Ravensdown Napier discharge consent - Assessment of Estuarine Ecological Effects

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Executive Summary

Potential effects covered

The potential effects of the current Ravensdown Napier discharge on the receiving environment have been summarised. Consideration was given to effects on a range of water quality parameters (including nutrients, metals and various physico-chemical properties), as well as process chemicals associated with the operations of the facility. Effects on marine ecology were also considered and included assessment of benthic macroinvertebrates, fish and macrophytes (past and present studies), as well as ecotoxicology of the whole effluent (WETT or Whole Effluent Toxicity Testing) following rainfall events.

Ravensdown has prepared a Water Discharge Strategy which underpins management of stormwater and process water on site. Effects of predicted discharge quality following staged installation of treatment devices proposed as part of this strategy are assessed and considered for different tidal stages. Effects associated with application to land are not included in our assessment.

Assessments undertaken

Potential effects on current and future water quality were assessed by comparison with relevant guidelines and standards, as well as consideration of upstream water quality and its influence on water quality downstream of the discharge (such as the HBRC-controlled pump and upstream industries such as BioRich). Trends over time in current discharge quality were also considered. Where available, we used predicted discharge quality following proposed treatment to derive receiving environment concentrations under high and low tide scenarios, taking into account dilutions determined from a dye study undertaken in 2020. Predicted receiving environment concentrations were then compared with a) receiving environment concentrations derived from discharge quality targets proposed by Ravensdown Napier and b) other relevant guidelines (including those defined by the National Policy Statement on Freshwater Management (2020), the Hawkes Bay Regional Council Coastal Plan and Plan Change 9 TANK (Tūtaekurī, Ahuriri, Ngaruroro, Karamu) Catchment Plan. Where predicted concentrations, or other values of water quality parameters needing to be assessed against guidelines and standards were not available, we used monitoring data from the previous 5 years to assess compliance.

Potential effects associated specifically with process chemical formulations in the current discharge were assessed by undertaking an ecological risk assessment. This approach was necessary as most of these chemicals are not generally able to be directly measured. Taking into account dilutions achieved in the mixing zone and consideration of tidal influence, measures of risk (risk quotients) were derived based on potential ecotoxicological effects, propensity to persist and/or bioaccumulate for each component chemical within a process chemical formulation.

Potential effects on marine ecology of the current discharge were assessed using the EIANZ guidelines for undertaking ecological impact assessments (Roper-Lindsay et al., 2018), which have been adapted for marine ecosystems. This method involved assigning ecological values based on threat classification and marine ecology value characteristics, and then identifying the magnitude of any effects in order to determine the overall level of effect of the proposal. The assessment considered the ecological value defined from past and current ecological assessments, along with receiving environment quality and ecotoxicological studies to determine overall effects. An assessment of the effects of the proposed discharge quality on marine ecology considered the potential response to improvements in water quality.

Results of assessments

Water quality monitoring indicates that the current Ravensdown Napier discharge is likely to be contributing concentrations of nickel, copper and aluminium to the receiving environment at levels above effects guidelines, with localised increases in concentrations during wet weather events. The results of the dye study indicated limited mixing within the Awatoto Channel, even under an outgoing tide. Significant improvement in water quality is predicted following the introduction of treatment devices in conjunction with the overall discharge management strategy. While this treatment is predicted to reduce both loads and concentrations of most contaminants, concentrations of some contaminants in the receiving environment, in particular aluminium and ammoniacal nitrogen, are predicted to continue to exceed guidelines. Higher upstream concentrations of some contaminants (when compared with downstream of the discharge) means Ravensdown Napier has no ability to meet these guidelines in isolation from other contributions. Despite these exceedances, there is no evidence to indicate that the discharge is having more than a minor effect on ecological values beyond the mixing zone. The improvement in water quality is likely to have a positive effect on the existing low ecological values.

Suggested approach for effects identified

Continued monitoring of the discharge at the frequency defined in the current consent conditions is recommended, with an extended set of parameters to allow for monitoring against compliance with the discharge targets.

Ravensdown Napier has an established monitoring programme which is designed to characterise ambient and rainfall-affected receiving environment quality. In addition, 5 yearly ecological assessments are undertaken to determine potential changes in benthic communities, sediment composition and quality, as well as ecotoxicity associated with the Ravensdown Napier discharge. A robust data set has been compiled since this monitoring was initiated, providing a valuable resource for assessing trends. It is recommended that this monitoring continue for the duration of the consent. Based on our assessment of the relevant regulatory standards, the following changes to the monitoring programme are recommended:

- Chlorophyll *a* determination – use an appropriate analytical method with a reduced detection limit to 0.001 mg/L to allow comparison with the relevant guideline.
- Add clarity measurements to the monitoring programme.
- If it is considered necessary to calculate Fish IBI, then fish monitoring would need to be added to the 5 yearly monitoring programme.

It is also recommended that the timing of the receiving environment monitoring be linked to the staging of the implementation of the treatment devices and the overall water discharge strategy.

While the proposed treatment will substantially reduce the loads and concentrations of a range of water quality parameters in the discharge and receiving environment, it is evident that tidal state is a significant factor in minimising adverse ecological effects. It is therefore recommended that, when discharge to water is necessary, it be undertaken preferentially on the ebbing tide. This recommendation is consistent with the proposed discharge strategy.

There may be potential to restore the ecological values to some extent through improved discharge water quality. As part of its discharge strategy, Ravensdown has proposed a Habitat Abundance Restoration Project (HARP) within an identified area of the Waitangi Estuary. All contributing activities (including other point and diffuse source discharges upstream of Ravensdown Napier's facility) would need to be considered to address the cumulative effects to be able to restore ecological values across the whole receiving environment. Streamlined Environmental will also provide advice to Ravensdown on the proposal for the Waitangi Estuary Habitat Abundance Restoration Project (HARP).

1. Introduction

1.1 Background to the project

Ravensdown Limited (Ravensdown) operates a fertiliser manufacturing plant at Awatoto, near Napier. Ravensdown holds a number of permits to enable operation of the plant, including a consent to discharge contaminants into water, with the receiving environment being the Tūtaekurī River and the associated Waitangi Estuary. This resource consent (DP040143Wa) expires on 31 May 2022. Ravensdown is preparing an application to renew this consent.

Streamlined Environmental Ltd (SEL), in partnership with Boffa Miskell Ltd (BML), was commissioned to provide technical expertise for the reconsenting process on the matters of water quality and aquatic ecology. An initial review of available information on the current state and effects of discharges arising from the Awatoto facility (Phillips et. al, 2020) identified additional information needs required to support a discharge consent application. A subsequent baseline information report was prepared (Phillips et al., 2021).

2. Scope of this report

This report presents an overall assessment of the potential ecological effects of the discharge of treated stormwater and process water from the Ravensdown Napier facility on the receiving environments (which includes the Ravensdown and Awatoto Drains, Tūtaekurī Blind Arm and River and the wider Waitangi Estuary).

This ecological assessment provides:

- A summary of the discharge quality;
- A summary of the receiving environment water quality and ecological resources;
- A description of the effects of the future discharge of treated stormwater and process water on the receiving environment and an outline of a monitoring programme.

This assessment does not consider the effects of discharge to land via spray irrigation, which is the subject of a separate report.

3. Description of the existing discharge

3.1 Location and general physical characteristics of the discharge

The discharge from the Ravensdown Napier Works is comprised of both stormwater and process water, and also receives truck wash runoff from the adjacent Sandfords distribution facility via the Ravensdown collection system. Stormwater and process water are collected in a drain system and diverted to a sump, where they can be pumped to a storage pool or to a settling pond. Stormwater collected from around the site accumulates in the Archimedes basin. Here the water is monitored and adjustments made to ensure the pH is between 6.5 and 8.5 (the existing consent limits) before entering a settling pond from which it is discharged (**Figure 1**). Discharge from the settling pond is controlled by the activation of two pumps, one used during baseflow conditions (up to 20 L/s) and the other also utilised during storm condition events (up to 200 L/s).

Figure 1. Stormwater drain adjacent to the Ravensdown facility (left), settling pond (upper right) and discharge pipe to Ravensdown Drain (lower right).

The receiving environment for the Ravensdown discharge is a series of drains that lead to the Tūtaekurī River, and ultimately the Waitangi Estuary (which have been identified as outstanding waterbodies under Proposed Plan Change 7[1]) (**Figure 2**). The discharge from the Ravensdown settling pond enters the Ravensdown Drain (**Figure 3**). Ravensdown Drain is approximately 2-3 m in width and 80 m in length, is grassed to the drain edge and is unshaded. Downstream the Ravensdown Drain discharges into the Awatoto Drain. The mixing zone encompasses the Ravensdown Drain and 90 m of the Awatoto Drain and has a total length of around 170 m. The Awatoto Drain is fed from upstream of the Ravensdown discharge point by the Waitangi Drain, Ravensdown Drain and the Mission Drain (**Figure 3**). Upstream of the Awatoto Drain is a pump station, occurring at the confluence of the Waitangi and Mission Drains. The pump station is operated by Hawke's Bay Regional Council and discharges into the Awatoto Drain when water levels are elevated, with discharge into the Awatoto drain equating to 0, 250, 900, or 1800 L/s at any one time.

[1] Decisions on first instance hearing pending.

Figure 2. Map showing location of Ravensdown Napier facilities and the receiving environment, surrounding land use and relevant features.

Figure 3. Waitangi Drain upstream/adjacent to the Ravensdown facility (upper), confluence of Mission Drain and Awatoto Drain with HBRC pump station and stop bank visible (lower left) and Awatoto Drain downstream of the stop bank (lower right).

3.2 Discharge quality

Ravensdown undertakes weekly and 6 monthly compliance monitoring of the quality of its discharge, with samples analysed for pH, total suspended solids (TSS), fluoride, sulphur, total phosphorus (TP) and soluble reactive phosphorus (SRP). In addition, 6 monthly flow-proportional composite sampling (over a period of 1 week) is also undertaken for total metals (copper, zinc, cadmium, chromium, aluminium, and sulphur). Discharge consent limits are set for the following parameters:

- pH to be between 6.5 and 8.5.
- Fluoride not to exceed 30 mg/L.
- TSS not to exceed 100 mg/L.
- Rate of discharge not to exceed 265 L/sec.
- TP over a 12 month period not to exceed 22 mg/L for more than 99% of the time or 17 mg/L for more than 95% of the time.
- SRP over a 12 month period not to exceed 20 mg/L for more than 99% of the time or 15 mg/L for more than 95% of the time.

Very high compliance has been recorded since 2012 for flow (100% compliance), pH (94% compliance), TSS (100% compliance), and fluoride (100% compliance) in the discharge. Very high compliance has also generally been observed for SRP and TP limits, excluding 2013 – 2014 (SRP, 95% limit; TP, 95% and 99% limit) and 2017-2018 (SRP, 95% limit), where exceedances were greater than allowable.

Analysis of trends in discharge quality between 2007 and 2020 (**Table 8**) indicates decreasing trends in concentrations of copper, fluoride, SRP, TP and TSS in the discharge that are meaningful (being statistically significant ($P<0.05$) and having greater than 1% change per year) (Phillips et al., 2021). A meaningful increasing trend in discharge flow (5.5% annually) reflects the recent change in practice of adding bore water directly to the settling pond as part of the dilution process. A significant increasing pH trend has also been observed, but this has not been meaningful (0.2% annual increase) and pH is still well within current consent limits.

Table 1 Summary of trend analysis results for parameters measured in the Ravensdown discharge. Significant trend arrows are in bold (non-significant trends are not bold); significant and meaningful increasing trends are highlighted in red and significant and meaningful decreasing trends are highlighted in blue.

Parameter	Median value	P	Mean annual Sen slope	RSKSE (%)	Trend
Copper (mg/L)	0.010	0.01	-0.001	-10.0	**↓**
Zinc (mg/L)	0.048	0.29	-0.001	-2.1	↓
Cadmium (mg/L)	0.001	0.02	<0.001	0.0	**→**
Chromium (mg/L)	0.006	0.22	<0.001	0.0	→
Aluminium (mg/L)	0.232	0.22	0.01	4.3	↑

Parameter	Median value	P	Mean annual Sen slope	RSKSE (%)	Trend
Sulphur (mg/L)	84.66	0.06	-3.777	-4.5	↓
Flow (L/s)	2.697	<0.001	0.149	5.5	🡅
pH	7.19	0.02	0.011	0.2	🡅
Fluoride (mg/L)	4.04	<0.001	-0.241	-6.0	🡇
SRP (mg/L)	7.778	<0.001	-0.54	-6.9	🡇
TP (mg/L)	8.99	<0.001	-0.754	-8.4	🡇
TSS (mg/L)	6.9	<0.001	-0.323	-4.7	🡇

4. Description of the receiving environment and effects of existing discharge

4.1 Physical setting

Catchments of Awatoto and Waitangi Drains comprise a mixture of agriculture, commercial, industrial and urban landuses and therefore the water quality, sediment quality and ecology are influenced by the contaminants from those landuses as well as the Ravensdown discharge. The Mission Drain captures runoff from both industrial and agricultural landuses, including orchards and an open compost and green waste facility (BioRich, **Figure 4**). Water quality in the Mission Drain will be influenced by contaminants originating from all of these landuses. The Awatoto Drain discharges to the Blind Arm of the Tūtaekurī River some 150 m downstream from the confluence of the Ravensdown Drain and the mouth of the Awatoto Drain. The discharge then enters the Waitangi estuary via the Tūtaekurī River (see Figure 2).

Figure 4. Biorich facility at confluence of Waitangi and Mission Drains.

4.2 Water quality – discharge and receiving environment

4.2.1 General introduction

As part of its discharge consent, Ravensdown collects monthly water quality samples from sites upstream and downstream of the discharge point to characterise ambient receiving environment water quality. These samples are analysed for nutrients, metals/metalloids and a range of other physico-chemical parameters. Six-monthly (summer and winter) rainfall-event related samples are also required to be collected and analysed for a similar suite of parameters. The location of ambient and rainfall sampling sites is illustrated in **Figure 5**.

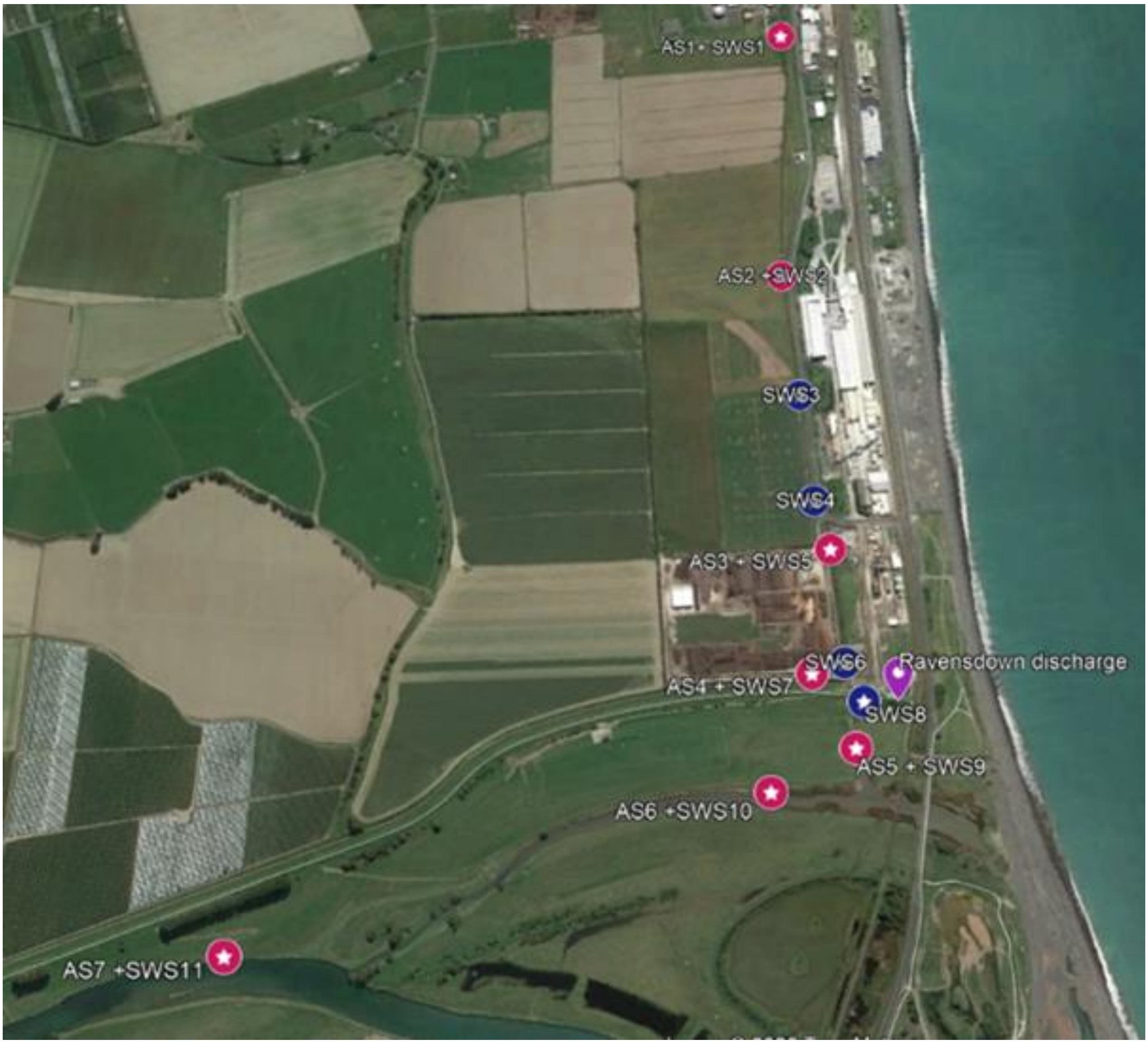


Figure 5. Locations of water quality monitoring sites determined by Strong (2013). Red stars are ambient (AS) and rainfall (SWS) sampling sites. Blue stars are rainfall only sampling sites. The purple marker is the location of the Ravensdown discharge point.

