Moa Point WWTP

Assessment of Effects of Reduced Hydraulic Capacity

PREPARED FOR Wellington Water | July 2023

We design with community in mind

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Revision schedule

Rev No	Date	Description	Signature of Typed Name (documentation on file)		
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Stantec
Wellington, New Zealand
Stantec House, Level 15, 10 Brandon Street
Wellington 6011
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Abbreviations

Enter Abbreviation	Enter Full Name
ADF	Average daily flow
ADWF	Average dry weather flow
Annual average daily mean flow	The daily mean flow, in litres per second, averaged over the year.
$cBOD_5$	Five-day carbonaceous biochemical oxygen demand
cfu	Colony forming units
CMA	Coastal Marine Area
DGV	Default guideline value
FC	Faecal coliform
g/m^3	Grams per cubic metre
L/s	Litres per second
m^3	Cubic metres
mg/L	Milligrams per litre
m/s	Meters per second
pNRP	Proposed Natural Resources Plan
PWWF	Peak Wet Weather Flow
TD	Total dilution
TSS	Total suspended solids
UV	Ultraviolet irradiation
WWTP	Moa Point Wastewater Treatment Plant

1 Introduction

1.1 Purpose of this report

Wellington Water proposes to replace the UV disinfection equipment at Moa Point Wastewater Treatment Plant (WWTP) as the existing equipment has reached the end of its useful life and soon will no longer be supported by the supplier. The new UV disinfection system must achieve disinfection compliance over the expected 20-year life of the new equipment and accommodate any additional load and increase in flow. It is anticipated that during the staged construction/installation process, flows to secondary treatment and UV disinfection would be reduced by 50%, with any excess flow bypassing these units.

The purpose of this report is to characterise the likely frequency and quality of bypass discharges while the WWTP is operating at reduced capacity, and to provide a high-level assessment of the potential effects of those discharges via the ocean outfall on the marine ecology and recreational water quality of Wellington's south coast.

1.2 Proposed activity

Replacement of the WWTP TrojanUV4000 system equipment is required because of its age and the upcoming lack of replacement parts. The difficulty of undertaking the physical works, as well as the requirement for replacement equipment that may be influenced by the impending sludge processing changes at the WWTP site, make it a complex project. The existing UV equipment is in a below ground building with limited access and a tight footprint. The existing equipment was installed, and the building constructed around it. Removal of the old medium pressure UV system and installation of the new equipment will need to be carefully planned, designed and managed by an experienced contractor. It is expected that the new UV equipment will need to be physically larger than the existing UV system and some civil works would be required on the plant's UV channels to house the new equipment.

An important initial phase in this project is to understand quantitatively what disinfection capability can be installed within the existing UV channels, whilst understanding what hydraulics can be maintained. Initial thoughts are that a staged construction/installation can be implemented in which one of the two existing UV channels will be taken offline whilst the new equipment is installed and commissioned in this channel prior to the conversion of the second channel for the new equipment.

The scenario considered in this assessment is that flow to secondary treatment and UV disinfection will be limited to approximately 1500L/s for the duration of the upgrade works due to one of the UV channels being taken offline.

1.3 Existing consents

The WWTP operates under three discharge permits which authorise:

- A continuous discharge of treated wastewater into the Coastal Marine Area (CMA) via an existing submarine outfall (WGN080003[31505]).
- An occasional discharge up to 4,500 litres per second of mixed disinfected secondary treated and milli-screened wastewater to the coastal marine area via an existing submarine outfall during and/or immediately after heavy rainfall, when the quantity of wastewater arriving at the Moa Point Wastewater Treatment Plant exceeds 3,000 litres per second (WGN080003[35047]).
- A continuous discharge of contaminants to air (including odour) from the WWTP air ventilation system (WGN080003[26183]).

During the replacement of the UV equipment, the existing discharge consent limits may not be able to be met in wet weather high flow conditions. Discussion will be required with Greater Wellington District Council (GWRC) on how to manage compliance and enforcement risks.

2 Other operations and maintenance issues

In addition to the need to replace the aging UV irradiation system, Wellington Water has recently been faced with several other challenges including:

- A period extending from mid-2020 to mid-2021 when several operational challenges at the WWTP resulted in poor treatment performance and on-going non-compliance with discharge standards for BOD, TSS and faecal coliforms bacteria.
- Failure of a slew bearing on clarifier 3 on 18 January 2022 resulting in clarifier 3 being taken off-line for repair. During the period that clarifier 3 was offline the hydraulic capacity of the plant was reduced from 3,000 L/s to approximately 2,200 L/s. The reduced capacity increased the frequency of bypass discharges, as described in the next section. Clarifier 3 has been repaired and was back in operation on 21 April 2023.
- The bearings in clarifiers 1 and 2 need to be inspected and might also need to be replaced. One of these clarifiers would possibly be replaced in combination with the UV upgrade.

3 Characterisation of bypass events

Wastewater is received at the Inlet Pump Station where up to 10 submersible pumps transfer it to the WWTP inlet works. The pumps operate at a fixed speed, they are either fully on or off, which results in stepwise changes of approximately 400-450 L/s in the inlet flow rate as the number of pumps required increases or decreases.

During normal operation of the Moa Point WWTP, the hydraulic capacity of the primary sedimentation tanks, biological process unit, clarifiers and UV disinfection unit is limited to 3,000L/s. During heavy rainfall, wastewater flows to the WWTP greater than 3,000 L/s, having passed through the step screens and grit removal unit, automatically bypass the above units (primary sedimentation tanks, biological process unit, clarifiers and UV disinfection). They then mix with the secondary treated wastewater, and the combined flow is discharged through the long (1.87 km) outfall to Cook Strait (Figure 3-1).

If one clarifier is taken out of operation **for maintenance**, the treatment capacity of the WWTP is reduced to approximately 2,200 L/s. The reduced capacity results in more frequent bypass discharges and, at such times, a greater proportion of partially treated wastewater in the final discharge. If one of the two UV channels is taken offline during the proposed upgrade the treatment capacity of the WWTP would be reduced to approximately 1500L/s.

