen is the most limiting nutrient, and thus it is the focus of this CEA; although phosphorus is also considered as an important secondary component of nutrient enrichment. The nitrogen cycle plays a waste-treatment role in processing potentially detrimental nitrogen-containing wastes that are derived from point sources such as wastewater discharges and diffuse non-point sources such as agricultural or urban run-off. Ultimately, nitrogen cycling processes assimilate these wastes into the food web or convert nutrient forms of nitrogen into non-nutrient nitrogen gas. Particulate organic nitrogen can also become buried in sediments to depths that reduce connectivity with the overlying seawater, therefore essentially removing it from food web networks. Nonetheless, dilution is also of major importance for mitigating negative effects of nutrient input. Based on the high denitrification rate reported for Tasman Bay (presented in Table 6), it can be concluded that there is little potential for bay-wide dysfunctional ecosystem enrichment effects to occur, even when allowing for possible future increases in catchment nutrient discharges (e.g. through conversion to nutrient-generating agricultural land uses) (Gillespie et al. 2011).

5.2. Comparison of receiving water nutrient concentrations to thresholds

A ‘benchmark’ for assessing the capacity of Tasman Bay to assimilate contaminants is achieved by comparing nutrient concentrations at coastal sites near the NWWTP discharge with standards / limits used to determine the nutrient enrichment status of coastal waters in Aotearoa New Zealand and overseas. Standards or limits for TN and TP were compiled from the literature and compared against median values for two sites near the discharge (Boulder Bank [approximately 100 m from the boundary of the discharge mixing zone] and Schnappers Point [primary contact recreation site, approximately 1 km from the mixing zone boundary]); these data are presented in

Table 7. In some cases, the standards apply to estuaries and therefore are less informative in assessing effects in open coastal environments because of the much higher wastewater dilution ratios available in these environments.

There are no national guideline values for nutrient concentrations in Aotearoa New Zealand marine waters. ANZECC (2000) recommended that, in the absence of locally derived criteria, the guideline values for southeast Australia can be used as a set of default criteria for Aotearoa New Zealand. But these values have consistently proved too conservative, with even relatively pristine waters from several Aotearoa New Zealand regions regularly exceeding the southeast Australian values. While several regional authorities have made efforts to develop a set of area-specific guideline values for coastal waters, there has been no formal process undertaken for the region incorporating Tasman Bay. Similar to ANZECC (2000), the ANZG (2018) guidelines that supersede them place an emphasis on developing such area-specific values using a combination of reference-site and laboratory- or field-effects data.

TN concentrations for coastal sites near the NWWTP discharge were mostly below the limit of detection of the testing method (300 mg/m^3). The median TN concentration in the discharge monitored during the same period (August 2020–December 2021) was 12,000 mg/m^3 (Morrisey and Campos 2023). To meet the ANZECC guideline for marine waters, the concentration in the discharge would require a dilution ratio of 100:1 in the receiving environment. According to hydrodynamic modelling undertaken by MetOcean, dilution ratios greater than 8,000:1 are achieved within the NWWTP discharge mixing zone boundary (MetOcean 2023).

As mentioned in Section 5.1, phosphorus is less likely to be associated with an elevated enrichment status in coastal waters than nitrogen. However, the median TP concentrations measured near the NWWTP discharge were below the limits / thresholds used in Aotearoa New Zealand and overseas.

Table 7. Comparison of nutrient concentrations measured in the receiving environment of the Nelson North Wastewater Treatment Plant (NWWTP) discharge with the limits / thresholds considered to assess eutrophication status in coastal environments.

