CLEAN OCEAN FOUNDATION

NATIONAL OUTFALL DATABASE

ANNUAL REPORT

National Outfall Database: Outfall ranking based on the nutrient loads discharged assessment for 2019/2020 financial year

Qurratu A'yunin Rohmana[1,2], Andrew Fischer[1], and John Gemmill[2]

[1]University of Tasmania
[2]Clean Ocean Foundation

August 2021

Enquiries should be addressed to:
John Gemmill
CEO Clean Ocean Foundation
0409 425 133
johng@cleanocean.org
www.cleanocean.org

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Preferred Citation

Rohmana, Q. A., Fischer, & Gemmill, J. 2021. National Outfall Database: Outfall Ranking Report 2019/2020 Financial Year. Report to the Department of Agriculture, Water and Environment. Australia: Clean Ocean Foundation and University of Tasmania.

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Acknowledgement

This work was undertaken for the Department of Agriculture, Water and Environment supported through funding from the Australian Government's National Environmental Science Program (NESP).

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EXECUTIVE SUMMARY

This report provides an analysis of the Australian coastal outfalls and ranks them according to the total flow volume and nutrients load to prioritise the potential degree of impact of each source to the environment and human health. Water quality data were collected from 43 Water Treatment Authorities (WTAs) around Australia by either downloading the water quality data reports directly from WTA websites or by formally requesting the data through email. The pollutant contribution index, based on nitrogen and phosphorous loads, was calculated for each outfall. Nitrogen and phosphorous loads were calculated according to the Load Calculation Protocol of New South Wales Department of Environment and Climate Change. Outfalls were ordered from lowest to highest index value to rank them according to their relative pollutant contribution to the coastal and marine environment. The index is based on a total nutrient load discharge using the variables of flow, nitrogen and phosphorous.

The results showed that total nutrient load from individual outfalls sites around Australia ranged from 12 to 6,934,136 kg, with a mean of 164,551 kg. The ranked loads throughout Australia were mapped by quartiles. The top quartile (lowest nutrient load) of outfalls seems to be more prevalent in regional areas and discharge less nitrogen and phosphorus loads into the coastal and marine environment. The bottom quartile, on the other hand, with higher nutrient loads principally occur around the major cities. The phosphorous concentrations contribute less to the overall outfall nutrient load and vary less between outfall sites. Nitrogen, on the other hand has a higher median contribution and high variability across the sites.

In general, the outfalls contributing higher nitrogen and phosphorous loads vary more than those delivering lower loads. There may be many reasons for this, but it could be related to the capacities of the treatment plants and storm water management in urban areas, resulting in increased in discharge at metropolitan outfall sites. There are some exceptions to this pattern with rural/regional sites contributing higher nutrient loads than urban areas. The reasons for them may vary, however, they may primarily be due to the conditions set out in their licenses. This ranking of nutrient loads from Australian outfalls by site at a national scale can therefore be useful in prioritizing treatment upgrade resources to manage biodiversity impacts and human health concerns.

1. INTRODUCTION

Wastewater disposal into the marine environment is one of the main factors leading to the deterioration of coastal water quality. Poorly managed disposal can lead to increased concentrations of nutrients, organic and inorganic pollutants, as well as alter levels of turbidity, pH and bacteria ((Carey and Migliaccio, 2009; Beck and Birch, 2012; Cheung et al., 2015). An increase in the level of pollutants can have an impact on coastal ecology and biodiversity and affect the health of recreational users (Schwarzenbach et al., 2010; Burd et al., 2012; Becherucci et al., 2016; Boehm et al., 2017).

