Appendix B: Georges River

This Appendix mainly includes graphical presentation of all monitoring data for the Georges River catchment. Summary tables, detailed statistical analyses outcomes are also included where relevant.

Under each WRRF (Sub-chapters B-1 to B-3), the results are presented following the **Pressure**, **Stressor** and **Ecosystem Receptor** (**P-S-ER**) causal pathway elements.

For the **Pressure**, trend plots are included on wastewater quantity (discharge and inflow) and quality. Trends plots on other supplementary data are also included to improve our understanding on:

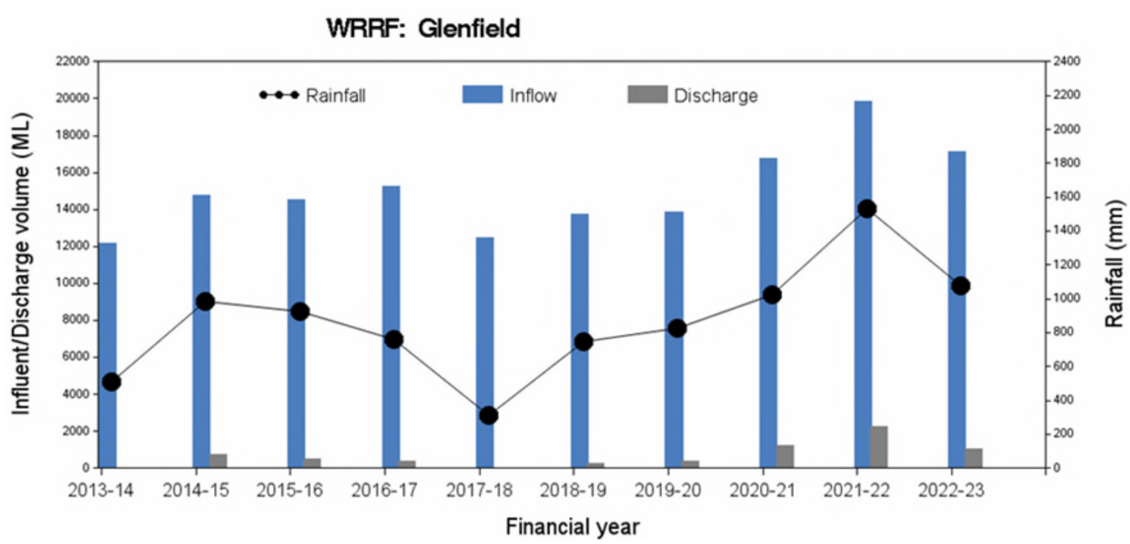
- weather condition ie catchment specific rainfall condition for each WRRF
- wastewater reuse/ recycling volume of relevant WRRF.

Tests conducted on wastewater are specified in the Environment Protection Licence (EPL) issued by the NSW EPA for each WRRF (B-4). Data for all these measured analytes that have EPL concentration and load limits are included (where applicable).

B-1 Glenfield WRRF

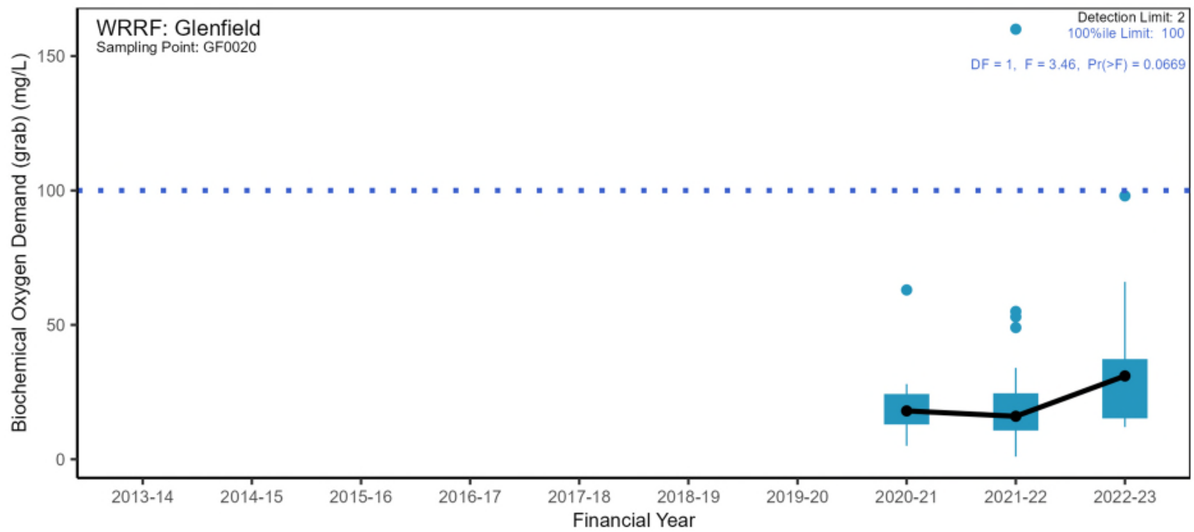
B-1.1 Pressure – Wastewater quantity

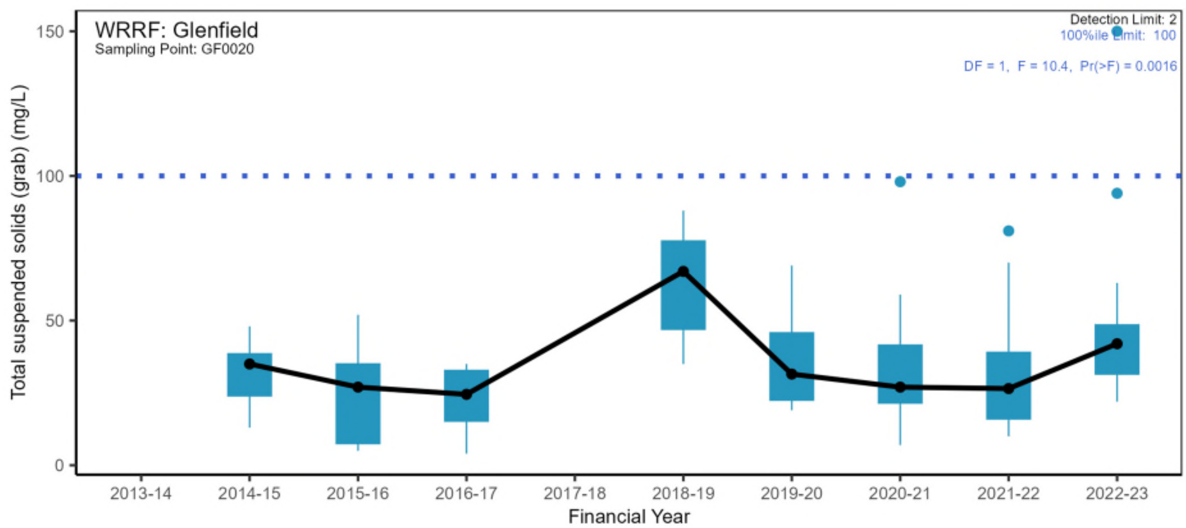
Inflow/ Discharge volume and rainfall



B-1.2 Pressure – Wastewater quality

Major conventional analytes

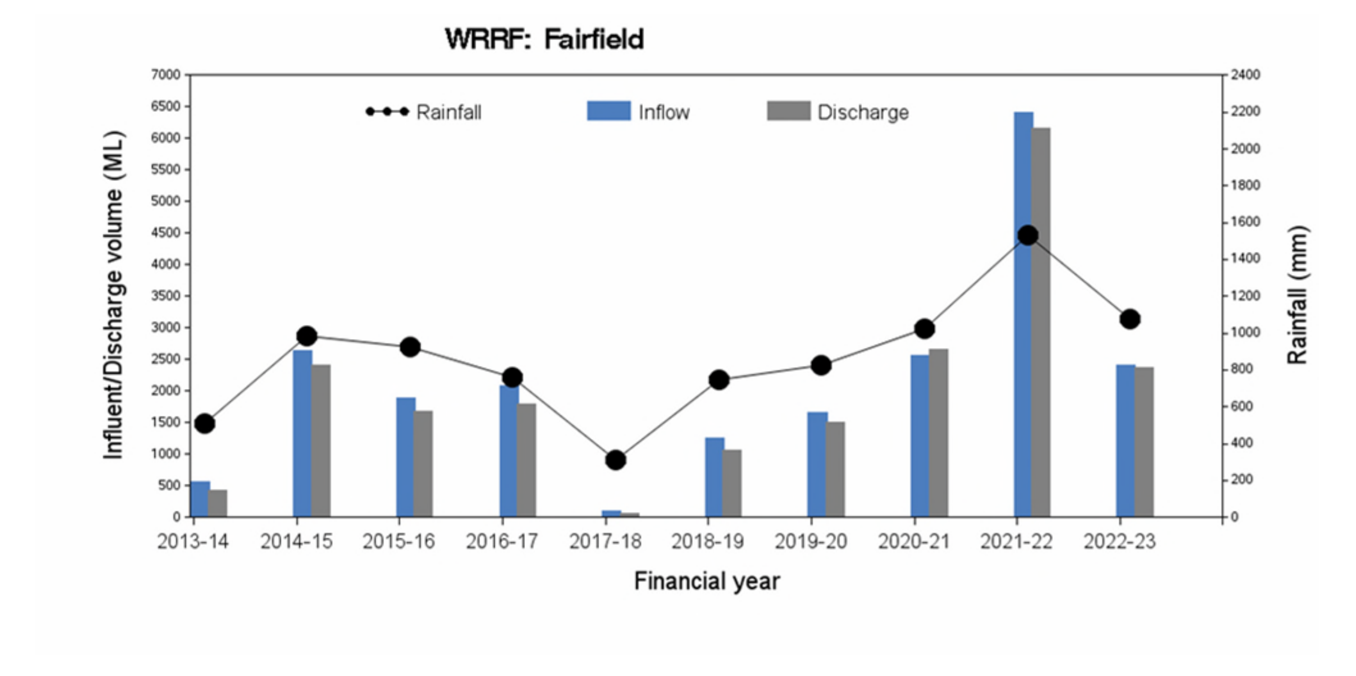




B-2 Fairfield WRRF

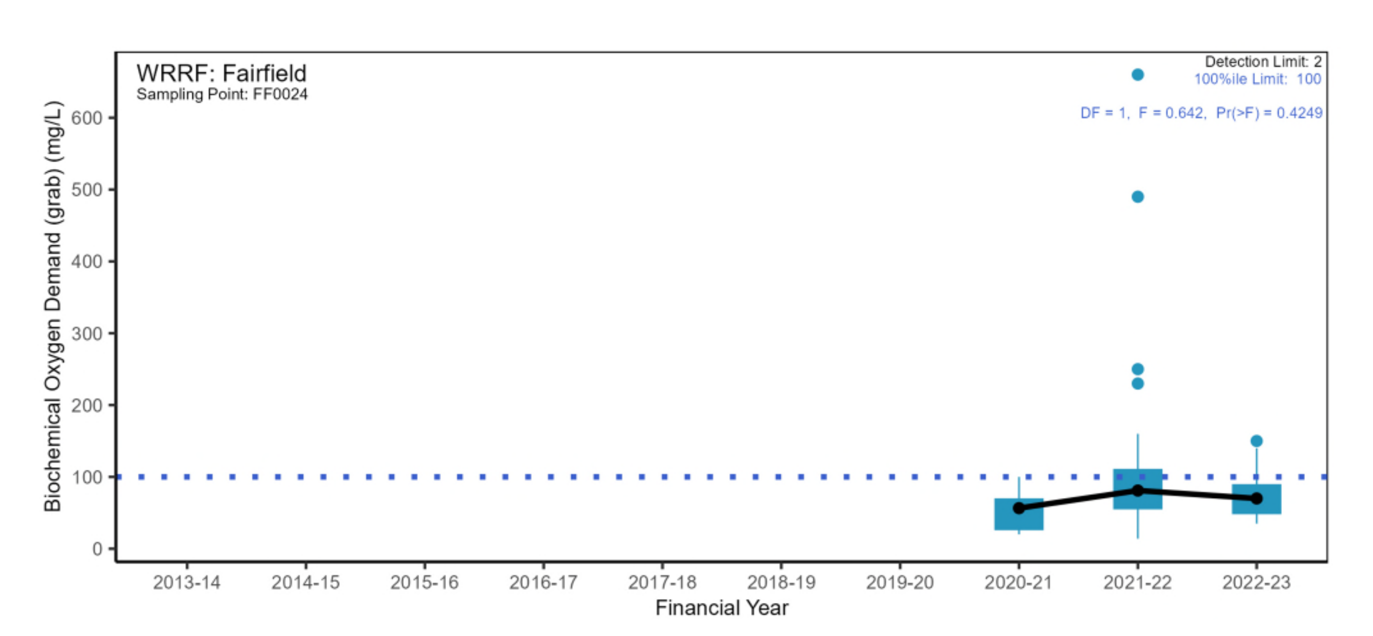
B-2.1 Pressure – Wastewater quantity

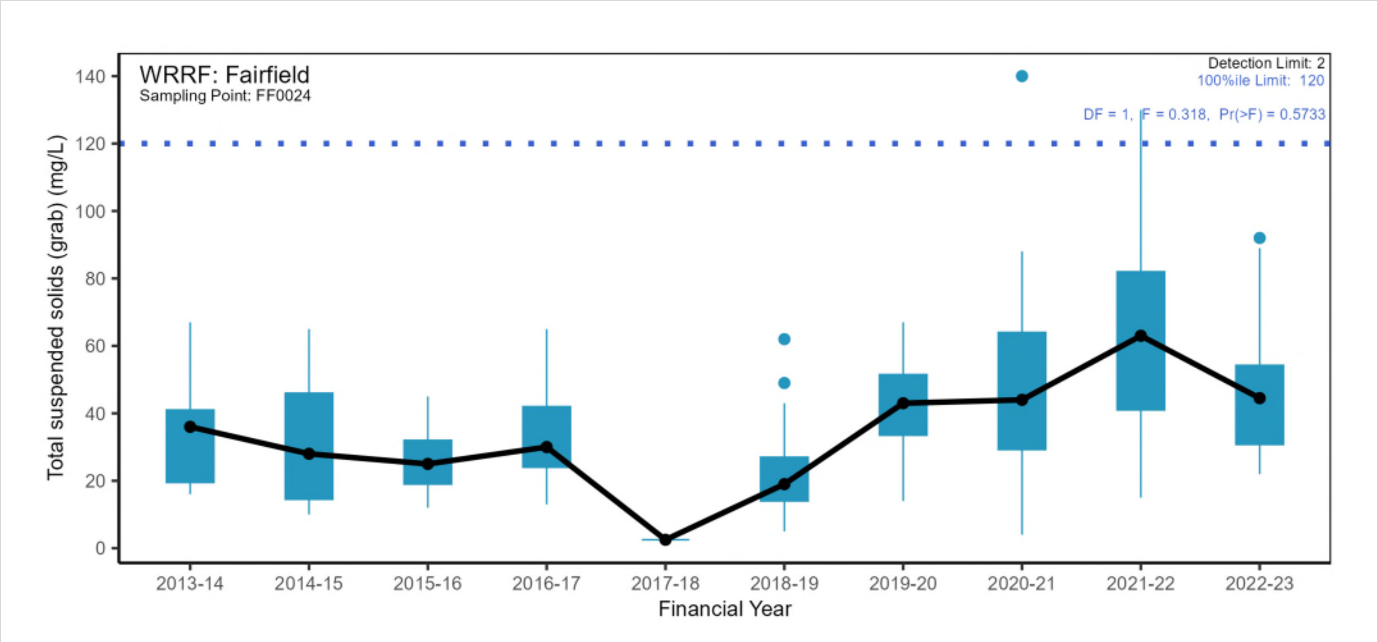
Inflow/ Discharge volume and rainfall



B-2.2 Pressure – Wastewater quality

Major conventional analytes

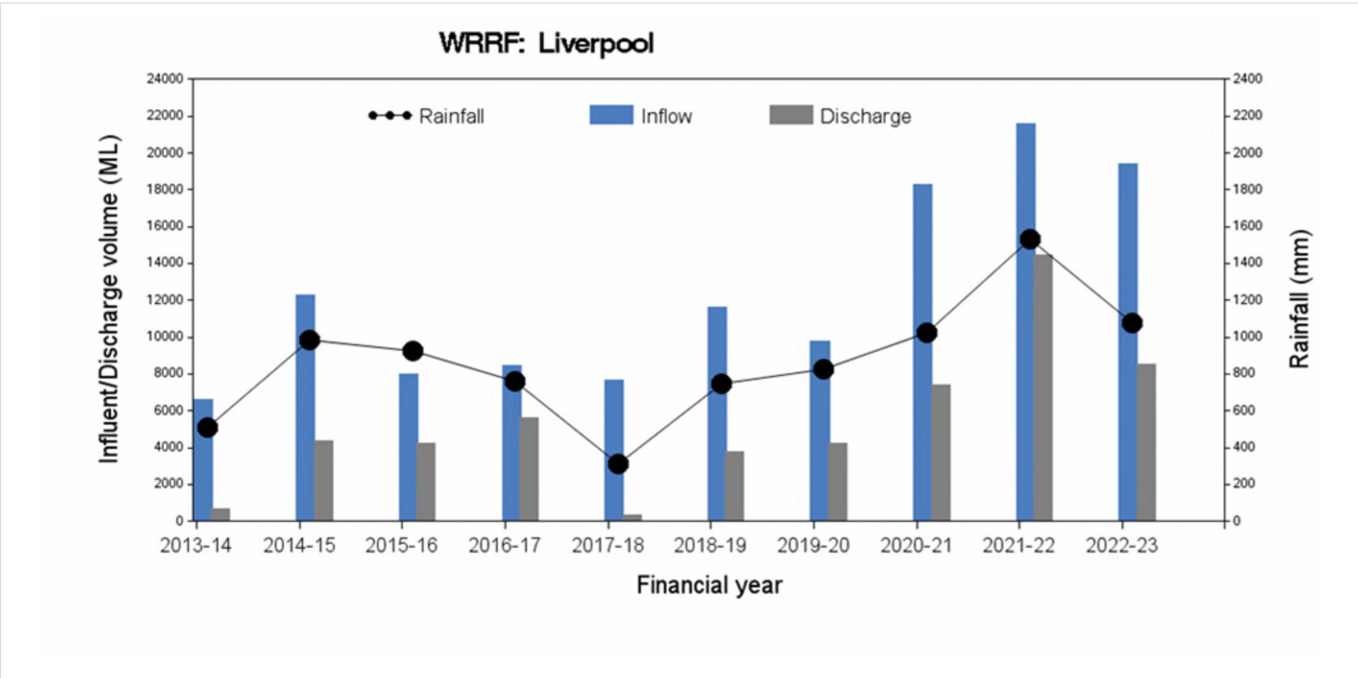




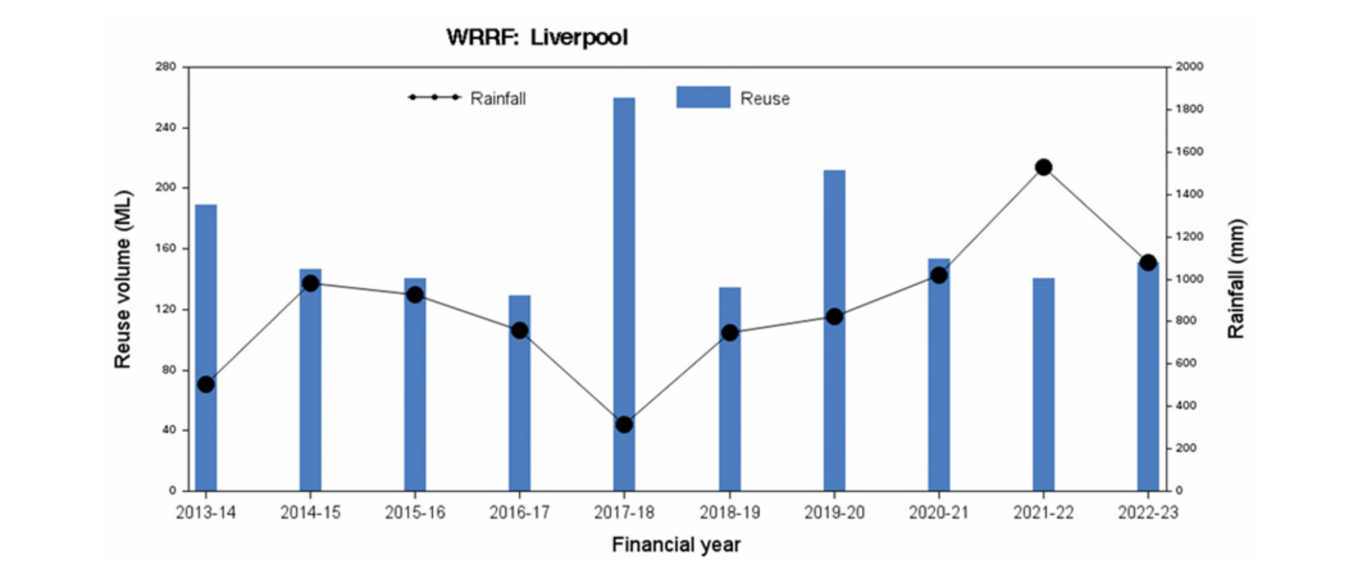
B-3 Liverpool WRRF

B-3.1 Pressure – Wastewater quantity

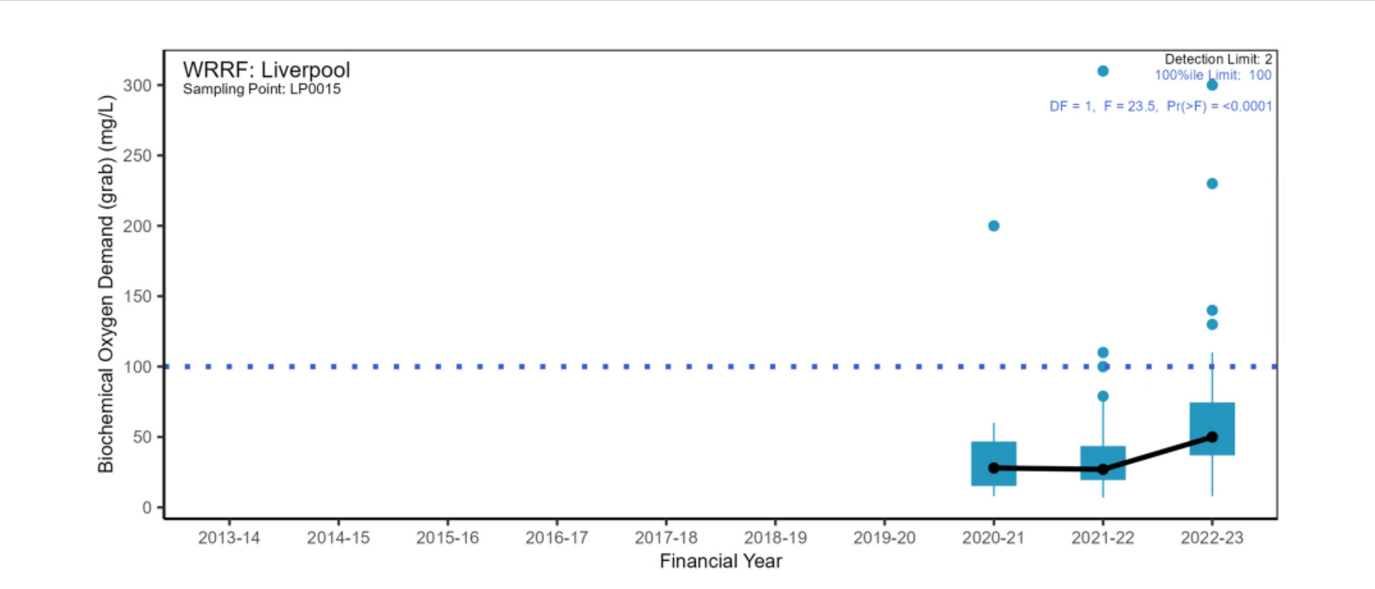
Inflow/ Discharge volume and rainfall

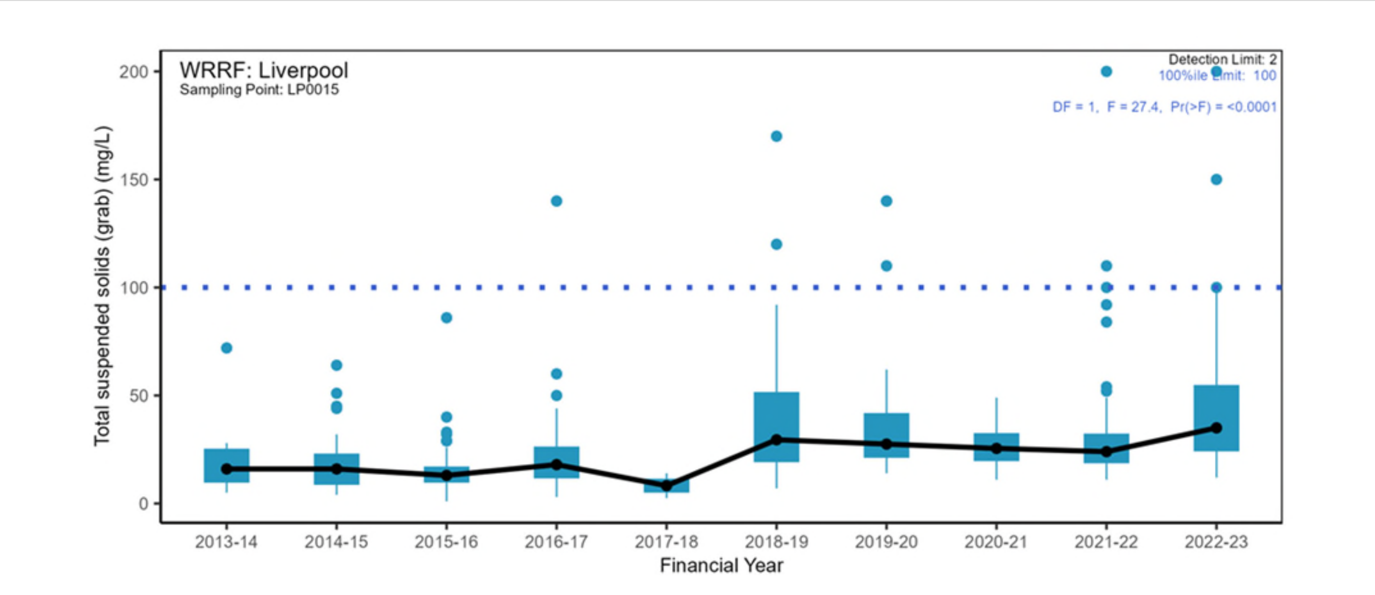


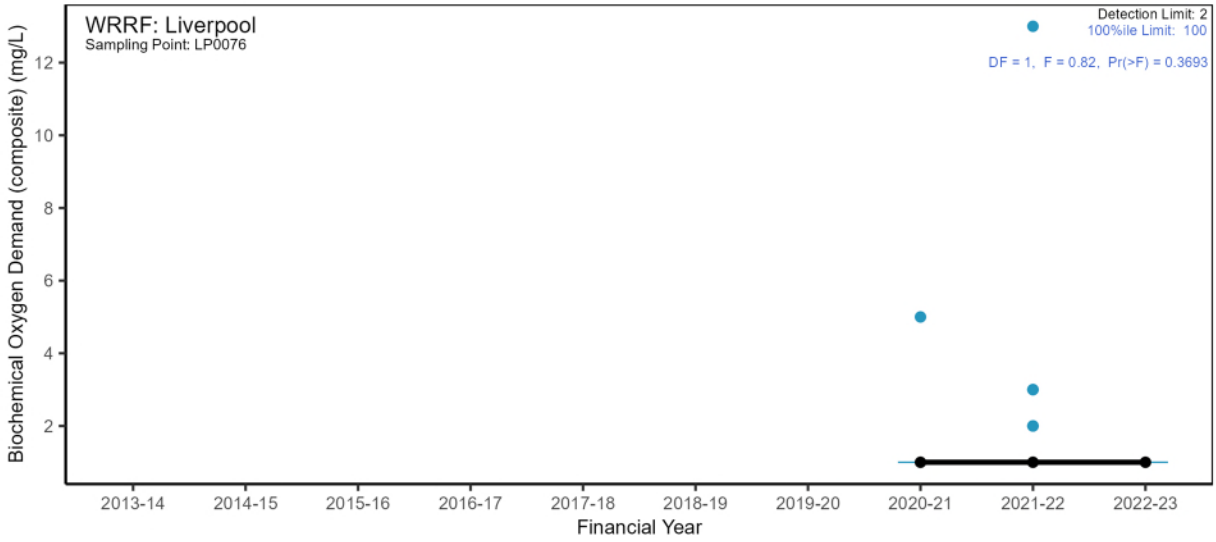
Reuse volume and rainfall



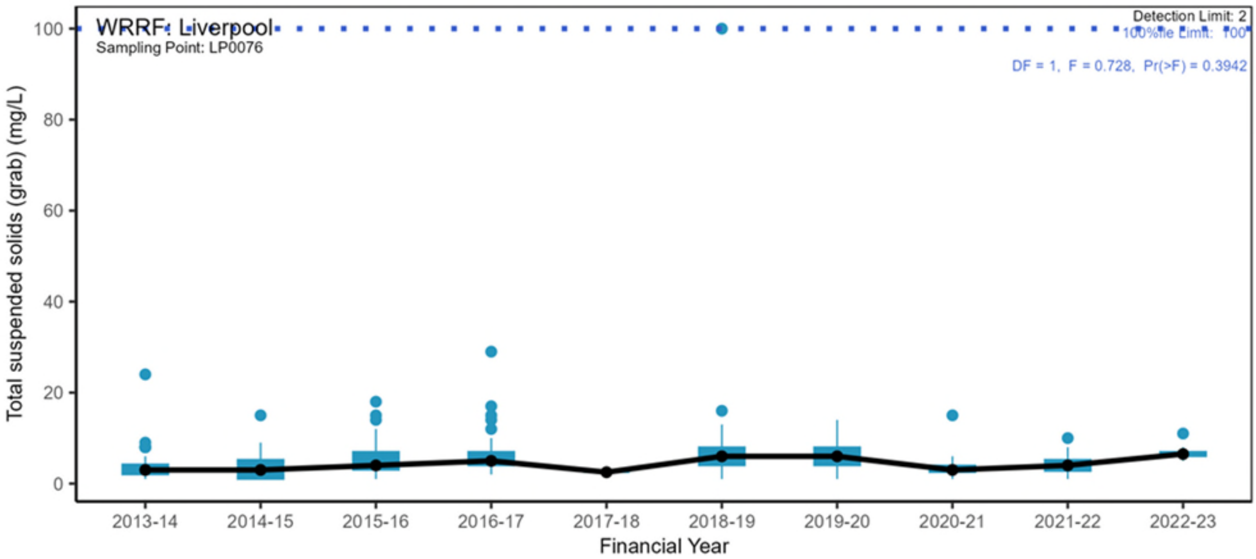
Major conventional analytes



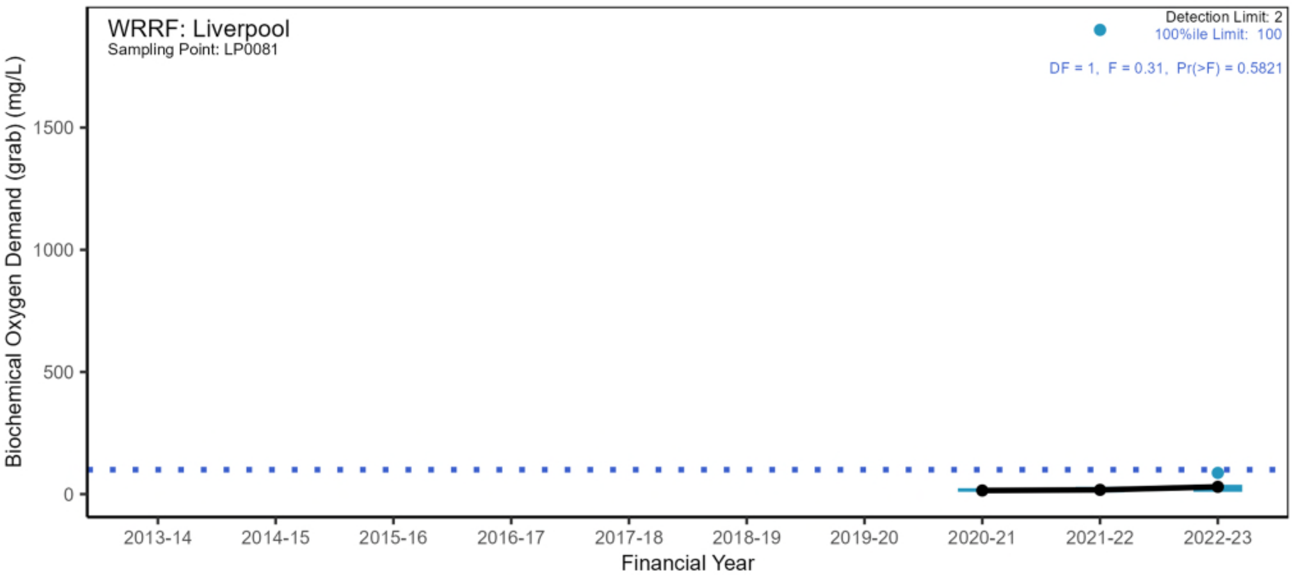




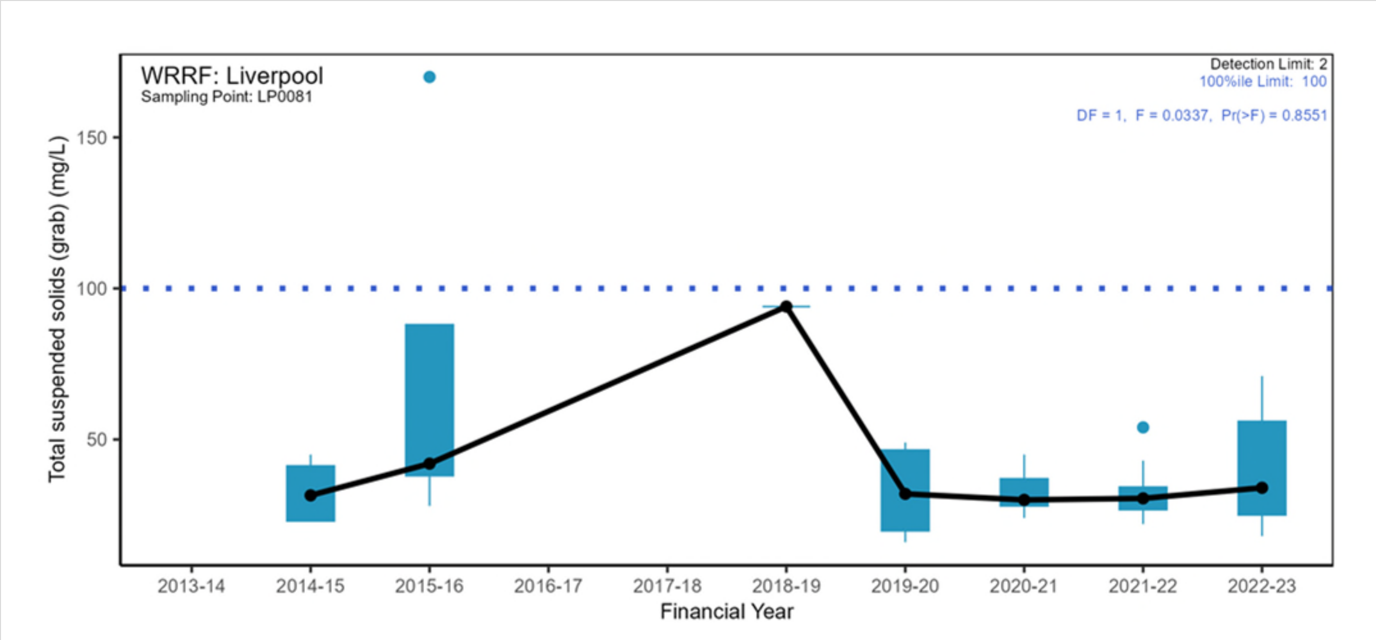
WRRF: Liverpool
Sampling Point: LP0076
Detection Limit: 2
100%ile Limit: 100
DF = 1, F = 0.82, Pr(>F) = 0.3693
Biochemical Oxygen Demand (composite) (mg/L)
12
10
8
6
4
2
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Financial Year



WRRF: Liverpool
Sampling Point: LP0076
Detection Limit: 2
100%ile Limit: 100
DF = 1, F = 0.728, Pr(>F) = 0.3942
Total suspended solids (grab) (mg/L)
100
80
60
40
20
0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Financial Year



WRRF: Liverpool
Sampling Point: LP0081
Detection Limit: 2
100%ile Limit: 100
DF = 1, F = 0.31, Pr(>F) = 0.5821
Biochemical Oxygen Demand (grab) (mg/L)
1500
1000
500
0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Financial Year



B-4 EPL limits of the Georges River WRRF

Table B-1 EPL concentration limits for the Georges River WRRFs (2022-23)

WRRF	Sampling Points	Biochemical Oxygen Demand (mg/L)	Total Suspended Solids (mg/L)
		100th %-ile	100th %-ile
Glenfield	GF0020 (G)	100	100
Fairfield	FF0024 (G)	100	120
Liverpool	LP0015 - discharge (G)	100	100
	LP0076 – irrigation (C)	100	100
	LP0081 - discharge (G)	100	100

Appendix C: Other monitoring – Freshwater

C-1 Other long-term Hawkesbury-Nepean River sites (SoE)

Water quality for the 12 SoE sites are presented in the following order from upstream to downstream:

- N67: Nepean River at Wallacia Bridge
- N51: Nepean River opposite Fitzgerald Creek
- N44: Nepean River at Yarramundi Bridge
- NS04A: Lower South Creek at Fitzroy Bridge
- N35: Hawkesbury River at Wilberforce
- NC11A: Lower Cattai Creek at Cattai Ridge Road
- N3001: Hawkesbury River off Cattai SRA
- N26: Hawkesbury River at Sackville Ferry
- N2202: Lower Colo River at Putty Road
- N18: Hawkesbury River at Leets Vale
- NB13: Berowra Creek at Calabash Bay
- NB11: Berowra Creek off Square Bay

The water quality trend plots are presented in the following groups and order of analytes:

Nutrients

- Ammonia nitrogen
- Oxidised nitrogen
- Total nitrogen
- Filterable total phosphorus
- Total phosphorus

Physico-chemical analytes

- Conductivity
- Dissolved oxygen (mg/L)
- Dissolved oxygen saturation (%)
- pH
- Temperature
- Turbidity

Phytoplankton

- Chlorophyll-a
- Total phytoplankton biovolume
- Blue-green biovolume
- Toxic blue-green species count

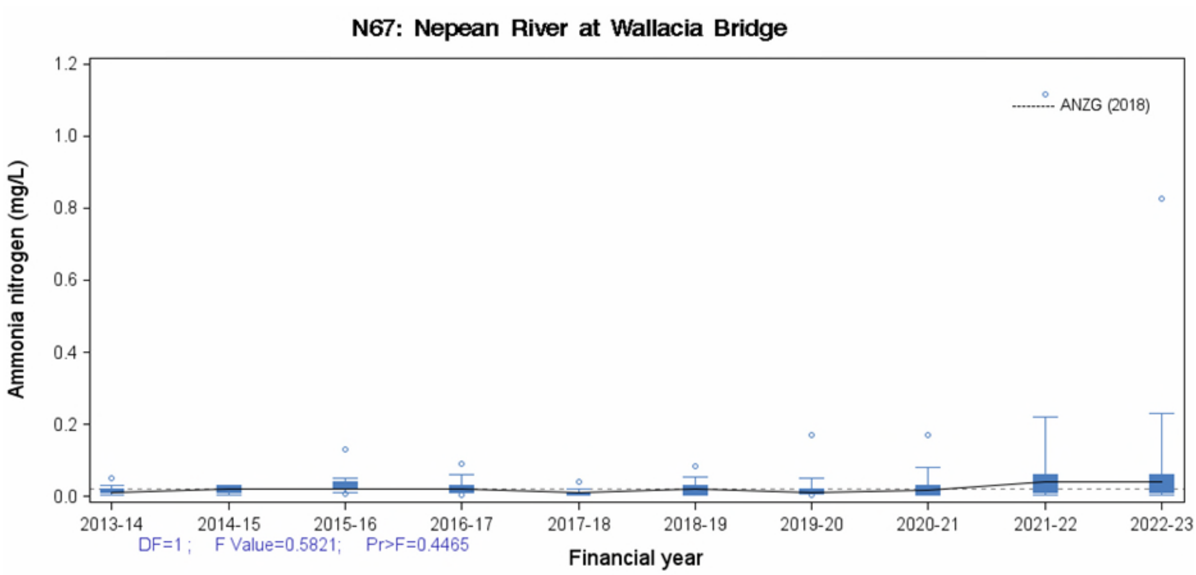
Freshwater macroinvertebrate monitoring is conducted at three of these sites:

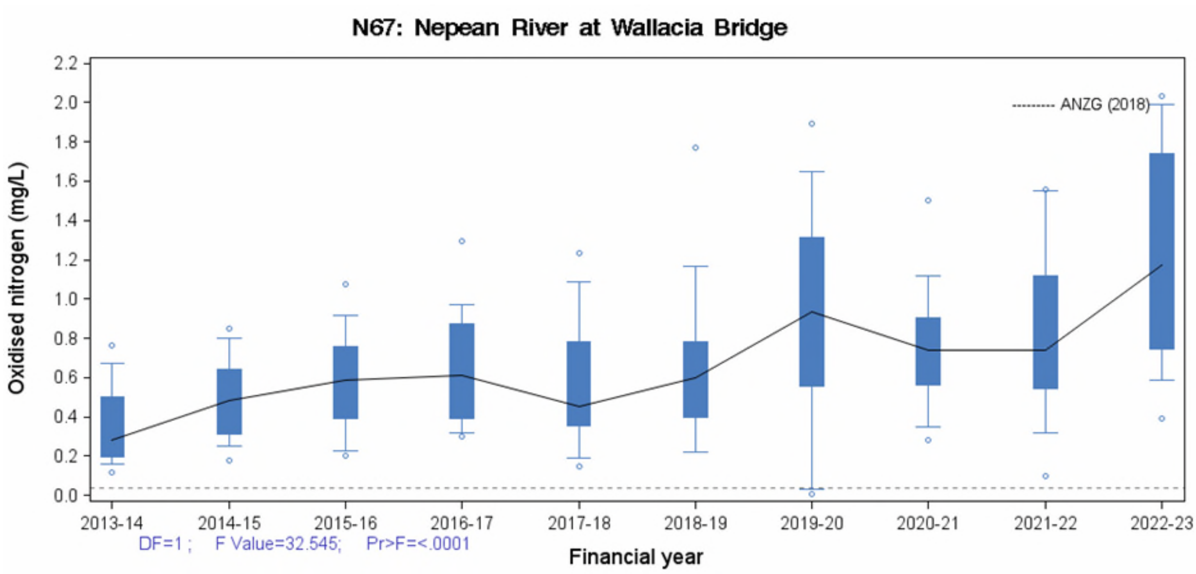
- N38: Hawkesbury River at Windsor Bridge, upstream South Creek
- N35: Hawkesbury River at Wilberforce
- N26: Hawkesbury River at Sackville Ferry

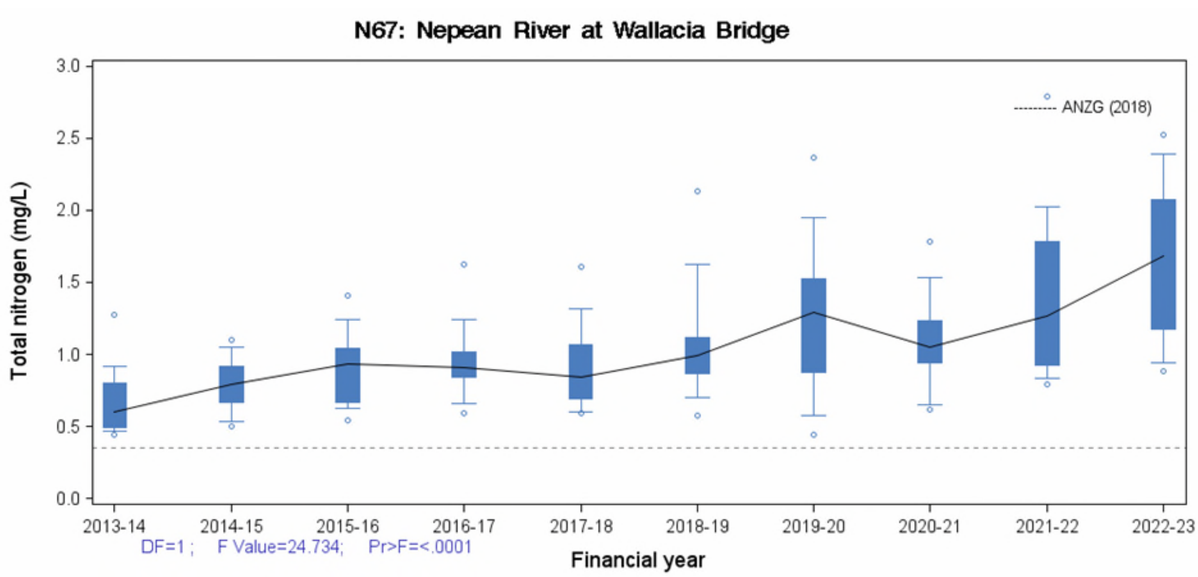
SIGNAL-SG charts are presented for these sites in relevant sections below.

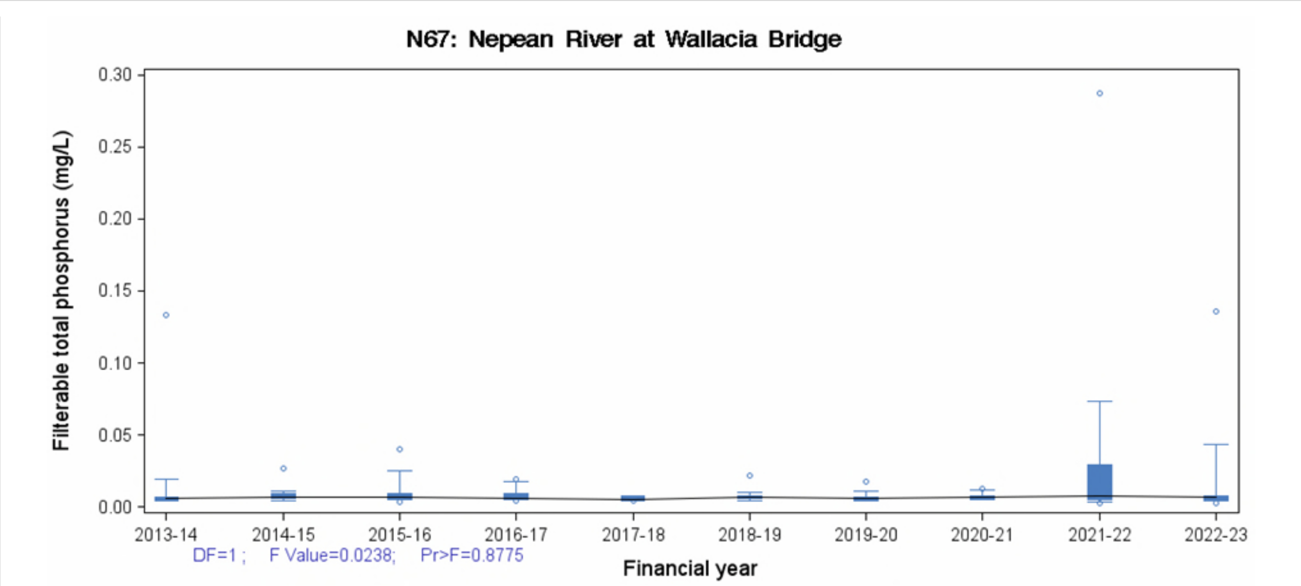
C-1.1 Nepean River at Wallacia Bridge (N67)

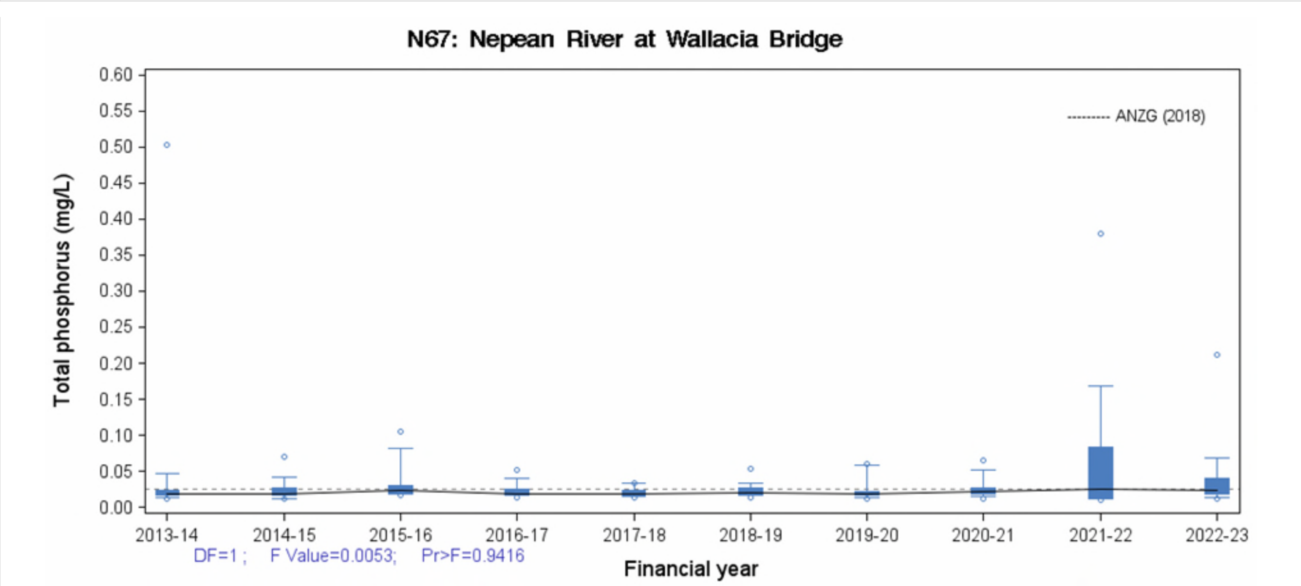
Stressors – Nutrients



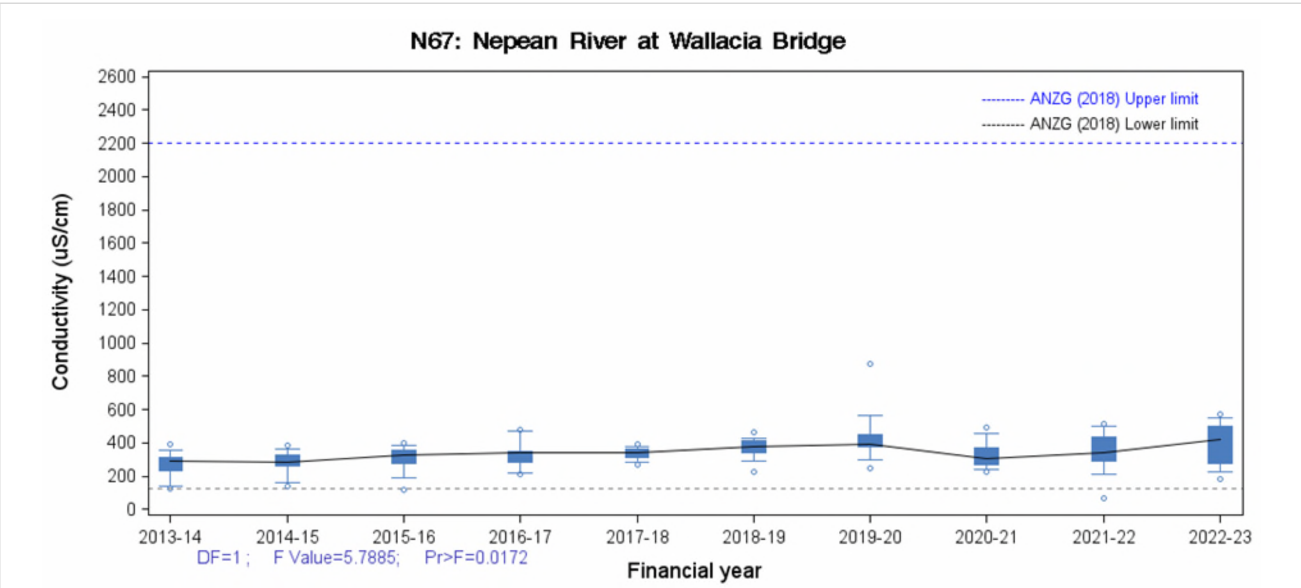


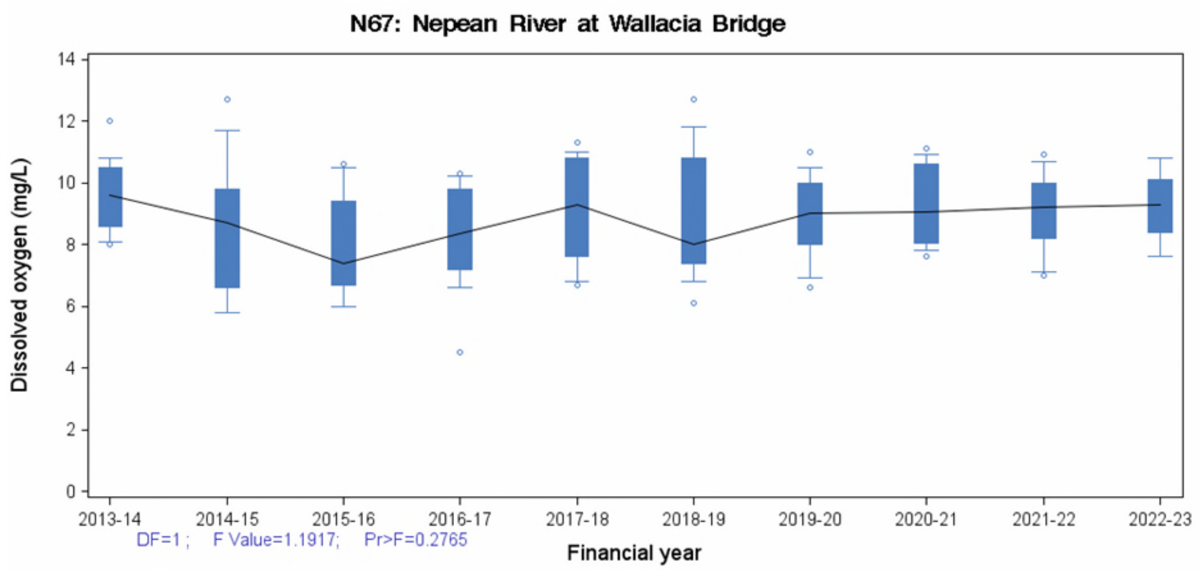




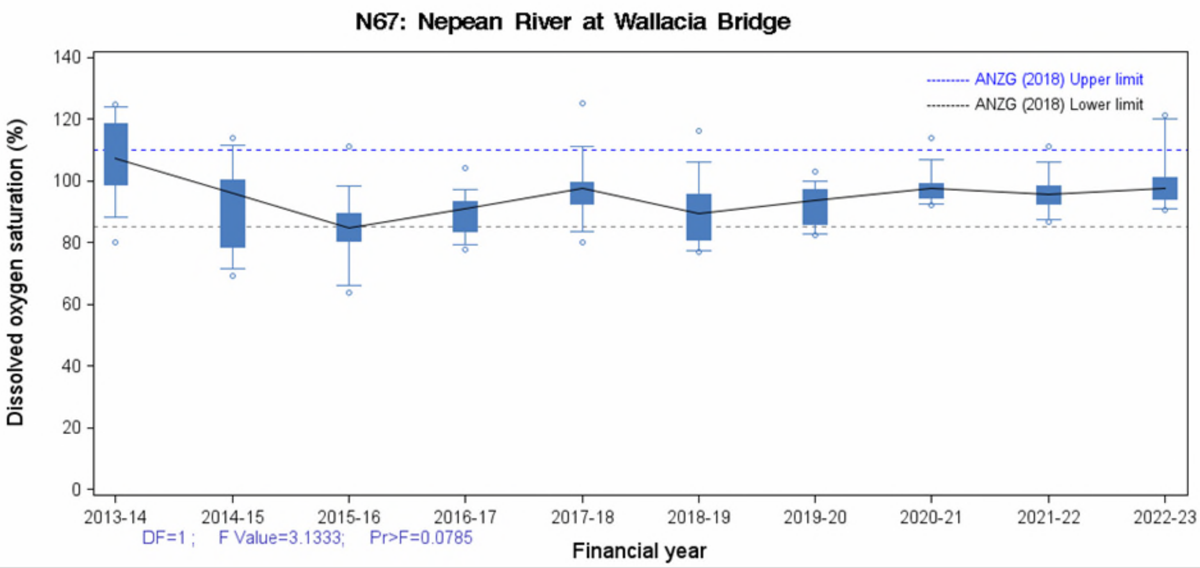


Stressors – Physico-chemical water quality

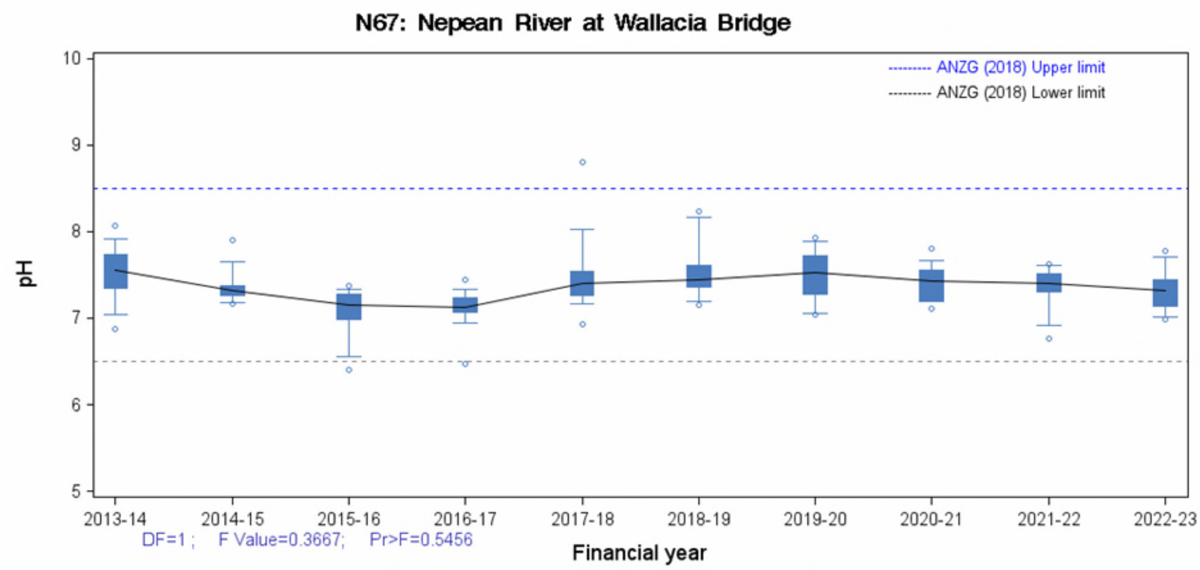




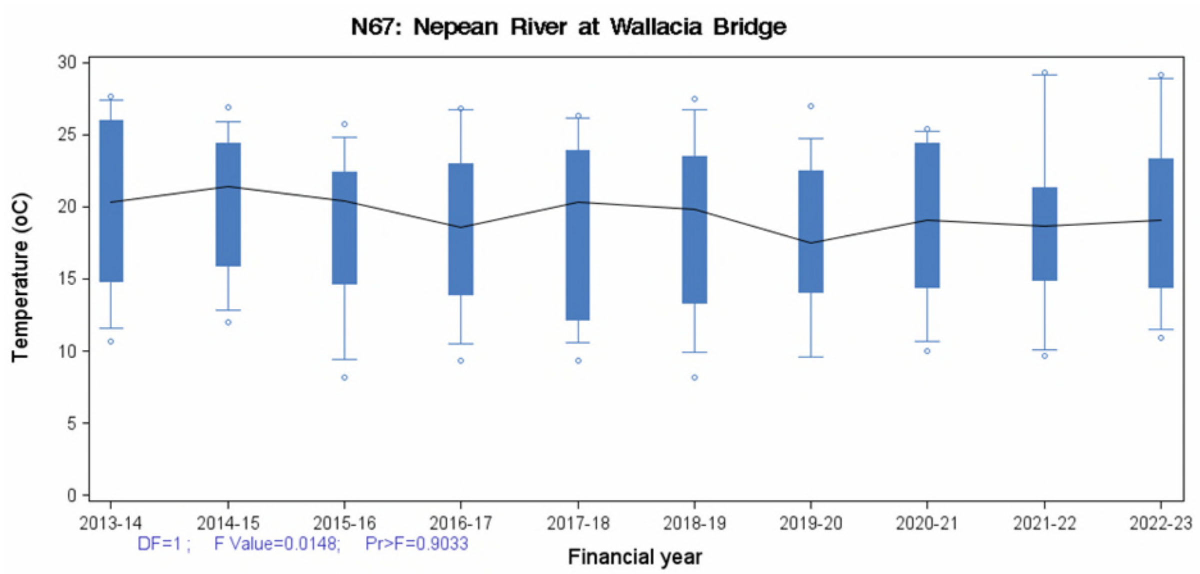
N67: Nepean River at Wallacia Bridge
Dissolved oxygen (mg/L)
0
2
4
6
8
10
12
14
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=1.1917; Pr>F=0.2765
Financial year

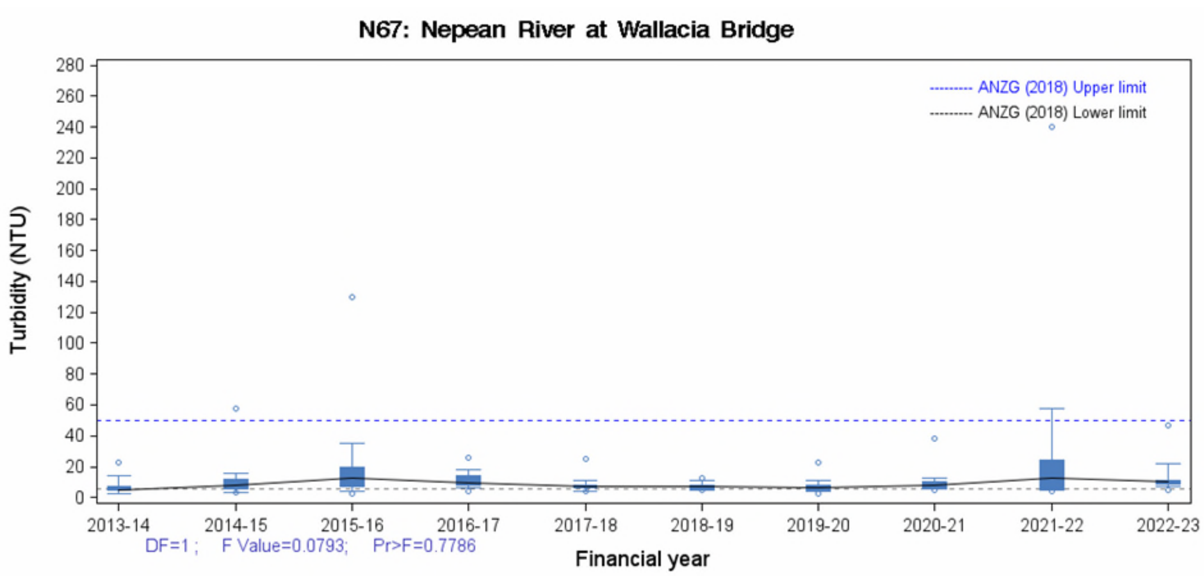


N67: Nepean River at Wallacia Bridge
ANZG (2018) Upper limit
ANZG (2018) Lower limit
Dissolved oxygen saturation (%)
0
20
40
60
80
100
120
140
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=3.1333; Pr>F=0.0785
Financial year

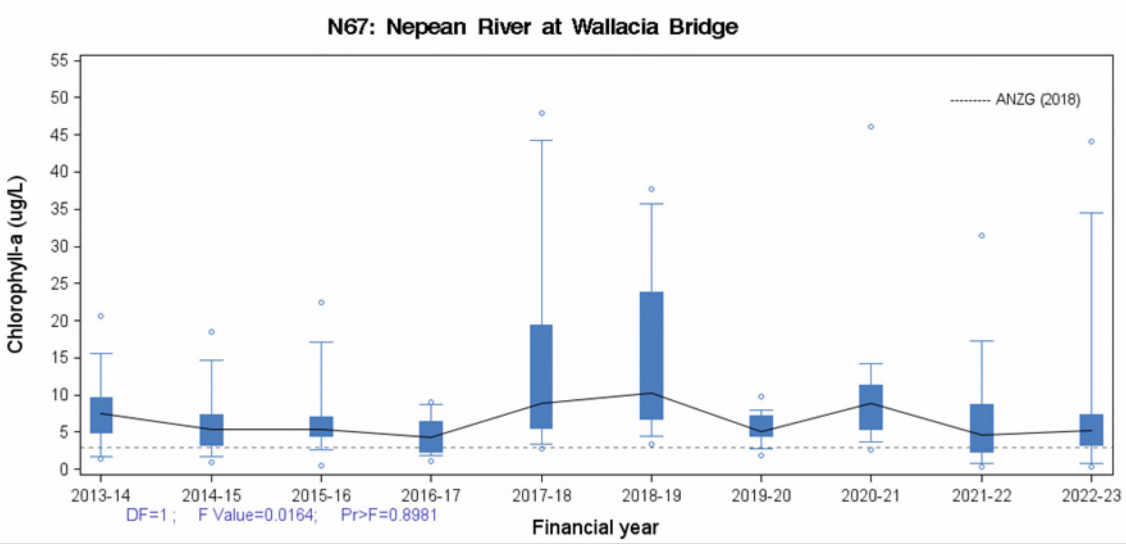


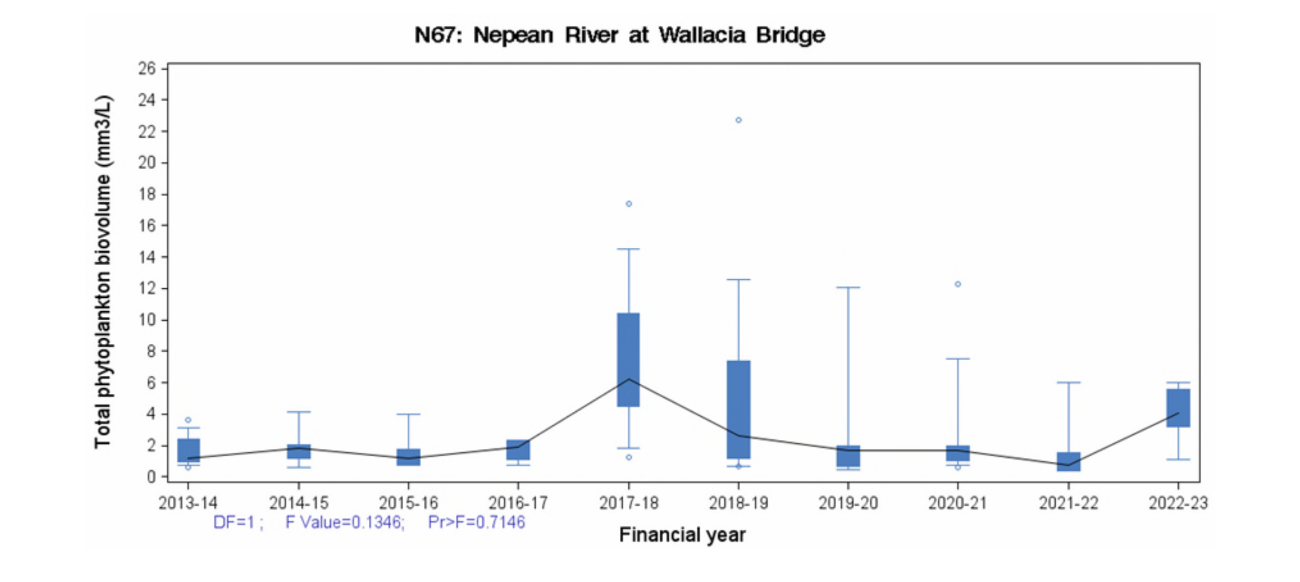
N67: Nepean River at Wallacia Bridge
ANZG (2018) Upper limit
ANZG (2018) Lower limit
pH
5
6
7
8
9
10
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=0.3667; Pr>F=0.5456
Financial year

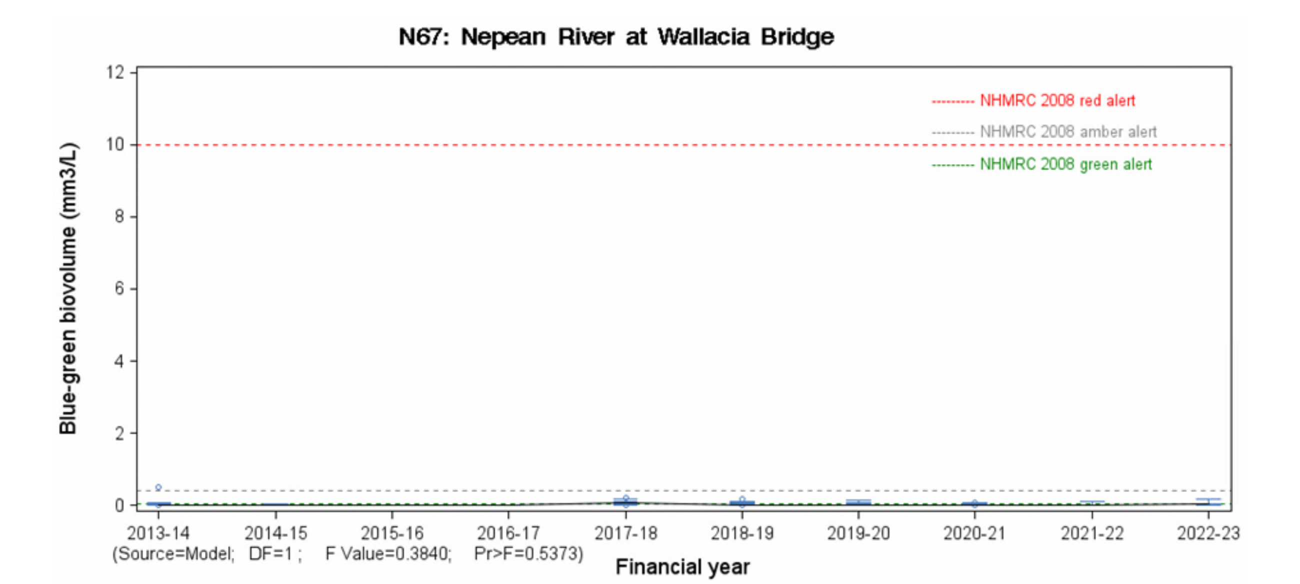


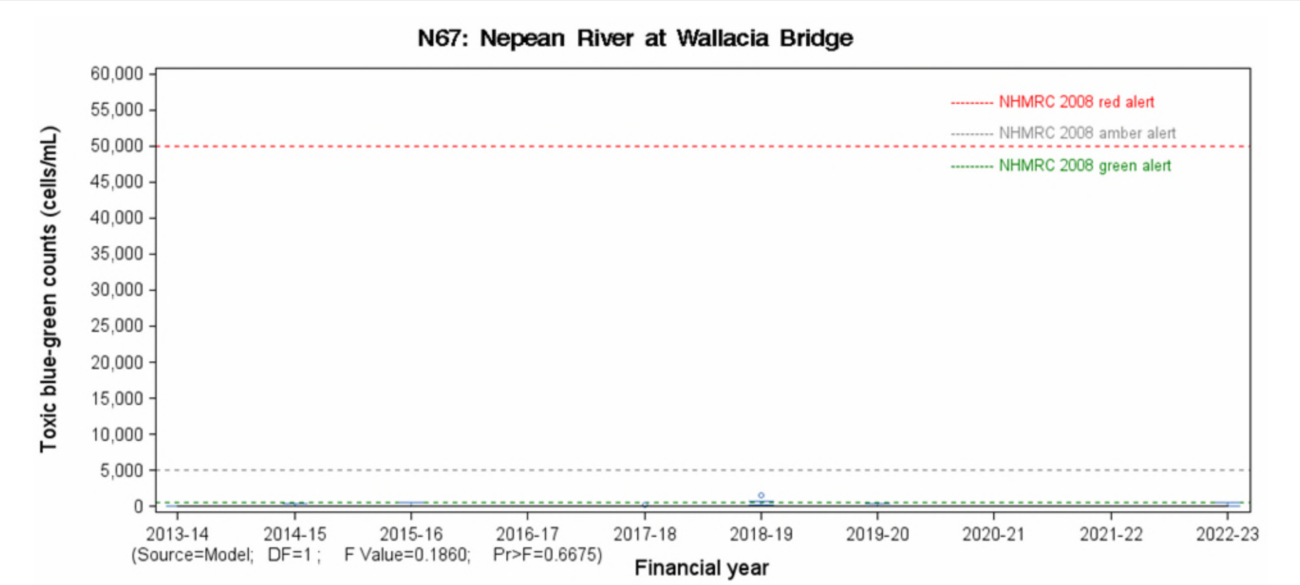


Ecosystem receptor – Phytoplankton



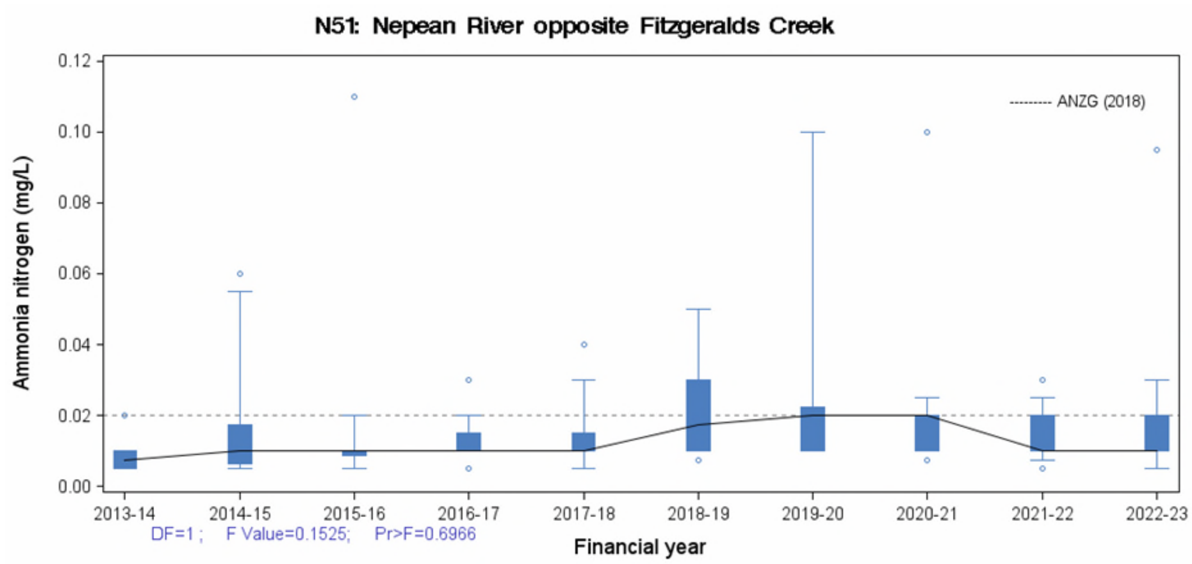

N67: Nepean River at Wallacia Bridge
Total phytoplankton biovolume (mm3/L)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=0.1346; Pr>F=0.7146
Financial year