4.2.2 Previous studies

Water quality sampling dating back to the early 1990s has been undertaken to characterise receiving environment water quality and potential ecological effects associated with the Ravensdown Napier discharge and these studies were succinctly summarised in Smith (2013). He reports that these studies generally conclude that the discharge appears to have a localised effect of increased contaminant concentrations in the Ravensdown and Awatoto drains, but that the blind arm of the Tūtaekurī River is relatively unaffected, except for elevated levels of phosphorus.

More recently collected data from 2013 and 2019 are reported in Death & Ekelund (2019). A summary of these studies is presented below.

Under ambient conditions:

- Nickel, copper and aluminium concentrations were higher in the mixing zone when compared with upstream or downstream sites. Nickel concentrations were below the ANZG (2018) 95% guideline value at all sites, whereas copper concentrations just exceeded the guideline at sites downstream of the discharge on the Awatoto Drain, although sites on the mainstem of the Tūtaekurī River were well below the ANZG (2018) trigger value for copper. Total aluminium concentrations exceeded ANZG (2018) trigger values (95% protection level) at all sites upstream and downstream of the discharge except in the mainstem of the Tūtaekurī River.
- Cadmium concentrations were much higher upstream of the discharge (including the Waitangi and Mission Drains), but were below the ANZG (2018) 95% trigger value at all sites.
- Chromium concentrations were similar across all sites in the Awatoto and Mission Drains, decreasing considerably in the mainstem of the Tūtaekurī River. Concentrations exceeded the ANZG (2018) trigger values (95% protection level) at all sites.
- Zinc concentrations were higher at sites upstream of the discharge when compared with downstream. Upstream sites exceeded the ANZG (2018) trigger value (80% protection level), whereas sites downstream (other than the mainstem of the Tūtaekurī River) exceeded the trigger value for 95% protection.
- Fluoride concentrations were highest in Mission Drain upstream of the discharge, decreasing through the mixing zone to the lowest concentrations in the mainstem of the Tūtaekurī River. Fluoride concentrations downstream of the discharge point have generally been below the guideline of 5 mg/L for protection of 95% of species developed by Hickey et al. (2004) for high salinity (25-35 psu) waters and which is applied here in the absence of any other guideline.
- Sulphur concentrations were highest at sites upstream of the discharge. There are no ANZG (2018) trigger values for sulphur.
- Nitrate concentrations were generally higher upstream of the discharge, with sites downstream of the discharge generally being in the NPS-FM (2020) A or B band for nitrate toxicity.
- Total ammoniacal nitrogen and total nitrogen concentrations were generally comparable between sites and exceeded the ANZG (95% protection level) trigger value at all sites other than the mainstem of the Tūtaekurī River.

- Nitrite concentrations were slightly higher within the mixing zone when compared with upstream or downstream sites.
- Phosphorus (total and soluble) concentrations were highest in the Waitangi Drain upstream of the discharge and exceeded ANZG (2018) 95% trigger values at all sites other than on the mainstem of the Tūtaekurī River.
- TSS was highest upstream of the discharge and lowest further downstream in the Tūtaekurī River, indicating that the Ravensdown discharge is not a significant source.
- Chlorophyll *a* concentration decreased downstream indicating the Ravensdown discharge is less likely to be contributing to increased algal growth in the Tūtaekurī River or wider Waitangi Estuary than upstream sites.
- Water pH, temperature and DO did not differ significantly between sites along the Awatoto Drain upstream and downstream of the discharge. In contrast, conductivity and salinity were much lower at AS7 (salinity = 0.1 ppt), indicating that this site is predominantly influenced by upstream Tūtaekurī River water. All other sites recorded salinity measurements were indicative of brackish water.
- Collectively these results indicated inputs from the Ravensdown discharge in terms of nickel, copper and aluminium.

Under rainfall conditions:

- Water quality sampling during rainfall events provided generally similar conclusions to those from the ambient sampling. However, the concentrations of some metals were higher and exceeded the ANZG trigger values.
    - Highest median aluminium concentrations were recorded upstream of the discharge. All sites exceeded the ANZG (2018) trigger value (95% protection level).
    - Cadmium and nickel concentrations within the mixing zone were higher than upstream. Cadmium exceeded the ANZG (2018) trigger value (95% protection level), while nickel concentrations were below the relevant trigger value.
    - The ANZG (2018) trigger values for chromium, copper, and zinc was exceeded at all but the furthest downstream site (SWS11).
- Both fluoride and sulphur were elevated in the mixing zone in comparison to upstream or downstream sites, although more recent sampling (2015-2019) reported reduced concentrations.
- Ammoniacal nitrogen, total nitrogen and SIN (Soluble Inorganic Nitrogen) were considerably elevated within the mixing zone and in the Tūtaekurī Blind Arm, when compared with upstream or downstream sites. More recent sampling (2015-2019) reported reduced concentrations. The ANZG (2018) trigger values (95% protection level) for ammoniacal nitrogen and total nitrogen were exceeded at all sites.
- Nitrate concentrations were generally comparable between sites and would generally meet the NPS-FM National Bottom Line for nitrate toxicity.
- Both TP and SRP were considerably elevated in the mixing zone and Tūtaekurī Blind Arm, when compared to upstream and downstream sites. The ANZG (2018) trigger value (95% protection level) was exceeded at all sites.
- TSS, pH, temperature and DO were comparable across all sites, whereas conductivity and salinity were more variable, both between sites and between years, most likely reflecting the extent of the rainfall prior to collection of the water quality samples.

Death & Ekelund (2019) concluded that the Ravensdown Napier discharge was having a localised effect on contaminant concentrations downstream during wet weather events, but that this effect dissipates with increasing distance from the discharge, due to dilution with river water.

4.2.3 Recent studies

Analysis of trends in the receiving environment under ambient and rainfall conditions was undertaken to identify any significant changes in the water quality of the receiving environment (Phillips et al., 2020). Trends were analysed between 2012 and 2020 for ambient water quality data and between 2014 and 2019 for rainfall water quality data. Trends were categorised as having no significant change (the trend is not statistically significant at $p < 0.05$), significant increase or decrease (the trend is statistically significant at $p < 0.05$) or significant and meaningful increase or decrease (the trend is statistically significant at $p < 0.05$ and there is a greater than 1% change in the magnitude of the trend each year (as defined by Scarsbrook, 2006).

A visual summary of results is presented in **Figure 6** to **Figure 10**. Only water quality parameters where at least 1 significant and meaningful result was obtained are presented.

Under ambient conditions, sulphur and fluoride concentrations are showing increasing trends at some upstream sites but are decreasing (albeit not significantly) downstream of the discharge (**Figure 6**). This indicates that the discharge is unlikely to be contributing to the increasing (non-significant) trend at the site in the Tūtaekurī Blind Arm. It is also evident that aluminium concentrations are generally decreasing or remaining unchanged at most sites.

Figure 6. Trends in sulphur, fluoride and aluminium concentrations under ambient conditions at sites upstream and downstream of the Ravensdown discharge point.

Under ambient conditions, significant and meaningful trends were observed for all nutrients at upstream sites AS1 and for SRP and TP and sites AS2 and AS3 (**Figure 7**). Decreasing but non-significant trends in nutrient concentrations is evident at all sites, other than on the mainstem of the Tūtaekurī River. At this site TN shows a non-significant increasing trend, with all other sites showing no change in concentration over time.

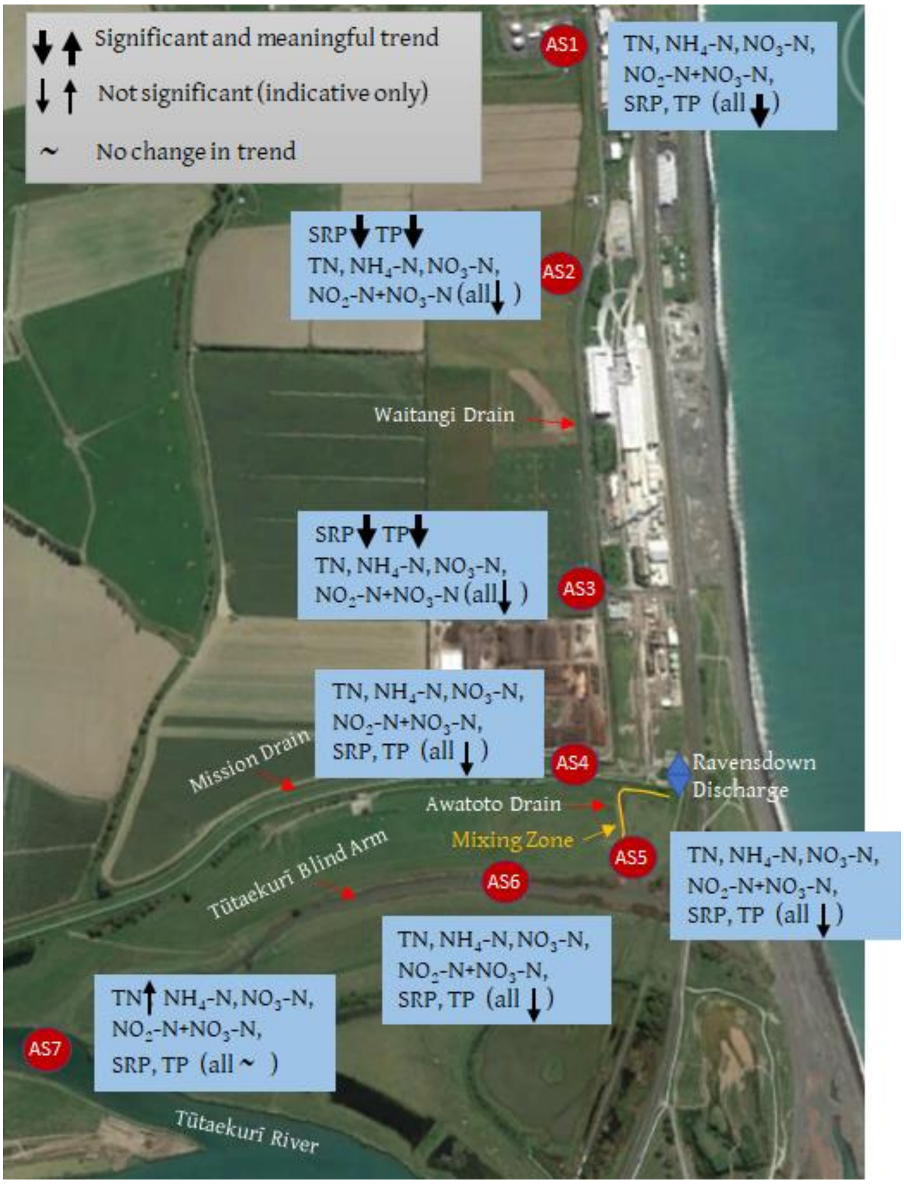


Figure 7. Trends in nutrient concentrations under ambient conditions at sites upstream and downstream of the Ravensdown discharge point.

Under ambient conditions, significant and meaningful increasing trends in conductivity were observed at some upstream sites (AS2 and AS3), while significant and meaningfully decreasing trends were observed at sites AS1 and AS6 (**Figure 8**). For salinity, a significant and meaningful decrease was observed at one upstream site (AS1), as well as at AS5 and AS6 downstream of the discharge. A significant and meaningful increase was observed at the upstream site AS2.

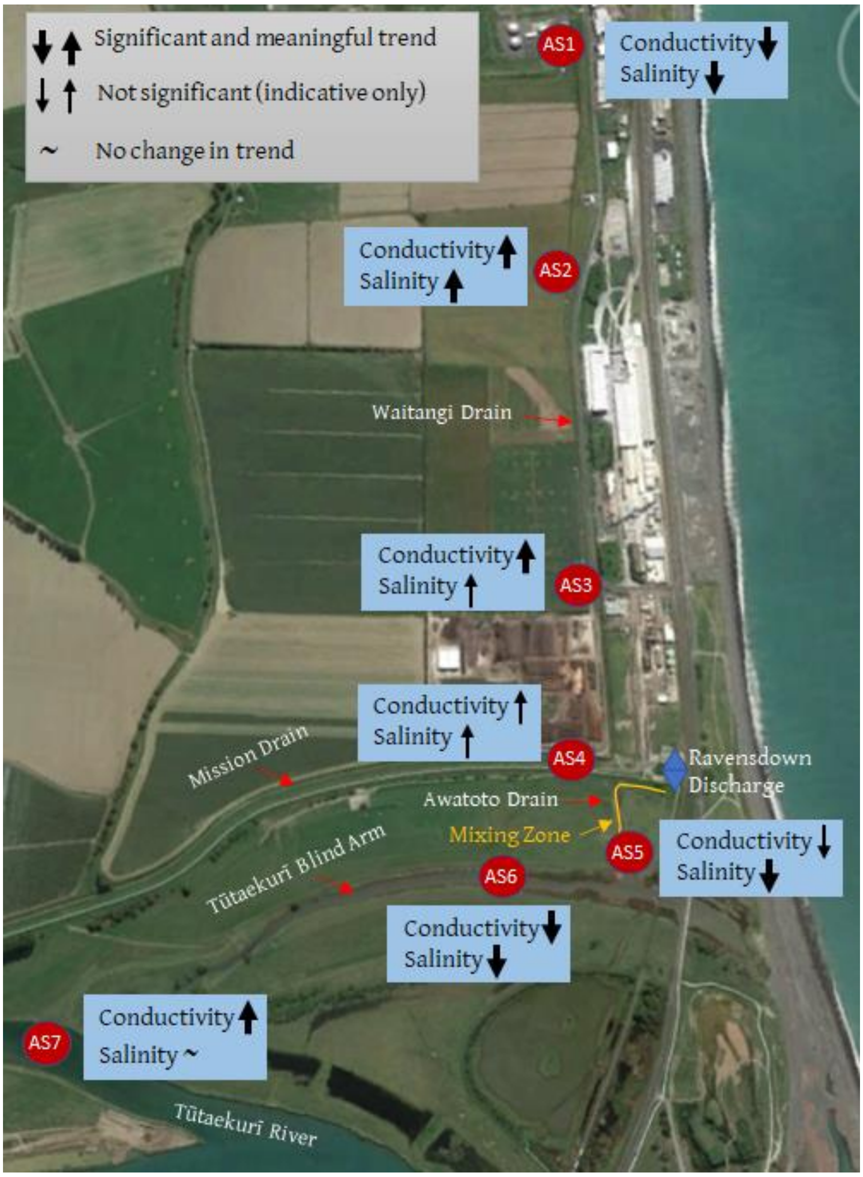


Figure 8. Trends in conductivity and salinity under ambient conditions at sites upstream and downstream of the Ravensdown discharge point.

Under rainfall sampling conditions, the only significant and meaningful trend for trace metals and elements was an increasing trend in fluoride concentrations, occurring at sites SWS2, SWS3, and SWS5, upstream of the Ravensdown discharge (**Figure 9**). Concentrations of fluoride have generally increased (though not significantly) at sites upstream of the discharge (other than the Mission Drain) and downstream of the discharge (other than on the mainstem of the Tūtaekurī River, where there has been no overall change).

Figure 9. Trends in fluoride concentrations under rainfall conditions at sites upstream and downstream of the Ravensdown discharge point.

Under rainfall conditions, the only nutrient that showed a significant and meaningful increasing trend was ammoniacal nitrogen, with this trend being observed only at sites SWS5 and SWS6, both upstream of the discharge (**Figure 10**). Concentrations of ammoniacal nitrogen have generally increased (though not significantly) at sites upstream of the discharge and decreased at sites downstream of the discharge, other than on the mainstem of the Tūtaekurī River, where there has been no overall change. There are likely to be multiple upstream sources of these elevated concentrations.

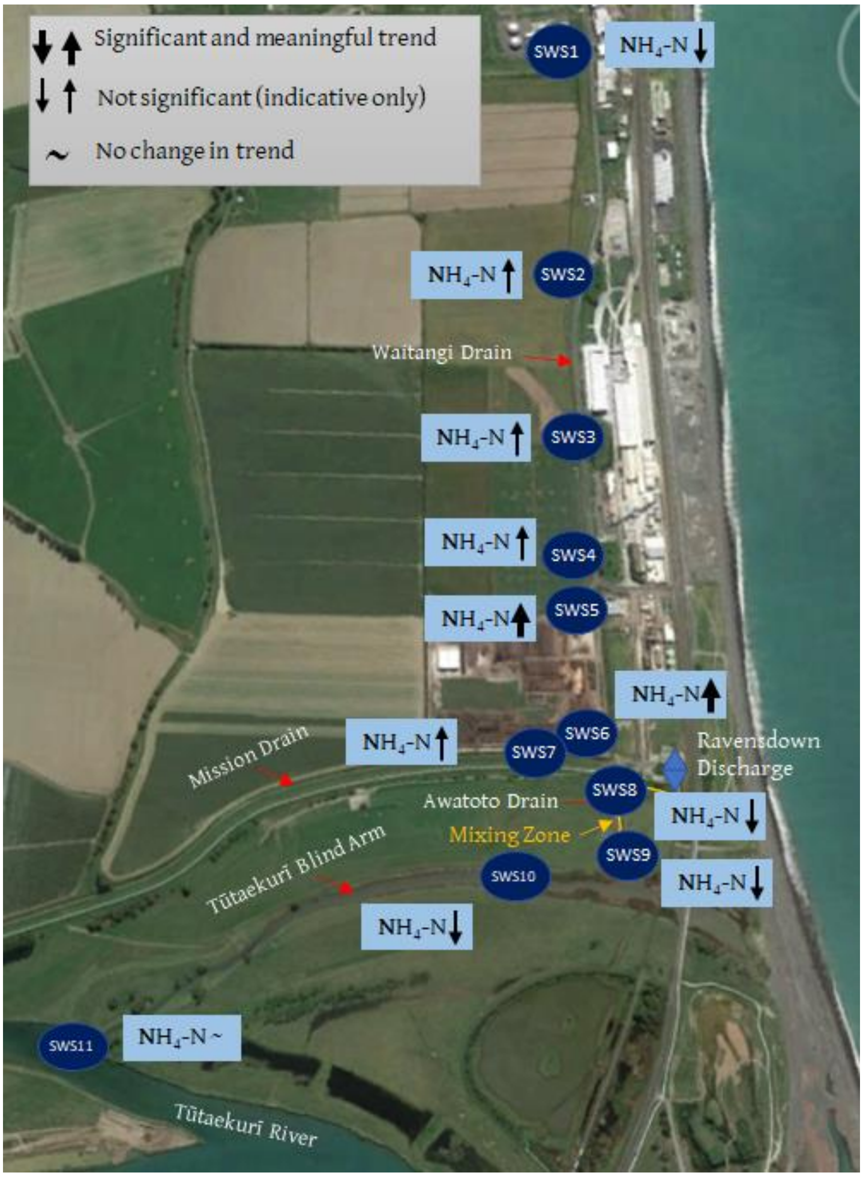


Figure 10. Trends in ammoniacal nitrogen concentrations under rainfall conditions at sites upstream and downstream of the Ravensdown discharge point.