In order to manage and safeguard aquatic and marine environments around Australia from the impacts of wastewater effluent, state/territory governments have each established Environment Protection Authorities (EPA). Each EPA acts as an independent environmental protection regulator to prevent and control pollutant impacts to human health and the environments. For example, in Victoria the EPA was established under section 5(1) of the Environmental Protection Act of 1970. In New South Wales, the Protection of the Environment Administration Act (1991) (POEA Act) served as the mechanisms to establish the environmental protection regulator. With regards to wastewater effluent each state or territory EPA has a role in regulating wastewater treatment plant (WWTP) discharges. For example, in New South Wales, the EPA regulates water pollution through the establishment of conditions in environmental protection licenses. These licenses take into account several factors, such as the community value of a waterway, the community's uses of a waterway and practical measures to prevent deterioration of waterway values and uses. (EPA NSW, 2013). Any activity that may produce a discharge of waste that by reason of volume, location or composition adversely affects the quality of any segment of the environment will require a licence from the Authority (DECC NSW, 2009). The basic requirement of the licence consists of an explanation of the activity, pollutant loads, and discharge limits. The actual load of a pollutant is the mass (in kilograms) of the pollutant (e.g. nitrogen, phosphorous, total suspended solids, oil and grease) released into the environment from the potential emission sources. Throughout each state and territory, emission sources are required to monitor their discharges and to be in compliance with the conditions set out in their licenses. Each WWTP is required to conduct monitoring within the vicinity of their outfalls, analyse the samples and report the results to the EPA (DECC NSW, 2009; EPA VIC, 2009).

The National Outfall Database (NOD), developed by the Clean Ocean Foundation in collaboration with State and Territory Governments, provides policy makers with a guide to help prioritise outfall reform and identify public and private sector opportunities for wastewater recycling (Marine Biodiversity Hub, 2015). In collaboration with the National Environmental Science Program – Marine Biodiversity Hub, the NOD also provides Australian water authorities and the public an accessible database to help identify pollutant loads and assess any potential health and environmental impact risks of sewerage outfalls on the marine environment and surrounding communities. The NOD provides an unprecedented national collection of water quality data, collected by water authorities and Local Governments according to guidelines set out in Environmental Protection Authority (EPA) licenses. Given the NOD's centralized collection of national scale water quality data the opportunity to examine the comprehensive impacts of sewerage outfalls at regional scales becomes possible.

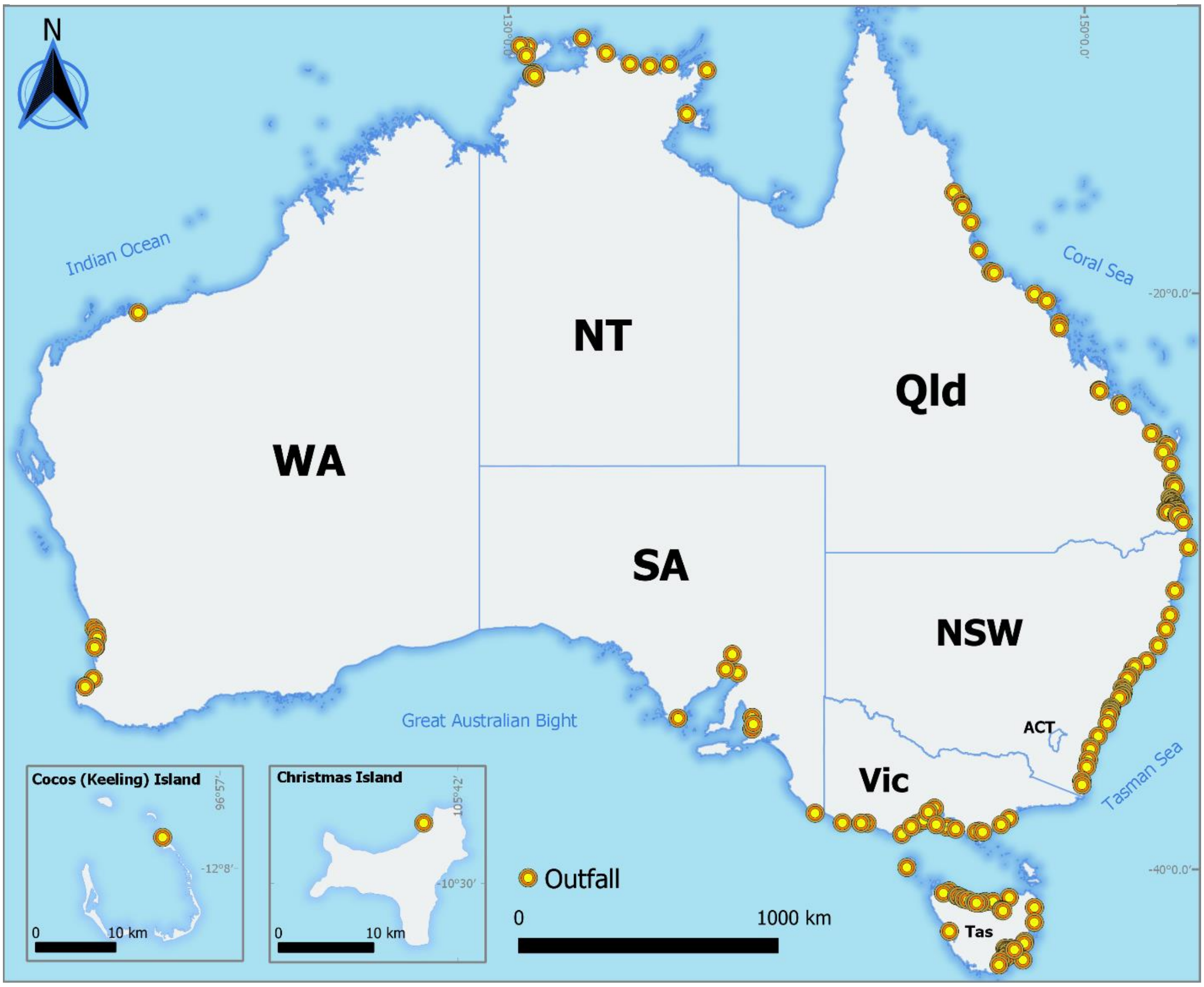
The aim of this report is to present a comprehensive collection of discharge monitoring data between 2019 and 2020 from outfalls across Australian coastal regions. This report also ranks each outfall according to the total flow volume and nutrients load to prioritise the potential degree of impact of each source to the environment and human health. In general, the results of this analysis will be able to provide stakeholders and the general community a better understanding of the relative impacts of outfalls to their coastal waterways and provide policy makers and managers evidence to prioritise outfall infrastructure reform and wastewater recycling initiatives.