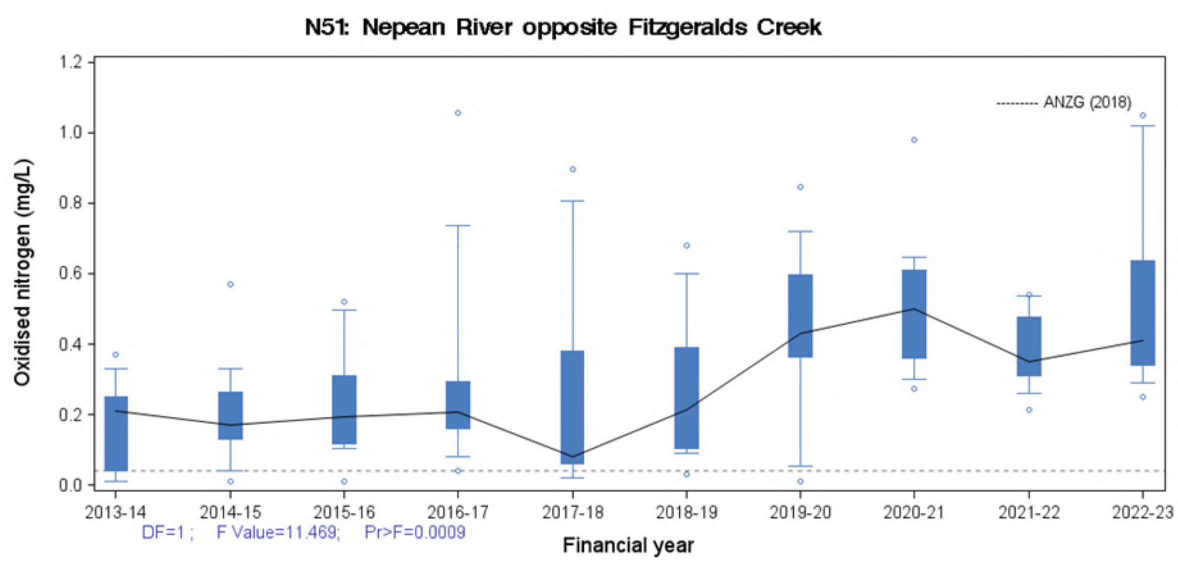

N67: Nepean River at Wallacia Bridge
Blue-green biovolume (mm3/L)
0
2
4
6
8
10
12
NHMRC 2008 red alert
NHMRC 2008 amber alert
NHMRC 2008 green alert
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
(Source=Model; DF=1 ; F Value=0.3840; Pr>F=0.5373)
Financial year

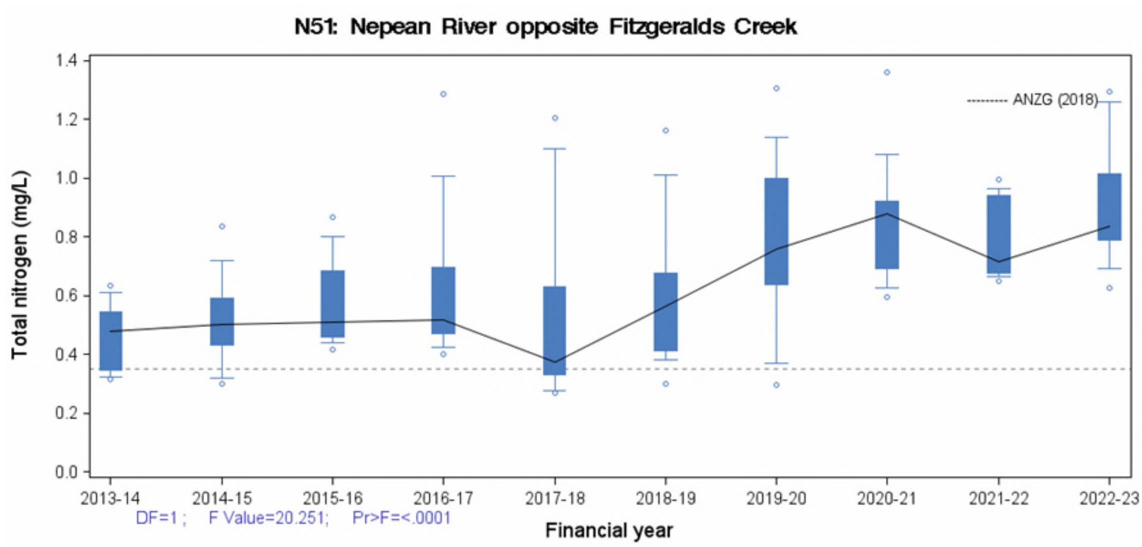

N67: Nepean River at Wallacia Bridge
Toxic blue-green counts (cells/mL)
0
5,000
10,000
15,000
20,000
25,000
30,000
35,000
40,000
45,000
50,000
55,000
60,000
NHMRC 2008 red alert
NHMRC 2008 amber alert
NHMRC 2008 green alert
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
(Source=Model; DF=1 ; F Value=0.1860; Pr>F=0.6675)
Financial year

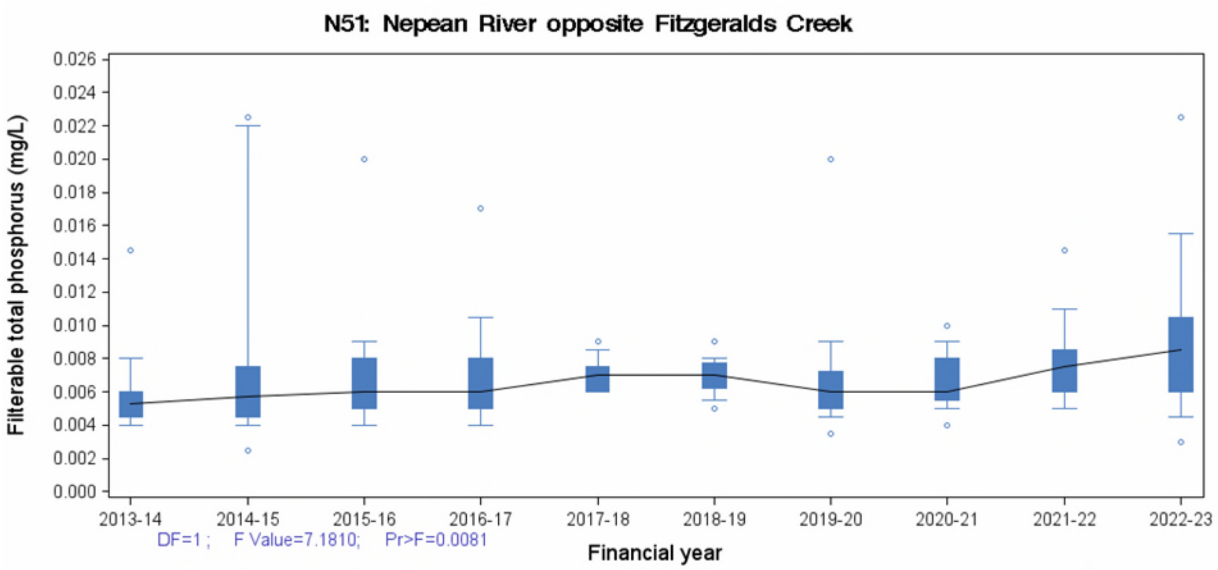
C-1.2 Nepean River opposite Fitzgeralds Creek (N51)

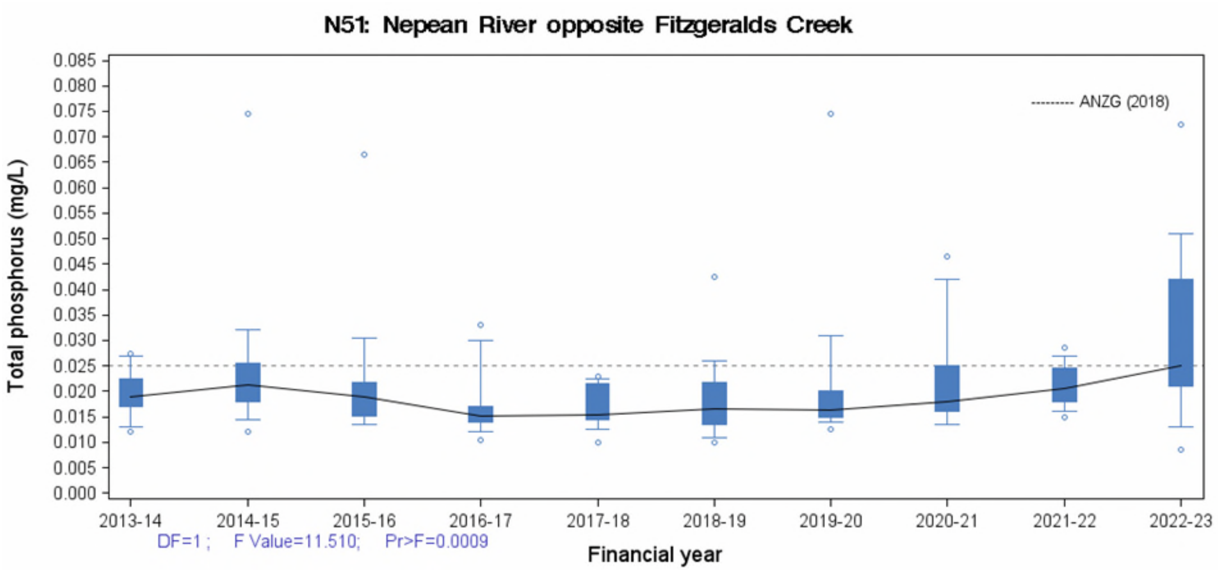
Stressors – Nutrients

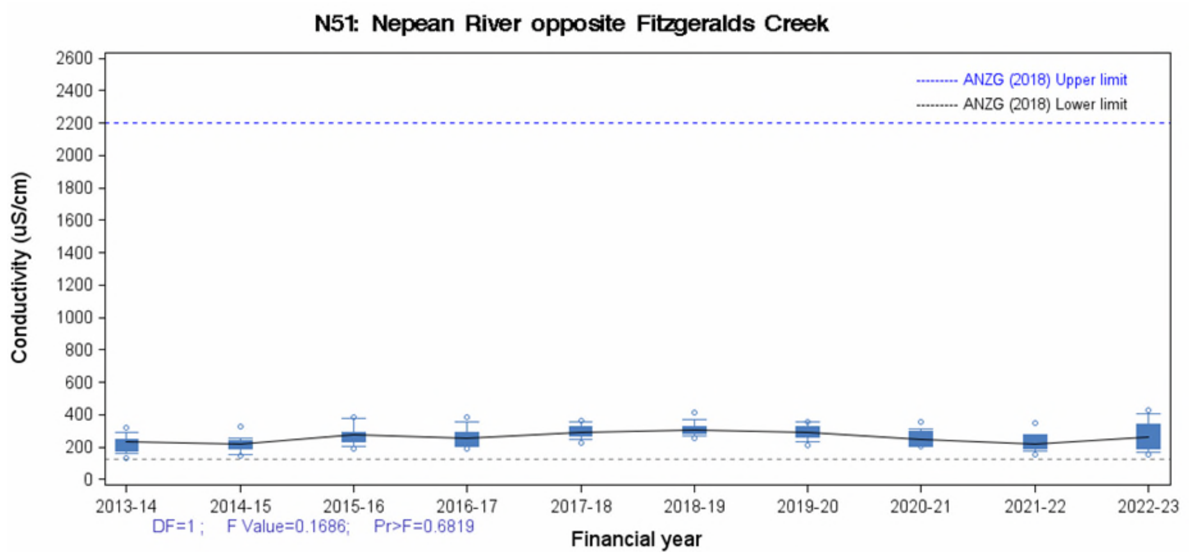


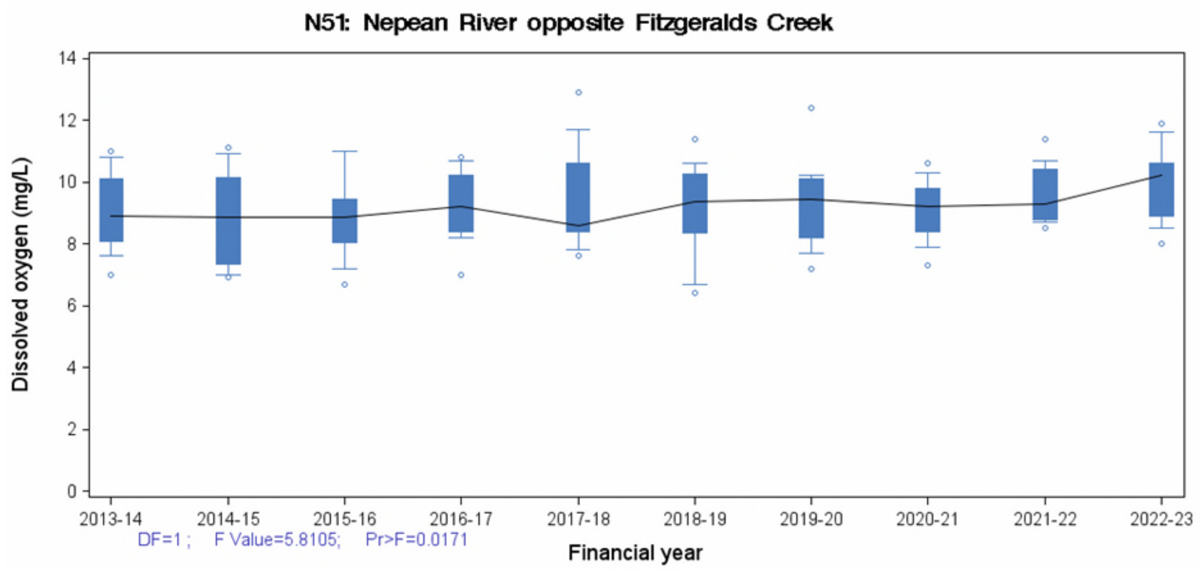


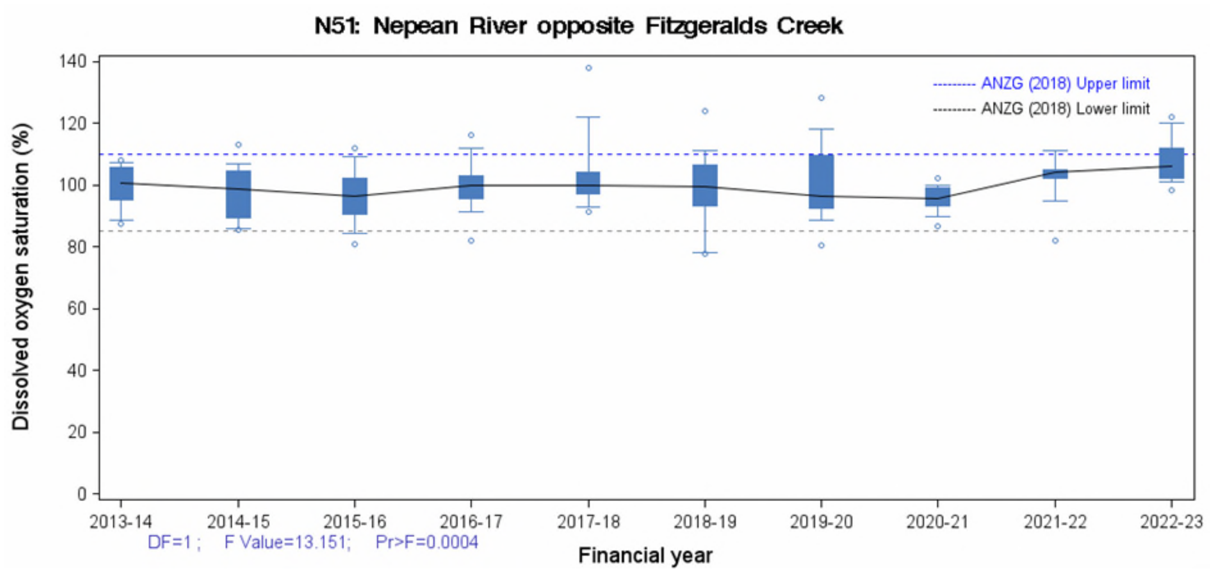


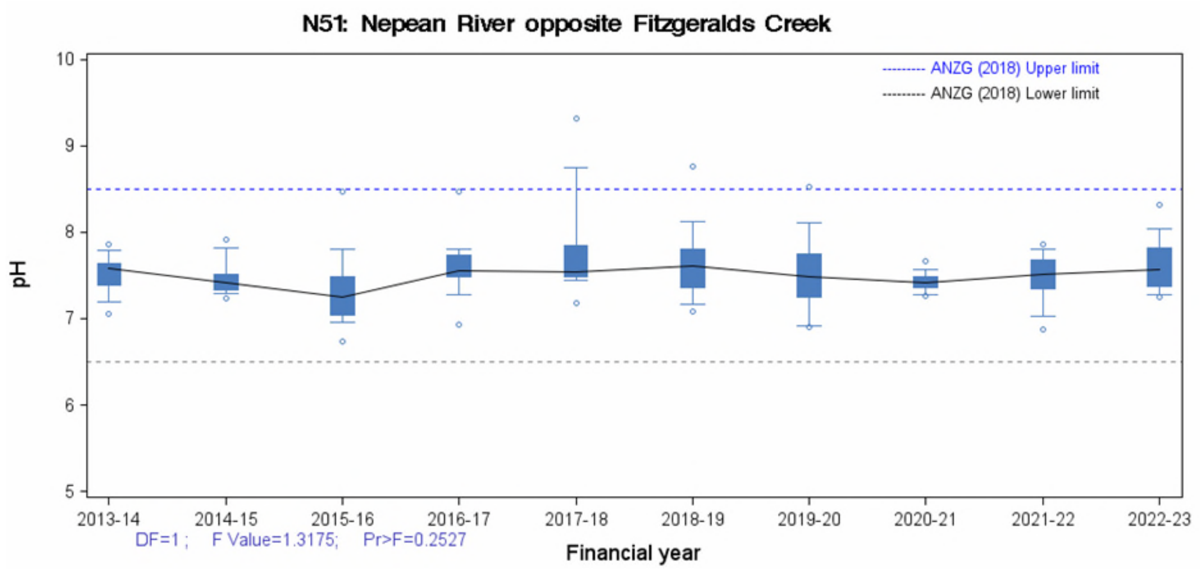

N51: Nepean River opposite Fitzgeralds Creek
Filterable total phosphorus (mg/L)
0.026
0.024
0.022
0.020
0.018
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=7.1810; Pr>F=0.0081
Financial year

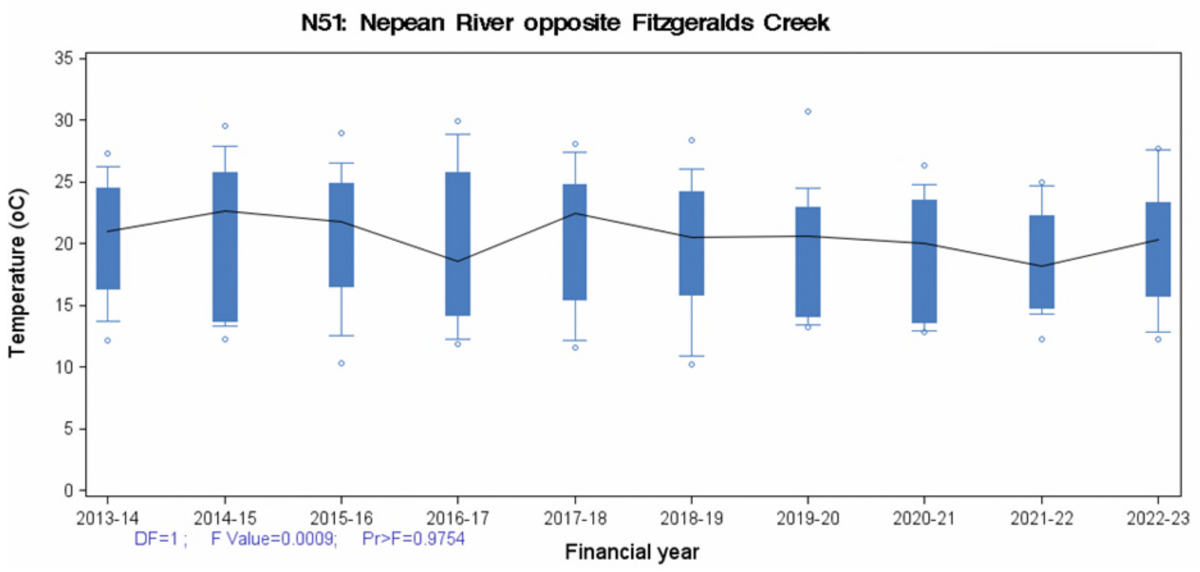

N51: Nepean River opposite Fitzgeralds Creek
Total phosphorus (mg/L)
0.085
0.080
0.075
0.070
0.065
0.060
0.055
0.050
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
-------- ANZG (2018)
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=11.510; Pr>F=0.0009
Financial year

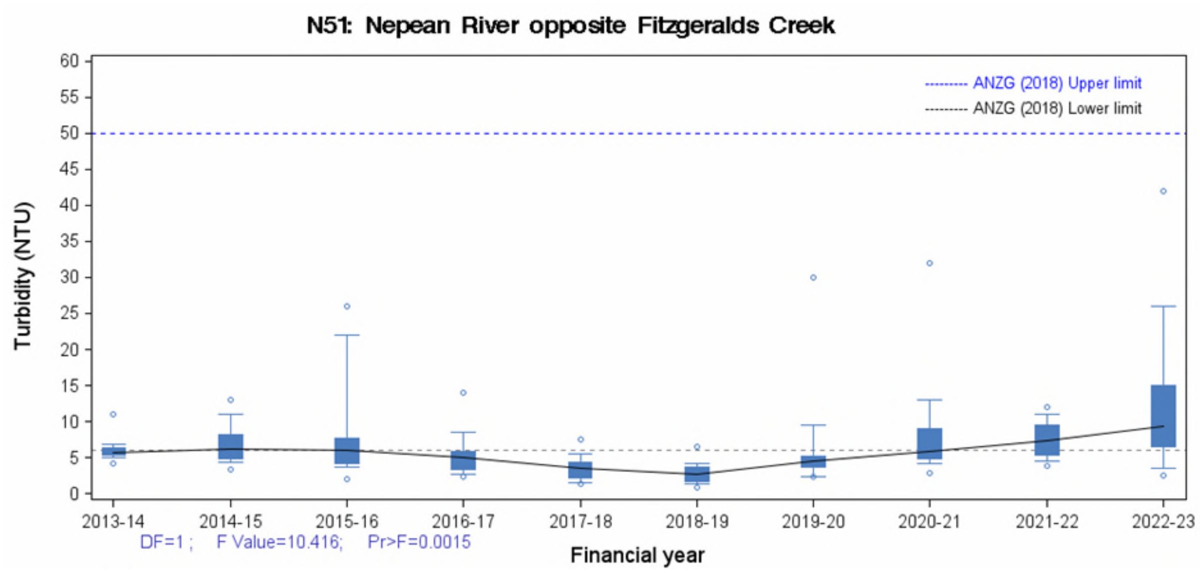

N51: Nepean River opposite Fitzgeralds Creek
ANZG (2018) Upper limit
ANZG (2018) Lower limit
Conductivity (uS/cm)
Financial year
DF=1 ; F Value=0.1686; Pr>F=0.6819


N51: Nepean River opposite Fitzgeralds Creek
Dissolved oxygen (mg/L)
Financial year
DF=1 ; F Value=5.8105; Pr>F=0.0171

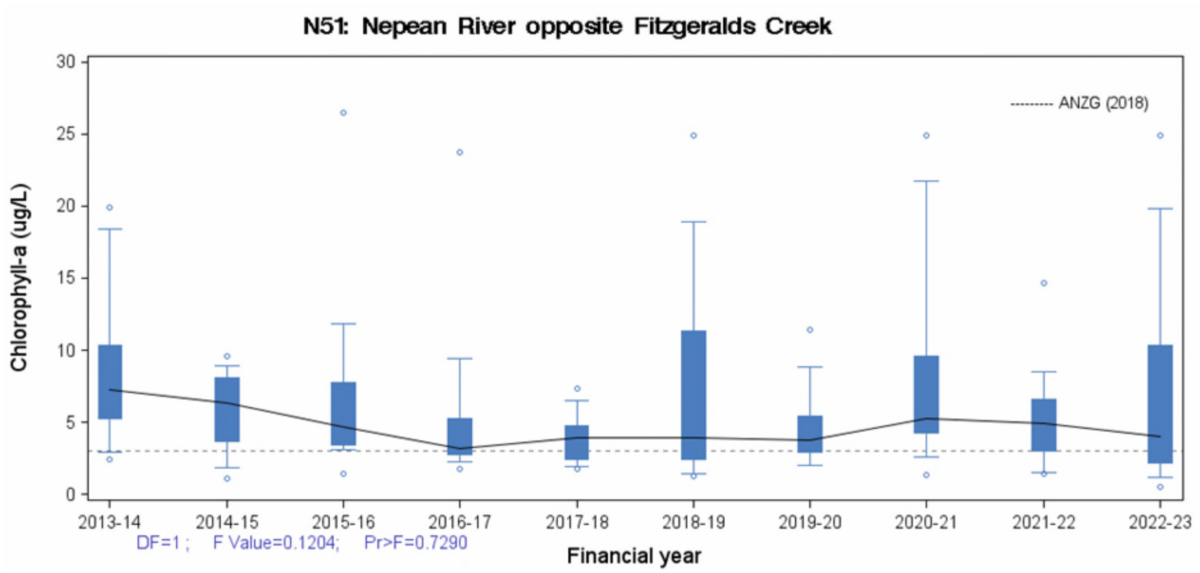

N51: Nepean River opposite Fitzgeralds Creek
ANZG (2018) Upper limit
ANZG (2018) Lower limit
Dissolved oxygen saturation (%)
Financial year
DF=1 ; F Value=13.151; Pr>F=0.0004

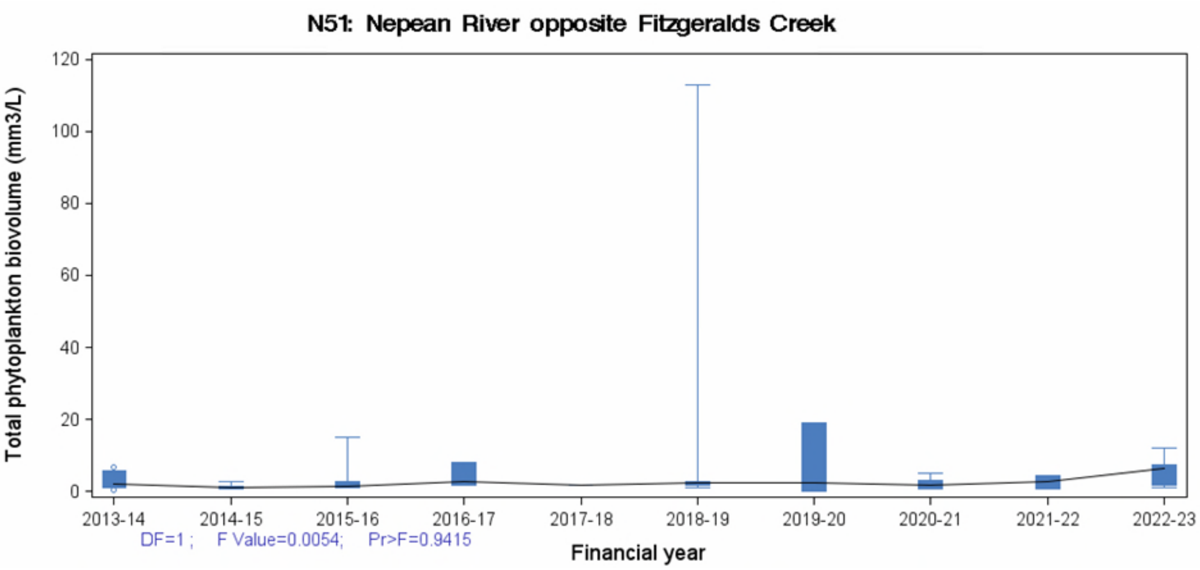

N51: Nepean River opposite Fitzgeralds Creek
ANZG (2018) Upper limit
ANZG (2018) Lower limit
pH
10
9
8
7
6
5
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=1.3175; Pr>F=0.2527
Financial year

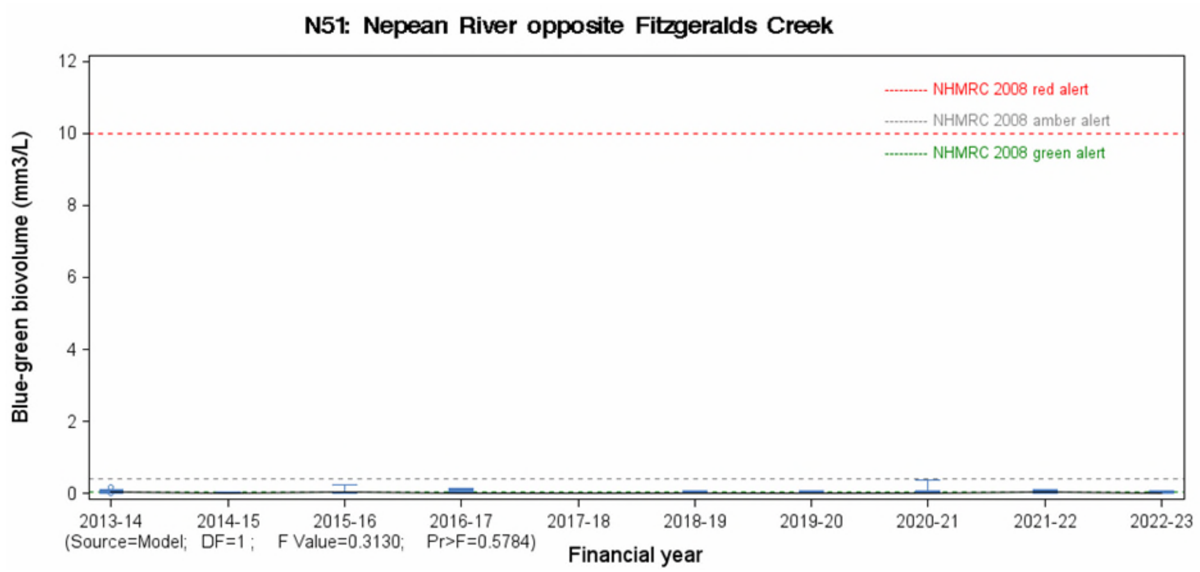

N51: Nepean River opposite Fitzgeralds Creek
Temperature (oC)
35
30
25
20
15
10
5
0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=0.0009; Pr>F=0.9754
Financial year

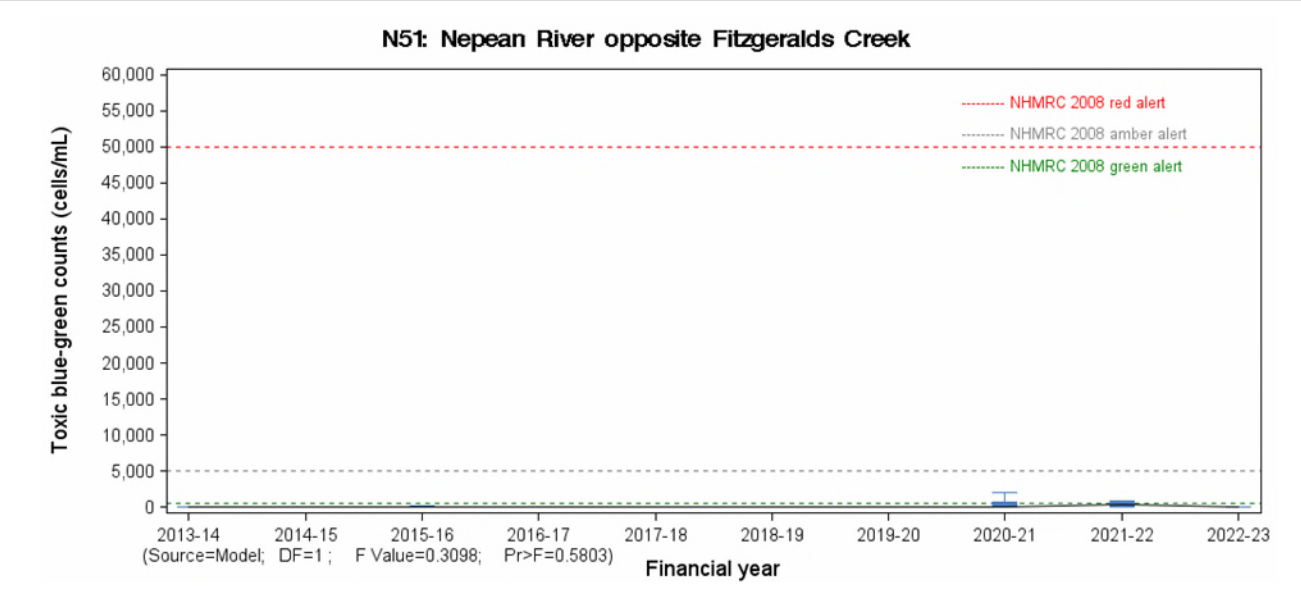

N51: Nepean River opposite Fitzgeralds Creek
ANZG (2018) Upper limit
ANZG (2018) Lower limit
Turbidity (NTU)
60
55
50
45
40
35
30
25
20
15
10
5
0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=10.416; Pr>F=0.0015
Financial year

Ecosystem receptor – Phytoplankton



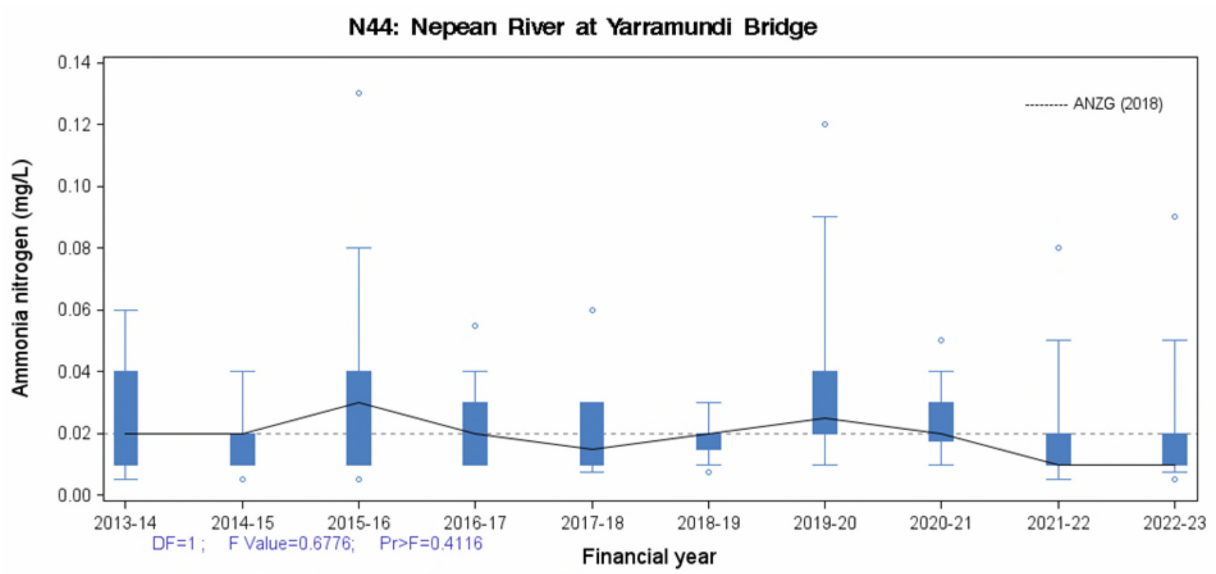


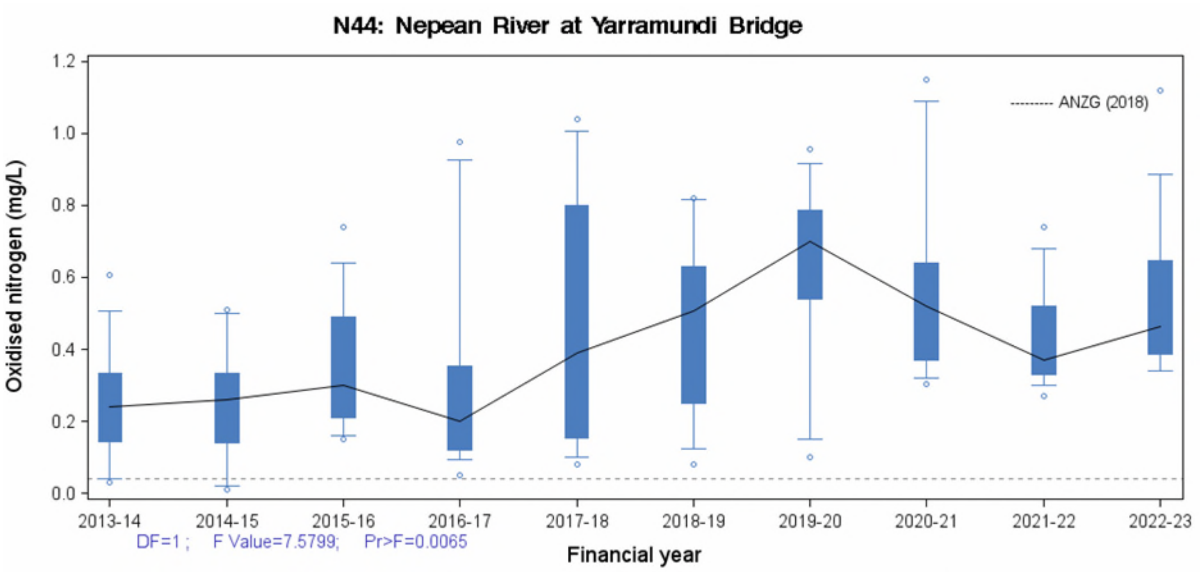


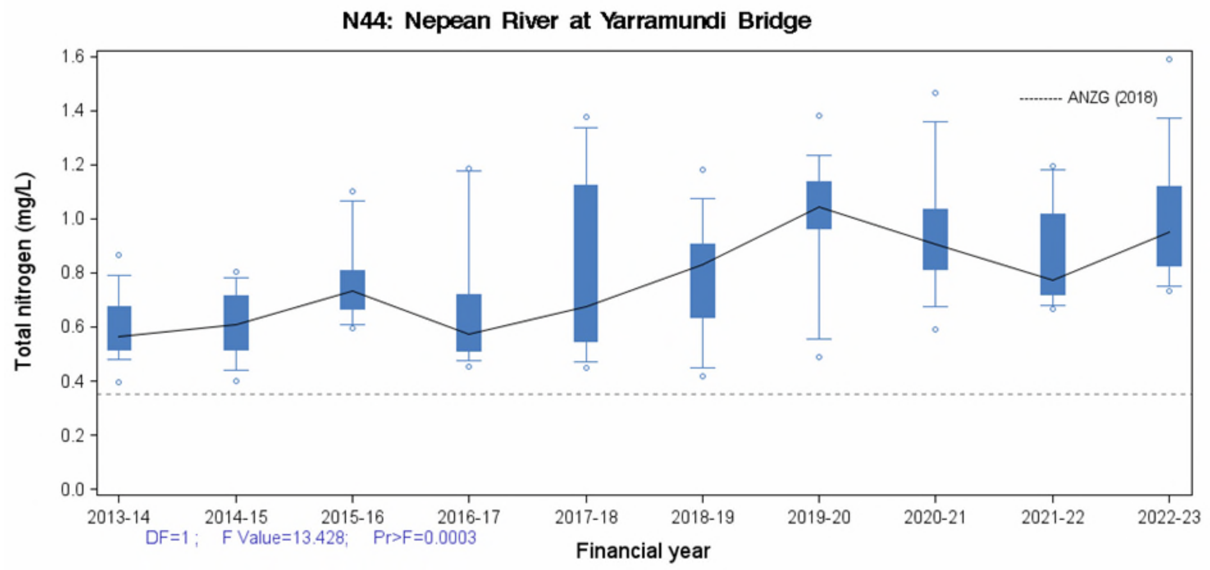

N51: Nepean River opposite Fitzgeralds Creek
Toxic blue-green counts (cells/mL)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
NHMRC 2008 red alert
NHMRC 2008 amber alert
NHMRC 2008 green alert
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
(Source=Model; DF=1 ; F Value=0.3098; Pr>F=0.5803)
Financial year

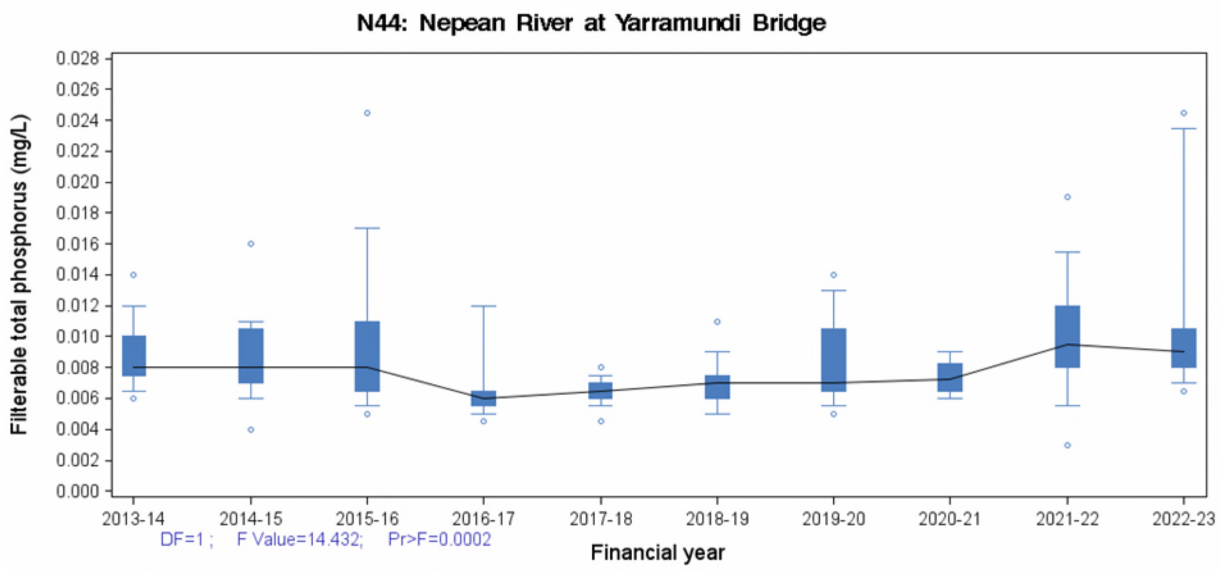
C-1.3 Nepean River Yarramundi Bridge (N44)

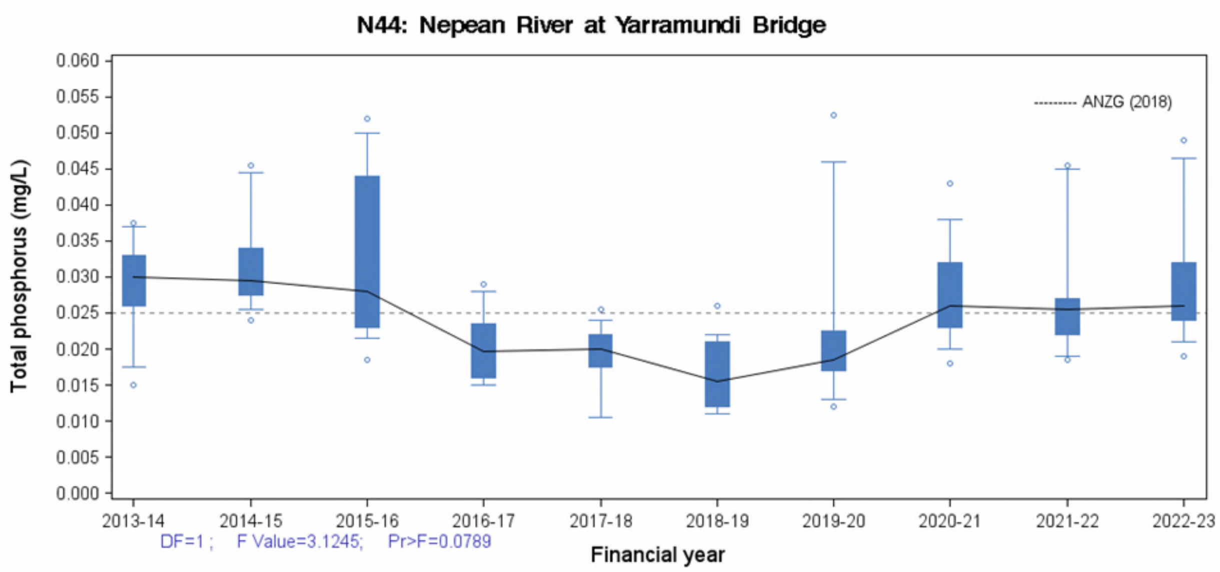
Stressors – Nutrients

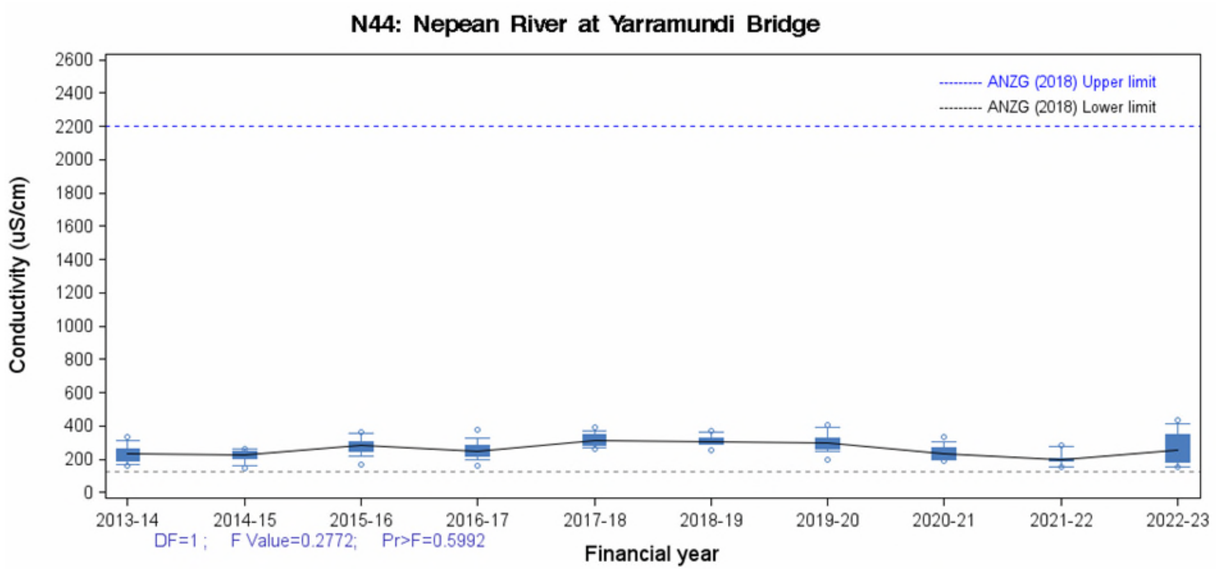


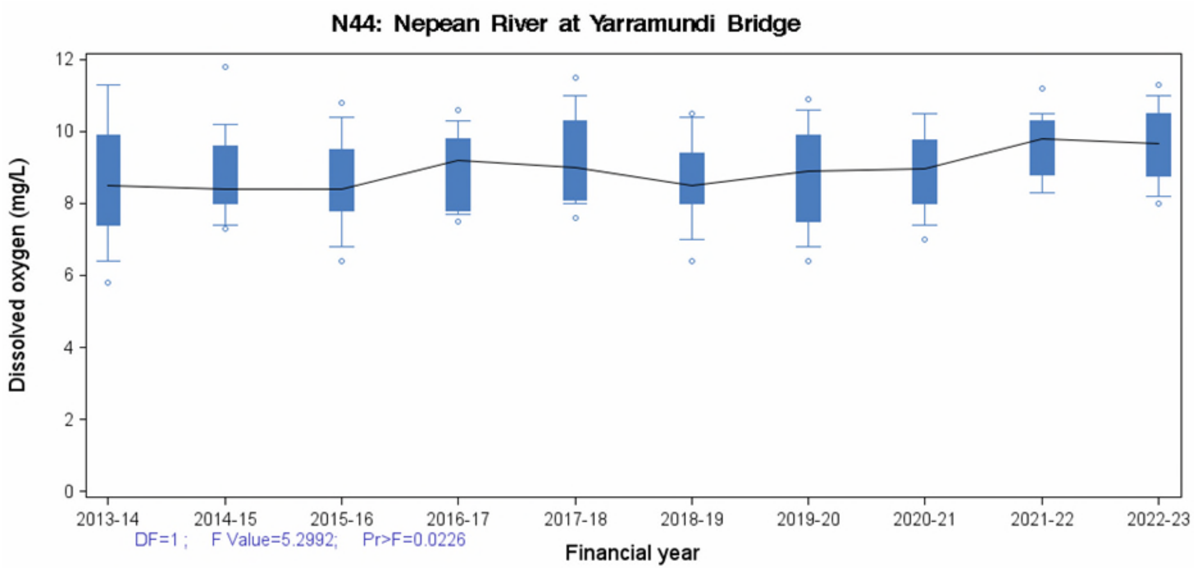


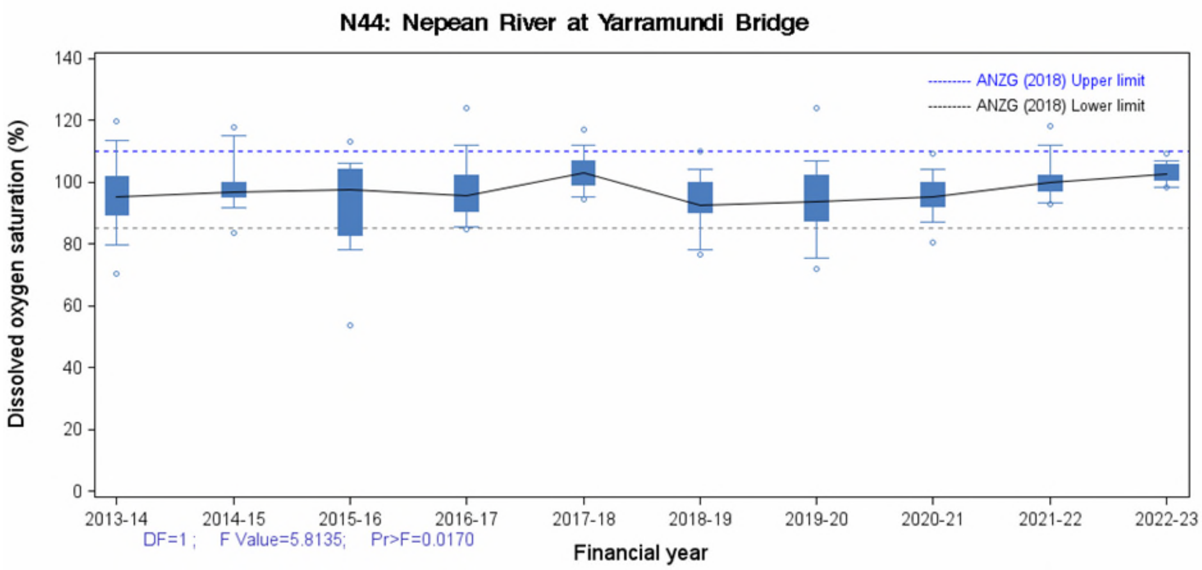

N44: Nepean River at Yarramundi Bridge
Total nitrogen (mg/L)
ANZG (2018)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=13.428; Pr>F=0.0003
Financial year

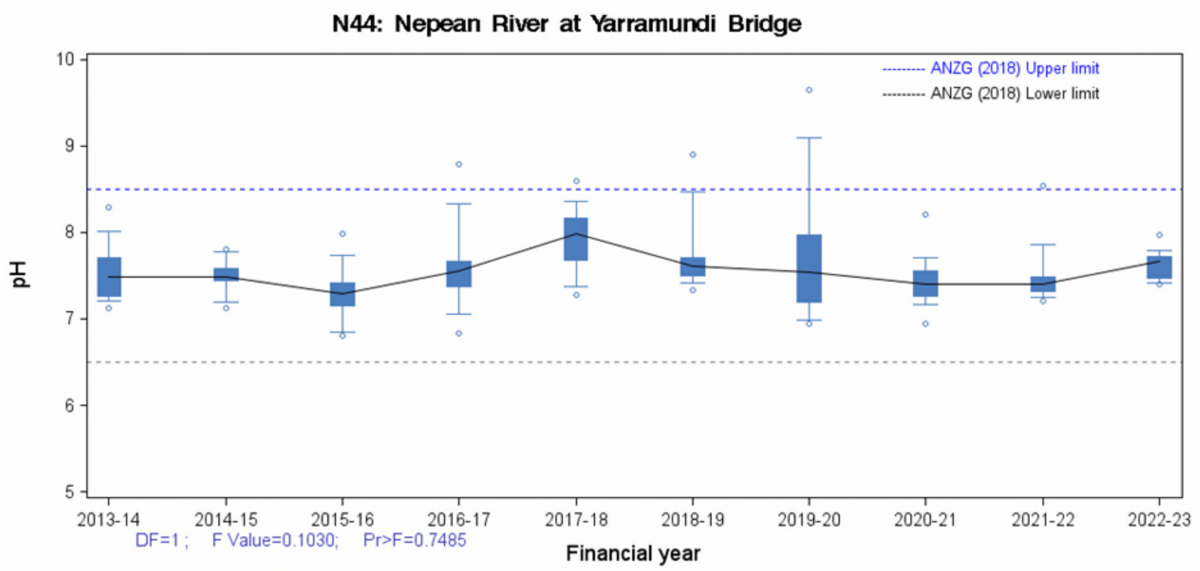

N44: Nepean River at Yarramundi Bridge
Filterable total phosphorus (mg/L)
0.028
0.026
0.024
0.022
0.020
0.018
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=14.432; Pr>F=0.0002
Financial year

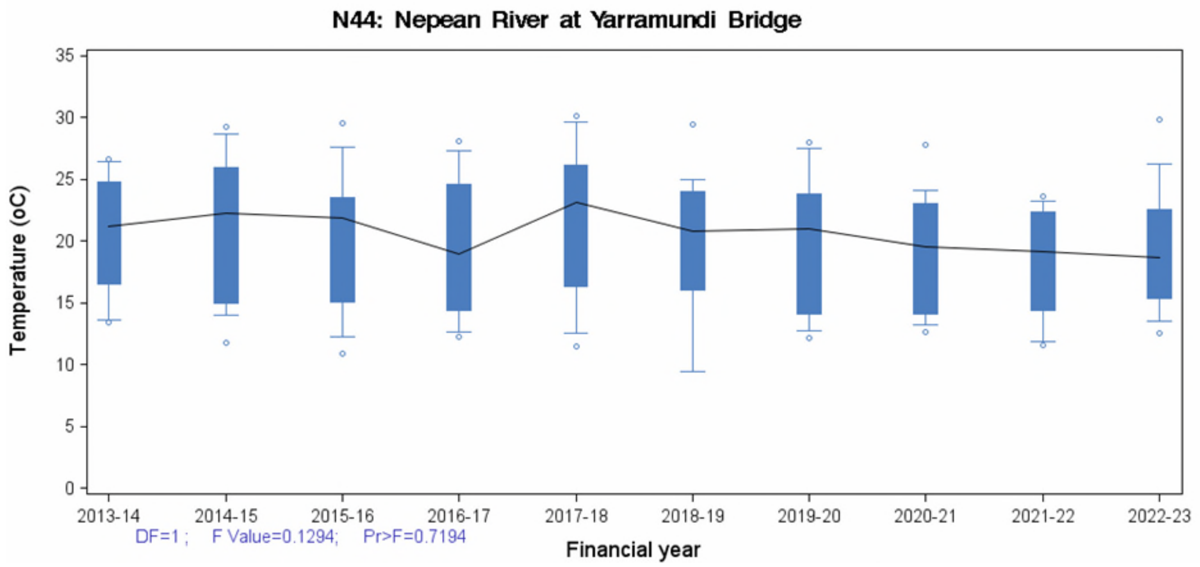

N44: Nepean River at Yarramundi Bridge
Total phosphorus (mg/L)
ANZG (2018)
0.060
0.055
0.050
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=3.1245; Pr>F=0.0789
Financial year

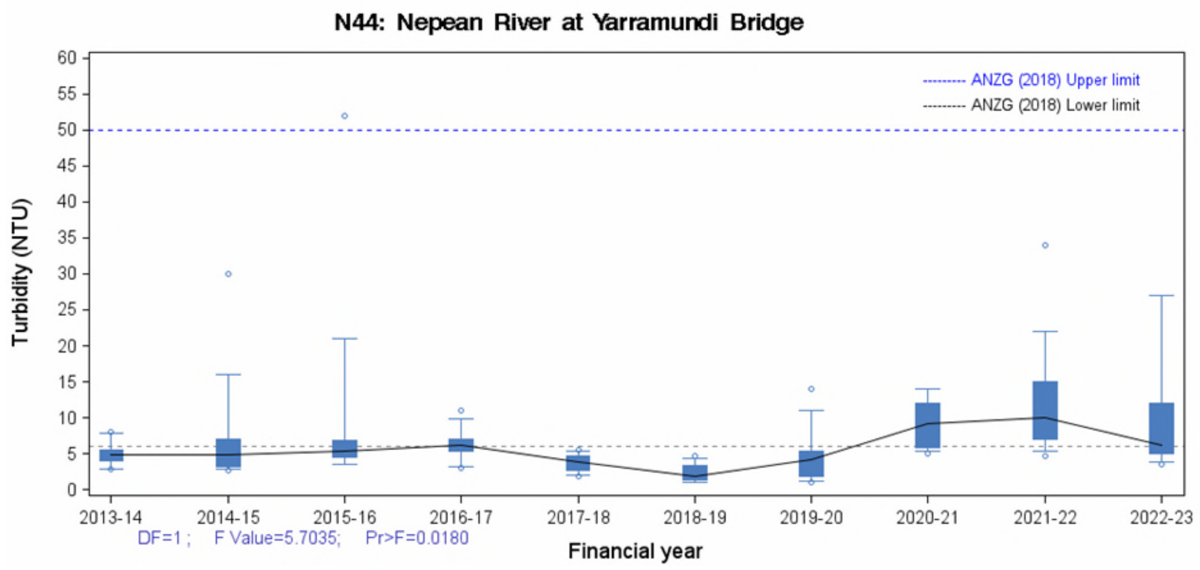

N44: Nepean River at Yarramundi Bridge
ANZG (2018) Upper limit
ANZG (2018) Lower limit
Conductivity (uS/cm)
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=0.2772; Pr>F=0.5992
Financial year


N44: Nepean River at Yarramundi Bridge
Dissolved oxygen (mg/L)
12
10
8
6
4
2
0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=5.2992; Pr>F=0.0226
Financial year

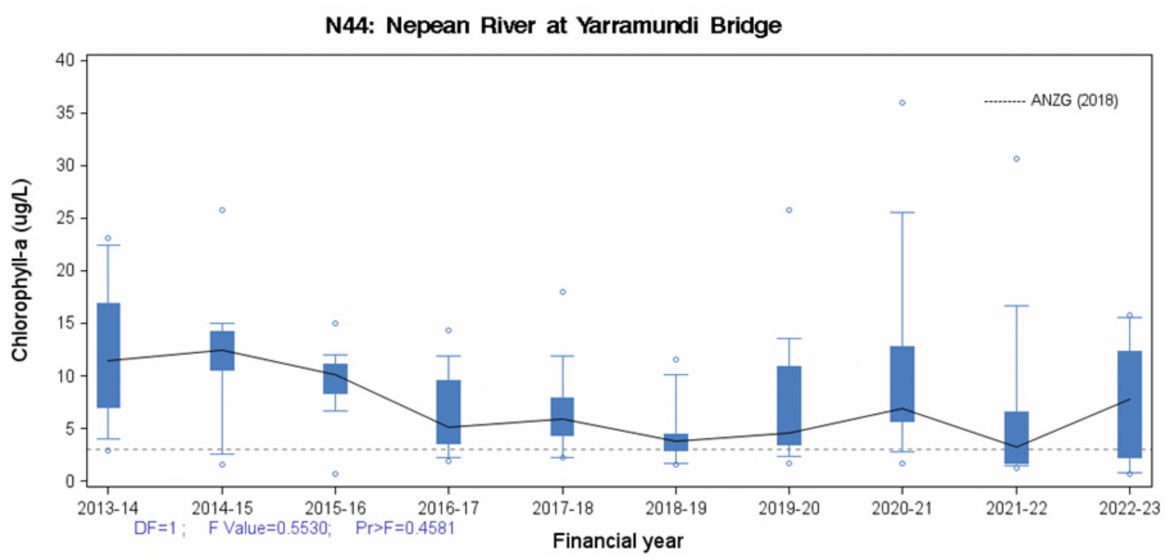

N44: Nepean River at Yarramundi Bridge
ANZG (2018) Upper limit
ANZG (2018) Lower limit
Dissolved oxygen saturation (%)
140
120
100
80
60
40
20
0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=5.8135; Pr>F=0.0170
Financial year

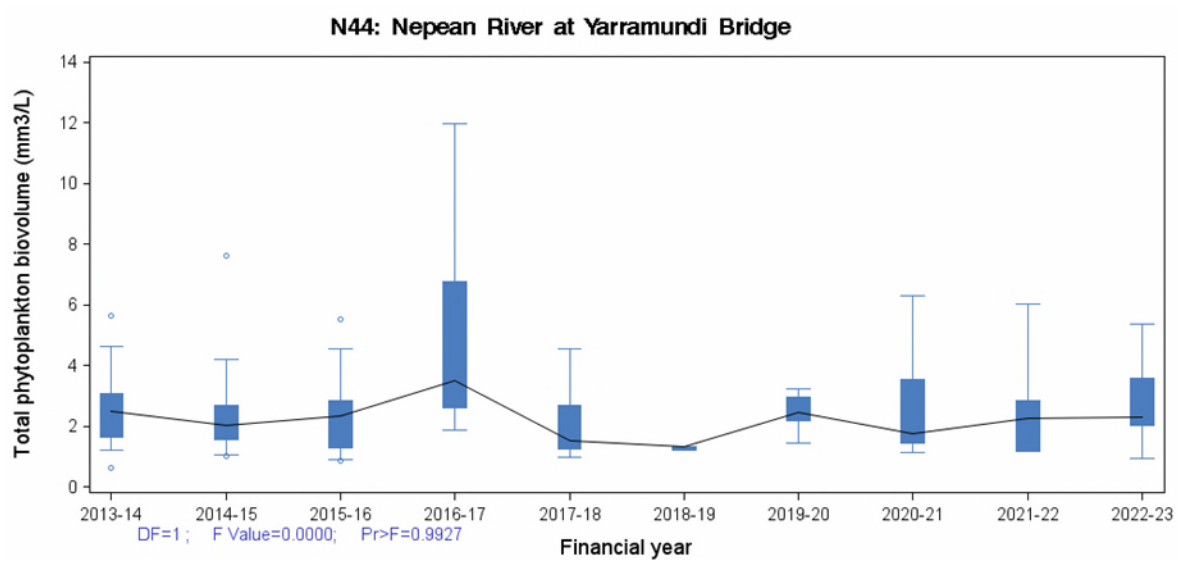

N44: Nepean River at Yarramundi Bridge
ANZG (2018) Upper limit
ANZG (2018) Lower limit
pH
Financial year
2013-14 2014-15 2015-16 2016-17 2017-18 2018-19 2019-20 2020-21 2021-22 2022-23
DF=1 ; F Value=0.1030; Pr>F=0.7485

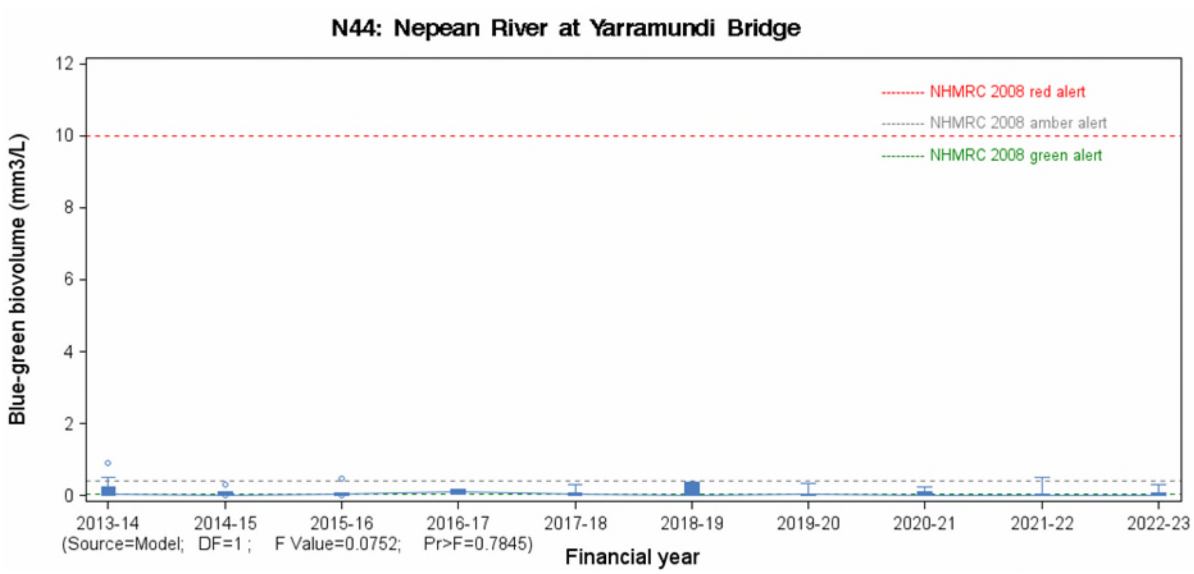

N44: Nepean River at Yarramundi Bridge
Temperature (oC)
Financial year
2013-14 2014-15 2015-16 2016-17 2017-18 2018-19 2019-20 2020-21 2021-22 2022-23
DF=1 ; F Value=0.1294; Pr>F=0.7194

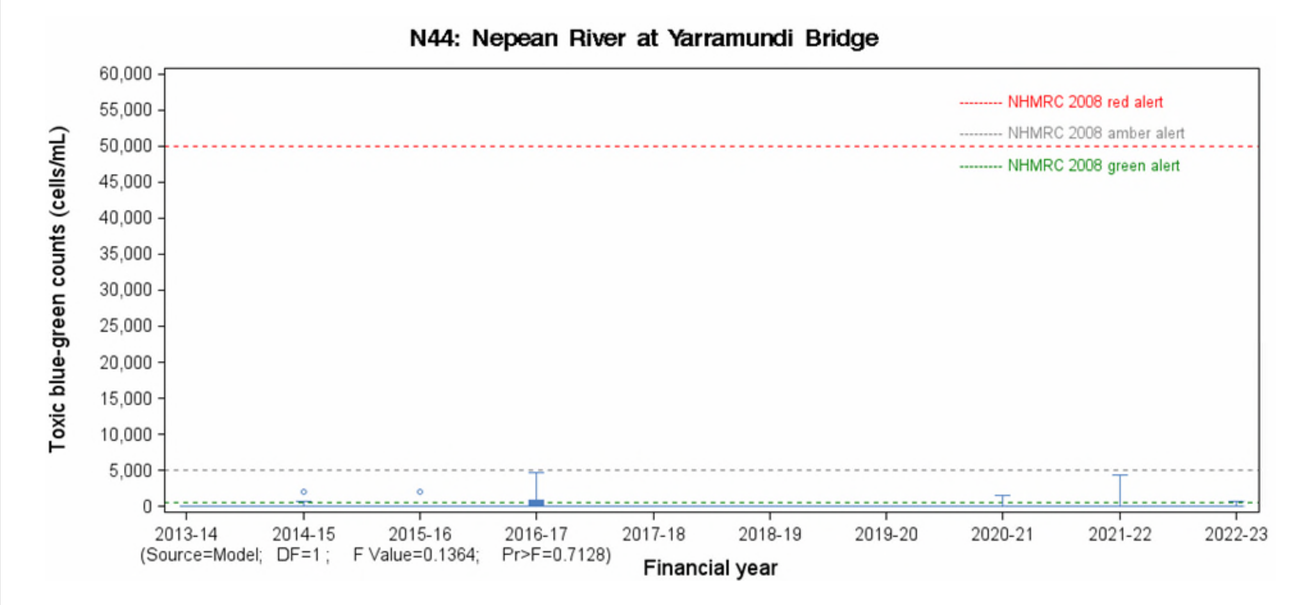

N44: Nepean River at Yarramundi Bridge
ANZG (2018) Upper limit
ANZG (2018) Lower limit
Turbidity (NTU)
Financial year
2013-14 2014-15 2015-16 2016-17 2017-18 2018-19 2019-20 2020-21 2021-22 2022-23
DF=1 ; F Value=5.7035; Pr>F=0.0180

Ecosystem receptor – Phytoplankton









C-1.4 Hawkesbury River at Windsor Bridge, upstream South Creek (N38)

Ecosystem receptor – Macroinvertebrates

Mean stream health in 2022-23 was within range recorded over the period back to 1995.