Nutrient species	Concentration threshold / receiving water concentration	Sampling site	Environment type	Country	Reference
TN	Concentrations mostly below the limit of detection of the method (300 mg/m^3)	NWWTP discharge (Boulder Bank)[(a)]	Inner Tasman Bay	Aotearoa New Zealand	This study (consent monitoring data)[(c)]
	Concentrations mostly below the limit of detection of the method (300 mg/m^3)	NWWTP discharge (Schnappers Point)[(b)]	Inner Tasman Bay	Aotearoa New Zealand	This study (consent monitoring data)[(c)]
	234 mg/m^3	Control site for Bells Island WWTP discharge	Inner Tasman Bay	Aotearoa New Zealand	Gillespie and Berthelsen (2017)
	249 mg/m^3	Control site for Bells Island WWTP discharge (2005–2016 data)	Inner Tasman Bay	Aotearoa New Zealand	Gillespie and Berthelsen (2017)
	120 mg/m^3 [(d)]		Marine waters	Southeast Australia	ANZECC (2000)
	220 mg/m^3	Monitoring sites in coastal waters, including contact recreation and shellfish gathering	Estuaries (Northland)	Aotearoa New Zealand	Northland Regional Council (2023)
TP	20 mg/m^3	NWWTP discharge (Boulder Bank)[(a)]	Inner Tasman Bay	Aotearoa New Zealand	This study (consent monitoring data)[(c)]
	16 mg/m^3	NWWTP discharge (Schnappers Point)[(b)]	Inner Tasman Bay	Aotearoa New Zealand	This study (consent monitoring data)[(c)]
	27 mg/m^3	Control site for Bells Island WWTP discharge	Inner Tasman Bay	Aotearoa New Zealand	Gillespie and Berthelsen (2017)
	38 mg/m^3	Control site for Bells Island WWTP discharge (2005–2016 data)	Inner Tasman Bay	Aotearoa New Zealand	Gillespie and Berthelsen (2017)
	25 mg/m^3 [(d)]		Marine waters	Southeast Australia	ANZECC (2000)

Nutrient species	Concentration threshold / receiving water concentration	Sampling site	Environment type	Country	Reference
	30 mg/m^3	Monitoring sites in coastal waters, including contact recreation and shellfish gathering	Estuaries (Northland)	Aotearoa New Zealand	Northland Regional Council (2023)
	9–44 mg/m^3 (< 25 used in most countries)[(e)]	Annual mean (WFD monitoring sites) in EU Member States	Coastal waters	Europe	Poikane et al. (2019)

a) CM AW 01 – Boulder Bank adjacent WWTP.
b) CM AW 02 – Schnappers Point.
c) Monitoring period: August 2020–December 2021.
d) Concentration threshold aims to protect from nutrient enrichment effects in southeastern Australian marine environments and therefore is considered as a benchmark of similar effects in Tasman Bay.
e) Threshold for 'good-to-moderate' classification under the EU Water Framework Directive (WFD).

5.3. Comment on nutrient concentrations in the NWWTP discharge and other catchment sources

Although comparisons with generalised guidelines established for other regions are useful to assess the sensitivity of Tasman Bay to contaminant inputs, the data from the NWWTP discharge also needs to be compared with inputs from other sources. As mentioned in Section 4, the most recent results of nutrient monitoring undertaken at the NWWTP show that the treatment plant achieves, on average, a 55% removal for TN and 22% removal for TP. Mean concentrations of these contaminants in the discharge have been below the consent limit and typical of those found in tertiary-treated effluents (from wetland systems) during baseflow conditions. Mean concentrations of TN and TP in the NWWTP discharge (TN: 8,000–37,000 mg/m^3; TP: 2,700–6,500 mg/m^3) are of the same order of magnitude of those in PSOs to the CMA (TN: 29,000–30,000 mg/m^3; TP: 4,000–5,000 mg/m^3) but much higher than those in stormwater discharges (first-flush samples) (TN: 1,300–2,300 mg/m^3; no TP data). However, as shown in the data compiled from previous studies, the NWWTP discharge contributes a very small proportion of the total discharge volume to Tasman Bay (4%). At the scale of the bay, other sources contribute similar or higher TN inputs (on an annual average basis), particularly rivers and streams (71% of the TN input). It should also be noted that the estimated total TN input from all pollution sources combined (NWWTP discharge, Bells Island WWTP discharge, Motueka WWTP discharge, Nelson fisheries discharge, Talley's factory discharge, rivers, wastewater overflows, biosolids applications on Moturoa / Rabbit Island) is estimated at 2,520 tonnes/year, which is lower than the estimated capacity of the bay to recycle nitrogen through denitrification (2,900 tonnes/year; Table 6). This indicates that there is capacity for the NWWTP discharge receiving environment to assimilate additional nitrogen without enrichment effects being manifested in the environment.