4.3 Water quality – Dilutions in the receiving environment

It was necessary for us to quantify the dilutions achieved in the mixing zone under base flow conditions during different tidal cycles. These dilutions were then used to assess potential ecological risks associated with process chemicals present in the discharge (**Section 4.4**). The dilutions were also used to compare with ecotoxicity results (**Section 4.5**) and was also used in determining discharge and receiving environment concentrations of a range of water quality parameters following installation of proposed treatment devices (**Section 5.1**).

The approach we used was to discharge a known concentration of fluorescent dye (rhodamine) from the Ravensdown Napier settling pond and track its progress to the boundary of the mixing zone in the Awatoto Drain, measuring the concentration at specific locations within the drain. This was undertaken during different tidal cycles.

4.3.1 Previous studies

Dye studies were undertaken in 1992 and 2006 by Bioresearches (reported in Bioresearches, 2006).

Both studies used a similar approach and collected samples at generally comparable locations, although greater intensity of sampling occurred at some sites in 2006. The dye study was conducted over 2 days in both studies, during a falling and a rising tide. The Bioresearches (2006) study was undertaken under low Tūtaekurī River flow conditions, which were identified as a worst case scenario.

The 1992 dye study indicated that dilutions were highly variable in Waitangi Drain with dilutions at a site just inside the mixing zone boundary ranging from 3.9-fold to 1111-fold, and dilutions at a site just outside the mixing zone boundary ranging from 256-fold to 10,000-fold. Dilutions in the Tūtaekurī Blind Arm were also variable and ranged from 159-fold to 10,000-fold.

The Bioresearches (2006) dye study reported that the concentrations of dye were highest along the eastern side of the Awatoto/Waitangi Drain and that dilution was rapid as the discharge entered the Tūtaekurī Blind Arm. Dilutions in the Tūtaekurī Blind Arm ranged from 344-fold to >100,000-fold, with a mean of 58,000-fold.

4.3.2 Recent studies

Phillips et al. (2021) report on a dye study undertaken by SEL between 29th March 2021 to 31st March 2021 under HBRC resource consent AUTH-126648-01. The general approach was for the dye to be pre-mixed, added to the settling pond, and allowed to mix before being discharged to the Awatoto Drain. Full methodology is provided in Phillips et al. (2021) and summarised below. Two discharge mixing scenarios were investigated, namely around 1 hour prior to low tide and around 1 hour prior to high tide.

Samples were collected at 7 sampling points of 15 m intervals down the Awatoto Drain from 0-90m corresponding with the mixing zone as defined in the existing consent. Sampling points commenced at the confluence of the Ravensdown Drain and the Awatoto Drain (0m - A1) and ended at the approximate boundary of the current mixing zone (90m - A7) (**Figure 11**). Samples were taken from the middle of the channel using a 'Mighty Gripper' sampling pole, with surface and sub-surface (500 mm depth) samples also being collected under the high tide scenario. The dilution is calculated as the dye concentration of the pond (taken at the time of discharge starting) divided by the concentration at each sample point.

Figure 11. Location of Ravensdown settling pond and discharge, Ravensdown Drain, sampling points (A1-A7) along Awatoto Drain, and the Blind Arm of the Tūtaekurī River. The end of the current consented mixing zone is shown by the blue line.

Results

Dilutions for the low tide and high tide scenarios are presented in **Figure 12** and **Figure 13**, respectively.

In Run 1 of the low tide scenario (**Figure 12**), dilutions ranged from 4.2-fold at A1 to 17.8-fold at A4, with an average dilution of 11.5-fold. At A7 (mixing zone boundary) the dilution was 8.4-fold. In Run 2 the dilutions were less variable across the sampling points ranging from 1.7-fold (A2) to 2.8-fold (A7) (**Figure 12**).

Dilutions for the high tide scenario (**Figure 13**) show that the majority of the discharge travels at the surface with minimal or non-existent vertical mixing to the sub-surface. Even after 2 hours of discharge there was still not complete mixing. This is consistent with the Bioresearches (2006) dye study, who found that at some sites sub-surface dye concentrations were higher than surface concentrations. They also found relatively little dilution between the discharge point and the Tutaekuri Blind Arm, with rapid dilution occurring as it entered the Arm. During Run 1 dilutions ranged from 5.6-fold (A3) to 14.9-fold (A7) at the surface, with an average dilution of 10.1-fold. During Run 2 dilutions at the surface ranged from 2.1-fold (A1) to 4.9-fold (A7), with an average of 3.2-fold. Conversely, for subsurface samples, during Run 1, there was no evidence of dye present at 6 out of the 7 sampling points, with dye concentrations of <1.0 µg/L. Minor vertical mixing occurred at A3, with a subsurface dilution of 64-fold (**Figure 13**). During Run 2 there was further evidence that vertical mixing was more apparent, with subsurface dilutions of between 51-fold and 114-fold between A1 and A3. From A4-A7, there was no evidence of vertical dye mixing with all dye concentrations <1.0 µg/L (**Figure 13**).

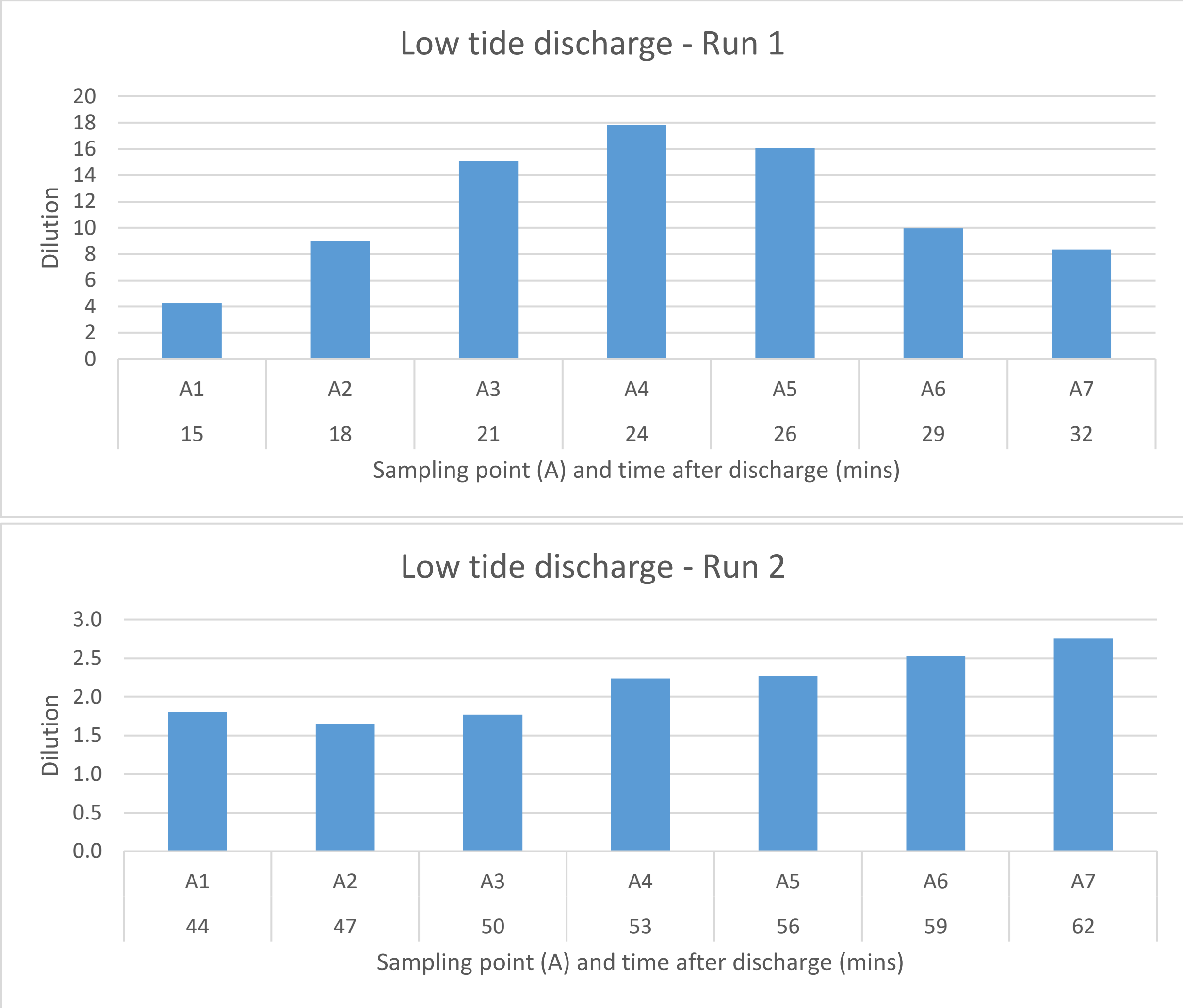
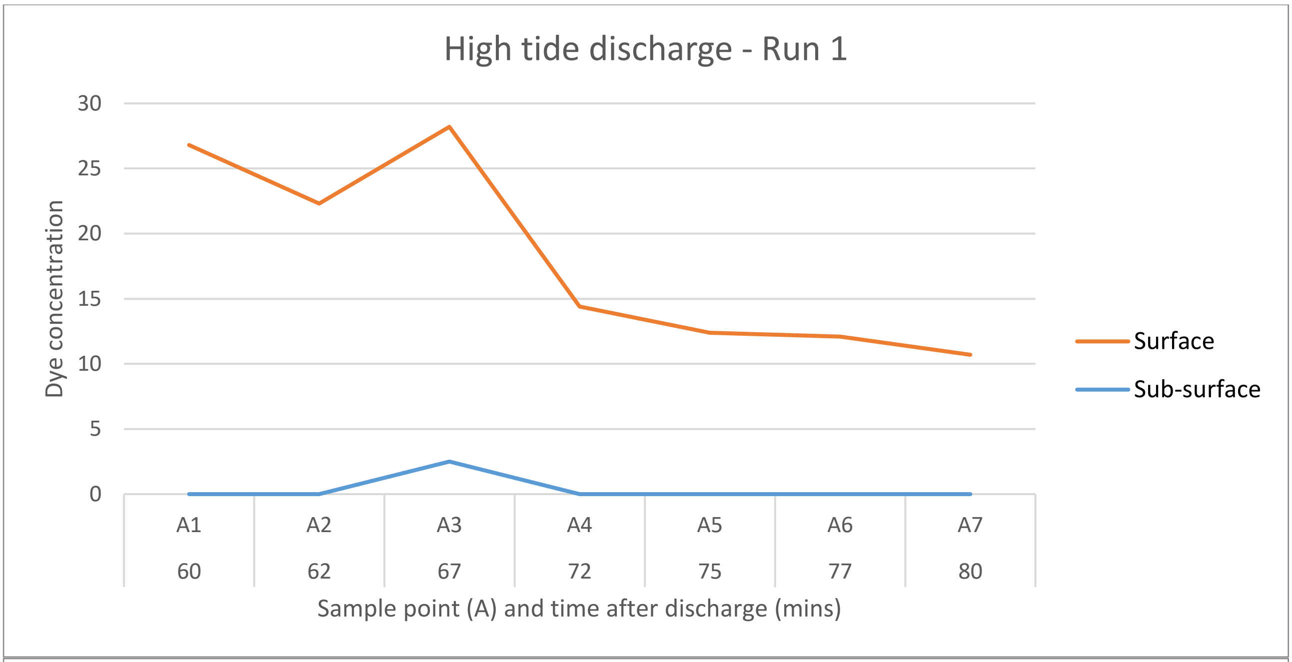


Figure 12. Dilutions of Run 1 (top) and Run 2 (bottom) at sampling points A1 to A7 in the Awatoto Drain at time after discharge for low tide scenario.



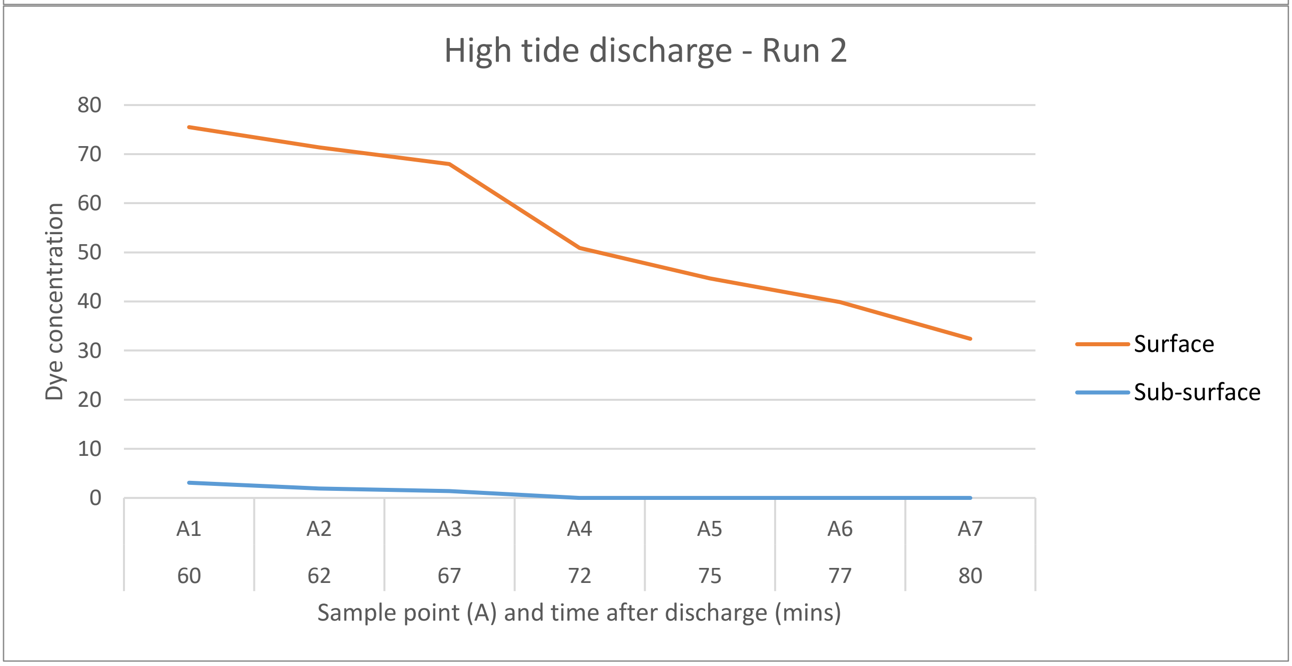


Figure 13. Dye concentration (µg/L) at sampling points A1 to A7 in the Awatoto Drain at time after discharge for high tide scenario.

<u>Summary</u>

The dye study provided dilutions at the mixing zone boundary under low tide and high tide scenarios. Under the low tide scenario, the discharge plume was well mixed, over time dilutions reduced and stabilised and after 62 minutes of continuous discharge the dilution at the mixing zone boundary (A7) was 2.8-fold. Under the high tide discharge scenario, the discharge plume tracked mostly at the surface with dilutions initially virtually the same as for the low tide scenario. Over time dilutions within the mixing zone stabilised to around 3.2-fold and there was evidence of minor vertical mixing. After 109 minutes of continual discharge the dilution at A7 was 4.9-fold at the surface.

4.4 Water Quality – Risk assessment of Process chemicals

Ravensdown use nine process chemicals as part of the operation of boilers and cooling systems of the Napier plant (**Table 2**). Furthermore, Sandford Transport wash their trucks off-site, with the resulting wastewater entering the stormwater drain on the Ravensdown site.[2] Process chemicals are generally bespoke and designed for a particular industrial process. As such, unlike more traditional contaminants (i.e., nutrients, metals etc), most process chemicals are not able to be measured in environmental matrices (such as water, sediment, biota). However, chemicals used in processing at Ravensdown Napier have the potential to enter the settling pond, and ultimately the receiving environment and hence pose a potential risk.

Table 2. Information on process chemicals used at Ravensdown fertiliser manufacture plant at Napier. Source: Ravensdown.

Formulation	Use	Area used
Cortrol OS7780	Water based dissolved oxygen scavenger / metal passivator	Boiler
Optisperse ADJ5150	Alkalinity builder	Boiler
Solus AP24	Internal boiler water treatment	Boiler
Steammate NA0880	Blend of neutralising amines	Boiler
Flogard MS6222	Water based corrosion inhibitor	Cooling system
Gengard GN8020	Deposit and fouling control agent	Cooling system
Inhibitor AZ8104	Water based corrosion inhibitor	Cooling system
Spectrus BD1500	Water based deposit control agent	Cooling system
Spectrus NX1100	Biocide	Cooling system
Road Film Remover	Fleet wash (Sandfords)	Sandfords truck wash
XT88	Replacement for Road Film Remover (Sandfords)	Sandfords truck wash

As most of these chemicals cannot be measured, a risk assessment approach is used to assess potential effects of process chemicals. Full details are provided in the SEL technical report (Phillips et al., 2021) and summarised here.

1. Important information on the composition, and physical and chemical properties of each individual chemical within each process chemical formulation was obtained from safety data sheets (provided by Ravensdown) and online chemical database.[3] Some process chemicals are proprietary and commercially sensitive. The identities of these were protected under a non-disclosure agreement (NDA) with the supplier and generic codes used in reporting.
2. Marine aquatic predicted no-effects concentration (PNEC) for individual chemicals within each formulation (where available) were obtained from The European Chemicals Agency (ECHA)[4] or the NORMAN Ecotoxicology Database[5].