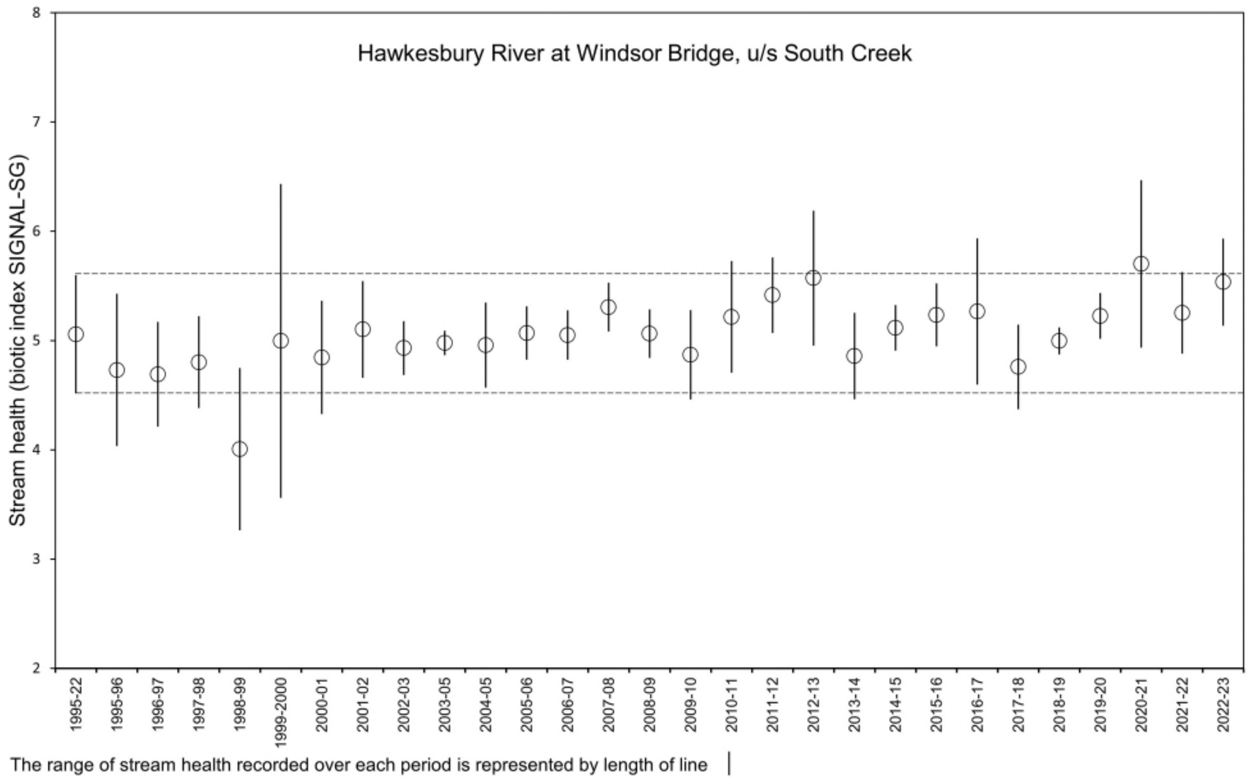
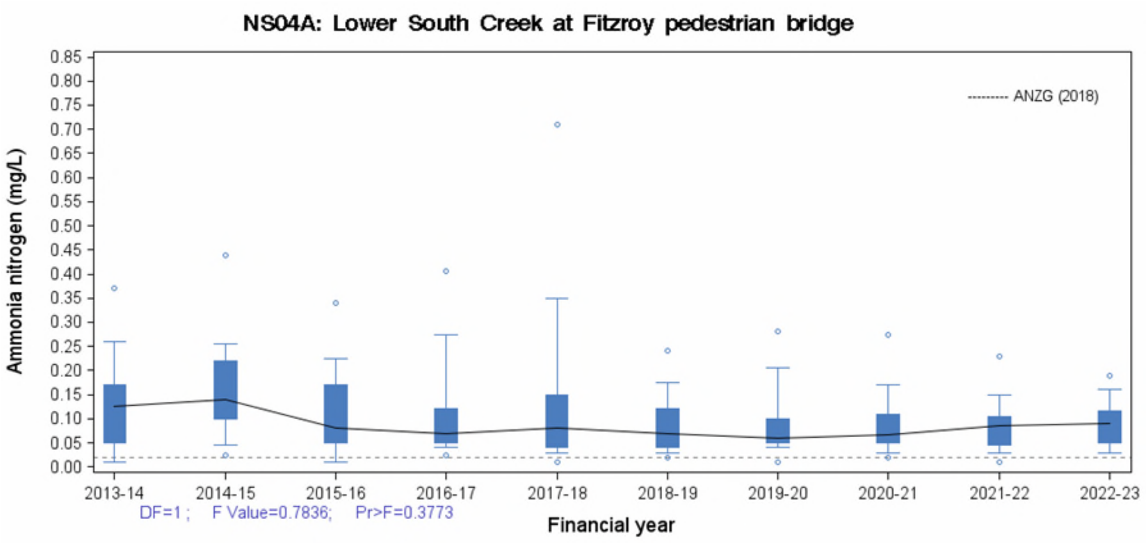
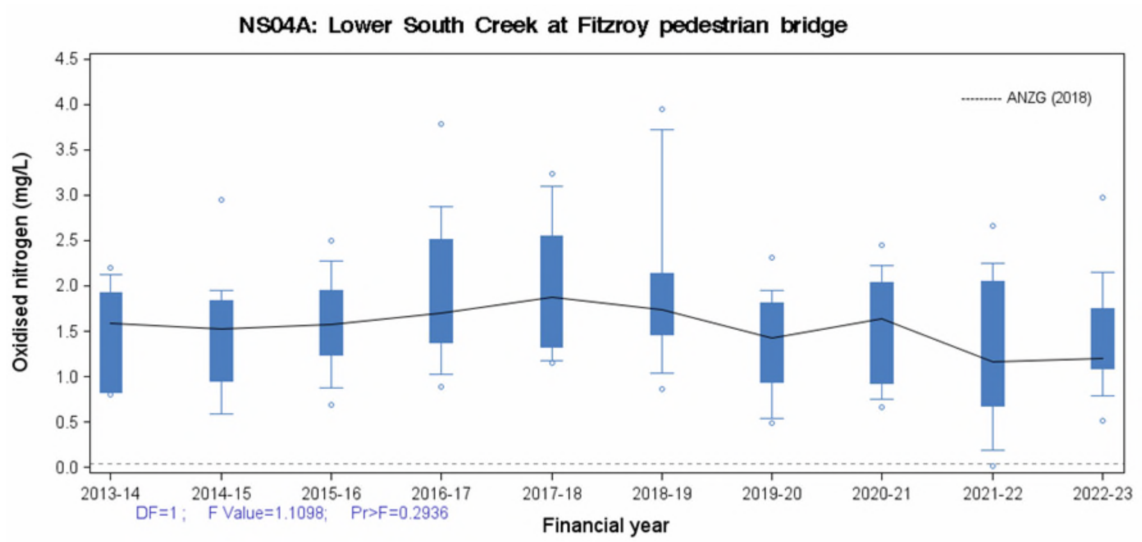


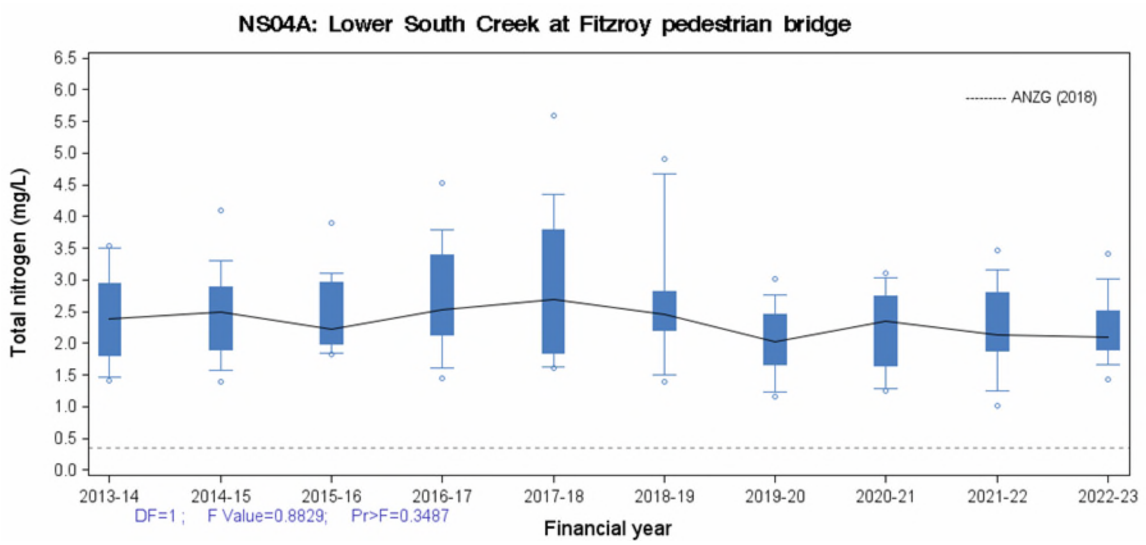
Figure C-1 Stream health of Hawkesbury River at Windsor Bridge, upstream of South Creek (N38)

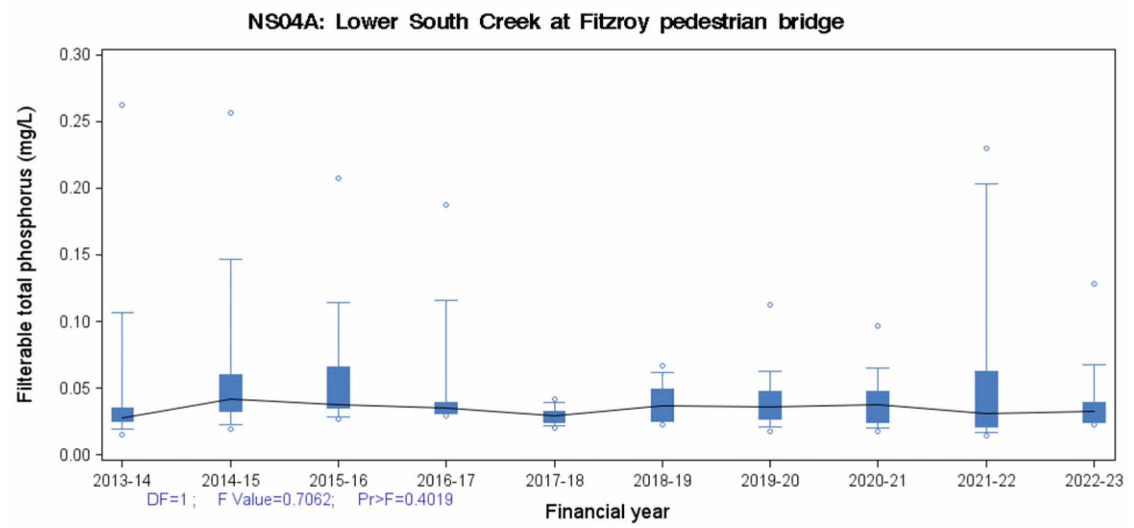
C-1.5 Lower South Creek at Fitzroy pedestrian bridge, Windsor (NS04A)

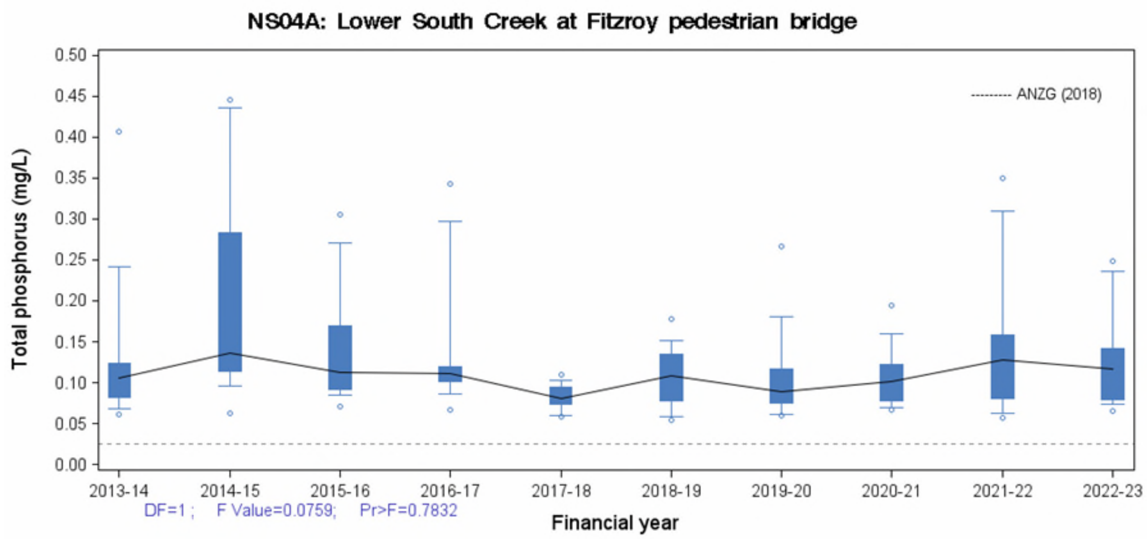
Stressors – Nutrients



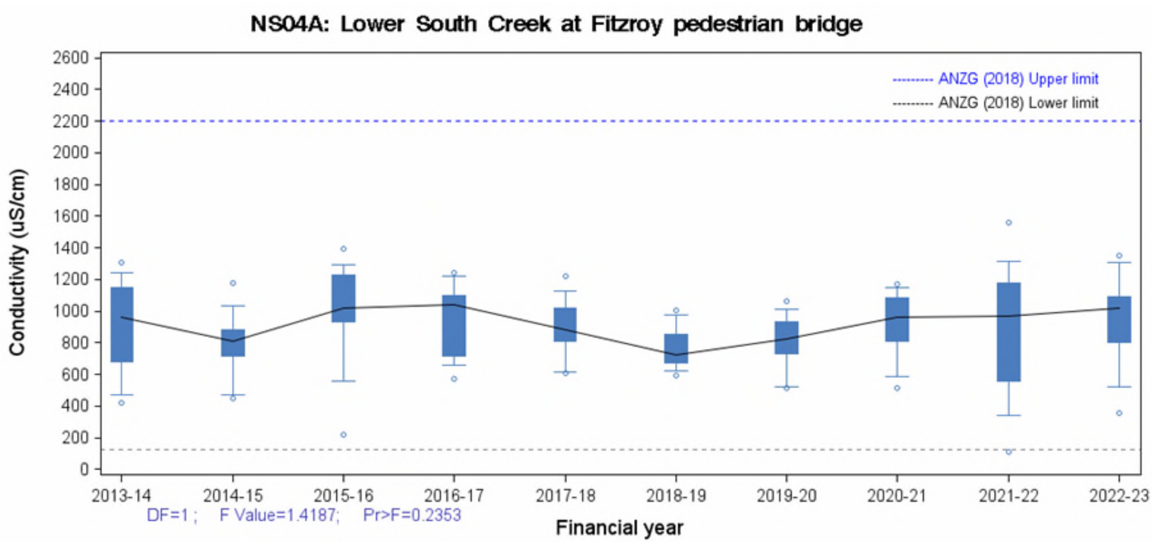


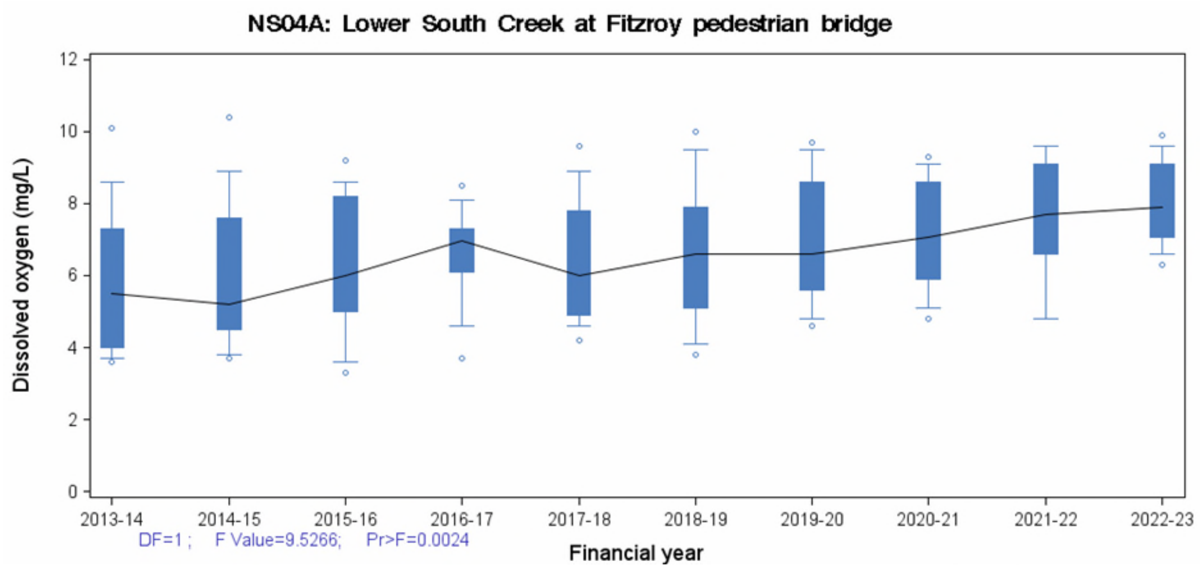


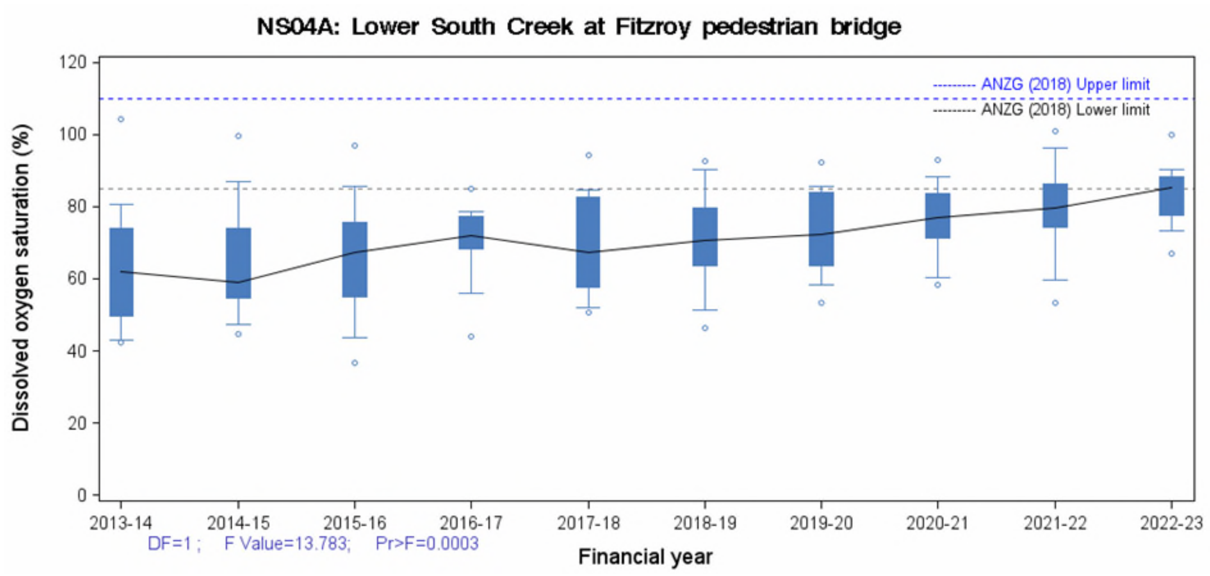


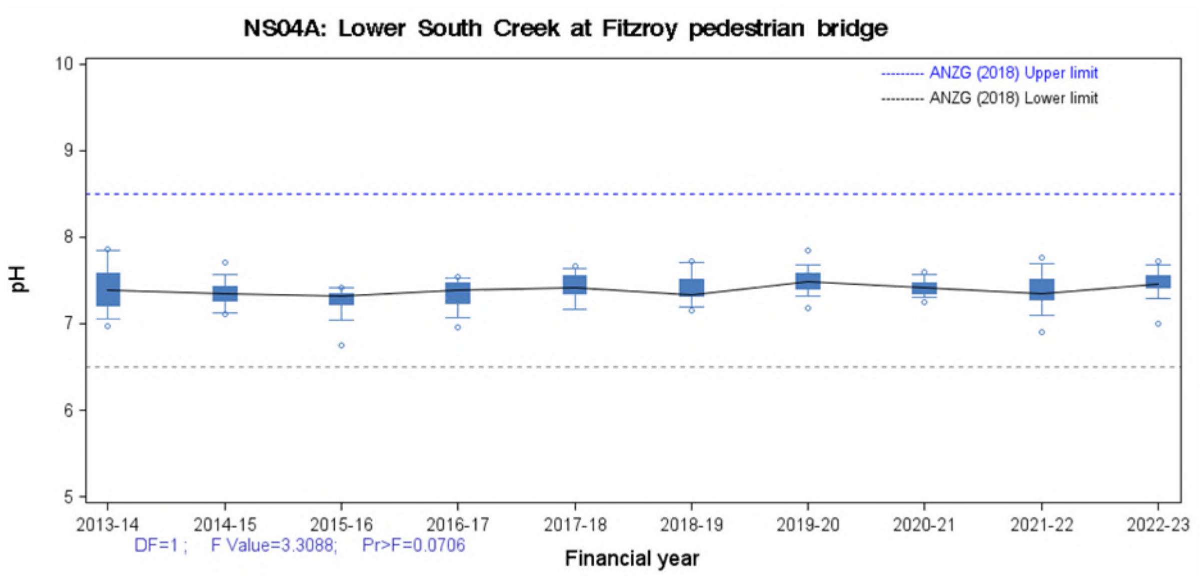


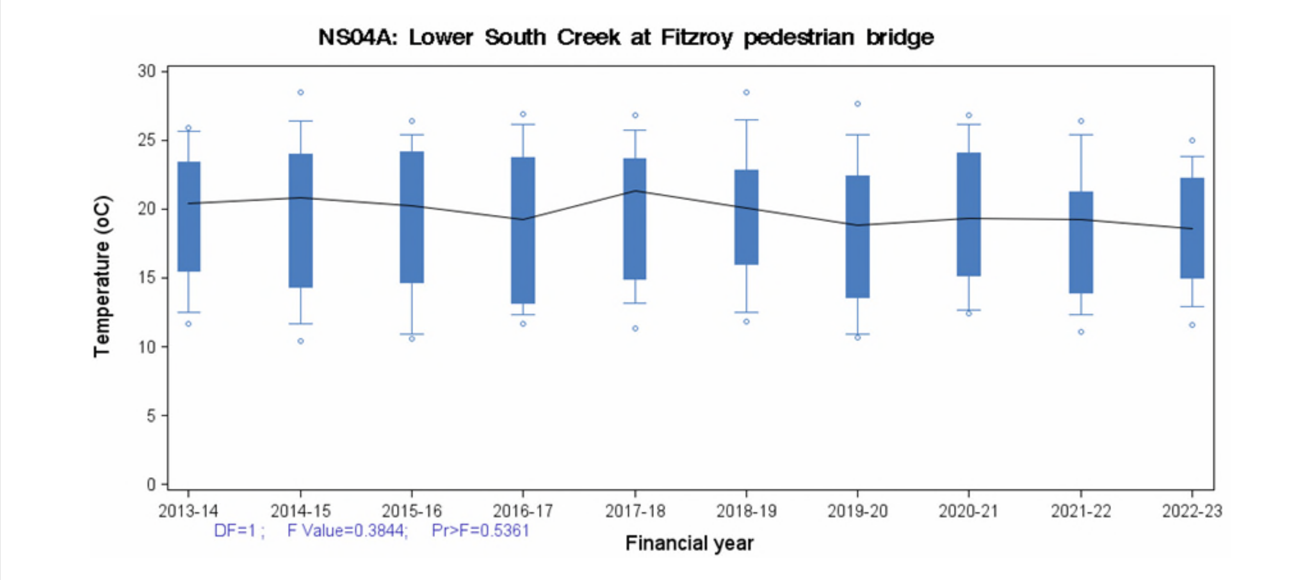
Stressors – Physico-chemical water quality

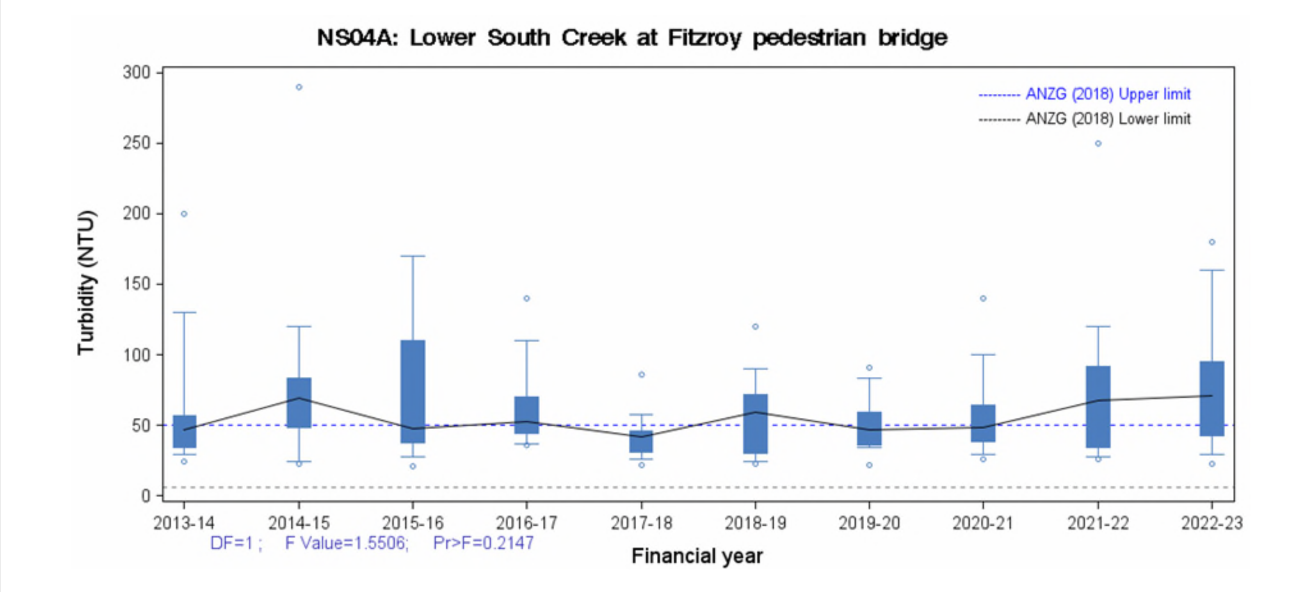



NS04A: Lower South Creek at Fitzroy pedestrian bridge
Dissolved oxygen (mg/L)
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=9.5266; Pr>F=0.0024
Financial year

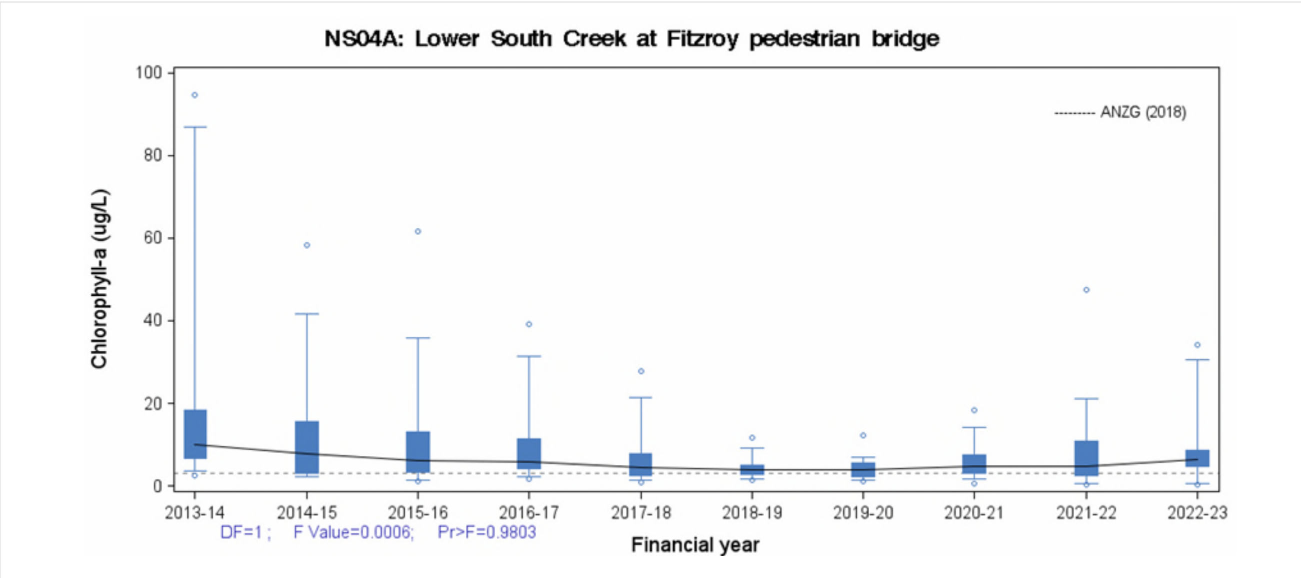

NS04A: Lower South Creek at Fitzroy pedestrian bridge
ANZG (2018) Upper limit
ANZG (2018) Lower limit
Dissolved oxygen saturation (%)
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=13.783; Pr>F=0.0003
Financial year

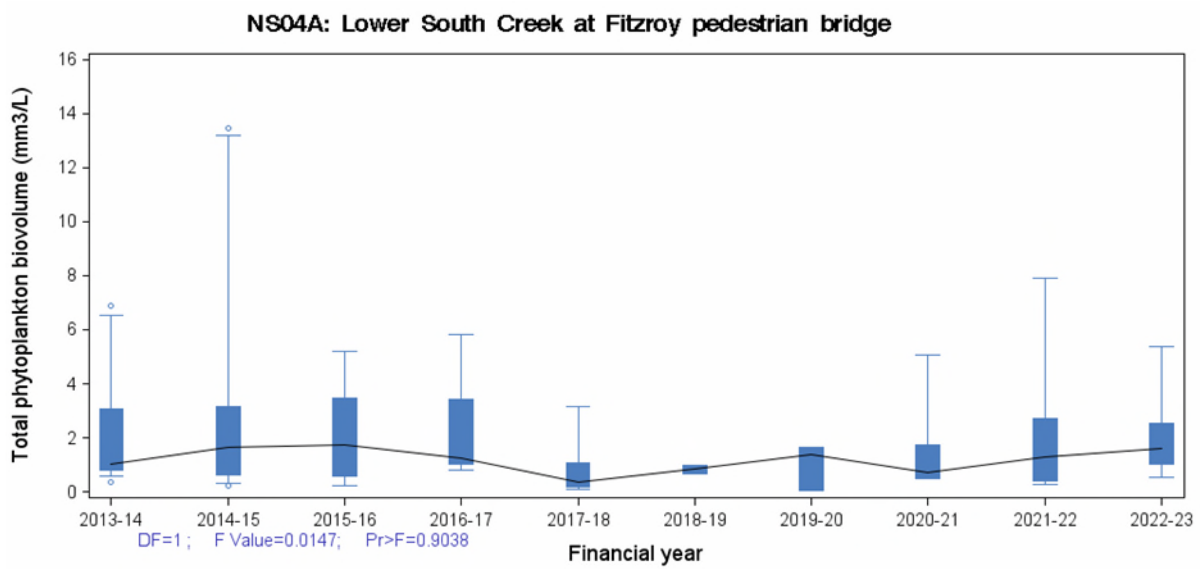

NS04A: Lower South Creek at Fitzroy pedestrian bridge
ANZG (2018) Upper limit
ANZG (2018) Lower limit
pH
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=3.3088; Pr>F=0.0706
Financial year

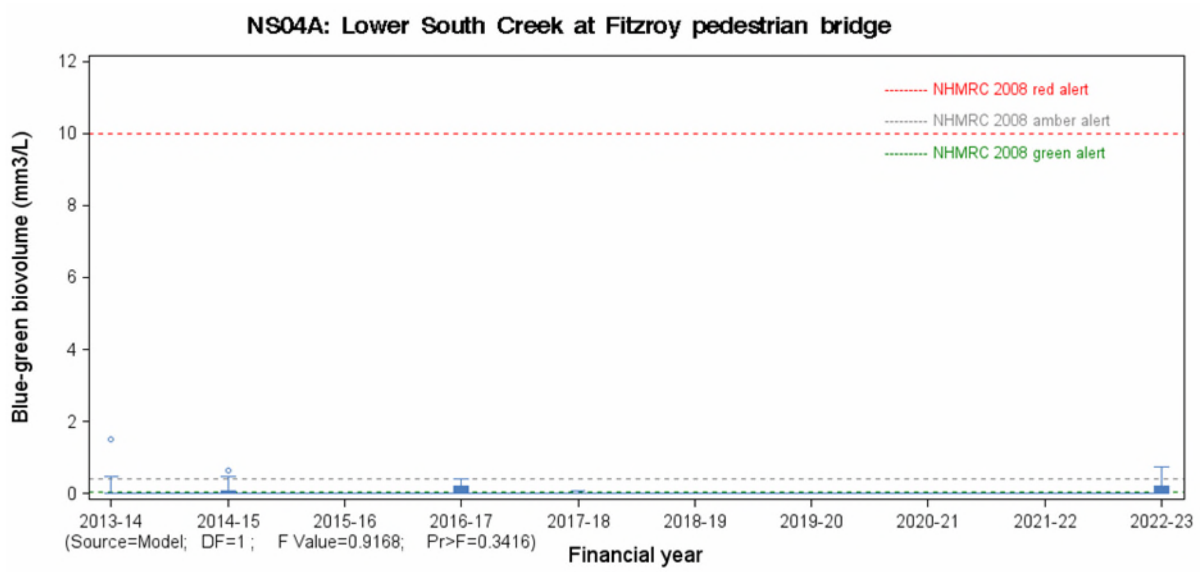


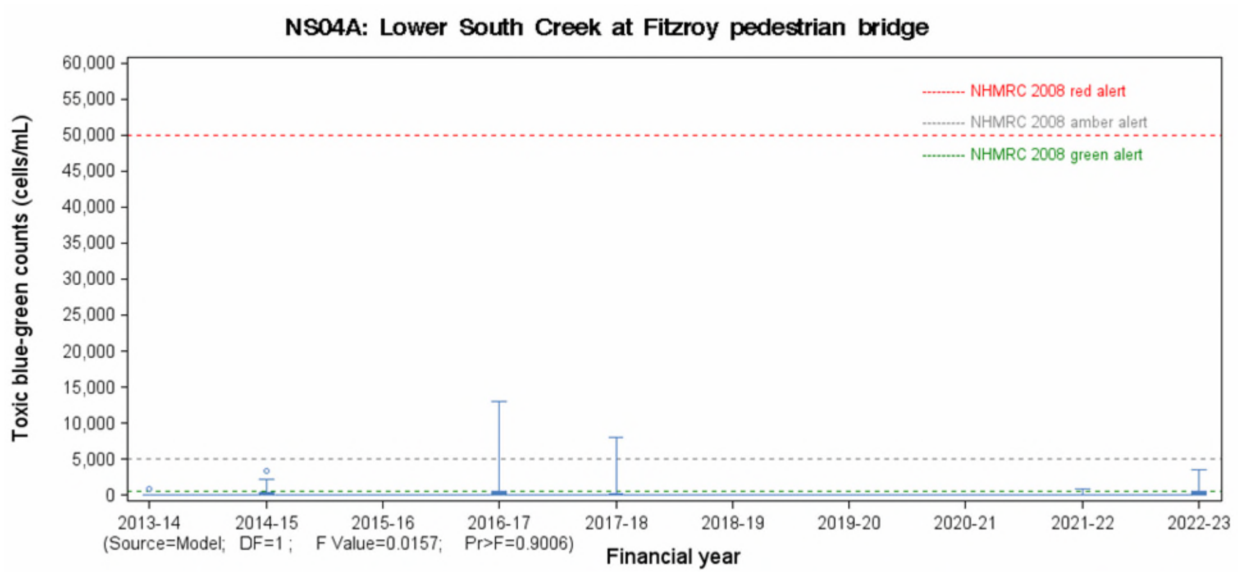


Ecosystem receptor – Phytoplankton



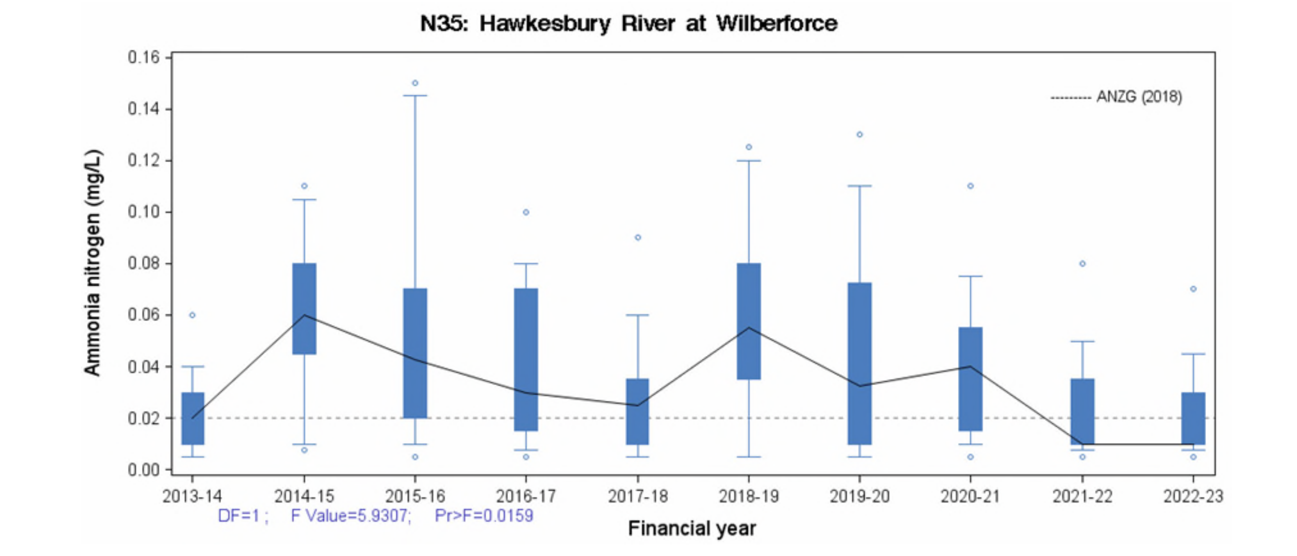

NS04A: Lower South Creek at Fitzroy pedestrian bridge
Total phytoplankton biovolume (mm3/L)
DF=1 ; F Value=0.0147; Pr>F=0.9038
Financial year
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23

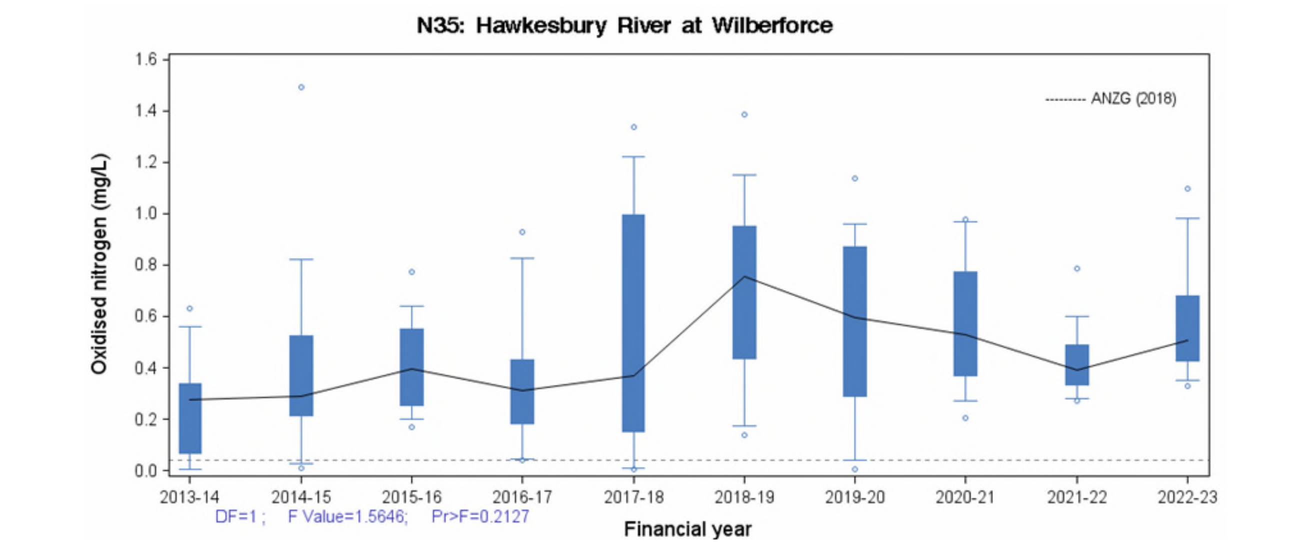

NS04A: Lower South Creek at Fitzroy pedestrian bridge
Blue-green biovolume (mm3/L)
NHMRC 2008 red alert
NHMRC 2008 amber alert
NHMRC 2008 green alert
(Source=Model; DF=1 ; F Value=0.9168; Pr>F=0.3416)
Financial year

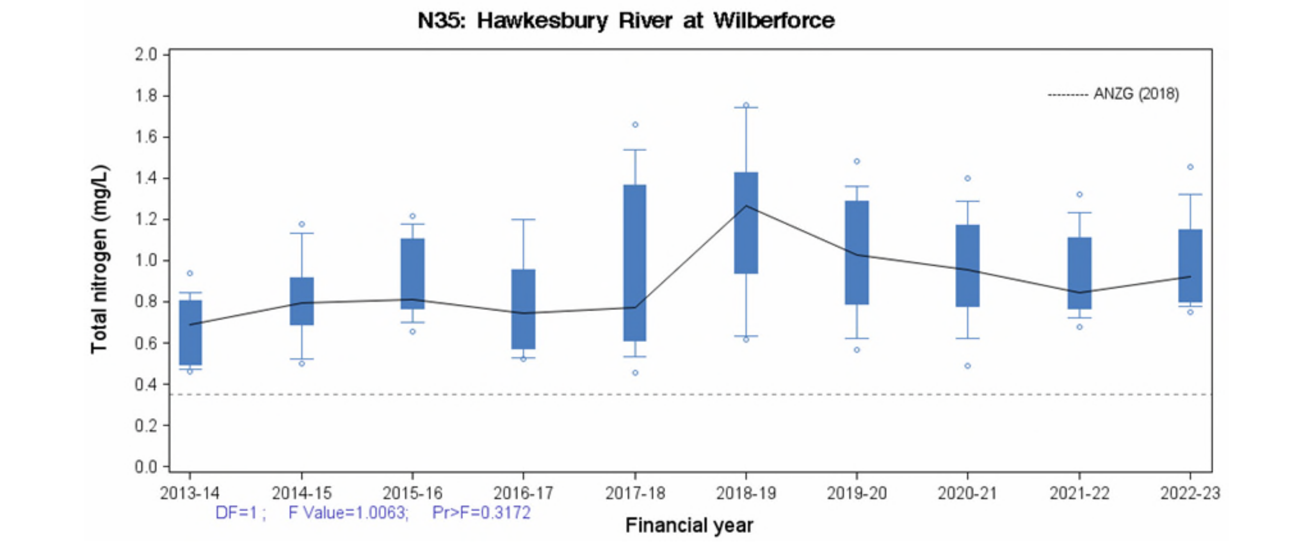

NS04A: Lower South Creek at Fitzroy pedestrian bridge
Toxic blue-green counts (cells/mL)
NHMRC 2008 red alert
NHMRC 2008 amber alert
NHMRC 2008 green alert
(Source=Model; DF=1 ; F Value=0.0157; Pr>F=0.9006)
Financial year

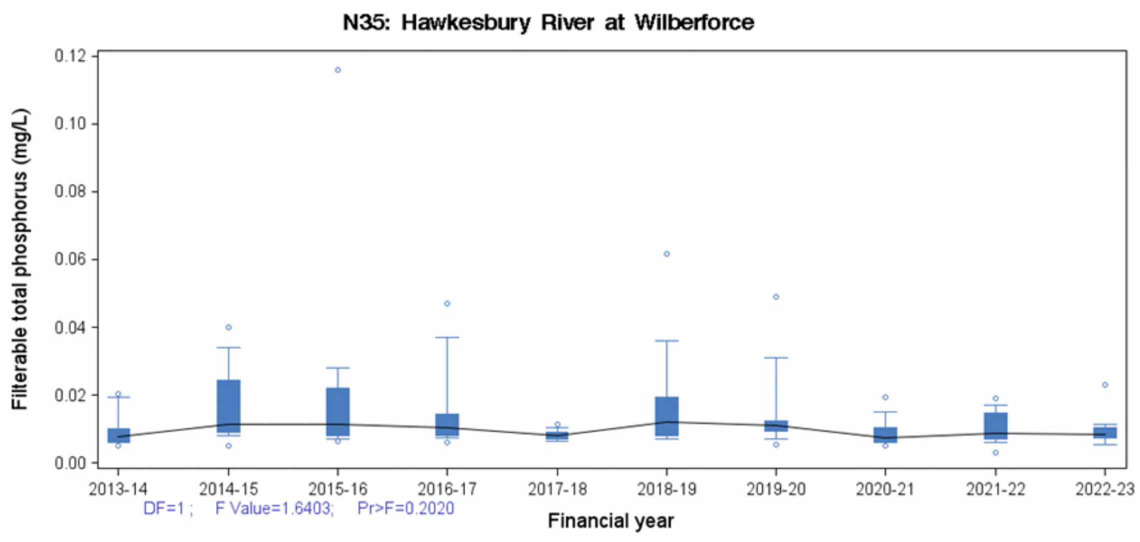
C-1.6 Hawkesbury River at Wilberforce, Butterfly farm, downstream of South Creek (N35)

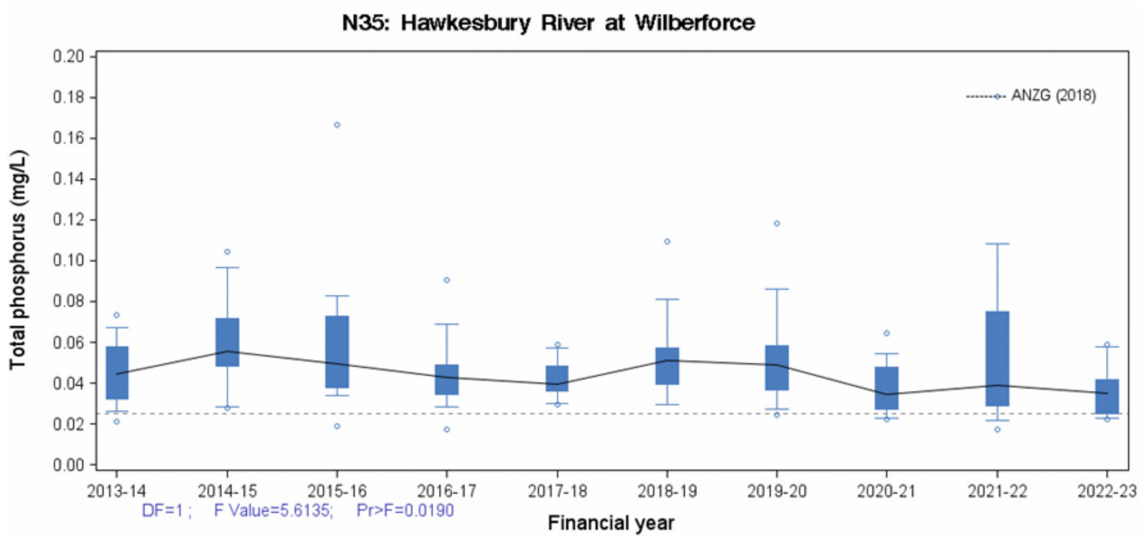
Stressors – Nutrients



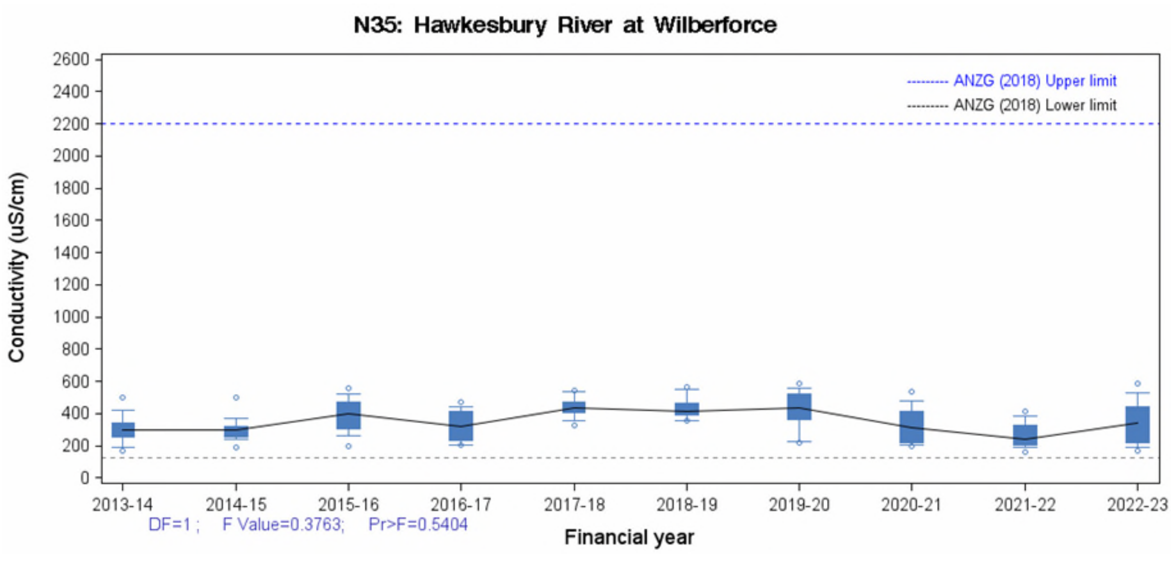


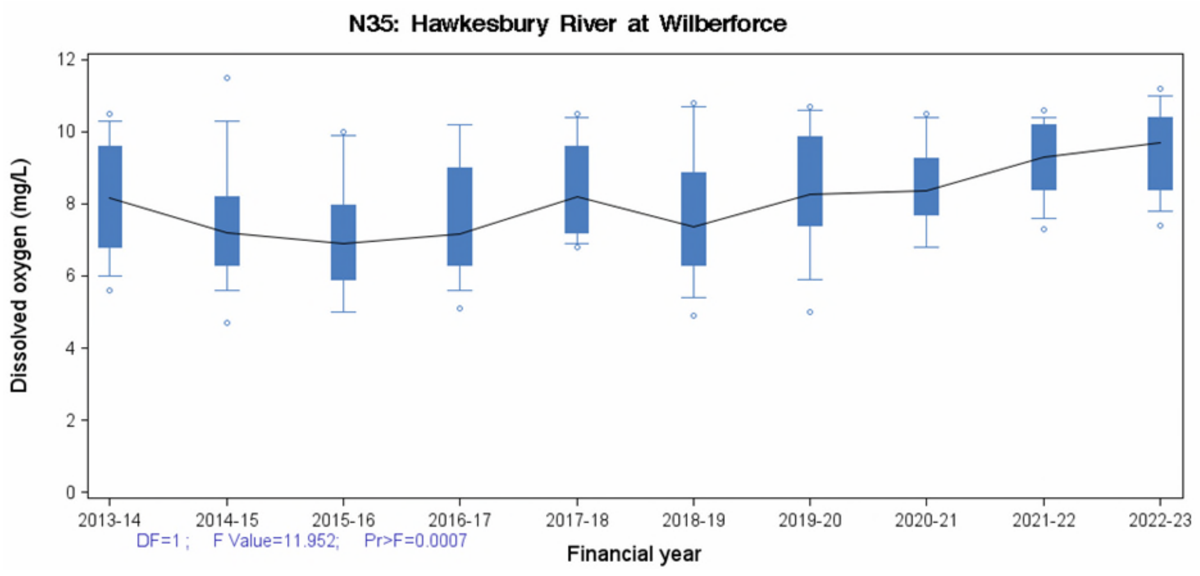


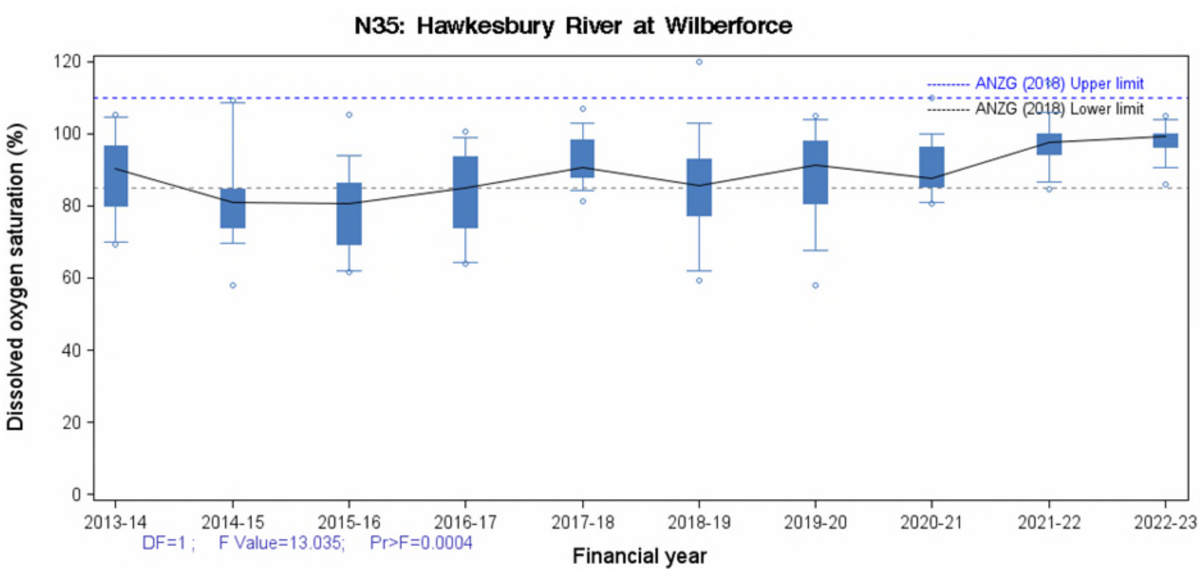


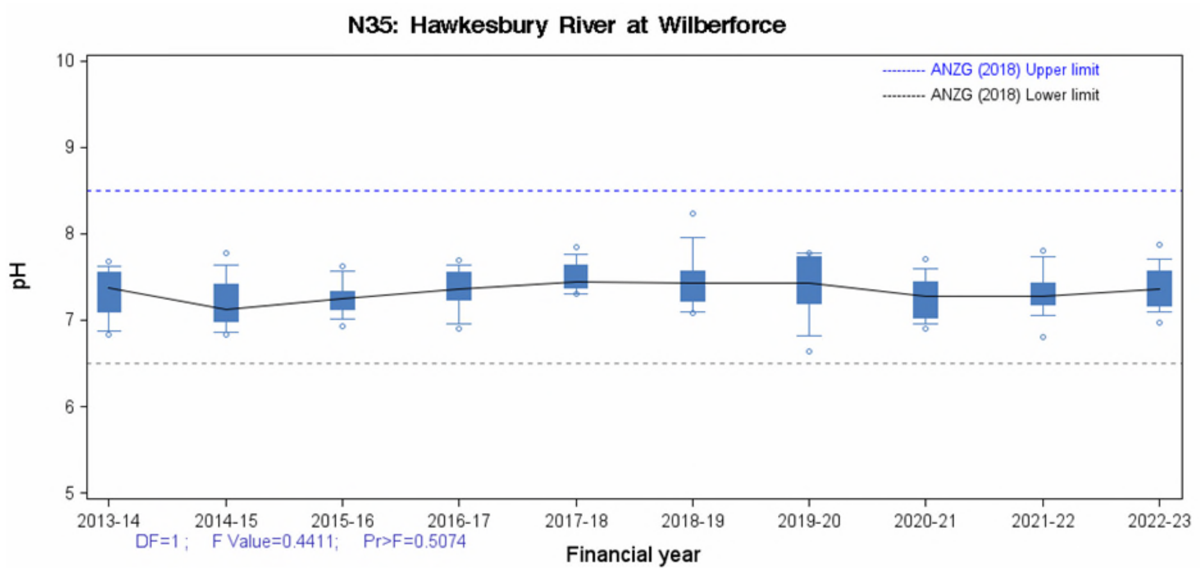


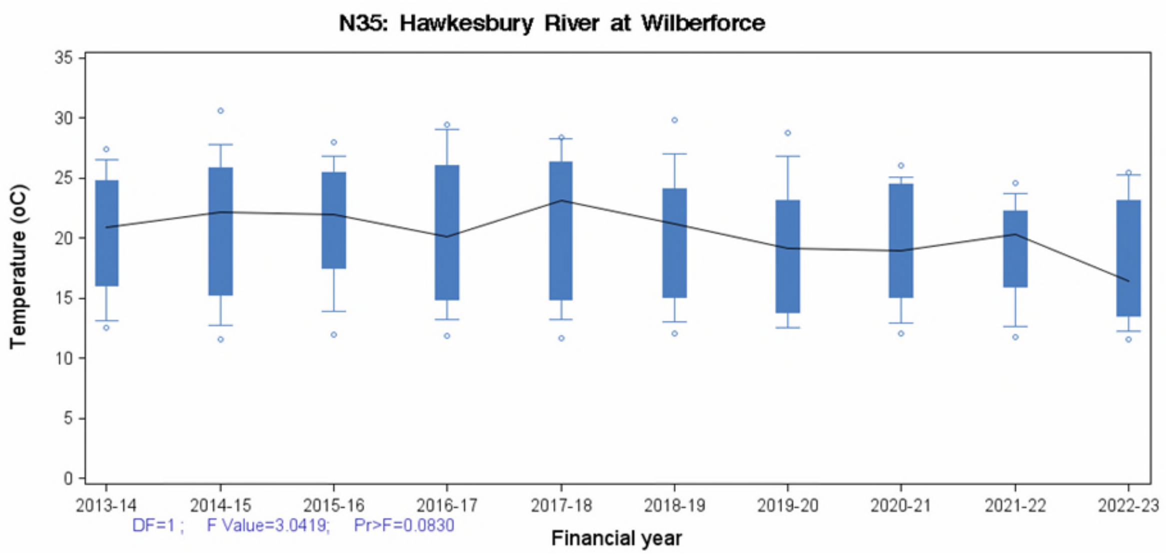
Stressors – Physico-chemical water quality

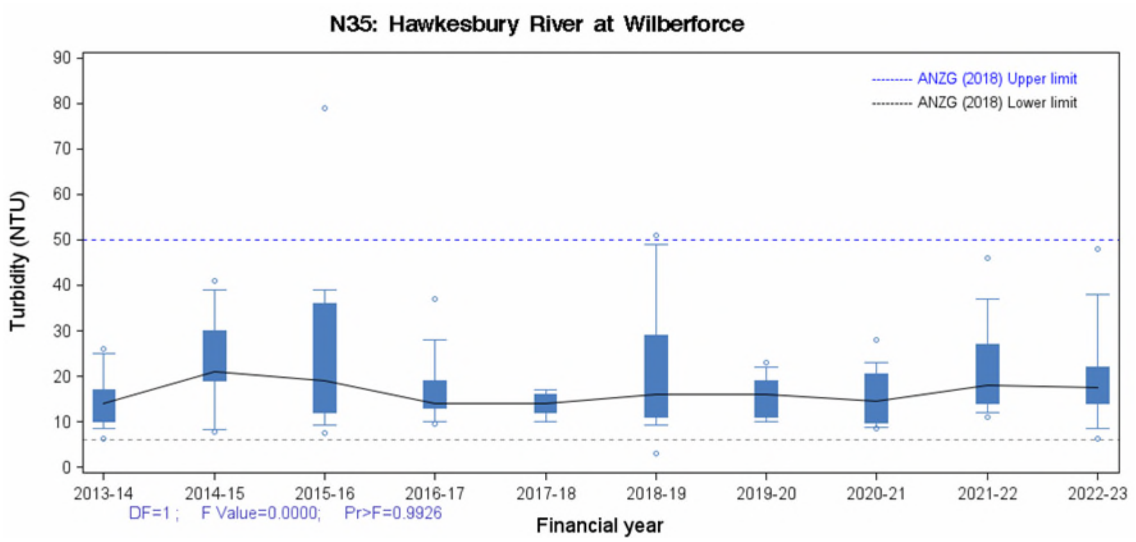



N35: Hawkesbury River at Wilberforce
Dissolved oxygen (mg/L)
Financial year
DF=1 ; F Value=11.952; Pr>F=0.0007

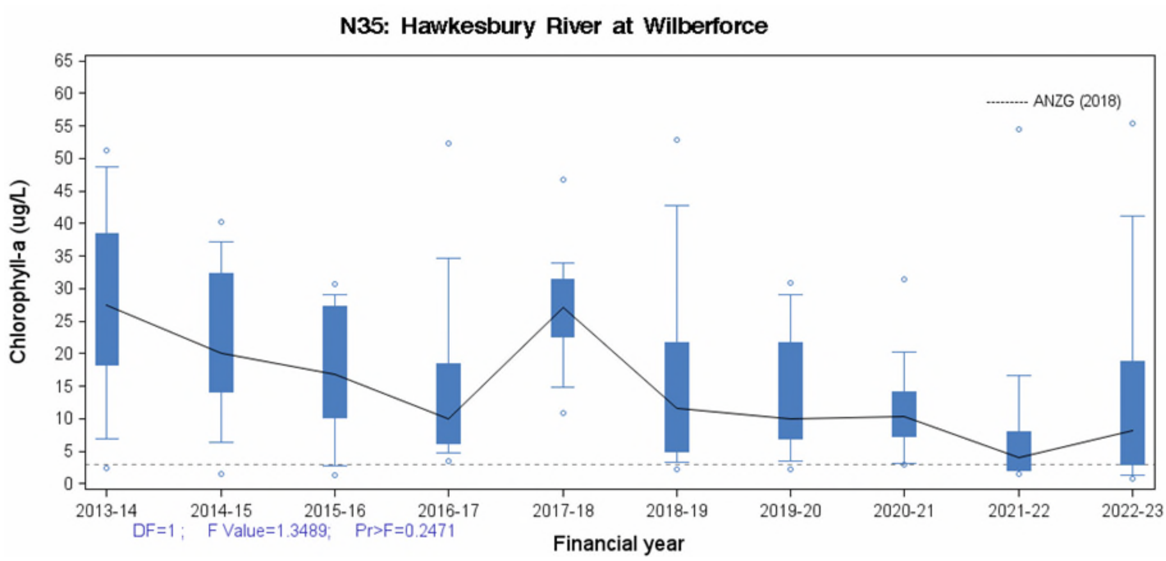

N35: Hawkesbury River at Wilberforce
Dissolved oxygen saturation (%)
ANZG (2018) Upper limit
ANZG (2018) Lower limit
Financial year
DF=1 ; F Value=13.035; Pr>F=0.0004

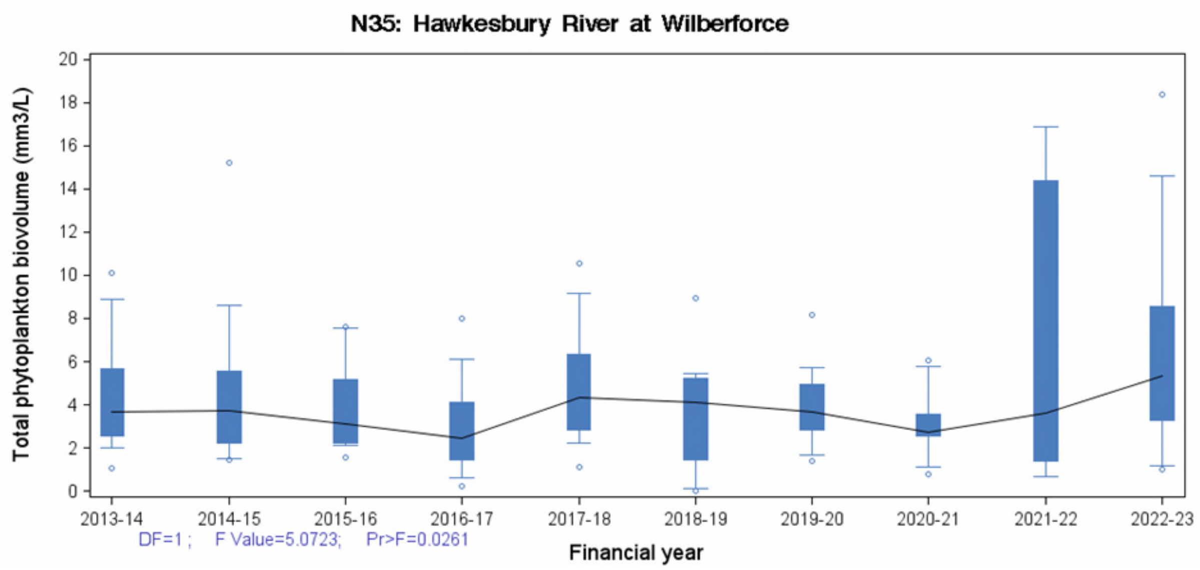

N35: Hawkesbury River at Wilberforce
pH
ANZG (2018) Upper limit
ANZG (2018) Lower limit
Financial year
DF=1 ; F Value=0.4411; Pr>F=0.5074

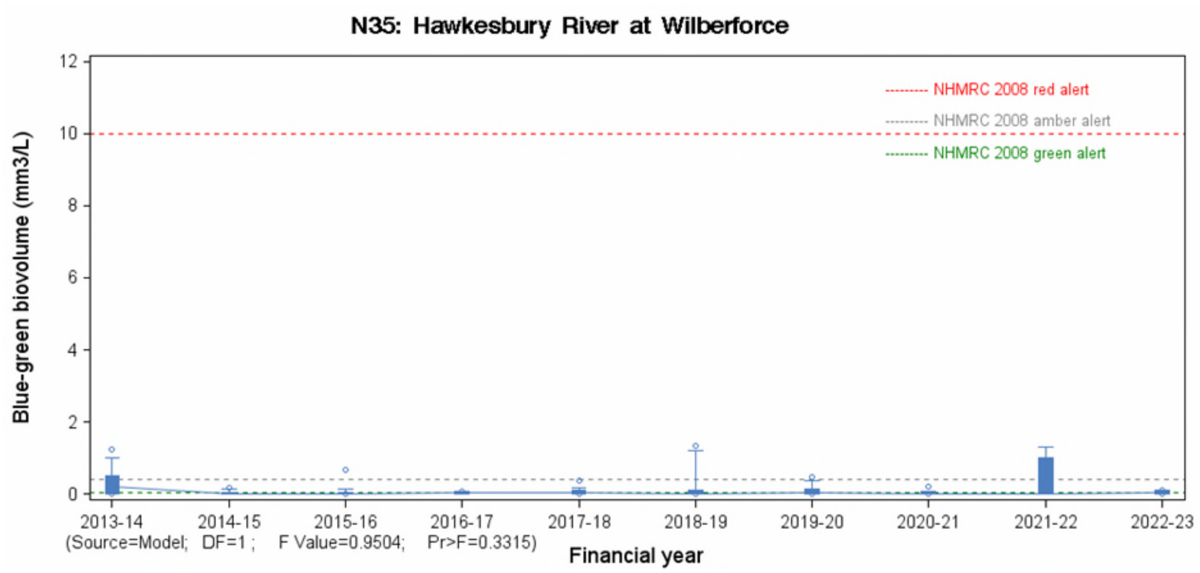


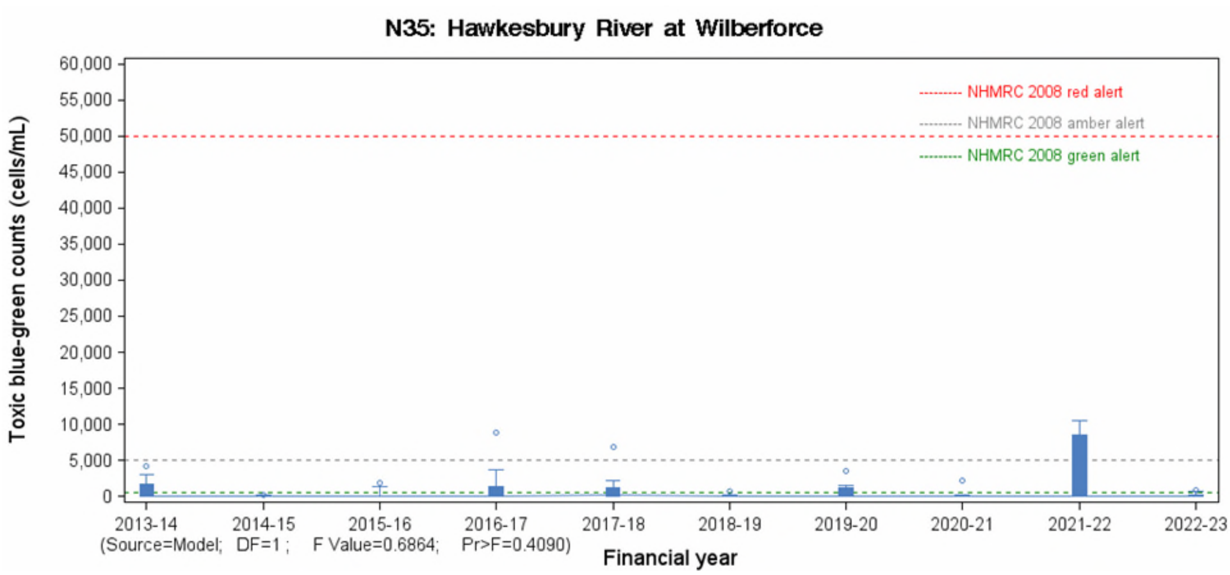


Ecosystem receptor – Phytoplankton




N35: Hawkesbury River at Wilberforce
Total phytoplankton biovolume (mm3/L)
20
18
16
14
12
10
8
6
4
2
0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=5.0723; Pr>F=0.0261
Financial year


N35: Hawkesbury River at Wilberforce
Blue-green biovolume (mm3/L)
12
10
8
6
4
2
0
NHMRC 2008 red alert
NHMRC 2008 amber alert
NHMRC 2008 green alert
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
(Source=Model; DF=1 ; F Value=0.9504; Pr>F=0.3315)
Financial year


N35: Hawkesbury River at Wilberforce
Toxic blue-green counts (cells/mL)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
NHMRC 2008 red alert
NHMRC 2008 amber alert
NHMRC 2008 green alert
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
(Source=Model; DF=1 ; F Value=0.6864; Pr>F=0.4090)
Financial year

Ecosystem receptor – Macroinvertebrates

Mean stream health in 2022-23 was within the range recorded over the period back to 1995.