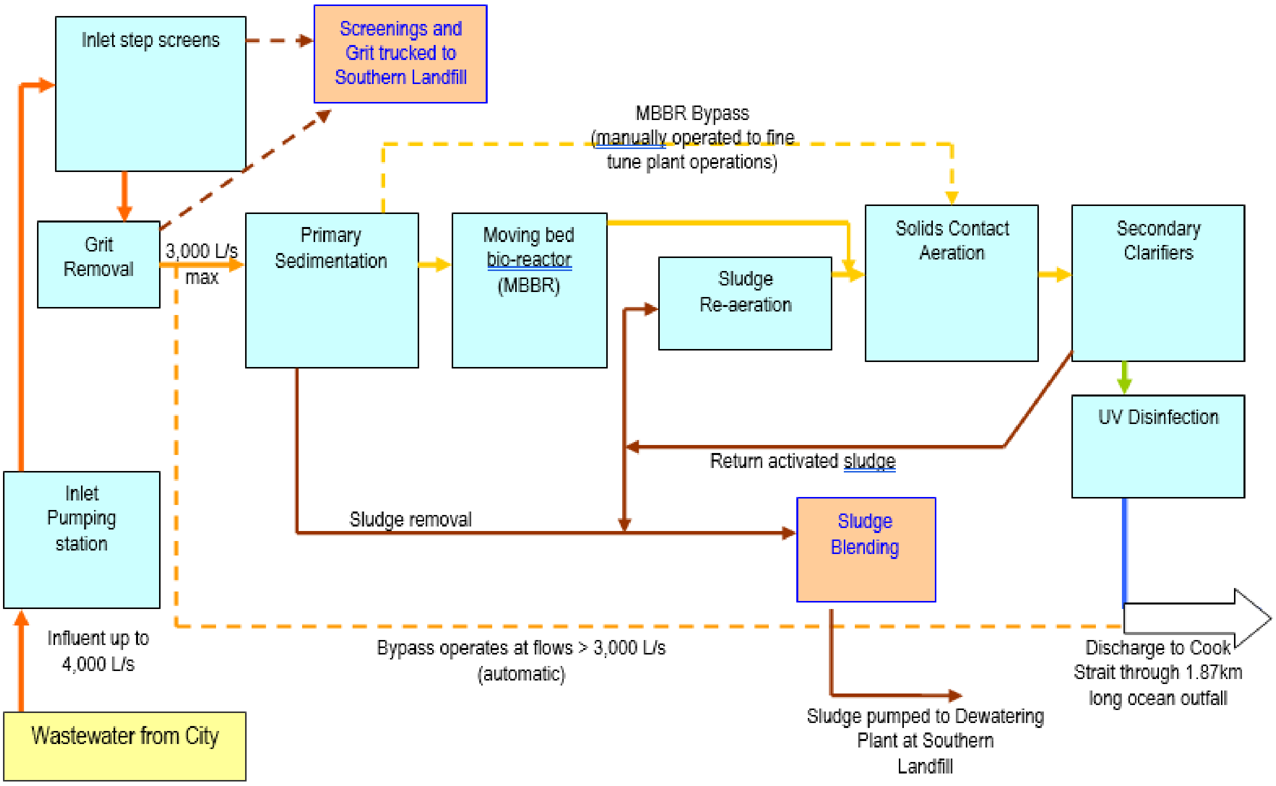

Figure 3-1: Schematic of Moa Point wastewater treatment processes

3.1 Flow statistics and bypass record

Over the five years from 2018 to 2022 the annual average daily mean effluent flow has varied between 661 and 907 L/s, the annual average daily peak flow varied between 1462 and 1760 L/s and the annual peak flow was typically close to 4000 L/s (Table 3-1). Bypass events normally occur when the inflow exceeds 3,000 L/s during sustained periods of wet weather, however the reduction in the WWTP treatment capacity in February 2022 together with the increased flows observed in 2022 resulted in an increase in the number of bypass events. In total, 14 bypass events of greater than 2 hours duration were recorded during 2022.

Table 3-1: Moa Point WWTP effluent flow statistics for years 2018 to 2022

Year	Annual average daily mean flow (L/s)	Annual average daily peak flow (L/s)	Peak flow (L/s)	Number of bypass events
2018	894	1,760	4,000	2
2019	731	1,550	4,000	2
2020	661	1,323	3,482	4
2021	825	1,462	4,000	4
2022	907	1,754	3,812	14

Notes: Bypass events with a duration of 2 hours or less are excluded.
Bypass events separated by less than 24 hours are treated a single event.
Flow data for the 2022 year is from the influent flow meter because the effluent flow meter is experiencing calibration issues which are yet to be resolved.

Table 3-2 and Figure 3-2 summarise the 27 bypass events of greater than 2 hours duration that occurred from February 2018 to December 2022.

Table 3-2: Moa Point WWTP bypass events from Feb 2018 to January 2023

Event	Duration (hr:min)	Bypass volume (m^3)	Volume treated during bypass (m^3)	Dilution ratio (treated: bypass)
20 Feb 2018	15:12	6,841	145,113	21:1
08 Jul 2018	11:02	7,304	97,549	13:1
11 Apr 2019	4:56	6,349	59,315	9:1
11 Nov 2019	9:34	11,447	92,135	8:1
29 Mar 2020	2:49	3,033	28,408	9:1
18 Jun 2020	27:50	19,724	212,757	11:1
8 Nov 2020	4:40	2,928	46,327	16:1
30 Nov 2020	4:31	3,199	54,181	17:1
31 May 2021	2:37	2,177	28,014	13:1
17 Jul 2021	16:17	24,774	171,145	7:1
6 Dec 2021	30:30	20,528	341,289	17:1
15 Dec 2021	2:05	222	21,130	95:1
5 Feb 2022	35:58	2,209	255,139	115:1
12 Feb 2022	28:56	52,828	264,480	5:1
20 Feb 2022	4:54	1,863	46,724	25:1
1 June 2022	25:22	49,110	111,930	2:1
9 June 2022	49:15	73,885	171,241	2:1
8 Jul 2022	2:09	124	18,419	148:1
12 Jul 2022	10:28	823	99,273	121:1
19 Jul 2022	44:13	13,251	383,549	23:1
26 Jul 2022	2:33	153	24,644	131:1
30 Jul 2022	38:08	15,301	333,397	17:1
8 Aug 2022	36:27	1,067	336,435	254:1
18 Aug 2022	59:10	27,110	557,086	17:1
30 Sep 2022	10:22	801	106,000	109:1
9 Dec 2022	2:37	1,918	22,596	12:1

Notes: Discharge events with a duration of 2 hours or less are excluded
Discharge events separated by less than 24 hours are treated a single event.

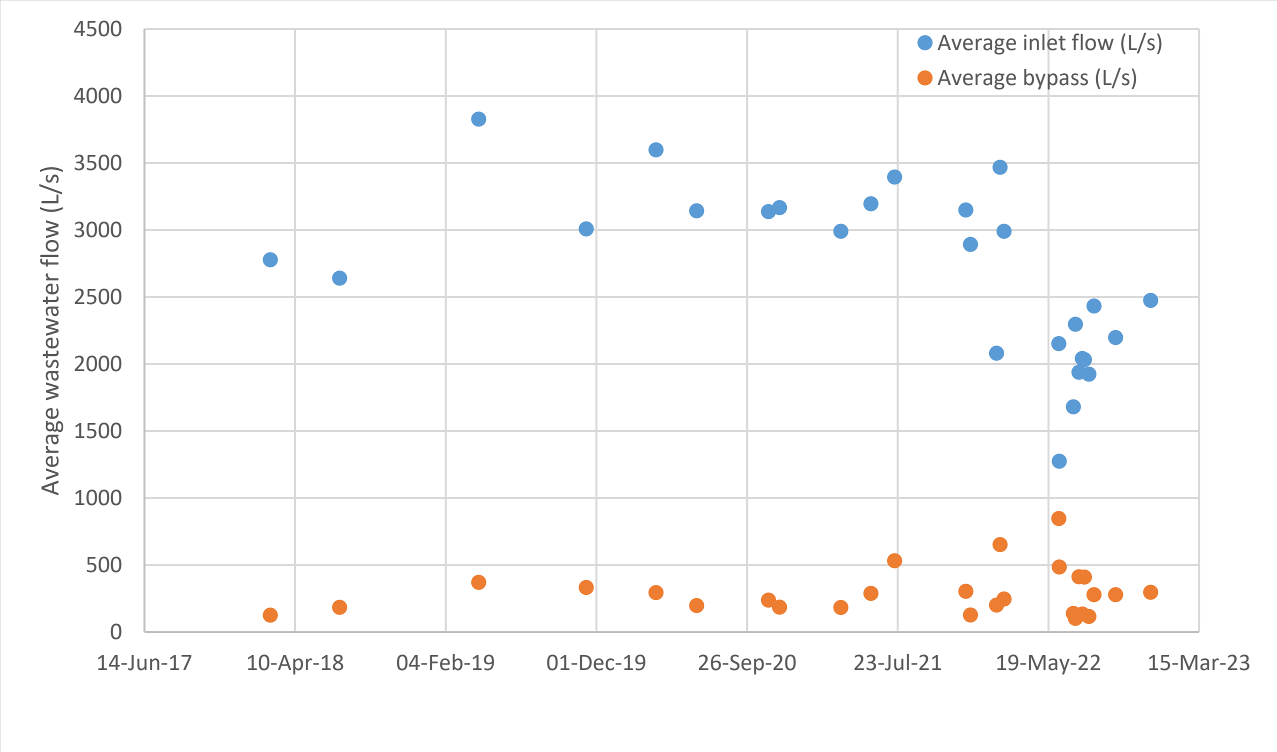

Figure 3-2: Scatter plot of bypass discharge flow rates and inlet flow rates (for discharges of >2 hours).

All bypass events shown in Figure 3-2 are driven by heavy rainfall in the catchment. Clarifier 3 was taken out of service in February 2022, prior to which bypass discharges occurred after inlet flow exceeded 3,000 L/s. After February 2022, bypasses occurred at inlet flows between 1,500 and 2,500 L/s. Clarifier 3 was returned to operation during April 2023.