2. METHODS

2.1 Data collection

Water quality data were collected from 43 Water Treatment Authorities (WTAs) around Australia (Figure 1) by either downloading the water quality data reports directly from WTA websites or by formally requesting the data through email. To standardize data collection, the NOD prepared a document outlining a predefined format in which the data was to be delivered. Through this process, the NOD collected, verified, and published data from 42 WTAs up until 2019/2020 financial year. This report analysed 2019/2020 financial year data, which is equal to 12 months in terms of calendar year. WTA monitoring requirements varied depending on EPA license requirements. Therefore, the type of pollutant data monitored varied across all outfall locations. In this report, we assess only nitrogen, phosphorus and flow volume (Table 1), as these three indicators were commonly measured across all WTAs.

Figure 1. The location of 185 wastewater discharge points managed by 43 water treatment authorities around Australia.



2.2 Data Analysis

The pollutant contribution index, based on nitrogen and phosphorous loads, was calculated for each outfall (Figure 1). Outfalls were ordered from lowest to highest index value to rank them according to their relative pollutant contribution to the coastal and marine environment. The index is based on a total nutrient load discharge (see below) using the variables of flow, and nitrogen and phosphorous concentrations.

Nitrogen and phosphorous (nutrient) load was calculated based on the Load Calculation Protocol (DECC NSW, 2009) using

$$N_l = \sum_{n,p} \frac{Tf * N_a}{1000}. (1)$$

where, N_l is the total nutrient load in tonnes, calculated for nitrogen and phosphorous individually, Tf is the total annual flow from each outfall in megalitres (ML) and N_a is the annual average nutrient concentration in mg/L. Nitrogen and phosphorous loads were summed to provide the total nutrient load. Values were sorted and ranked for each outfall location for 150 outfall locations and grouped into quartiles. Those sites with incomplete data for 2019/2020 financial year were not considered in the final ranking.

3. RESULTS

The NOD has been consistently collecting data from the WTAs since 2015. As for current data collection, water quality data collected were from 38 out of 43 WTAs. Across these several years, Queensland, South Australia, Tasmania, Western Australia were able to maintain consistency in providing water quality data (Table 1). Despite having various WTAs, Victoria has been successfully maintaining the data submission to the NOD. Due to various circumstances, some WTAs in New South Wales and the Northern Territory were experiencing difficulties to supply the requested information as previous years (Gemmill et al., 2019).

Table 1. Outfalls water quality data collected for 2019/2020 financial year.