[2] After the initial results of the risk assessment were communicated, Sandfords have ceased the use of Road Film Remover and replaced it with another formulation, XT88.
[3] http://www.chemspider.com/
[4] https://echa.europa.eu/information-on-chemicals
[5] NORMAN is a network of reference laboratories, research centres and related organisations for monitoring of emerging environmental substances. NORMAN has a membership of more than 70 leading laboratories and authorities across Europe and North America.
https://www.norman-network.com/nds/ecotox/lowestPnecIndex.php

3. A highly conservative worst-case settling pond concentration of each chemical within each formulation was calculated through mass balance.
4. A risk quotient (RQ1) was calculated for individual chemicals by dividing the settling pond concentration by the PNEC, with a value >1 indicating a potential ecotoxicological effect. The RQ1 value also indicates the dilution required within the mixing zone to reduce the concentration of the chemical in the receiving environment to below ecotoxicological guidelines.
5. Where RQ1 was >1, a receiving environment risk quotient (RQ2) was calculated by dividing RQ1 by the dilution at the boundary of the mixing zone, provided from the rhodamine dye study as described in **Section 4.3**.
6. Where RQ2 was >1, the potential for long-term effects involving persistence and/or bioaccumulation within the receiving environment was also assessed by reference to (a) biodegradation data and (b) a bioaccumulation concentration factor (BCF).[6]

We note that the risk assessment is highly conservative. This assumes that all the process chemicals used enter the settling pond, with no degradation or evaporation (of any volatile chemicals) considered, unless there are specific data to support this. We understand that this may over-estimate the ecological risk, however, we consider this most prudent in the absence of degradation data (for most process chemicals) and the inability to measure most of the process chemicals in the pond or receiving environment (due to lack of accredited laboratory methods).

Results

Three of the process chemical formulations used at Ravensdown Napier – Optisperse ADJ5150, Solus AP24, and Flogard MS6222 – present with negligible risk in the settling pond, even before allowing for dilution in the receiving environment, i.e. RQ1< 1.

Six of the remaining process chemical formulations used at Ravensdown Napier present with a risk quotient RQ1 >1 in the settling pond, indicating the potential for adverse ecological effects in the receiving environment. These are summarised in Error! Reference source not found.**Table 3**, with RQ1 ranging from 1.5 (Cort2, a component of Cortrol OS7780 protected under the NDA) to 67 (BD1 a component of Spectrus BD1500 protected under the NDA). The Sandfords Road Film Remover presented with an extremely high RQ1 (680) for technical nonylphenol. Based on this information, Sandfords ceased use of this formulation and replaced it with another, XT88. XT88 presents with a significantly reduced ecological risk, with an RQ1=2.2 (**Error! Reference source not found.Table 3**).

Receiving environment risk quotients (RQ2) were calculated from RQ1 using dilutions calculated at the mixing zone boundary derived from the 2021 dye study (**Section 4.3**). Dilutions applied to RQ1 were calculated for:

- a low tide dilution scenario of 2.8-fold (vertically mixed), and;
- a high tide dilution scenario of 4.9-fold (surface only).

[6] We have followed the definition of US EPA, who define a chemical with BCF <1000 as having a low bioaccumulation potential.

The RQ2 values for low tide and high tide dilution scenarios are summarised in **Table 3** along with the bioaccumulation concentration factor (BCF). Using the USEPA definition, a chemical with BCF <1000 is considered to have a low bioaccumulation potential.

Table 3: Summary of ecological risk for process chemical formulations.

Formulation	Component	RQ1	RQ2 (low tide discharge scenario) - vertically mixed	RQ2 (high tide discharge scenario) - surface only	BCF
Cortrol OS7780	1,4-Benzoquinone	14	5.0	2.9	1.00
	Cort2	1.5	0.5	0.3	6.96
Steammate NA0880	Monoethanolamine	44	16	8.9	1.00
	DMAPA	28	10	5.8	1.00
	SM1	1.0	0.4	0.2	1.00
Genguard GN8020	Gen1	8.0	2.9	1.6	1.00
Inhibitor AZ8104	Sodium tolyltriazole	4.6	1.6	0.9	No data
Spectrus BD1500	BD1	67	24	14	No data
Spectrus NX1100	Bronopol	28	9.8	5.6	1.34
	Kathron 886	4.3	1.5	0.9	4.19
Road Film Remover	Nonylphenol (technical)	680	243	139	1.00
	Sodium xylenesulfonate	102	36	21	1.00
	EDTA	1.5	0.6	0.3	1.00
XT88	Sodium dodecylbenzenesulfonate	2.2	0.8	0.4	No data

Colour codes: RQ< 1 = green; RQ>1 orange

For Sandfords XT88, the risk is negligible under either the low tide or high tide scenario, i.e. RQ2<1.

For the low tide discharge scenario, RQ2 values ranged from 1.5 (Kathron 886 contained in Spectrus NX1100) to 243 (nonylphenol (technical) contained in Sandfords Road Film Remover) (**Table 3**). As stated above, Sandfords Road Film Remover is no longer used, but is included here for completeness. We note that while biodegradation of chemical constituents of a number of these formulations is possible, it is considered unlikely that this would result in a significant reduction in potential effects, given that the RQ2 values are up to orders of magnitude greater than 1. Furthermore, as there was clear evidence for vertical mixing for the low tide scenario, these components will potentially lead to more than minor adverse effects on both water dwelling and surface sediment dwelling organisms.

For the high tide discharge scenario, there was no evidence for vertical mixing of the discharge plume to the stream bed, and it was present at the surface only. Therefore, under the high tide discharge scenario, the plume would potentially lead to adverse effects only on water dwelling organisms.

For one formulation – Inhibitor AZ8104 – the risk is negligible on water dwelling organisms in the receiving environment (RQ2 = 0.9).

For the remaining six formulations – Cortrol OS7780, Steammate NA0880, Genguard GN8020, Spectrus BD1500, Spectrus NX1100, and Road Film Remover – there is a potential for more than minor adverse effects on water dwelling organisms in the receiving environment (i.e. RQ2>1) (**Table 3**). These will be discussed individually.

For Cortrol OS7780 an RQ2 of 2.9 was calculated for 1,4-benzoquinone. As some biodegradation is likely and it is unlikely to persist in the environment or bioaccumulate (BCF=1), we consider the risk associated with 1,4-benzoquinone in the formulation Cortrol OS7780 is unlikely to result in more than minor effects.

For Steammate NA0880, an RQ2 of 8.9 and 5.8 was calculated for monoethanolamine and DMAPA, respectively (**Table 3**). Both are considered readily biodegradable in water[7,8]. They also have low potential for bioaccumulation (BCF=1). Therefore, we consider the risk associated with these components of Steammate NA0880is unlikely to result more than minor effects are.

For Genguard GN8020, an RQ2 of 1.6 was calculated for Gen1. Gen1 is considered readily biodegradable in water and has low potential for bioaccumulation (BCF=1).[9] Therefore, we consider it from the risk associated with Gen1 in the formulation Genguard GN8020 is unlikely to result in more than minor effects.

For Spectrus BD1500, an RQ2 of 14 was calculated for BD1. Due to a lack of information on biodegradation and bioaccumulation, as well as uncertainty around its ecotoxicological properties, no further refinement could be made on the risk from BD1 in the formulation Spectrus BD1500 and more than minor effects are possible.

For Spectrus NX1100, an RQ2 of 5.6 was calculated for bronopol. Bronopol is considered readily biodegradable in water.[10] and has low potential for bioaccumulation (BCF=1.34). Therefore, we consider the risk from bronopol in the formulation Spectrus NX1100 is unlikely to result in more than minor effects.

Summary

Although the risk assessment methodology used is conservative and may over-estimate risk from process chemicals, it is considered to be the most prudent approach in the absence of degradation data (for most process chemicals) and the inability to measure most of the process chemicals in the pond or receiving environment (due to lack of accredited laboratory methods).

The potential risk when discharging prior to low tide is elevated for the majority of the formulations used at the Ravensdown Napier site and there is the potential for more than minor adverse effects on both water dwelling and surface sediment dwelling organisms.

The potential risk when discharging prior to high tide is markedly reduced and constrained to effects on water dwelling organisms as the discharge plume is not vertically mixed within the mixing zone.

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[7] https://echa.europa.eu/registration-dossier/-/registered-dossier/15808/5/3/2/?documentUUID=33551d85-a5f9-40f6-9227-92987bae3050
[8] https://echa.europa.eu/registration-dossier/-/registered-dossier/14823/5/3/2
[9] References withheld as Gen1 is covered under an NDA between Suez and SEL.
[10] https://echa.europa.eu/registration-dossier/-/registered-dossier/11419/5/3/2/?documentUUID=4cc4c467-964e-4db2-bab4-3db79f01ea78

Four of the five formulations that present as a potential ecological risk under the high tide discharge scenario (RQ2>1) – Cortrol OS7780, Steammate NA0880, Genguard GN8020, Spectrus NX1100 are likely to be readily biodegradable and have low potential for bioaccumulation. Thus more than minor effects are considered unlikely.

However, there is a lack of information on biodegradability and bioaccumulation potential for Spectrus BD1500, and more than minor effects are possible.

Due to low persistence or bioaccumulation potential any effects from process chemicals are assessed as being unlikely if discharged on ebbing tide.

4.4.1 Effects of existing discharge on water quality

Based on comparison with guideline values (**Section 4.2.2**), localised effects of contaminants in the discharge may occur under ambient conditions associated with increased concentrations of copper. In addition, while aluminium, chromium, and zinc concentrations downstream of the discharge exceed guideline values, concentrations of these metals are comparable at sites upstream of the discharge and therefore also exceed the guideline value. Zinc concentrations exceed the 95% protection level guideline downstream but exceed the 80% protection level upstream. Therefore, although it is difficult to determine the relative contribution of the discharge to effects downstream based on these metals, significant upstream sources are evident.

In addition, guidelines for cadmium are exceeded at sites downstream of the discharge under rainfall conditions and localised effects of contaminants in the discharge may occur. Aluminium concentrations exceed the guideline value both upstream and downstream of the discharge, with higher concentrations upstream. Thus, it is difficult to determine the relative contribution of the discharge to effects downstream based on aluminium concentrations.

Concentrations of ammoniacal nitrogen, TN, TP and SRP are higher downstream of the discharge but concentrations both upstream and downstream exceed guideline values under rainfall conditions. As concentrations of these contaminants are higher downstream than upstream of the discharge, it is likely that the discharge is causing localised effects at sites immediately downstream of the site under rainfall conditions.

Overall, it is likely that the discharge is causing localised effects downstream of the discharge point following rainfall events, with potential localised effects associated with copper under ambient conditions.

In terms of process chemicals, the potential risk when discharging prior to low tide is elevated for the majority of the formulations used at the Ravensdown Napier site, with biodegradation unlikely to reduce concentrations below levels of concern. There is the potential for more than minor adverse effects on both water dwelling and surface sediment dwelling organisms under the low tide discharge scenario. The potential risk when discharging prior to high tide is markedly reduced and constrained to effects on water dwelling organisms as the discharge plume is not vertically mixed within the mixing zone. Biodegradation and a general lack of persistence or bioaccumulation ability means most process chemicals are unlikely to present more than minor adverse effects under the high tide scenario.

4.4.2 Summary – water quality

- The Ravensdown Napier discharge has generally been compliant with consent conditions.
- There has been a decreasing trend in the concentrations of copper, fluoride, SRP, TP and TSS in the discharge since 2007.
- The discharge is likely to be contributing to elevated concentrations of nickel, copper, aluminium and nitrite downstream of the discharge point under ambient conditions.
- The discharge is likely to be contributing to elevated concentrations of cadmium, nickel, fluoride, sulphur, ammoniacal nitrogen, TN, TP and SRP under rainfall conditions.
- Overall, it is likely that the discharge is causing localised effects downstream of the discharge point following rainfall events, with potential localised effects associated with copper under ambient conditions.
- During a low tide, dilutions of 2.8-fold are achieved at the boundary of the mixing zone, while during a high tide, dilutions of 4.9-fold occur.
- Under a low tide scenario, most process chemicals present an elevated risk of more than minor adverse effects on both water dwelling and surface sediment dwelling organisms.
- Under a high tide scenario, biodegradation and a general lack of persistence or bioaccumulation ability means most process chemicals are unlikely to present more than minor adverse effects. A lack of information on biodegradability and bioaccumulation potential for Spectrus BD1500 means effects cannot be ruled out. However, due to the highly conservative nature of the risk assessment, any effects are expected to be minor.

4.5 Ecotoxicity of the discharge

Every fourth year since commencement of the discharge consent, Ravensdown has been required to undertake whole effluent toxicity (WET) testing on the discharge water. Collection of discharge samples for WET testing from the Ravensdown Napier site is undertaken by creating a composite sample from 24 samples collected over a 12-hour period during moderate rainfall (1.7 mm/hr average over the previous 24 hours) using an autosampler. Samples are collected after first flush in order to represent average stormwater quality. The composite sample is divided into two samples that are dispatched on the same day of collection (chilled), one being sent to NIWA for WET testing and one being sent to Hill Laboratories for contaminant analyses. The WET testing is carried out on three test species – a marine alga, an estuarine amphipod and an estuarine snail. Water samples are also analysed by Hill Laboratories for pH, TP, SRP, fluoride, total sulphur, TSS and the metals copper, zinc, cadmium, chromium and aluminium.

Compliance is based on achieving no significant toxicity to any test species at a dilution of no less than 100:1.

4.5.1 Previous studies

The results of previous WET tests undertaken in 2011 (Smith, 2013), 2015 (NIWA, 2015) and 2019 (NIWA, 2019) indicated that, on all occasions, the discharge would not cause significant ecotoxic adverse effects on the species tested (marine alga: *Minutocellus polymorphus*, estuarine amphipod: *Chaetocorophium lacasi*, and an estuarine snail: *Potamopyrgus estuarinus*) after a 100-fold dilution. Hence, the discharge would be considered non-toxic to organisms in the receiving environment.

Concentrations of aluminium, cadmium, chromium, copper, nickel, fluoride and ammoniacal-nitrogen in the 2011 discharge exceeded water quality guidelines. However, once reasonable mixing was allowed for (at 100:1), these concentrations would be below guidelines. Concentrations of copper and zinc, as well as fluoride and ammonia exceeded the relevant guidelines in 2015, while cadmium, chromium, copper and zinc, along with ammonia, exceeded relevant guidelines in 2019. However, on both occasions the calculated dilutions required to achieve the guidelines would be less than the 'no toxicity' criterion of no significant effect at a 1:100 dilution defined in the consent condition. In addition, the fluoride concentration on both occasions was well below the maximum allowed by the resource consent (30 mg/L).

4.5.2 Recent studies

Toxicity testing was undertaken on two samples: a settling pond discharge sample (collected 17 August 2020) to determine resource consent compliance, and a sample (also collected 17 August 2020) from upstream of the discharge was also analysed (NIWA, 2020). The upstream sample was collected and tested to provide a context for any toxicity associated with the discharge sample, as contaminants sourced from upstream of the site may also be contributing to effects observed in the Awatoto Drain and Tūtaekurī River.

Three marine species were tested and comprised an estuarine snail (*Potamopyrgus estuarinus* - 96-hour survival and morbidity), an amphipod (*Chaetocorophium cf. lucasi* - 96-hour survival and morbidity) and a marine alga (*Minutocellus polymorphus* - 48-hour growth response). The upstream sample showed no toxicity to the survival or morbidity of estuarine snails or amphipods; however, there was a significant reduction in algal growth at 32% dilution. Using the EC_{50} (concentration at which 50% of the population show an effect) as a comparative measure between the three test species, the settling pond discharge was most toxic to the alga at 6.5% concentration. Therefore, the upstream site was less toxic to algae than the settling pond site. However, based on the estuarine snail, amphipod and alga test results for the supplied settling pond discharge sample, the settling pond water complied with the consent compliance criterion for no toxicity when diluted 100 times with uncontaminated water.

In addition to the WET testing, a sub-sample of the settling pond discharge sample was also analysed for metals, sulphide and ammoniacal-N and compared to guideline values from ANZG (2018) guidelines. Safety Factors were calculated for each contaminant of interest. The Safety Factor defines the lowest dilution required for the concentration of a particular component of the sample to be reduced to ANZG value. It is a derived ratio of the guideline value to the analyte concentration when diluted 100-fold. A Safety Factor >1 indicates a concentration below the ANZG guideline. The concentrations of zinc and ammoniacal-N exceeded the ANZG (2018) guidelines. However, after diluting the samples 100 times, the resulting concentration would be less than the guideline value. The fluoride concentration was well below the maximum concentration allowed by the resource consent.

A dye study undertaken in March 2021 (Phillips et al. 2021) determined that within the mixing zone, dilutions at the surface range between 1.7-fold and 17.8-fold (median = 3.5-fold, average = 6.8-fold) when discharged prior to low tide and between 2.1-fold and 14.9-fold (median = 5.3-fold, average = 6.6-fold) when discharged prior to high tide. Dilutions of up to 113-fold were recorded at 500 mm below the surface under high tide conditions, but there was generally little evidence of vertical mixing. While these dilutions are generally lower than the 100-fold dilution required to meet the toxicity compliance limit, this does not mean toxic effects have occurred. For example, the 2020 WET testing results indicated that dilutions of only 13-fold and 25-fold were necessary to achieve no toxicity. These dilutions are comparable with those recorded from the dye study.

4.5.3 Summary – Ecotoxicity

- WET testing results for 2011, 2015, 2019 and 2020 consistently indicate that the discharge would not cause significant ecotoxic adverse effects to organisms in the receiving environment once diluted 1:100..
- WET testing results for the discharge have consistently complied with the consent requirement of no toxicity of at least 1:100 dilution.
- While a dye study undertaken in March 2021 indicates such dilutions are not always being achieved, the results of the WET testing indicate that much lower dilutions (than the 1:100 consent requirement) are required to achieve no toxicity of the discharge. For example, the 2020 WET testing results indicated that dilutions of only 13-fold and 25-fold were necessary to achieve no toxicity.