3.2 Discharge quality during normal operation

Table 3-3 summarises the treated wastewater quality achieved during the 2018 year, which is representative of normal operation, prior to the recent maintenance issues.

Table 3-3: Summary statistics of daily treated wastewater quality for the 2018 year

Parameter	Unit	Sample size	Minimum	Median	95-percentile	Maximum
TSS	mg/L	365	3	13	32	73
cBOD5	mg/L	365	<3	3	9	23
Faecal coliforms	cfu/100ml	365	<4	44	370	800

3.3 Discharge quality during bypass operation

Table 3-4 provides a summary of the derived wastewater quality of the final discharge based on the monitoring results of the secondary treated wastewater and the bypassed flow and the relative volumes of the two discharge volumes. Data are presented for the years 2020 and 2021 where the WWTP operated at its normal hydraulic capacity of 3,000 L/s.

Table 3-5 provides a summary of the derived wastewater quality of the final discharge for those events that occurred after January 2022 when clarifier 3 was taken out of service and the WWTP operated at a reduced secondary treatment capacity of approximately 2,200 L/s.

The most notable differences are that faecal indicator bacteria concentrations were far higher and TSS was somewhat higher with clarifier 3 out of service. It is noted the Wellington Water implemented an optimization project from October 2022 with the objective of improving the WWTP operation.

Table 3-4: Summary of the derived wastewater quality of the final discharge during bypass events from Feb 2018 to Feb 2022 (hydraulic capacity 3,000 L/s)

	$cBOD_5$ (g/m^3)	TSS (g/m^3)	Faecal coliforms (cfu/100ml)	pH (unitless)	Total ammonia nitrogen (g/m^3)	Oil & grease (g/m^3)	Cadmium (g/m^3)	Chromium (g/m^3)	Copper (g/m^3)	Lead (g/m^3)	Nickel (g/m^3)	Zinc (g/m^3)
20 Feb-18	22	76	354,960	-	9	16.0	<0.001	0.005	0.037	0.003	0.002	0.070
8-Jul-18	12	32	24,198	7.0	5	6.0	<0.001	0.002	0.013	0.002	0.001	0.050
11-Apr-19	30	76	125,072	7.0	13	5.0	<0.001	0.002	0.023	0.005	0.002	0.057
11-Nov-19	18	42	193,574	7.0	7.0	6.0	<0.001	0.003	0.015	0.006	0.002	0.062
29-Mar-20	13	38	241,582		9.46	26.0	0.005	0.005	0.014	0.003	0.002	0.057
18-Jun-20	21	62	177,187	6.6	7.78	17.3	0.0001	0.004	0.025	0.006	0.002	0.633
8-Nov-20	138	296	170,315	6.8	6.77	11.2	0.0002	0.005	0.096	0.010	0.003	0.150
30-Nov-20	5	13	223,008	6.9	4.75	7.0	0.0001	0.002	0.007	0.0008	0.001	0.027
31-May-21	110	211	75,530	6.8	13.53	13.1	0.0002	0.003	0.066	0.0077	0.003	0.115
17-Jul-21	22	47	83,015	7.0	7.07	8.1	0.0001	0.003	0.017	0.0062	0.002	0.066
6-Dec-21	39	65	78,191	6.9	7.00	16.0	0.0001	0.003	0.022	0.0066	0.002	0.072
15-Dec-21	4	25	29,321	6.71	3.00	6.2	0.0001	0.0021	0.0111	0.0019	0.0017	0.0483
05-Feb-22	13	31	47,975	7.10	6.28	5.1	0.0005	0.0050	0.0122	0.0016	0.0022	0.0475
median	**21**	**47**	**125,072**	**6.9**	**7.0**	**8**	**0.0001**	**0.003**	**0.017**	**0.0050**	**0.002**	**0.062**
80^{th} percentile	**35**	**76**	**211,234**	**7.0**	**9.3**	**16**	**0.0003**	**0.005**	**0.032**	**0.0064**	**0.002**	**0.098**
90^{th} percentile	**96**	**184**	**237,867**	**7.0**	**12.3**	**17**	**0.0014**	**0.005**	**0.060**	**0.0075**	**0.003**	**0.143**
90th percentile (excluding outliers on 8 Nov-20 and 31-May-21)	**30**	**76**	**241,582**	**7.0**	**9.0**	**17**	**0.0023**	**0.0050**	**0.025**	**0.0062**	**0.002**	**0.072**

Notes: Discharge quality is calculated by mass balance from measured contaminant concentrations and flows in the bypass and treated wastewater.

Discharge events with a duration of 2 hours or less are excluded.

Table 3-5: Summary of the derived wastewater quality of the final discharge for bypass events during 2022 (hydraulic capacity limited to 2,200 L/s)

Event	$cBOD_5$ (g/m^3)	TSS (g/m^3)	Faecal coliforms (cfu/100ml)	pH (unitless)	Total ammonia nitrogen (g/m^3)	Oil & grease (g/m^3)	Cadmium (g/m^3)	Chromium (g/m^3)	Copper (g/m^3)	Lead (g/m^3)	Nickel (g/m^3)	Zinc (g/m^3)
12-Feb-22	23	42	1570,021	7.13	8.40	6.4	0.0001	0.0022	0.0168	0.0023	0.0015	0.0410
20-Feb-22	12	33	66,228	7.00	3.66	6.8	0.0001	0.0160	0.0142	0.0057	0.0020	0.0528
01-Jun-22	75	150	1,470,907	6.89	12.82	8.6	0.0001	0.0041	0.0341	0.0077	0.0026	0.1462
09-Jun-22	79	122	1,780,542	7.12	13.87	10.3	0.0001	0.0034	0.0288	0.0129	0.0025	0.0710
10-Jun-22	37	128	1,909,525	6.95	17.50	6.7	0.0002	0.0025	0.0376	0.0028	0.0017	0.0591
08-Jul-22	160	620	163,395	6.7	12.5	11	0.0003	0.005	0.210	0.010	0.005	0.220
19-Jul-22	17	44	59,441	6.83	4.05	5.5	0.0001	0.0011	0.0127	0.0009	0.0011	0.0267
26-Jul-22	9	26	10,667	7.10	4.21	6.4	0.0001	0.0012	0.0073	0.0006	0.0008	0.0223
30-Jul-22	15	34	289,758	7.19	10.30	6.3	0.0001	0.0010	0.0091	0.0013	0.0011	0.0283
08-Aug-22	100	369	35,774	6.7	4.0	10	0.0002	0.005	0.110	0.010	0.003	0.180
18-Aug-22	19	38	394,249	6.8	12.4	7	0.0000	0.000	0.010	0.000	0.000	0.028
30-Sep-22	13	41	35,274	7.10	4.93	7.3	0.0001	0.0034	0.0151	0.0056	0.0016	0.0472
09-Dec-22	16	38	19,377	7.00	7.68	4.4	0.0010	0.0011	0.0146	0.0011	0.0010	0.0373
median	**19**	**42**	**163,395**	**7.00**	**8.4**	**6.8**	**0.0001**	**0.0025**	**0.0151**	**0.0028**	**0.0016**	**0.0472**
80th percentile	**77**	**141**	**1,530,375**	**7.11**	**12.7**	**9.4**	**0.0002**	**0.0046**	**0.0362**	**0.0091**	**0.0026**	**0.1161**
90th percentile	**96**	**325**	**1,738,437**	**7.13**	**13.7**	**10.3**	**0.0003**	**0.0051**	**0.0952**	**0.0100**	**0.0029**	**0.1730**
90th percentile (excluding outliers 8 July and 8 August)	**75**	**128**	**1,780,542**	**7.13**	**13.9**	**8.6**	**0.0002**	**0.0041**	**0.0341**	**0.0077**	**0.0025**	**0.071**

Notes: Discharge quality is calculated by mass balance from measured contaminant concentrations and flows in the bypass and treated wastewater.

Discharge events with a duration of 2 hours or less are excluded.