States/Territory	Number of outfalls	Outfalls collected	Data repository (%)
New South Wales	34	20	60%
Northern Territory	14*	0	0%
Queensland	55	55	100%
South Australia	10	10	100%
Tasmania	47	47	100%
Victoria	19	19	100%
Western Australia	12	12	100%

Asterix (*) indicates that only four outfalls are provided for the NOD.

Top and bottom quartiles of the outfall rankings are presented in Table 2. Total nutrient load from individual outfalls sites ranged from 12 to 5,103,568 kg, with a mean of 115,489 kg. Tasmania had 16 outfall sites in the top quartile (lowest nutrient load). Queensland and Victoria each had five outfalls in the top quartile. New South Wales and Western Australia each had four outfalls. Only one South Australian outfall recorded in the top quartile. The bottom quartile (highest nutrient load) was represented by nine outfalls each from Queensland and Victoria. Tasmania, Western Australia and South Australia each had seven, five and four, respectively. Compared to previous ranking (Rohmana et al., 2020), New South Wales managed to have only one outfall recorded in the bottom quartile. There is almost no difference between previous (Rohmana et al., 2020) and current results. The top and bottom quartile were dominated by the same outfalls.

Table 2. Top (green) and bottom (red) quartiles of outfall ranking for 2019/2020 financial year data.

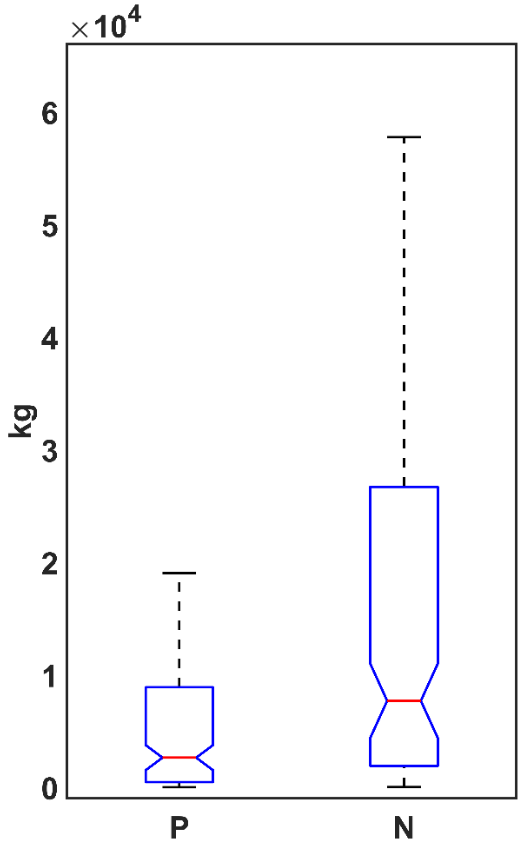
Rank	State	Outfall	Total Nutrient Load (kg)
1	South Australia	Christies Beach-Southern	12
2	New South Wales	Iluka	15
3	Tasmania	Beaconsfield	32
4	New South Wales	Crescent Head	42
5	Tasmania	Swansea	51
6	Tasmania	Cambridge	151
7	Tasmania	Bicheno	164
8	Queensland	Bundaberg North	185
9	Tasmania	Rokeby	287
10	Western Australia	Cocos (Keeling) Island	291

Rank	State	Outfall	Total Nutrient Load (kg)
11	Tasmania	Sisters Beach	391
12	Tasmania	Triabunna	403
13	Western Australia	Wickham	419
14	Western Australia	Christmas Island	436
15	Western Australia	Busselton (North)	508
16	Tasmania	Boat Harbour	522
17	Tasmania	St Helens	543
18	Victoria	Toora	561
19	Victoria	Port Welshpool	626
20	Tasmania	Port Arthur	631
21	New South Wales	Bermagui	1,010
22	Tasmania	Beauty Point	1,016
23	Queensland	Karana Downs	1,080
24	Queensland	Port Douglas	1,121
25	Tasmania	Dover	1,210
26	Victoria	Apollo Bay	1,531
27	Queensland	Bowen	1,620
28	Victoria	Lorne	1,717
29	Tasmania	Stanley	1,824
30	Tasmania	Orford	1,936
31	Victoria	Anglesea	2,243
32	New South Wales	Camden Head	2,423
33	Tasmania	Cygnet	2,513
34	Tasmania	Risdon	2,588
35	Queensland	Cannonvale	2,657
106	Victoria	Delray Beach	34,315
107	Queensland	Merrimac	36,592
108	Victoria	Baxter's Beach	36,655
109	Victoria	Altona	38,354
110	Tasmania	Cameron Bay	46,220
111	Tasmania	Newnham	51,912
112	Queensland	Elanora	52,066
113	Queensland	Rockhampton North	52,316
114	Western Australia	Bunbury	54,120
115	Victoria	Port Fairy	57,729
116	South Australia	Christies Beach-Northern	63,023
117	South Australia	Bolivar High Salinity	65,998
118	Queensland	Gibson Island	67,840
119	Tasmania	Smithton	68,620
120	Queensland	Loganholme	101,003
121	Tasmania	Prince of Wales	101,969
122	Queensland	Coombabah	102,068