5.4. Comment on future NWWTP discharge flows

Several decades of discharge monitoring have found few discernible effects from the NWWTP discharge on seabed communities, and effects on water quality have been highly localised within, for example, the confines of the mixing zone (Barter and Forrest 1998; Sneddon 2018; Morrisey 2021).[12] Potentially negative ecological impacts are minimised through a high level of sewage treatment, a subtidal diffuser discharge that promotes rapid mixing and dilution of the effluent, and a tidally-driven effluent dispersion. The treatment process serves to avoid effects on the shoreline and valued recreational areas and habitats in the vicinity of the discharge. Results of the consent monitoring programme undertaken in 2020–2021 (data presented in Section 4 and Morrisey and Campos 2023) also indicated that the chemical quality of the NWWTP discharge consistently meets consent limits and receiving water quality guidelines.

Predicted influent wastewater flows (average dry weather and peak wet weather) to the NWWTP for 2059 were provided by Stantec. The results, presented in Table 8 show a very small increase in average discharge volumes to Tasman Bay, from the current 3% to 5% in 2059 (relative to average dry weather flows).

Table 8. Predicted changes in Nelson North Wastewater Treatment Plant (NWWTP) discharge volume for current (2022) and future (2059) discharge conditions.

	Discharge volume budget	
	2022	2059
NWWTP discharge (average dry weather flows)	3% ($7,400\ m^3$/day)	5% ($10,100\ m^3$/day)
NWWTP discharge (peak wet weather flow)	3% ($36,800\ m^3$/day)	4% ($49,800\ m^3$/day)

[12] Under the conditions of the present discharge permit, qualitative ecological surveys of the seabed around the NWWTP outfall diffuser are carried out every 5 years.

6. ACKNOWLEDGEMENTS

The following contributions are gratefully acknowledged:

- Lisa Floerl (Cawthron Institute) for GIS mapping and CLUES modelling.
- Emma Reeves (Nelson City Council) for providing the rainfall and river flow data.
- Atsushi Ota (Nelson City Council) for providing data on wastewater overflows.

7. REFERENCES

[ANZECC] Australia and New Zealand Environmental and Conservation Council. 2000. Australian and New Zealand guidelines for fresh and marine water quality. National Water Quality Management Strategy Paper 4. Canberra: Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand.

[ANZG] Australian and New Zealand Governments. 2018. Australian and New Zealand guidelines for fresh and marine water quality. Australian and New Zealand Governments and Australian state and territory governments, Canberra ACT, Australia. https://www.waterquality.gov.au/anz-guidelines

Barter P, Forrest B. 1999. Wakapuaka sewage outfall emergency discharge EIA. Nelson: Cawthron Institute. Cawthron Report No. 499. Prepared for Nelson City Council.

Campos C. 2022. Resource consents renewal for Nelson Wastewater Treatment Plant: quarterly review of environmental monitoring data - August 2020 to December 2021. Nelson: Cawthron Institute. Cawthron Advice Letter No. 2221. Prepared for Stantec New Zealand.

Campos C. 2023. Ecological and human health impacts of wet weather wastewater overflows and other discharges in the Nelson catchment. Nelson: Cawthron Institute. Cawthron Report No. 3943. Prepared for Nelson City Council.

Campos C, Johnston O. 2021a. Environmental monitoring programme for pump station overflows into Waimea inlet; results of the second baseline survey. Nelson: Cawthron Institute. Cawthron Advice Letter 2102. Prepared for Nelson Regional Sewerage Business Unit.