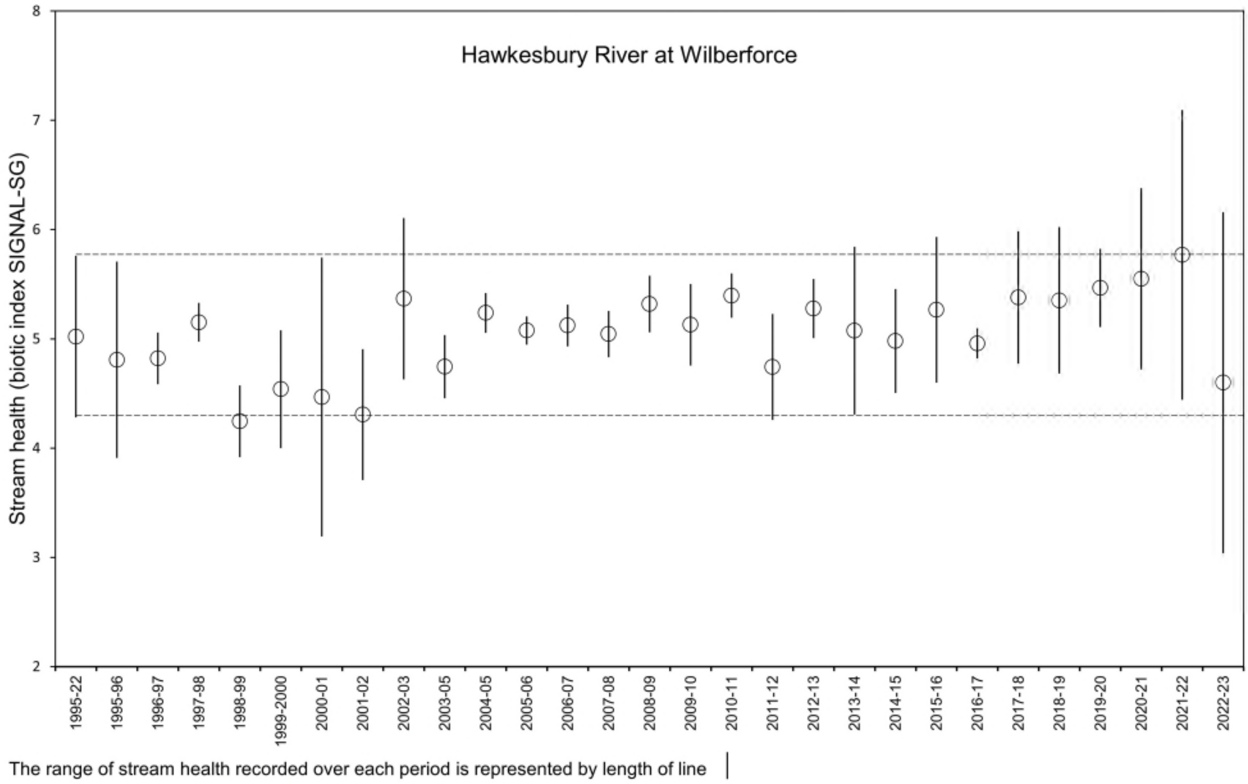
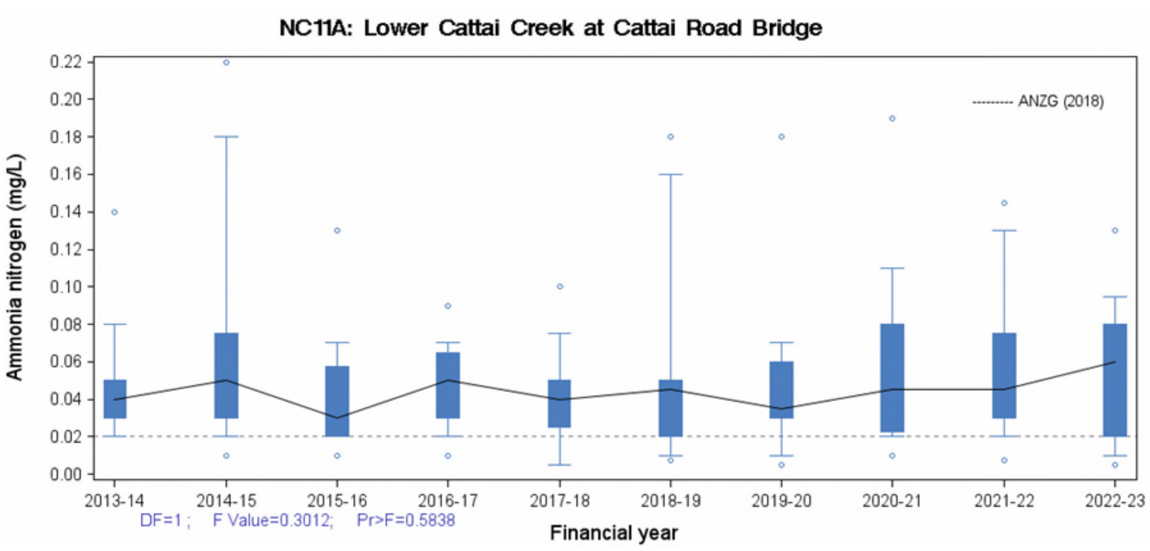
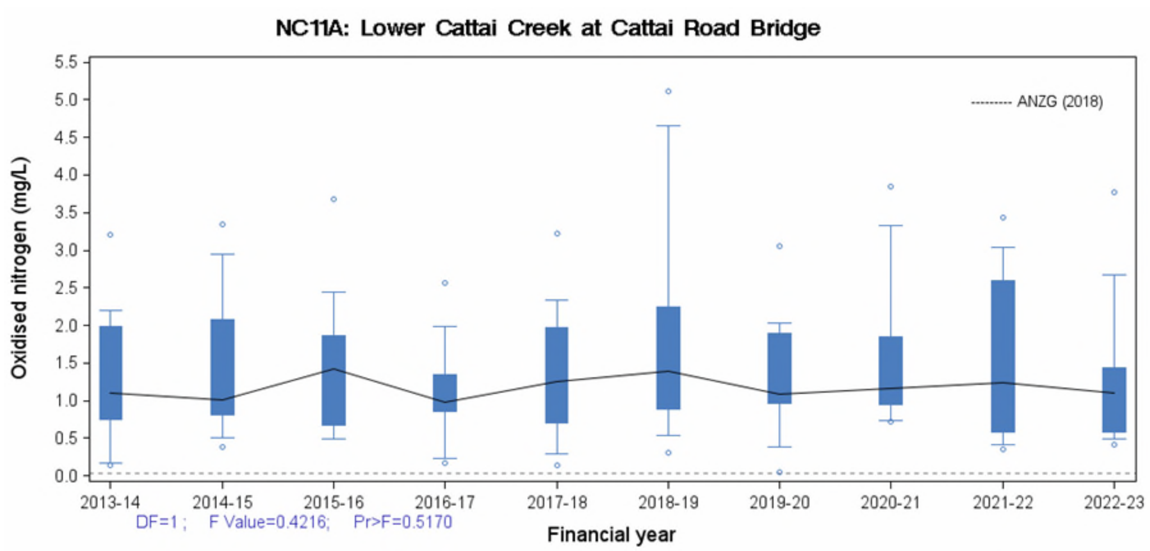


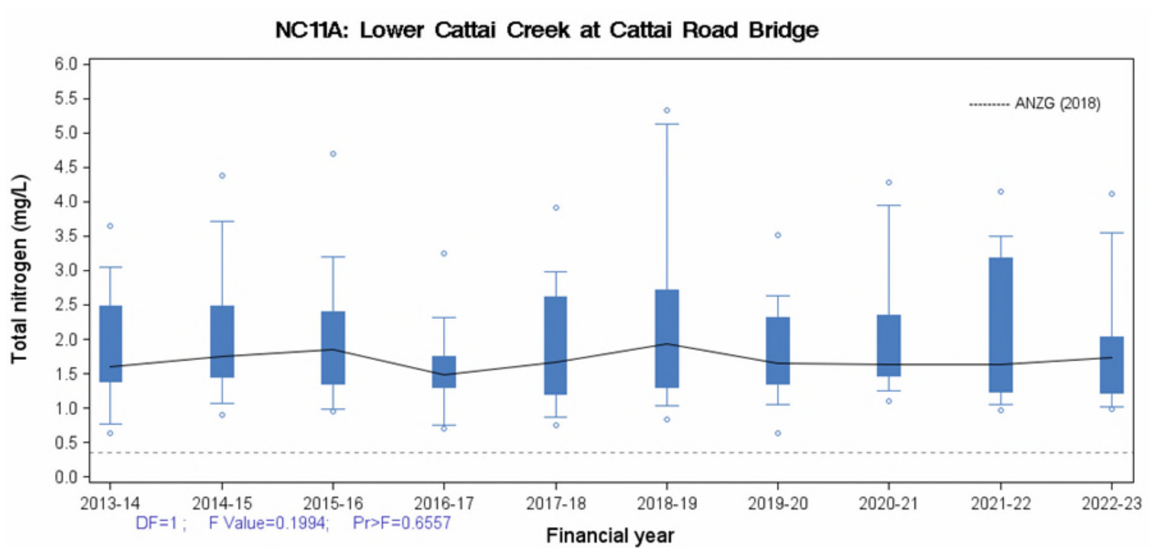
Figure C-2 Stream health of Hawkesbury River at Wilberforce (N35)

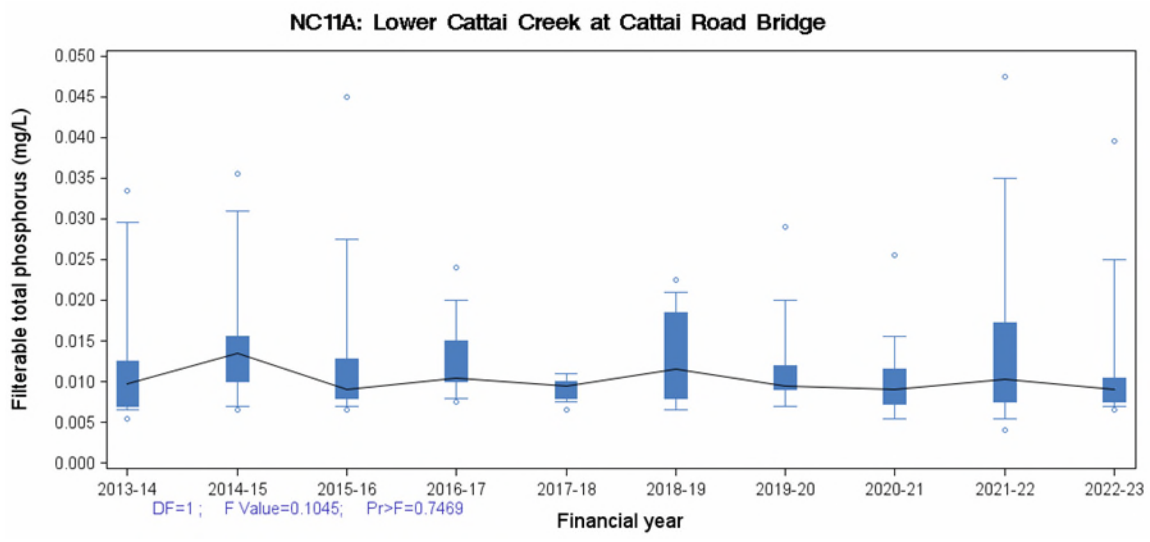
C-1.7 Lower Cattai Creek at Cattai Road Bridge, 100m downstream of bridge (NC11A)

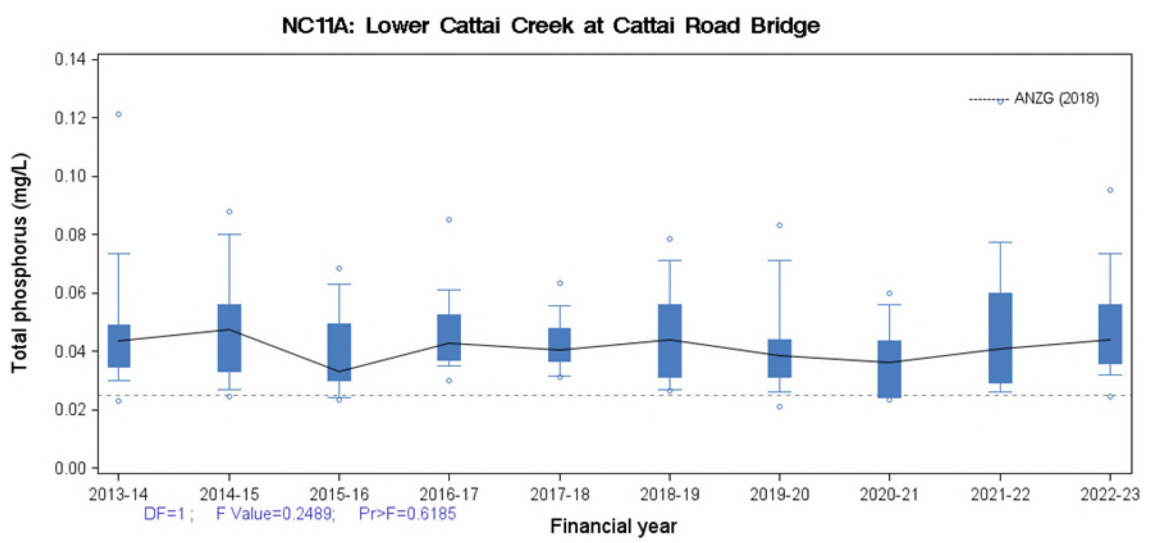
Stressors – Nutrients



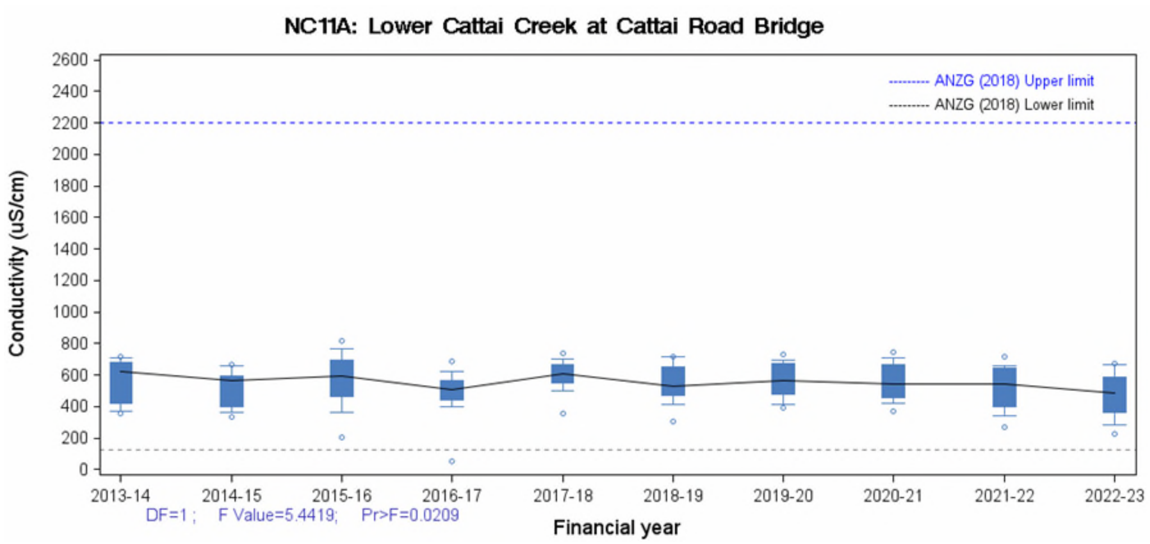


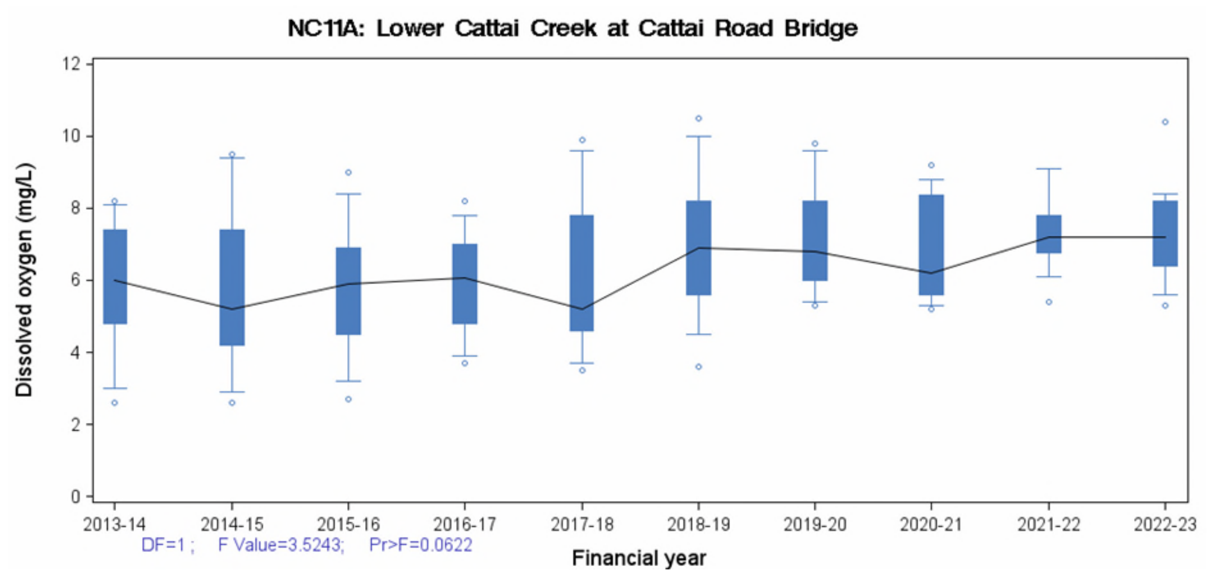


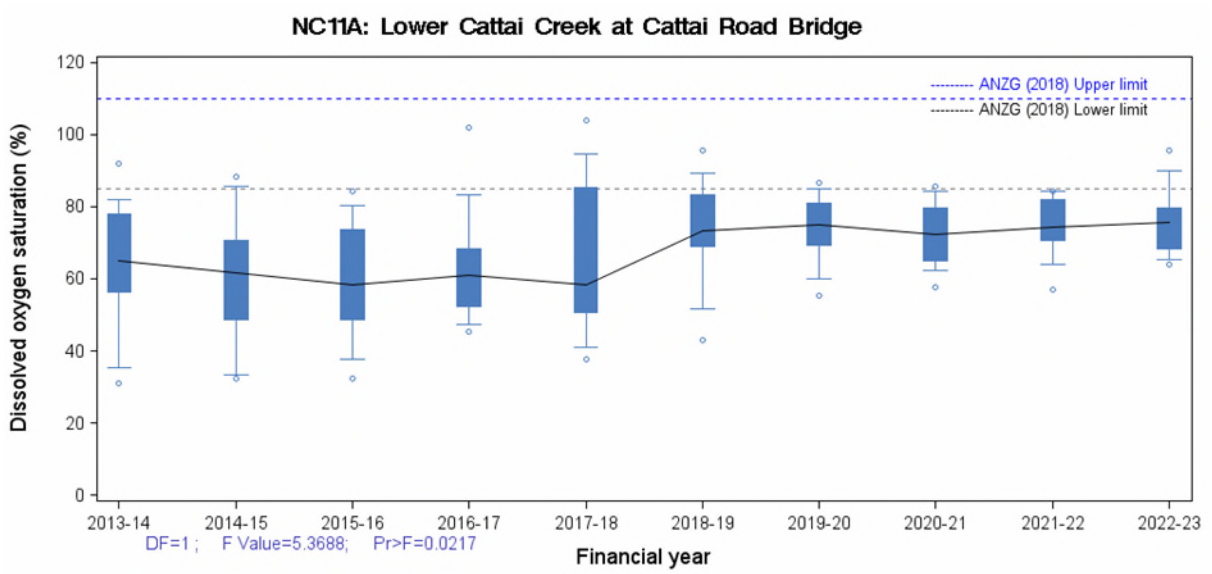


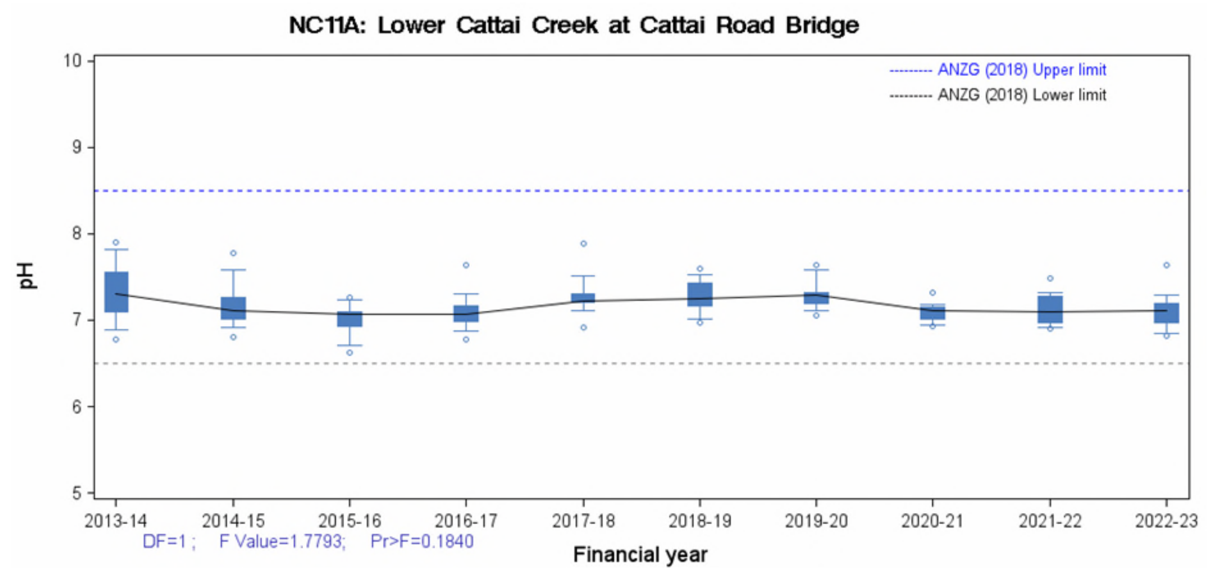


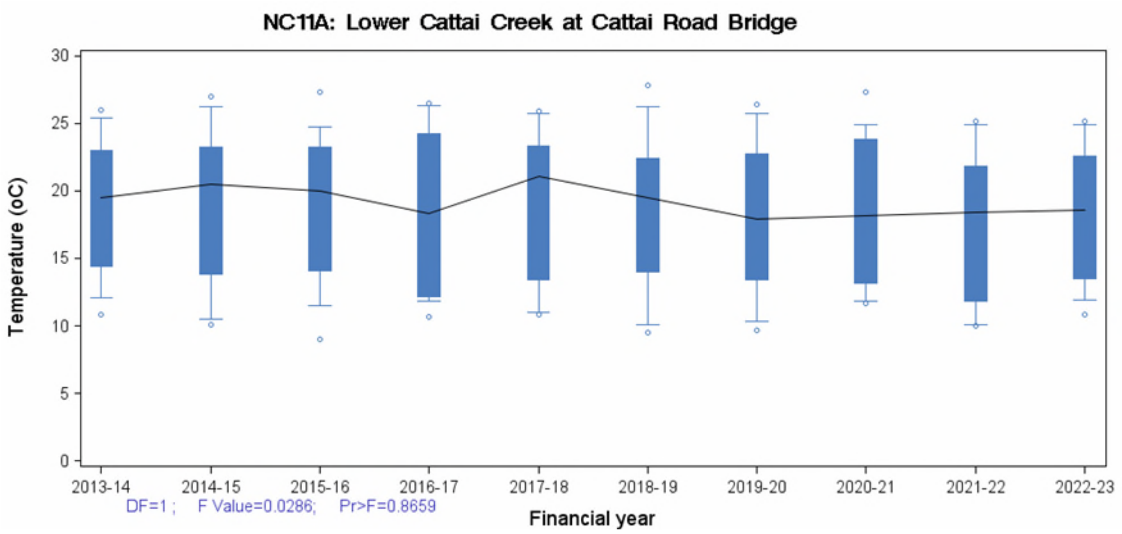
Stressors – Physico-chemical water quality

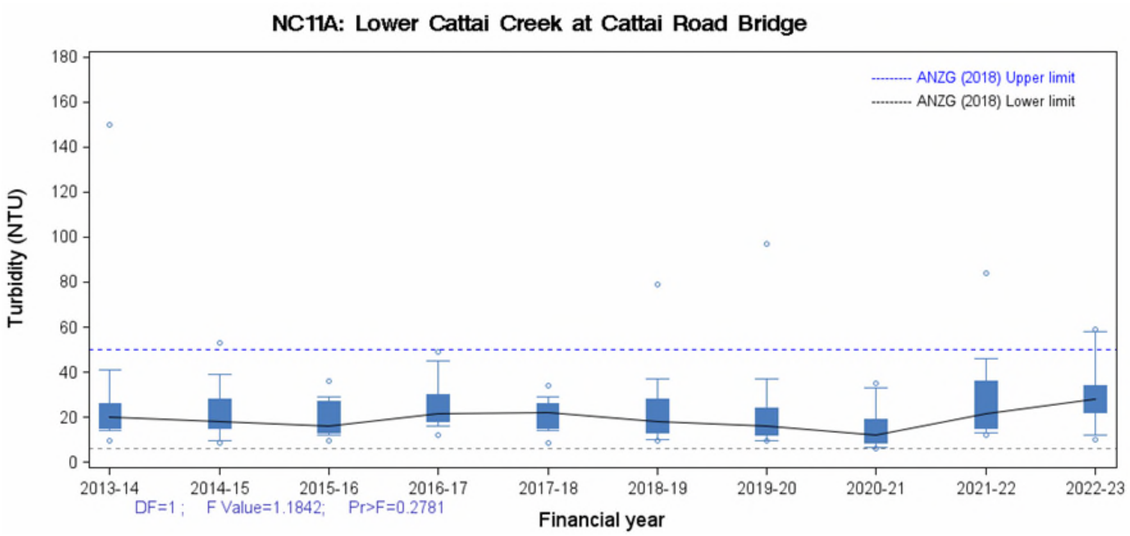



NC11A: Lower Cattai Creek at Cattai Road Bridge
Dissolved oxygen (mg/L)
0
2
4
6
8
10
12
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=3.5243; Pr>F=0.0622
Financial year

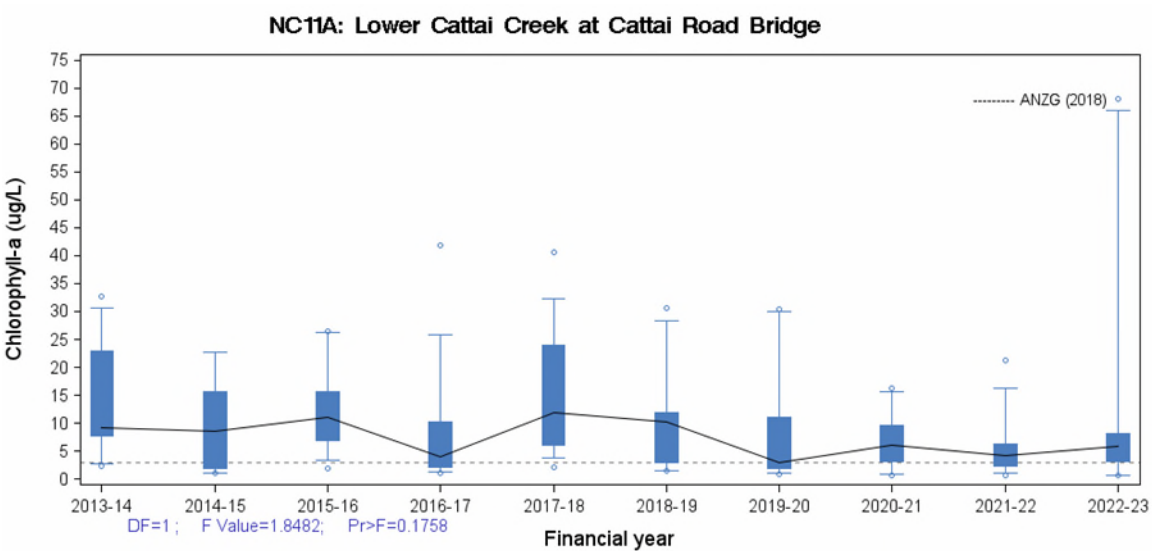

NC11A: Lower Cattai Creek at Cattai Road Bridge
ANZG (2018) Upper limit
ANZG (2018) Lower limit
Dissolved oxygen saturation (%)
0
20
40
60
80
100
120
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=5.3688; Pr>F=0.0217
Financial year

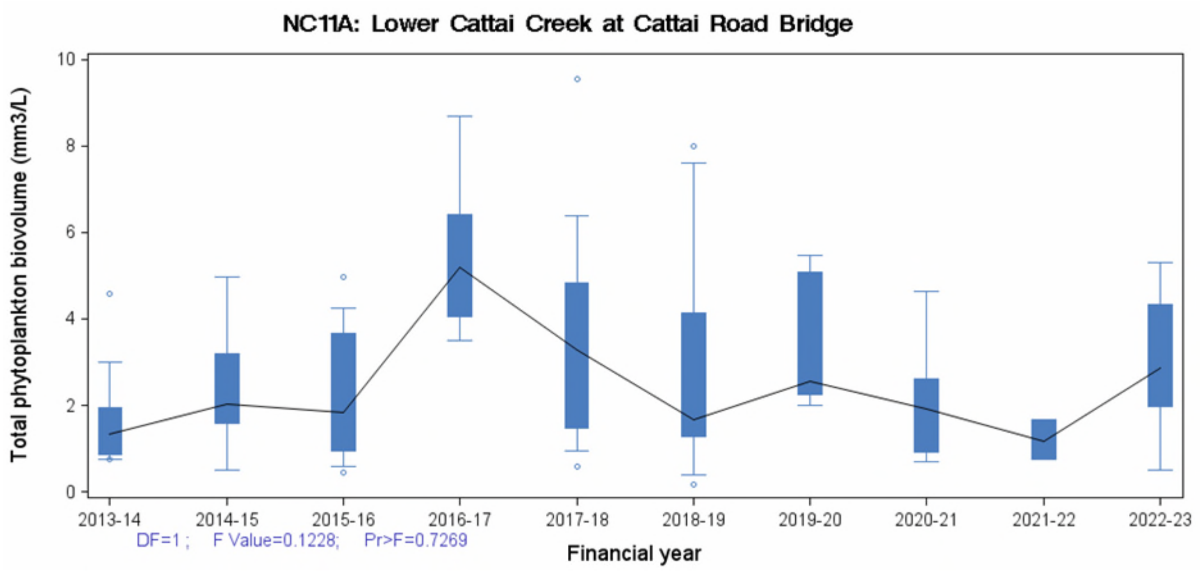

NC11A: Lower Cattai Creek at Cattai Road Bridge
ANZG (2018) Upper limit
ANZG (2018) Lower limit
pH
5
6
7
8
9
10
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=1.7793; Pr>F=0.1840
Financial year

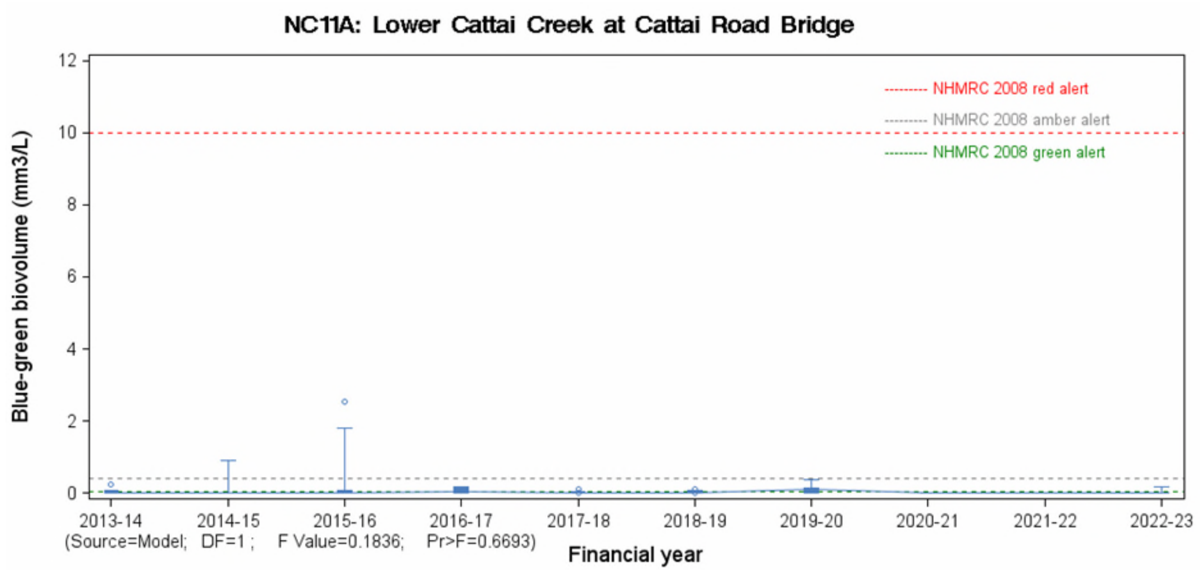


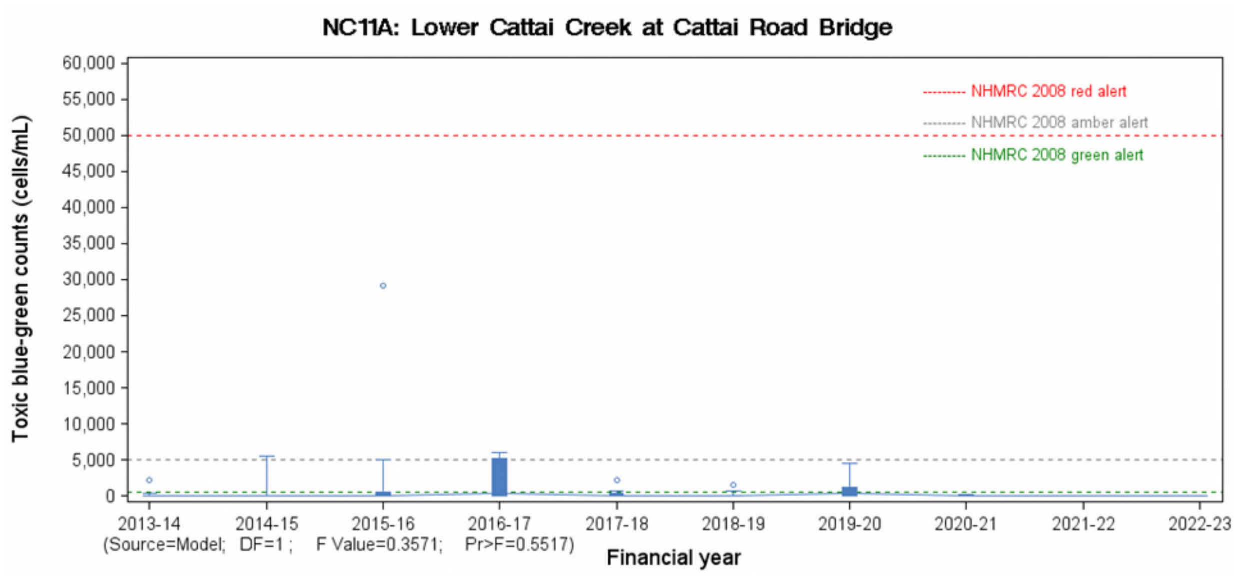


Ecosystem receptor – Phytoplankton



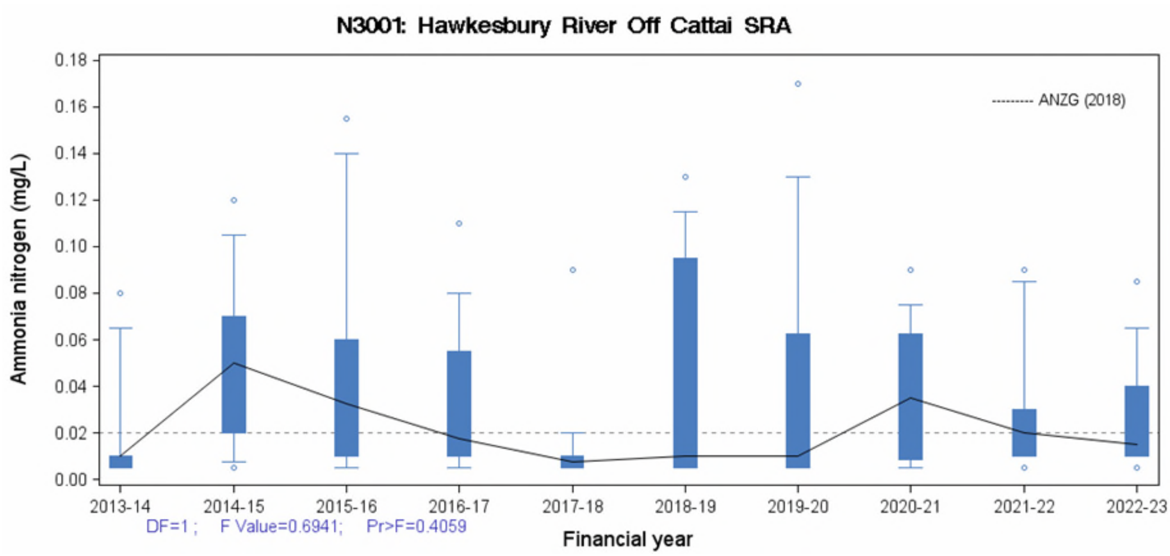

NC11A: Lower Cattai Creek at Cattai Road Bridge
Total phytoplankton biovolume (mm3/L)
10
8
6
4
2
0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=0.1228; Pr>F=0.7269
Financial year

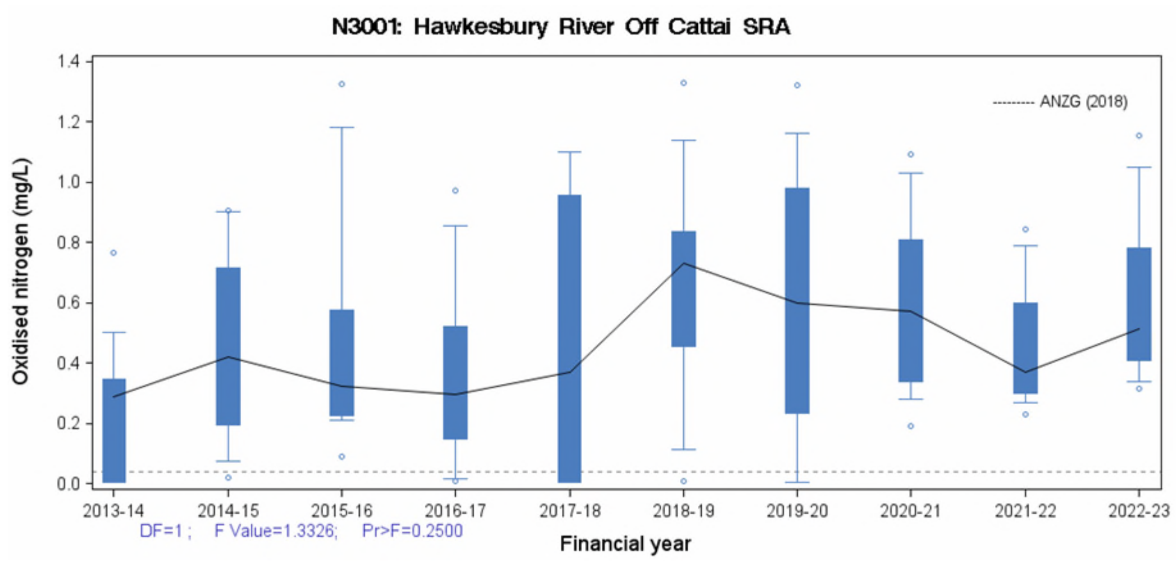

NC11A: Lower Cattai Creek at Cattai Road Bridge
Blue-green biovolume (mm3/L)
NHMRC 2008 red alert
NHMRC 2008 amber alert
NHMRC 2008 green alert
12
10
8
6
4
2
0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
(Source=Model; DF=1 ; F Value=0.1836; Pr>F=0.6693)
Financial year

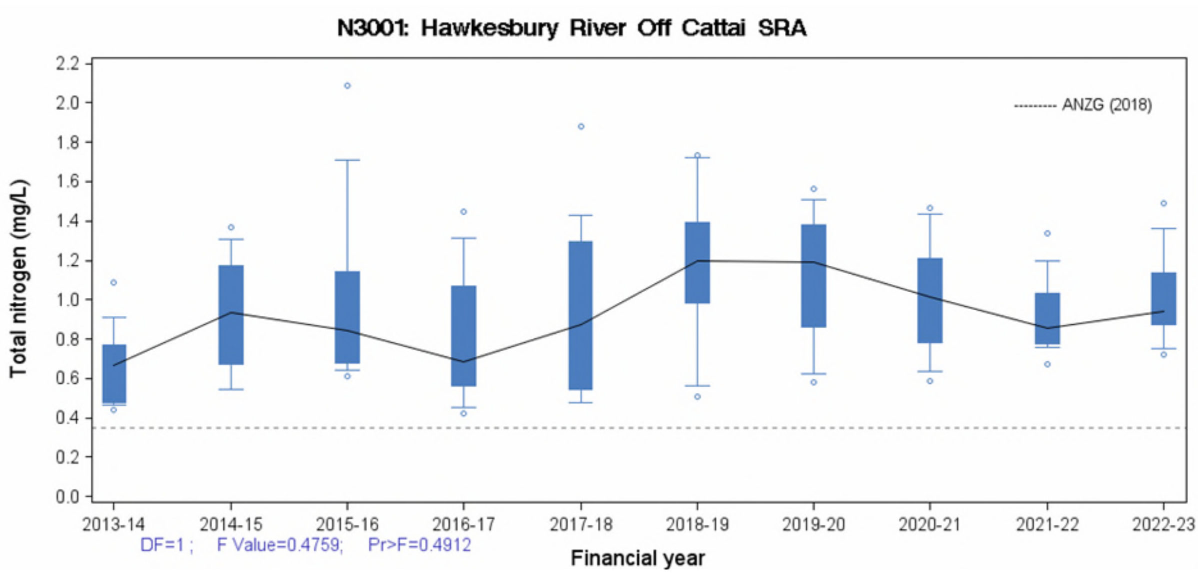

NC11A: Lower Cattai Creek at Cattai Road Bridge
Toxic blue-green counts (cells/mL)
NHMRC 2008 red alert
NHMRC 2008 amber alert
NHMRC 2008 green alert
60,000
55,000
50,000
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
(Source=Model; DF=1 ; F Value=0.3571; Pr>F=0.5517)
Financial year

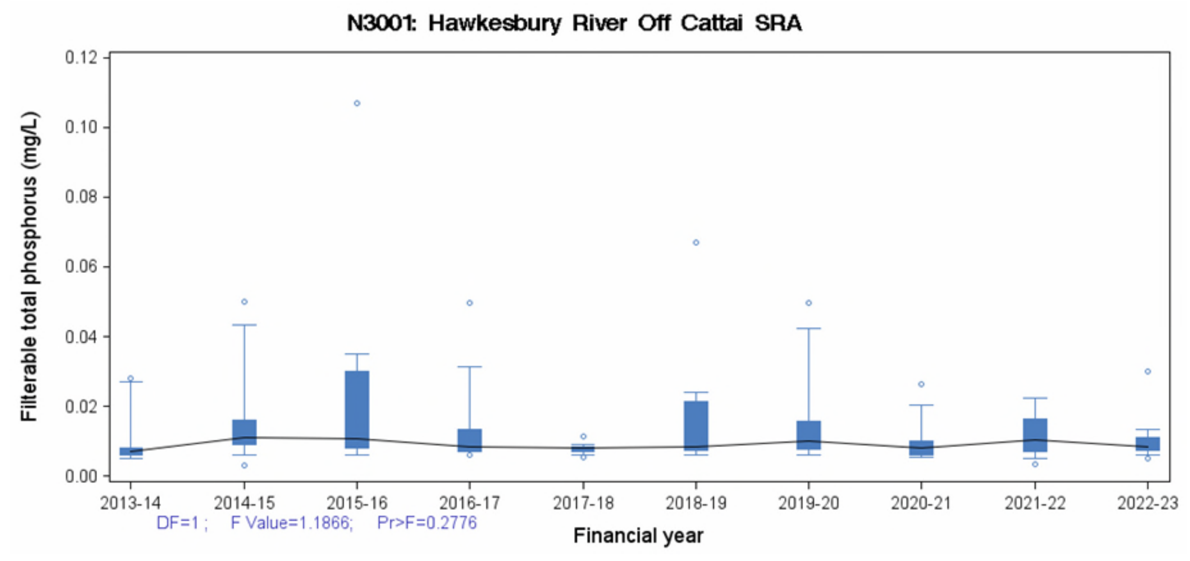
C-1.8 Hawkesbury River off Cattai SRA (N3001)

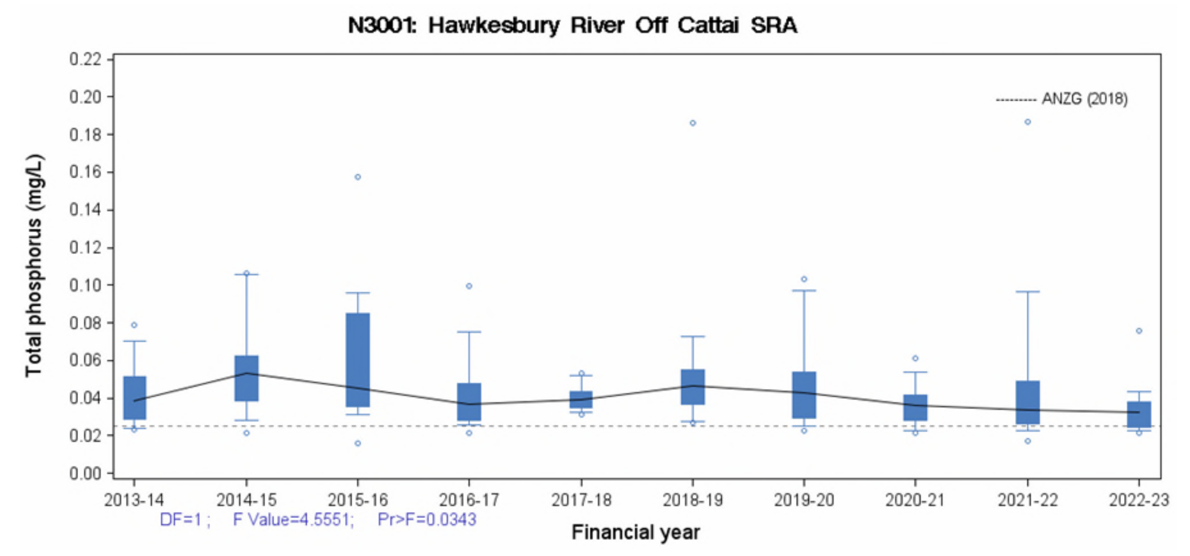
Stressors – Nutrients



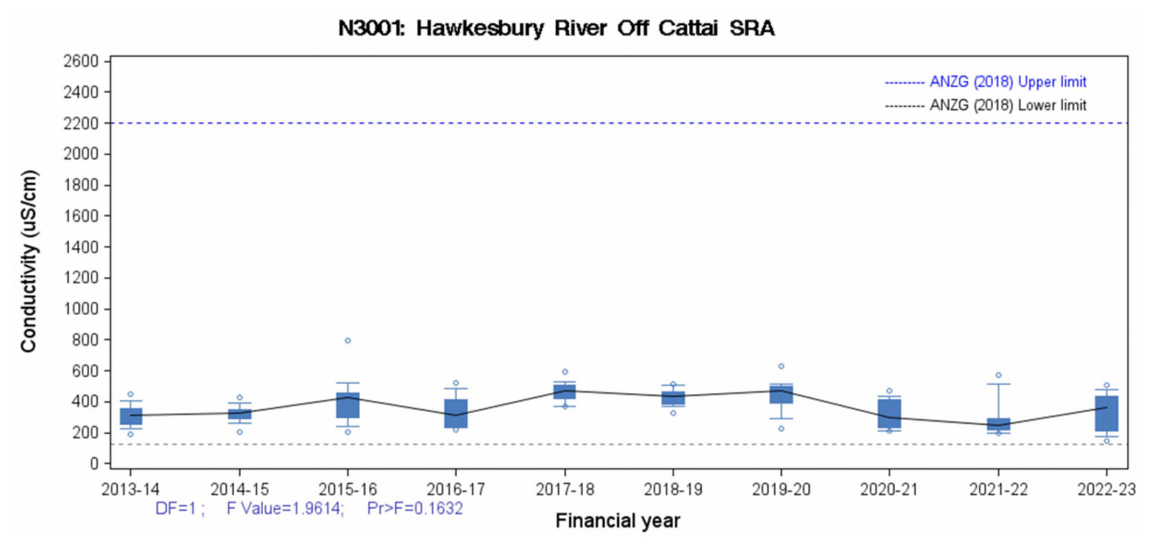


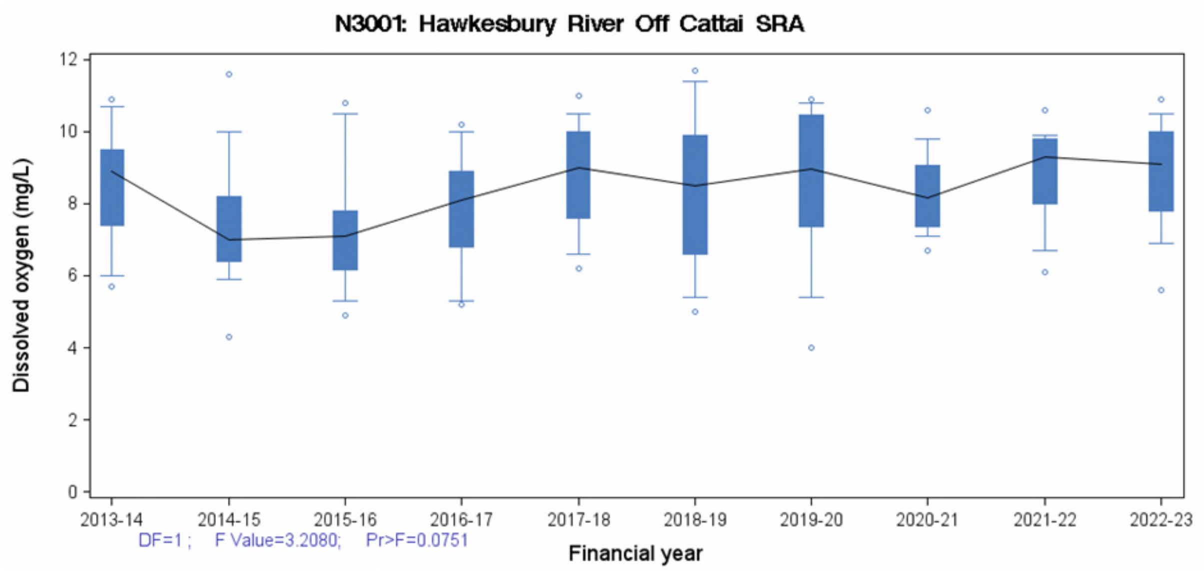


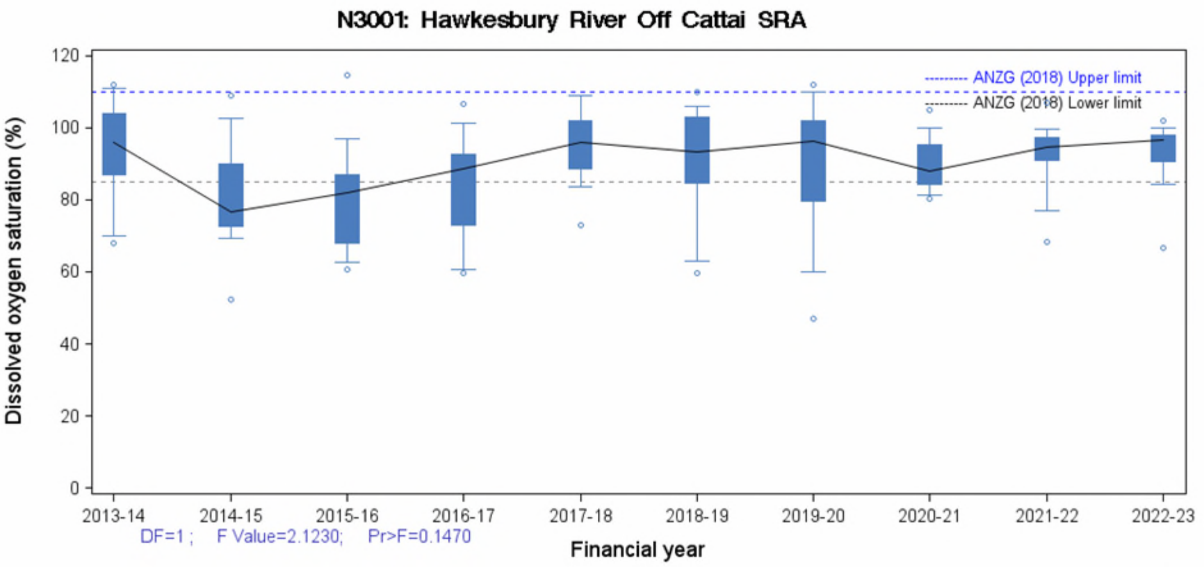


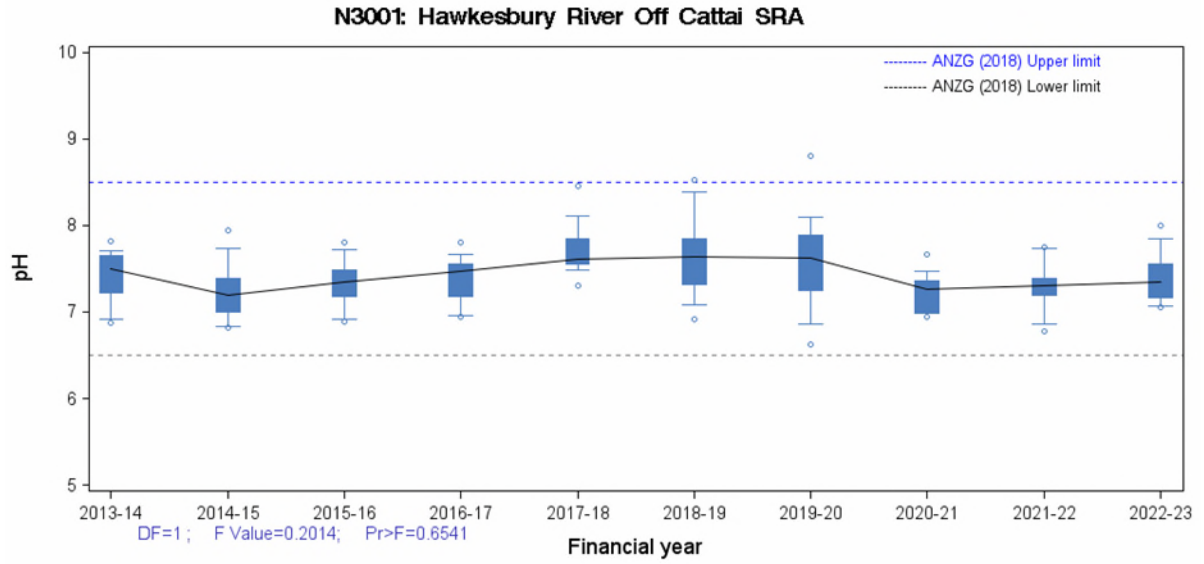


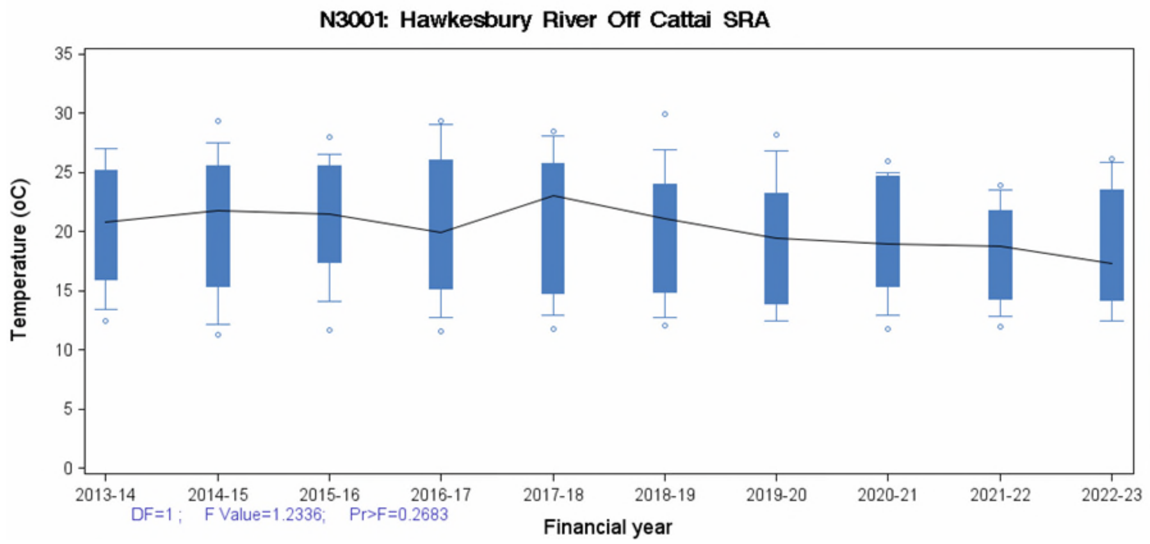
Stressors – Physico-chemical water quality

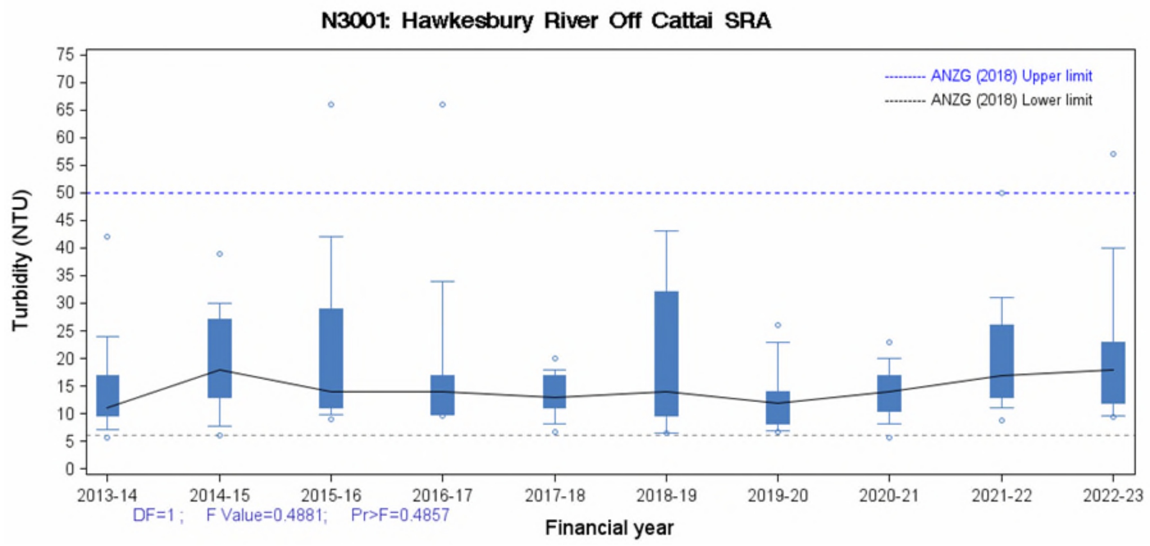



N3001: Hawkesbury River Off Cattai SRA
Dissolved oxygen (mg/L)
Financial year
DF=1 ; F Value=3.2080; Pr>F=0.0751

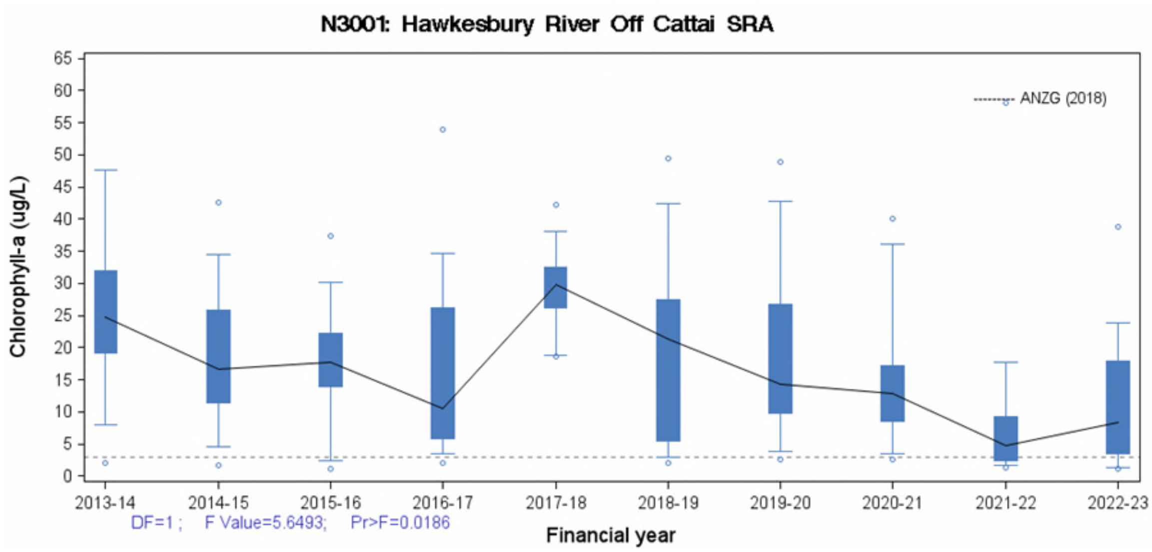

N3001: Hawkesbury River Off Cattai SRA
ANZG (2018) Upper limit
ANZG (2018) Lower limit
Dissolved oxygen saturation (%)
Financial year
DF=1 ; F Value=2.1230; Pr>F=0.1470

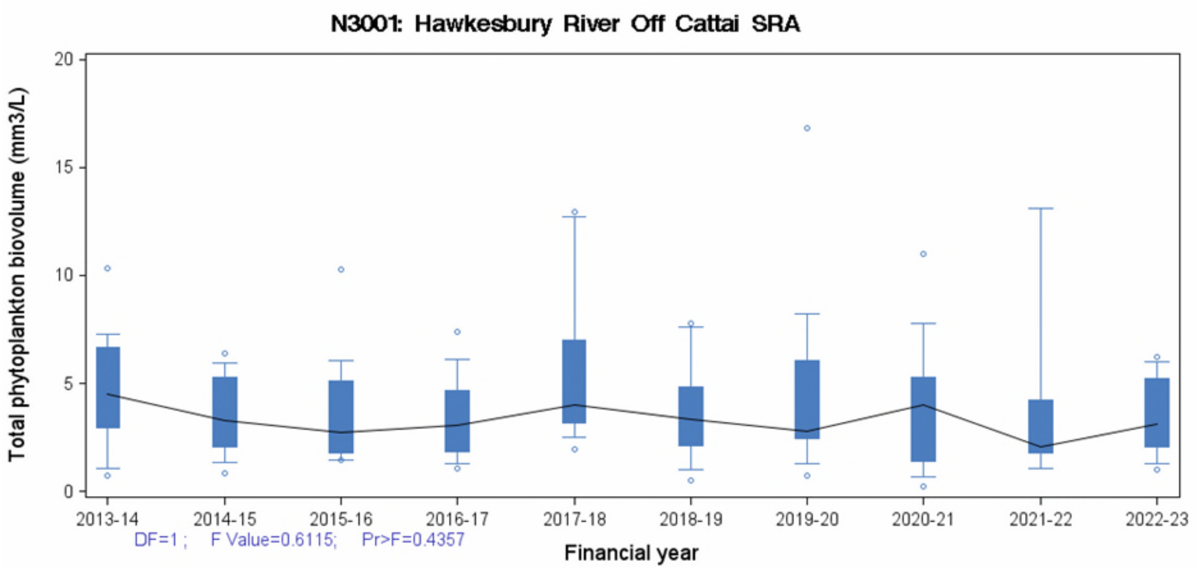

N3001: Hawkesbury River Off Cattai SRA
ANZG (2018) Upper limit
ANZG (2018) Lower limit
pH
Financial year
DF=1 ; F Value=0.2014; Pr>F=0.6541

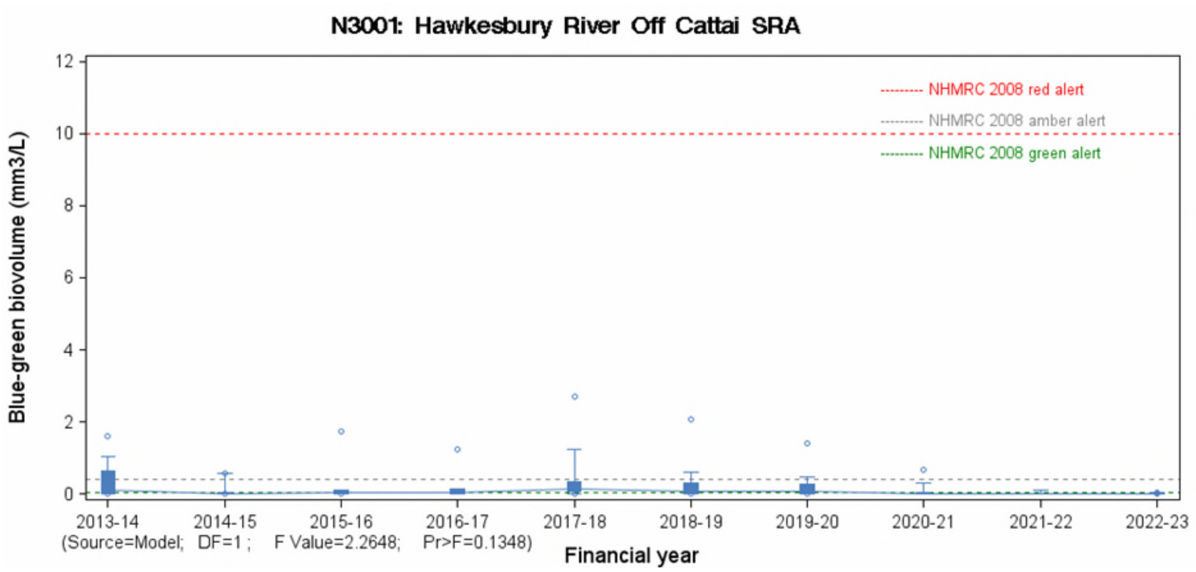


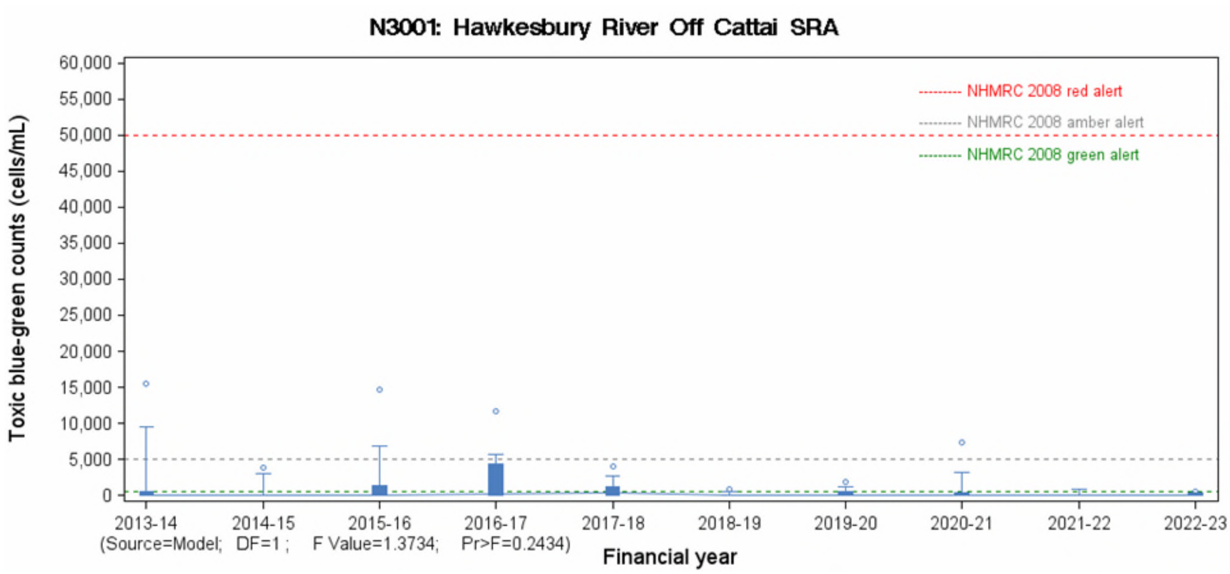


Ecosystem receptor – Phytoplankton



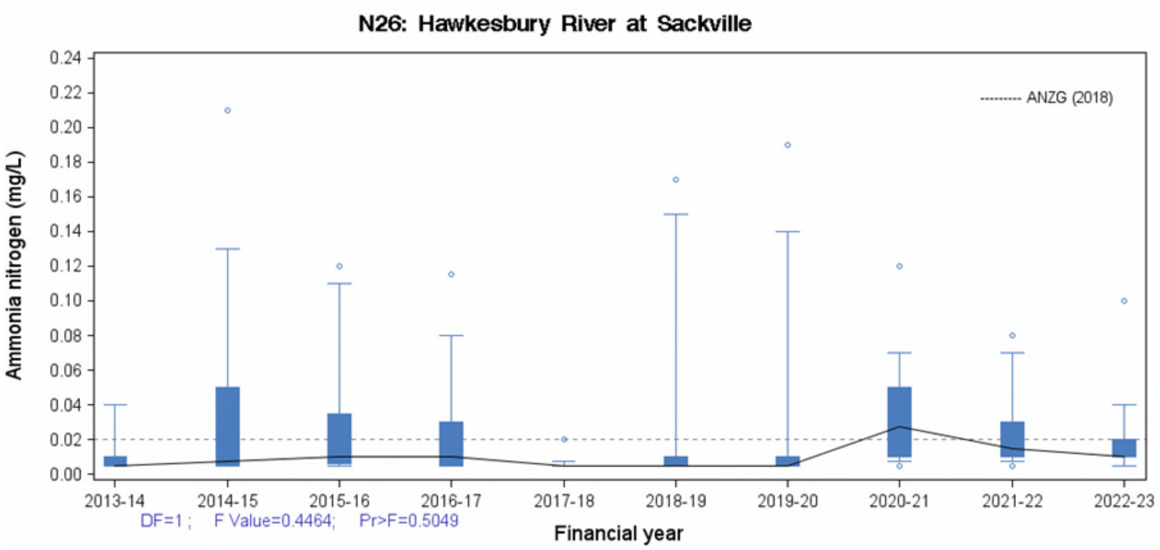

N3001: Hawkesbury River Off Cattai SRA
Total phytoplankton biovolume (mm3/L)
2013-14 2014-15 2015-16 2016-17 2017-18 2018-19 2019-20 2020-21 2021-22 2022-23
DF=1 ; F Value=0.6115; Pr>F=0.4357
Financial year

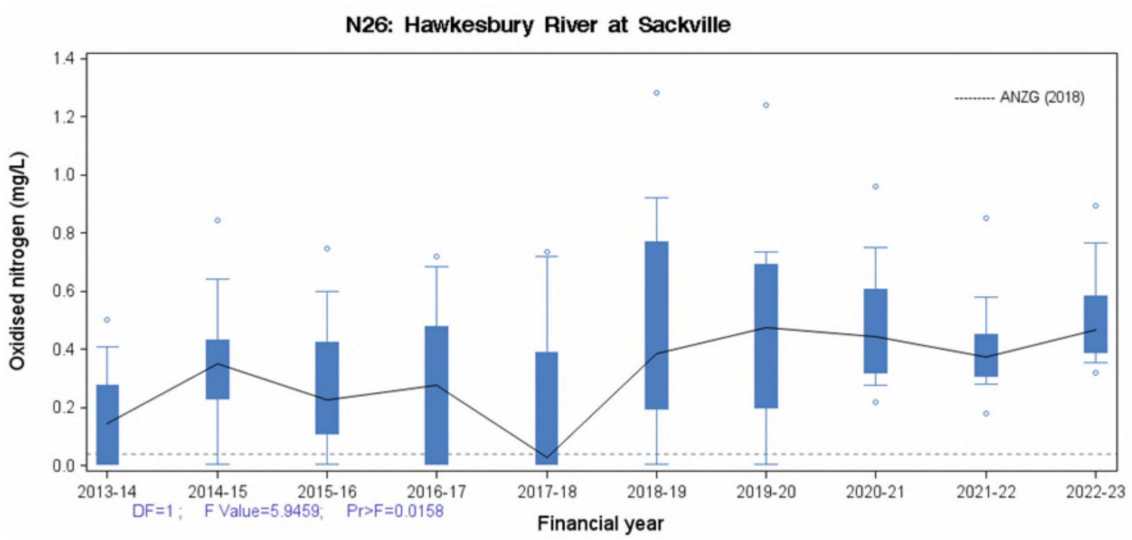

N3001: Hawkesbury River Off Cattai SRA
NHMRC 2008 red alert
NHMRC 2008 amber alert
NHMRC 2008 green alert
Blue-green biovolume (mm3/L)
2013-14 2014-15 2015-16 2016-17 2017-18 2018-19 2019-20 2020-21 2021-22 2022-23
(Source=Model; DF=1 ; F Value=2.2648; Pr>F=0.1348)
Financial year

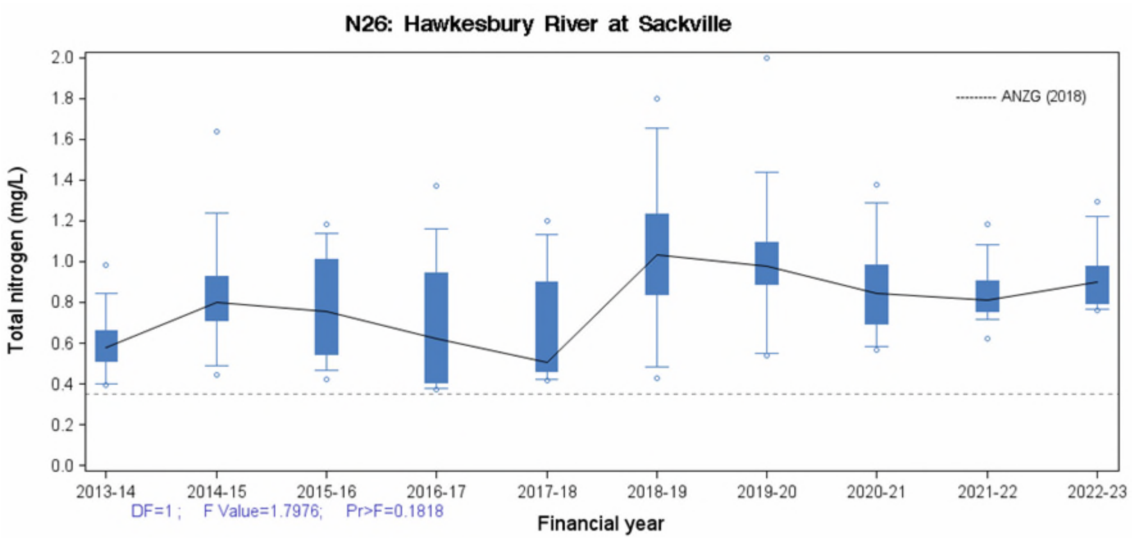

N3001: Hawkesbury River Off Cattai SRA
NHMRC 2008 red alert
NHMRC 2008 amber alert
NHMRC 2008 green alert
Toxic blue-green counts (cells/mL)
2013-14 2014-15 2015-16 2016-17 2017-18 2018-19 2019-20 2020-21 2021-22 2022-23
(Source=Model; DF=1 ; F Value=1.3734; Pr>F=0.2434)
Financial year

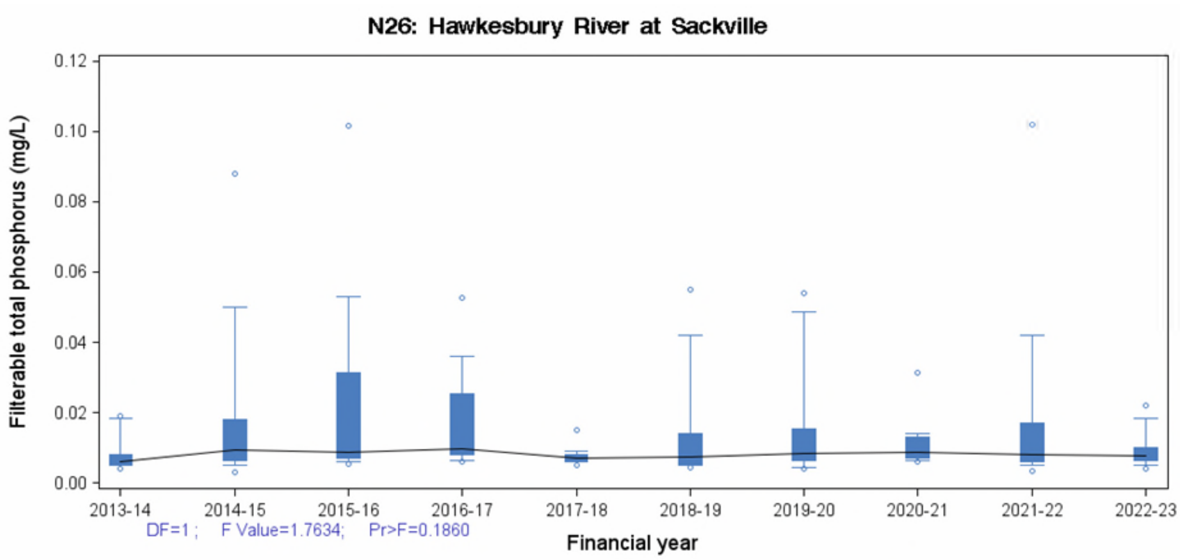
C-1.9 Hawkesbury River at Sackville Ferry, downstream of Cattai Creek (N26)