Rank	State	Outfall	Total Nutrient Load (kg)
123	Tasmania	Ti-tree Bend	152,605
124	Victoria	Boags Rock (Boneo, Mt Martha, Somers)	156,658
125	Tasmania	Macquarie Point	160,696
126	Queensland	Oxley	207,249
127	Tasmania	Pardoe	210,031
128	Victoria	Black Rock	227,317
129	New South Wales	Winney Bay (Kincumber)	239,581
130	Queensland	Kawana	243,404
131	South Australia	Glenelg	260,974
132	Victoria	Warrnambool	285,982
133	South Australia	Bolivar WWTP	366,621
134	Western Australia	Subiaco	421,021
135	Western Australia	Point Peron	448,070
136	Queensland	Luggage Point	517,419
137	Western Australia	Beenyup	681,269
138	Western Australia	Woodman Point	1,011,506
139	Victoria	Boags Rock (Eastern Treatment Plant)	3,479,639
140	Victoria	Werribee (Western Treatment Plant)	5,103,568

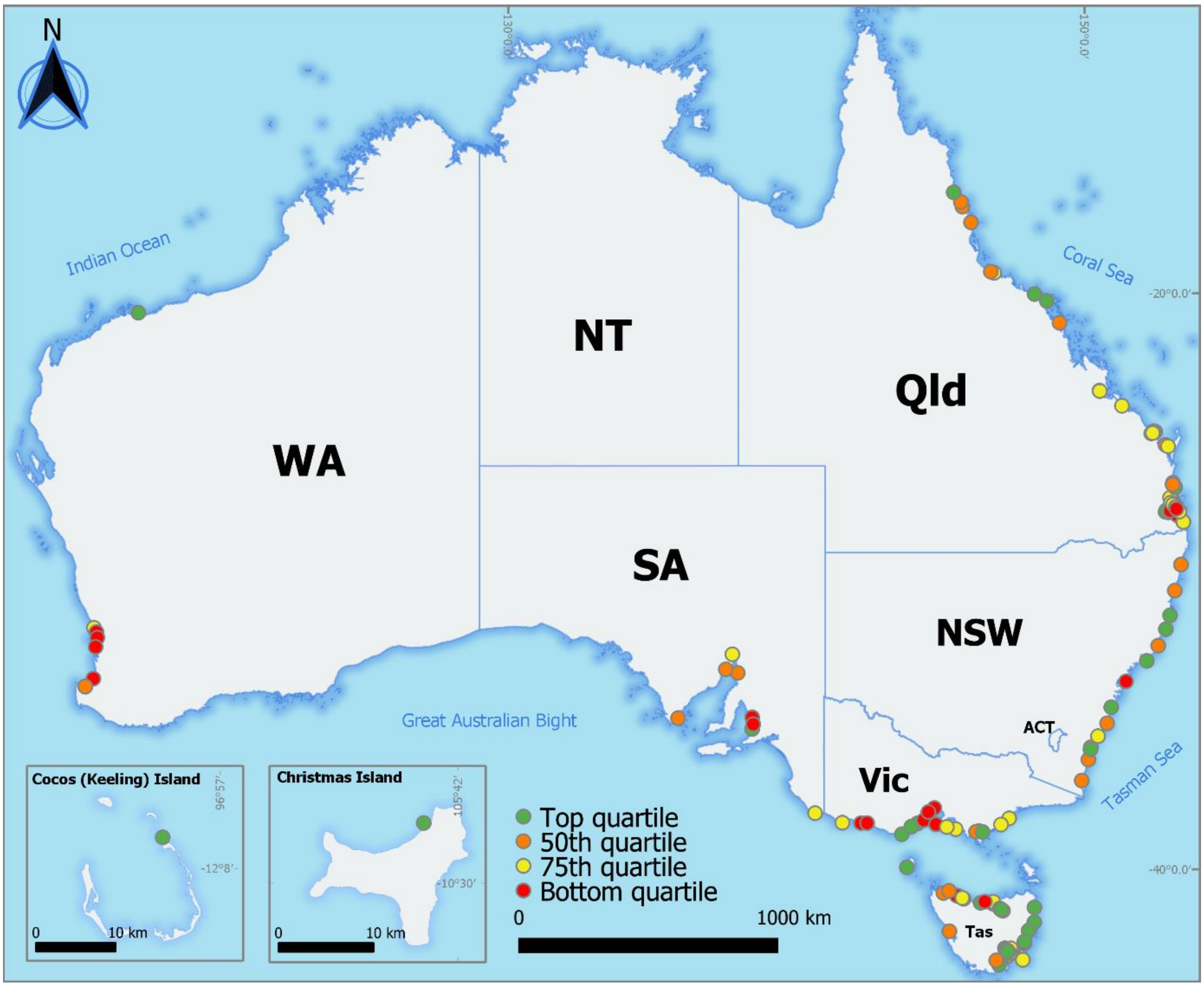
The boxplot (Figure 2), with outliers removed, shows the difference between the median contributions of nitrogen and phosphorous in the total nutrient load. Phosphorous concentrations contribute less to the overall outfall nutrient load and vary less between outfall sites. Nitrogen, on the other hand has a higher median contribution and high variability across the sites. The outfalls contributing higher nitrogen and phosphorous loads vary more than those delivering lower loads.