Campos C, Johnston O. 2021b. Environmental monitoring programme for pump station overflows into Waimea inlet; results of the third baseline survey. Nelson: Cawthron Institute. Cawthron Advice Letter 2199. Prepared for Nelson Regional Sewerage Business Unit.

Campos C, Masterton H, Pantos O. 2023a. Risk assessment of microplastics in the treated wastewater discharge from the Nelson North Wastewater Treatment

Plant. Nelson: Cawthron Institute. Cawthron Report No. 3871. Prepared for Nelson City Council.

Campos C, Northcott GL, Tremblay LA. 2023b. Risk assessment of emerging organic contaminants in the treated effluent discharge from the Nelson Wastewater Treatment Plant. Nelson: Cawthron Institute. Cawthron Report No. 3843. Prepared for Nelson City Council.

Canter LW, Atkinson SF. 2011. Multiple uses of indicators and indices in cumulative effects assessment and management. Environmental Impact Assessment Review. 31:491–501.

Capuzzo JM, Moore MN, Widdows J. 1988. Effects of toxic chemicals in the marine environment: predictions and impacts from laboratory studies. Aquatic Toxicology. 11:303–311.

Cordell M, Setiawan A. 2007. Nelson Wastewater Treatment Plant upgrade. Operation and maintenance manual. Volume 1. Opus International Consultants Limited. Revision 2, April 2007.

Cornelisen CD, Kirs M, Gilpin B, Scholes P. 2012. Microbial Source Tracking (MST) tools for water quality monitoring. Nelson: Cawthron Institute. Cawthron Report No. 2047. Prepared for Regional Councils and the Coastal Special Interest Group.

Christensen PB, Glud RN, Dalsgaard T, Gillespie P. 2003. Impacts of longline mussel farming on oxygen and nitrogen dynamics and biological communities of coastal sediments. Aquaculture. 218:567–588.

EIANZ [Environment Institute of Australia and New Zealand]. 2018. Ecological impact assessment (EcIA). EIANZ guidelines for use in New Zealand: terrestrial and freshwater ecosystems. 2nd Edition. Environment Institute of Australia and New Zealand Inc.

Elliott AH, Semadeni-Davies AF, Shankar U, Zeldis JR, Wheeler DM, Plew DR, Rys GJ, Harris SR. 2016. A national-scale GIS-based system for modelling impacts of land use on water quality. Environmental Modelling & Software. 86:131–144.

Gillespie P. 2008. Preliminary assessment of the environmental status of the Nelson Haven. Nelson: Cawthron Institute. Cawthron Report No. 1545. Prepared for Nelson City Council.

Gillespie P, Asher R, Doyle M. 2001. Impact of the Nelson (Bell Island) regional sewerage discharge on Waimea Inlet. Part II. Nutrient enrichment potential of receiving waters. Nelson: Cawthron Institute. Cawthron Report No. 680. Prepared for the Nelson Regional Sewerage Business Unit and Tasman District Council.

Gillespie P, Berthelsen A. 2017. Capacity of the marine receiving environment of the Bell Island Wastewater Treatment Plant to assimilate additional nutrients. Nelson: Cawthron Institute. Cawthron Report No. 3077. Prepared for the Nelson Regional Sewerage Business Unit.

Gillespie PA, Forrest RW, Knight BR, Cornelisen CD, Young RG. 2011. Variation in nutrient loading from the Motueka River into Tasman Bay, New Zealand, 2005–2009: implications for the river plume ecosystem. New Zealand Journal of Marine and Freshwater Research. 45(3):497–512.

Gold AJ, Sims JT. 2005. Eutrophication. In: Encyclopedia of soils in the environment. Reference module in earth systems and environmental sciences; p. 486–494.

Grant L, Le Cren S. 2017. Land use contribution to water quality issues in the Nelson Region. Nelson: LandVision Ltd.

Hauber G. 1995. Wastewater treatment in NZ: evaluation of 1992/93 performance data – ORGD. Water and Wastes in NZ. May:28–34.

Helsel DR. 2012. Statistics for censored environmental data using *Minitab*® and *R*. Hoboken (NJ): John Wiley & Sons.