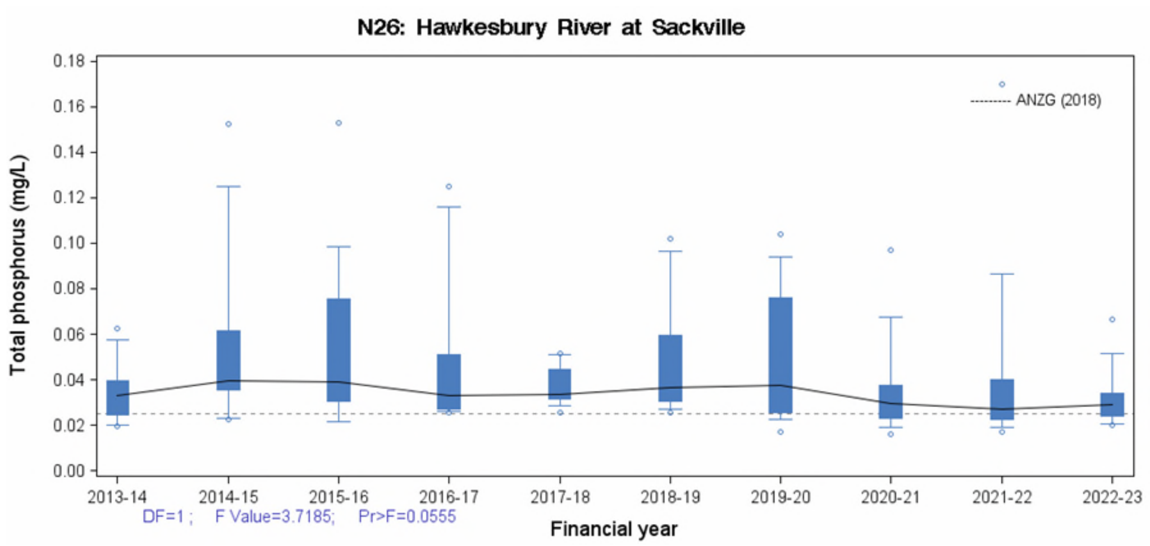
Stressors – Nutrients



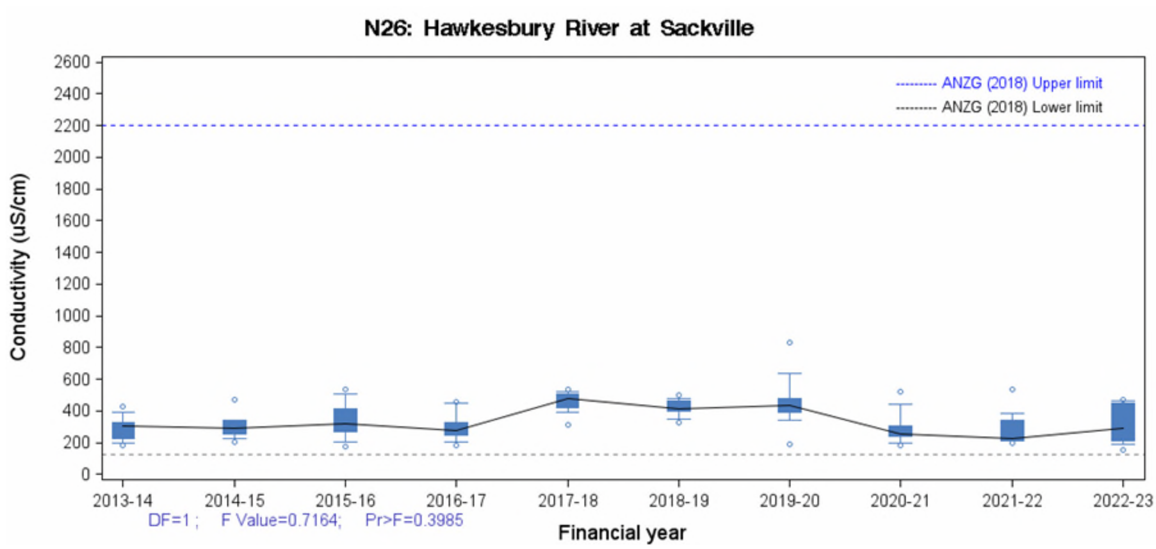


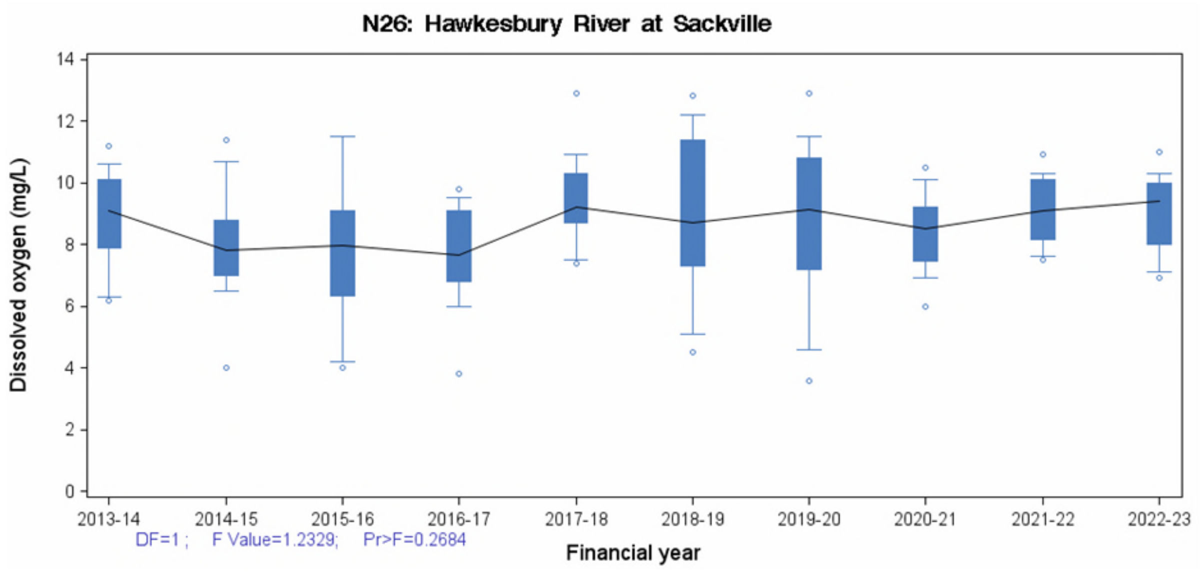


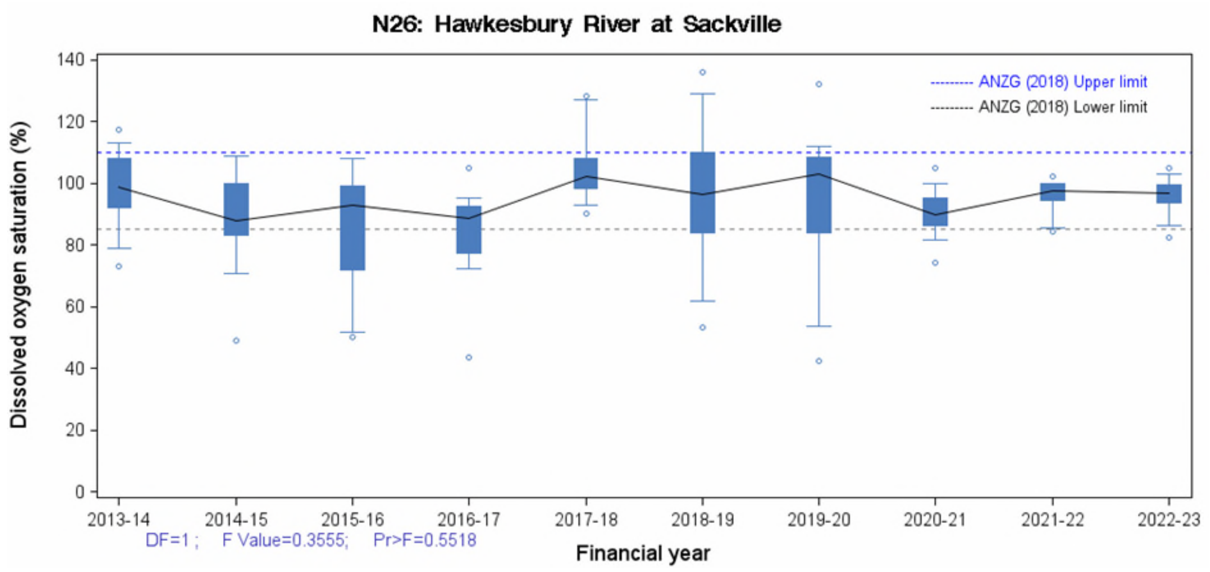


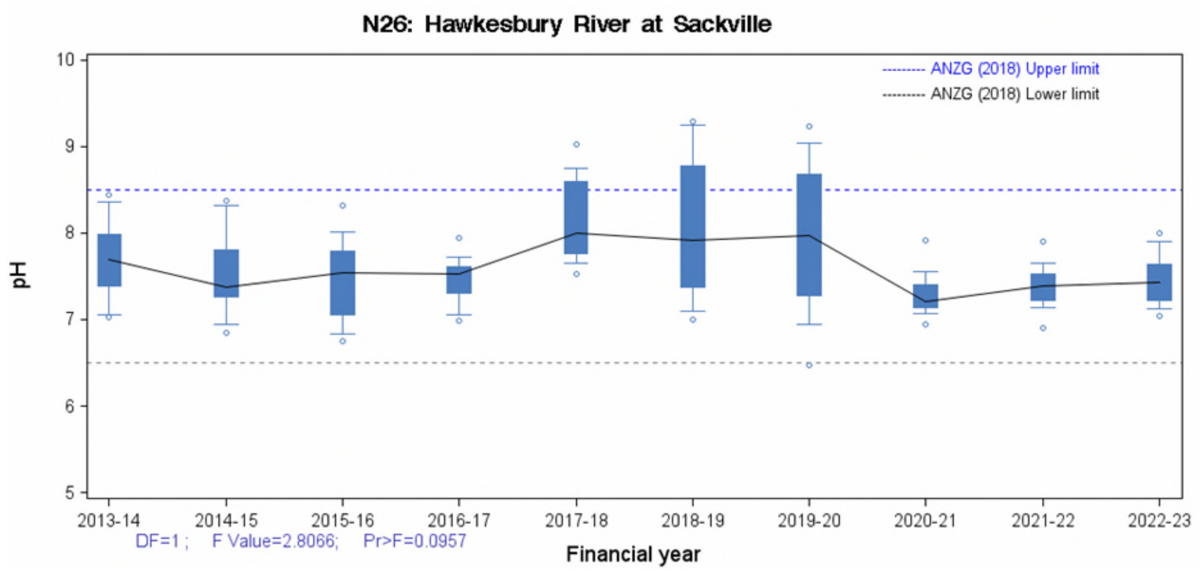


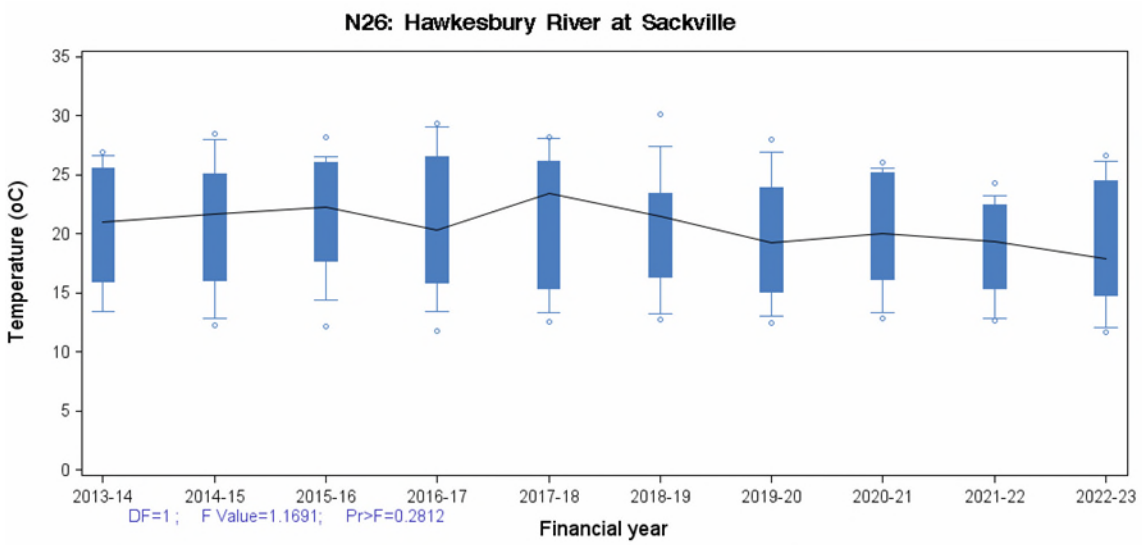
Stressors – Physico-chemical water quality

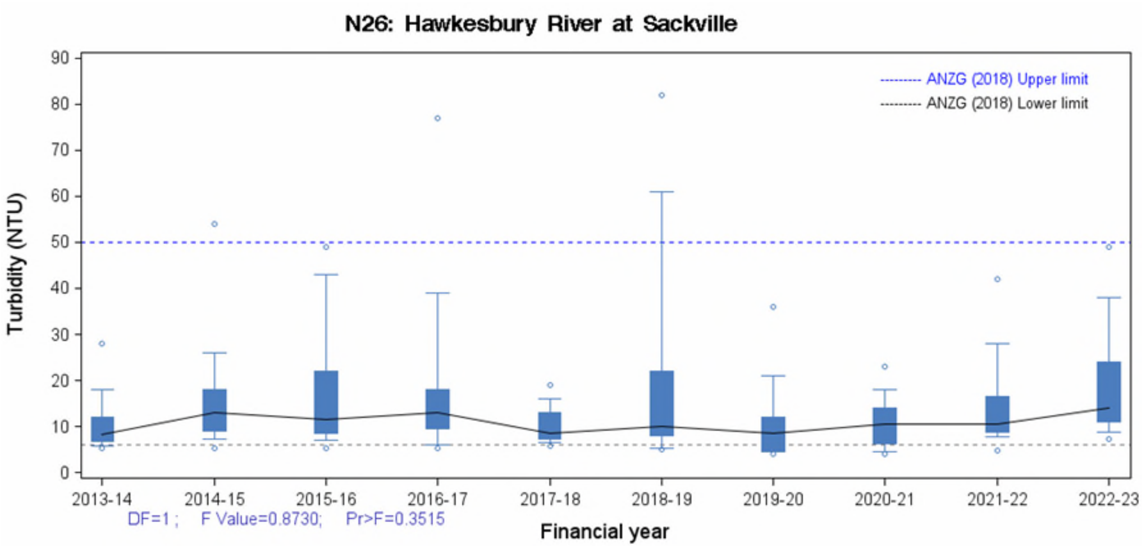



N26: Hawkesbury River at Sackville
Dissolved oxygen (mg/L)
Financial year
2013-14 2014-15 2015-16 2016-17 2017-18 2018-19 2019-20 2020-21 2021-22 2022-23
DF=1 ; F Value=1.2329; Pr>F=0.2684

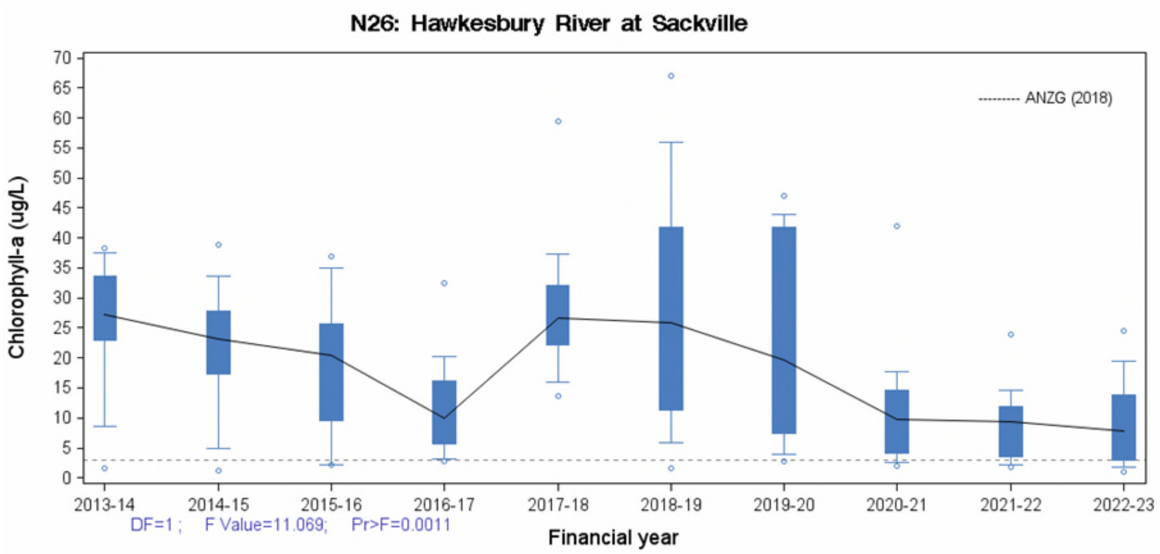

N26: Hawkesbury River at Sackville
Dissolved oxygen saturation (%)
ANZG (2018) Upper limit
ANZG (2018) Lower limit
Financial year
2013-14 2014-15 2015-16 2016-17 2017-18 2018-19 2019-20 2020-21 2021-22 2022-23
DF=1 ; F Value=0.3555; Pr>F=0.5518

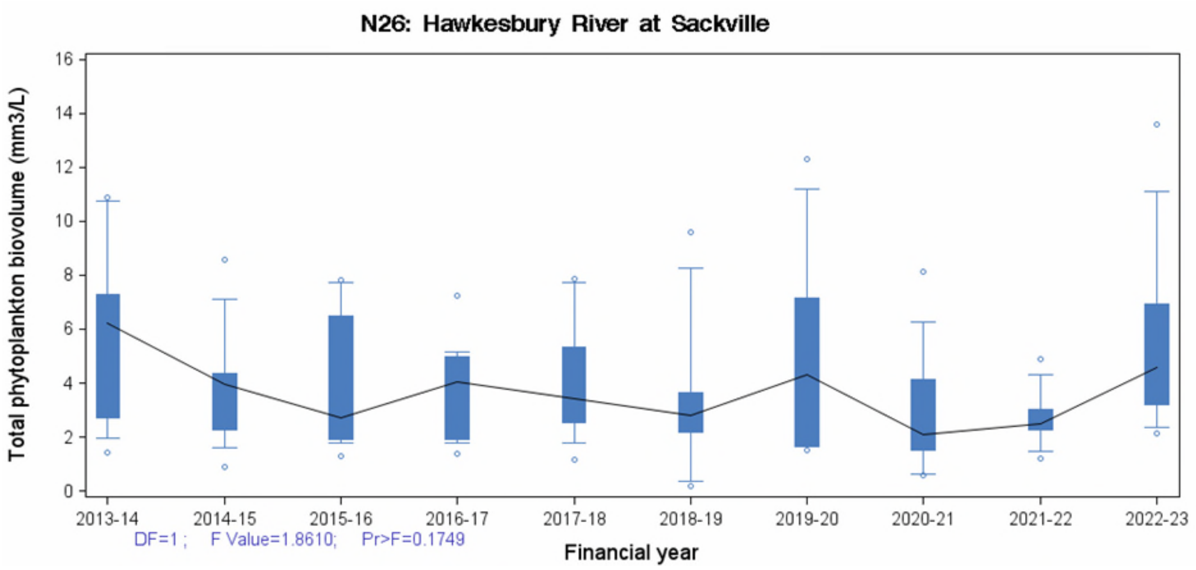

N26: Hawkesbury River at Sackville
pH
ANZG (2018) Upper limit
ANZG (2018) Lower limit
Financial year
2013-14 2014-15 2015-16 2016-17 2017-18 2018-19 2019-20 2020-21 2021-22 2022-23
DF=1 ; F Value=2.8066; Pr>F=0.0957

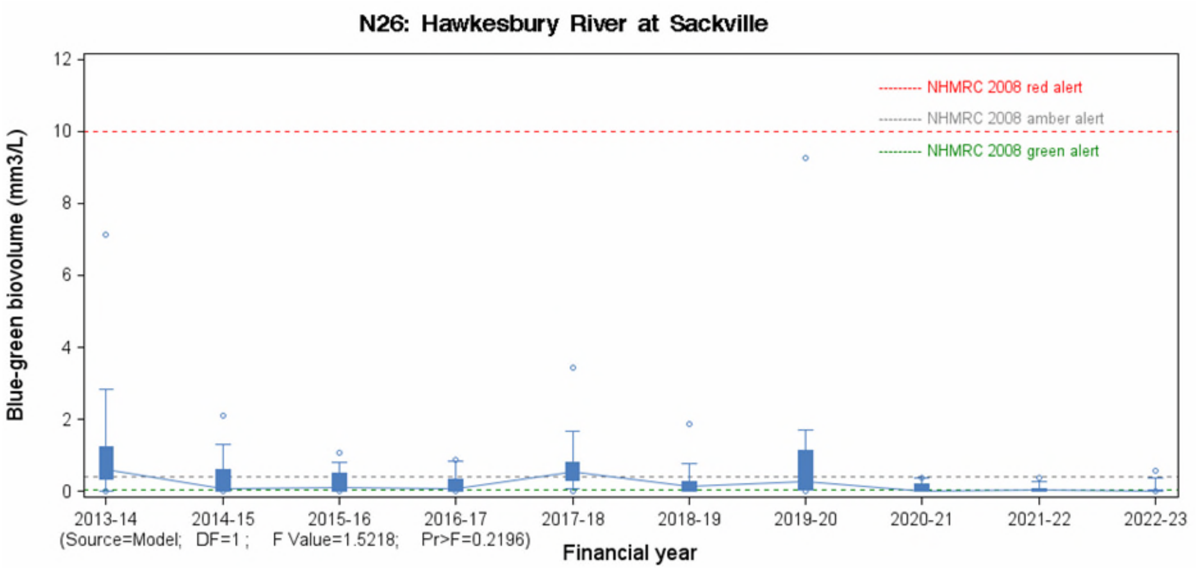


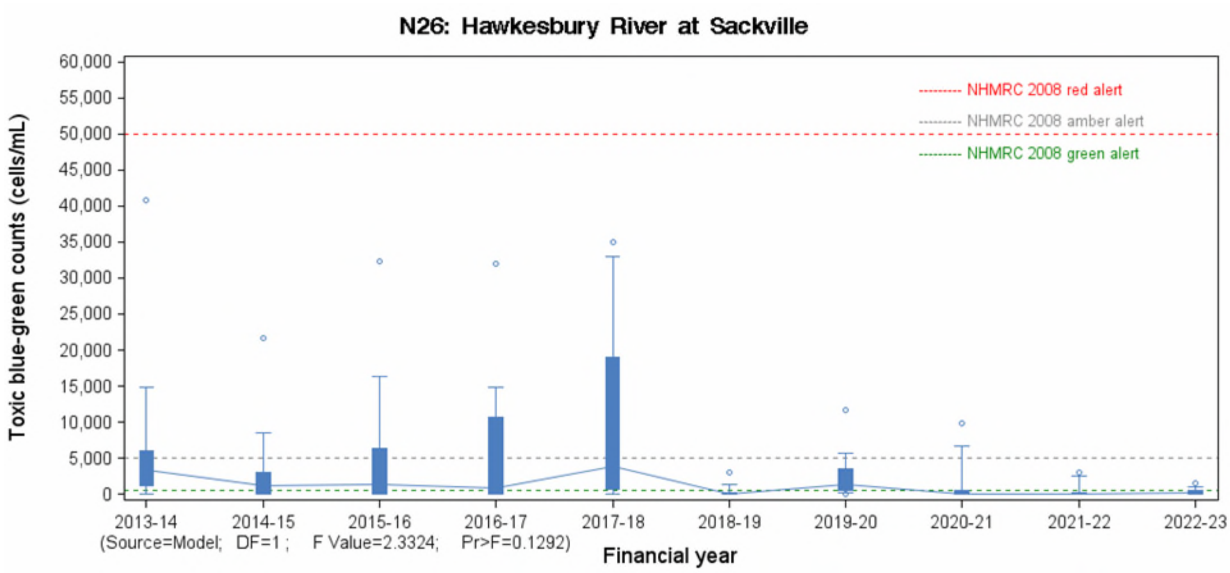


Ecosystem receptor – Phytoplankton




N26: Hawkesbury River at Sackville
Total phytoplankton biovolume (mm3/L)
DF=1 ; F Value=1.8610; Pr>F=0.1749
Financial year
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23


N26: Hawkesbury River at Sackville
Blue-green biovolume (mm3/L)
NHMRC 2008 red alert
NHMRC 2008 amber alert
NHMRC 2008 green alert
(Source=Model; DF=1 ; F Value=1.5218; Pr>F=0.2196)
Financial year
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23


N26: Hawkesbury River at Sackville
Toxic blue-green counts (cells/mL)
NHMRC 2008 red alert
NHMRC 2008 amber alert
NHMRC 2008 green alert
(Source=Model; DF=1 ; F Value=2.3324; Pr>F=0.1292)
Financial year
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23

Ecosystem receptor – Macroinvertebrates

Mean stream health in 2022-23 was above the range recorded over longer period back to 1995.

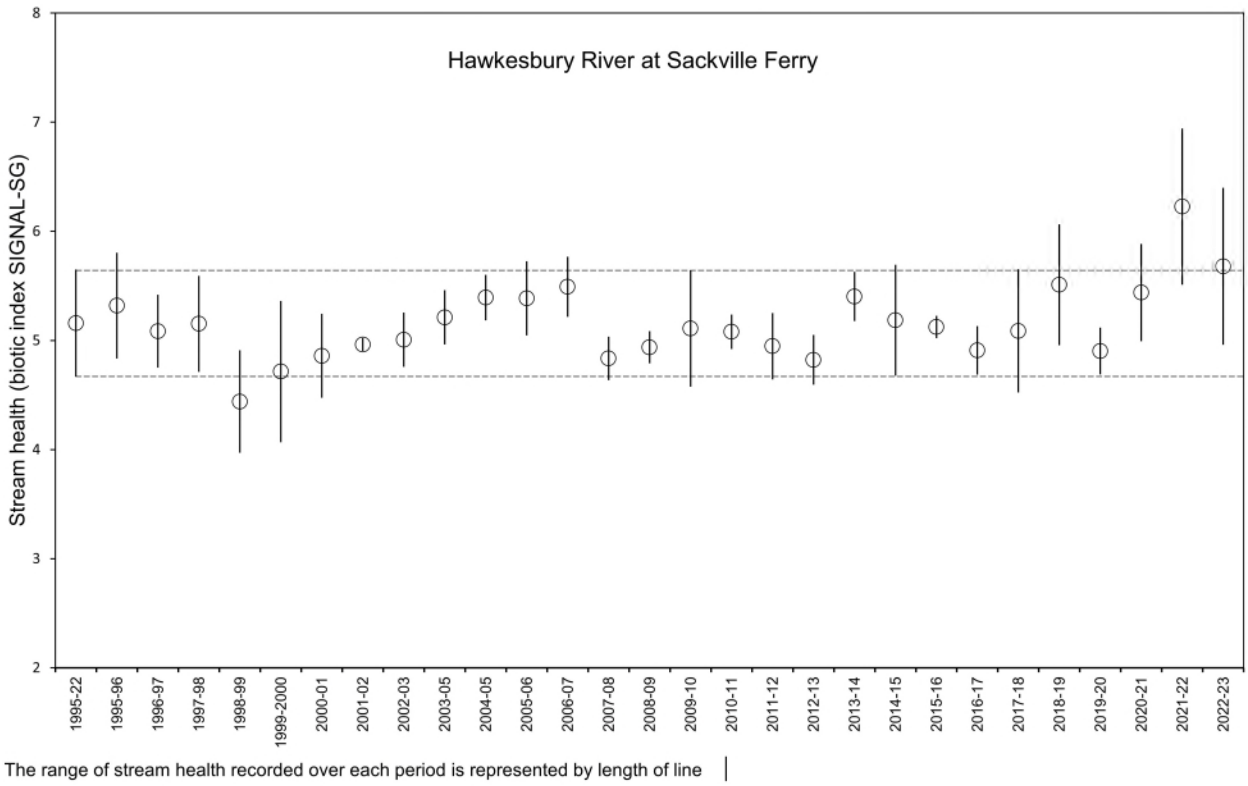
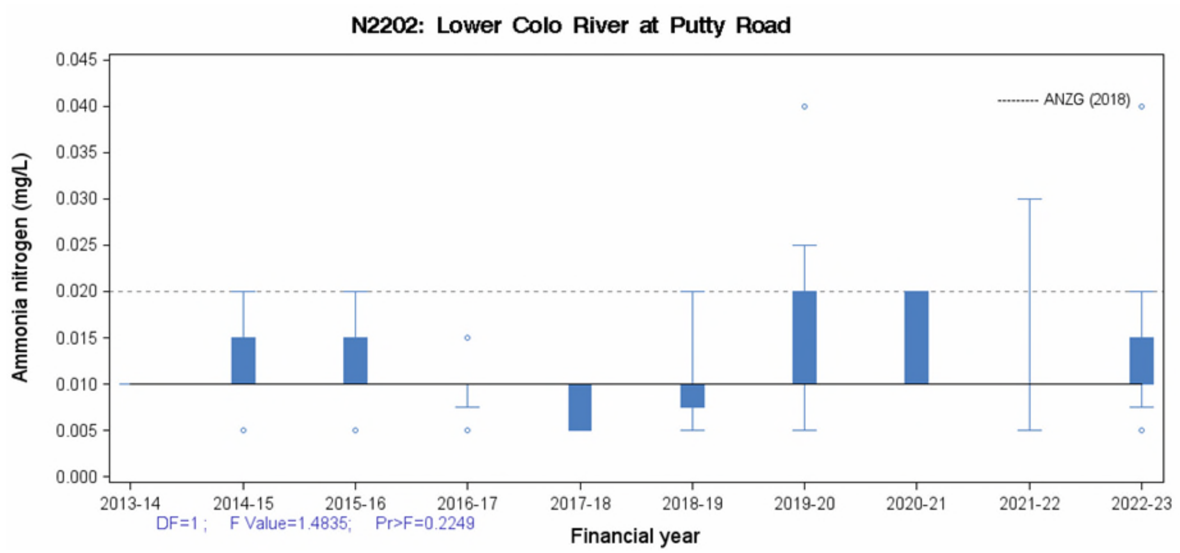
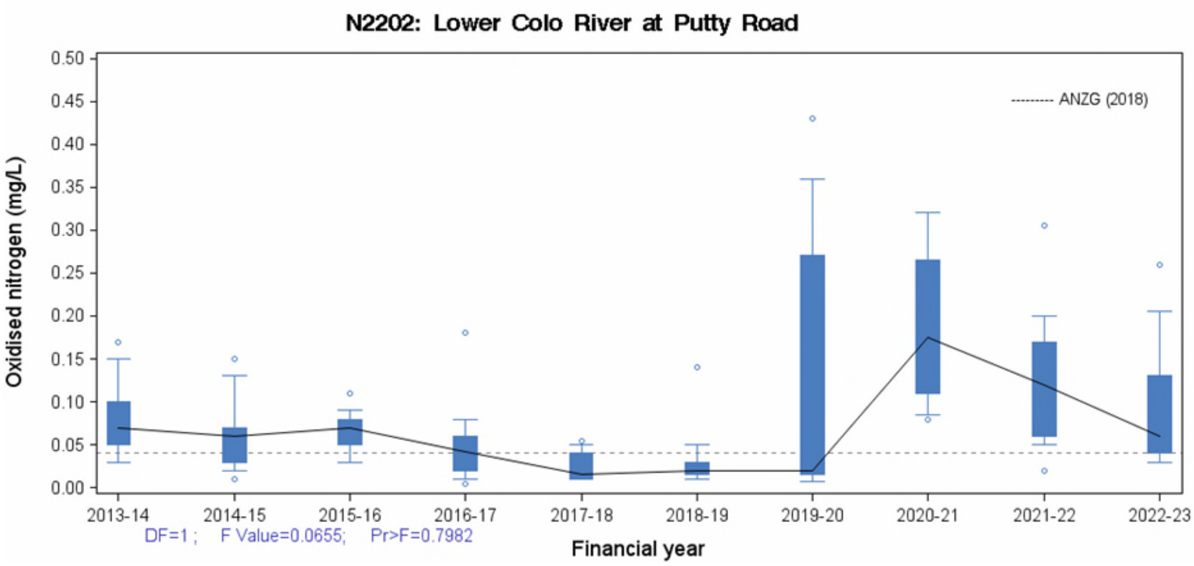


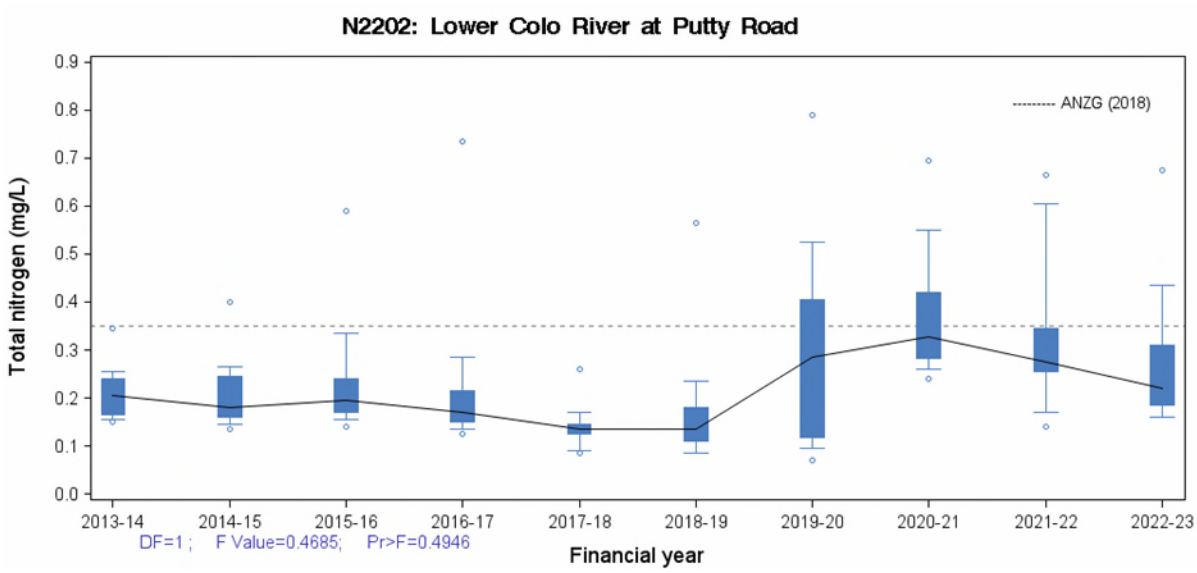
Figure C-3 Stream health of Hawkesbury River at Sackville Ferry (N26)

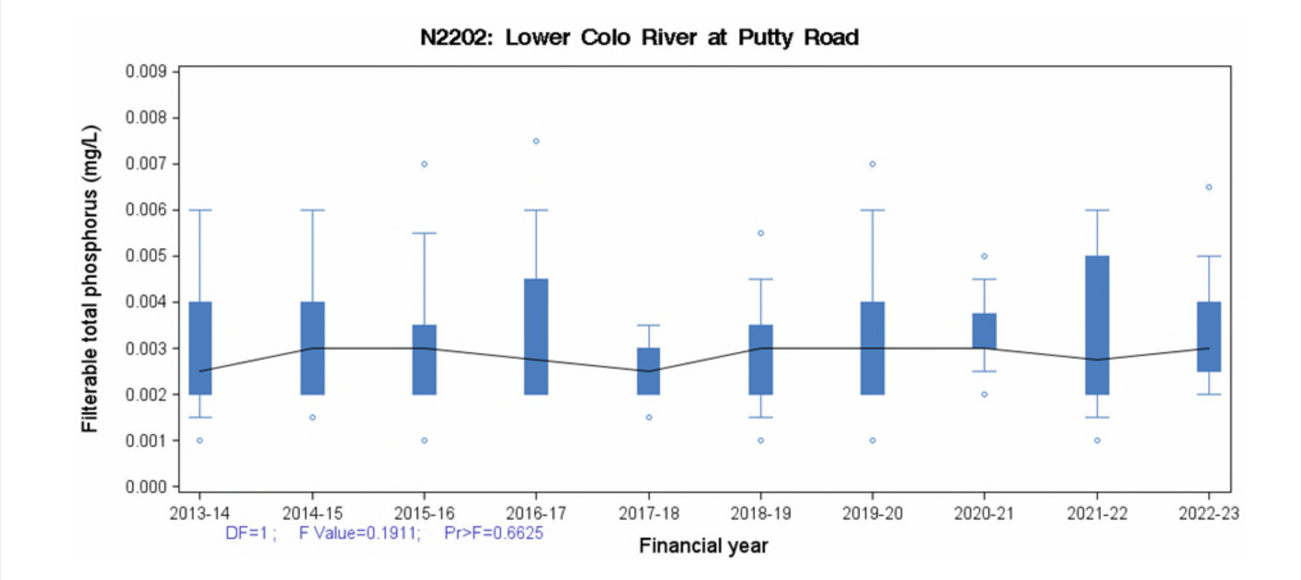
C-1.10 Lower Colo River at Putty Road Bridge (N2202)

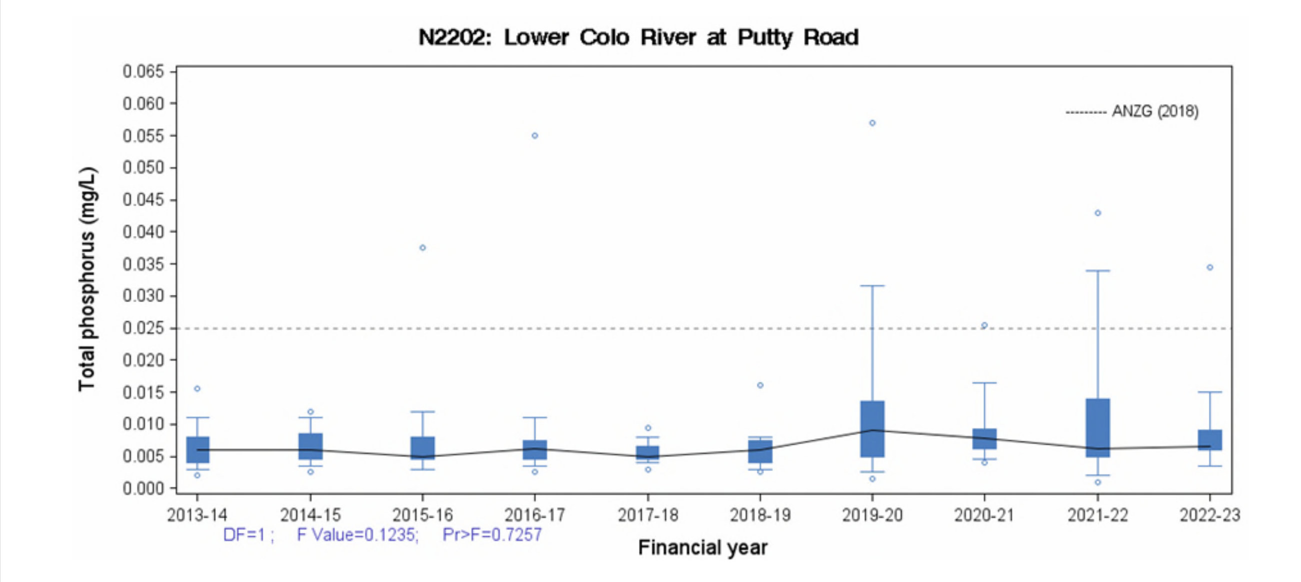
Stressors – Nutrients



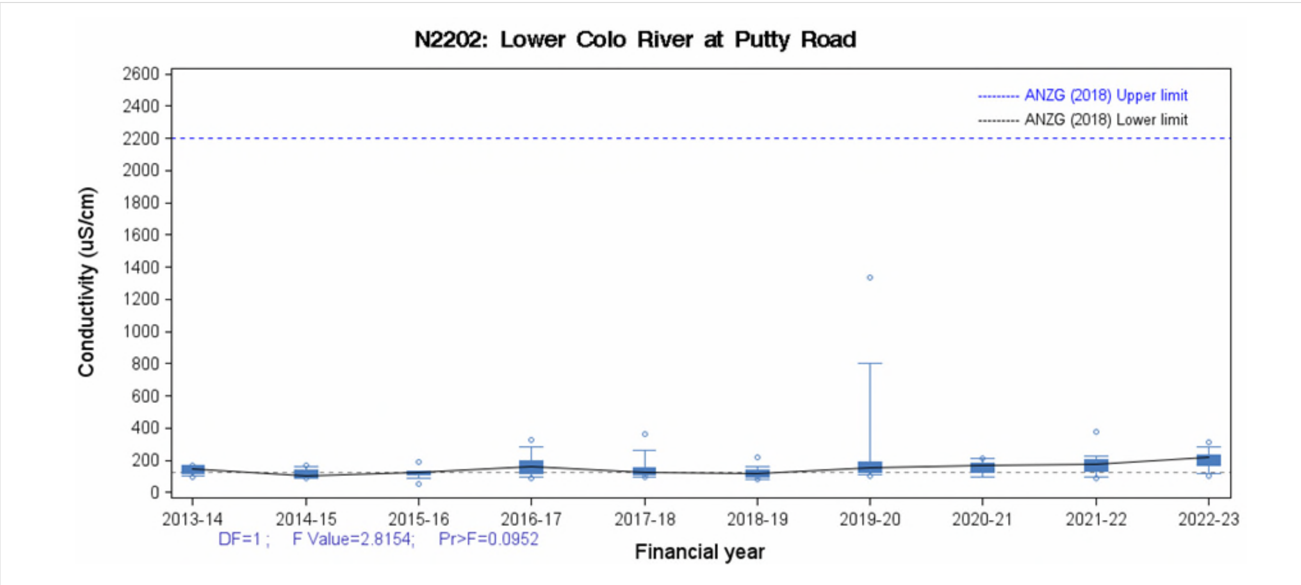


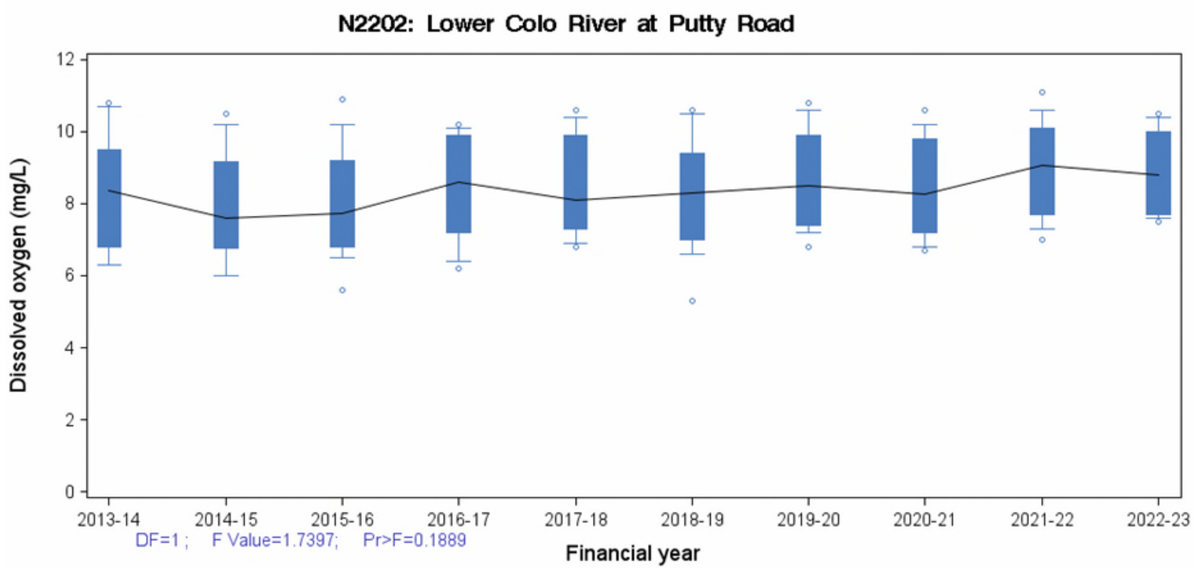


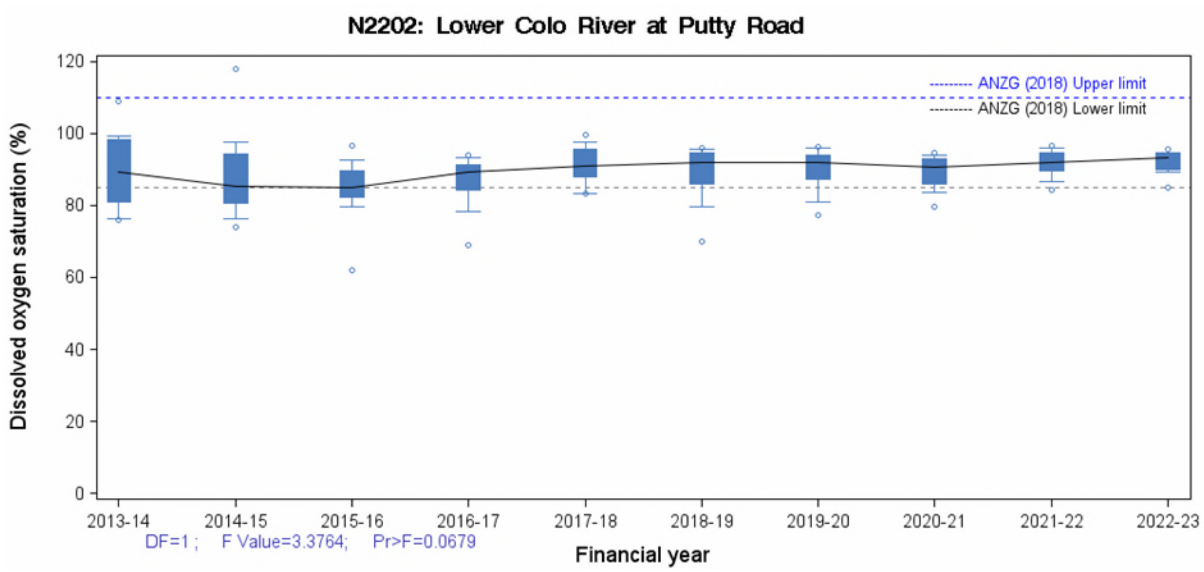


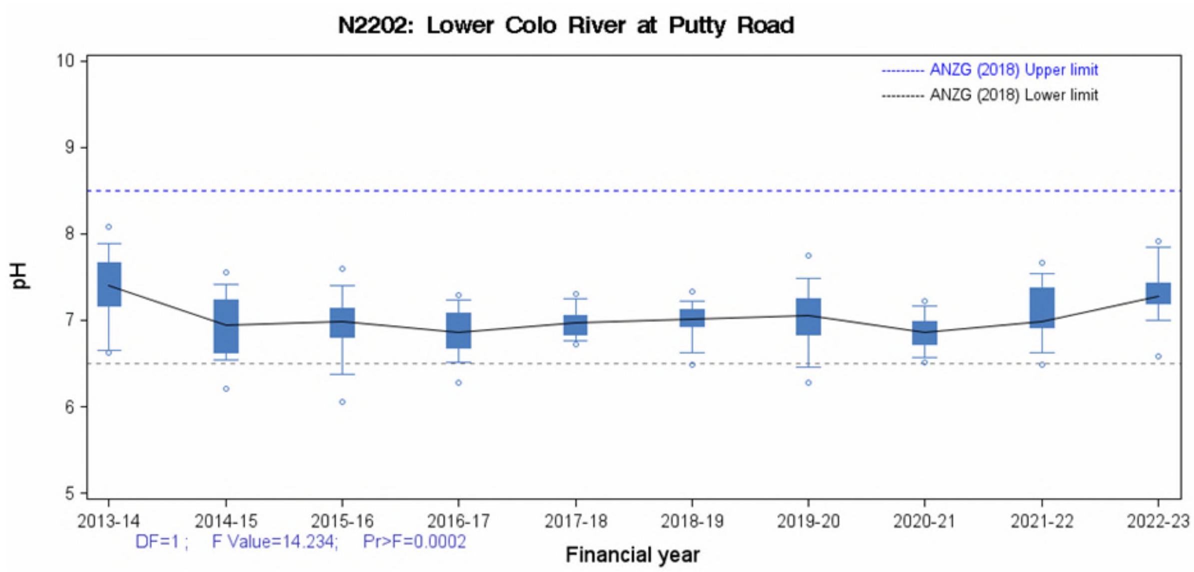


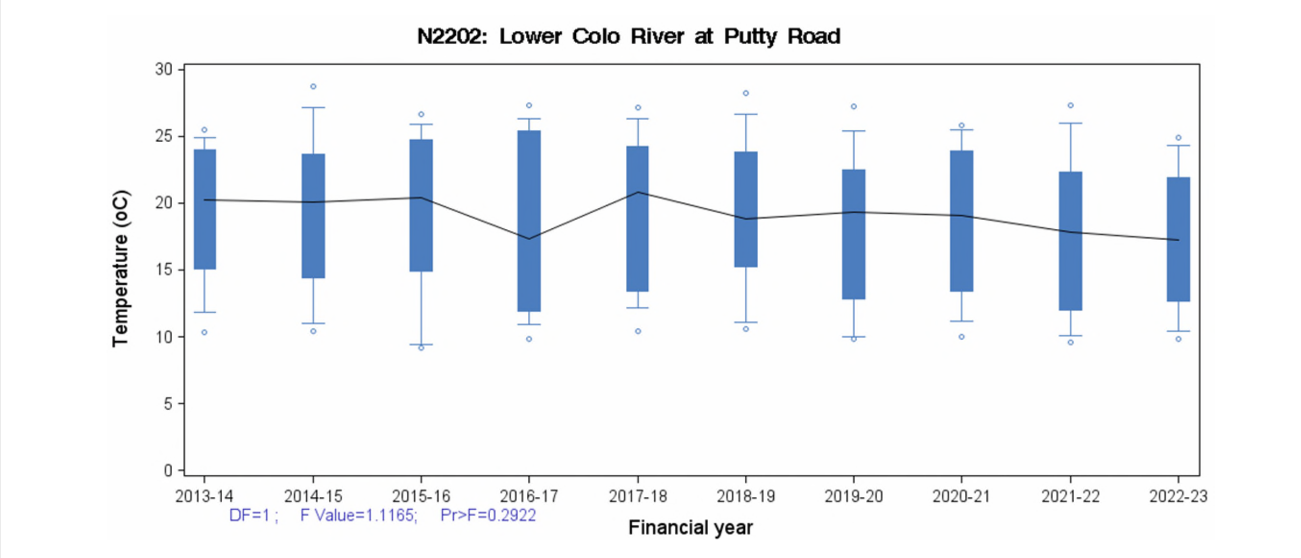
Stressors – Physico-chemical water quality

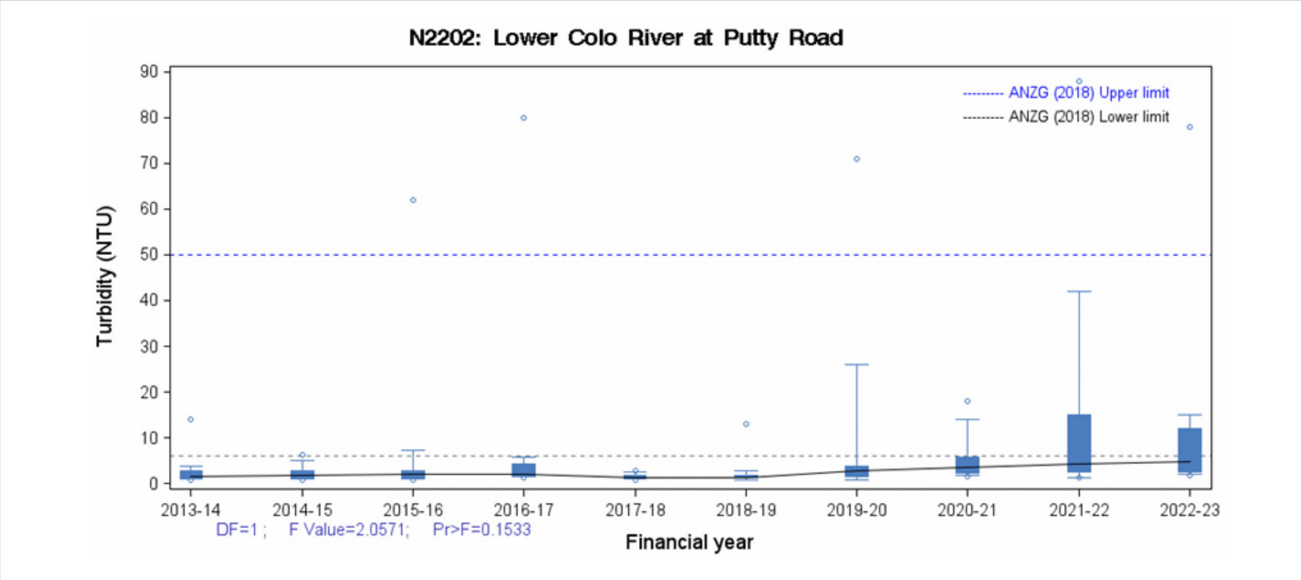



N2202: Lower Colo River at Putty Road
Dissolved oxygen (mg/L)
Financial year
DF=1 ; F Value=1.7397; Pr>F=0.1889

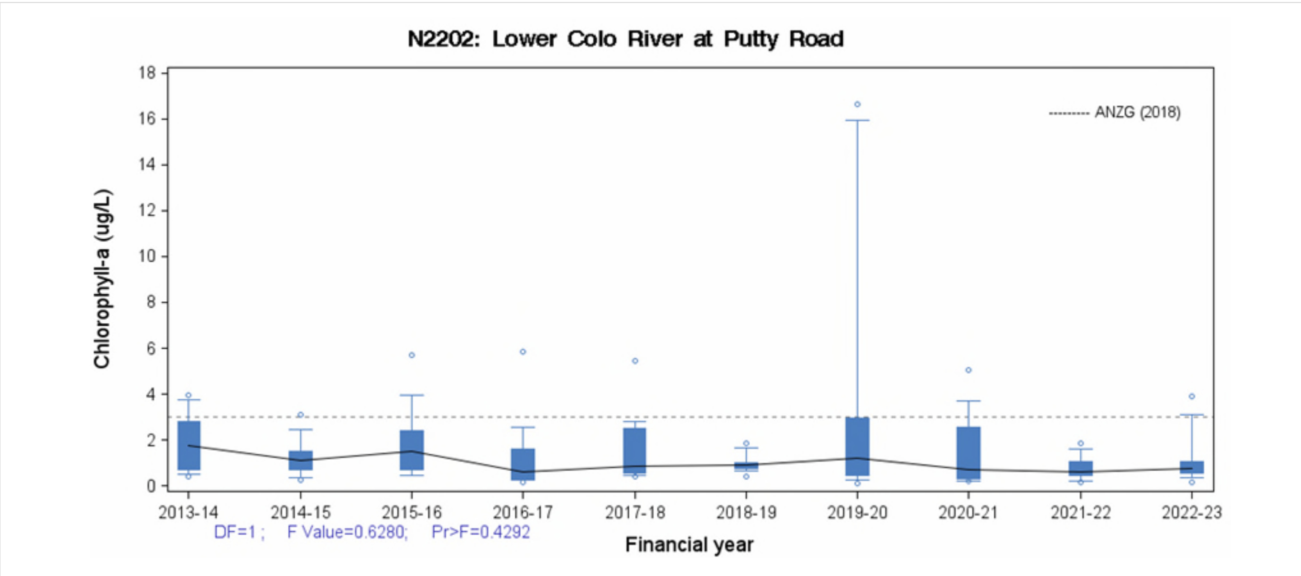

N2202: Lower Colo River at Putty Road
ANZG (2018) Upper limit
ANZG (2018) Lower limit
Dissolved oxygen saturation (%)
Financial year
DF=1 ; F Value=3.3764; Pr>F=0.0679

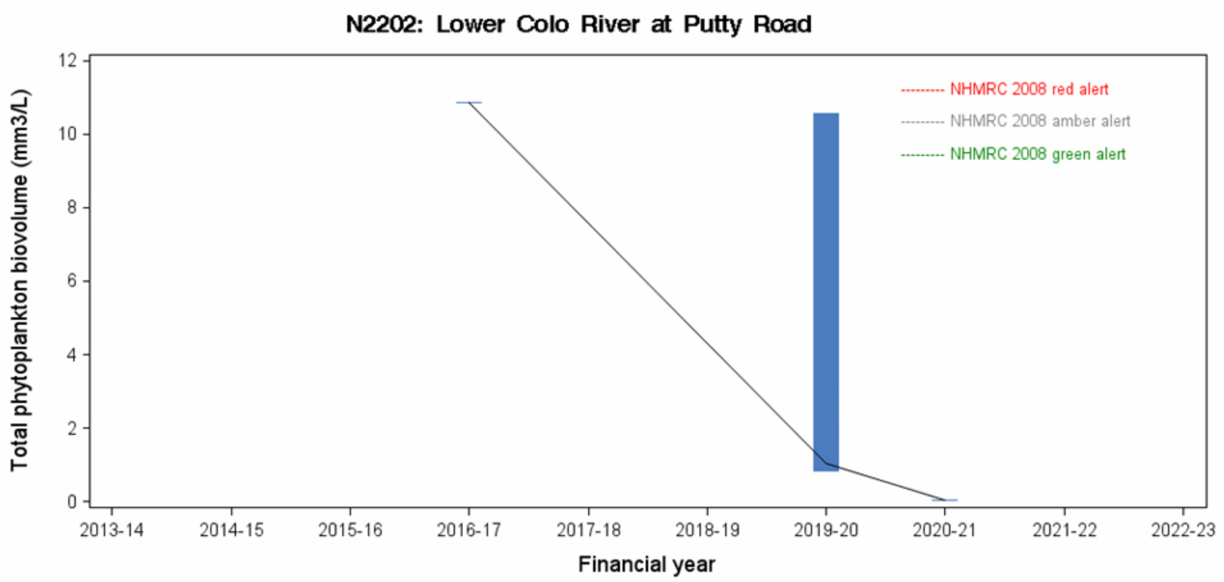

N2202: Lower Colo River at Putty Road
ANZG (2018) Upper limit
ANZG (2018) Lower limit
pH
Financial year
DF=1 ; F Value=14.234; Pr>F=0.0002

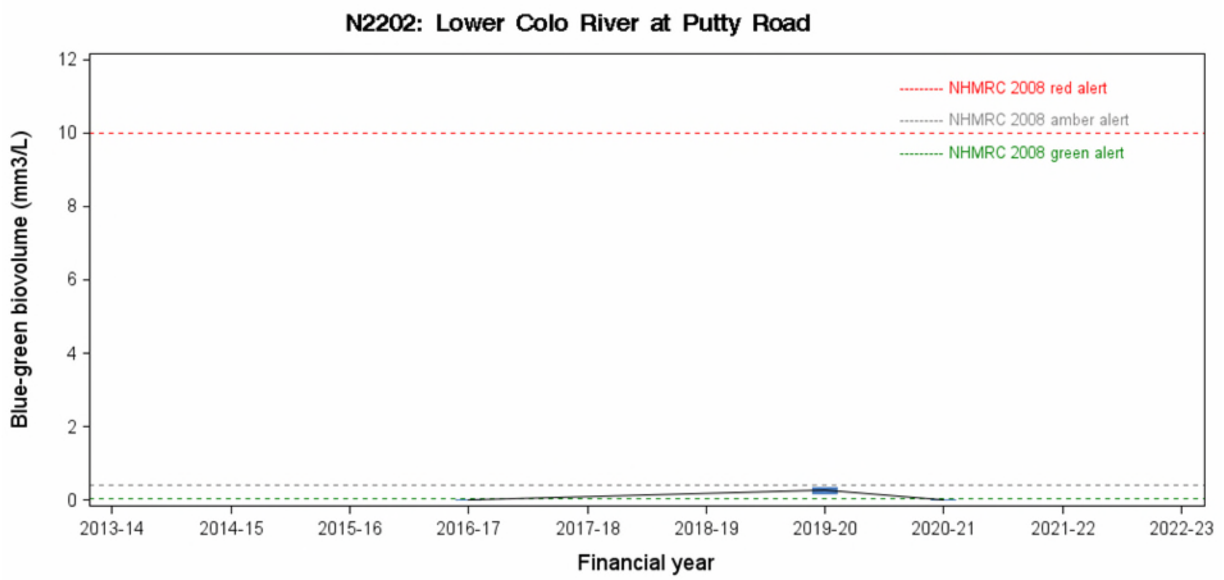


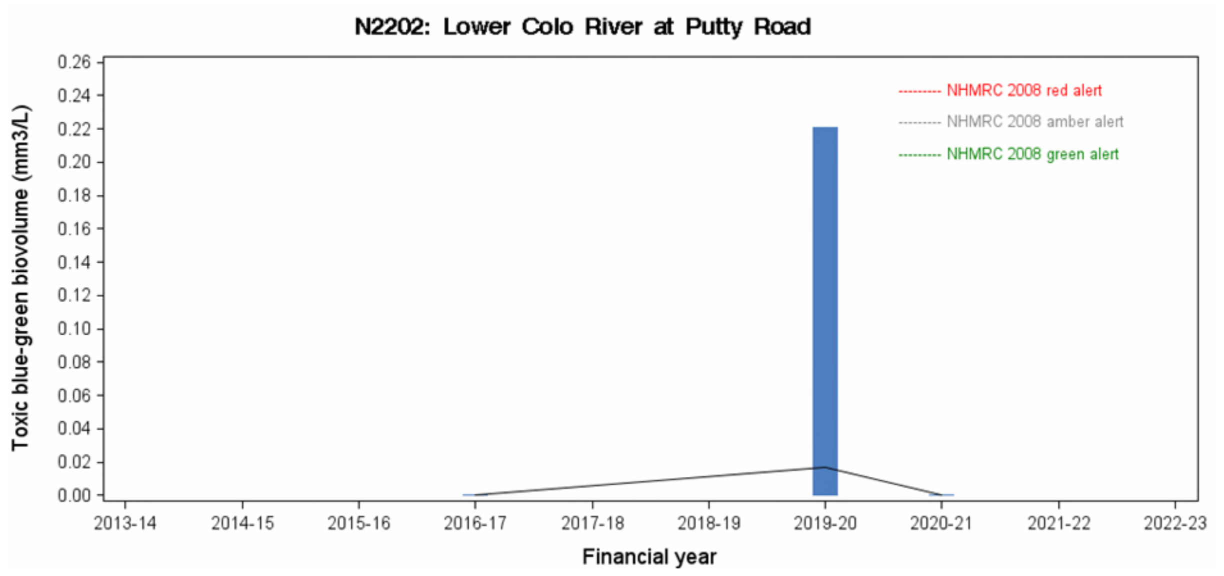


Ecosystem receptor – Phytoplankton



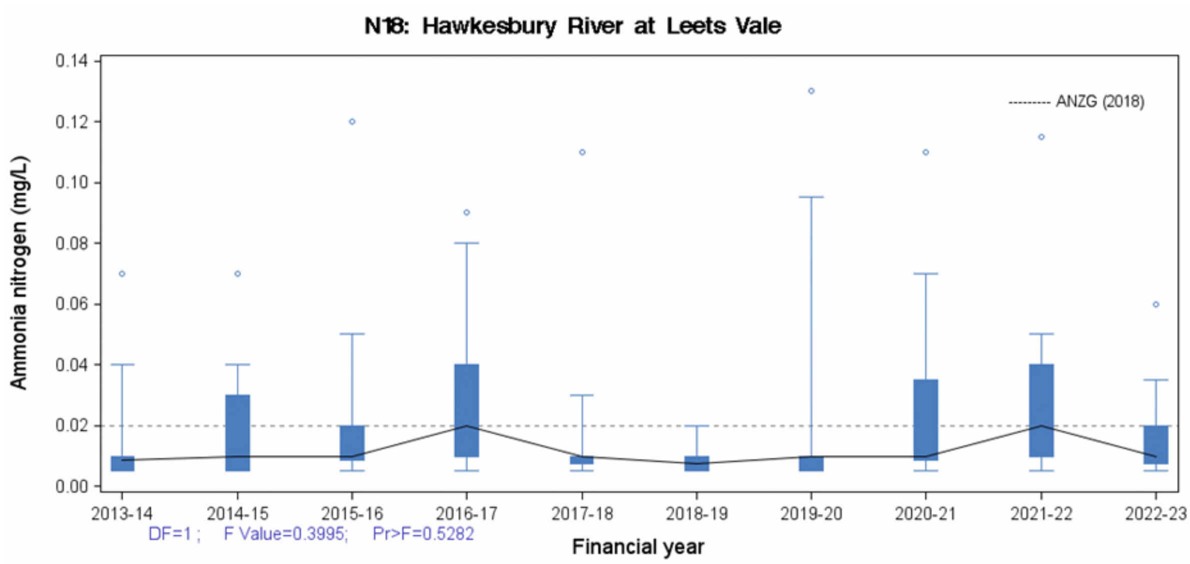

N2202: Lower Colo River at Putty Road
Total phytoplankton biovolume (mm3/L)
NHMRC 2008 red alert
NHMRC 2008 amber alert
NHMRC 2008 green alert
Financial year
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23

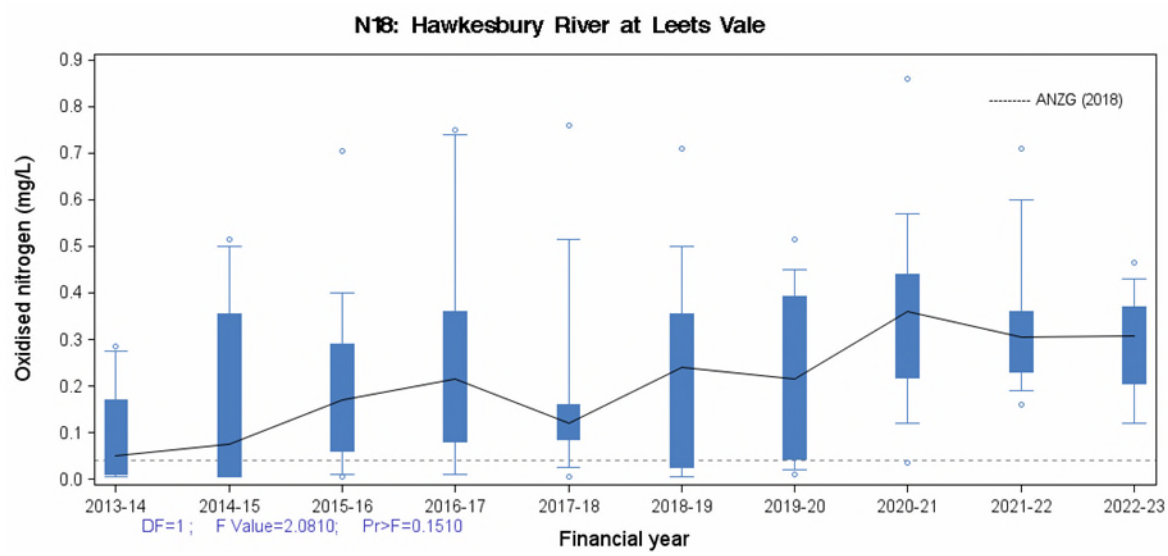

N2202: Lower Colo River at Putty Road
Blue-green biovolume (mm3/L)
NHMRC 2008 red alert
NHMRC 2008 amber alert
NHMRC 2008 green alert
Financial year
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23

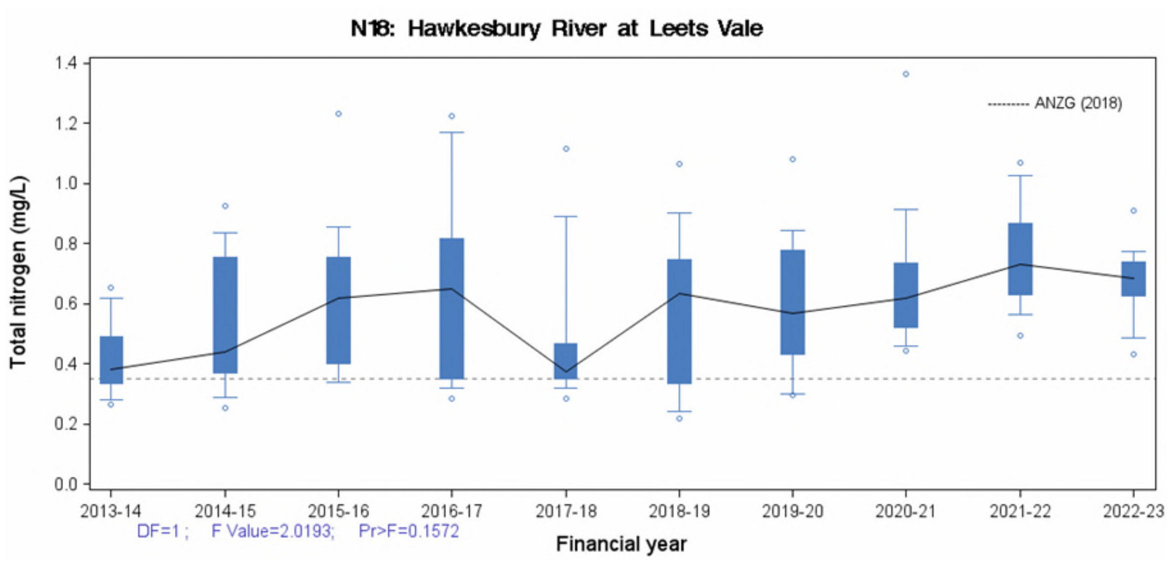

N2202: Lower Colo River at Putty Road
Toxic blue-green biovolume (mm3/L)
NHMRC 2008 red alert
NHMRC 2008 amber alert
NHMRC 2008 green alert
Financial year
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23

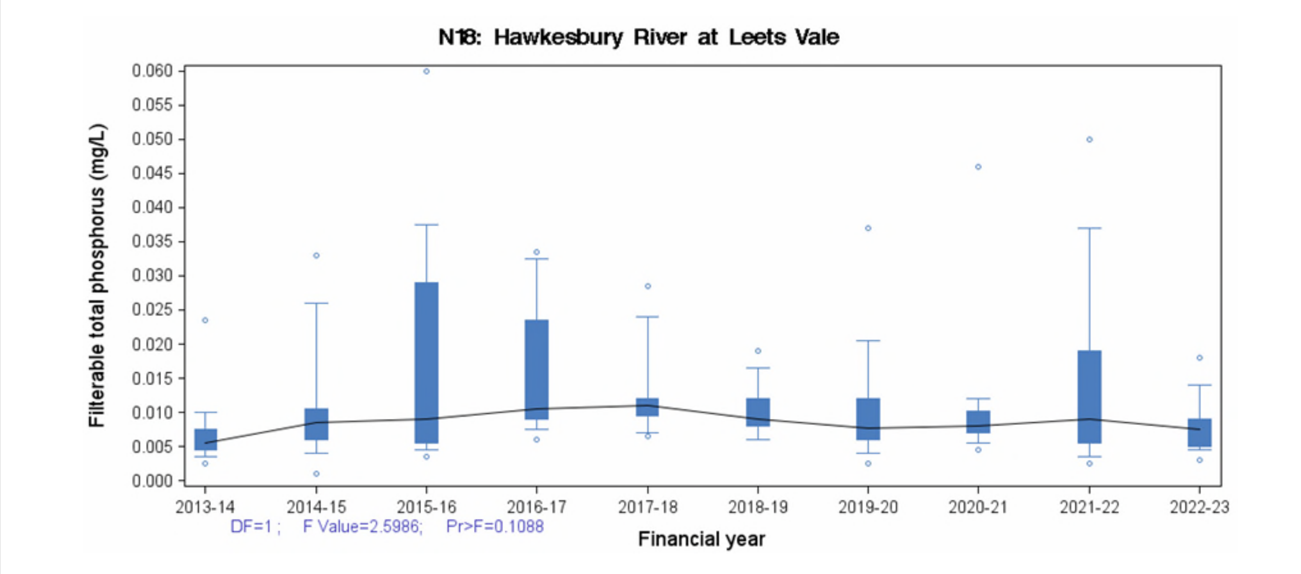
C-1.11 Hawkesbury River at Leets Vale (N18)

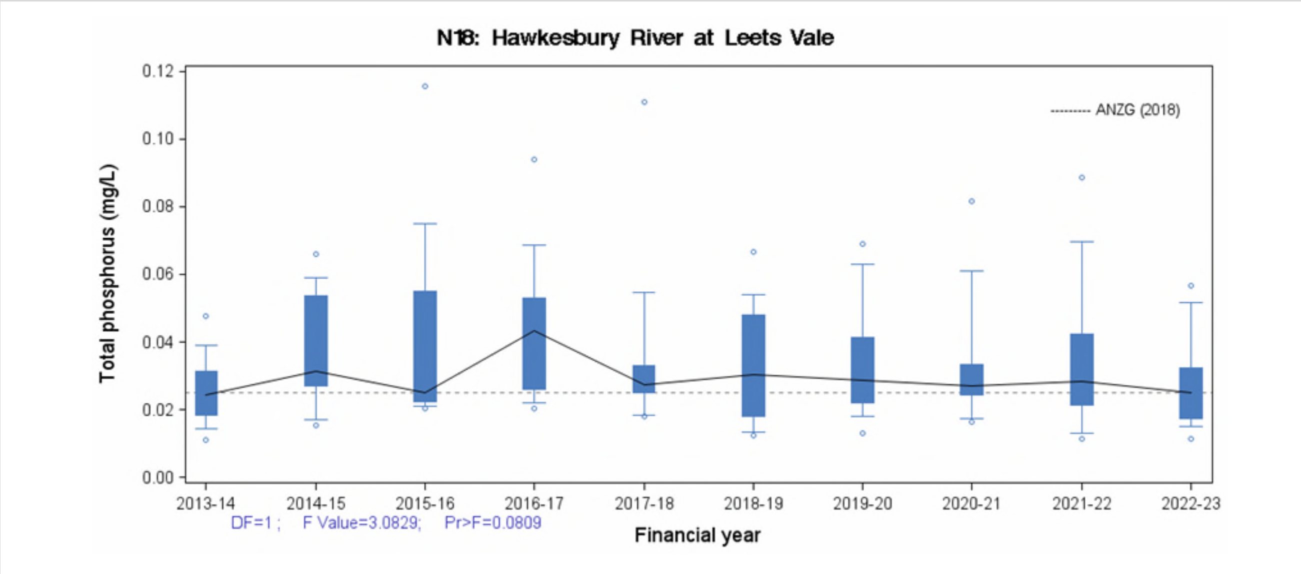
Stressors – Nutrients



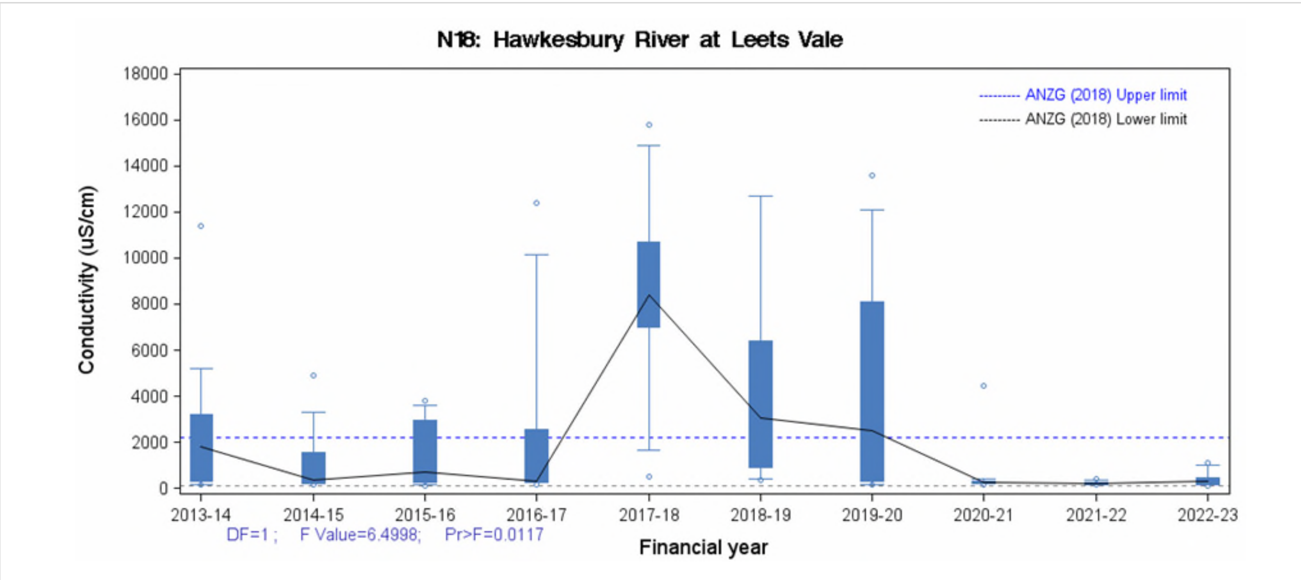


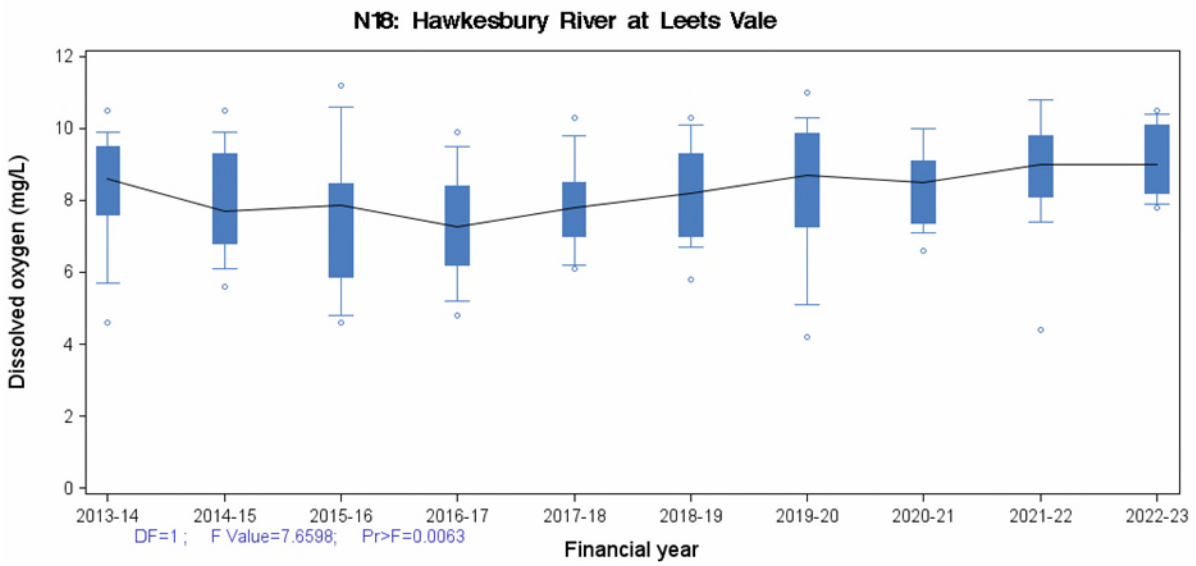


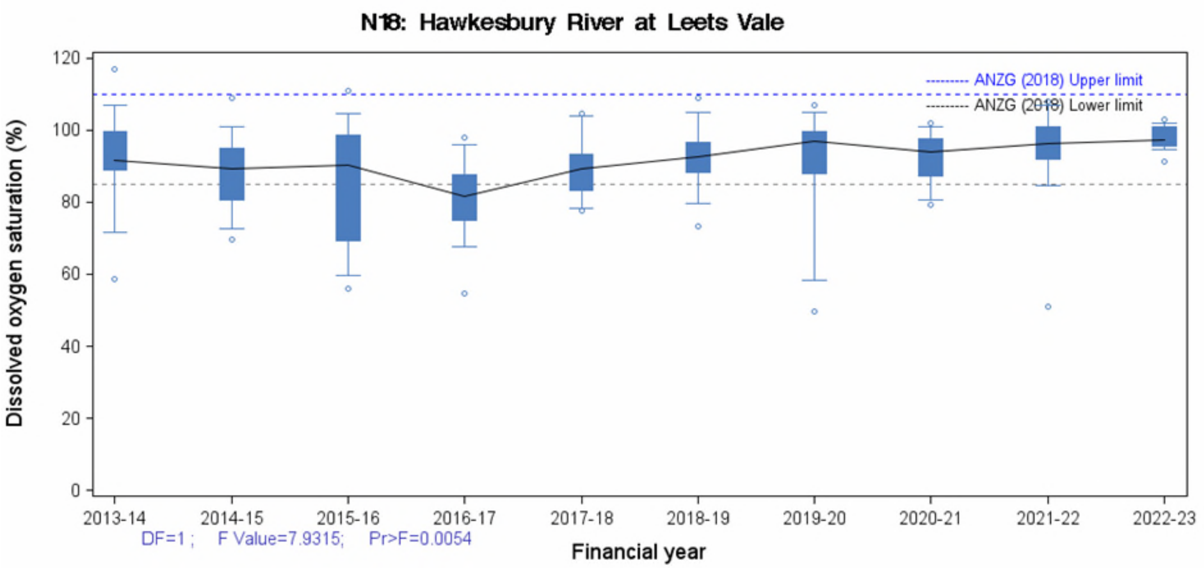


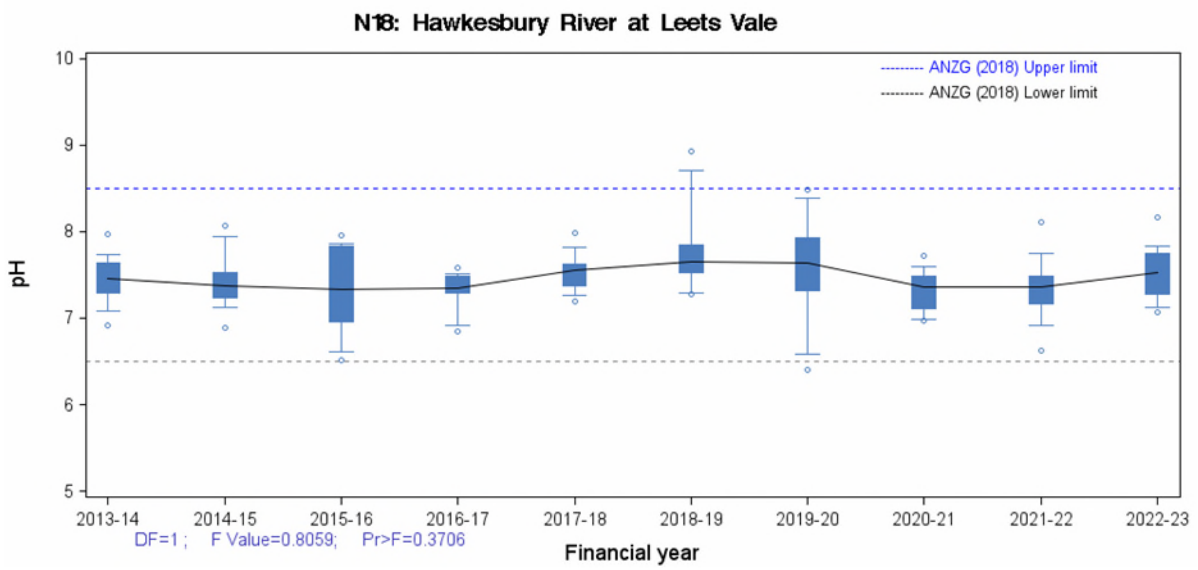


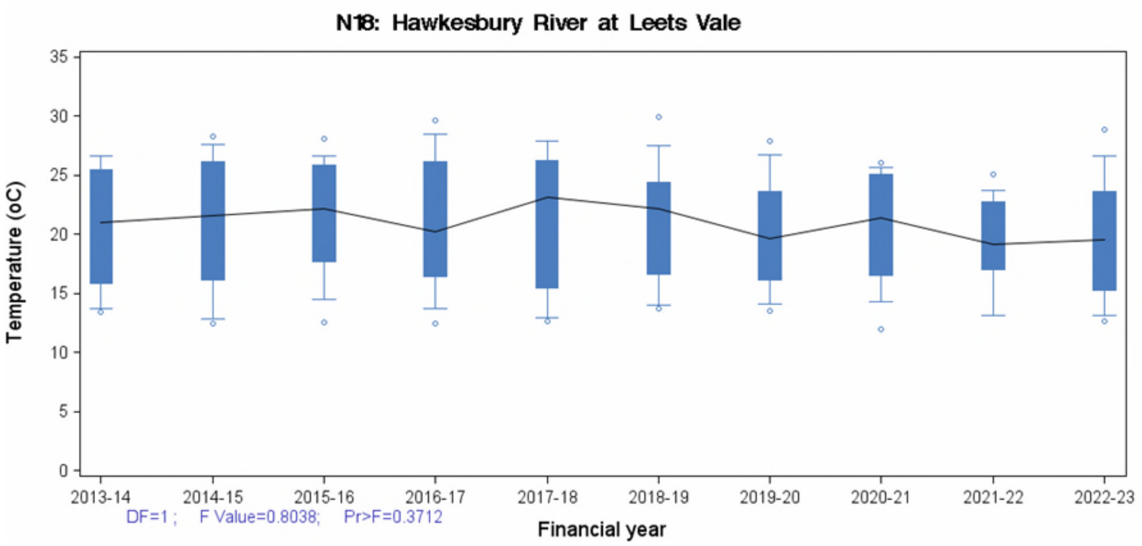
Stressors – Physico-chemical water quality