4.6 Marine Ecology of the receiving environment

4.6.1 General introduction

The marine/estuarine receiving environment has received historical discharges from various land use activities and continues to receive a range of discharges (including discharges from Ravensdown activities) that compromise the marine/estuarine ecological values. These discharges and modifications to the receiving environment have likely contributed, in a cumulative manner, to the existing ecological values.

4.6.2 Previous studies

Previous studies have found that the discharges from Ravensdown Napier are unlikely to have had significant adverse effects on the receiving environment.

<u>Smith (2013)</u>

A survey undertaken by Environmental Assessments and Monitoring NZ Limited (EAM) in 2013 assessed the effects of the discharge from Ravensdown Napier on water quality, sediment quality and floral/faunal communities and also examined the ecotoxicity of the discharge on laboratory organisms. Key findings from this survey include:

- Water quality was not significantly adversely affected by the consented discharge, noting that most parameters, excluding phosphorus and fluoride, returned to concentrations similar to that upstream of the discharge.
- With the exception of cadmium and phosphorus, sediment quality at the discharge point was found to be within the mid-range of reference freshwater and estuarine values,.
- Macrobenthic invertebrate communities varied spatially and temporally, suggesting that an unbalanced/transitional community was present in the lower Awatoto Drain and

Tūtaekurī Blind Arm. It was concluded that there was little evidence of deterioration of assemblages over time.

- Adverse effects from the discharge on the receiving environment were assessed as being no more than minor.

<u>Boffa Miskell, 2019</u>

As part of ecological surveys undertaken for Death & Ekelund (2019), Boffa Miskell (2019) reported on macrofaunal sampling undertaken in March 2019 and compared these results with two previous surveys undertaken in 2011 and 2015. They found significant differences in the macrobenthic assemblages between 2011 and 2019 (**Figure 14**). High variability in benthic assemblages (whilst dominated by pollution tolerant species at all sites) was detected over time.

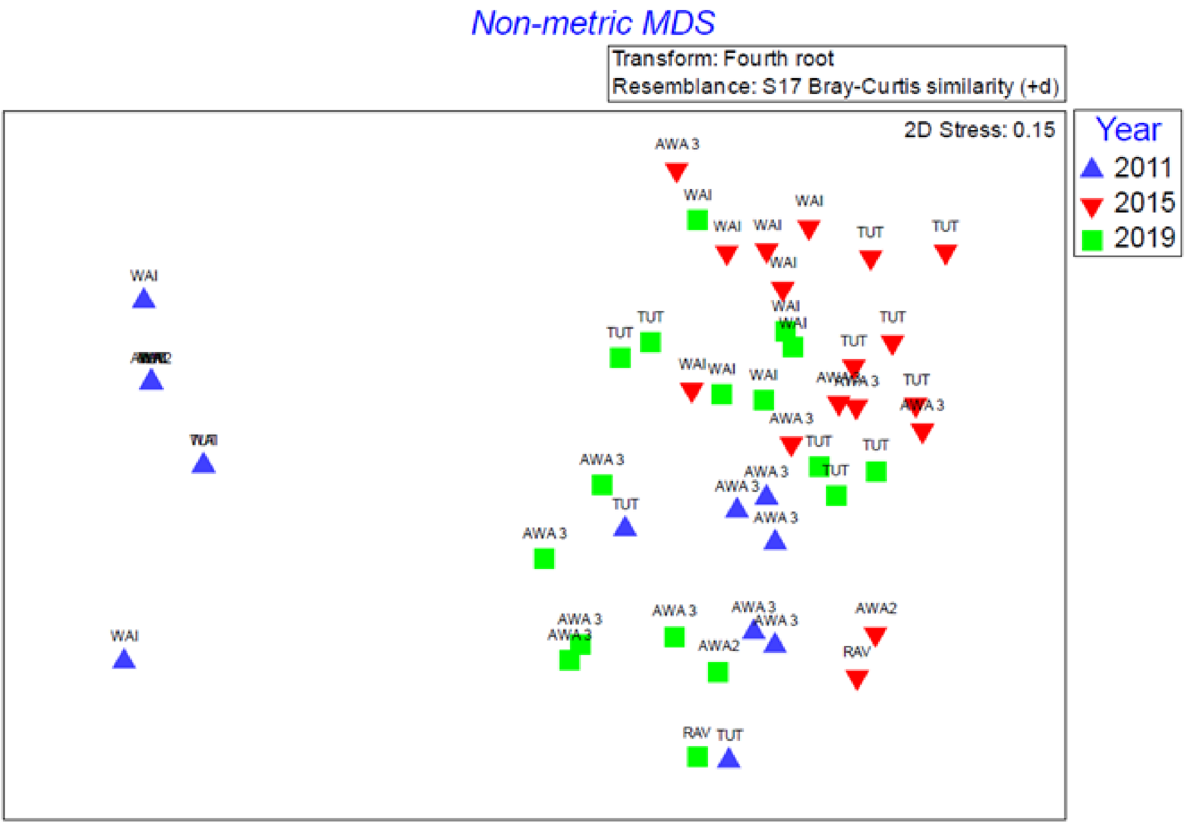

Figure 14. nMDS plot of benthic macroinvertebrate assemblage at samples sites on 3 sampling occasions. Source: Boffa Miskell (2019).

Boffa Miskell (2019) noted that while there had been increases in the value of a number of measures at the reference site over time (WAI), these increases were not observed at the impact sites. They suggested this could potentially be due to the influence of the discharge, nevertheless the species assemblages at these sites were typical of upper estuarine environments that naturally receive higher concentrations of fine sediment and freshwater runoff. They concluded that it was therefore likely that the natural habitat differences between sites within the estuary was the main driving factor in differences in species assemblages observed between sites. These results as a whole do not appear to indicate degradation in ecosystem health between sites or over time (throughout the sample period between 2011 and 2019), resulting from impacts associated with stormwater and process water discharges. Spatial and temporal changes that have occurred appear to be as a result of natural variation over time and natural habitat differences within the estuary.

<u>Death and Ekelund (2019)</u>

Ecological surveys have been undertaken previously in 2011, 2015 and 2019 (Death & Ekelund, 2019). A detailed summary of the key findings is presented in Phillips et al. (2021).

Sites included in these surveys are described as follows (see **Figure 15** and **Figure 16**):

- Ravensdown Drain (RAV1 - immediately below discharge, RAV2 - at the confluence of Ravensdown and Awatoto Drains).
- Awatoto Drain (AWA 1 - upstream of discharge but below the Council pumping station at the flood control stop bank, AWA2 - within/at the boundary of the mixing zone, AWA3 - downstream of mixing zone at the confluence with Tūtaekurī (Blind Arm).
- Tūtaekurī (Blind Arm) (TUT - downstream of confluence of Awatoto Drain and Tūtaekurī River). This is the Distant Impact Site.
- Waitangi Estuary (WAI - close to the mouth of the Waitangi Clive River). This is a Reference Site.

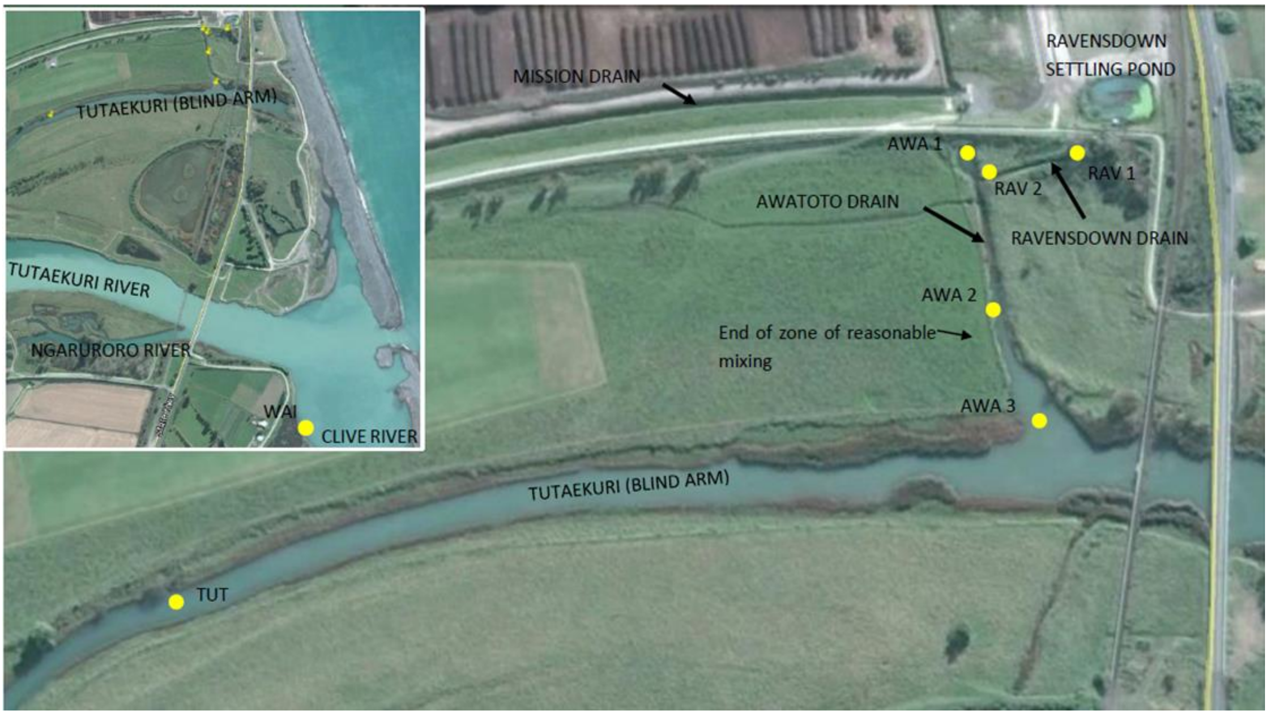

Figure 15. Sites previously monitored in relation to the Ravensdown discharge (Source: Death & Ekelund, 2019).

Figure 16. Sampling locations at sites monitored in relation to the Ravensdown discharge. Insets for AWA3, TUT and WAI sites are indicative only of actual locations sampled (Source: Death & Ekelund, 2019).

The main findings of Death and Ekelund (2019) with respect to marine ecology were as follows:

- Spatial and temporal changes in macroinvertebrates that have occurred among previous years surveys appear to be as a result of natural variation over time and natural habitat differences within the estuary.
- Concentrations of all metals have generally been elevated in the Ravensdown Drain (RAV2) compared with all other sites, across all previous years. Concentrations of contaminants generally decreased with increasing distance downstream, with the concentrations at TUT and WAI being similar to the regional background levels.
- In 2019, trace metal concentrations in sediments were generally below the ANZG Default Guideline Value (DGV) (Australian and New Zealand Governments, 2018) at most sites monitored (RAV2, AWA2, AWA3, TUT), except for zinc and cadmium at RAV2 where the concentrations were just above the DGV. Nickel concentrations were elevated at all sites in 2019, and especially at the reference site WAI, which exceeded the GV-High guideline value. Chromium and zinc were also elevated at this site in 2019, exceeding the relevant DGVs.
- Fluoride concentrations have historically been highest at RAV2, decreasing with increased distance downstream. It should be noted that the concentration of fluoride in the Ravensdown discharge in 2019 was consistently below the threshold concentration required in the conditions of consent (and WET testing did not indicate significant toxicity for the discharge).
- Phosphorus concentrations in sediment showed a similar pattern to metals, with elevated concentrations at RAV2 and a decrease with distance downstream. Excessive phosphorus in aquatic systems can cause increased growth of algae and large aquatic plants, which

can result in decreased levels of dissolved oxygen as the plants degrade (via eutrophication).

- While it is difficult to determine the exact effects from the Ravensdown discharge on fish communities in the Tūtaekurī River and wider Waitangi Estuary, the large number of species which have been observed in the river and estuary, including non-migratory species, would suggest that any effects are most likely short-lived, localised and are not impacting on fish communities here.
- No species of macrophytes were observed at any of the sites in 2019. Given the complete absence, it was concluded that the discharge did not appear to be having any effect on macrophyte communities downstream of the discharge point.

4.6.3 Recent studies

Based on our analysis of information gaps (Phillips et al, 2020), further sampling of benthic macrofauna and sediment grain size, sediment contaminants, redox depth and physico-chemical parameters were conducted in 2020 to address the lack of replication of benthic sampling at specific sites and large natural variance between the reference site and other sampling sites chosen in the previous monitoring assessments (Phillips et al. 2021). A new reference site (NGA1) replaced the previously sampled reference site (WAI). A map of the estuarine sampling sites is presented in **Figure 17**.

Figure 17. Marine ecological survey sampling sites (blue circles). Orange triangle represents Ravensdown discharge outfall.

The main findings were as follows:

Infauna community composition

- Highest species richness was recorded at TUT3 (near the confluence with Tūtaekurī River), NGA1 (reference site discharging to the Ngaruroro River) and was lowest at RAV1 (downstream of the Ravensdown discharge point).
- Poorest species diversity was observed at TUT2 (mid-way along the unnamed tributary of Tūtaekurī River).
- Species diversity was poor overall, being lowest at the Ravensdown discharge point (RAV1), moderate downstream in the Tūtaekurī River (TUT2) and the reference site in the Ngaruroro River (NGA1) and highest downstream in the Tūtaekurī River (TUT3).
- The main taxa groups were similar across all sites, although different individual taxa dominated at the TUT sites and the reference site (NGA1).
- RAV1, RAV2 (at the confluence with the drain below Ravensdown discharge point), AWA1 (immediately upstream of the Ravensdown discharge point in main drain), AWA2 (approximately halfway along main drain before discharge to the unnamed tributary of Tūtaekurī River), and AWA3 (at the confluence of the main drain and the unnamed tributary of Tūtaekurī River) had high numbers of species tolerant of a wide range of habitats and typical of habitats with large freshwater influences.
- TUT1, TUT2, and TUT3 all showed lower numbers of freshwater influenced species and increasing diversity. TUT2 and TUT3 had a higher number of burrowing amphipods.
- NGA1 had the highest number of species present, but lowest number of individuals.
- There is moderate variability within sites and high variability between sites.
- All sites revealed some degree of impacted/disturbed invertebrate assemblages.

Surface sediment

Grain size

- All sites were predominantly comprised of silt and clay. Sites downstream of the mixing zone gradually got sandier, as was seen upstream of the mixing zone.
- RAV2 and AWA1 had similar amounts of sand and silt and clay.
- AWA2 had the highest proportion of silt and clay of all sites.
- RAV1 had the lowest proportion of silt and clay and the largest proportion of coarser grain sizes.

Sediment contaminants

- Cadmium, nickel, and zinc were all above ANZG (2018) Default Trigger Values at RAV1 (at Ravensdown discharge point) and NGA1 (reference site). Zinc was also above ANZG (2018) DGVs at site AWA1 (adjacent to Ravensdown discharge point).
- Total recoverable phosphorus, total sulphur and fluoride largely followed the same pattern as trace metals.
- NGA1 (reference site) had much higher phosphorus and fluoride concentrations than most sites, and a comparable phosphorus concentration as RAV1 (at Ravensdown discharge point).

- Downstream of the mixing zone, contaminant concentrations were below consent limits and below ecological effects thresholds.

Redox layer

- The average depth detected of the oxygenated layer across all sites except TUT3 (no anoxic layer detected below oxygenated sediment) was less than 1 cm, indicating anoxic surface sediment.

Water Physiochemistry

- Dissolved oxygen (%) was well below guideline (20th percentile) at sites RAV1 and RAV2.
- Conductivity (µS/cm) was variable across the sites due to freshwater influences.
- pH was generally within DGVs across all sites.

4.6.4 Marine Ecological Assessment

The methods used to undertake this assessment are consistent with the EIANZ guidelines for undertaking ecological impact assessments (Roper-Lindsay et al., 2018), whereby ecological values are assigned (refer to **Table 4** for threat classification and **Table 5** for marine ecology value characteristics) and the magnitude of effects identified (**Table 6**) in order to determine the overall level of residual effect of the proposal (**Table 7**).

In New Zealand, no regional or national guidelines or criteria for the assessment of marine ecological values have been developed to date. In the absence of such guidelines, we have adopted the EIANZ guidelines (Roper-Lindsay et al., 2018) approach to assess marine ecological value by using a suite of factors relating to abundance, diversity and benthic invertebrate species richness, sediment grain size composition and sediment contaminant concentrations.[11]

Table 4 Criteria for assigning ecological value to species (Roper-Lindsay et al., 2018).

Ecological Value	Species Classification
NEGLIGIBLE	Exotic species, including pests, species having recreational value.
LOW	Nationally and locally common indigenous species.
MODERATE	Species listed as any other category of At Risk (Recovering, Relict, Naturally Uncommon) found in the ZOI[12] either permanently or seasonally; or Locally (ED[13]) uncommon or distinctive species.
HIGH	Species listed as At Risk – Declining found in the ZOI either permanently or seasonally.
VERY HIGH	Nationally Threatened (Nationally Critical, Nationally Endangered, Nationally Vulnerable) species found in the ZOI either permanently or seasonally.

Table 5 Characteristics of marine ecological values to guide assessment.