Figure 2. A boxplot of nitrogen (N) and phosphorous (P) loads (kg) for each outfall's reported data (n=140).



The map in Figure 3 shows the distribution ranked outfalls throughout Australia grouped by quartiles. The top quartile (lowest nutrient load) of outfalls seems to be more prevalent in regional areas and discharge less nitrogen and phosphorus loads into the coastal and marine environment. Discharges in the top quartile ranged between 12 to 2,657 kg (Table 1). The bottom quartile, on the other hand, with higher nutrient loads appear to occur around the major cities. The total load discharged by this quartile ranged between 34,315 to 5,103,568 kg. Each quartile consisted of 35 outfalls. The rankings for all the outfalls appear in Appendix A.

Figure 3. Australian coastal and river/estuary outfalls ranked by quartiles for 2019/2020 financial year data.



4. DISCUSSION

Due to significant changes caused by COVID-19, some WTAs have to reduce the capacity of human resources in their organisations. This has impacted the NOD data collection for 2019/2020 financial year. Under normal circumstances, the data collection timeframe is between one to two months and receives almost all water quality data. Currently, a quite large number of outfalls were not included in the data analysis, hence the incompleteness compared to last year (Rohmana et al., 2020).

Nutrient concentrations and discharge flow data was collected from 140 outfalls around Australia. These outfalls were ranked according to their combined nutrient load (nitrogen and phosphorous). General patterns show that the highest nutrient loads tend to occur through those outfalls serving metropolitan and surrounding areas. Outfalls with lower nutrient loads seem to occur in regional areas, however, the loads varied across individual outfalls. The nitrogen and phosphorous loads seemed to vary more across sites with higher nutrient loads. This may simply be related to the high population levels in urban areas and the resulting increase in general discharge at metropolitan and outfall sites. There are some exceptions to this pattern, with rural/regional sites contributing higher nutrient loads than urban areas. These include places such as Smithton in Tasmania, Rockhampton in Queensland and Warrnambool, Victoria. The reasons for them may vary, however, and they may primarily be due to the condition set out in the licenses. License conditions are determined by a variety of factors, including the conditions of the waterway being discharged to, and the communities uses of the waterway (EPA NSW, 2013; EPA VIC, 2017). For example, Warrnambool has a nitrogen concentrations limit of 30 mg/L, compared to the combined Melbourne Eastern Treatment Plant (ETP) and Boneo (Table 2) outfalls that each has the same concentration limit of 25 mg/L. In addition to existing conditions and the uses of waterways, available resources for treatment plant upgrades and community pressure may also contribute to WWTP load. Boag's Rock outfall, which is run by the Melbourne ETP, have come under significant community pressure in the past and upgraded to tertiary treatment in 2012 (Melbourne Water, 2017). Therefore, Warrnambool, which is a secondary treatment plant, ranks in the bottom quartile with the outfalls that service the Melbourne metropolitan area.