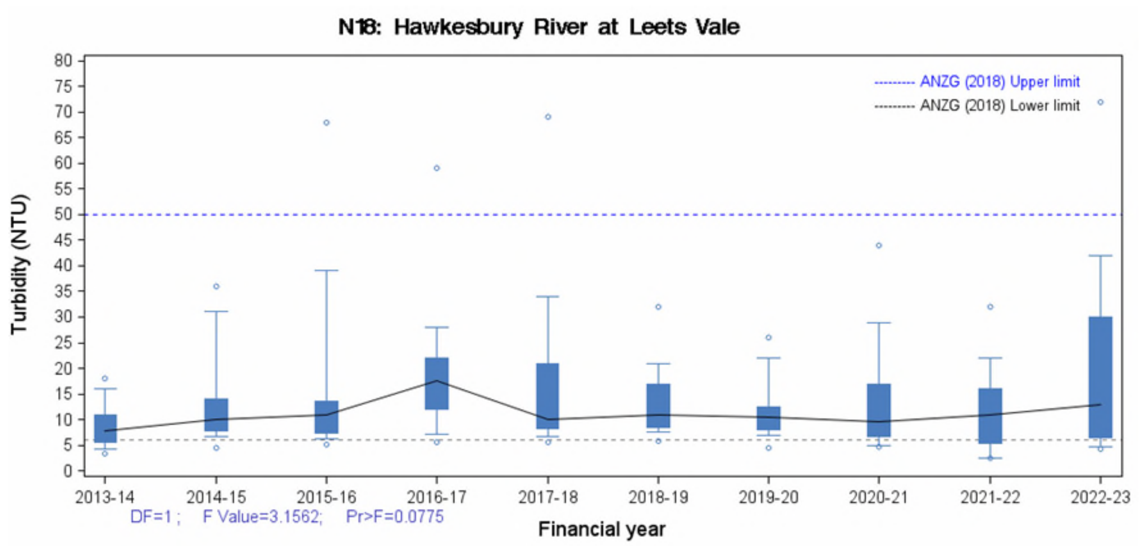



N18: Hawkesbury River at Leets Vale
Dissolved oxygen (mg/L)
Financial year
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=7.6598; Pr>F=0.0063

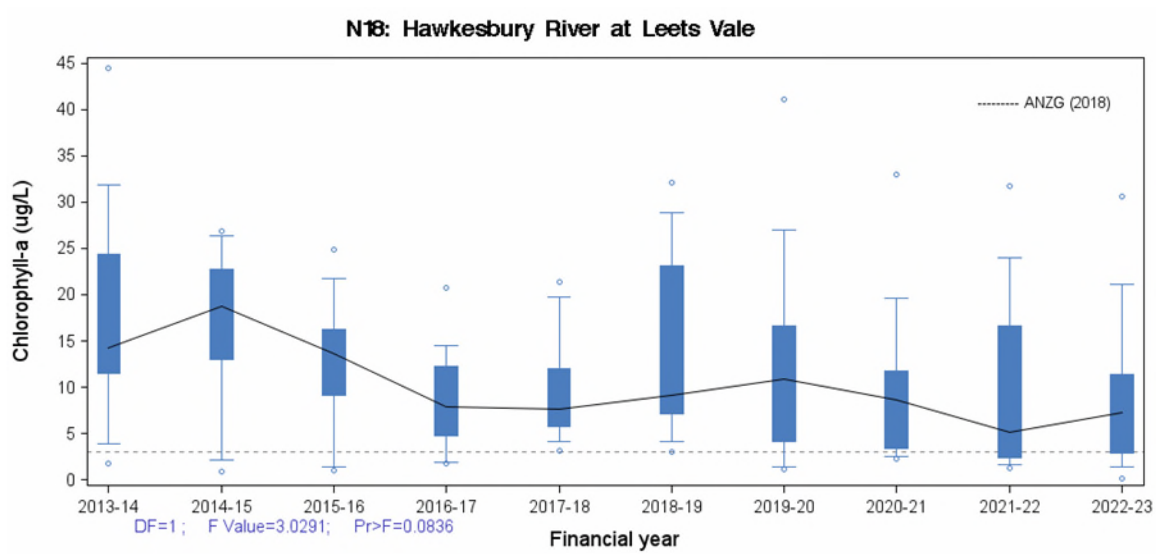

N18: Hawkesbury River at Leets Vale
Dissolved oxygen saturation (%)
ANZG (2018) Upper limit
ANZG (2018) Lower limit
Financial year
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=7.9315; Pr>F=0.0054

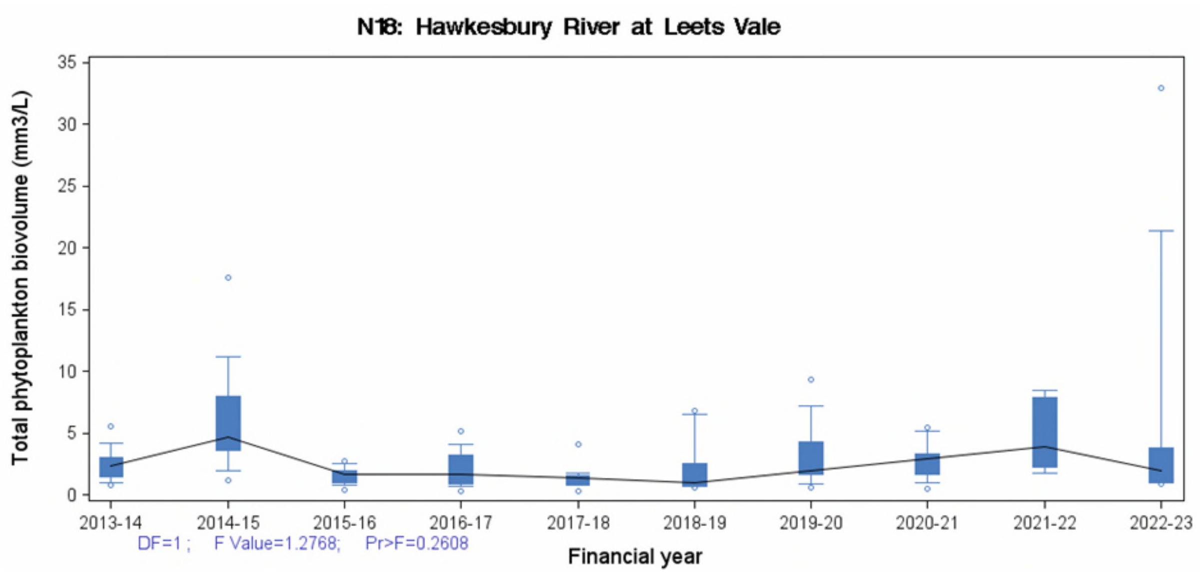

N18: Hawkesbury River at Leets Vale
pH
ANZG (2018) Upper limit
ANZG (2018) Lower limit
Financial year
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=0.8059; Pr>F=0.3706



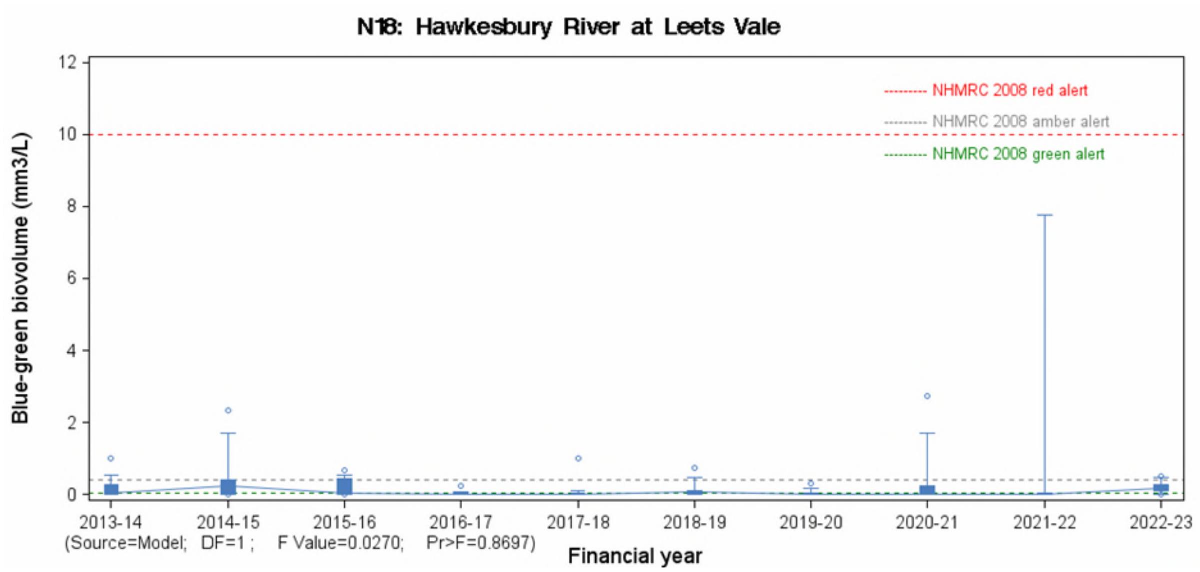


Ecosystem receptor – Phytoplankton

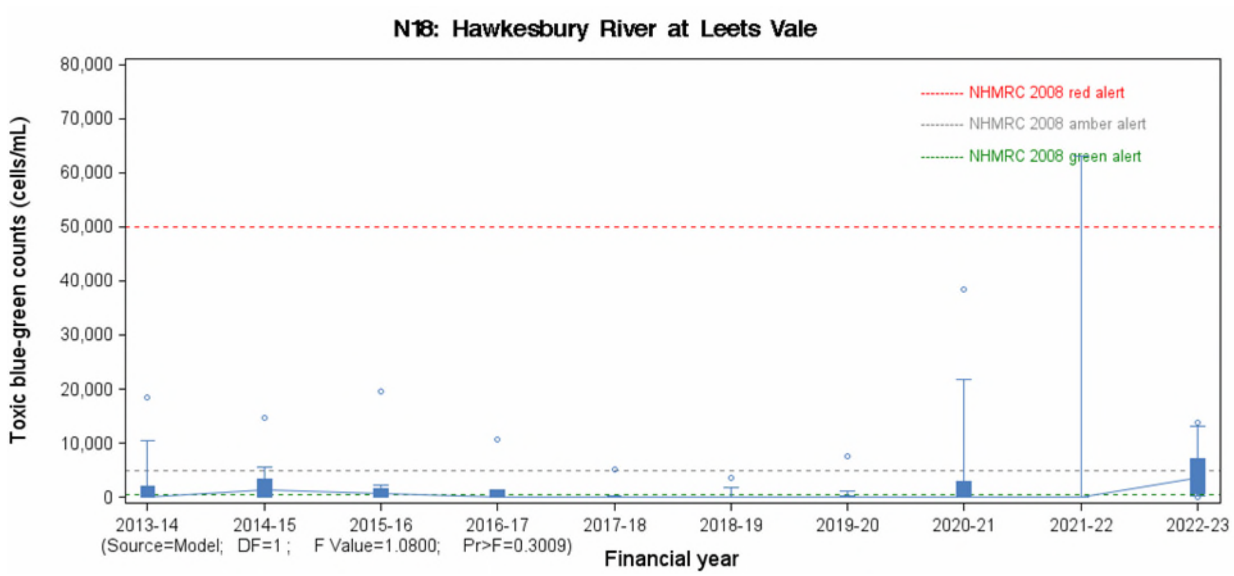




N18: Hawkesbury River at Leets Vale
Total phytoplankton biovolume (mm3/L)
Financial year
DF=1 ; F Value=1.2768; Pr>F=0.2608



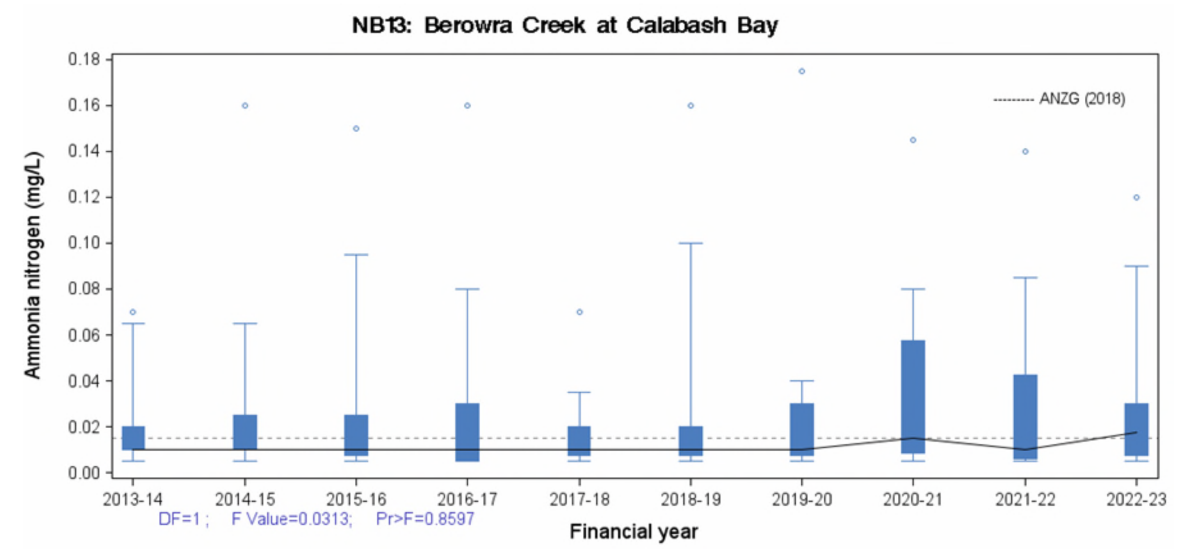
N18: Hawkesbury River at Leets Vale
Blue-green biovolume (mm3/L)
NHMRC 2008 red alert
NHMRC 2008 amber alert
NHMRC 2008 green alert
Financial year
(Source=Model; DF=1 ; F Value=0.0270; Pr>F=0.8697)

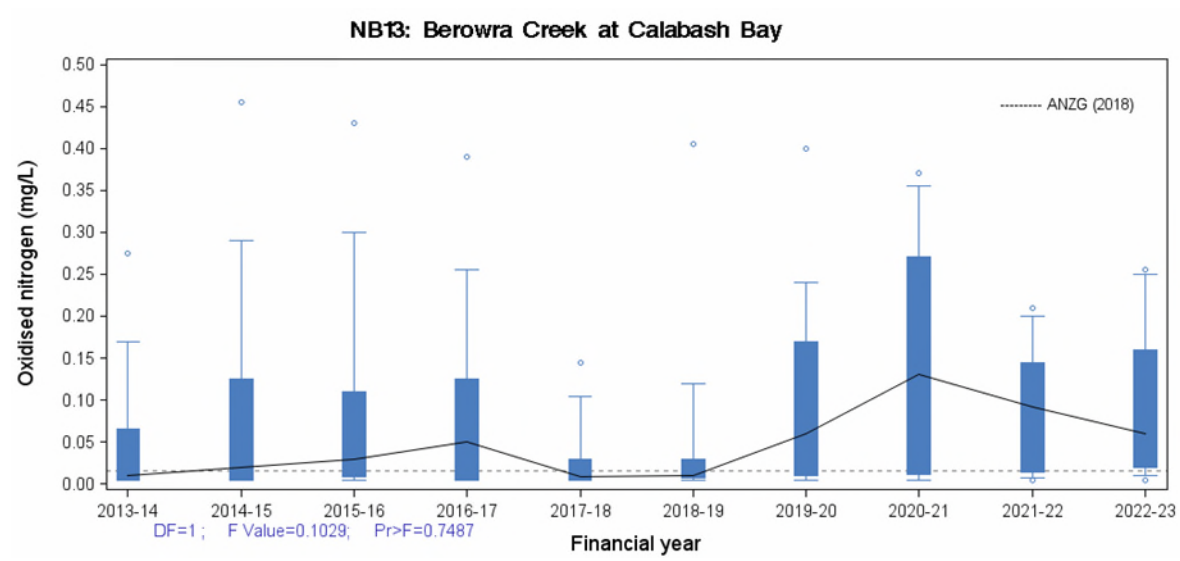


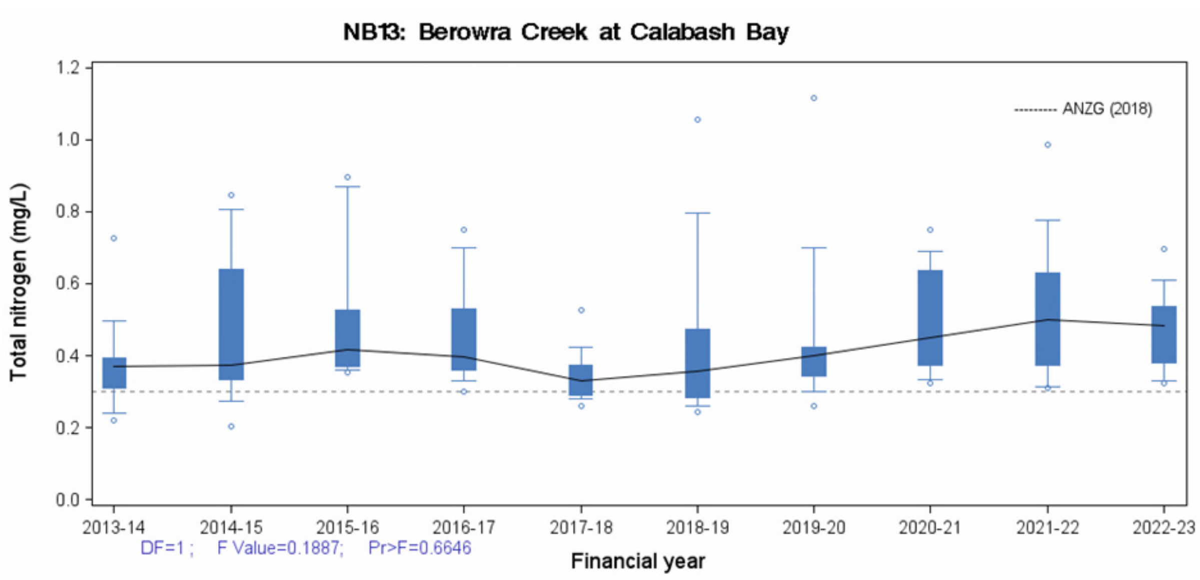
N18: Hawkesbury River at Leets Vale
Toxic blue-green counts (cells/mL)
NHMRC 2008 red alert
NHMRC 2008 amber alert
NHMRC 2008 green alert
Financial year
(Source=Model; DF=1 ; F Value=1.0800; Pr>F=0.3009)

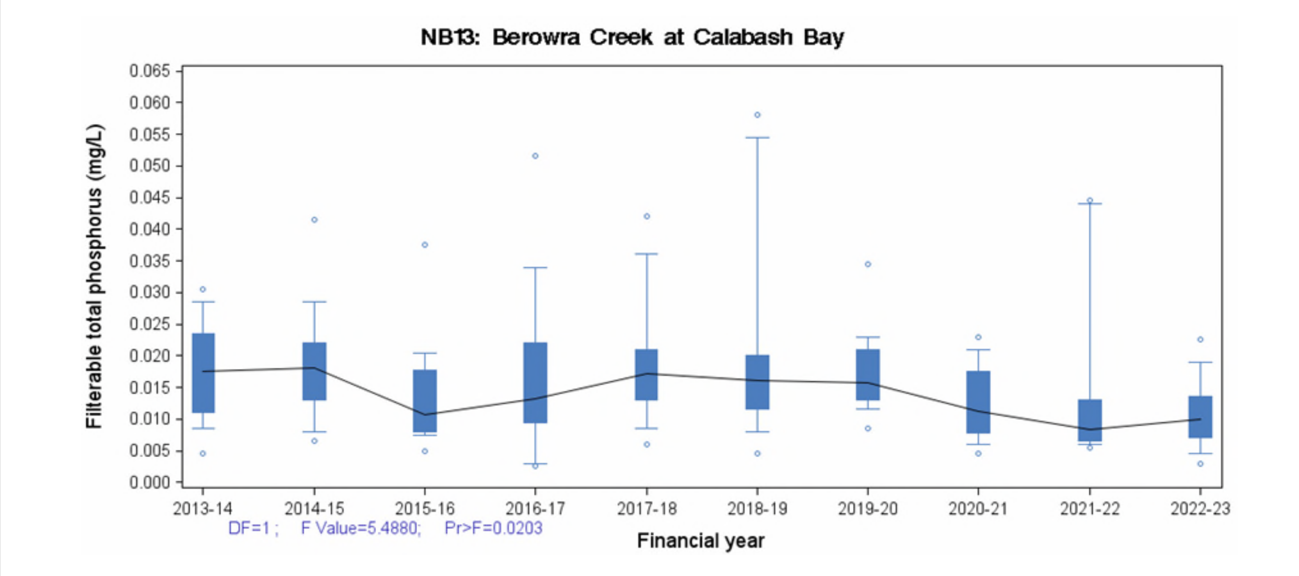
C-1.12 Berowra Creek at Calabash Bay (NB13)

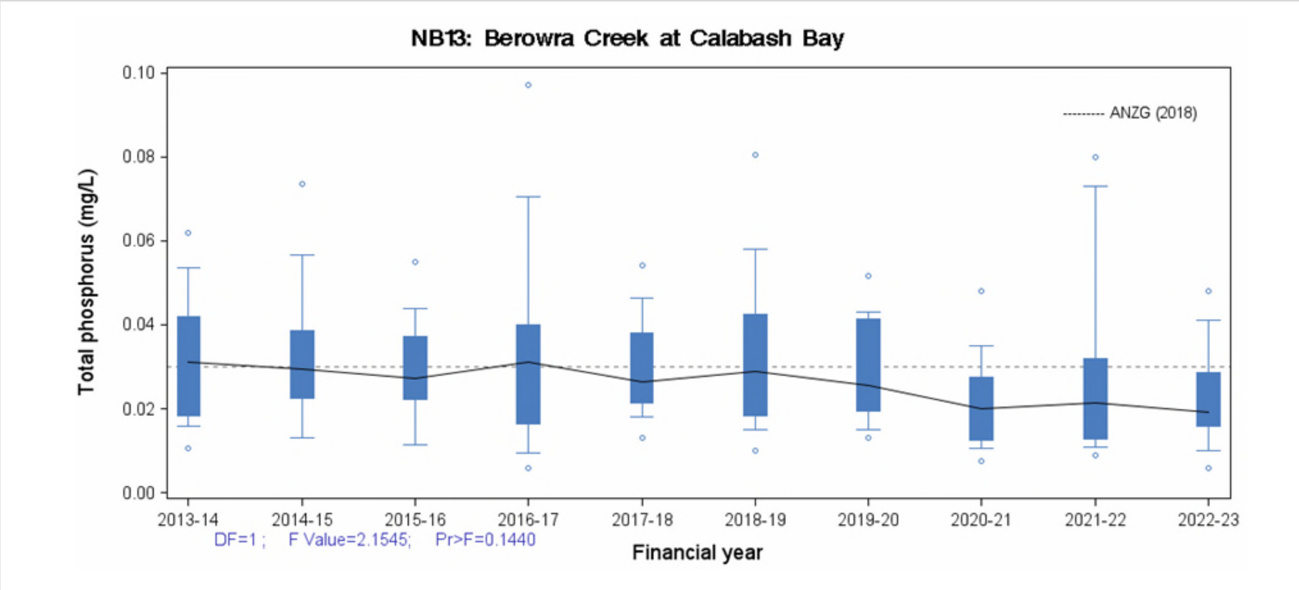
Stressors – Nutrients



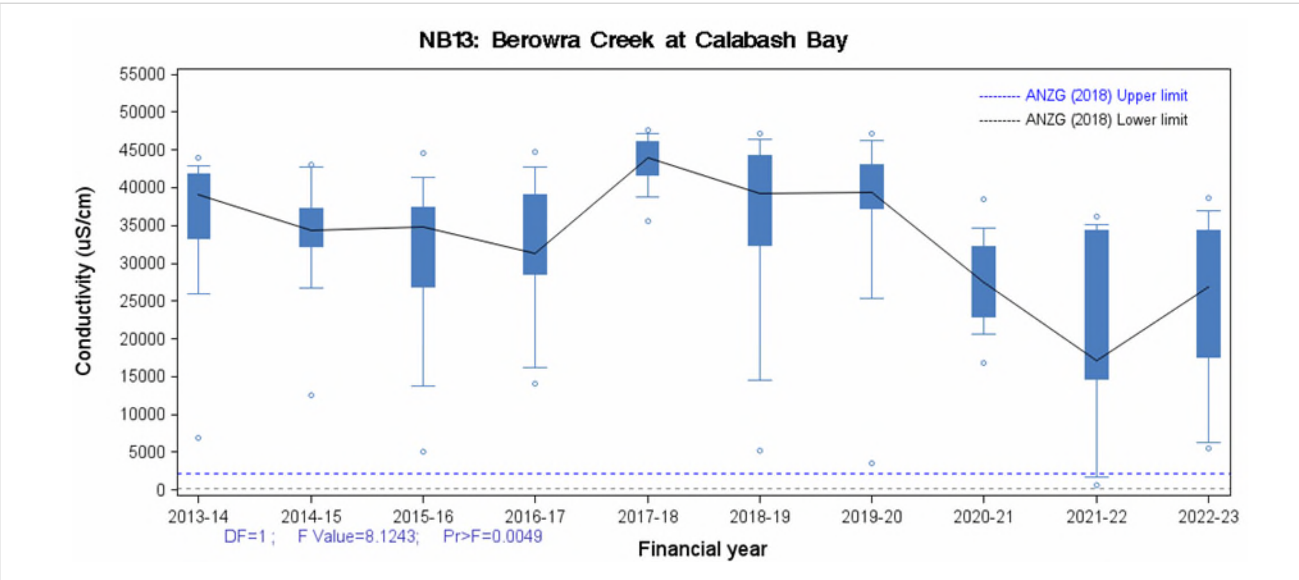


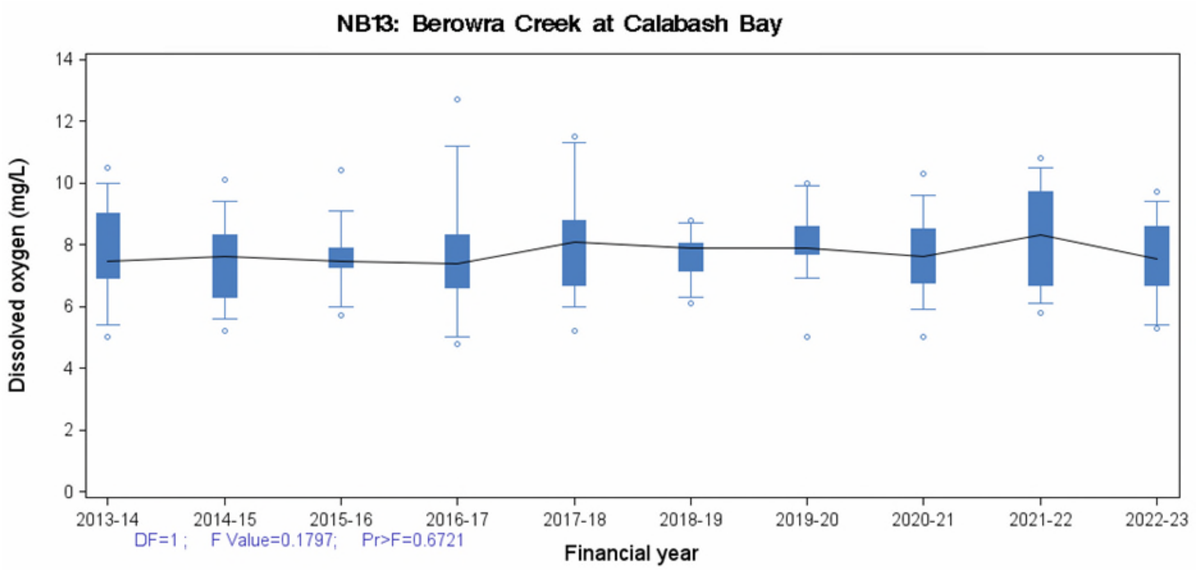


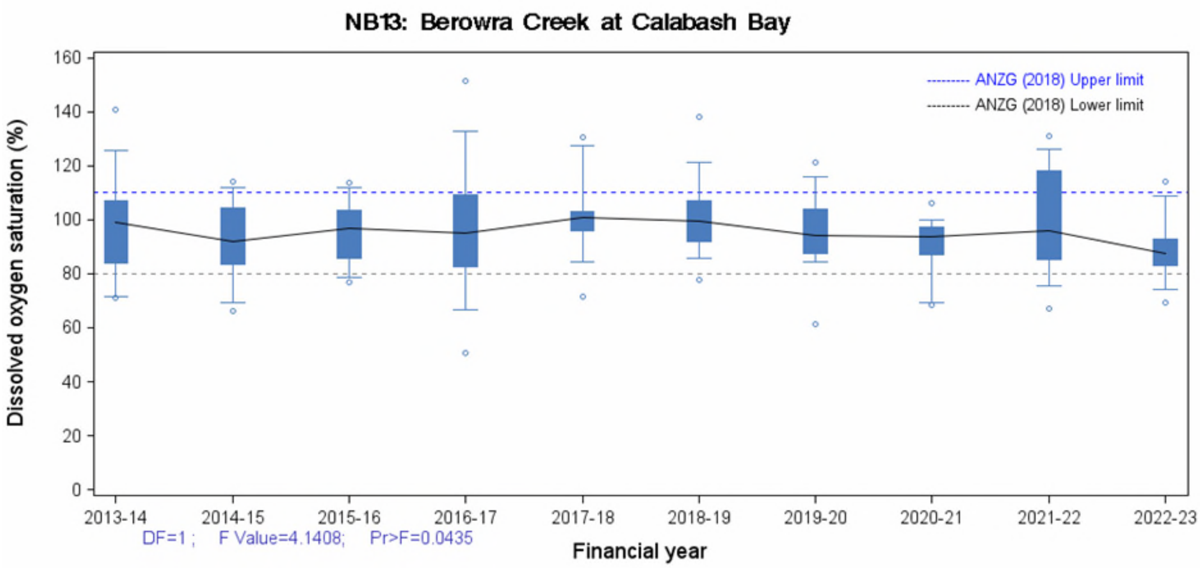


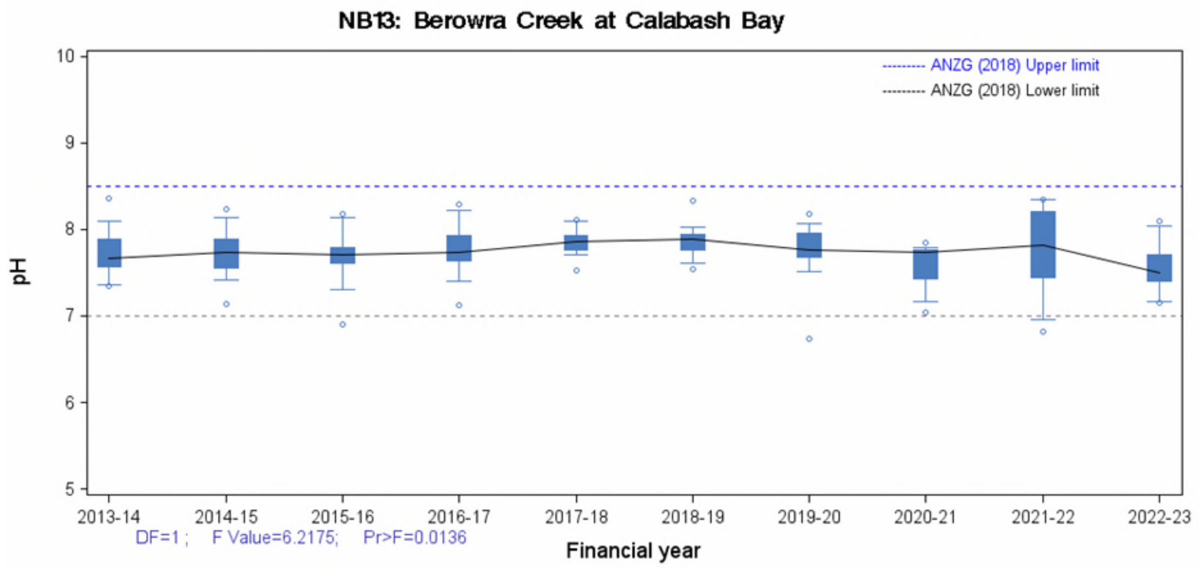


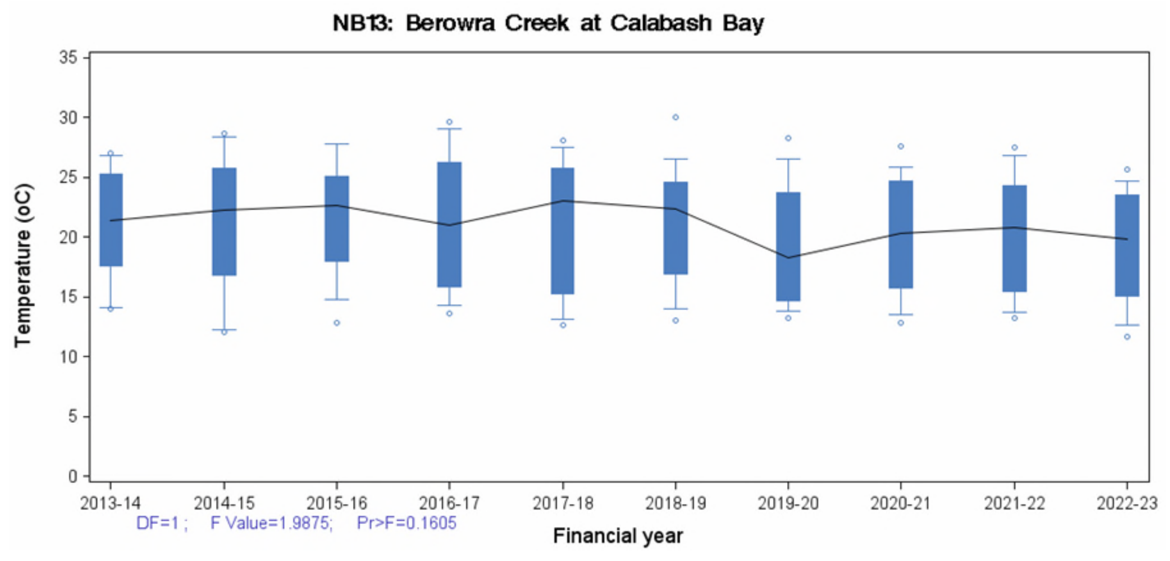
Stressors – Physico-chemical water quality

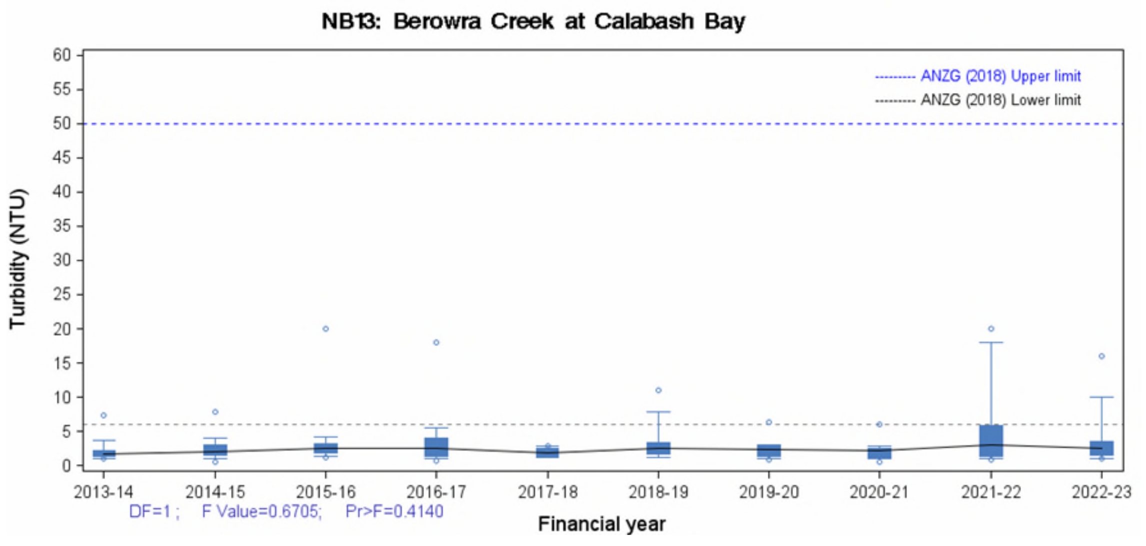



NB13: Berowra Creek at Calabash Bay
Dissolved oxygen (mg/L)
0
2
4
6
8
10
12
14
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=0.1797; Pr>F=0.6721
Financial year

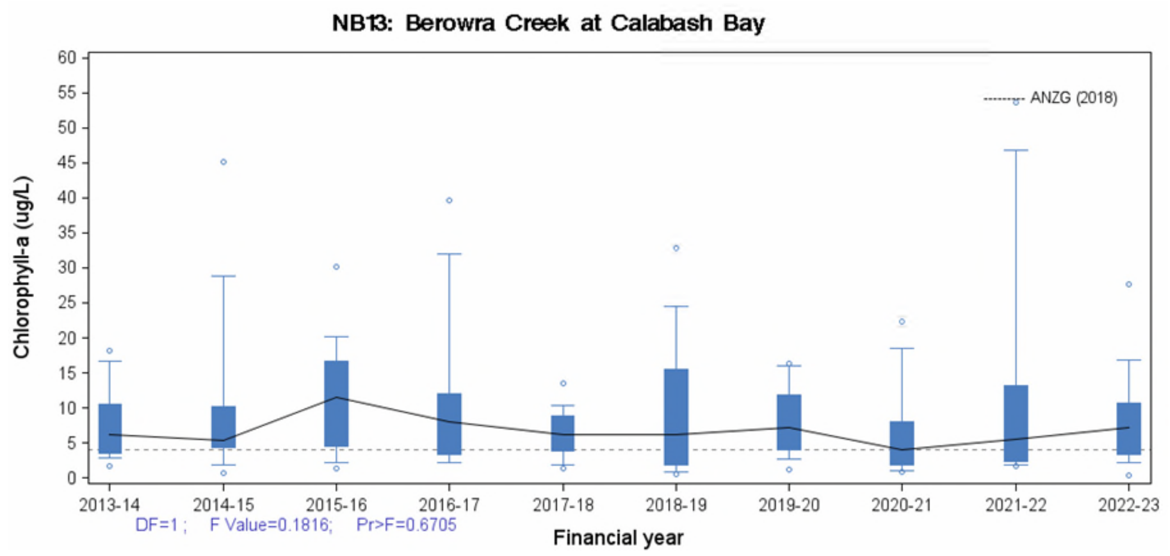

NB13: Berowra Creek at Calabash Bay
ANZG (2018) Upper limit
ANZG (2018) Lower limit
Dissolved oxygen saturation (%)
0
20
40
60
80
100
120
140
160
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=4.1408; Pr>F=0.0435
Financial year

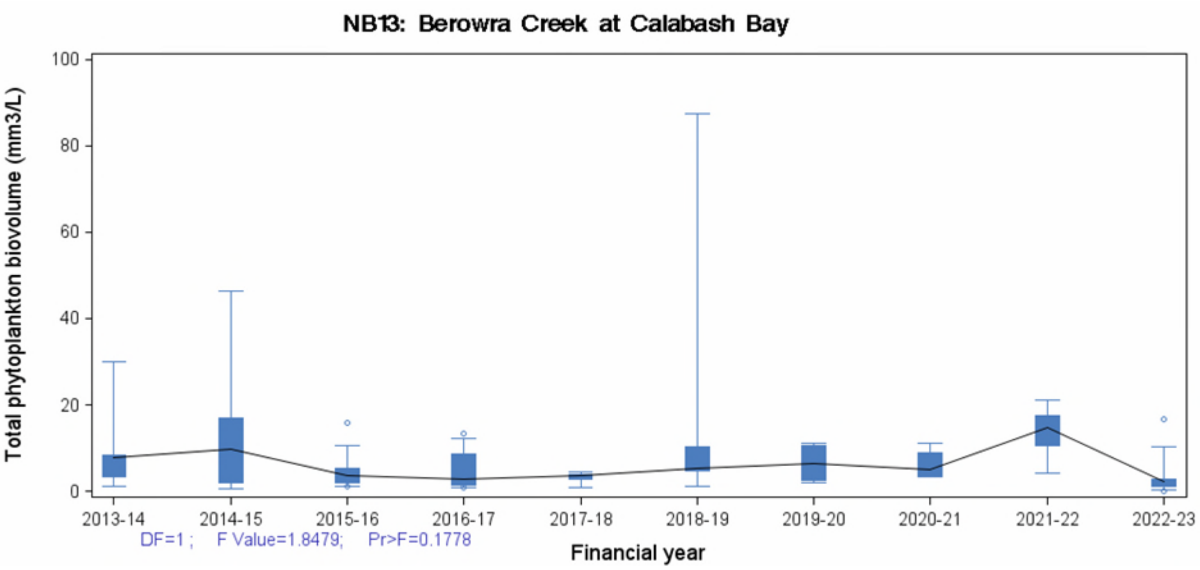

NB13: Berowra Creek at Calabash Bay
ANZG (2018) Upper limit
ANZG (2018) Lower limit
pH
5
6
7
8
9
10
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=6.2175; Pr>F=0.0136
Financial year

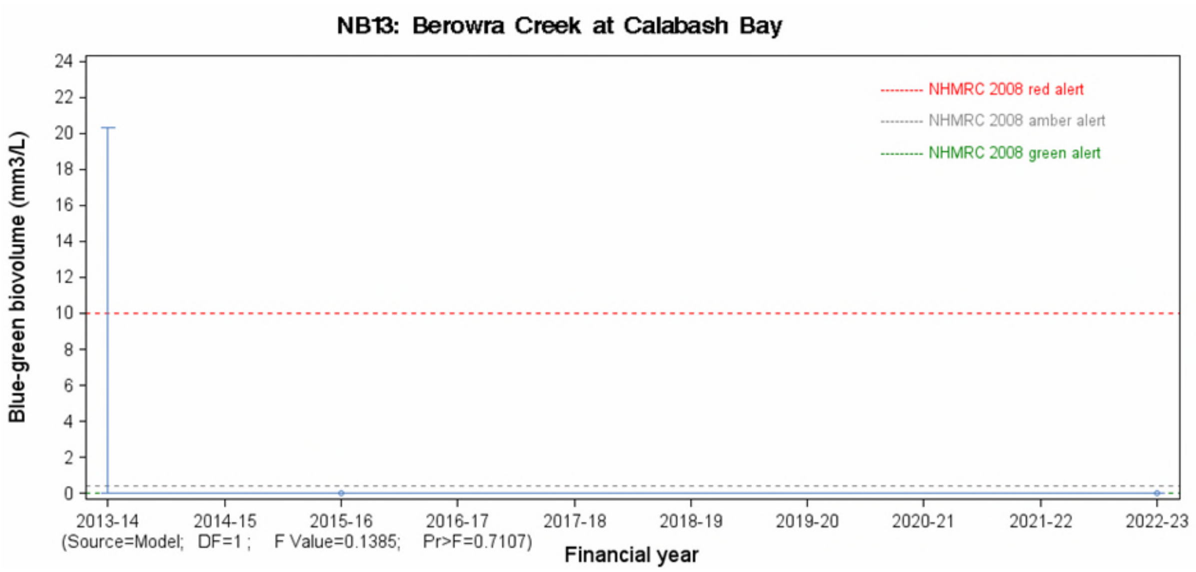


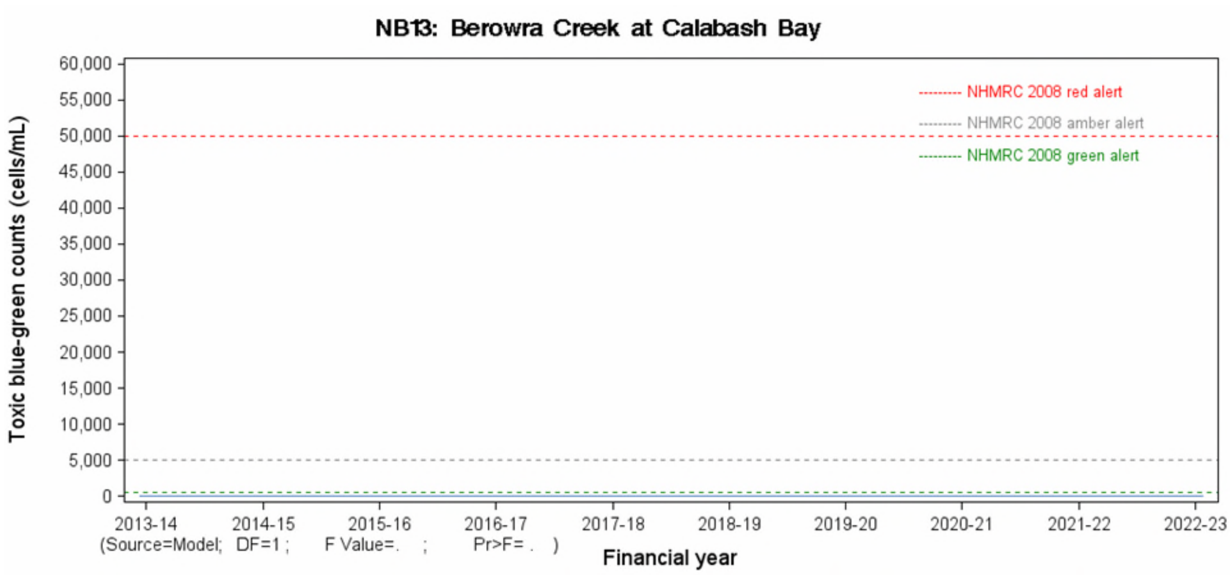


Ecosystem receptor – Phytoplankton



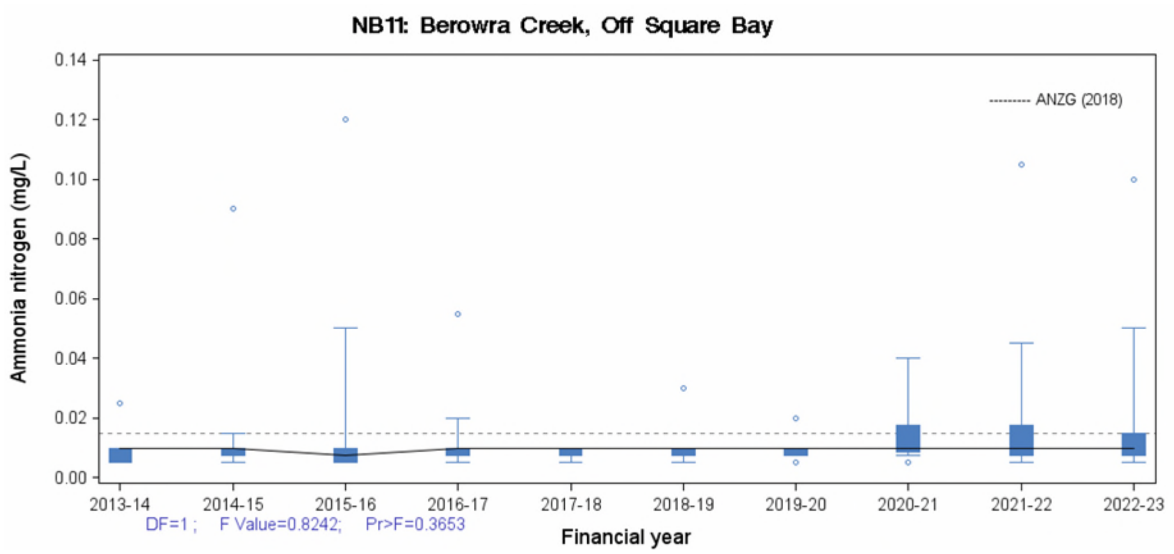

NB13: Berowra Creek at Calabash Bay
Total phytoplankton biovolume (mm3/L)
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=1.8479; Pr>F=0.1778
Financial year

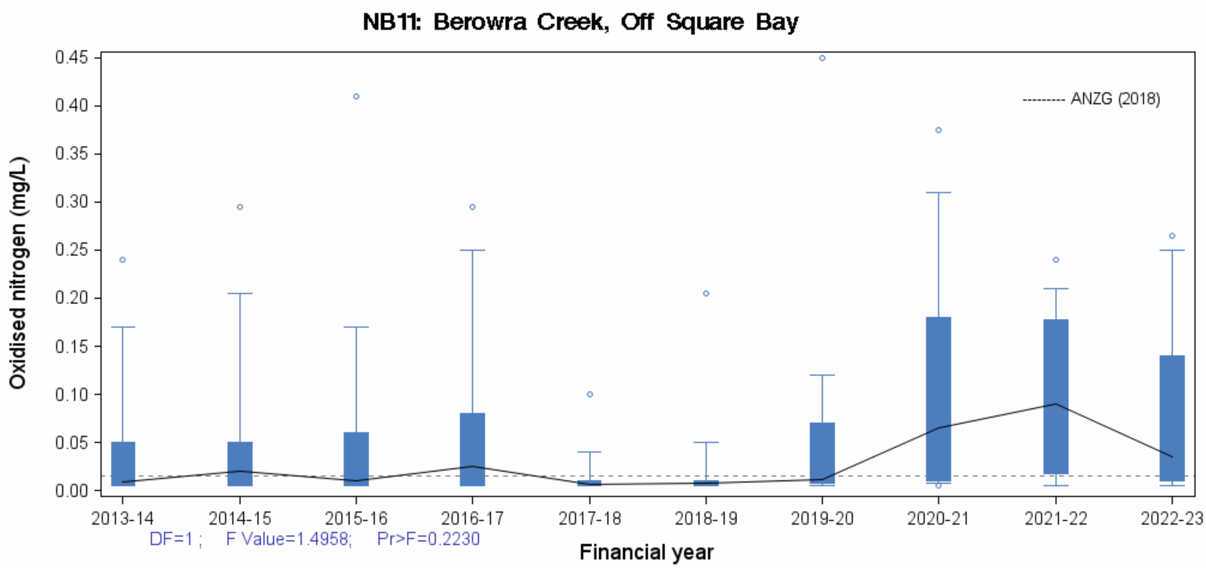

NB13: Berowra Creek at Calabash Bay
Blue-green biovolume (mm3/L)
NHMRC 2008 red alert
NHMRC 2008 amber alert
NHMRC 2008 green alert
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
(Source=Model; DF=1 ; F Value=0.1385; Pr>F=0.7107)
Financial year

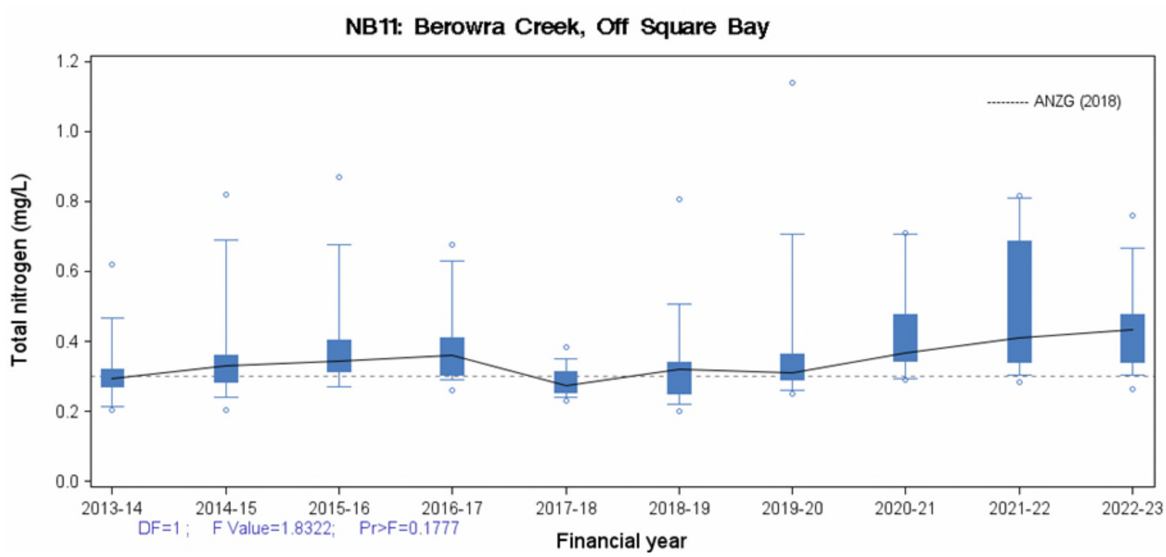

NB13: Berowra Creek at Calabash Bay
Toxic blue-green counts (cells/mL)
NHMRC 2008 red alert
NHMRC 2008 amber alert
NHMRC 2008 green alert
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
(Source=Model; DF=1 ; F Value= . ; Pr>F= .)
Financial year

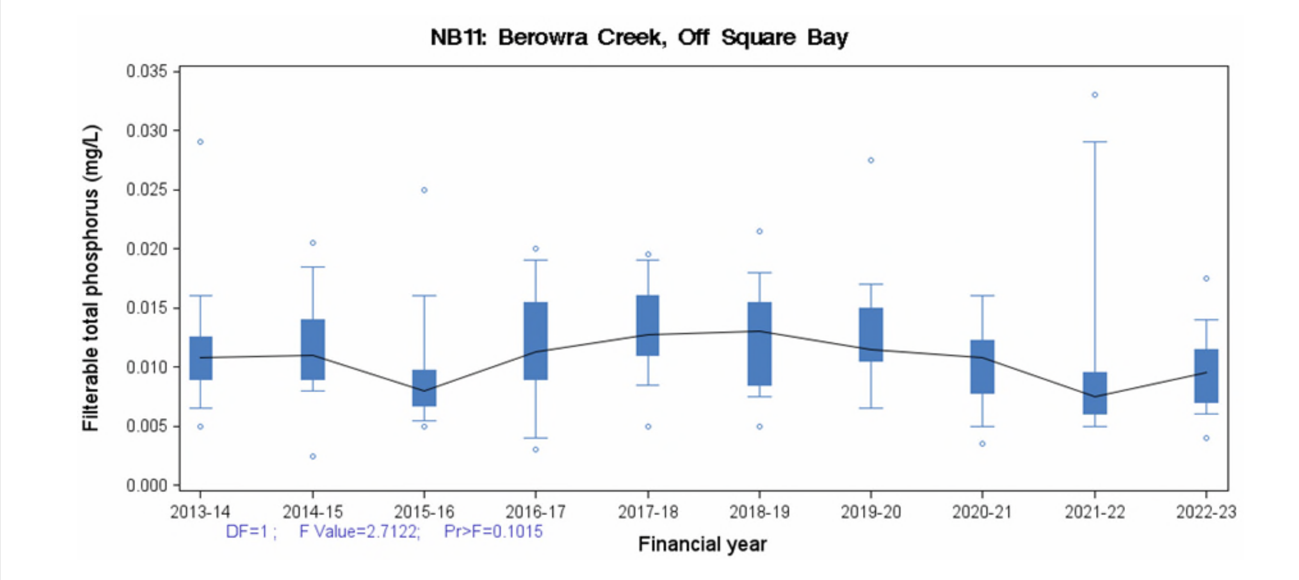
C-1.13 Berowra Creek Off Square Bay (Oaky Point) (B11)

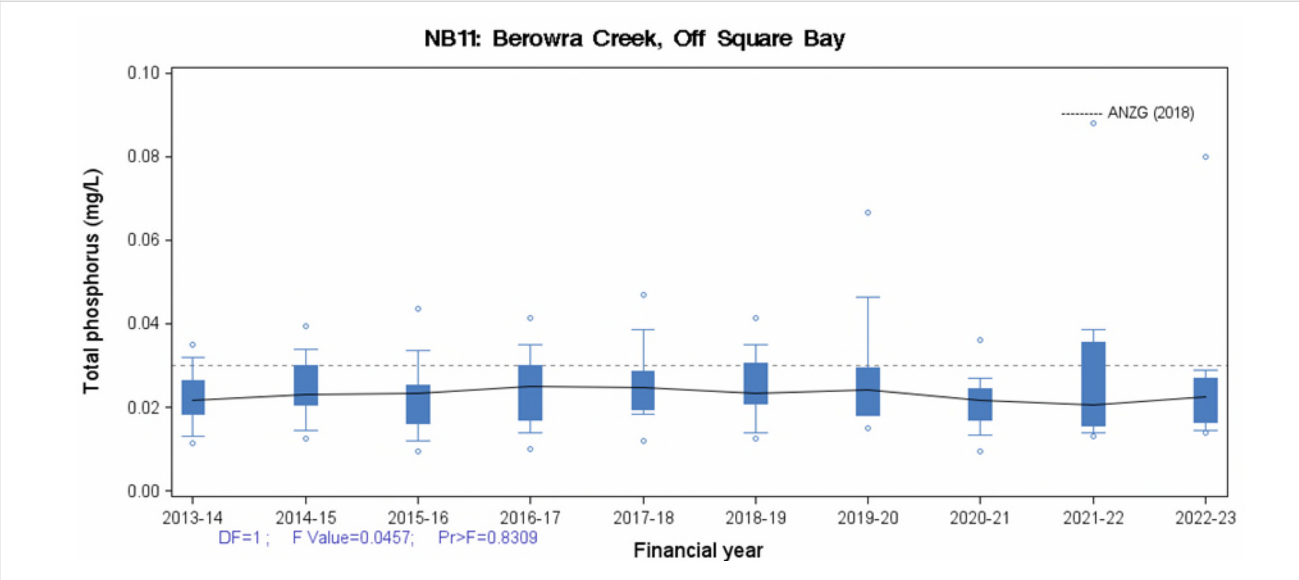
Stressors – Nutrients



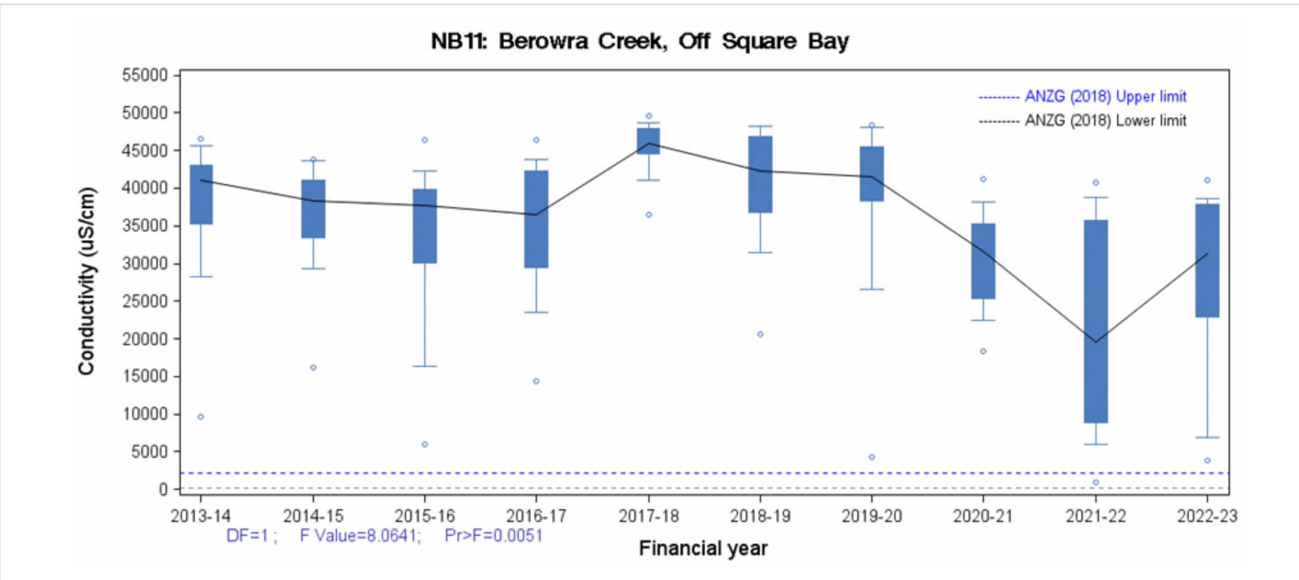


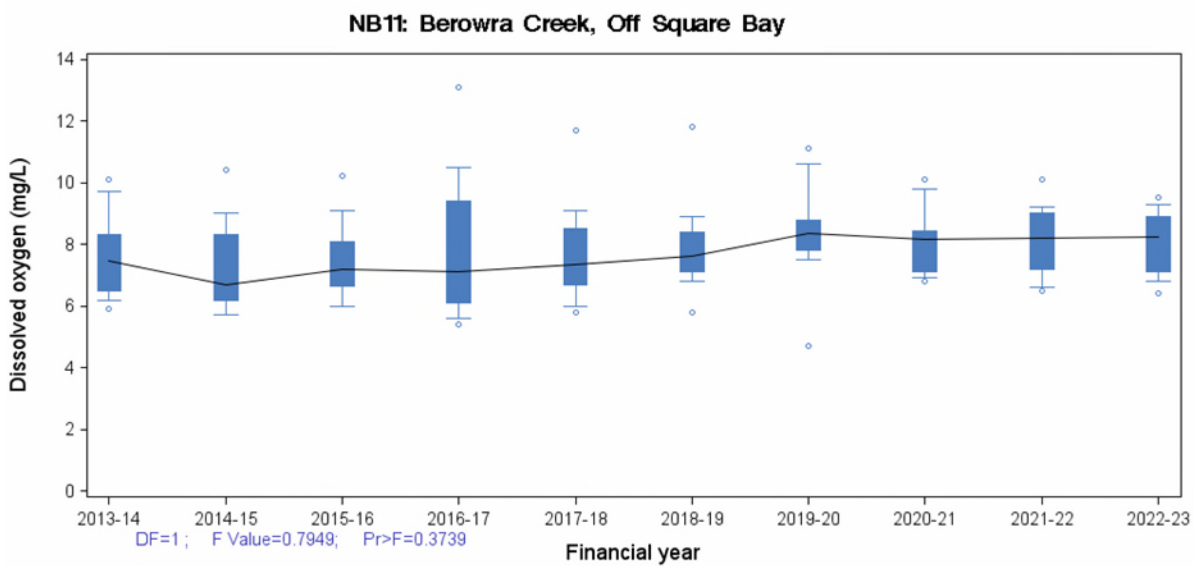


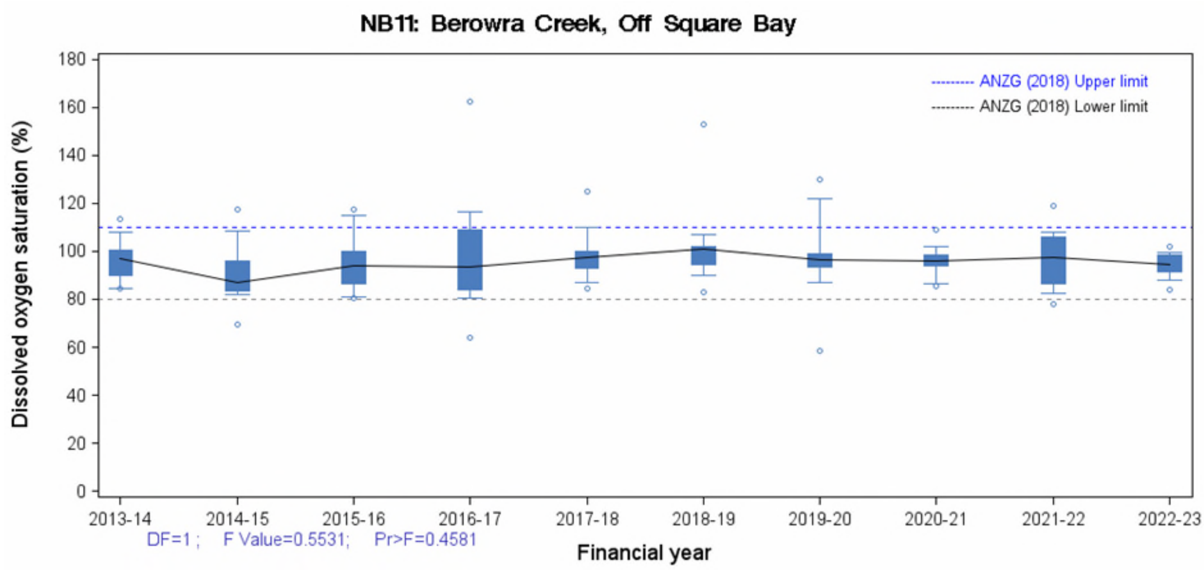


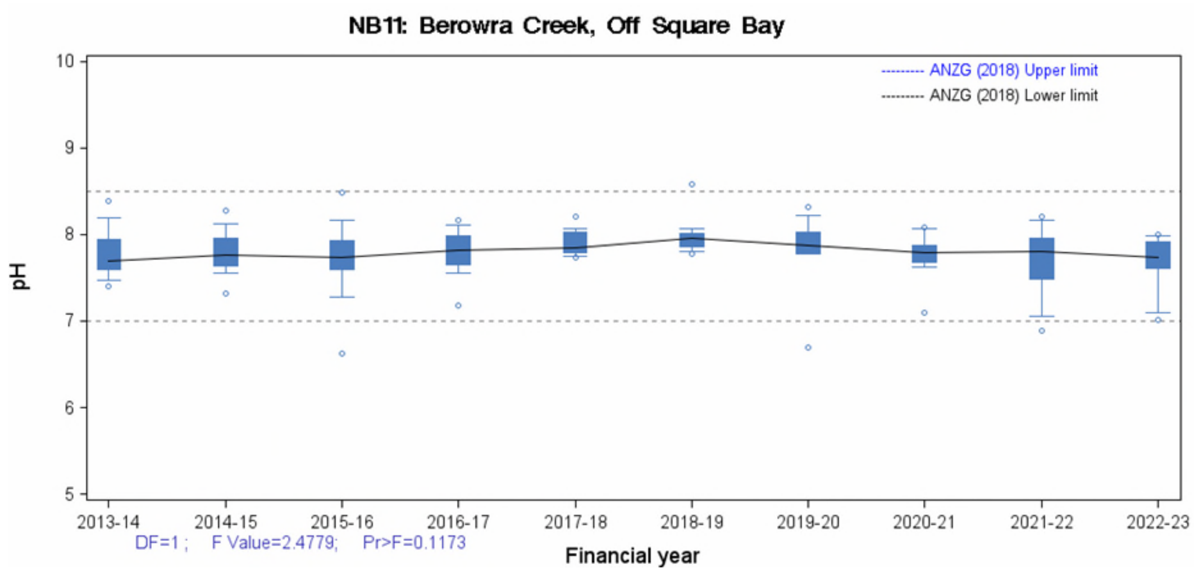


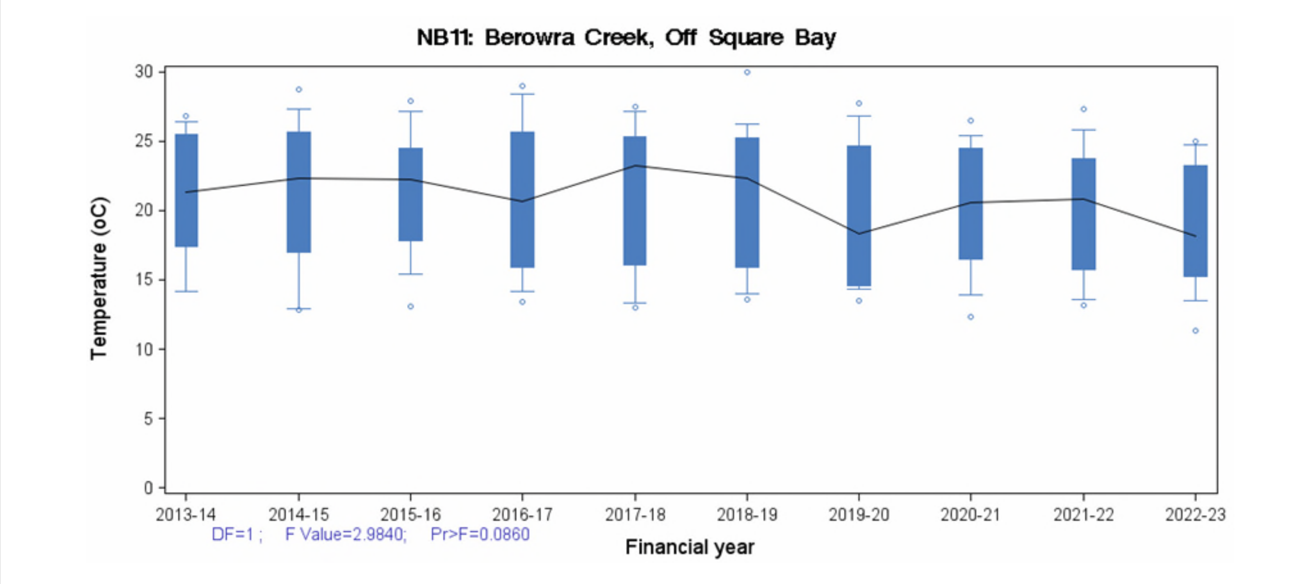
Stressors – Physico-chemical water quality