[11] In the absence of guidelines for assessing marine ecological values, Dr Sharon De Luca has developed a set of characteristics to guide the assessment of marine ecological values. These criteria have been developed presented in Board of Inquiry and Environment Court hearings previously, without any challenge.
[12] The 'zone of influence' (ZOI) refers to all land, water bodies and receiving environments that could be potentially impacted by the project.
[13] "Locally" should refer to the Ecological District (ED) unless the relevant Regional or District Plan provides an alternative definition

Ecological Value	Characteristics
VERY LOW	Benthic invertebrate community degraded with very low species richness, diversity and abundance for the habitat type. Benthic invertebrate community dominated by organic enrichment tolerant and mud tolerant organisms with no sensitive taxa present. Marine sediments dominated by silt and clay grain sizes (>85%). Surface sediment anoxic (lacking oxygen). Elevated contaminant concentrations in surface sediment, above ANZG Default Guideline Values (DGV) effects threshold concentrations[14]. Invasive, opportunistic and disturbance tolerant species highly dominant. Native estuarine vegetation or macroalgae absent. Habitat extremely modified.
LOW	Benthic invertebrate community degraded with low species richness, diversity and abundance for the habitat type. Benthic invertebrate community dominated by organic enrichment tolerant and mud tolerant organisms with few/no sensitive taxa present. Marine sediments dominated by silt and clay grain sizes (>70%). Surface sediment predominantly anoxic (lacking oxygen). Elevated contaminant concentrations in surface sediment, above ANZG DGV effects threshold concentrations. Invasive, opportunistic and/or disturbance-tolerant species dominant. Native estuarine vegetation or macroalgae dominated by exotic species. Habitat highly modified.
MODERATE	Benthic invertebrate community typically has moderate species richness, diversity and abundance for the habitat type. Benthic invertebrate community has both (organic enrichment and mud) tolerant and sensitive taxa present. Marine sediments typically comprise less than 50-70% silt and clay grain sizes. Shallow depth of oxygenated surface sediment. Contaminant concentrations in surface sediment generally below ANZG DGV effects threshold concentrations. Few invasive opportunistic and/or disturbance tolerant species present. Estuarine vegetation or macroalgae dominated by a mixture of native and exotic species. Habitat modification limited.
HIGH	Benthic invertebrate community typically has high diversity, species richness and abundance for the habitat type. Benthic invertebrate community contains many taxa that are sensitive to organic enrichment and mud. Marine sediments typically comprise <50% silt and clay grain sizes. Surface sediment oxygenated. Contaminant concentrations in surface sediment significantly below ANZG DGV effects threshold concentrations. Invasive opportunistic and/or disturbance tolerant species largely absent. Estuarine vegetation or macroalgae dominated by native species. Habitat largely unmodified.
VERY HIGH	Benthic invertebrate community typically has very high diversity, species richness and abundance for the habitat type. Benthic invertebrate community contains dominated taxa that are sensitive to organic enrichment and mud. Marine sediments typically comprise <25% smaller grain sizes. Surface sediment oxygenated with no anoxic sediment present. Contaminant concentrations in surface sediment significantly below ANZG DGV effects threshold concentrations. Invasive opportunistic and disturbance tolerant species absent. Native estuarine vegetation or macroalgal sequences intact and provides significant habitat for native fauna. Habitat unmodified.

[14] ANZG (2018) Australian and New Zealand Guidelines for Freshwater and Marine Water Quality (replaced previous ANZECC guidelines)

Table 6 Criteria for describing magnitude of effect.

MAGNITUDE	DESCRIPTION
Very High	Total loss of, or very major alteration, to key elements/ features of the baseline conditions such that the post development character/ composition/ attributes will be fundamentally changed and may be lost from the site altogether; AND/OR Loss[15] of a very high proportion of the known population or range of the element / feature.
High	Major loss or major alteration to key elements/ features of the existing baseline conditions such that the post-development character, composition and/or attributes will be fundamentally changed; AND/OR Loss[16] of a high proportion of the known population or range of the element / feature.
Moderate	Loss or alteration to one or more key elements/features of the existing baseline conditions, such that post-development character, composition and/or attributes will be partially changed; AND/OR Loss[16] of a moderate proportion of the known population or range of the element / feature.
Low	Minor shift away from baseline conditions. Change arising from the loss/alteration will be discernible, but underlying character, composition and/or attributes of the existing baseline condition will be similar to pre-development circumstances/patterns; AND/OR Having a minor effect on the known population or range of the element / feature.
Negligible	Very slight change from existing baseline condition. Change barely distinguishable, approximating to the "no change" situation; AND/OR Having a negligible effect on the known population or range of the element / feature.

Table 7 Criteria for describing the level of effect (Roper-Lindsay et al., 2018).

LEVEL OF EFFECT		ECOLOGICAL AND/OR CONSERVATION VALUE				
		Very High	High	Moderate	Low	Negligible
MAGNITUDE	Very High	Very High	Very High	High	Moderate	Low
	High	Very High	Very High	Moderate	Low	Very Low
	Moderate	High	High	Moderate	Low	Very Low
	Low	Moderate	Low	Low	Very Low	Very Low
	Negligible	Low	Very Low	Very Low	Very Low	Very Low
	Positive	Net gain	Net gain	Net gain	Net gain	Net gain

According to Roper-Lindsay et al. (2018), the overall level of effect can then be used to guide the extent and nature of the ecological management response required (including the need for biodiversity offsetting):

- Very High adverse effects require a net biodiversity gain.[16]
- High and Moderate adverse effects require no net loss of biodiversity values.
- Low and Very Low adverse effects should not normally be a concern. If effects are assessed taking impact management developed during project shaping into consideration, then it

[15] In the context of mobile fauna, the term "loss" can include displacement from an area.
[16] Though when ecological compensation is required because biodiversity offsetting is not possible, the principles of no-net-loss or net-gain do not apply (Maseyk et al., 2018).

is essential that prescribed impact management is carried out to ensure Low or Very Low effects.

Assessment of Marine Ecological Values

The marine ecological values of the primary receiving environment are characterised (**Table 4**) as having low invertebrate species richness, diversity and abundance and being dominated by organic enrichment tolerant and mud tolerant organisms, with no sensitive or Threatened/At Risk[17] taxa present. Marine sediments were dominated by silt and clay (50-70% across most sites). Surface sediment was largely anoxic with a shallow oxygenated layer (<1 cm generally). Sediment contaminants contained cadmium, nickel, and zinc above ANZG (2018) Default Guideline Values (DGV) at RAV1 (immediately below the Ravensdown discharge) and NGA1 (downstream reference site). Zinc was also above ANZG (2018) DGVs at site AWA1 (upstream of the Ravensdown discharge). Total phosphorus, total sulphur and fluoride largely followed the same pattern as trace metals. Native estuarine vegetation and/or macroalgae were largely absent. Habitat has been modified by a range of discharges from numerous activities within the catchment.

Overall, based on the above evidence, the ecological values of marine receiving environment are assessed as being **low** (**Table 4**).

4.6.5 Effects of existing discharge on marine ecology

Water quality

The assessment of effects on water quality in receiving environment determined that it is likely that the current discharge is causing localised effects downstream of the discharge point following rainfall events, with potential localised effects associated with copper under ambient conditions.

Ecotoxicology

Based on the ecotoxicology tests on an estuarine snail, amphipod and alga test for the supplied settling pond discharge sample, the settling pond discharge complies with the consent compliance criterion for no toxicity when diluted 100:1. These results indicated that dilutions of only 13-fold and 25-fold were necessary to achieve no toxicity. These dilutions are comparable with those recorded from the dye study summarised below.

Dye Study

As stated in Section 4.3, during a low tide discharge, dilutions of 2.8- fold are achieved at the boundary of the mixing zone, while during a high tide, dilutions of 4.9- fold occur. These dilutions are generally lower than the 100 fold dilution required to meet the toxicity compliance limit.

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[17] Freeman, D., Schnabel, K., Marshall, B., Gordon, D., Wing, S., Tracey, D., & Hitchmough, R. A. (2014). *Conservation status of New Zealand marine invertebrates, 2013* (New Zealand Threat Classification Series No. 9). Department of Conservation.

The water quality, ecotoxicology tests and dye study do not suggest significant adverse effects on marine ecological values beyond the mixing zone boundary.

Based on the existing ecological values of the marine receiving environment, which have historically been, and continue to be, subject to a range of activities influencing environmental quality, the magnitude of effect of the discharge from Ravensdown on marine ecological values is assessed as considered to be **negligible** (**Table 6**), involving a very slight, barely distinguishable change from existing baseline condition.

A **negligible** magnitude of effect combined with **low** ecological values results in a **very low** level of effect (**Table 7**) on marine ecological values.

4.6.6 Summary – Marine Ecology

The marine/estuarine receiving environment has received historical discharges and continues to receive a range of discharges (including discharges from Ravensdown Napier activities) that compromise the ecological values. These discharges and modifications have all contributed to the low ecological values and the temporal variability observed. There may be potential to restore the ecological values to some extent, but this would likely require an integrated reduction from all discharges present, not just those from Ravensdown

5. Assessment of Ecological Effects with Improved Treatment

5.1 Description of the future treatment system and discharge quality

While implementation of future source control measures and process water improvements is expected to result in significant reductions in contaminant concentrations, the residual contamination will require further treatment to reduce the potential for adverse effects.Ravensdown Napier have developed a Discharge to Water Strategy which describes the proposed treatment system (Torrens, 2021). A combination of treatment options is proposed, with the opportunity for discharge to land or directly to the estuarine environment also being considered subject to seasonal factors, receiving environment conditions and any weather events that may generate excessive volumes of stormwater. The proposed treatment devices are summarised in **Table 8**. An initial two stage approach is proposed. Those modifications that can be quickly added to the existing system and are expected to have an immediate and significant impact on quality of the water being discharged from the site are proposed to be implemented within 1 year following the granting of the new discharge permits (Stage 1). Further improvements would be implemented within 5 years of granting of the new discharge permits (Stage 2) and would include a site-wide stormwater management solution through the implementation of a wetland-based treatment system. Monitoring is proposed after each stage to assess performance of the system against discharge permit conditions and to inform the design of further works (if needed).

These controls form part of an overall discharge management plan which prioritises discharge to land via irrigation. If discharge to water is required then this would occur on an ebbing tide as a preference, with discharge on low tide as the least preferred option and would only occur if excess water on site needed to be discharged (e.g. following a significant rainfall event). Our assessment of effects (**Section 5.3**) considers all possible scenarios for discharge to water, as it is not possible to determine the frequency with which each of the three options would occur.

Table 8 Proposed treatment devices (Source: Torrens, 2021)

Treatment Device	Treatment / Management Target Contaminant	Proposed Implementation Timeframe
Stage 1		
Clarifier (and Holding Pond)	Dissolved Reactive Phosphorus (DRP) Some Fluoride, Heavy Metals and Total Suspended Sediments (TSS)	Within 1 year after grant of new discharge permits
Bioretention Device	Nitrogen	
Stage 2		
Settling Pond (New)	TSS	Within 5 years after grant of new discharge permits
Constructed Wetland	N, Phosphorus, Heavy Metals	
Discharge Pond	Flow	

Based on the proposed treatment devices, Aurecon (2021) have calculated predicted discharge quality, in terms of both concentrations and loads of contaminants (**Table 9**). Aurecon (2021) note that these values are based on broad assumptions around the source of contaminants and the overall removal efficacy of the proposed devices and are not based on modelling. The actual performance of the system may vary significantly depending on a range of factors. Further, they note that the reductions are those that are expected to occur as a result of the treatment processes only. A parallel effort to address the source of contaminants and implement source control measures will be undertaken and will result in further reductions that are not quantified by their analysis. These predictions are therefore likely to be highly conservative (D. Delagarza, pers. comm., September 2021).

As a result of implementation of Stage 1 treatment devices, mass loads of almost all contaminants are predicted to be reduced by at least 50% when compared with the existing discharge, and over 70% for SRP, nitrate nitrogen, TN, TSS, fluoride, copper and cadmium (**Table 9**). Chromium and zinc mass loads would not be greatly reduced by this stage but would be reduced by greater than 80% following implementation of further treatments (Stage 2). All contaminants other than ammoniacal nitrogen and fluoride would be reduced by at least 80% as a result of Stage 2 treatment, with 65% reduction in ammoniacal nitrogen and 78% reduction in fluoride over the same time period. Collectively these reductions represent a substantial reduction in overall contaminant loads entering the Ravensdown Napier discharge over a relatively short period.

Addition of a secondary clarifier is considered a potential option to address residual contamination following Stage 2 (D. Delagarza, pers. comm., Sep 2021) and is referred to as Stage 3 (**Table 10**). This would result in further reductions in most nutrients (except ammoniacal nitrogen), but not in TSS, fluoride or metals.

Table 9 Summary of existing and proposed discharge characteristics at Stage 1 and Stage 2 (Source: Aurecon, 2021 and D. Delagarza, pers. comm., Sep 2021)

Contaminant	Current				Stage 1					Stage 2				
	Existing Discharge concentration (mg/L)			Approx Annual Mass1	Proposed Discharge concentration (mg/L)[2]			Approx Annual Mass[1]	% Mass Reduction	Proposed Discharge concentration (mg/L)[2]			Approx Annual Mass[1]	% Mass Reduction
	Average	**Median**	**90%**	**kg**	**Average**	**Median**	**90%**	**kg**		**Average**	**Median**	**90%**	**kg**	
Dissolved reactive phosphorus (DRP)	9.32	7.81	17.42	1205.00	0.94	0.79	1.75	121.25	89.94%	0.72	0.60	1.34	92.76	92.30%
Ammoniacal nitrogen (NH_4-N)	6.02	1.50	17.80	231.43	2.77	0.69	8.19	106.46	54.00%	2.10	0.52	6.22	80.91	65.04%
Nitrate nitrogen (NO_3-N)	9.50	6.40	11.90	987.45	1.98	1.33	2.48	205.39	79.20%	0.44	0.30	0.56	46.21	95.32%
Nitrite nitrogen (NO_2-N)	0.94	0.22	4.00	33.94	0.38	0.09	1.62	13.78	59.40%	0.14	0.03	0.58	4.96	85.38%
Total nitrogen (TN)	14.43	9.69	31.80	1495.07	5.13	2.11	12.29	325.63	78.22%	2.69	0.86	7.36	132.08	91.17%
Total suspended solids (TSS)	9.25	10.86	19.80	1675.59	4.84	0.96	5.69	148.22	91.15%	0.19	0.04	0.23	5.93	99.65%
Fluoride (F)	5.02	4.07	9.05	627.96	0.99	0.89	1.39	137.69	78.07%	0.99	0.89	1.39	137.69	78.07%
Al	0.50	0.26	1.11	40.15	0.09	0.06	0.15	9.76	75.70%	0.039	0.028	0.067	4.39	89.06%
Cu	0.029	0.010	0.052	1.54	0.004	0.003	0.007	0.404	73.82%	0.002	0.001	0.003	0.19	87.75%
Cd	0.002	0.001	0.002	0.12	0.0005	0.0002	0.0003	0.023	81.00%	0.00004	0.00001	0.00003	0.002	98.29%
Cr	0.009	0.010	0.019	1.54	0.009	0.019	1.543	0.00	0.00%	0.001	0.001	0.002	0.15	90.10%
Zn	0.078	0.050	0.178	7.71	0.067	0.043	0.099	6.673	13.50%	0.02	0.01	0.02	1.50	80.54%

[1] Based on median levels.
[2] End of pipe concentrations.

Table 10 Summary of existing and proposed discharge characteristics with secondary clarifier installed (Source: Delagarza, pers. comm., Sep 2021).

Contaminant	Existing Discharge				Proposed Discharge				% Mass Reduction
	Average	Median	90^{th} %	Annual Mass (kg)	Average	Median	90^{th} %	Annual Mass (kg)	
Dissolved Reactive Phosphorus (DRP)	9.32	7.81	17.42	1205.00	0.01	0.01	0.01	1.56	99.97%
Ammoniacal nitrogen (NH_4-N)	6.02	1.50	17.80	231.43	2.10	0.52	6.22	80.91	65%
Nitrate nitrogen (NO_3-N)	9.50	6.40	11.90	987.45	0.09	0.06	0.11	9.24	99%
Nitrite (NO_2-N)	0.94	0.22	4.00	33.94	0.12	0.03	0.50	4.22	88%
Total nitrogen (TN)	14.43	9.69	31.80	1495.07	2.31	0.61	6.83	94.37	94%
Total suspended solids (TSS)	9.25	10.86	19.80	1675.59	0.00	0.01	0.23	1.19	99.9%
Fluoride (F)	5.02	4.07	9.05	627.96	0.99	0.89	1.01	137.69	78%
Al	0.50	0.26	1.11	40.15	0.039	0.028	0.067	4.39	89%
Cu	0.029	0.010	0.052	1.54	0.002	0.001	0.003	0.19	88%
Cd	0.002	0.001	0.002	0.12	0.000004	0.00001	0.00003	0.002	98%
Cr	0.009	0.010	0.019	1.54	0.001	0.001	0.002	0.14	91%
Zn	0.078	0.050	0.178	7.71	0.02	0.01	0.02	1.50	81%

5.2 Standards and limits to be considered

As stated previously, the ultimate receiving environment for the Ravensdown Napier discharge is the Waitangi Estuary. The receiving environment water quality standards are complex as there are overlapping regional and national requirements applying to the Waitangi Estuary, with both coastal and freshwater regulations relevant. The different regulatory documents have differing water quality requirements, with different parameters specified, and various methods of measurement. The regulatory instruments that are expected to be relevant to the Ravensdown Napier discharge are as follows:

- National Policy Statement of Freshwater Management 2020 (**NPS-FW**);
- Hawkes Bay Regional Council Coastal Environment Plan (**RCEP**); and
- Plan Change 9 TANK (Tūtaekurī, Ahuriri, Ngaruroro, Karamu) Catchment Plan (**TANK**).

5.2.1 Ravensdown Napier targets

Ravensdown has taken a conservative approach and has used the most stringent numeric receiving environment water quality standards (if there is more than one prescribed) (**Table 11**) to develop discharge quality targets for those water quality parameters included in the proposed treatment system (**Table 12**). As there is no standard for fluoride included in these instruments, a guideline developed by Hickey et al. (2004) has been applied.

Table 11 Relevant guideline values used to derive discharge targets.