Hudson N, Wood D. 2023. Quantitative microbial risk assessment for Nelson North Wastewater Treatment Plant. NIWA Client Report No. 2023056HN. Prepared for Nelson City Council.

Hwang H-T, Frey SK, Park Y-J, Pintar KDM, Lapen DR, Thomas JL, Spoelstra J, Schiff SL, Brown SJ, Sudicky EA. 2019. Estimating cumulative wastewater treatment plant discharge influences on acesulfame and *Escherichia coli* in a highly impacted watershed with a fully-integrated modelling approach. Water Research. 157:647–662.

Johnston O. 2011. Assessment of environmental effects from accidental wastewater overflow on Nelson city receiving environments: Section 92(1) response. Nelson: Cawthron Institute. Cawthron Report No. 1977. Prepared for Nelson City Council.

Johnston O. 2017. Nelson Regional Sewerage Business Unit (NRSBU) aberrational wastewater overflows. Nelson: Cawthron Institute. Cawthron Report No. 3091. Prepared for Nelson Regional Sewerage Business Unit.

Johnston O, Campos C. 2023. Results of baseline monitoring for assessing the environmental effects of pump station overflows into Waimea Estuary. Prepared for Nelson Regional Sewerage Business Unit. Cawthron Report No. 3885. 35 p. plus appendices.

Large M. 2021. Inflow and infiltration: sub-catchment key performance indicators. Tonkin & Taylor Memorandum Number 1006675.0310 of 25 January 2021.

LAWA. 2023. https://www.lawa.org.nz/

Laws EA. 2013. Evaluation of in situ phytoplankton growth rates: a synthesis of data from varied approaches. Annual Reviews in Marine Science. 5:247–268.

LRIS. 2018. LCDB v5.0 - Land Cover Database version 5.0, Mainland New Zealand. https://lris.scinfo.org.nz/layer/104400-lcdb-v50-land-cover-database-version-50-mainland-new-zealand/

MacKenzie L, Gillespie P, Thompson S. 2003. River inputs, re-mineralisation and the spatial and temporal distribution of inorganic nutrients in Tasman Bay. Nelson: Cawthron Institute. Cawthron Report No. 837. Motueka Integrated Catchment Management (Motueka ICM) Programme Report Series.

McArthur K. 2016. Nelson freshwater quality: an analysis of state and issues. Palmerston North: Catalyst Group. Report No. 2016/068. http://www.nelson.govt.nz/assets/Environment/Downloads/Water/freshwater-working-groups/Nelson-Freshwater-Quality-An-Analysis-of-State-and-Issues.pdf. Accessed 23 April 2020

MetOcean. 2023. Nelson North Wastewater Treatment Plant (NWWTP) dispersion modelling: technical note on dilution near the outfall. Report prepared for Nelson City Council.

MfE [Ministry for the Environment]. 2006. A guide to preparing a basic assessment of environmental effects: an essential reference for people preparing an AEE. https://environment.govt.nz/publications/a-guide-to-preparing-a-basic-assessment-of-environmental-effects/

MfE [Ministry for the Environment]. 2018. Livestock numbers, 1994–2017. https://data.mfe.govt.nz/table/95344-livestock-numbers-19942017/

MfE [Ministry for the Environment]. 2023. National Policy Statement for Freshwater Management. https://environment.govt.nz/acts-and-regulations/national-policy-statements/national-policy-statement-freshwater-management/

Morrisey D. 2021. Qualitative ecological survey of Nelson North Wastewater Treatment Plant outfall 2021. Nelson: Cawthron Institute. Cawthron Report No. 3638. Prepared for Nelson City Council.

Morrisey D, Campos C. 2023. Assessment of effects of the Nelson North Wastewater Treatment Plant discharge on coastal ecology and kaimoana. Nelson: Cawthron Institute. Cawthron Report No. 3884. Prepared for Nelson City Council.