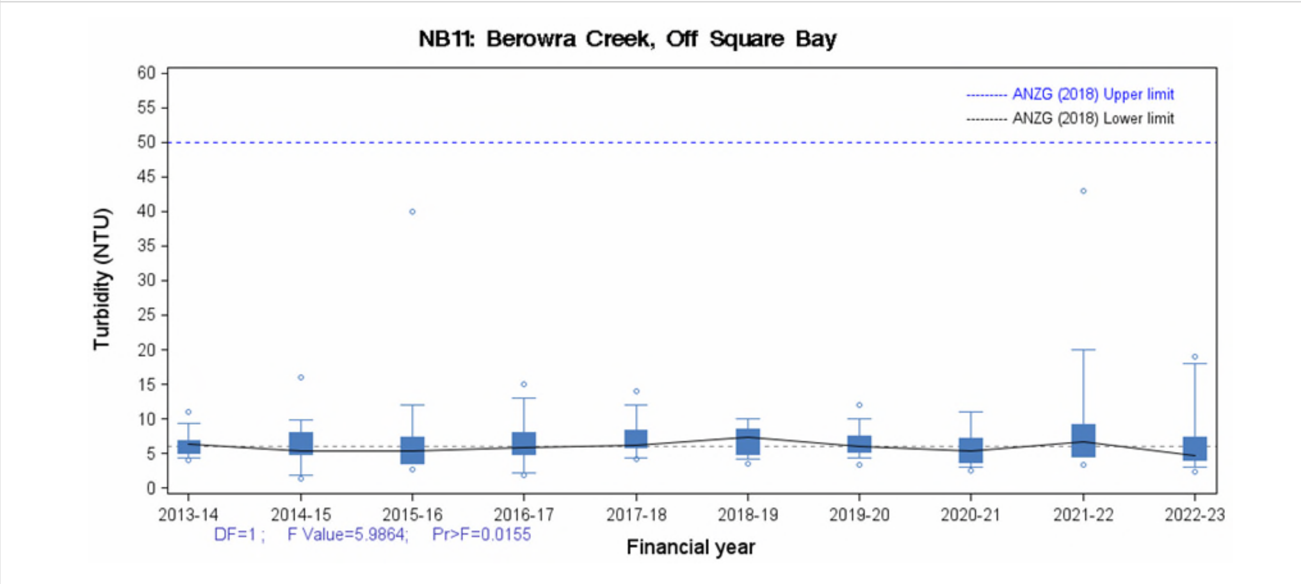



NB11: Berowra Creek, Off Square Bay
Dissolved oxygen (mg/L)
14
12
10
8
6
4
2
0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=0.7949; Pr>F=0.3739
Financial year

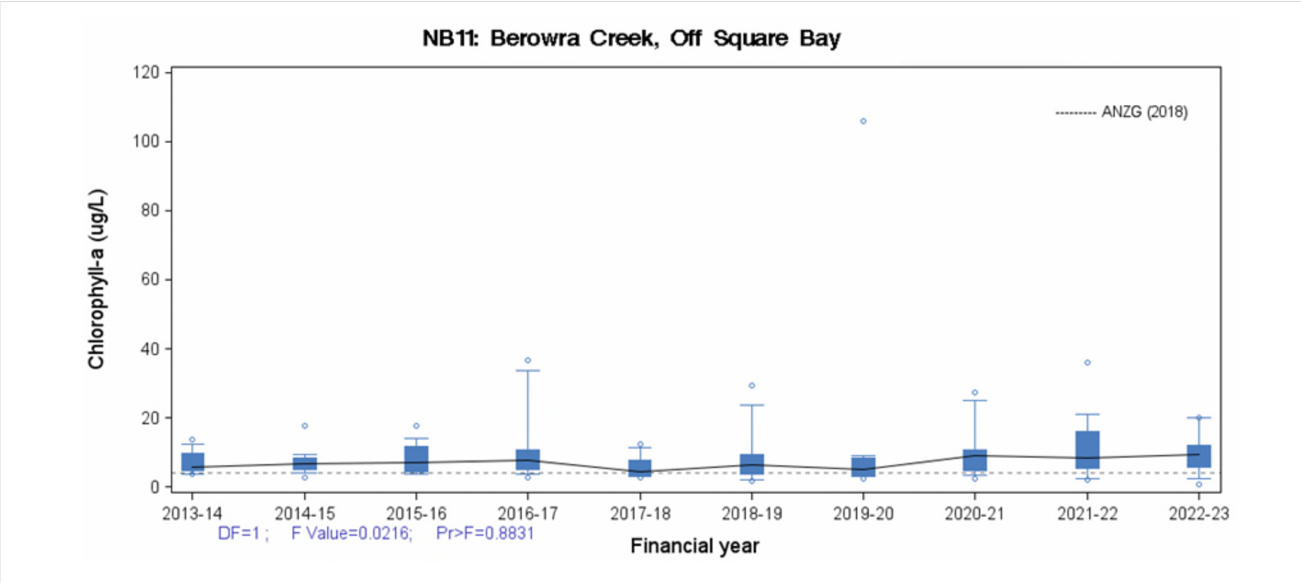

NB11: Berowra Creek, Off Square Bay
ANZG (2018) Upper limit
ANZG (2018) Lower limit
Dissolved oxygen saturation (%)
180
160
140
120
100
80
60
40
20
0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=0.5531; Pr>F=0.4581
Financial year

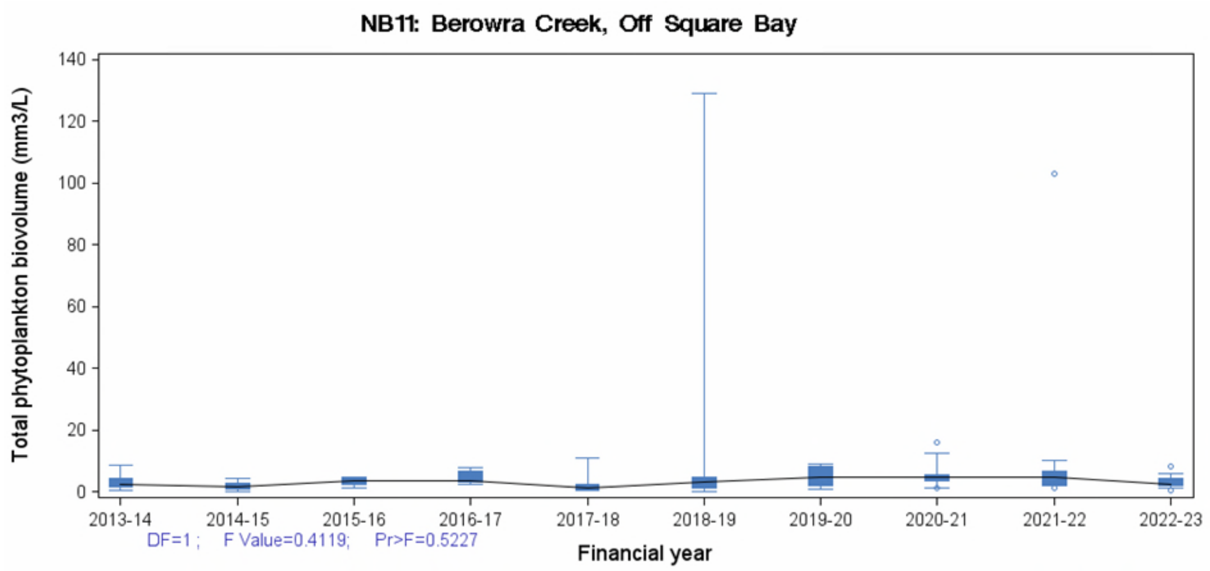

NB11: Berowra Creek, Off Square Bay
ANZG (2018) Upper limit
ANZG (2018) Lower limit
pH
10
9
8
7
6
5
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=2.4779; Pr>F=0.1173
Financial year



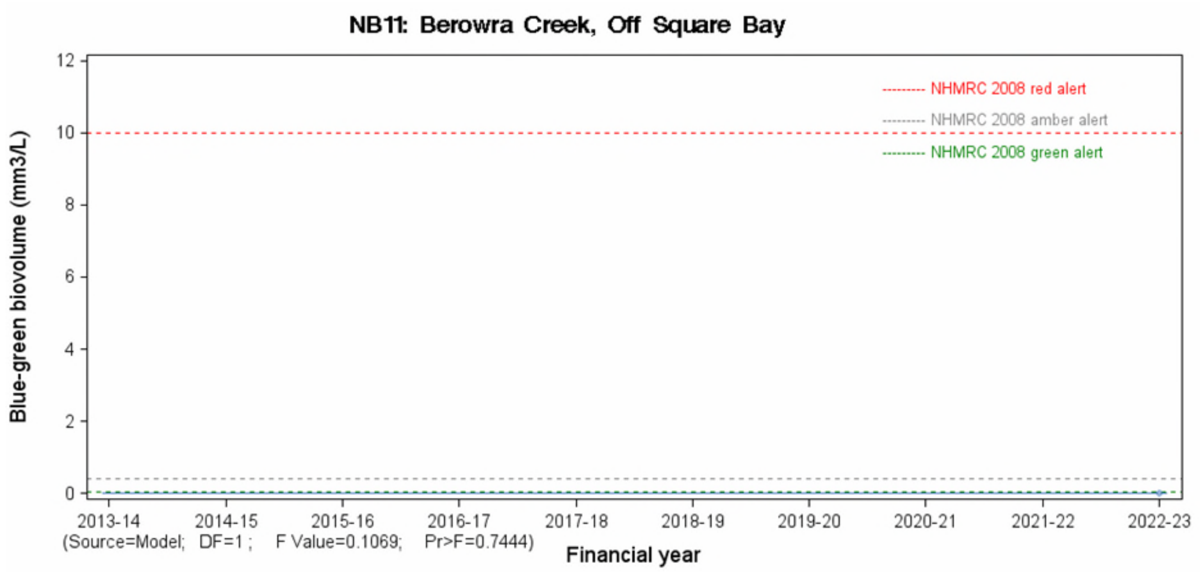


Ecosystem receptor – Phytoplankton

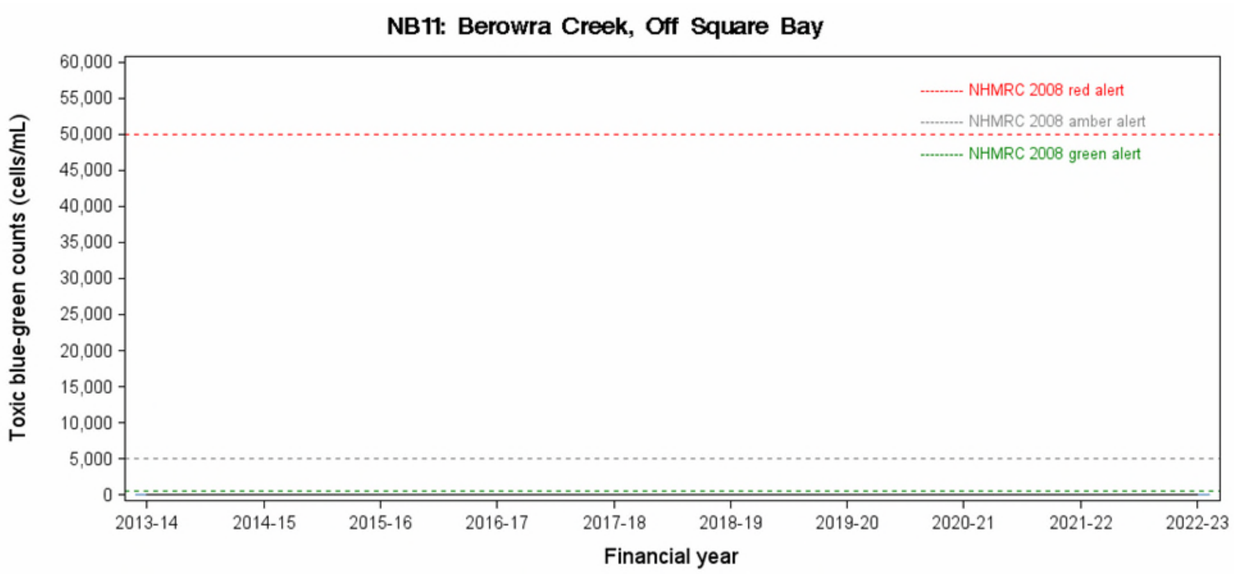




NB11: Berowra Creek, Off Square Bay
Total phytoplankton biovolume (mm3/L)
140
120
100
80
60
40
20
0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=0.4119; Pr>F=0.5227
Financial year



NB11: Berowra Creek, Off Square Bay
Blue-green biovolume (mm3/L)
NHMRC 2008 red alert
NHMRC 2008 amber alert
NHMRC 2008 green alert
12
10
8
6
4
2
0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
(Source=Model; DF=1 ; F Value=0.1069; Pr>F=0.7444)
Financial year



NB11: Berowra Creek, Off Square Bay
Toxic blue-green counts (cells/mL)
NHMRC 2008 red alert
NHMRC 2008 amber alert
NHMRC 2008 green alert
60,000
55,000
50,000
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Financial year

C-2 Other urban rivers and reference sites - Ecosystem health

Eight sites are monitored for the macroinvertebrate indicator in freshwater streams to assess the general condition of stream health in urban areas. Among these, four are control sites located upstream of any likely impact from urban areas. The control sites include Lynch's Creek (N451) a tributary of Hawkesbury-Nepean River, Hacking River at McKell Avenue in Royal National Park (PH22), the upper Georges River system at O'Hares Creek (GE510) and Georges River at Ingleburn Reserve (GR24). Three out of the four urban sites are situated in areas just upstream of estuarine limits of the Parramatta River (PJPR), Lane Cove River (PJLC) and Georges River (GR22). The fourth urban site is situated about 5 km further up in the Georges River (GR23).

Results from 2022-23 indicate stream health for all of the four control sites (N451, PH22, GE510 and GR24) was typical of natural water quality in bushland areas that do not receive urban stormwater runoff or sewer overflows (Figure C-4 and Figure C-5).

Urban sites within the Port Jackson rivers upstream of Lane Cove Weir (PJLC) and Parramatta Weir (PJPR) were in the 'moderate water pollution' category (Figure C-4), while the sites in the G eorges River were between the moderate to mild water pollution categories in 2022-23 (Figure C-5). The Georges River results were typical of the stream health that has been recorded for these urban sites over the previous 1995 to 2022 period.

Results from these test sites represent the ambient condition of the combined impact of urban stormwater runoff and sewer overflows. These two influences cannot be teased apart. Pilot studies are being designed under Sydney Water's wet weather overflow program to model a stormwater control condition, which may then better define the impact of sewer overflows on urban streams than these current single site assessments.

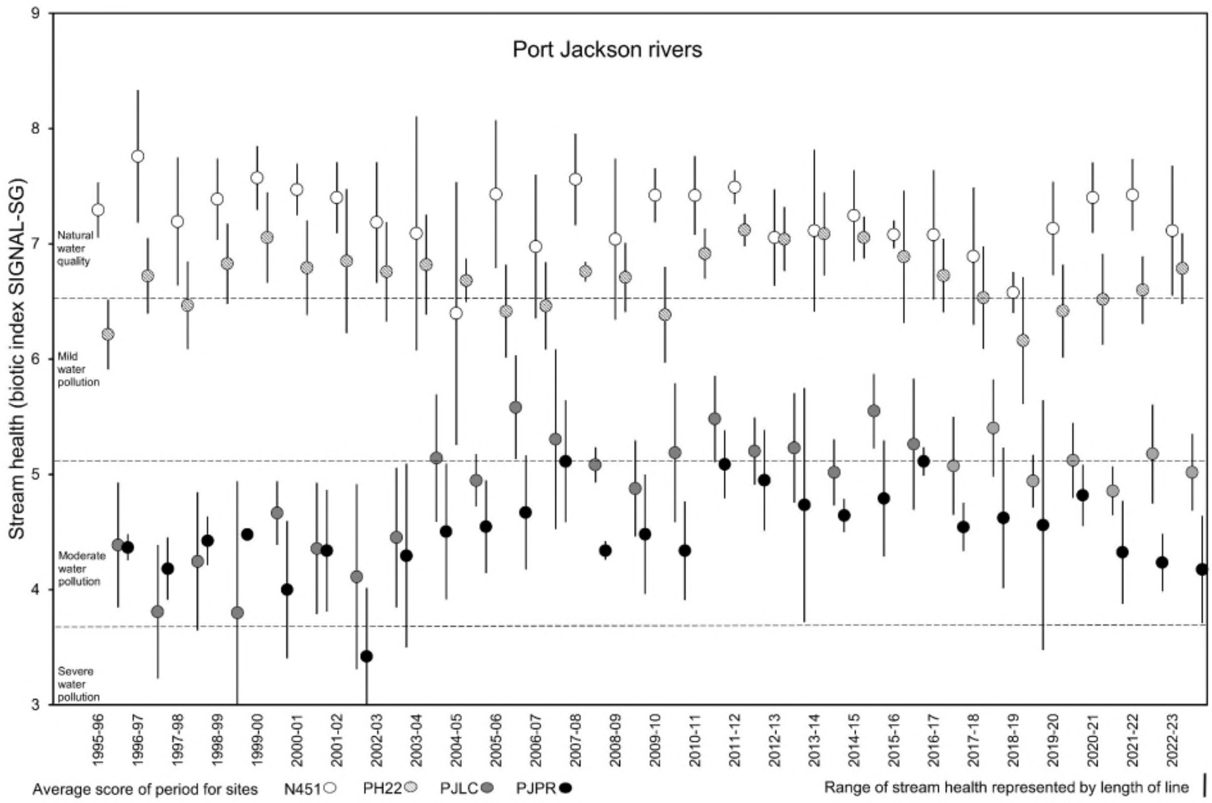


Figure C-4 Stream health of Lane Cove and Parramatta rivers in comparison to control sites

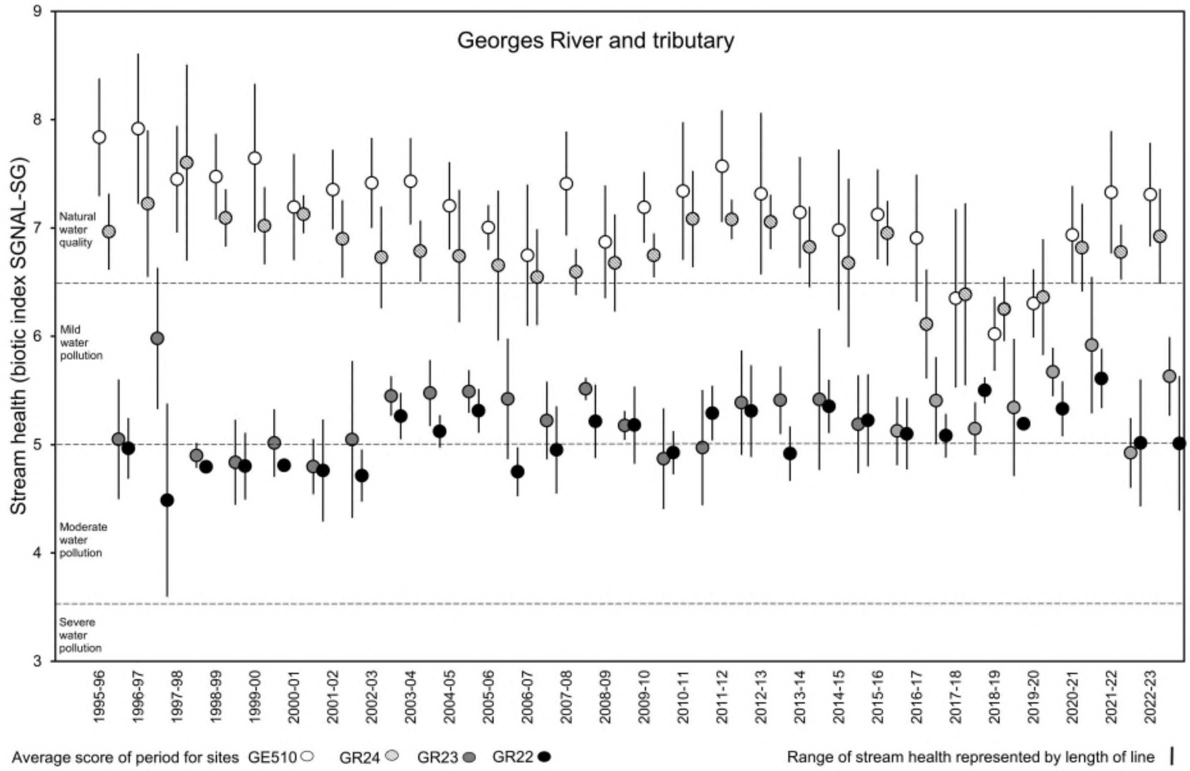


Figure C-5 Stream health of lower freshwater Georges River sites compared to control sites in the upper Georges River system

Appendix D: Nearshore marine environment

This Appendix includes graphical presentation of all monitoring data for the Nearshore Marine catchment. Summary tables and detailed statistical analyses outcomes are also included where relevant.

The Water Resource Recovery Facilities (WRRFs) that are discharging into this catchment are ordered from North (Warriewood) to South (Bombo).

Under each WRRF (Sub-chapters D-1 to D-6), the results are presented following the **Pressure**, **Stressor** and **Ecosystem Receptor** (**P-S-ER**) causal pathway elements.

For the **Pressure**, trend plots are included on wastewater quantity (discharge and inflow), quality, toxicity and discharge loads. Trends plots on other supplementary data are also included to improve our understanding on:

- weather condition ie catchment specific rainfall condition for each WRRF
- wastewater reuse/ recycling volume of relevant WRRF.

Wastewater quality and load plots are included in following four sub-groups, and then within each sub-group, analytes presented in alphabetical order:

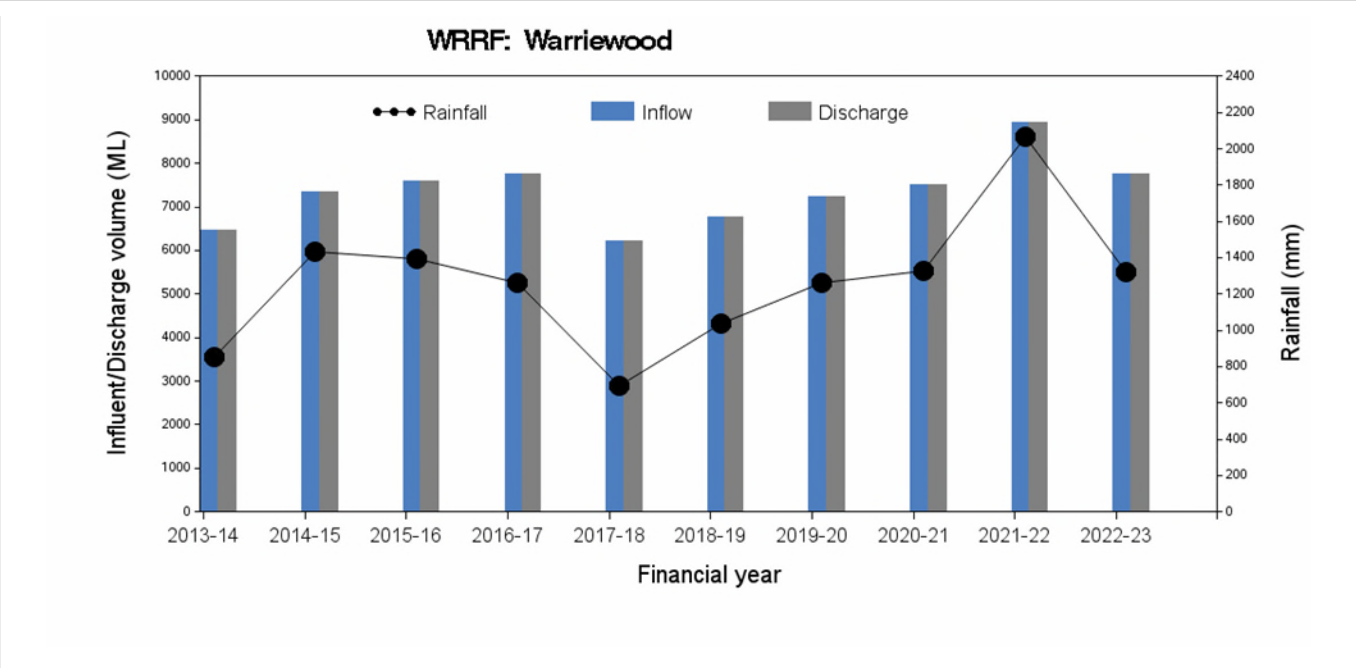
- nutrients
- major conventional analytes
- trace metals
- other chemicals and organics (including pesticides)

Tests conducted on wastewater are specified in the Environment Protection Licence (EPL) issued by the NSW EPA for each WRRF (D-7)). Data for all these measured analytes that have EPL concentration and load limits are included.

D-1 Warriewood WRRF

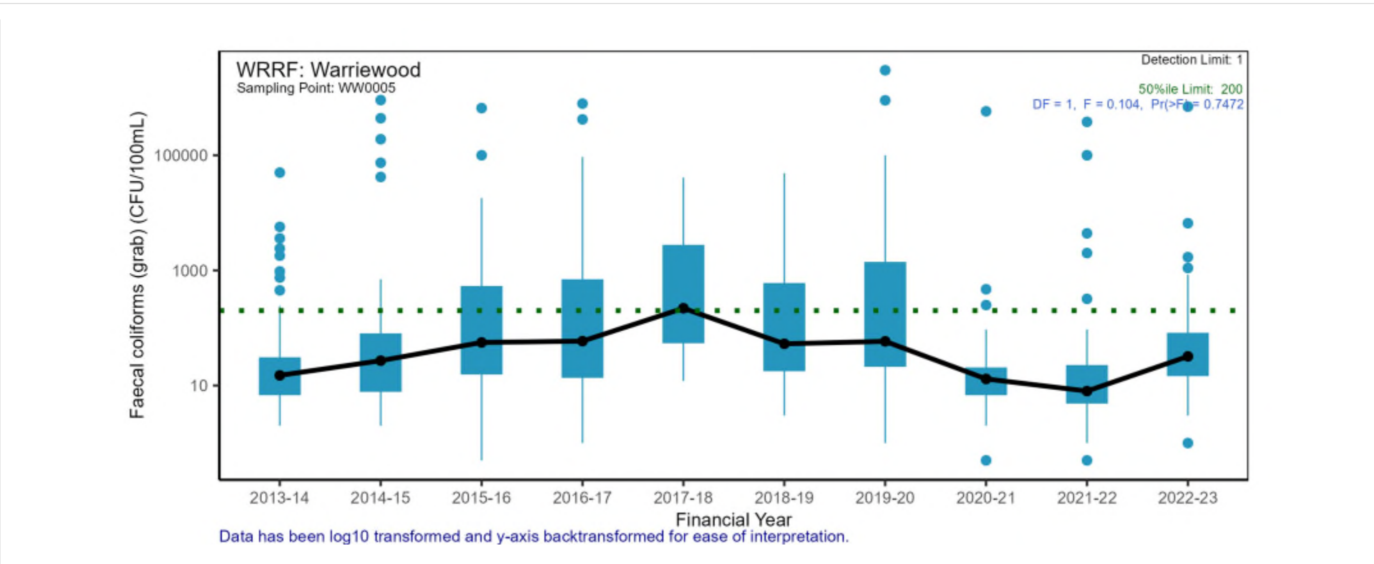
D-1.1 Pressure – Wastewater quantity

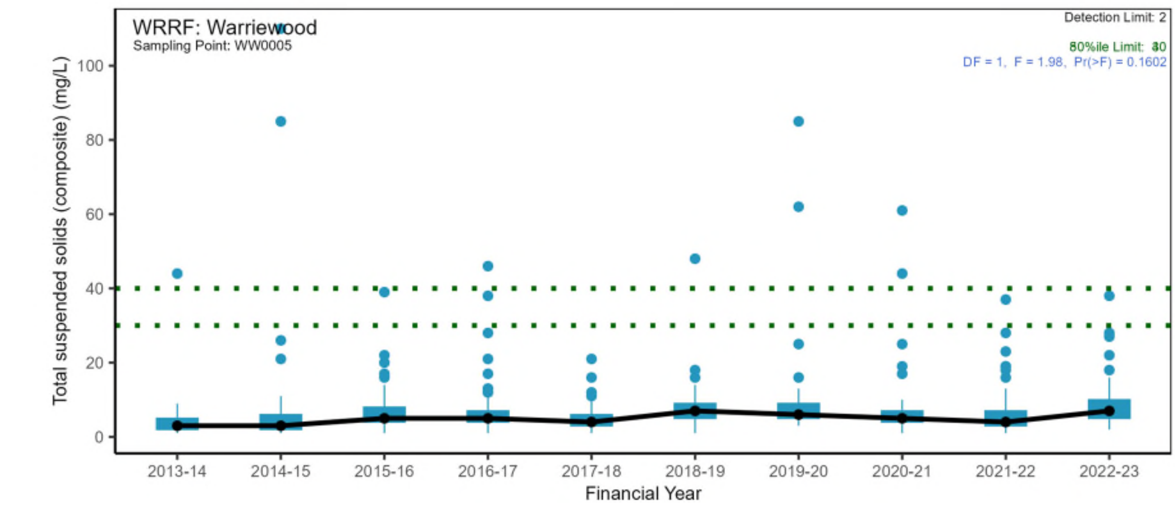
Inflow/ Discharge volume and rainfall



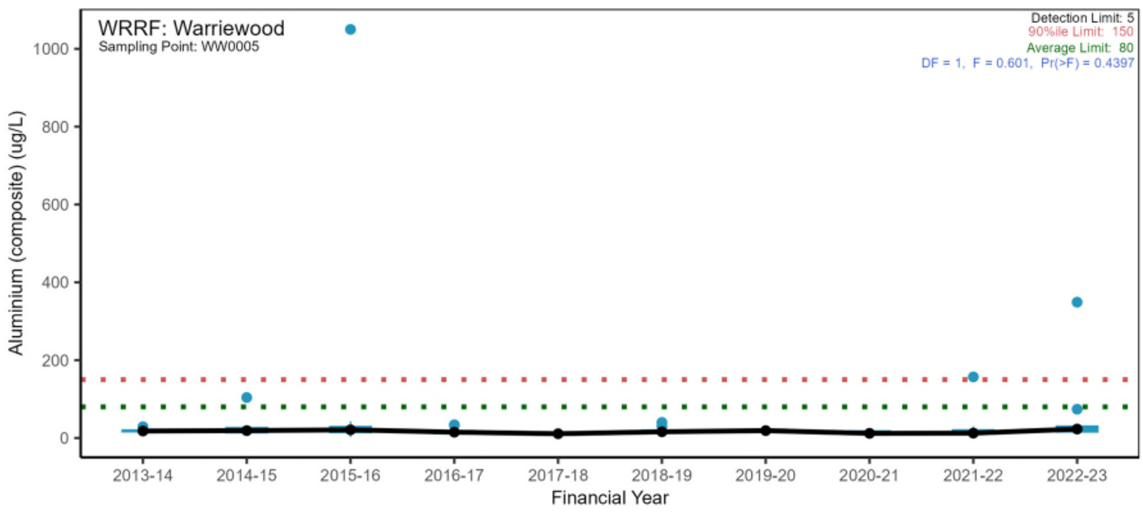
D-1.2 Pressure – Wastewater quality

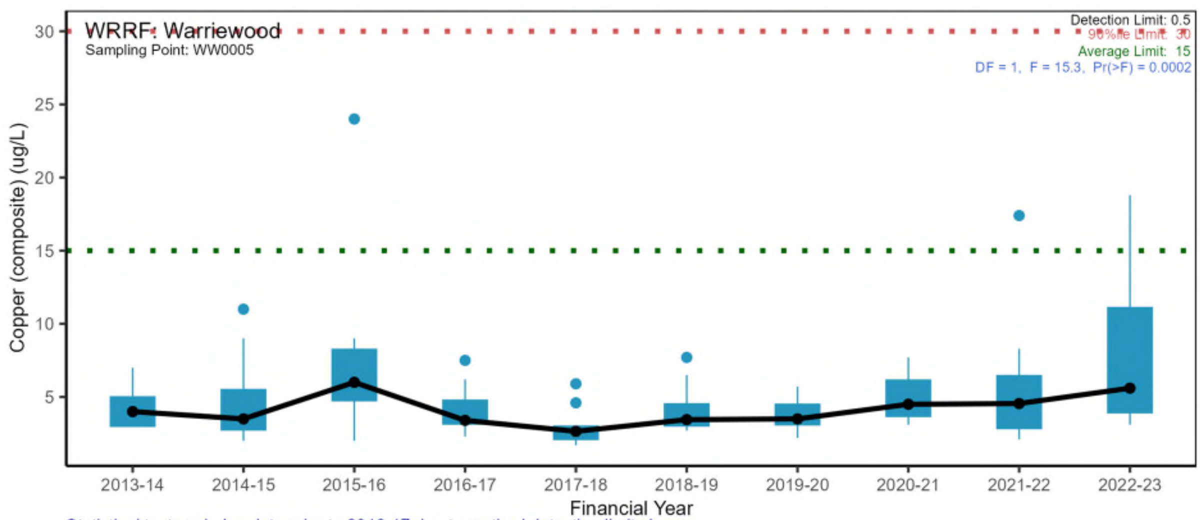
Major conventional analytes





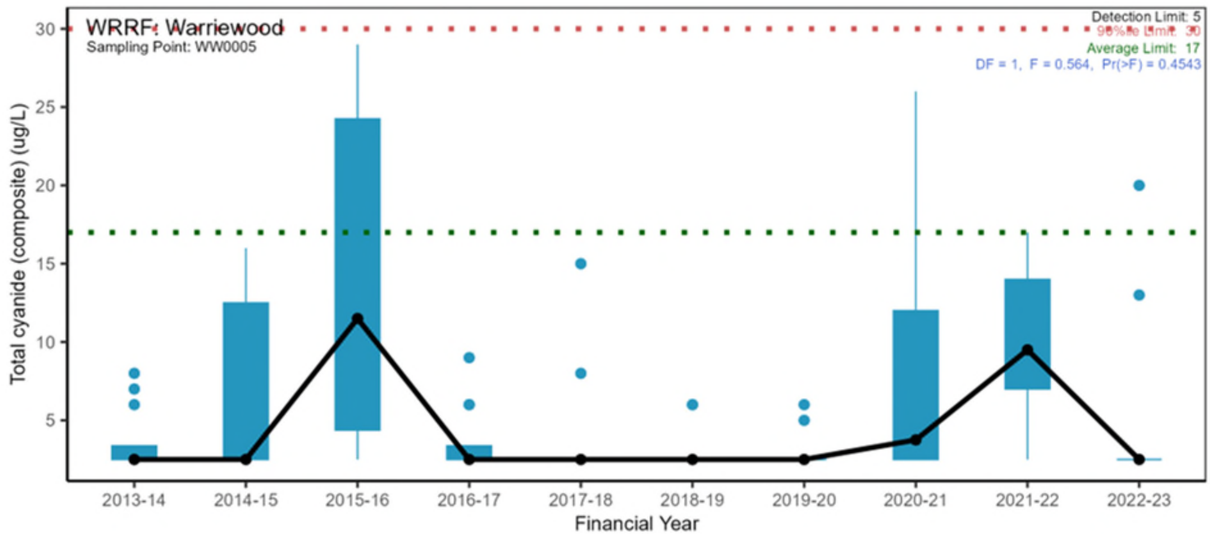
Trace metals

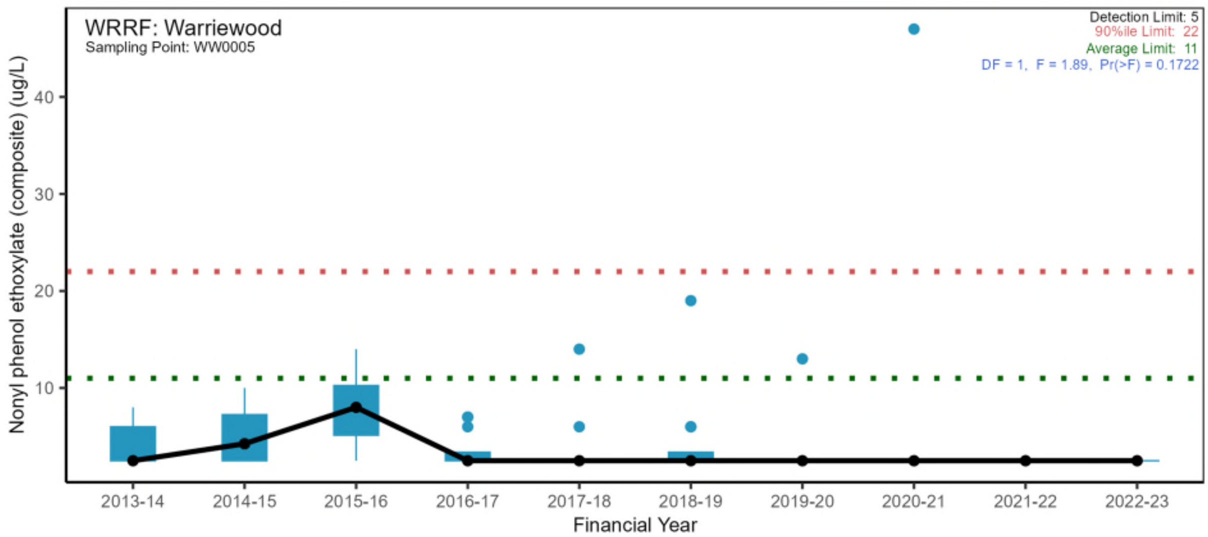




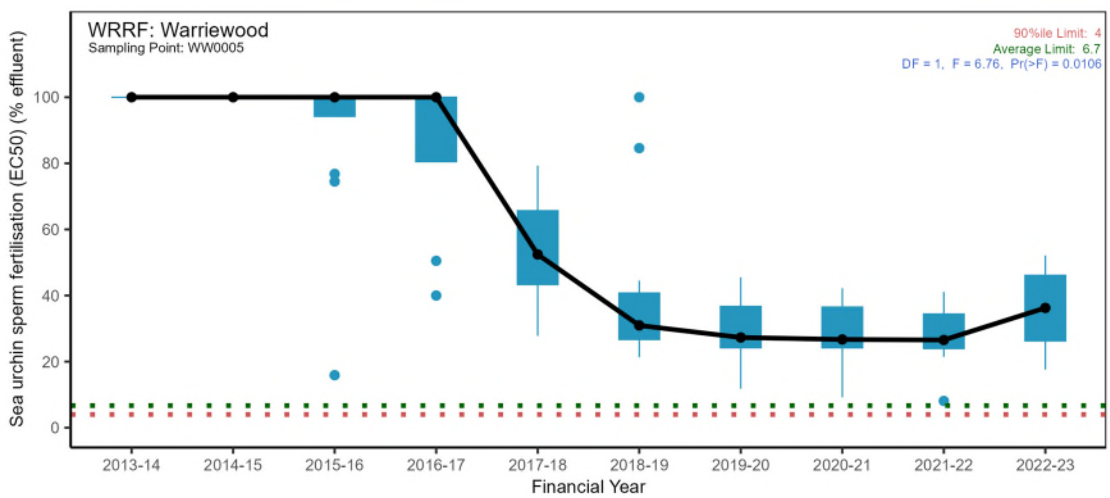
Statistical test excludes data prior to 2016-17 due to method detection limit change.

Other chemicals and organics (including pesticides)



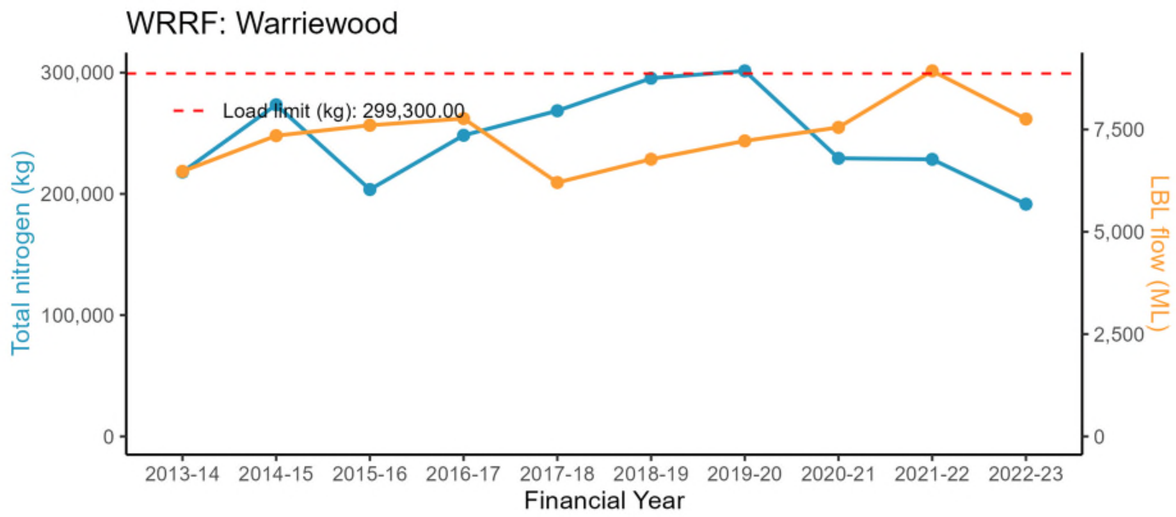


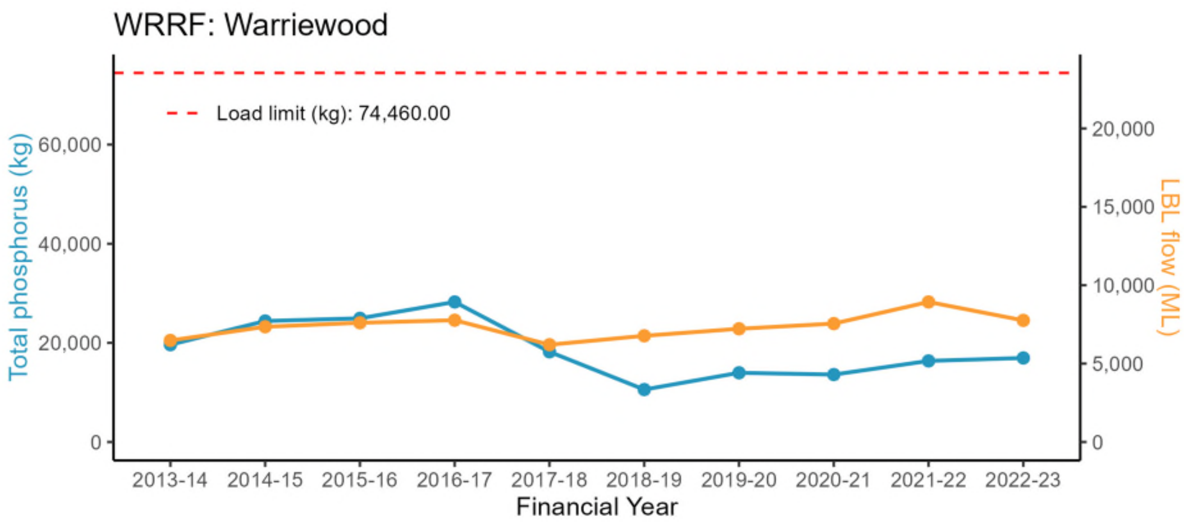
D-1.3 Pressure – Wastewater toxicity



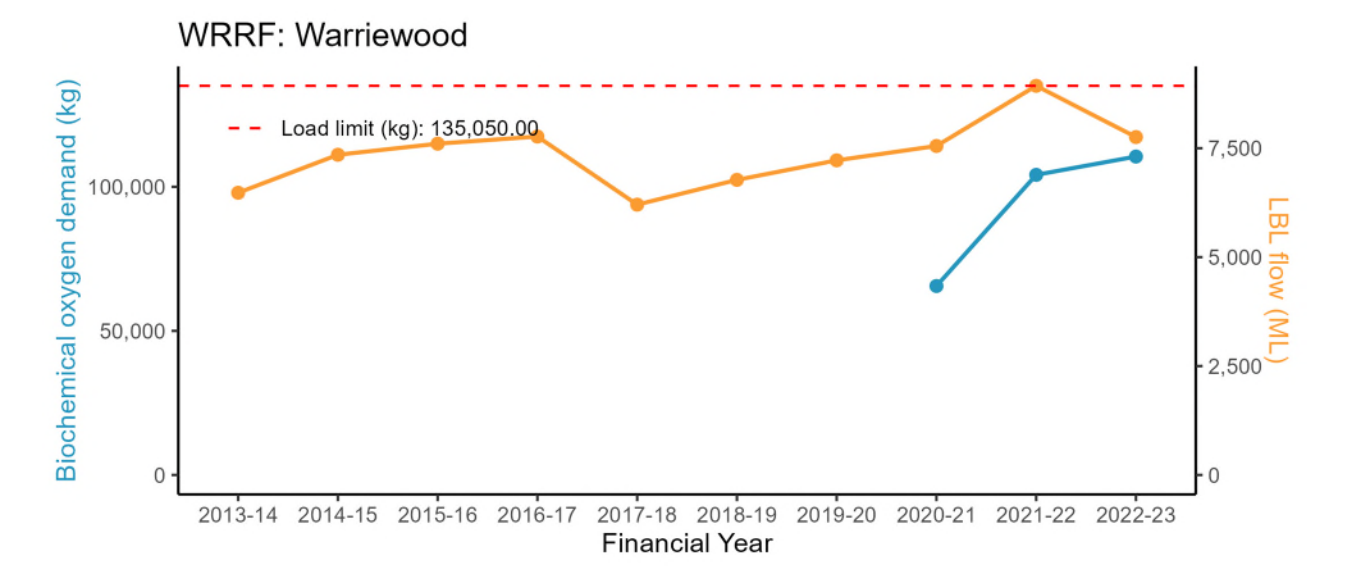
D-1.4 Pressure – Wastewater discharge load

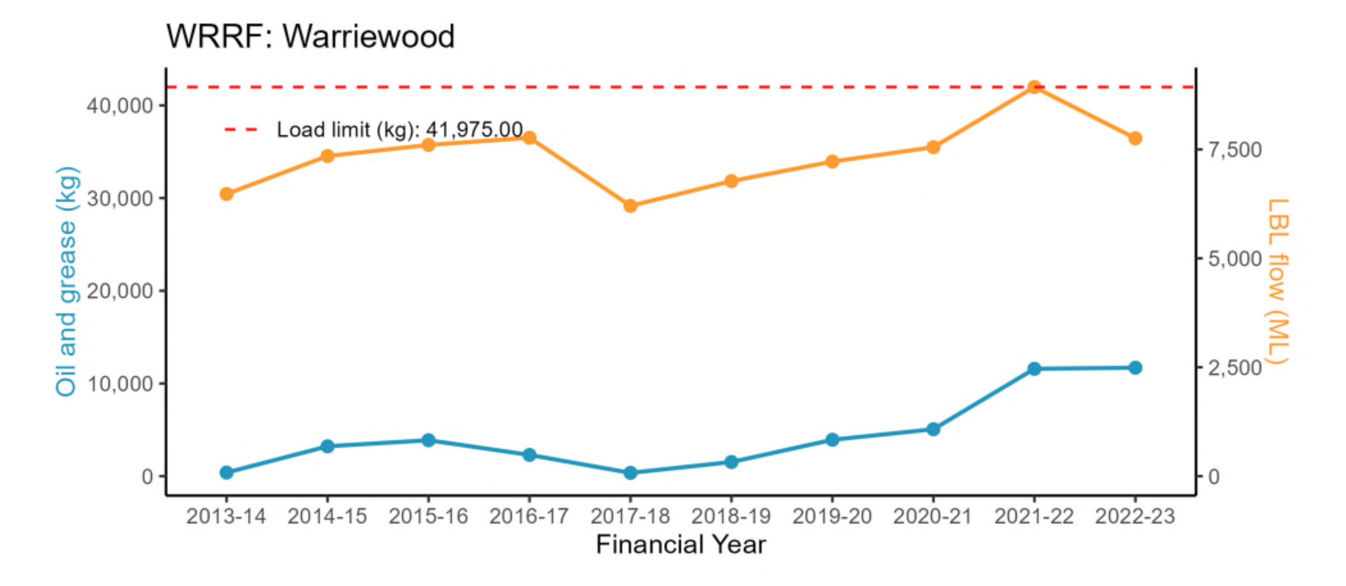
Nutrients

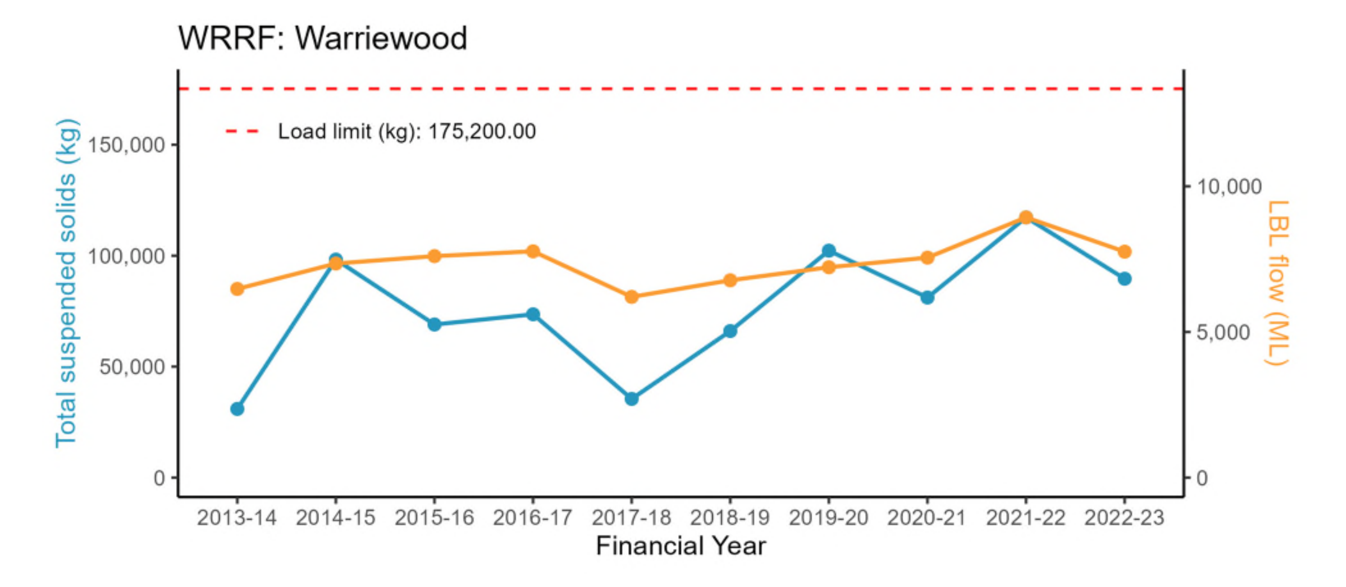




Major conventional analytes



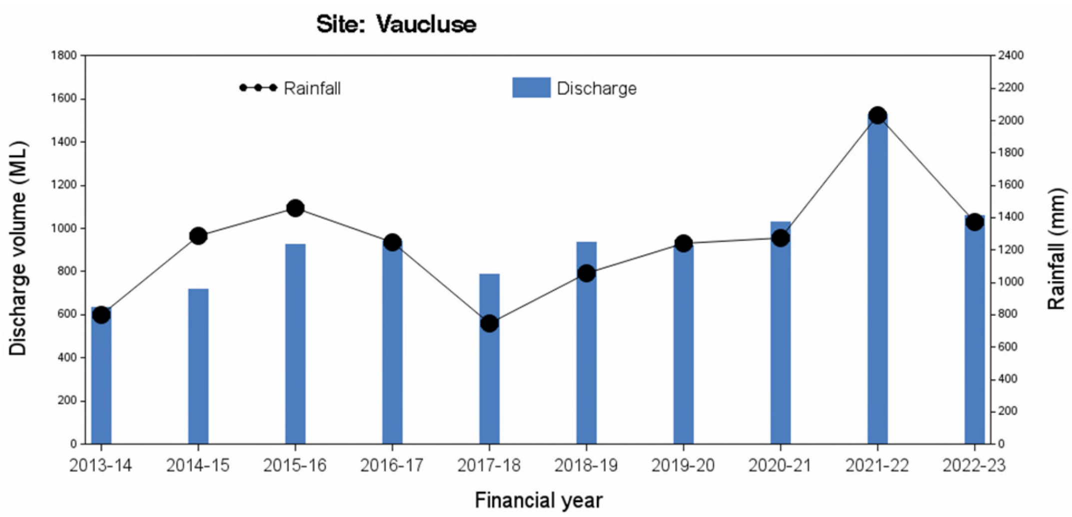


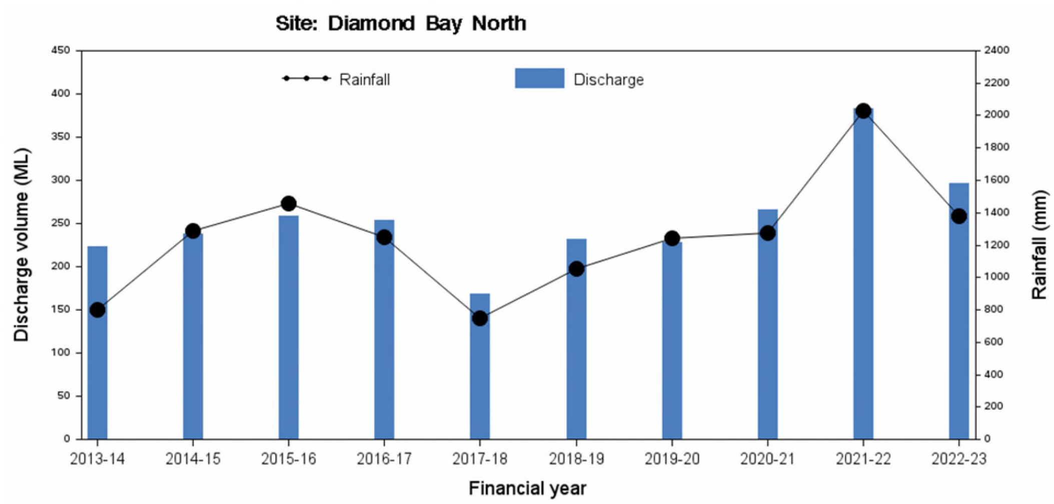


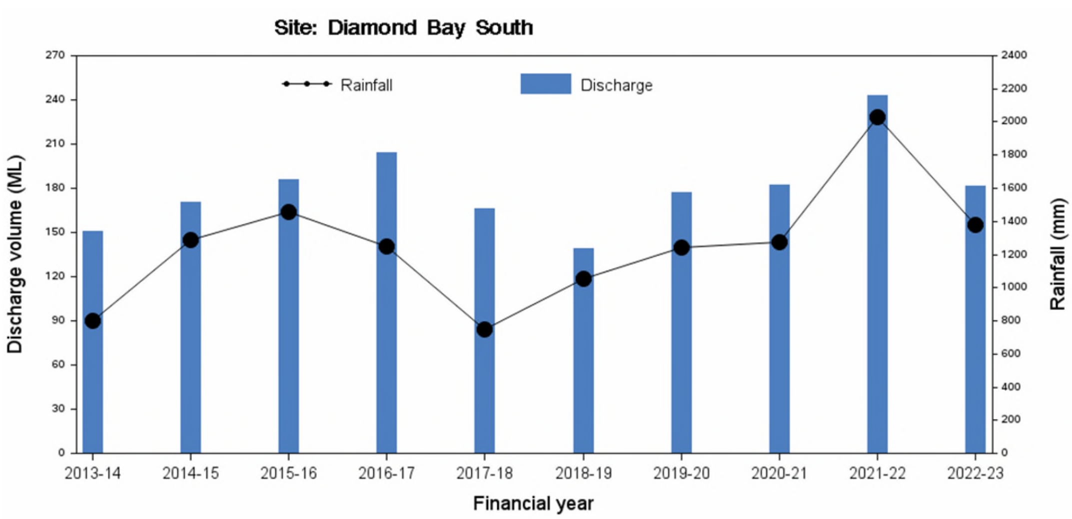
D-2 Bondi WRRF (Nearshore discharges, Vaucluse and Diamond Bay)

D-2.1 Pressure – Wastewater quantity

Inflow/ Discharge volume and rainfall



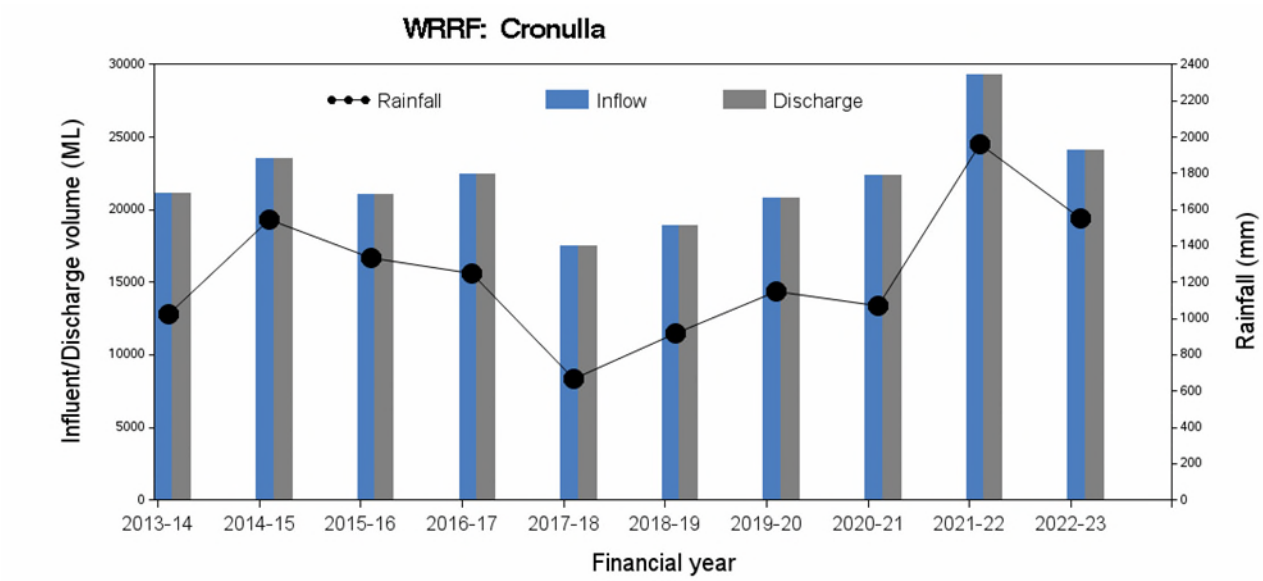




D-3 Cronulla WRRF

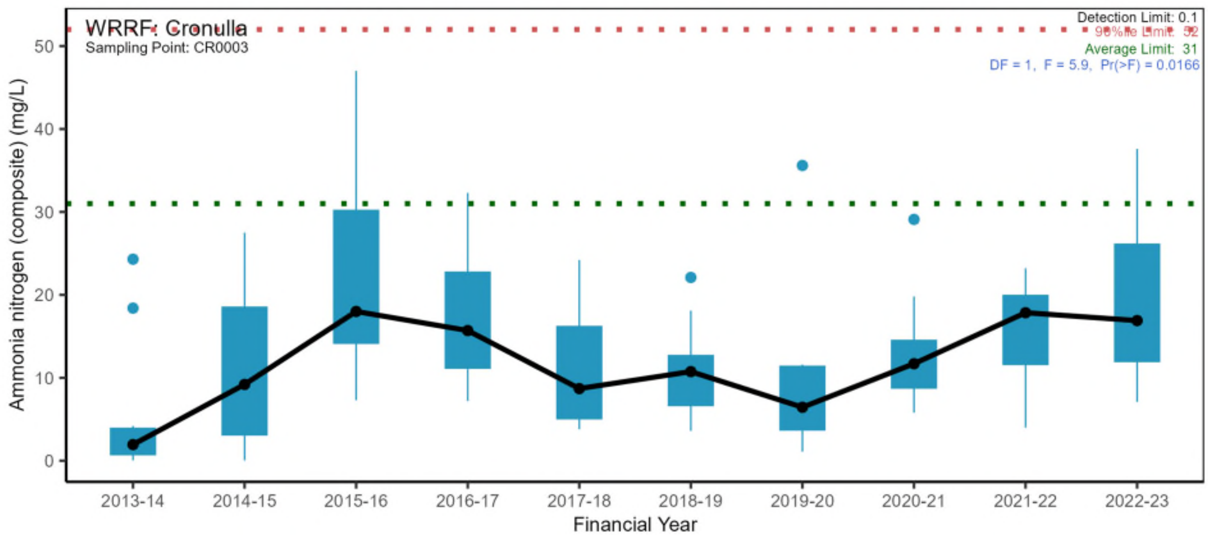
D-3.1 Pressure – Wastewater quantity

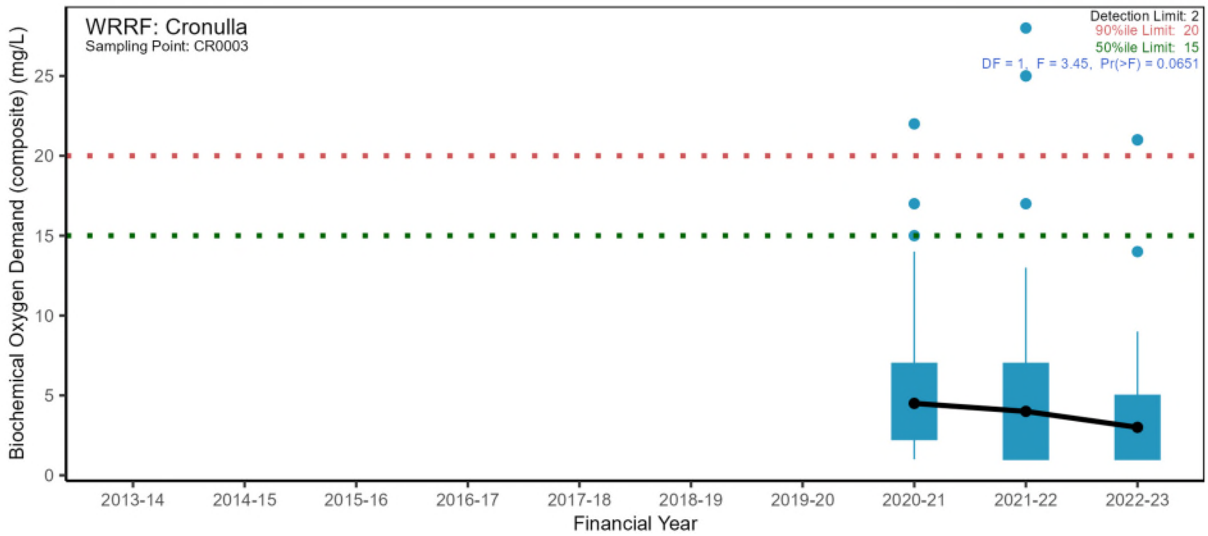
Inflow/ Discharge volume and rainfall

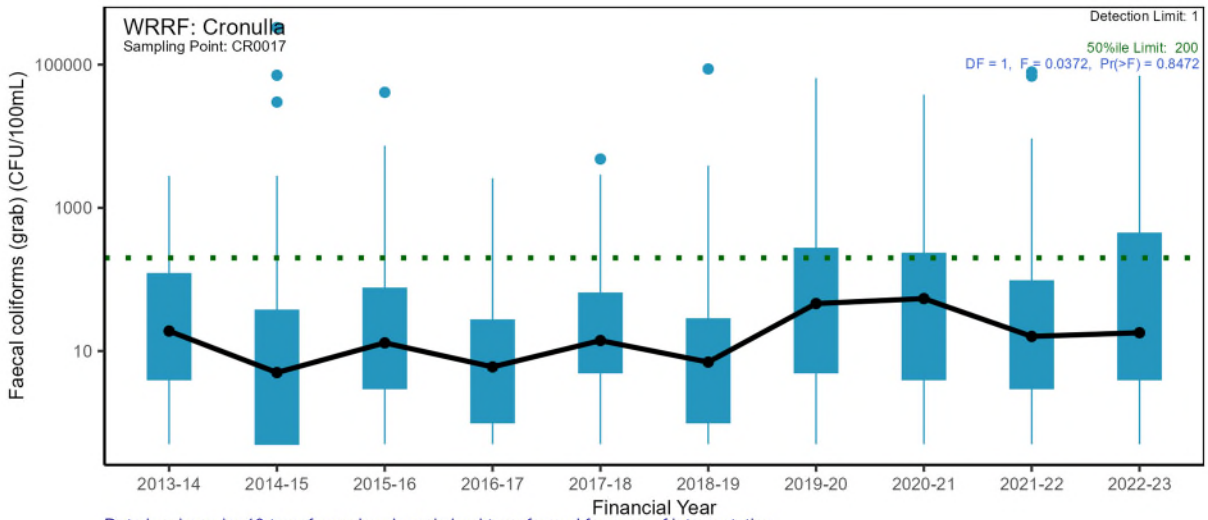


D-3.2 Pressure – Wastewater quality

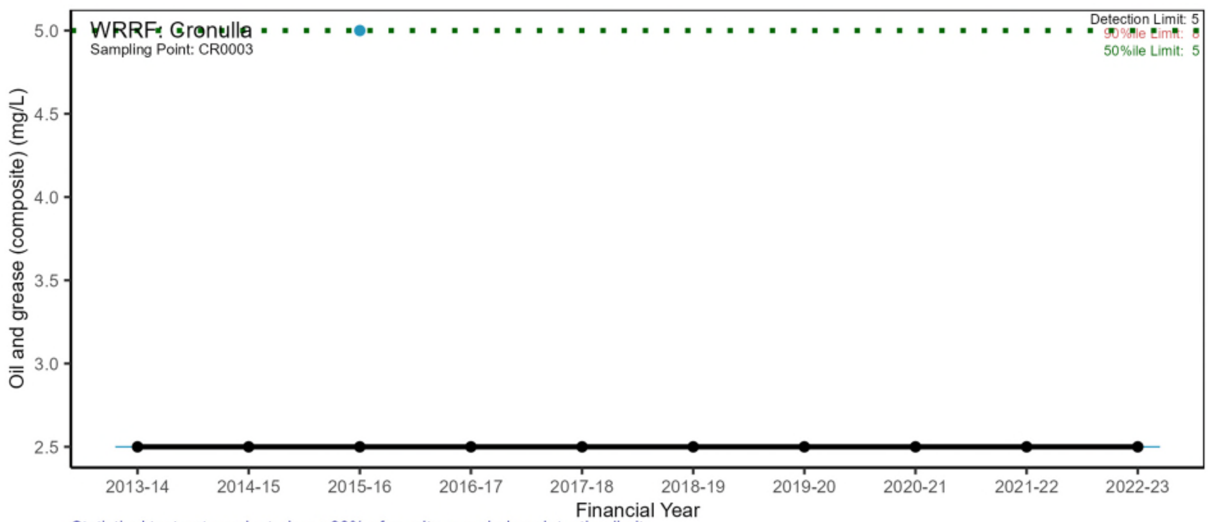
Nutrients



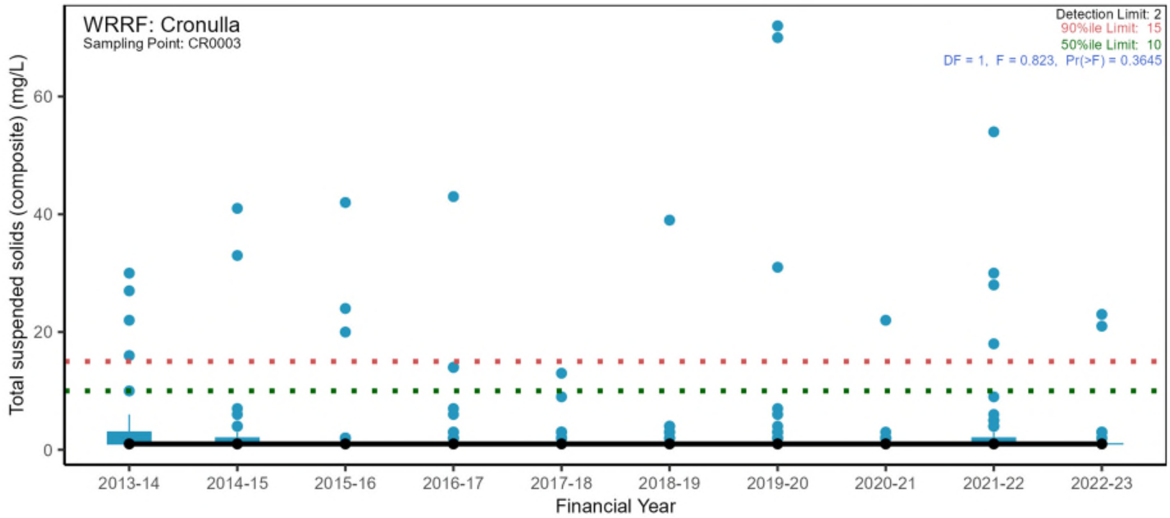




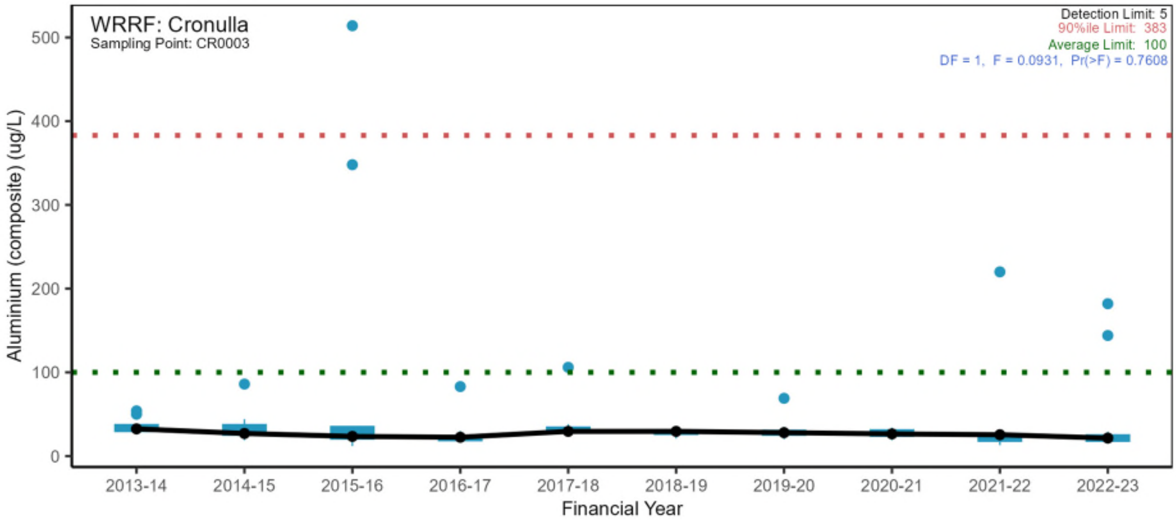
Data has been log10 transformed and y-axis backtransformed for ease of interpretation.