3.4 Predicted frequency and duration of bypass events

3.4.1 Frequency

Table 3-6 provides an analysis of predicted and recorded bypass events during the period from 1 February 2022 to 31 January 2023, when treatment capacity was limited to 2,200L/s. Peak inlet flow rates exceeded the treatment capacity on 44 days during that year while a total 24 bypass events were recorded at the WWTP. That is, 55% of predicted bypass events were recorded as an actual bypass event. Many of the predicted events are of very short duration (as discussed below) in which case the excess volume might be stored within the WWTP without a bypass event necessarily occurring. Another factor is that many of the predicted events are multiple discharges occurring on the same day in response to the single heavy rain event, as the fifth pump switches off and on (and which should be reported as a single event). It is noted also that 14 of the 44 predicted events (32%) had a duration of 2 hours or greater; of sufficient duration to impact receiving water quality.

If treatment capacity had been limited to 1,500 L/s during this period, capacity exceedances would have occurred on 202 days during year, and on most days during the winter period. Extrapolating from the above results, bypass events with a duration of 2 hours or greater are predicted to have occurred on 65 days of the year (18%). If, for instance, a period of 90 days was required to replace the UV facility, a bypass with a duration of 2 hours or greater would occur, on average, on 16 of those days. In general bypass frequency would be highest in the winter months of June, July, and August (although in recent years February and March have also been very wet).

Table 3-6: Bypass events predicted & recorded from February 2022 to January 2023, treatment capacity limited to 2,200 L/s

Month	Number of days when peak inflow exceeds treatment capacity (based on flow data)		Reported bypass events (treatment capacity limited to 2,200L/s)	
	1,500L/s	2,200L/s	All bypass events	>2hours duration
February 2022	21	8	5	3
March	18	0	0	0
April	12	1	0	0
May	17	1	1	0
June	22	4	3	2
July	25	11	6	5
August	27	11	3	2
September	5	2	1	1
October	15	1	0	0
November	18	2	2	1
December	13	1	1	0
January 2023	9	2	2	0
Total	202	44	24	14

3.4.2 Duration

The monitoring data reflect many occasions in dry settled weather when the inlet flow exceeded 1,500L/s, typically during the daily peak flow period in the late morning. However, many of these events have a duration of only five to ten minutes, occurring as the fifth pump switches on and off. Figure 3-3 illustrates an example of these events over a three-day period in early March 2022. Because the treatment capacity was 2,200 L/s at that time, no bypass events were recorded. However, if treatment capacity had been limited to 1,500 L/s, four bypass events are expected to have been recorded over this period with a combined duration of 20 minutes.

Figure 3-4 illustrates wetter conditions during July 2022 when wastewater inflows were far higher. After the onset of rain on 12 July the inlet flow jumped to well above 1,500 L/s and remained there for much of the day. The WWTP records show a bypass event of 10 hours 28 minutes duration on July 12th. If treatment capacity had been limited to 1,500 L/s this is expected to have resulted in a bypass discharge of 18 hours duration.

Figure 3-5 illustrates very wet conditions from August 18 to 21 which produced the longest duration bypass event of the 2022 year. The WWTP records show a duration of 59 hours and 10 minutes during this period. If treatment capacity had been limited to 1,500L/s the expected duration of bypass discharge is approximately 84 hours.

In summary, the flow record shows many very short duration exceedances of 1,500 L/s associated with the daily peak flow, and a smaller number of long duration events driven by sustained periods of heavy rain.