Contaminant	Regulatory instrument	How is it measured	Relevant guideline[18]
Dissolved Reactive Phosphorus (DRP)	TANK	Annual median of no fewer than 8 samples in a 12 month period	0.015 mg/L (trigger value)
Ammoniacal nitrogen (NH_4-N)	TANK	Receiving environment concentration	0.1 mg/L
Nitrate nitrogen (NO_3-N)	TANK	Maximum concentration	0.05 mg/L (trigger value)
Total Nitrogen (TN)	TANK	Receiving environment concentration	0.11 mg/L (trigger value)
Total Suspended Solids (TSS)	RCEP	Receiving environment concentration	25 mg/L
Fluoride (F)	Hickey et al. (2004)	Receiving environment concentration	5mg/L
pH	TANK	Receiving environment concentration	7.0 < and < 8.5
Al			0.055 mg/L
Cu			0.013 mg/L
Cd			0.0055 mg/L
Cr			0.027 mg/L
Zn			0.015 mg/L

Table 12 Proposed discharge targets to be achieved or moved towards by 2040 (Source: Torrens, 2021).

Parameter	Currently Measured	Existing Consent Conditions	Proposed Quality Target[19]
Dissolved Reactive Phosphorus (DRP)	Yes Weekly discharge composite sample	95% - 15 mg/L 99% - 20 mg/L	Discharge concentration of 0.074 mg/L
Ammoniacal nitrogen (NH_4-N)	Yes One week composite per month	Not considered	Maximum discharge concentration of 0.49 mg/L
Nitrate nitrogen (NO_3-N)	Yes One week composite per month	Not considered	Discharge concentration of 0.245 mg/L
Total Nitrogen (TN)	Yes One week composite per month	Not considered	Discharge concentration of 0.539 mg/L

[18] 1 = HBRC Coastal Environment Plan (RCEP) (Schedule D, Surface Water Quality), 2 = TANK Waitangi Estuary (schedule 26.5.2 from s42A addendum) - 2040 target attribute state, 3 = NPS-FM (2020)
[19] Measured using a 95%ile value over any 12-month period

Parameter	Currently Measured	Existing Consent Conditions	Proposed Quality Target[19]
Total Phosphorus (TP)	Yes Weekly discharge composite sample	95% - 17 mg/L 99% - 22 mg/L	Discharge concentration of 0.196 mg/L
Suspended Solids (TSS)	Yes Weekly discharge composite sample	Maximum 100 mg/L	Maximum discharge concentration of 100 mg/L
Fluoride (F)	Yes Weekly discharge composite sample	Maximum 30 mg/L	Discharge concentration of 24.5 mg/L
pH	Yes Weekly discharge composite sample	6.5-8.5	7.0-8.5
Heavy Metals	Yes One week composite per six months	No specific concentration limits identified	Al – 0.270 mg/L Cu – 0.006 mg/L Cd – 0.027 mg/L Cr – 0.132 mg/L Zn – 0.073 mg/L Ni – 0.343 mg/L
Flow	Yes Flow meters in place on both discharge lines	Maximum 265 L/s	To be confirmed

5.2.2 Other relevant standards

In addition to those parameters included in **Table 8** the relevant regulatory instruments set standards and guidelines for parameters which are not directly targeted with the proposed treatment system. These standards and guidelines are presented in

Table 18 as part of the assessment of effects. In summary, receiving environment quality needs to be assessed against guidelines for the parameters listed in **Table 13**.

Table 13 Water quality and ecological parameters to be considered.

Parameter	Regulatory instrument[#]
Ammonia (toxicity)	1, 2
Ammoniacal nitrogen	3, 4
Biochemical oxygen demand (BOD)	3
Clarity	4
Contaminants	5
Deposited fine sediment	1
Dissolved oxygen	1, 2, 3, 4, 5
Dissolved reactive phosphorus	1, 2, 3, 4
E. coli (primary contact sites)	1
Faecal coliforms	6
Fish (rivers) (Fish Index of Biotic Integrity (F-IBI)	1
Hazardous substances	3
Macroinvertebrates (ASPM)	1

Parameter	Regulatory instrument#
Macroinvertebrates (MCI and QMCI)	1
Metals	3
Nitrate	2
Nitrate (toxicity)	1, 2
Nuisance macroalgae cover	2
Nutrients	3
Pathogenic organisms	3
Periphyton	1, 5
pH	2, 3, 5
Sediment mud content	2
Suspended fine sediment	1
Suspended Solids (mg/l)	6
Temperature	2, 3, 4, 5
Total nitrogen	2
Total phosphorus	2
Toxicants in sediments	2
Toxicants in water	2
Water column Chlorophyll a	2

1 = NPS-FM; 2 = TANK Surface Water Quality (Table 26.5.2: Waitangi Estuary Ecosystem Health (Water Quality)), 3 = HBRC Coastal Environment Plan (RCEP) (Rule 17); 4 = HBRC Coastal Environment Plan (RCEP) (Schedule D, Surface Water Quality); 5 = HBRC Coastal Environment Plan (RCEP) (Schedule E, Coastal Water Quality); 6 = HBRC Coastal Environment Plan (RCEP) (Schedule D, Tutaekuri Catchment Specific)

5.3 Assessment of ecological effects with the improved discharge

Our effects assessment firstly compares predicted receiving environment concentrations (based on the proposed discharge concentrations (**Table 9**) against the standards and guidelines that were used to derive the Ravensdown Napier discharge targets (**Table 11**). We then consider the potential effects of the proposed treatment on those parameters for which Ravensdown Napier have not set specific targets, but which are defined in relevant regulatory instruments and which will therefore need to be complied with. This also includes assessment against less stringent guidelines than those used by Ravensdown Napier for deriving their discharge targets.

5.3.1 Effects on water quality based on guidelines used to derive Ravensdown Napier discharge targets

Using the predicted discharge quality (**Table 9**) we have calculated the receiving environment concentrations for high and low tide discharge scenarios at Stage 1 (**Table 14**), Stage 2 (**Table 15)** and if an additional clarifier were added to the system (Stage 3) **(Table 16**). We have compared these receiving environment concentrations to the relevant guidelines used to derive the discharge targets (**Table 11**). We summarise the key findings of this assessment for each group of contaminants.

<u>Nutrients</u>

Despite significant reductions in mass loads of most nutrients following implementation of Stage 1 treatment devices (**Table 14**), concentrations of DRP, ammoniacal, nitrate and total nitrogen are predicted to exceed the guideline under both high and low tide scenarios (albeit with total nitrogen only exceeded at the 90th %ile concentration at high tide). Following installation of Stage 2 treatment devices (**Table 15**) total nitrogen would be below the guideline value under either tide scenario. DRP, nitrate and ammoniacal nitrogen would continue to exceed the guideline under both low and high tide scenarios. Following installation of an additional clarifier (Stage 3) (**Table 16**), DRP, nitrate and total nitrogen would be below the guideline under both low and high tide scenarios (other than the 90^{th} %ile total nitrogen at low tide), while ammoniacal nitrogen would continue to exceed the guideline values under both tide scenarios.

Metals

Again, despite significant reductions in mass loads (other than chromium), aluminium and copper concentrations would exceed guideline values under both low and high tide scenarios following Stage 1 (**Table 14**). Aluminium concentrations would not be reduced to below the guideline even after the installation of an additional clarifier (Stage 3) (**Table 16**). In contrast, copper concentrations would be reduced to below guideline values under both tide scenarios following installation of Stage 2 devices (other than the 90^{th} %ile at low tide, which persists at Stage 3 also) (**Table 15**). Concentrations of cadmium, chromium and zinc would be below guideline values following installation of Stage 1 treatment devices.

Other parameters

TSS and fluoride concentrations would be below guideline values following installation of Stage 1 treatment devices (**Table 14**).

Table 14 Predicted receiving environment concentrations under low and high tide conditions by Stage 1. Values in bold exceed guidelines (Table 11).

Contaminant	Low tide			High tide		
	Average	Median	90^{th} %ile	Average	Median	90^{th} %ile
Dissolved Reactive Phosphorus (DRP)	**0.312**	**0.262**	**0.582**	**0.187**	**0.157**	**0.349**
Ammoniacal nitrogen (NH_4-N)	**0.923**	**0.230**	**2.729**	**0.554**	**0.138**	**1.638**
Nitrate nitrogen (NO_3-N)	**0.659**	**0.444**	**0.825**	**0.395**	**0.266**	**0.495**
Total nitrogen (TN)	**0.127**	0.030	**0.541**	0.076	0.018	**0.325**
Total suspended solids (TSS)	1.709	0.704	4.096	1.025	0.422	2.457
Fluoride (F)	1.615	0.320	1.896	0.969	0.192	1.137
Al	**0.329**	**0.297**	**0.463**	**0.197**	**0.178**	**0.278**
Cu	**0.029**	**0.021**	**0.049**	**0.017**	0.013	**0.030**
Cd	0.0015	0.0009	0.0023	0.0009	0.0005	0.0014
Cr	0.00016	0.00005	0.00012	0.0001	0.00003	0.00007
Zn	0.0031	0.0033	0.0062	0.0019	0.0020	0.0037

Table 15 Predicted receiving environment concentrations under low and high tide conditions by Stage 2. Values in bold exceed guidelines (Table 11).

Contaminant	Low tide			High tide		
	Average	Median	90^{th} %ile	Average	Median	90^{th} %ile
Dissolved Reactive Phosphorus (DRP)	**0.239**	**0.200**	**0.445**	**0.143**	**0.120**	**0.267**
Ammoniacal nitrogen (NH_4-N)	**0.702**	**0.175**	**2.074**	**0.421**	**0.105**	**1.245**
Nitrate nitrogen (NO_3-N)	**0.148**	**0.100**	**0.186**	**0.089**	**0.060**	**0.111**
Total nitrogen (TN)	0.046	0.011	**0.195**	0.027	0.006	0.117
Total suspended solids (TSS)	0.896	0.285	2.455	0.537	0.171	1.473
Fluoride (F)	0.065	0.013	0.076	0.039	0.008	0.045

Contaminant	Low tide			High tide		
	Average	Median	90th %ile	Average	Median	90th %ile
Al	**0.329**	**0.297**	**0.463**	**0.197**	**0.178**	**0.278**
Cu	0.013	0.009	**0.022**	0.008	0.006	0.013
Cd	0.0007	0.0004	0.0011	0.0004	0.0002	0.0006
Cr	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001
Zn	0.0003	0.0003	0.0006	0.0002	0.0002	0.0004

Table 16 Predicted receiving environment concentrations under low and high tide conditions with secondary clarifier installed (Stage 3). Values in bold exceed guidelines (Table 11).

Contaminant	Low tide			High tide		
	Average	Median	90th %ile	Average	Median	90th %ile
Dissolved Reactive Phosphorus (DRP)	0.003	0.003	0.003	0.002	0.002	0.002
Ammoniacal nitrogen (NH_4-N)	**0.702**	**0.175**	**2.074**	**0.421**	**0.105**	**1.245**
Nitrate nitrogen (NO_3-N)	0.030	0.020	0.037	0.018	0.012	0.022
Total nitrogen (TN)	0.039	0.009	**0.166**	0.023	0.005	0.099
Total suspended solids (TSS)	0.770	0.204	2.277	0.462	0.122	1.366
Fluoride (F)	0.001	0.003	0.076	0.000	0.002	0.045
Al	**0.329**	**0.297**	**0.338**	**0.197**	**0.178**	**0.203**
Cu	0.013	0.009	**0.022**	0.008	0.006	0.013
Cd	0.0007	0.0004	0.0011	0.0004	0.0002	0.0006
Cr	0.000001	0.000004	0.000010	0.000001	0.000002	0.000006
Zn	0.0003	0.0003	0.0006	0.0002	0.0002	0.0004

5.3.2 Compliance of predicted concentrations with other standards or guidelines

For completeness, we have compared predicted concentrations of water quality parameters against other numeric standards than those used to derive the Ravensdown Napier discharge targets (Table 13). The results of this analysis are presented in **Table 17** and discussed below.

Nutrients

Ammonia toxicity guidelines would be met under the high tide scenario following Stage 1, whereas under the low tide scenario these would not be met until Stage 3. Ammoniacal nitrogen concentrations would meet some guidelines following Stage 1, but would not meet others at all. Nitrate toxicity guidelines would be met following Stage 1 or 2, while nitrate guidelines would be met following Stage 2 or 3. Total nitrogen guidelines would be met generally following Stage 1 or 2. DRP guidelines would not be met until Stage 3.

Metals

Concentrations of all metals other than aluminium and copper would meet guidelines after Stage 1. Copper would meet these guidelines following Stage 2 (other than 90th %ile), whereas aluminium concentrations would exceed guidelines even after Stage 3.

Other parameters

TSS concentrations would meet the guideline following implementation of treatments proposed in Stage 1.

Table 17 Assessment of compliance with other standards or guidelines based on predicted concentrations.

Objective or target	Regulatory instrument	Standard	Based on predicted concentrations
Aluminium	HBRC Coastal Environment Plan (RCEP) (Rule 17)	must not exceed ANZECC (2000[20]) guidelines = 0.055 mg/L (Freshwater, DGV)	Predicted concentrations would not meet the guideline.
Ammonia toxicity	NPS-FM (2020) Attribute state	0.24 mg NH_4-N/L (NBL[21]) (annual median) (rivers and lakes)	Median concentrations would be below this guideline after Stage 1 under high tide scenario but not low tide. Low tide concentrations would not be below the guideline until Stage 3.
	TANK Surface Water Quality (Table 26.5.2: Waitangi Estuary Ecosystem Health (Water Quality)	Annual maxima for 12 month period when corrected for pH and temperature: 95% species protection <0.46 mg/L	Median concentrations would be below this guideline after Stage 1 under high tide scenario but not low tide. Low tide concentrations would not be below the guideline until Stage 3.
Ammoniacal nitrogen	HBRC Coastal Environment Plan (RCEP) (Rule 17) HBRC Coastal Environment Plan (RCEP) (Schedule D, Surface Water Quality)	not to exceed 0.1 mg/L after reasonable mixing	Concentrations would not meet this guideline.
	HBRC Coastal Environment Plan (RCEP) (Rule 17)	must not exceed ANZECC (2000) guidelines[22] = 0.91 mg/L, 80th %ile	Median low tide and average and median high tide concentrations would be below this guideline after Stage 1. 90th %ile concentrations would not meet this guideline.
Cadmium	HBRC Coastal Environment Plan (RCEP) (Rule 17)	must not exceed ANZECC (2000) guidelines = 0.0055 mg/L (Marine, DGV)	Median concentrations would be below this guideline after Stage 1 under high and low tide scenarios.
Chromium	HBRC Coastal Environment Plan (RCEP) (Rule 17)	must not exceed ANZECC (2000) guidelines = 0.027 mg/L , Freshwater, DGV, Cr III)	Median concentrations would be below this guideline after Stage 1 under high and low tide scenarios.
Copper	HBRC Coastal Environment Plan (RCEP) (Rule 17)	must not exceed ANZECC (2000) guidelines = 0.0013 mg/L, Marine, DGV)	Concentrations would be reduced to below guideline values under both tide scenarios after Stage 2 (other than 90th %ile under low tide).
Dissolved Reactive Phosphorus (DRP)	NPS-FM (2020) Attributes requiring action plans	Needs to be determined based on current state (median of monthly monitoring over 5 years): Attribute Band C Annual	Concentrations would be reduced to below the guideline after Stage 3.

[20] ANZG (2018) default trigger values for 95% protection level as the ANZECC (2000) guidelines have been superseded.
[21] National Bottom Line

Objective or target	Regulatory instrument	Standard	Based on predicted concentrations
		median >0.010, ≤0.018 and 95th %ile >0.030, ≤0.054	
	TANK Surface Water Quality (Table 26.5.2: Waitangi Estuary Ecosystem Health (Water Quality)	Annual median of no less than 8 samples in a 12 month period: <0.02 mg/L with improving trend where trigger exceeded	Concentrations would be reduced to below the guideline after Stage 3 under both tide scenarios.
	HBRC Coastal Environment Plan (RCEP) (Schedule D, Surface Water Quality)	not to exceed 0.015 mg/L after reasonable mixing	Concentrations would be reduced to below the guideline after Stage 3 under both tide scenarios.
	HBRC Coastal Environment Plan (RCEP) (Rule 17)		
Nickel	HBRC Coastal Environment Plan (RCEP) (Rule 17)	must not exceed ANZECC (2000) guidelines = 0.07 mg/L, Marine, DGV	Median concentrations would be below this guideline after Stage 1 under high and low tide scenarios.
Nitrate	HBRC Coastal Environment Plan (RCEP) (Rule 17)	must not exceed ANZECC (2000) guidelines[23] = 0.195 mg/L, 80th %ile	Average and median concentrations would be below this guideline under the high tide scenario after Stage 3
	TANK Surface Water Quality (Table 26.5.2: Waitangi Estuary Ecosystem Health (Water Quality)	Annual median of no less than 8 samples in a 12 month period: < 0.26 mg/L with improving trend where trigger exceeded	Median high and low tide concentrations would meet this guideline after Stage 2.
Nitrate (toxicity)	NPS-FM (2020) Attribute state	2.4 mg/L NO_3-N/L (NBL) (annual median) (rivers)	Median high and low tide concentrations would meet this guideline after Stage 1.
	TANK Surface Water Quality (Table 26.5.2: Waitangi Estuary Ecosystem Health (Water Quality)	Annual median ≤0.26 mg/L; Annual 95th %ile ≤0.57 mg/L (Hazen method)	Median high and low tide concentrations would meet this guideline after Stage 2
Suspended Solids (TSS)	HBRC Coastal Environment Plan (RCEP) (Schedule D, Tutaekuri Catchment Specific[24])	25 mg/L	High and low tide concentrations would meet this guideline after Stage 1.
Total Nitrogen	TANK Surface Water Quality (Table 26.5.2: Waitangi Estuary Ecosystem Health (Water Quality)	Annual median of no less than 8 samples in a 12 month period: < 0.45 mg/L with improving trend where trigger exceeded	Median high and low tide concentrations would meet this guideline after Stage 1 (other than 90th %ile low tide).
	HBRC Coastal Environment Plan (RCEP) (Rule 17)	must not exceed ANZECC (2000) guidelines = 0.281, 80th %ile	90th %ile high and low tide concentrations would meet this guideline after Stage 2.
Zinc	HBRC Coastal Environment Plan (RCEP) (Rule 17)	must not exceed ANZECC (2000) guidelines = 0.015 mg/L, Marine, DGV	Median concentrations would be below this guideline after Stage 1 under high and low tide scenarios.