Morrisey D, Campos C, Gillespie P. 2020. Assessment of the effects on the coastal environment of biosolids application to land on Moturoa / Rabbit Island. Nelson: Cawthron Institute. Cawthron Report No. 3500. Prepared for Nelson Regional Sewerage Business Unit.

[NCC] Nelson City Council. 1997. Nelson Regional Policy Statement. http://www.nelson.govt.nz/assets/Our-council/Downloads/regional-policy-statement-1997.pdf

[NCC] Nelson City Council. 2018. Wastewater – asset management plan 2018–2028. http://www.nelson.govt.nz/assets/Our-council/Downloads/asset-managment-plans/2018/2018-28-Wastewater-Asset-Management-Plan-6Dec2018.pdf

[NCC] Nelson City Council. 2020. Nelson Wastewater Treatment Plant. http://www.nelson.govt.nz/services/facilities/infrastructure/nwwtp/

[NCC] Nelson City Council. 2021. Draft 2021–2031 wastewater activity management plan: Mahere Waipara. http://www.nelson.govt.nz/assets/Our-council/Downloads/2013-AMPs/2021-31-Draft-Wastewater-Activity-Management-Plan.pdf

[NCC] Nelson City Council, [TDC] Tasman District Council. 2021. Top of the South Maps. [accessed 15 January 2021]. https://www.topofthesouthmaps.co.nz/app/

Northland Regional Council. 2023. Proposed regional plan for Northland. Appeals Version - 7 June 2023. https://www.nrc.govt.nz/media/lnqhzibe/proposed-regional-plan-updated-appeals-version-june-2023.pdf

National Research Council. 1993. Managing wastewater in coastal urban areas. The National Academies Press: Washington DC.

National Research Council. 2000. Clean coastal waters: understanding and reducing the effects of nutrient pollution. Washington, DC: National Academies Press.

[NZWERF] New Zealand Water Environment Research Foundation. 2002. New Zealand municipal wastewater monitoring guidelines. Edited by D.E. Ray.

Parliamentary Counsel Office. 2020. Resource Management Act 1991. http://www.legislation.govt.nz/act/public/1991/0069/latest/DLM231795.html

Phiri BJ, Pita AB, Hayman DTS, Biggs PJ, Davis MT, Fayaz A, Canning AD, French NP, Death RG. 2020. Does land use affect pathogen presence in New Zealand drinking water supplies? Water Research. 185:116229.

Poikane S, Kelly MG, Herrero FS, Pitt JA, Jarvie HP, Claussen U, Leujak W, Solheim AL, Teixeira H, Phillips G. 2019. Nutrient criteria for surface waters under the European Water Framework Directive: current state-of-the-art, challenges and future outlook. Science of the Total Environment. 695:133888.

Semadeni-Davies A, Elliott S, Shankar U. 2016. CLUES - Catchment Land Use for Environmental Sustainability user manual. 5th ed. CLUES 10.3. NIWA Client Report No. AKL2016-017.

Singh SK, Pahlow M, Booker DJ, Shankar U, Chamorro A. 2019. Towards baseflow index characterisation at national scale in New Zealand. Journal of Hydrology. 568:646–657.

Sneddon R. 2018. Qualitative dive survey on Wakapuaka wastewater outfall 2018. Nelson: Cawthron Institute. Cawthron Report No. 3245. Prepared for Nelson City Council.

Sneddon R, MacNeil C. 2023. Nelson stormwater monitoring 2022–23: sampling and six-year review. Nelson: Cawthron Institute. Cawthron Report 3870. Prepared for Nelson City Council.

Sneddon R, Newcombe E, Dunmore R, Peacock L. 2014. Motueka wastewater treatment plant: baseline study and water quality assessment for proposed marine outfall. Nelson: Cawthron Institute. Cawthron Report No. 2620. Prepared for Tasman District Council.

Stapleton CM, Kay D, Jackson GF, Wyer MD. 2000. Estimated inorganic nutrient inputs to the coastal waters of Jersey from catchment and waste water sources. Water Research. 34(3):787–796.