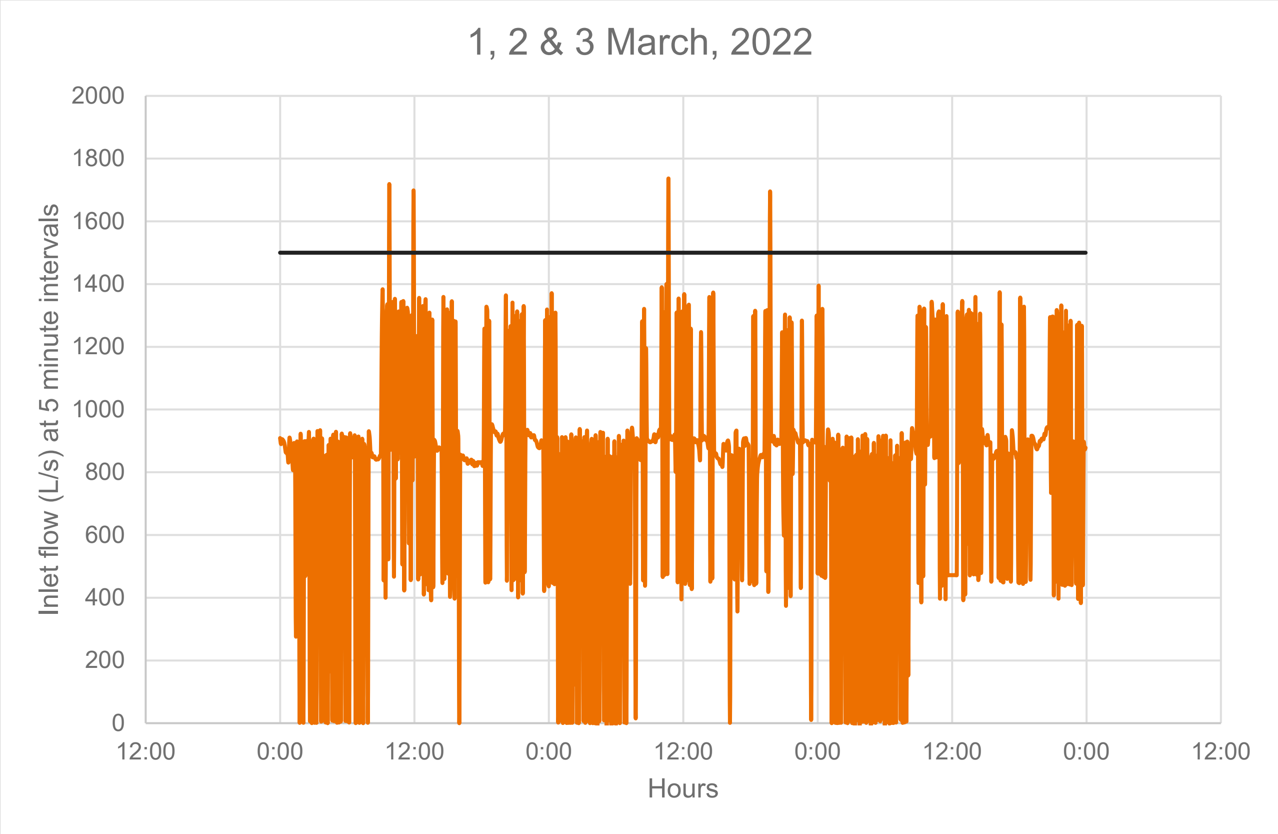

Figure 3-3: Inlet flow rate (L/s) over three days in dry weather conditions

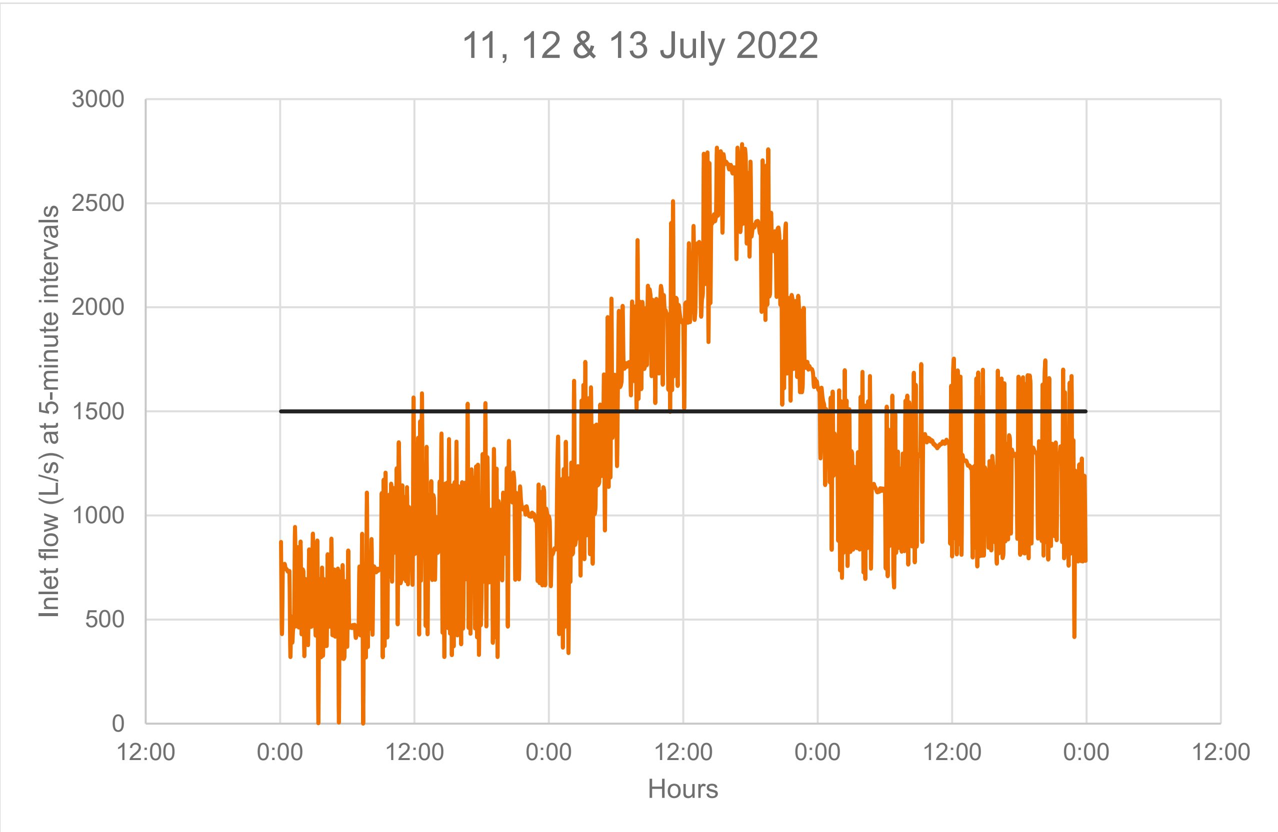

Figure 3-4: Inlet flow rate (L/s) over three days in wet weather conditions

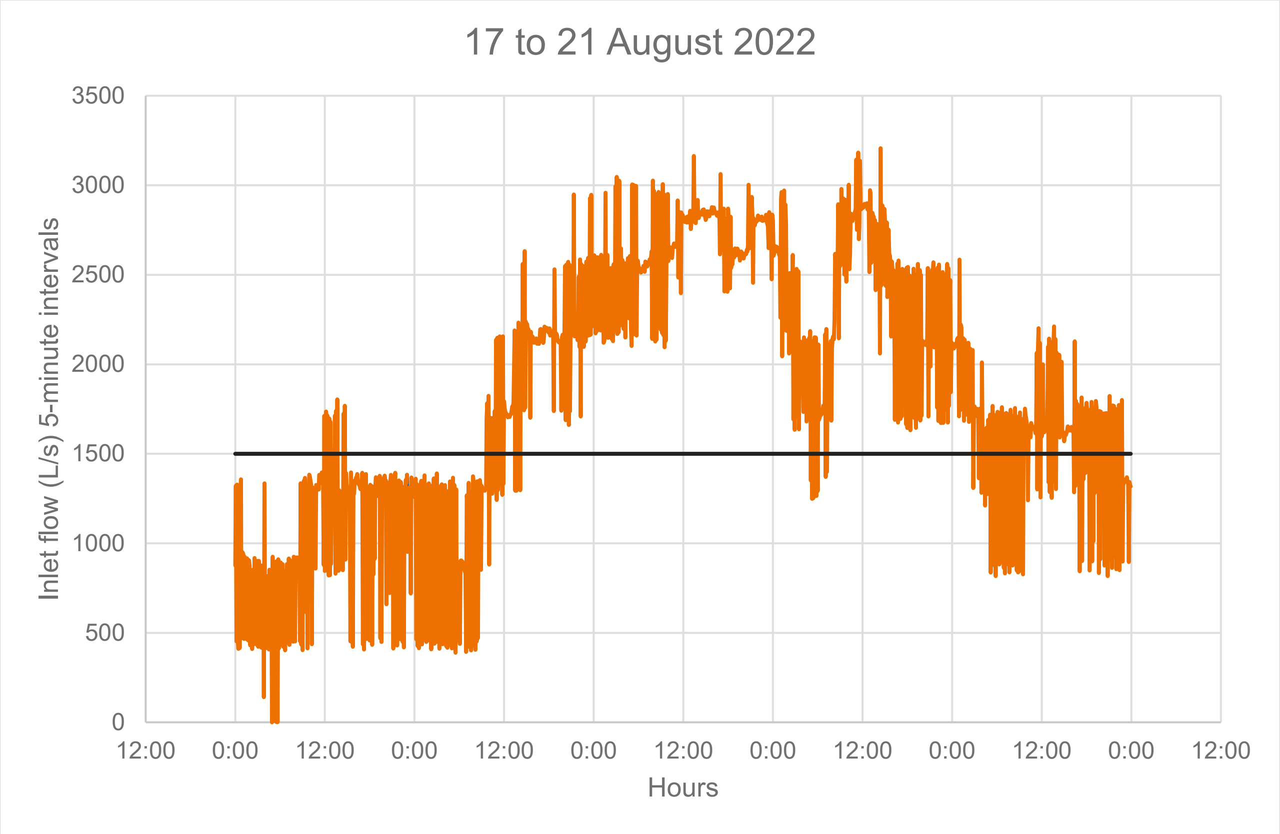

Figure 3-5: Inlet flow rate (L/s) over five days in very wet weather conditions

4 Receiving environment

4.1 Values

Habitats with significant indigenous biodiversity values in the coastal marine area are identified in Schedule F5 of the Proposed Natural Resources Plan (PNRP), several of which are known along Wellington's south-west coastline. These include subtidal rocky reefs and giant kelp (*Macrocystis pyrifera*).

The closest rocky reef habitat from which paua, kina and other seafood is collected for human consumption are located approximately 700m northwest of the outfall at Te Raekaihau and approximately 700 m northeast at Hue te Taka Peninsula. The filter feeding green lipped mussel (*Perna canaliculus*) is rare or absent. The little black mussel (*Xenostrobus pulex*) is present on the rocky shore at either end of Lyall Bay but not on the exposed outcrops at Te Raekaihau or Hue te Taka Peninsula.

The nearest popular bathing beaches are at Princess Bay and Lyall Bay, 1.9km and 2.5km from the outfall, respectively. Both beaches support a high level of recreational activity including bathing, surfing, wind surfing, kite surfing and small boat sailing.

4.2 Water quality

GWRC and Wellington City Council collect weekly water samples at popular bathing beaches during the bathing season, from 1 November to 31 March. All samples are tested for enterococci which is the faecal indicator bacteria most suitable for use in marine waters. The variations in water quality (i.e., the concentration of enterococci) observed at Breaker Bay, Lyall Bay and Princess Bay for the summers of 2019/2020, 2020/2021 and 2021/2022 are summarised in Table 4-1. The locations of monitoring sites are shown in Figure 4-1.

Table 4-1: Summary statistics for enterococci (cfu/100ml) monitoring results at bathing beaches closest to the ocean outfall diffuser (data obtained from WWL)

Site	Distance from outfall diffuser (m)	2020/2021			2021/2022			2022/2023			PNRP
		Nr.	95%ile	% >500	Nr.	95%ile	% >500	Nr.	95%ile	% >500	95%ile
Breaker Bay	4,400	15	22	0	17	23	0	11	98	0	≤500
Lyall Bay (Tirangi)	2,600	29	961	6.9	30	444	6.7	19	188	5.2	
Lyall Bay (Queens Dr)	2,500	11	218	0	31	175	0	11	60	0	
Lyall Bay (Onepu)	2,400	16	173	0	16	129	0	11	34	0	
Princess Bay	1,900	15	64	0	16	26	0	11	4	0	

The Princess Bay bathing beach monitoring site is the closest to the WWTP outfall diffuser, located 1,900 m to the north-west. The three Lyall Bay sites are located 2,400 to 2,600 m north of the outfall diffuser, while the Breaker Bay site is located 4,400 m to the north-east. At Princess Bay the highest enterococci concentration recorded during this period was 80 cfu/100ml on 24 March 2021. The annual 95th percentile values for the 2020/21, 2021/22 and 2022/23 years are 64, 26 and 4 cfu/100ml, respectively, easily achieving the PNRP Objective of ≤500. GWRC gives Princess Bay a 'long term suitability for swimming grade' of 'Good'.