95% protection level beyond mixing zone as moderately disturbed environment.
* Also included as a requirement under Schedule D of the RCEP as surface water quality standards
[24] Tutaekuri River downstream of the Expressway Bridge

5.3.3 Compliance of monitoring data with standards or guidelines

As we do not have predicted values for all water quality parameters in formats directly comparable with standard or guideline values, we have used monitoring data from the last 5 years at the site on the Awatoto Drain immediately beyond the mixing zone (AW6/SW10) to assess whether compliance would be achieved (

Table 18). Assuming that the treatments proposed will improve the discharge quality, then compliance of the current receiving environment quality with these guidelines would indicate that the future receiving environment quality would also meet these guidelines.

Most contaminants would not meet the guideline which requires no more than 5% increase in concentration after reasonable mixing, with more frequent exceedances under ambient than rainfall conditions due to dilution effects. We note that this guideline does not take into account whether or not the concentrations present an adverse effect through, for example, exceedance of a guideline.

The ANZG (2018) guidelines for copper, aluminium, chromium, zinc, ammoniacal nitrogen, total nitrogen, total phosphorus and DRP have been exceeded downstream of the discharge (**Section 4.2.2**). However, it is important to place this in a spatial context. Upstream concentrations of these contaminants also exceed these guidelines and in some cases to a greater extent than downstream of the discharge. For example, zinc concentrations upstream of the discharge exceed the guideline for 80% level of protection, whereas downstream concentrations only exceed the 95% level of protection. In addition, ammoniacal nitrogen and total nitrogen concentrations are comparable between upstream and downstream sites. Also, TP and DRP concentrations are higher upstream than downstream, with the 95% level of protection being exceeded at all sites monitored. Under rainfall conditions some short term increases in concentrations are recorded downstream but remain comparable with ambient conditions in terms exceedance of guidelines.

It should also be noted that most of these contaminants will be significantly reduced in concentration once Stage 1 or 2 treatment devices are installed and would not exceed guidelines based on predicted receiving environment concentrations (**Table 17**). Only aluminium and ammoniacal nitrogen would continue to exceed guidelines following implementation of Stages 1 and 2. While predicted discharge concentrations of TP are not available, it is assumed that this would be largely derived from DRP and hence would be expected to meet guidelines following Stage 3 (**Table 10**).

Of the remaining parameters for which data are available, pH and temperature would be expected to meet guidelines. While dissolved oxygen concentrations have been recorded below the 80% saturation guideline, limited data indicate that a summer 1 day minimum temperature would most likely be met. We consider that it is unlikely that the discharge would significantly reduce temperature or dissolved oxygen levels.

While there are no data suitable for direct assessment of clarity or suspended fine sediment, we note that TSS concentrations would meet the guideline following installation of Stage 1 treatment devices. In addition, TSS concentrations upstream of the discharge have been higher than downstream.

There is no data available to assess the Fish IBI metric.

Some parameters which are included in **Table 18** are considered unlikely to be relevant to the Ravensdown Napier discharge (namely E. coli, pathogens, BOD and faecal coliforms, which tend to be associated with organic wastewater streams) or are unsuitable for use in brackish waters (MCI, QMCI and ASPM, which are derived for freshwater environments). Therefore, no further comment is provided on these parameters.

Table 18 Assessment of compliance with other standards or guidelines based on monitoring data (2014 – 2019).

Objective or target	Regulatory instrument	Standard	Concentration after reasonable mixing
Aluminium	HBRC Coastal Environment Plan (RCEP) (Rule 17)	concentration must not increase by >5%, after reasonable mixing	Under ambient conditions, 55% of occasions concentrations increase by >5% downstream Under rainfall conditions 36% of occasions concentrations increase by >5% downstream
Ammoniacal nitrogen	HBRC Coastal Environment Plan (RCEP) (Rule 17)	concentration must not increase by >5%, after reasonable mixing	Under ambient condition, 18% of occasions concentrations increase by >5% downstream Under rainfall conditions 9% of occasions concentrations increase by >5% downstream
Biochemical oxygen demand (BOD)	HBRC Coastal Environment Plan (RCEP) (Rule 17)	< 2 g/m^3 after reasonable mixing	No data available
Cadmium	HBRC Coastal Environment Plan (RCEP) (Rule 17)	concentration must not increase by >5%, after reasonable mixing	Under ambient condition, 16% of occasions concentrations increase by >5% downstream Under rainfall conditions 22% of occasions concentrations increase by >5% downstream
Chromium	HBRC Coastal Environment Plan (RCEP) (Rule 17)	concentration must not increase by >5%, after reasonable mixing	Under ambient condition, 18% of occasions concentrations increase by >5% downstream Under rainfall conditions 0% of occasions concentrations increase by >5% downstream
Clarity	HBRC Coastal Environment Plan (RCEP) (Schedule D, Surface Water Quality)	In areas used for contact recreation, the horizontal sighting range of the 200mm black disk shall exceed 1.6m	No data available
Contaminants	HBRC Coastal Environment Plan (RCEP) (Schedule E, Coastal Water Quality)	any discharge into water that results in adverse effects on aquatic life	Some nutrients and metals exceed guideline values
Copper	HBRC Coastal Environment Plan (RCEP) (Rule 17)	concentration must not increase by >5%, after reasonable mixing	Under ambient condition, 33% of occasions concentrations increase by >5% downstream Under rainfall conditions 0% of occasions concentrations increase by >5% downstream
Deposited fine sediment	NPS-FM (2020) Attributes requiring action plans	NBL ranges between 21 and 29% cover, depending on sediment class	No data available
Dissolved oxygen	HBRC Coastal Environment Plan (RCEP) (Rule 17)	not less than 80% after reasonable mixing	Under ambient condition, 34% of occasions concentrations were less than 80%.

Objective or target	Regulatory instrument	Standard	Concentration after reasonable mixing
	HBRC Coastal Environment Plan (RCEP) (Schedule D, Surface Water Quality)		Data too limited to assess under rainfall conditions
	HBRC Coastal Environment Plan (RCEP) (Schedule E, Coastal Water Quality)		
	NPS-FM (2020) Attribute state	5.0 mg/L (NBL) (7 day mean minimum, summer period: 1 November to 30th April), 4.0 mg/L (1 day minimum, summer period)	Based on monthly sampling 100% of samples comply with the 1 day minimum.
	TANK Surface Water Quality (Table 26.5.2: Waitangi Estuary Ecosystem Health (Water Quality)	Summer monitoring; 7 day mean ≥7.0 mg/L, 7 day minimum ≥6.0 mg/L; 1 day minimum 5.0 mg/L	Based on monthly sampling 97% of samples comply with the 1 day minimum.
Dissolved Reactive Phosphorus (DRP)	HBRC Coastal Environment Plan (RCEP) (Rule 17)	concentration must not increase by >5%, after reasonable mixing	Under ambient condition, 19% of occasions concentrations increase by >5% downstream Under rainfall conditions 18% of occasions concentrations increase by >5% downstream
E. coli (primary contact sites)	NPS-FM (2020) Attribute state	540 E. coli/100ml (95th %ile) (NBL)	No data available.
Fish (rivers) (Fish Index of Biotic Integrity (F-IBI)	NPS-FM (2020) Attributes requiring action plans	Average IBI	No data available.
Faecal coliforms	HBRC Coastal Environment Plan (RCEP) (Schedule D, Tutaekuri Catchment Specific)	150 cfu/100ml	No data available
Fluoride	HBRC Coastal Environment Plan (RCEP) (Rule 17)	concentration must not increase by >5%, after reasonable mixing	Under ambient condition, 18% of occasions concentrations increase by >5% downstream Under rainfall conditions 9% of occasions concentrations increase by >5% downstream
Hazardous substances	HBRC Coastal Environment Plan (RCEP) (Rule 17)	concentration must not increase by >5%, after reasonable mixing	No data available for substances other than metals and nutrients
Macroinvertebrates (ASPM)	NPS-FM (2020) Attributes requiring action plans	0.3 (NBL)	ASPM not appropriate for brackish waters
Macroinvertebrates (MCI and QMCI)	NPS-FM (2020) Attributes requiring action plans	MCI = 90, QMCI = 4.5 (NBLs)	MCI is for use in freshwaters and is therefore not appropriate for brackish waters
Nickel	HBRC Coastal Environment Plan (RCEP) (Rule 17)	concentration must not increase by >5%, after reasonable mixing	Under ambient condition, 17% of occasions concentrations increase by >5% downstream Under rainfall conditions 0% of occasions concentrations increase by >5% downstream
Nitrate	HBRC Coastal Environment Plan (RCEP) (Rule 17)	concentration must not increase by >5%, after reasonable mixing	Under ambient condition, 22% of occasions concentrations increase by >5% downstream

Objective or target	Regulatory instrument	Standard	Concentration after reasonable mixing
			Under rainfall conditions 9% of occasions concentrations increase by >5% downstream
Nitrite	HBRC Coastal Environment Plan (RCEP) (Rule 17)	concentration must not increase by >5%, after reasonable mixing	Under ambient condition, 19% of occasions concentrations increase by >5% downstream Under rainfall conditions 18% of occasions concentrations increase by >5% downstream
Nitrite+ Nitrate-N	HBRC Coastal Environment Plan (RCEP) (Rule 17)	concentration must not increase by >5%, after reasonable mixing	Under ambient condition, 21% of occasions concentrations increase by >5% downstream Under rainfall conditions 9% of occasions concentrations increase by >5% downstream
Nuisance macroalgae cover	TANK Surface Water Quality (Table 26.5.2: Waitangi Estuary Ecosystem Health (Water Quality)	To be confirmed	Limited data available
Pathogenic organisms	HBRC Coastal Environment Plan (RCEP) (Rule 17)	no increase	No data available
		must not exceed contact recreation microbiological guidelines (MfE, 2003)	No data available
Periphyton	HBRC Coastal Environment Plan (RCEP) (Schedule E, Coastal Water Quality)	No undesirable biological growths as a result of any discharge of a contaminant into the water	Limited data available. No evidence of excessive macrophyte growth.
	NPS-FM (2020) Attribute state	200 mg Chla/m^2(NBL[25]) (exceeded no more than 8% of samples) (rivers)	No data available
pH	HBRC Coastal Environment Plan (RCEP) (Rule 17)	change <0.2 units or outside range of 6.5 to 9.0, after reasonable mixing	Under ambient conditions, pH >0.2 units on 13% of occasions; pH values within specified range on all occasions Under rainfall conditions, pH has been ≥0.2 units in receiving environment on 36% of occasions; pH values within specified range on all occasions
	HBRC Coastal Environment Plan (RCEP) (Schedule E, Coastal Water Quality)	any change that results in adverse effects on aquatic life	pH has always been between 6.5 and 9.0 under both ambient and rainfall conditions.
	TANK Surface Water Quality (Table 26.5.2: Waitangi Estuary Ecosystem Health (Water Quality)	Daily summer maxima: pH is greater than 7.0 and less than 8.5	pH has never been less than 7.0 under either ambient or rainfall conditions, and has been >8.5 on 4% of occasions (ambient conditions only).
Sediment mud content	TANK Surface Water Quality (Table 26.5.2: Waitangi Estuary Ecosystem Health (Water Quality)	% composition. Areal extent of soft mud should not increase from current extent	No data available
Sulfur	HBRC Coastal Environment Plan (RCEP) (Rule 17)	concentration must not increase by >5%, after reasonable mixing	Under ambient condition, 6% of occasions concentrations increase by >5% downstream

[25] NBL = National Bottom Line

Objective or target	Regulatory instrument	Standard	Concentration after reasonable mixing
			Under rainfall conditions 9% of occasions concentrations increase by >5% downstream
Suspended fine sediment	NPS-FM (2020) Attribute state	Measured as visual clarity	No data available
Temperature	HBRC Coastal Environment Plan (RCEP) (Rule 17)	not greater than 3 deg C after reasonable mixing	There has only been 1 exceedance of this standard under ambient conditions and no exceedances under rainfall conditions, with the downstream site being 3.2 deg C higher than within the mixing zone.
	HBRC Coastal Environment Plan (RCEP) (Schedule E, Coastal Water Quality)		
	TANK Surface Water Quality (Table 26.5.2: Waitangi Estuary Ecosystem Health (Water Quality)		
	HBRC Coastal Environment Plan (RCEP) (Schedule D, Surface Water Quality)	temperature shall be suitable for sustaining aquatic life	Average temperatures at all sites have been comparable and less than 3 deg C change on all but 1 occasion.
Total Kjeldahl Nitrogen	HBRC Coastal Environment Plan (RCEP) (Rule 17)	concentration must not increase by >5%, after reasonable mixing	Under ambient condition, 18% of occasions concentrations increase by >5% downstream Under rainfall conditions 9% of occasions concentrations increase by >5% downstream
Total Nitrogen	HBRC Coastal Environment Plan (RCEP) (Rule 17)	concentration must not increase by >5%, after reasonable mixing	Under ambient condition, 19% of occasions concentrations increase by >5% downstream Under rainfall conditions 9% of occasions concentrations increase by >5% downstream
Total Phosphorus	HBRC Coastal Environment Plan (RCEP) (Rule 17)	concentration must not increase by >5%, after reasonable mixing	Under ambient condition, 19% of occasions concentrations increase by >5% downstream Under rainfall conditions 18% of occasions concentrations increase by >5% downstream
		must not exceed ANZECC (2000) guidelines = 0.023 mg/L, 80th %ile	Under ambient conditions, 100% of samples have exceeded this value
	TANK Surface Water Quality (Table 26.5.2: Waitangi Estuary Ecosystem Health (Water Quality)	Annual median of no less than 8 samples in a 12 month period: <0.04 mg/L with improving trend where trigger exceeded	Annual median = 0.88 mg/L under ambient conditions and 2.2 mg/L under rainfall conditions.
Toxicants in sediments	TANK Surface Water Quality (Table 26.5.2: Waitangi Estuary Ecosystem Health (Water Quality)	Annual median site replicates: Does not exceed the interim sediment quality guidelines (ISQG) - High	ISQG-High values have not been exceeded on any occasion
Toxicants in water	TANK Surface Water Quality (Table 26.5.2: Waitangi Estuary Ecosystem Health (Water Quality)	Does not exceed 95% level of protection in ANZG 2018	See specific metals

Objective or target	Regulatory instrument	Standard	Concentration after reasonable mixing
Water column Chlorophyll a	TANK Surface Water Quality (Table 26.5.2: Waitangi Estuary Ecosystem Health (Water Quality)	Annual median of no less than 8 samples in a 12 month period: <0.001 mg/L	Average annual median = 0.005 mg/L (detection limit = 0.003 mg/L)
Zinc	HBRC Coastal Environment Plan (RCEP) (Rule 17)	concentration must not increase by >5%, after reasonable mixing	Under ambient condition, 33% of occasions concentrations increase by >5% downstream Under rainfall conditions 0% of occasions concentrations increase by >5% downstream

5.3.4 Effects on marine ecology

Currently, the ecological values of the receiving environment are assessed as being low. This is due to the cumulative effect of a number of historical and ongoing activities in the catchment (including discharges from Ravensdown).

As part of its discharge strategy, Ravensdown has proposed a Habitat Abundance Restoration Project (HARP) within the estuary. This will include development of a wetland within an area encompassing the Ravensdown Drain and part of the Awatoto Drain. Once the proposed HARP wetland area has been established, the Ravensdown discharge will be used to augment the water supply to the wetland, which will be primarily supplied by a dedicated bore water flow. The activities proposed to further treat the discharges from Ravensdown before discharge to the marine/estuarine receiving environment and wetland are likely to assist with increasing these ecological values, through improvements in water quality.

5.3.5 Overall summary of effects

Water quality monitoring indicates that the Ravensdown Napier discharge is likely to be contributing nickel, copper and aluminium to the receiving environment at levels above effects guidelines, with localised increases in concentrations during wet weather events. Significant improvement in water quality is predicted following the introduction of treatment devices in conjunction with the overall discharge management strategy. While this treatment is predicted to reduce both loads and concentrations of most contaminants, concentrations of some contaminants, in particular aluminium and ammoniacal nitrogen, are predicted to continue to exceed guidelines. As the concentrations of these contaminants are actually higher upstream than downstream of the discharge, this means Ravensdown Napier has no ability to meet these guidelines in isolation from other contributions. Despite these exceedances, there is no evidence to indicate that the discharge is having more than a minor effect on ecological values beyond the mixing zone. The improvement in water quality is likely to have a positive effect on existing low ecological values.

5.4 Monitoring and mitigation

Continued monitoring of the discharge at the frequency defined in the current consent conditions, but with an extended set of parameters to allow for monitoring against compliance with the discharge targets (**Table 12**).

Ravensdown Napier has an established receiving environment monitoring programme which is designed to characterise ambient and rainfall-affected receiving environment quality. In addition, 5 yearly ecological assessments are undertaken to determine potential changes in benthic communities, sediment composition and quality, as well as ecotoxicity associated with the Ravensdown Napier discharge. An ecological monitoring plan is prepared prior to each monitoring period and approved by Hawkes Bay Regional Council to ensure fit for purpose. A robust data set has been compiled since this monitoring was initiated, providing a valuable resource for assessing trends. It is recommended that this monitoring continue. Based on our assessment of the relevant regulatory standards, the following changes to the monitoring programme are recommended:

1. Chlorophyll a determination – use an appropriate analytical method with a reduced the detection limit to 0.001 mg/L to allow comparison with the relevant guideline
2. Add clarity measurements to the monitoring programme
3. If it is considered necessary to calculate Fish IBI, then fish monitoring would need to be added to the 5 yearly monitoring programme.

It is also recommended that the timing of the receiving environment monitoring be linked to the staging of the implementation of the treatment devices and the overall water discharge strategy.

While the proposed treatment will substantially reduce the loads and concentrations of a range of water quality parameters in the discharge and receiving environment, it is evident that tidal state is a significant factor in minimising adverse ecological effects. It is therefore recommended that if discharge to water is required, it be undertaken on an ebbing tide. This recommendation is consistent with the proposed discharge strategy.

6. References

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