Several sites that ranked toward the bottom of the highest quartile were sites that do not have nitrogen and phosphorous concentration limits as conditions in their licenses (Appendix B - Figure 4). This essentially means that they will not be in breach of their license regardless of the amount of nitrogen and phosphorous discharged. Werribee treatment plant in Victoria has no nitrogen concentration limit restrictions in its license. This, however, is a tertiary treatment plant, which tends to be more efficient at the removal of bacteria and the further reduction of organics, turbidity, nitrogen and phosphorous.

As illustrated here, this ranking and the identification of nutrient loads by site can therefore be useful in prioritizing treatment upgrade resources. In addition, these discrepancies in treatment level and license conditions warrant further examination of water quality guidelines at a national scale, as well as wastewater reuse policies. The top quartile (lowest nutrient load) of wastewater treatment plants contributes only 0.2% of the overall nutrient load to the coastal and marine environment, while the bottom quartile contributes about 94%. Perhaps, treatment plants in the bottom quartile should be the target of an upgrade feasibility assessment in order to achieve the greatest benefit per cost in upgrade investment (Blackwell and Gemmill, 2019). In addition, some sites (e.g., Richmond and Rokeby in Tasmania) reported zero discharge. These sites are already fully recycling and diverting their wastewater to agricultural use, highlighting the success of a program that could be implemented in other areas.

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APPENDIX A – OUTFALL RANKINGS

Table 3. Australian coastal outfalls ranking by quartiles.

Rank	State	Outfall	Total Nutrient Load (kg)
1	South Australia	Christies Beach-Southern	12
2	New South Wales	Iluka	15
3	Tasmania	Beaconsfield	32
4	New South Wales	Crescent Head	42
5	Tasmania	Swansea	51
6	Tasmania	Cambridge	151
7	Tasmania	Bicheno	164
8	Queensland	Bundaberg North	185
9	Tasmania	Rokeby	287
10	Western Australia	Cocos (Keeling) Island	291
11	Tasmania	Sisters Beach	391
12	Tasmania	Triabunna	403
13	Western Australia	Wickham	419
14	Western Australia	Christmas Island	436
15	Western Australia	Busselton (North)	508
16	Tasmania	Boat Harbour	522
17	Tasmania	St Helens	543
18	Victoria	Toora	561
19	Victoria	Port Welshpool	626
20	Tasmania	Port Arthur	631
21	New South Wales	Bermagui	1,010
22	Tasmania	Beauty Point	1,016
23	Queensland	Karana Downs	1,080
24	Queensland	Port Douglas	1,121
25	Tasmania	Dover	1,210
26	Victoria	Apollo Bay	1,531
27	Queensland	Bowen	1,620
28	Victoria	Lorne	1,717
29	Tasmania	Stanley	1,824
30	Tasmania	Orford	1,936
31	Victoria	Anglesea	2,243
32	New South Wales	Camden Head	2,423
33	Tasmania	Cygnet	2,513
34	Tasmania	Risdon	2,588
35	Queensland	Cannonvale	2,657
36	Tasmania	Bridgewater	2,740
37	Queensland	Landsborough	2,907
38	Tasmania	Currie	2,929