At Breaker Bay the highest enterococci concentration recorded was 84 cfu/100ml on 7 January 2022. The annual 95th percentile values for the 2020/21, 2021/22 and 2022/23 years are 22, 23 and 98 cfu/100ml, respectively, easily achieving the PNRP Objective. GWRC gives Breaker Bay a 'long term suitability for swimming grade' of 'Good'.

There is no indication from routine monitoring data that the Moa Point WWTP discharge during 2020, 2021, 2022 or 2023 has adversely affected the microbiological water quality at either Princess Bay or Breaker Bay.

The Lyall Bay east monitoring site at Tirangi Road had the poorest water quality of all sites listed in Table 4-1, although a progressive reduction in the 95%ile value is seen over the last three summers. The highest enterococci concentration recorded at the Tirangi Road was 2,000 cfu/100ml on 14 July 2021, likely due to a local wastewater network fault or overflow (this site is monitored throughout the year, not just during the bathing season).

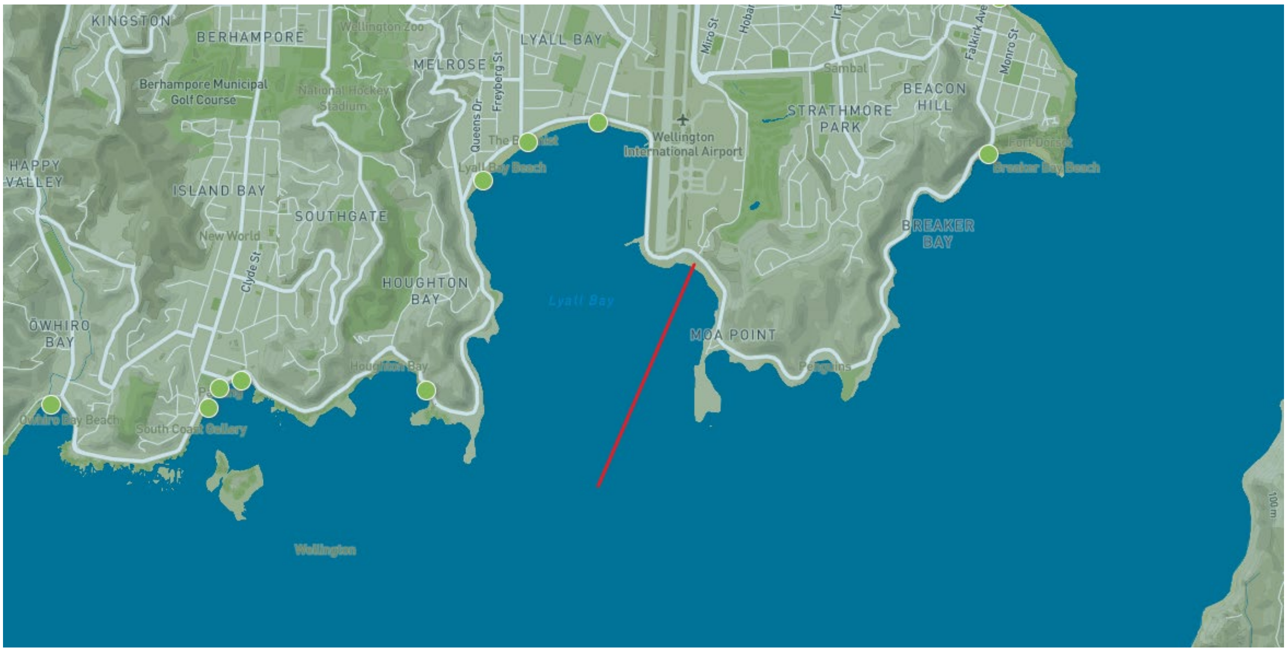

Figure 4-1: Location of bathing beach routine water quality monitoring sites (green dots) and indicative location of Moa Point outfall (red line)

In addition to routine bathing beach monitoring, grab samples of nearshore coastal waters are collected at 13 sites on days one, two, and three after each WWTP bypass discharge in accordance with condition 10 of discharge permit WGN080003[35047]. Each sample is analysed for faecal coliforms and enterococci. The enterococci monitoring results from March 2020 to November 2022 are summarised in Table 4-2.

Table 4-2: Variability in enterococci concentrations at shoreline sites during and after bypass events (March 2020 to November 2022)

Site	N or NE wind (n = 30)				S or SE wind (n = 52)			
	Minimum	Median	95th percentile	Maximum	Minimum	Median	95th percentile	Maximum
49 Moa Point Rd	<2	12	120	120	<2	20	896	3,900
Dorrie Leslie Park South Side	<2	30	260	5,400	<2	36	2,810	6,800
Dorrie Leslie Park West Side	<2	30	260	5,400	<2	36	2,810	6,800
Dorrie Leslie Park at Boat Ramp	<2	30	1,100	1,400	<2	23	866	6,600
Houghton Bay Westside	<2	23	420	11,000	<2	22	1,222	37,000
Hue te Taka Peninsula	<2	15	76	80	<2	19	939	8,500
Hue te Taka Peninsula West	<2	15	78	100	<2	25	968	3,500
Island Bay Marine Centre Eastside	2	36	2,545	11,000	<2	54	2,480	8,800
Island Bay Westside	2	62	1,750	16,000	<2	62	6,720	17,000
Lyall Bay Beach Eastern Side	<2	42	1,010	1,200	2	39	964	6,300
Te Raekaihau Peninsula Queens Drive	<2	24	500	2,400	<2	23	1,520	35,000
Tarakena Bay Beach at Boat Ramp	<2	18	1,370	2,700	<2	21	1,120	9,100
Tarakena Bay Western Side	<2	14	393	5,000	<2	20	596	3,500

When bypass events occurred in southerly or south-easterly winds the highest enterococci concentrations were recorded at Dorrie Leslie Park, Te Raekaihau Peninsula, the west side of Houghton Bay and the west side of Island Bay, all of which is consistent with discharge plume movement to the northwest under onshore wind conditions. The median enterococci value at all sites was less than 65 cfu/100ml, indicating good water quality most of the time.

5 Assessment of environmental effects

For the purposes of this assessment the following assumptions are made in respect of the WWTP performance during the proposed replacement of UV equipment, when secondary treatment and UV disinfection is limited to 1500L/s:

- Wastewater quality of the final discharge is based on data reported for 2022 when the flow to secondary treatment was limited to approximately 2,200 L/s (refer section 3.3), and
- The 90th percentile values are assumed to be representative, to account for the poorer bypass discharge quality expected when UV treatment capacity is limited to 1,500 L/s.
- Bypass events with a duration of 2 hours or more occur, an average, on 18% of days on which the flow to secondary treatment is limited to 1,500 L/s (refer section 3.4).

It is possible that replacement of the UV equipment could occur at a time when one of the three clarifiers is taken out of operation for maintenance, however this would not alter the level of treatment provided; secondary treatment and UV disinfection would remain limited to 1500 L/s.

5.1 Dilution and dispersion

Final treated wastewater is discharged via an ocean outfall and diffuser located south of Lyall Bay. The outfall terminates in a multiport diffuser at the offshore end of a buried pipe running 1,800 m in a southwest direction from the shoreline. Wastewater is discharged from 18 risers spaced at 5 m intervals along the 90 m diffuser. The risers project 1.4 m above the seabed. Each riser has two discharge ports, one of which is blocked off on some of the risers so as to maintain optimal discharge jet velocity. The diffuser is in 21 to 23 m depth of water.

The position of the Moa Point outfall was determined during the 1980's after extensive studies of the pattern of dilution and dispersal showed that effluent released from a long outfall would move mostly parallel to the coast, westward on an ebb tide and eastwards on a flood tide. It was found that the duration of the ebb tide is about 40 minutes longer than the duration of the flood tide, so there is a net transport in a westerly direction towards Sinclair Head.