Stapleton CM, Kay D, Magill SH, Wyer MD, Davies C, Watkins J, Kay C, McDonald AT, Crowther J. 2011. Quantitative microbial source apportionment as a tool in aiding the identification of microbial risk factors in shellfish harvesting waters: the Loch Etive case study. Aquaculture Research. 42:1–20.

Water New Zealand. 2020. Wet weather overflows per 1000 connections to the wastewater network. https://www.waternz.org.nz/ModularPage?Action=View&ModularPage_id=89

Zeldis JR, Swaney DP. 2018. Balance of catchment and offshore nutrient loading and biogeochemical response in four New Zealand coastal systems: implications for resource management. Estuaries and Coasts. 41:2240–2259.

8. APPENDICES

Appendix 1. Total area and percentage cover of land-use categories within the 27 freshwater management units in the Nelson catchment.

River catchment	FMU	Area (ha)	Percent cover								
			EF	H	HPEG	LPG	OEV	NV	R/L	U	O
Haven	Akersten Street	14.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
Haven	Atawhai	13.8	65.8	0.0	4.4	12.1	0.0	0.0	0.0	17.7	0.0
Haven	Bayview	23.3	0.0	0.0	10.8	2.3	47.8	0.0	0.0	39.2	0.0
Coastal	Boulder Bank	46.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Maitai	Brook Stream	1,755.1	15.3	0.0	4.1	2.5	7.2	64.5	0.0	5.5	0.9
Haven	Brooklands	40.8	4.4	0.0	14.9	18.9	33.0	0.0	0.0	28.9	0.0
Haven	Cemetery	12.2	33.2	0.0	4.7	0.0	0.0	0.0	0.0	62.1	0.0
Haulashore Is.	Haulashore Is.	5.7	59.4	0.0	0.0	40.6	0.0	0.0	0.0	0.0	0.0
Hillwood	Hillwood Stream	1,466.0	11.5	0.3	45.0	3.8	9.7	23.2	2.8	0.9	2.8
Maitai	Maitai River	7,454.9	28.5	0.0	1.7	0.9	5.7	57.1	0.5	4.6	0.9
Haven	Malvern	57.8	9.5	0.0	0.6	5.5	28.4	0.0	0.0	56.0	0.0
Haven	Marybank	165.3	4.1	1.4	45.9	0.0	2.5	10.8	0.4	34.8	0.1
Haven	Neale Park	63.7	14.3	0.0	11.6	0.0	8.2	0.0	0.0	66.0	0.0
Haven	Oldham Creek	360.6	9.0	0.0	17.2	4.7	9.7	43.8	0.0	15.7	0.0
Haven	Ruffell Place	27.6	2.5	0.0	14.0	43.1	9.9	0.0	0.0	30.5	0.0
Haven	Russell Street	36.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
Haven	Sealords	8.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
Coastal	The Cliffs	28.1	0.0	0.0	0.0	0.0	0.0	0.3	0.0	99.7	0.0
Haven	The Port	8.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
Haven	The Wood	44.7	0.0	0.0	0.0	0.0	0.0	0.0	0.1	99.9	0.0
Haven	Todd Valley Stream	571.5	8.6	0.6	22.1	1.2	15.6	41.3	0.1	6.5	4.2
Coastal	Tui Glen	11.5	0.0	0.0	0.0	0.0	0.0	14.8	0.0	85.2	0.0
Haven	Vickerman Street	13.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
Haven	Victoria Road	6.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
Haven	Wakefield Quay	16.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
Haven	Walters Bluff	52.4	15.2	0.0	2.8	1.1	20.1	0.0	0.0	60.9	0.0
Maitai	York Stream	712.1	11.9	0.0	7.7	1.2	13.0	9.0	0.0	56.0	1.2

FMU: freshwater management unit; EF: exotic forest; H: horticulture; HPEG: high-producing exotic grassland; LPG: low-producing grassland; OEV: other exotic vegetation; NV: native vegetation; R/L: river or lake; U: urban; O: other.