39	New South Wales	Merimbula	2,938
40	Tasmania	Geeveston	3,081
41	Queensland	Bargara	3,251
42	Western Australia	Busselton (South)	3,298
43	Queensland	Innisfail	3,941
44	Tasmania	Strahan	4,082
45	Queensland	Edmonton	4,277
46	New South Wales	Yamba	4,423
47	New South Wales	Long Nose (Tomakin)	4,654
48	Queensland	Capalaba	4,982
49	Queensland	Nambour	5,077
50	Queensland	Rubyanna	5,153
51	Victoria	Foster	5,401
52	Queensland	Victoria Point	5,432
53	Queensland	Thorneside	5,630
54	Tasmania	Bridport	5,708
55	New South Wales	Penguin Heads (REMS)	5,812
56	Tasmania	Somerset	5,983
57	Queensland	Marlin Coast	6,025
58	New South Wales	Narooma	6,063
59	Queensland	Fairfield	6,455
60	New South Wales	Coffs Harbour	6,957
61	Queensland	Millbank	7,137
62	South Australia	Whyalla	7,464
63	South Australia	Port Lincoln	8,321
64	New South Wales	Batemans Bay	8,450
65	Queensland	Coolum	8,465
66	Queensland	Luggage Point Advanced	8,771
67	Tasmania	Legana	9,736
68	Queensland	Mackay North	10,062
69	South Australia	Port Pirie	10,420
70	New South Wales	Forster	10,727
71	Tasmania	George Town	10,987
72	Queensland	Mt St John	13,009
73	New South Wales	Ulladulla	13,144
74	Queensland	Beenleigh	13,334
75	Queensland	Carole Park	13,438
76	Western Australia	East Rockingham	13,685
77	South Australia	Port Augusta East	14,081
78	Queensland	Wynnum	14,314
79	Western Australia	Alkimos	14,854
80	Queensland	Sandgate	15,510
81	Queensland	Wacol	15,798

82	Tasmania	Round Hill	16,370
83	Queensland	Murrumba Downs	17,316
84	Tasmania	Blackmans Bay	18,027
85	Tasmania	Hoblers Bridge	18,089
86	Queensland	Caboolture South	18,456
87	Queensland	Maroochydore	19,866
88	Queensland	Woree (Southern WWTP)	19,908
89	Tasmania	Port Sorell	20,777
90	Tasmania	Selfs Point	20,869
91	Queensland	Goodna	21,654
92	Queensland	Redcliffe	22,540
93	Tasmania	Turners Beach	22,628
94	Queensland	Burpengary East	23,993
95	Victoria	McGaurans Beach	24,358
96	Tasmania	Ulverstone	24,651
97	Queensland	Bundamba	25,711
98	South Australia	Finger Point	25,828
99	Tasmania	Wynyard	26,312
100	Tasmania	Rosny	26,844
101	Queensland	Rockhampton South	27,186
102	Queensland	Cleveland Bay	30,969
103	Tasmania	Riverside	32,440
104	Victoria	Portland	33,477
105	Victoria	Phillip Island	34,174
106	Victoria	Delray Beach	34,315
107	Queensland	Merrimac	36,592
108	Victoria	Baxter's Beach	36,655
109	Victoria	Altona	38,354
110	Tasmania	Cameron Bay	46,220
111	Tasmania	Newnham	51,912
112	Queensland	Elanora	52,066
113	Queensland	Rockhampton North	52,316
114	Western Australia	Bunbury	54,120
115	Victoria	Port Fairy	57,729
116	South Australia	Christies Beach-Northern	63,023
117	South Australia	Bolivar High Salinity	65,998
118	Queensland	Gibson Island	67,840
119	Tasmania	Smithton	68,620
120	Queensland	Loganholme	101,003
121	Tasmania	Prince of Wales	101,969
122	Queensland	Coombabah	102,068
123	Tasmania	Ti-tree Bend	152,605
124	Victoria	Boags Rock (Boneo, Mt Martha, Somers)	156,658

125	Tasmania	Macquarie Point	160,696
126	Queensland	Oxley	207,249
127	Tasmania	Pardoe	210,031
128	Victoria	Black Rock	227,317
129	New South Wales	Winney Bay (Kincumber)	239,581
130	Queensland	Kawana	243,404
131	South Australia	Glenelg	260,974
132	Victoria	Warrnambool	285,982
133	South Australia	Bolivar WWTP	366,621
134	Western Australia	Subiaco	421,021
135	Western Australia	Point Peron	448,070
136	Queensland	Luggage Point	517,419
137	Western Australia	Beenyup	681,269
138	Western Australia	Woodman Point	1,011,506
139	Victoria	Boags Rock (Eastern Treatment Plant)	3,479,639
140	Victoria	Werribee (Western Treatment Plant)	5,103,568
Total Load			**16,168,516**

Note:

= Top quartile

= 50th quartile

= 75th quartile

= Bottom quartile

APPENDIX B – OUTFALLS HISTOGRAM

Figure 4. 10 outfalls with high discharged nutrient load (bottom quartile)