In 2006, the Cawthron Institute was commissioned to predict the dilution and dispersal characteristics of the following discharge scenarios:

- Treated wastewater at 2006 Average Dry Weather Flow (ADWF) of 760 L/s
- Treated wastewater at predicted 2043 ADWF of 980 L/s
- Partially treated (mixed screened & fully treated) at Peak Wet Weather Flow (PWWF) of 4,000 L/s

The modelling results indicate that for the 2006 and 2043 ADWF's the average initial dilution (as wastewater jets from the diffuser and rises to the surface) is approximately 352:1 and 196:1, respectively (Barter, Clark, & Sneddon, 2006). During the PWWF of 4,000 L/s, an average initial dilution of 95:1 is predicted. The near field region (NFR) distance within which initial dilution is complete extends no more than 107m from the outfall for all flows (Barter, Clark, & Sneddon, 2006). These results are summarised in Table 5-1.

Table 5-1: Near Field Region mixing zone output from Cormix (Barter et al. 2006)

Flow (L/s)	*Discharge Velocity (m/sec)*	*NFR distance (m)*	*Plume ½ width @NFR (m)*	*NFR dilution (x:1)*	*Dilution at 700m distance from outfall (x:1)*
760	1.65	38	75	352	530
980	2.13	41	53	196	325
1,500	3.26	32	53	136	235
2,000	4.35	26	53	108	192
4,000	8.71	107	215	95	127

5.2 Suspended solids, colour, clarity, oil, grease and odour

The effects of the Moa Point WWTP discharge on receiving water concentrations of total suspended solids can be determined by mass balance calculation. The predicted receiving water contaminant concentration (*Cx*) at any location *x* is given by equation 1:

$$Cx = \frac{(Co - Cb)}{TD} + Cb \qquad (1)$$

Where: *Co* = the wastewater concentration of the contaminant.
Cb = the background concentration in the ocean, and
TD = the total dilution.

Predicted TSS concentrations in surface waters above the diffuser resulting from 90-percentile wastewater concentrations at the average daily flow (ADF), and PWWF with 3,000 L/s and 1,500 L/s treatment capacity are summarised in Table 5-2.

Table 5-2: Predicted suspended solids concentration in surface water after initial mixing

Flow conditions	Wastewater concentration 90th percentile (C_o; mg/L)	Background seawater concentration (C_b; mg/L)	Minimum dilution (x-fold) (TD)	Predicted concentration after initial dilution (C_x: mg/L)	Predicted increase (mg/L)
1. ADF for 'typical' year (2018)	32	5	196	5.13	0.13
2. Bypass – 3,000 L/s capacity	76	5	95	5.75	0.75
3. Bypass – 1,500 L/s capacity	128	5	95	6.29	1.29

The typical ADF discharge, when all wastewater to the WWTP is fully treated, has negligible impact on the receiving water concentration of suspended solids. A bypass discharge in peak wet weather conditions (>3,000L/s) when flows up to 3,000L/s are fully treated and the excess is partially treated, causes a slight but probably undetectable increase in the concentration of suspended solids even when viewed from an elevated position. The third option, in peak wet weather conditions (>3,000L/s) where wet weather flows up to 1,500L/s are fully treated and the excess is partially treated, has a slight to moderate effect, where the concentration of suspended solids after initial mixing is increased by approximately 25% above the background concentration. The reduced capacity also results in a sharp increase in the frequency of bypass discharges compared with normal operation, estimate at 65 events per year on average, although it is acknowledged there is considerable uncertainty about this estimate. The higher bypass frequency in combination with the lower discharge quality does not greatly increase the probability of the discharge plume being visible to members of the local community or having an adverse effect of amenity values.

The 90th percentile wastewater concentration of oil and grease during a bypass discharge when the hydraulic capacity is limited to 1,500 L/s (estimated at 10 mg/L) is predicted to cause an oil and grease concentration of approximately 0.1 mg/L in surface water above the outfall diffuser, which would be barely discernible. Similarly, the 1,500 L/s capacity discharge scenario is unlikely to produce conspicuous scums, foam, or objectionable odour in surface waters near the diffuser.

In summary, bypass discharges occurring when hydraulic capacity is limited to 1,500 L/s carry elevated sediment concentrations but, because of the high level of dilution achieved by the multiport diffuser, such discharges are unlikely to cause a conspicuous discharge plume much beyond the initial mixing zone. Bypass discharges are, however, predicted to occur at a higher frequency resulting in a slightly higher risk of adverse effects.

5.3 Potential effects on aquatic life

Partially treated wastewater discharges to the ocean can affect marine habitats and aquatic life in diverse ways, but primarily by:

a) Temperature changes, pH differentials or oxygen depletion.

b) Suspended sediment (reducing visual clarity) or fine sediment deposition on the seabed (reducing habitat quality for aquatic plants, invertebrates and fish).

c) Salinity change (reduced salinity, favouring estuarine rather than marine taxa).

d) Nutrient enrichment (increased or excessive production of plants and invertebrates), or

e) Toxic effects of contaminants (including EOCs).

5.3.1 Temperature, pH and oxygen depletion

The characteristics of the blended treated wastewater in terms of temperature, pH and dissolved oxygen are relatively benign, particularly when discharged via a multiport diffuser to a large body of well buffered seawater. No adverse effects are anticipated in respect of these constituents.

5.3.2 Suspended solids and sediment deposition

As summarised in Table 5-2 the concentration of suspended solids in the discharge plume after initial mixing in seawater is somewhat higher for peak wet weather flows when hydraulic capacity is limited to 1,500L/s compared with 3,000L/s. However, as these effects are intermittent and mostly limited to the immediate vicinity of the outfall diffuser, the consequent risks to aquatic life from particulates suspended in the water column are very low.

The risk of sediment deposition on the seafloor is also low. An annual pipeline inspection conducted in February 2021 notes that the seabed consists of cobbles, gravel, and sands (Undersea Construction Ltd, 2021). It also notes the existence of large ripples in the seabed, indicating relatively strong seawater currents capable of transporting fine sediments away from the diffuser. Plates 5-1 and 5-2 show a diffuser riser and the surrounding seabed.

Plate 5-1: View of a diffuser riser and fouling assemblage, February 2021

Plate 5-2: Seabed deposits of cobbles, gravel and sands around the diffuser position, February 2021

5.3.3 Salinity

Salinity is expected to be reduced below the ambient concentration of 32 PSU (Practical Salinity Unit) within the initial mixing zone as wastewater jets from the diffuser ports and rises to the surface, typically forming a low salinity surface plume overlaying the denser seawater. As the plume disperses away from the point of discharge the low salinity plume becomes thinner and begins to break up under the influence to wind or tide induced turbulence. Reducing the WWTP hydraulic capacity from 3,000 L/s to 1,500 L/s is not expected to alter the existing salinity regime near the outfall diffuser.

5.3.4 Nutrient enrichment

Nutrients, especially nitrogen and phosphorus, are vital to the coastal marine ecosystem and both generally become depleted in shallow coastal waters during the spring and summer period. Nitrogen is normally the main limiting nutrient in New Zealand coastal waters. The principal cause of nutrient depletion is uptake by phytoplankton, which typically reach their highest concentration in spring. Sources of nutrient replenishment include recycling from the seafloor, inputs from deep oceanic upwelling and inputs from terrestrial sources following high flows in watercourses.

The blended treated wastewater (when treatment capacity is limited to 1,500L/s) is expected to contain relatively high concentrations of both nitrogen and phosphorus, but concentrations are much reduced after initial mixing and further reduced as the discharge plume disperses away from the point of discharge under the influence of wind and tide driven currents. Because of the rapid dilution and dispersion, it is expected that phytoplankton exposure to elevated nutrient concentrations would be brief and unlikely to stimulate excessive growth. No adverse effects are anticipated in respect of nutrients.

5.3.5 Toxicity

Toxicants known to be present in the bypass and treated wastewater discharge include total ammonia nitrogen and metals such as copper, chromium, lead, nickel, and zinc. The predicted concentrations of toxicants in the receiving waters during a bypass discharge are summarised in Table 5-3.

Table 5-3: Predicted concentrations on toxic contaminants in surface waters after initial mixing of the bypass discharge (within approximately 100m of the outfall diffuser)

Wastewater constituent	Wastewater concentration 90th percentile (C_o; mg/L)	Background seawater concentration[1] (C_b; mg/L)	Minimum dilution (x-fold) TD	Predicted concentration after initial dilution (C_x: mg/L)	Predicted increase (mg/L)	(ANZG 2018) guideline
Total ammonia N	13.9	0.005	95	0.151	0.146	0.91
Total chromium	0.004	0.0016	95	0.0016	0.0000	0.0044
Total copper	0.034	<0.0005	95	0.0009	0.0004	0.0013
Total lead	0.008	<0.0005	95	0.0006	0.0001	0.0044

[1] Background seawater concentrations are sourced from MBARI (http://www.mbari.org/) and Roper et al 2006)

Wastewater constituent	Wastewater concentration 90th percentile (C_o; mg/L)	Background seawater concentration[1] (C_b; mg/L)	Minimum dilution (x-fold) TD	Predicted concentration after initial dilution (C_x: mg/L)	Predicted increase (mg/L)	(ANZG 2018) guideline
Total nickel	0.003	0.003	95	0.0030	0.0000	0.007
Total zinc	0.171	<0.0005	95	0.0023	0.0018	0.015

The results indicate that, with treatment capacity limited to 1,500L/s, a bypass discharge is unlikely to cause any exceedance of toxicity guidelines in receiving waters after initial mixing. It is noted also that the assessment is based on total metal content rather than the bioavailable dissolved fraction and is therefore conservative. Overall, the risk of toxicity in the water column during a bypass discharge is low.

The risk of sediment toxicity is also low, largely because of the dispersive characteristics of this environment which is swept by strong currents capable of transporting fine sediments away from the diffuser (as described in section 5.3.2).

5.3.6 Microbiological water quality

Table 5-4 summarises the predicted 'worst-case' concentrations of faecal coliforms in surface waters above the diffuser resulting from the 90th-percentile concentration in the discharge at the average daily flow (ADF), and for bypass discharge events assuming treatment capacities of 3,000 L/s and 1,500 L/s.

Table 5-4: Predicted faecal coliform concentrations in surface waters after initial mixing (at a distance of up to 107 m from the diffuser)

Flow conditions	Wastewater concentration 90th percentile (C_o; CFU/100)	Background seawater concentration (C_b, CFU/100ml)	Minimum dilution (x-fold) TD	Predicted concentration after initial dilution (C_x, CFU/100ml)	Predicted FC increase (CFU/100ml)
1. ADF for 'typical' year (2018)	370	4	196	6	2
2. Bypass – 3,000 L/s capacity	241,585	4	95	2,547	2,543
3. Bypass – 1,500 L/s capacity	1,780,542	4	95	18,747	18,743

During average flow conditions the discharge has a low microbiological content and negligible impact on faecal indicator bacteria concentrations in the receiving waters. At such times the discharge is unlikely to increase the risk profile for contact recreation activities, even for those occurring in waters immediately above the outfall diffuser.

Wet weather bypass discharges when the WWTP is operating at its normal hydraulic capacity of 3,000 L/s are rare short-term events. They do, however, carry a relatively high microbiological load and can cause a marked increase in the concentration of faecal indicator bacteria in surface waters above the outfall diffuser. The discharge plume normally moves parallel to the coast under the influence of tidal currents, toward Te Raekaihau Peninsular to the west or Hue te Taka Peninsula to the east. The plume becomes increasing dilute as it disperses away from the initial mixing zone and is unlikely to cause much change in near shore water quality. In strong southern winds the plume may be pushed northwards into Lyall Bay, but strong winds produce turbulence which increases mixing efficiency and rapidly disperses the discharge plume. At such times the predominant source of faecal contamination in Lyall Bay is likely to be overflows from the local wastewater network, driven by rainwater inflows into the wastewater network. There may be an increase level of risk associated with contact recreation activities such as swimming, surfing, wind surfacing and kite surfing, but the increased risk is attributed primarily to local wastewater network overflows.

Wet weather bypass discharges when the WWTP is operating at reduced hydraulic capacity of 1,500 L/s has effects similar to when the plant is at full capacity except that bypass events occur far more frequently, and each event carries a higher microbiological load because a higher proportion of the discharge is partially treated. The east-west tidal currents in combination with southerly wind and sea conditions could occasionally result in high faecal indicator bacteria concentrations in nearshore waters at Te Raekaihau Peninsular to the northwest and Hue te Taka Peninsula to the north-east. Indeed, the predicted plume concentrations in Table 5-4 are consistent with the measured concentrations in nearshore waters during a bypass discharge, as summarised in Table 4-2.

In summary, a WWTP hydraulic capacity reduction to 1,500 L/s is predicted to result in elevated concentrations of faecal indicator bacteria in surface waters near the outfall diffuser during a bypass discharge, and to cause a marked increase in the frequency of such events. There is in an increased risk for contact recreation activities occurring in waters near the outfall diffuser, including nearshore waters along Te Raekaihau Peninsula and Hue te Taka Peninsula. These risks are partially mitigated by the following:

- Bypass discharges are occasional short-term events triggered by heavy rainfall, often in southerly conditions, when recreational use of receiving waters is much reduced, although some activities including surfing, wind surfing and kite surfing may continue to occur in Lyall Bay in such conditions.
- The effects of bypass discharges on coastal water quality are short lived and rapidly dispersed by tidal currents after the discharge event ceases. The infection risk could therefore be managed by notification of a short (24-hour) stand-down period after each discharge event with a duration greater than 2 hours.

- While contaminants from bypass discharges can be accumulated by filter feeding shellfish and may persist in the shellfish gut for up to four weeks after the discharge ceases, there are no significant populations of filter feeding shellfish on Wellington's south coast. The little black mussel is present on the rocky reef habitat at either end of Lyall Bay, but this species is not regarded as a viable seafood resource due to its small size, and is seldom taken for human consumption.

6 Conclusions

The proposal to reduce hydraulic capacity of the WWTP to facilitate replacement of the UV equipment would markedly increase the frequency of wet weather bypass discharges, and reduce the quality of those discharges, particularly in respect of microbiological load. Many of these events will be of very short duration, with little impact on receiving water quality, however bypass discharges with a duration of greater that 2-hours are expected to cause a measurable but temporary reduction in water quality. The consequences for the receiving environment of reduced treatment capacity are summarised as follows:

- Bypass discharges carry elevated sediment concentrations but, because of the dilution achieved by the multiport diffuser, such discharges are unlikely to cause a conspicuous discharge plume much beyond the initial mixing zone. Nor are bypass discharges likely to form a conspicuous oil film, scum, foam, colour or odour in receiving waters.
- The potential for adverse effects on aquatic life is slightly increased by intermittently reduced wastewater quality and a higher frequency of bypass events.
- The microbiological content of bypass discharges is predicted to increase markedly during and immediately after the worst-case events, which, in combination with a higher bypass frequency, is expected to increase the risk for contact recreation users of nearby coastal waters, including in near shore rocky reef habitat to the east and west at Te Raekaihau and Hue te Taka Peninsula.
- Those risks could be effectively managed by:
  - Veolia optimising the hydraulic throughput of the plant above 1500L/s, as far as practicable.
  - Minimising the duration of time when the WWTP is operated at reduced capacity (if practicable by upgrading the UV system in parallel with the maintenance required in clarifiers).
  - Notification of a 24-hour stand-down period after each discharge event with a duration greater than 2 hours.
  - Implementation of an effective public engagement strategy to inform the community of the expected increased level of risk during or immediately after a heavy rainfall event, for the duration of the repairs.
- The long ocean outfall and multiport diffuser will play an important role in mitigating the adverse effects of reduced treatment capacity by separating the point of discharge from sensitive receptors and ensuring a high level of initial dilution.

References

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Stantec House, Level 15, 10 Brandon Street, Wellington, 6011
PO Box Address 13-052, Armagh, Christchurch, 8141
New Zealand +64 4 381 6700 | www.stantec.com