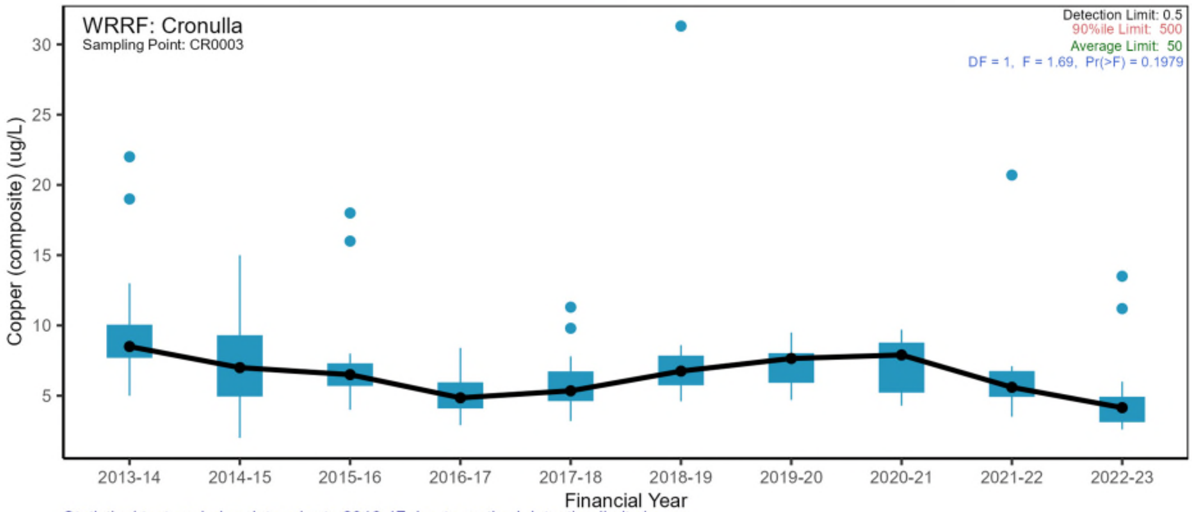


Statistical test not conducted as >90% of results were below detection limits

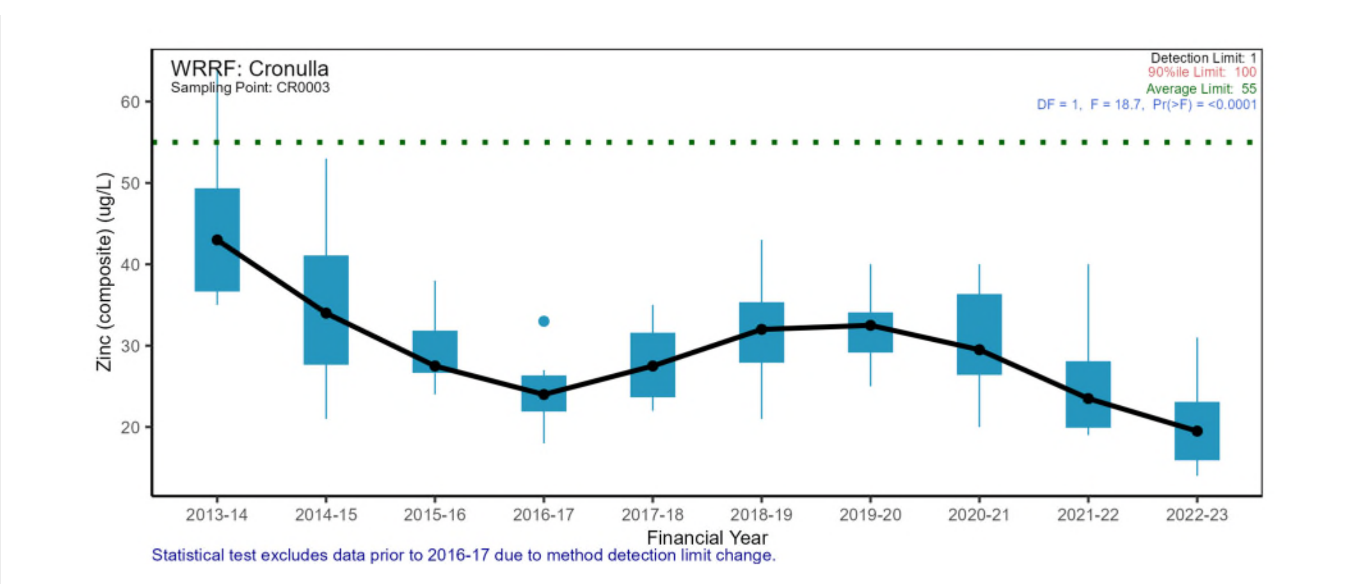


Trace metals

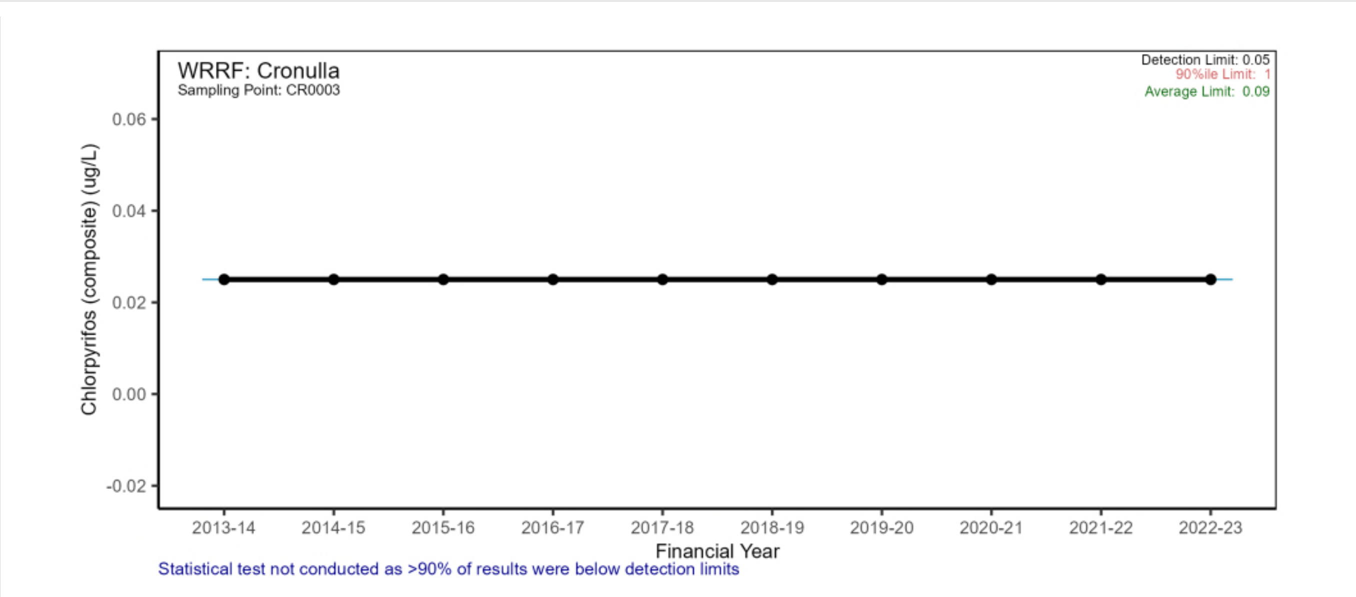


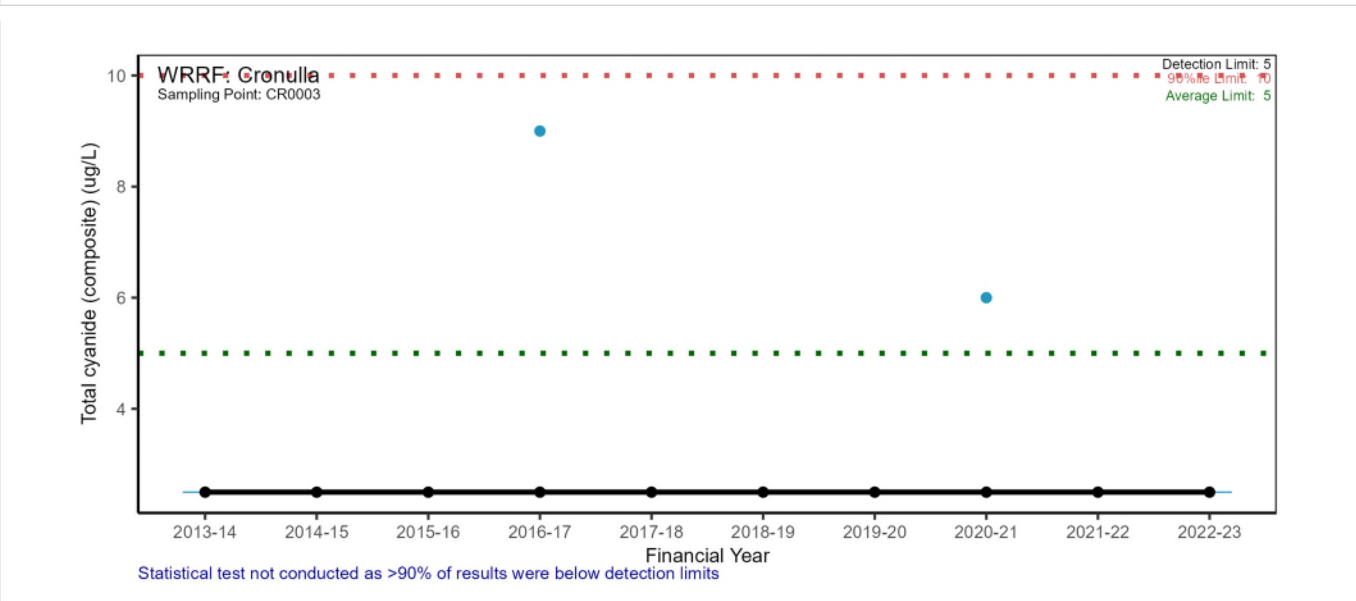


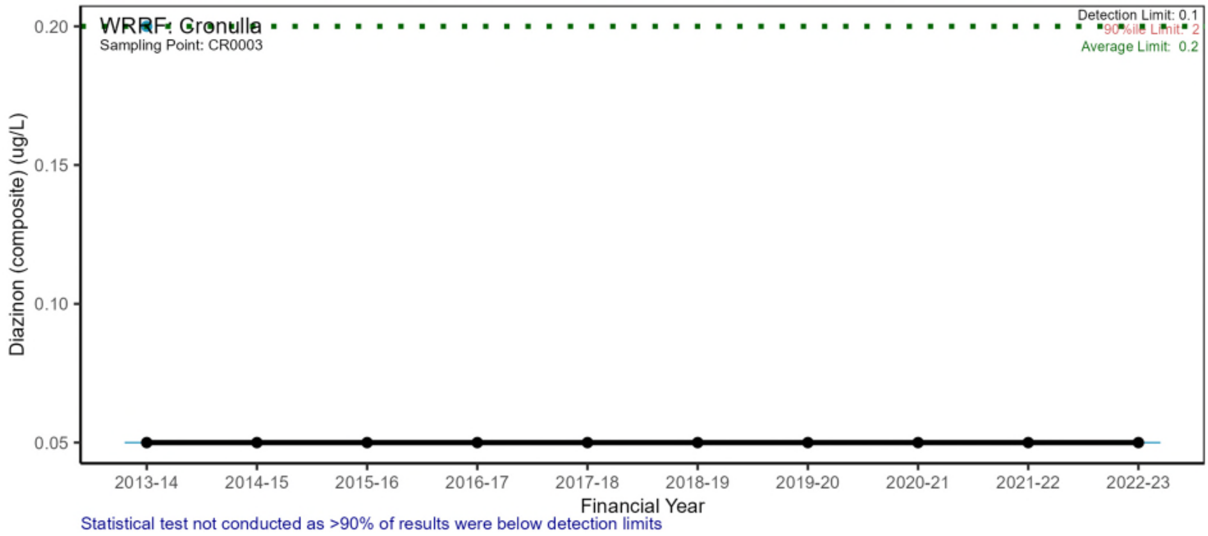
Statistical test excludes data prior to 2016-17 due to method detection limit change.

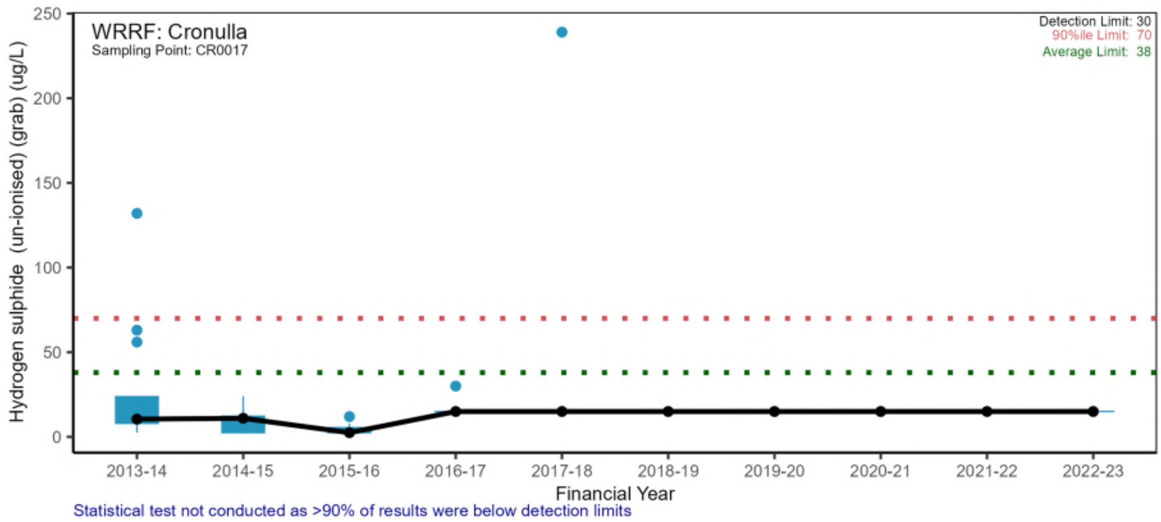


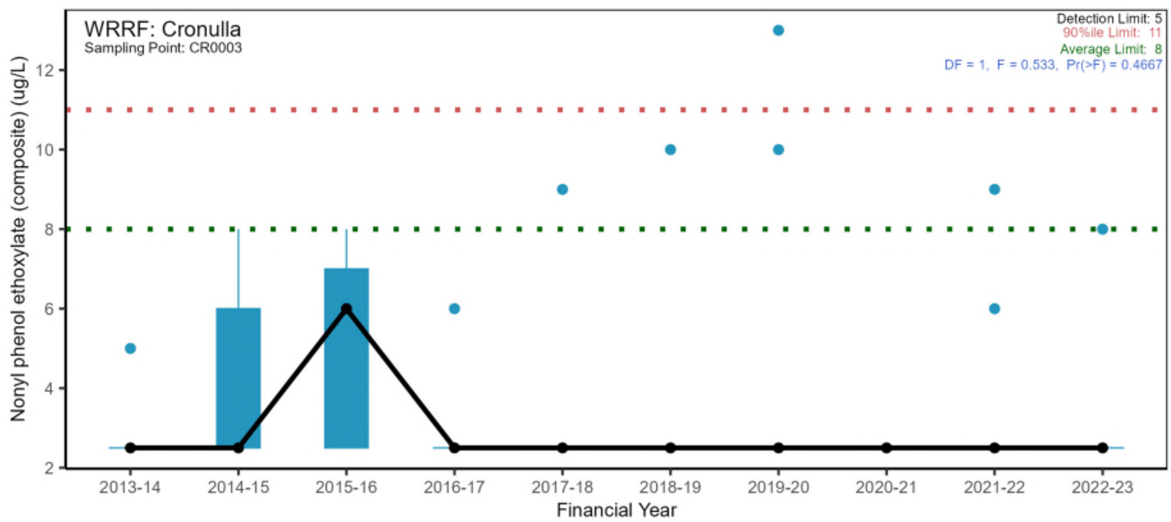
Other chemicals and organics (including pesticides)



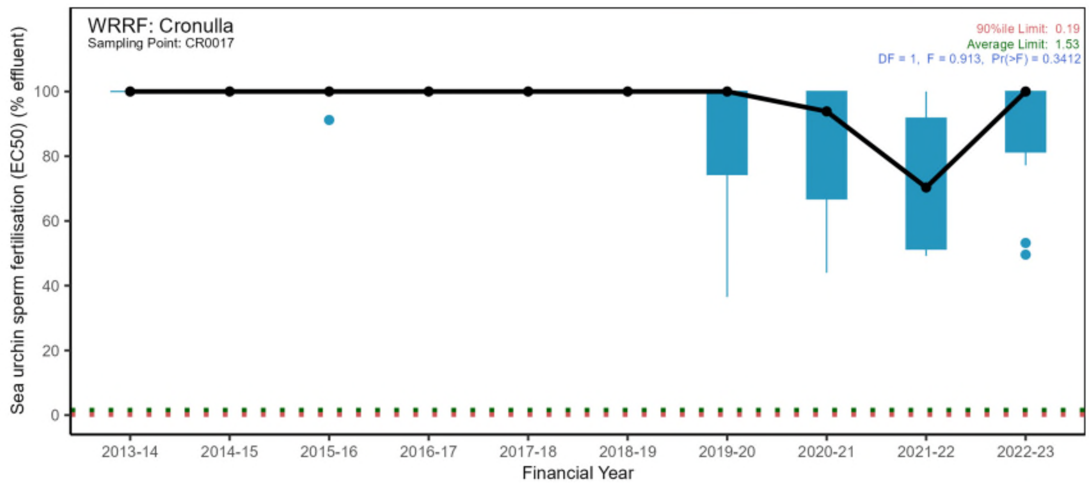



WRRF: Cronulla
Sampling Point: CR0003
Detection Limit: 0.1
90%ile Limit: 2
Average Limit: 0.2
Diazinon (composite) (ug/L)
0.20
0.15
0.10
0.05
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Financial Year
Statistical test not conducted as >90% of results were below detection limits


WRRF: Cronulla
Sampling Point: CR0017
Detection Limit: 30
90%ile Limit: 70
Average Limit: 38
Hydrogen sulphide (un-ionised) (grab) (ug/L)
250
200
150
100
50
0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Financial Year
Statistical test not conducted as >90% of results were below detection limits

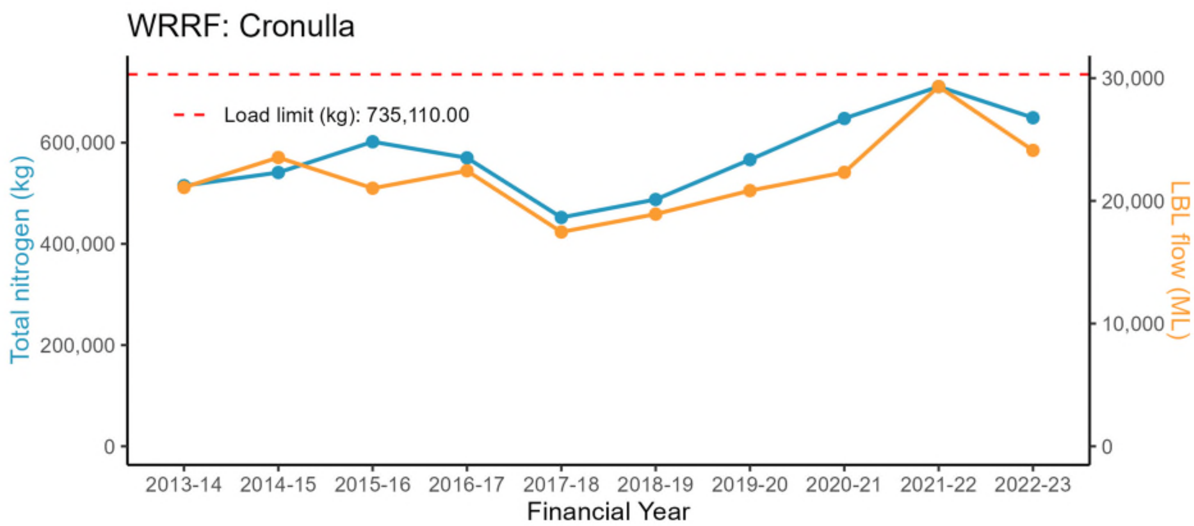

WRRF: Cronulla
Sampling Point: CR0003
Detection Limit: 5
90%ile Limit: 11
Average Limit: 8
DF = 1, F = 0.533, Pr(>F) = 0.4667
Nonyl phenol ethoxylate (composite) (ug/L)
12
10
8
6
4
2
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Financial Year

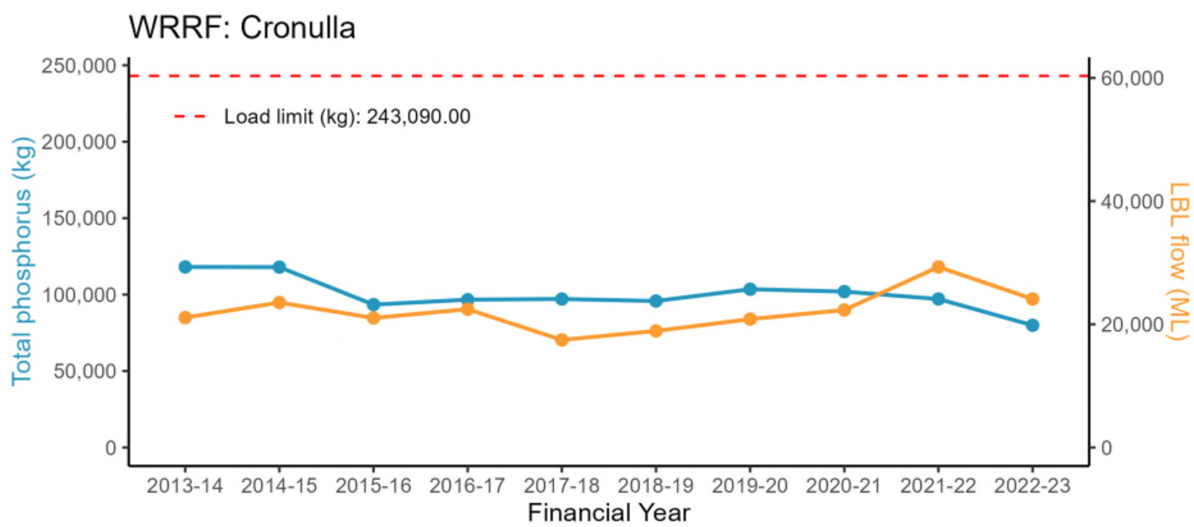
D-3.3 Pressure – Wastewater toxicity



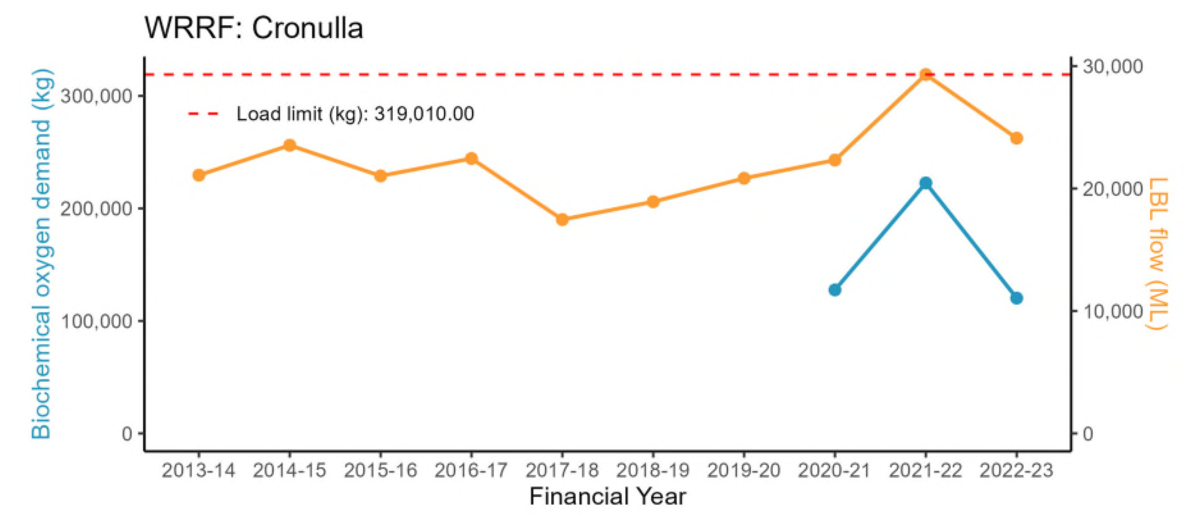
D-3.4 Pressure – Wastewater discharge load

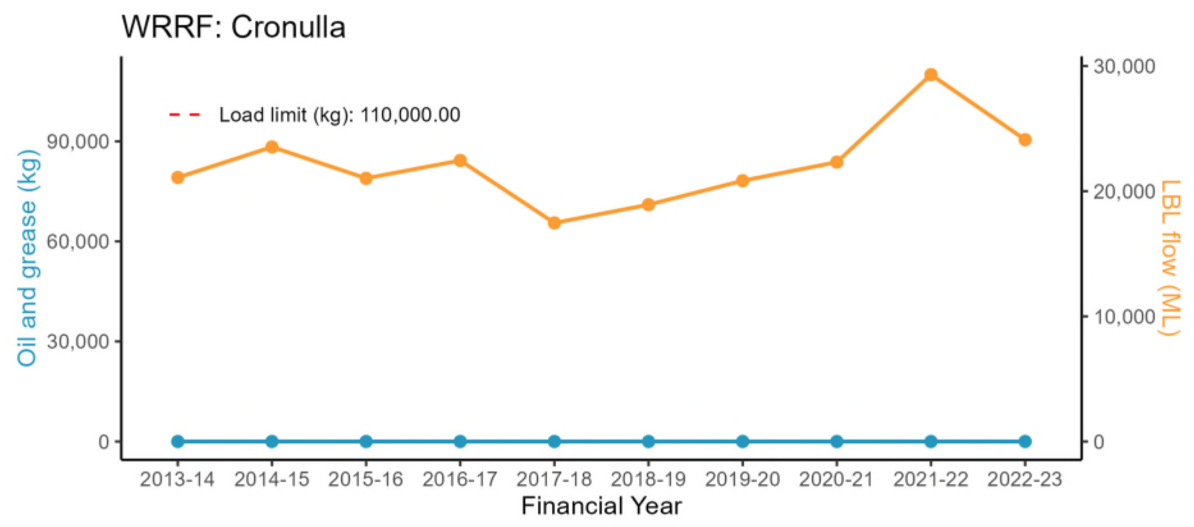
Nutrients

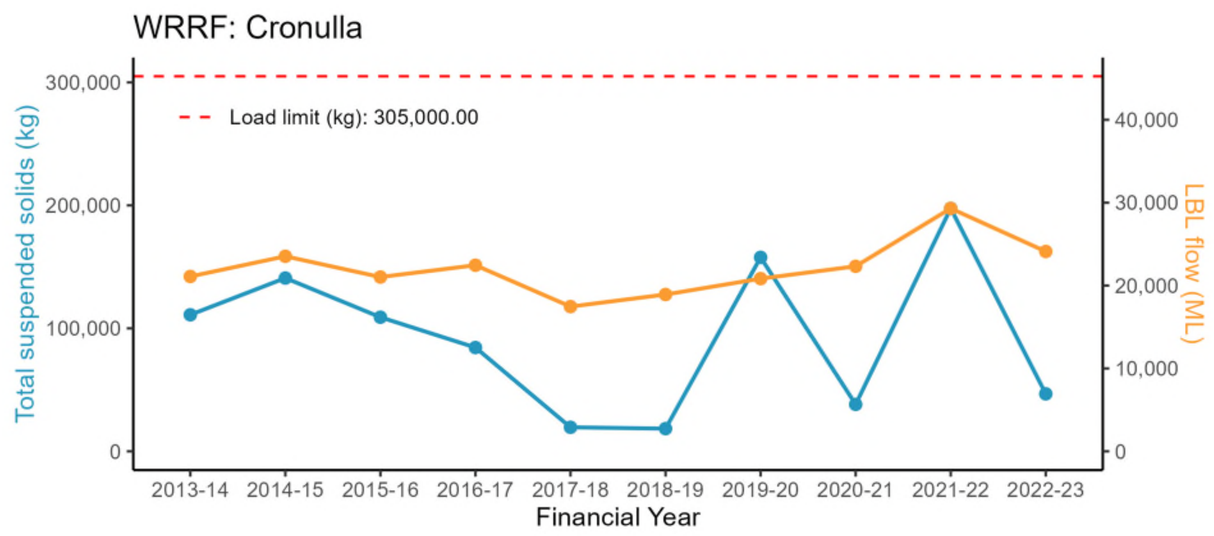




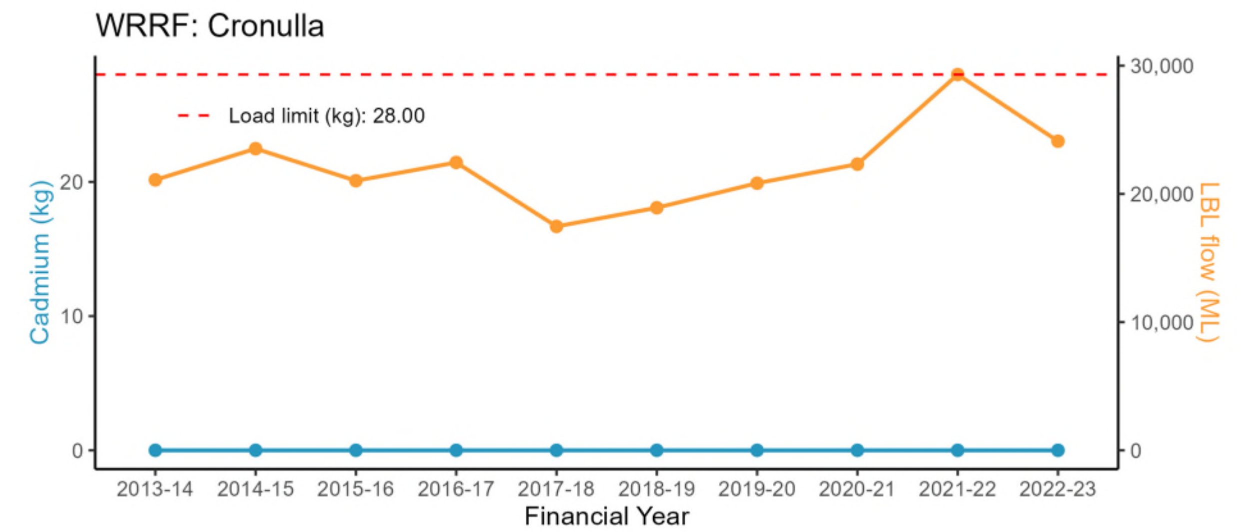
Major conventional analytes

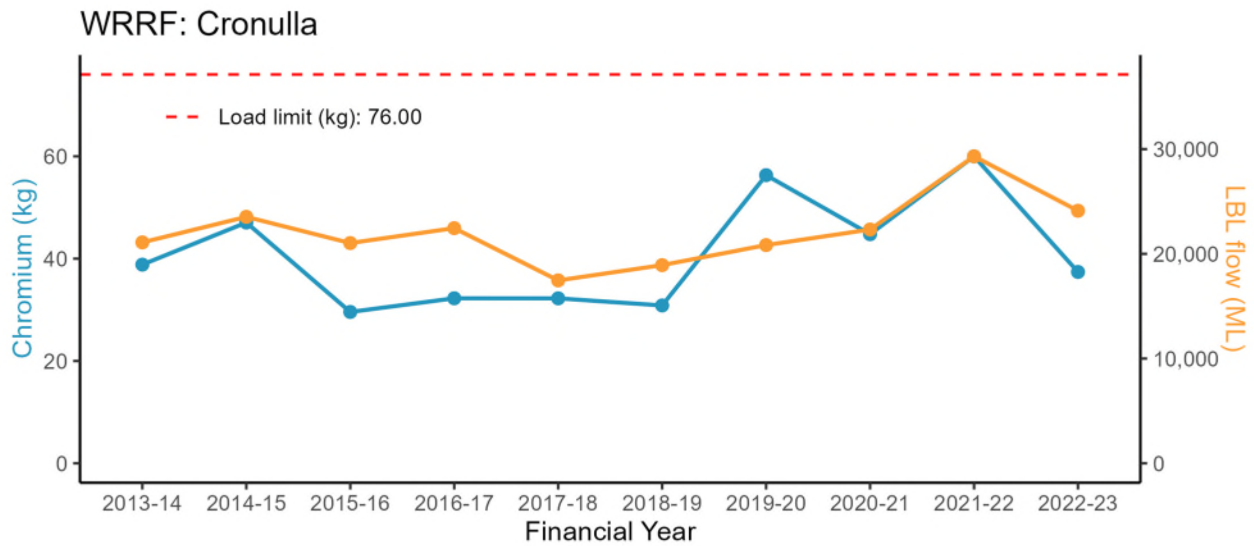


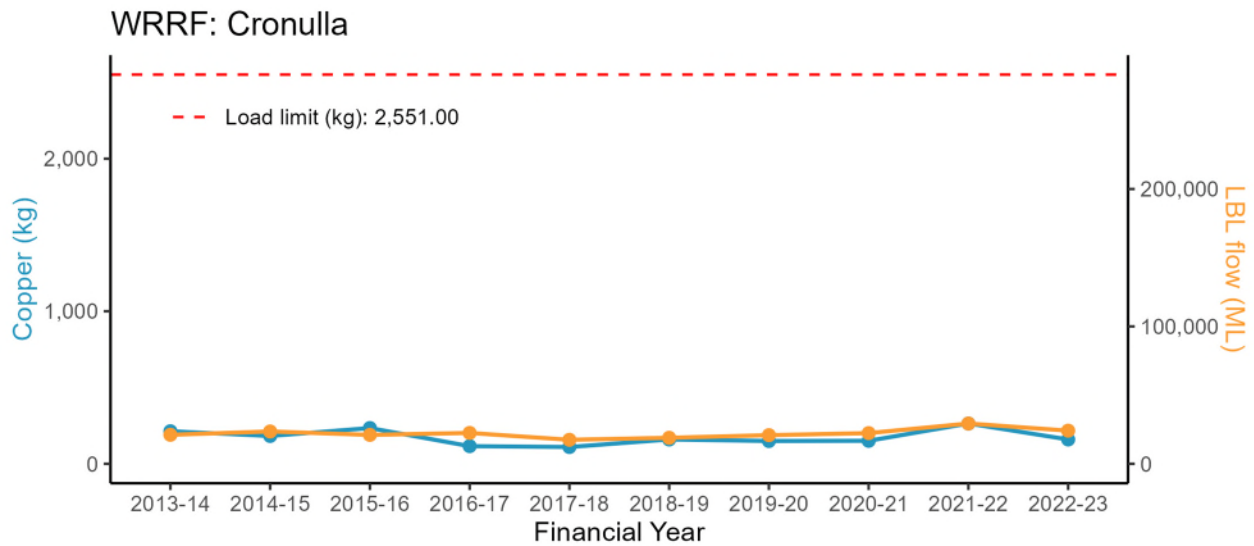


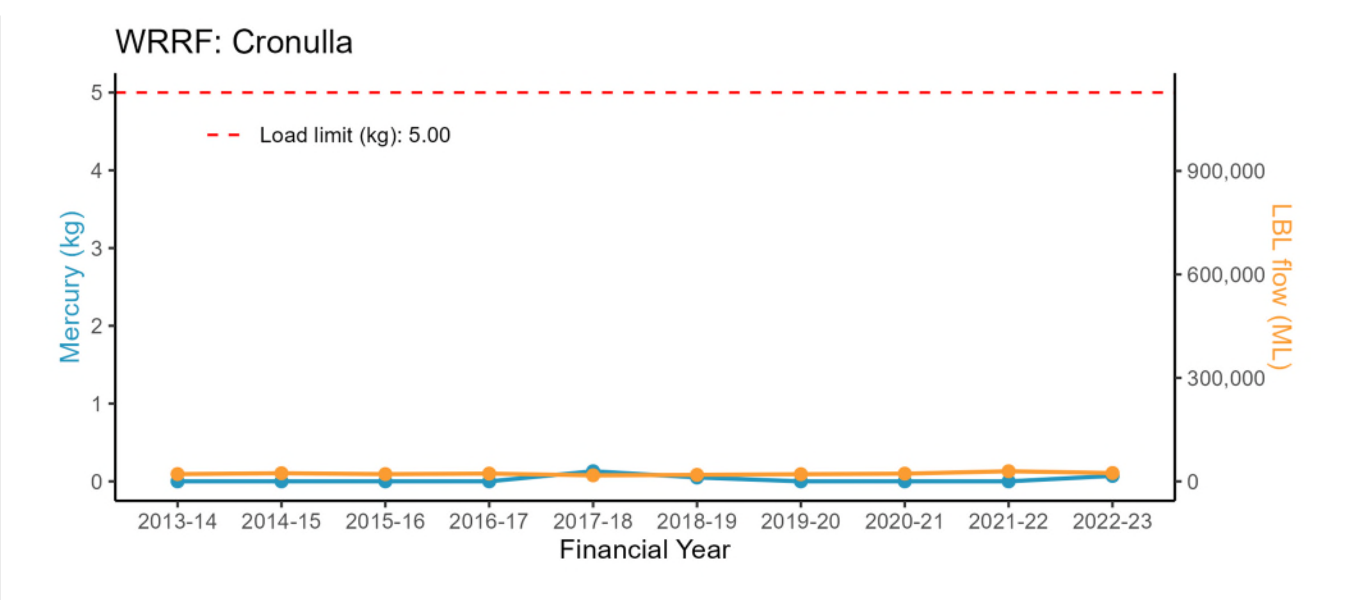


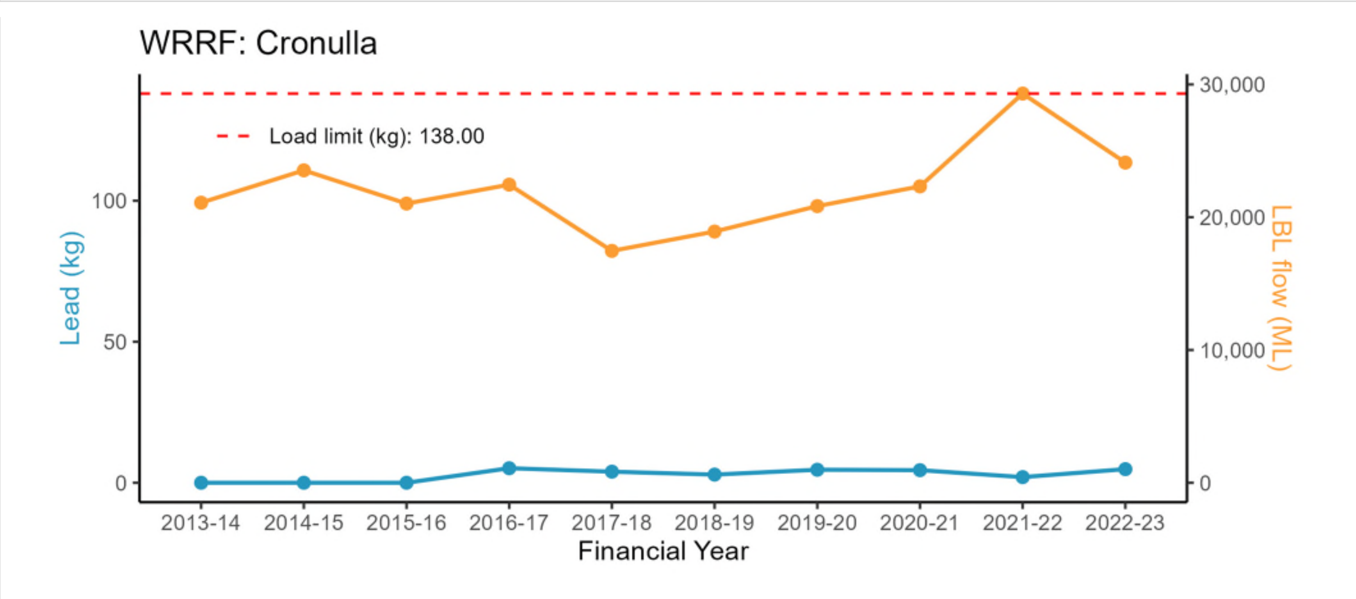
Trace metals

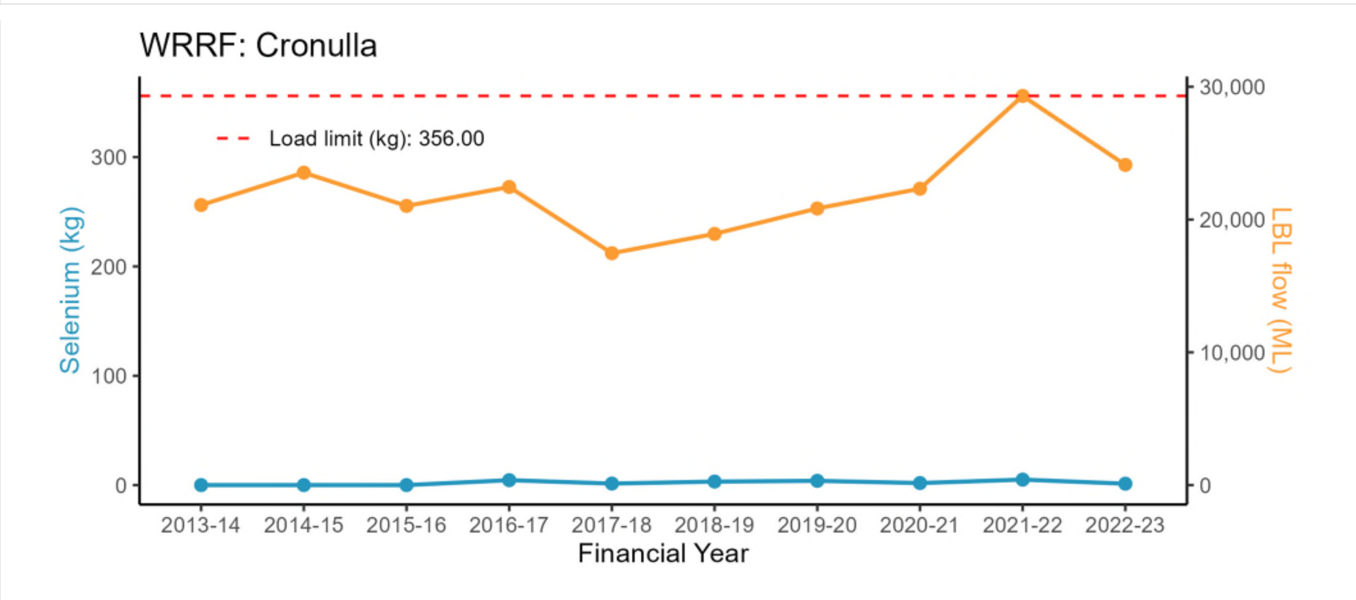


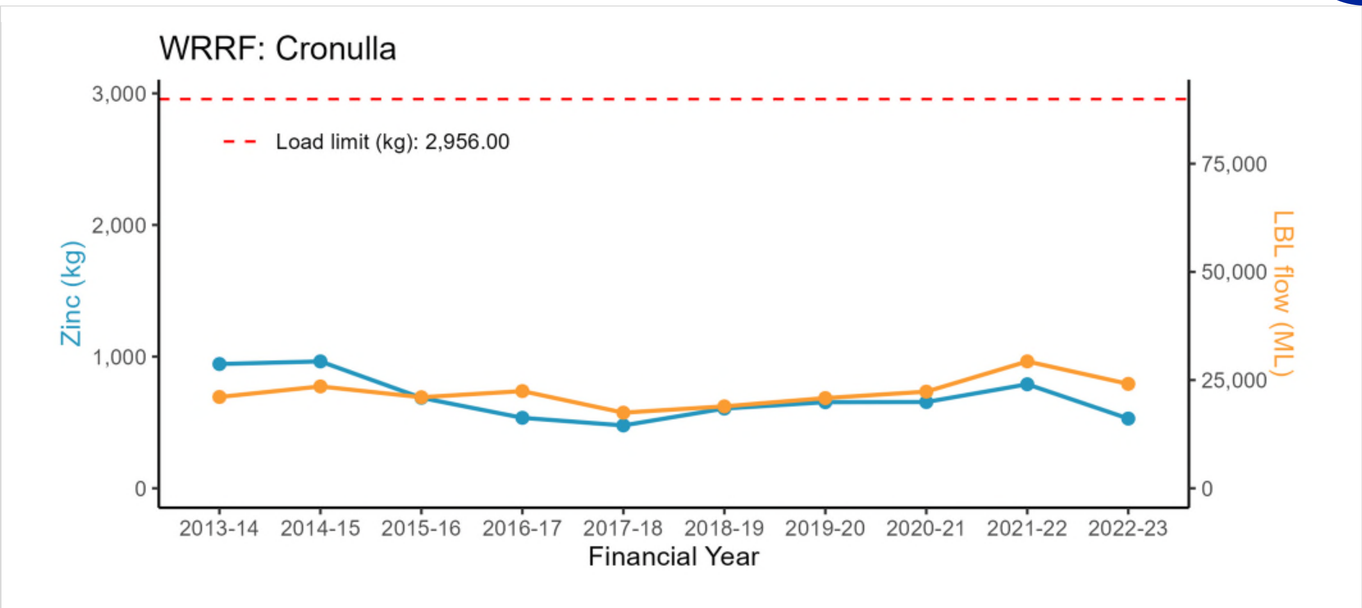




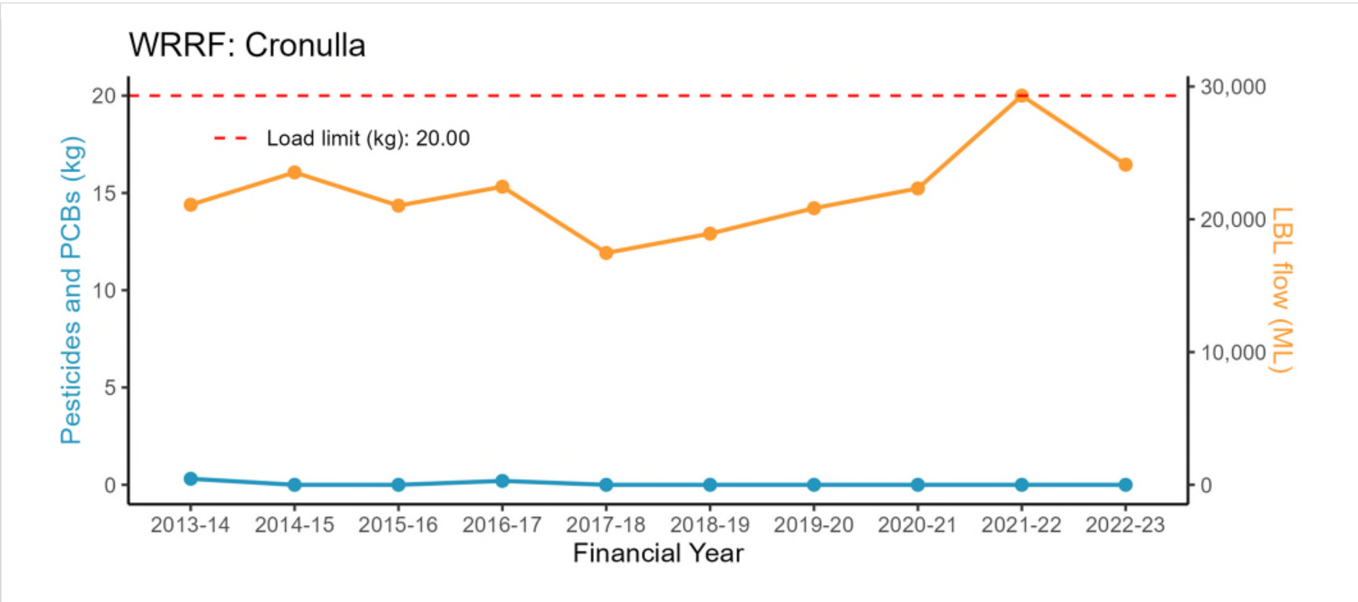

WRRF: Cronulla
Load limit (kg): 5.00
Mercury (kg)
LBL flow (ML)
Financial Year
5
4
3
2
1
0
900,000
600,000
300,000
0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23


WRRF: Cronulla
Load limit (kg): 138.00
Lead (kg)
LBL flow (ML)
Financial Year
100
50
0
30,000
20,000
10,000
0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23


WRRF: Cronulla
Load limit (kg): 356.00
Selenium (kg)
LBL flow (ML)
Financial Year
300
200
100
0
30,000
20,000
10,000
0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23



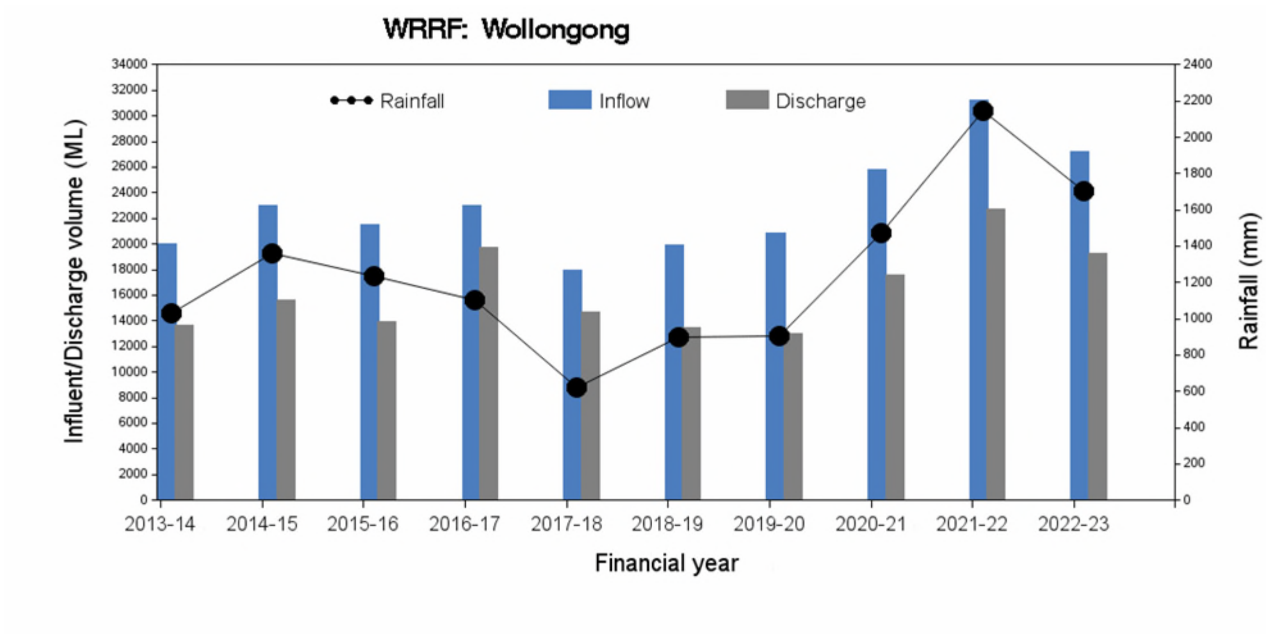
Other chemicals and organics (including pesticides)

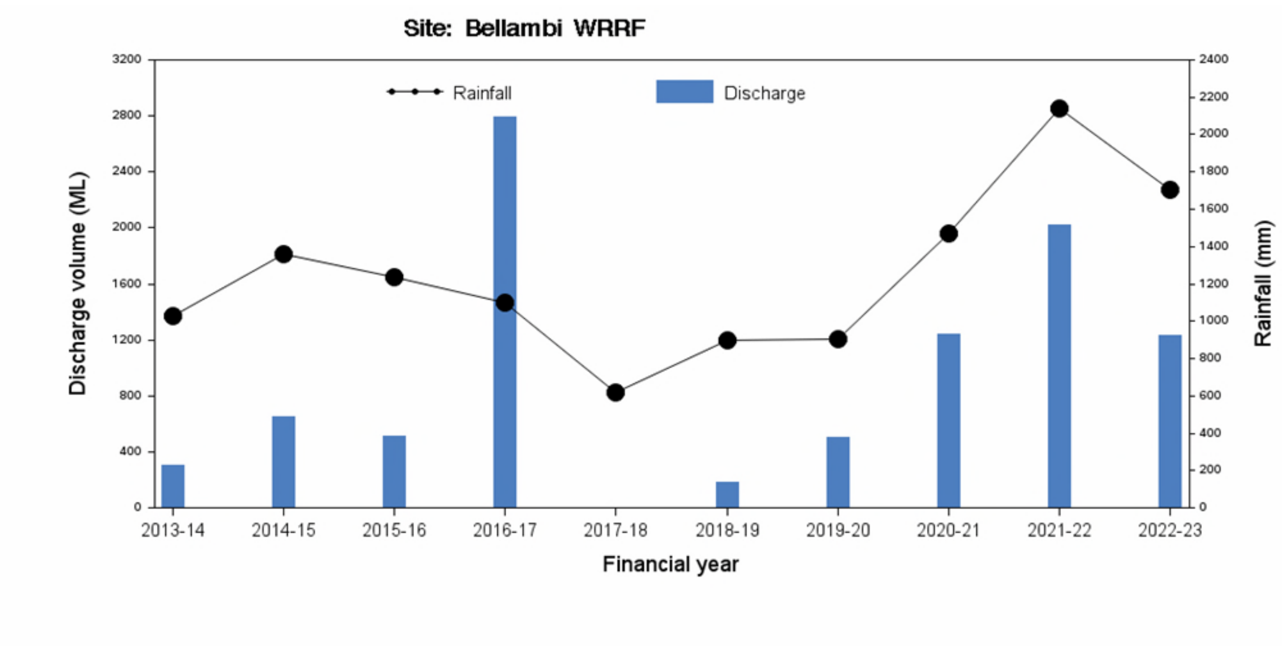


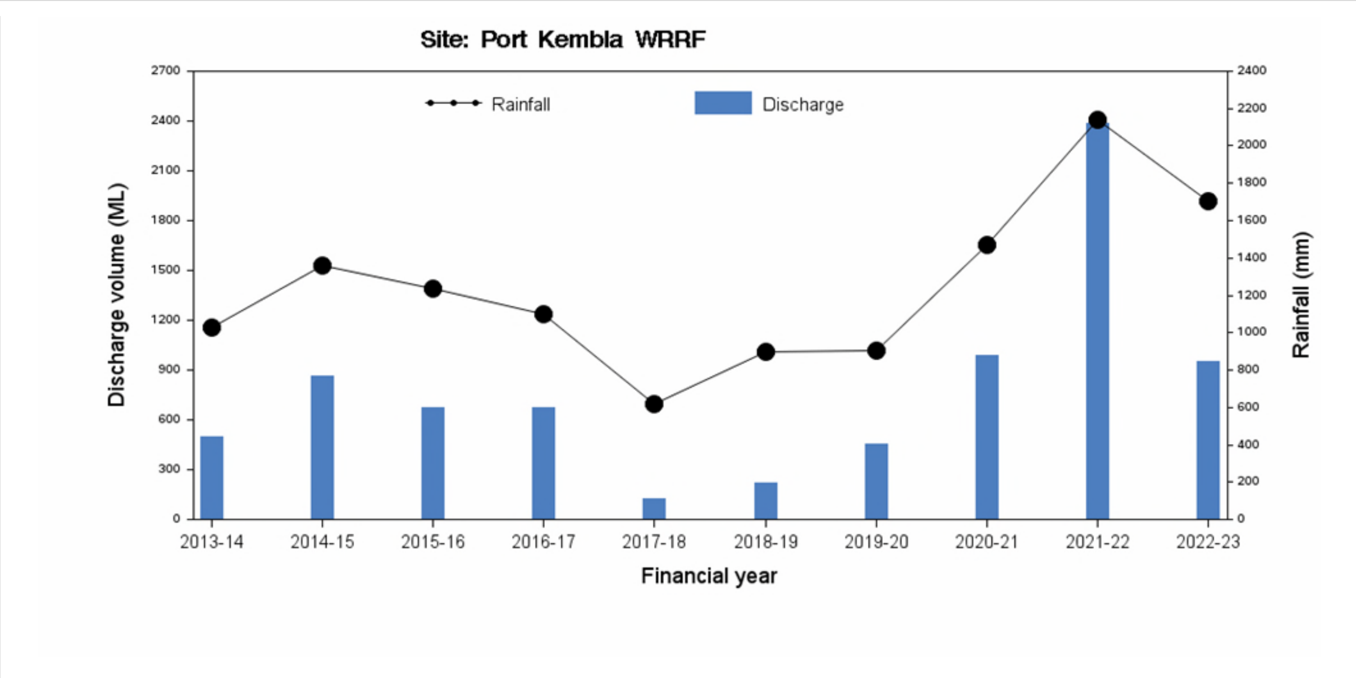
D-4 Wollongong WRRF

D-4.1 Pressure – Wastewater quantity

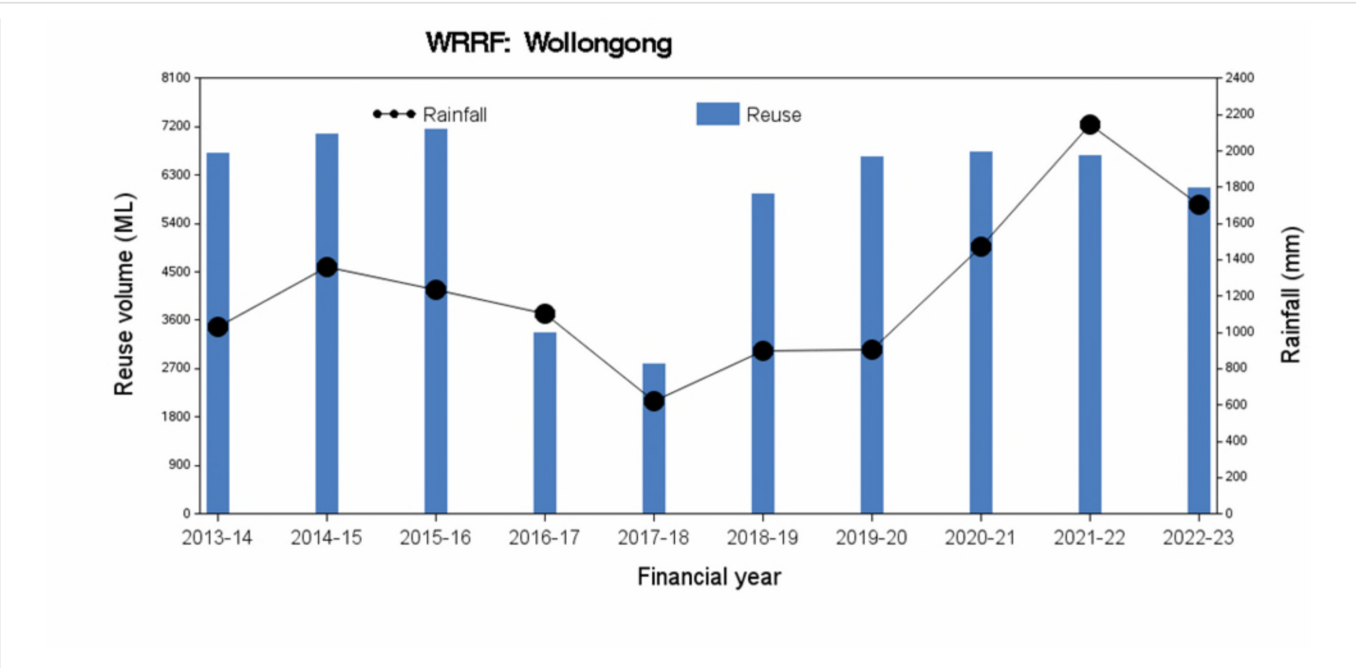
Inflow/ Discharge volume and rainfall





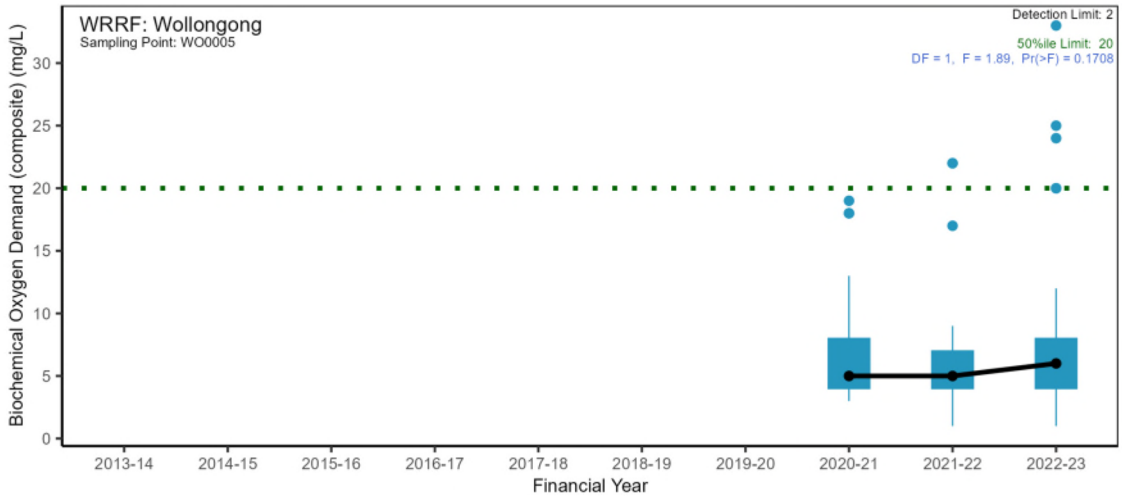


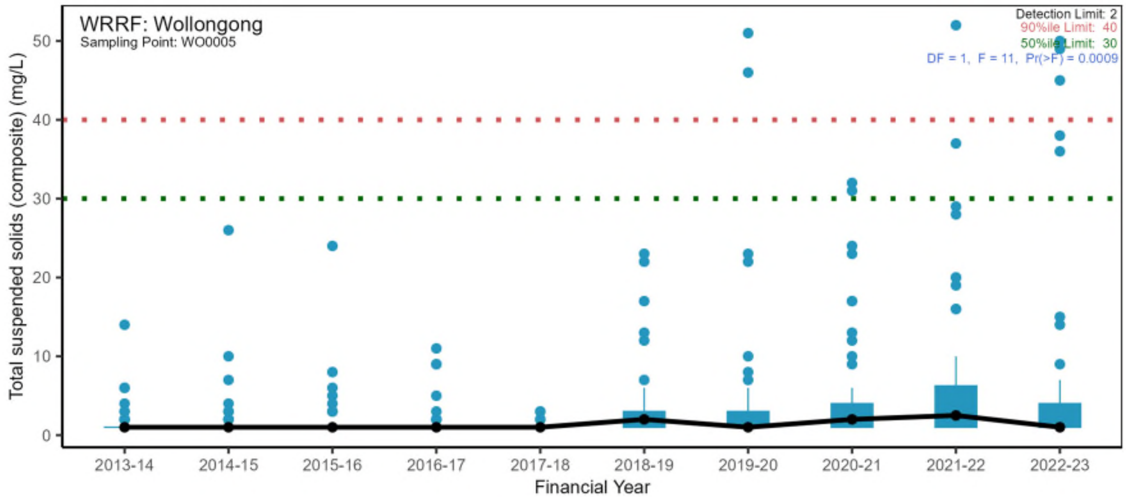
Reuse volume and rainfall



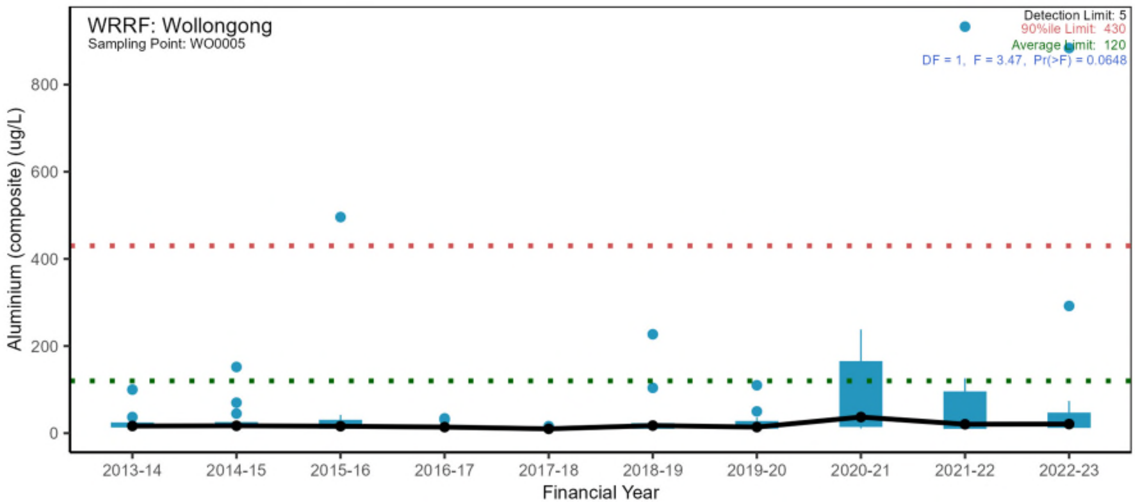
D-4.2 Pressure – Wastewater quality

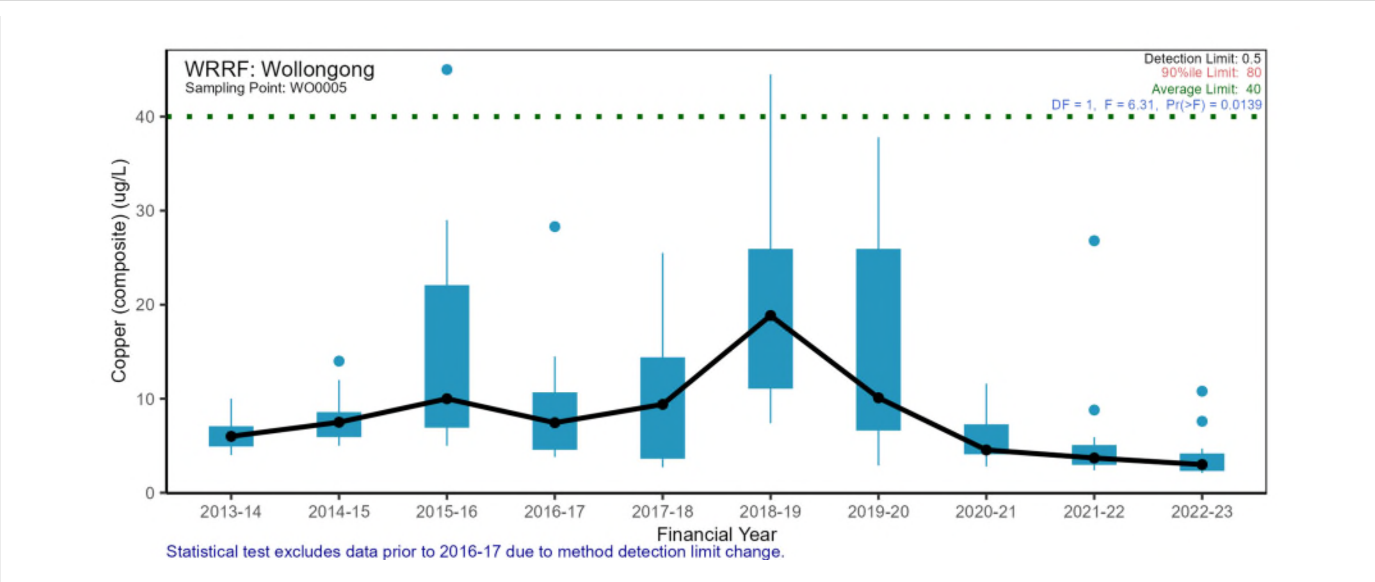
Major conventional analytes



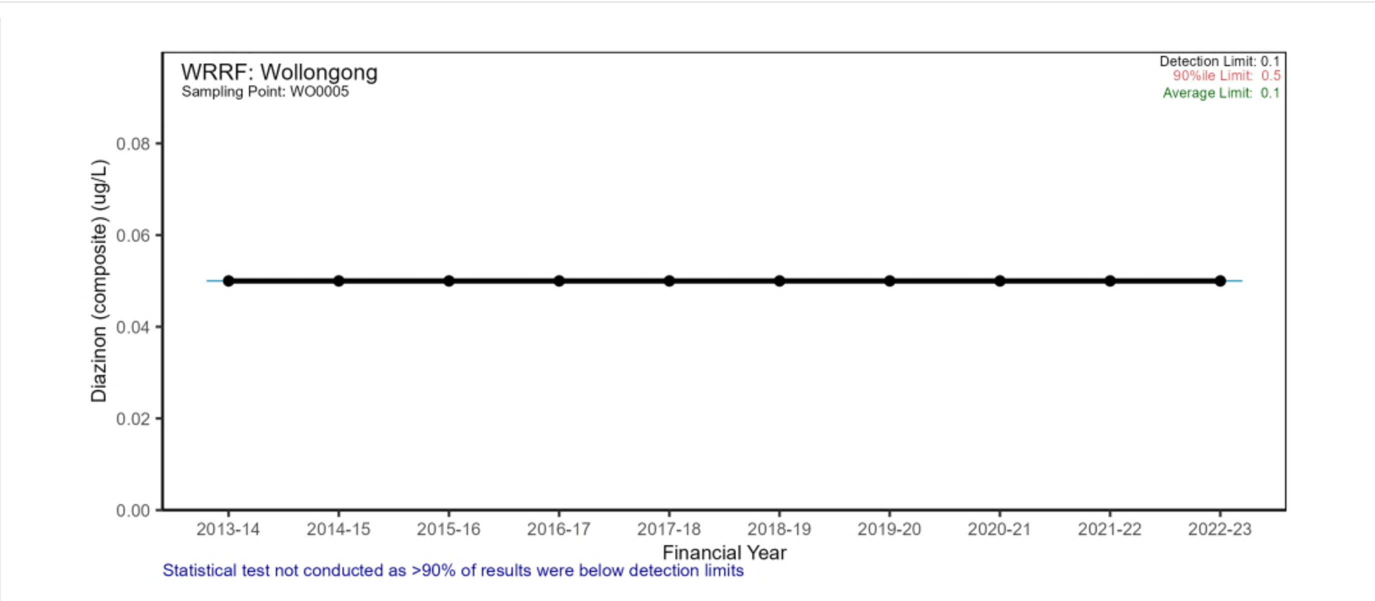


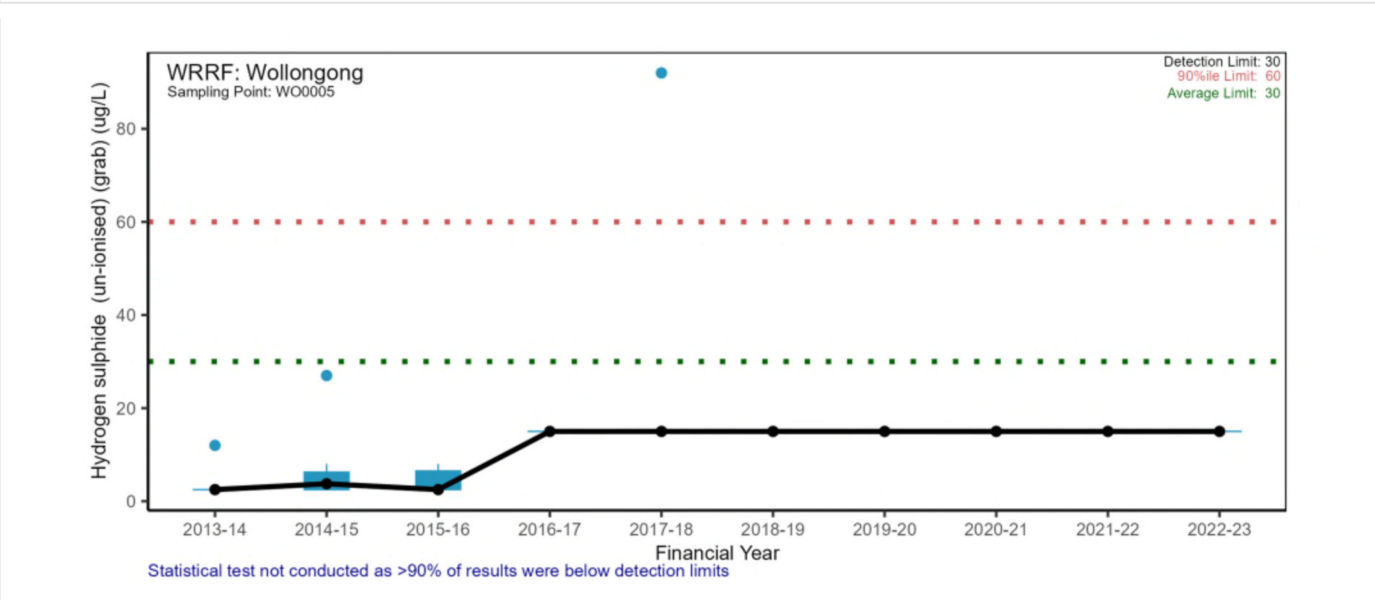
Trace metals





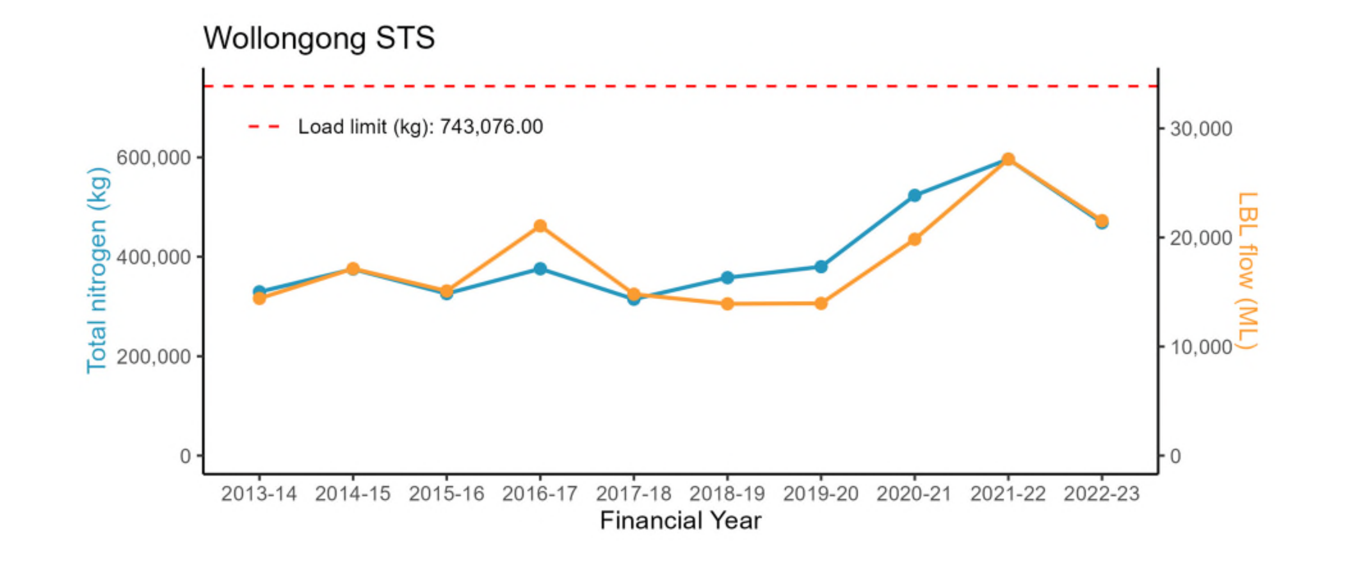
Other chemicals and organics (including pesticides)

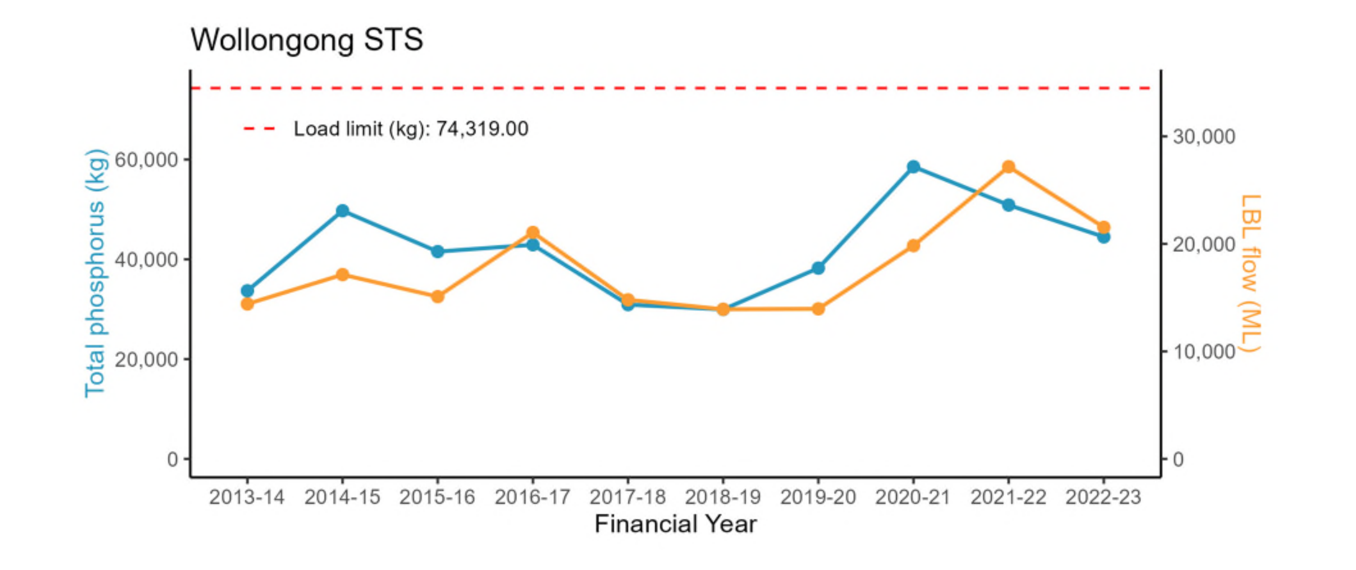




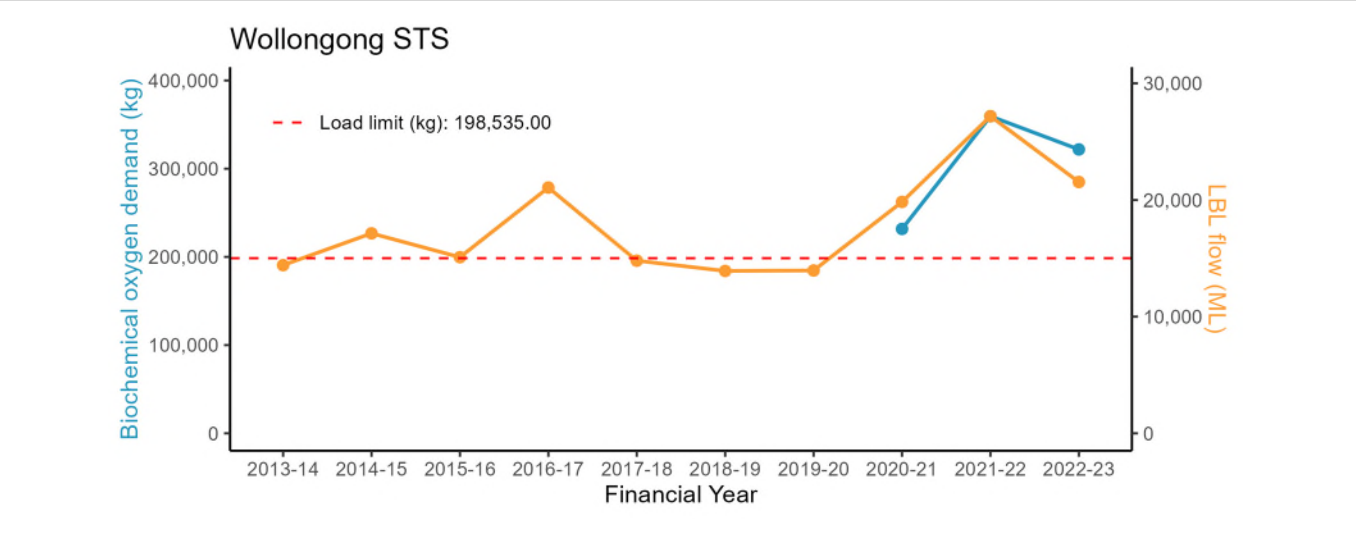
D-4.3 Pressure – Wastewater discharge load

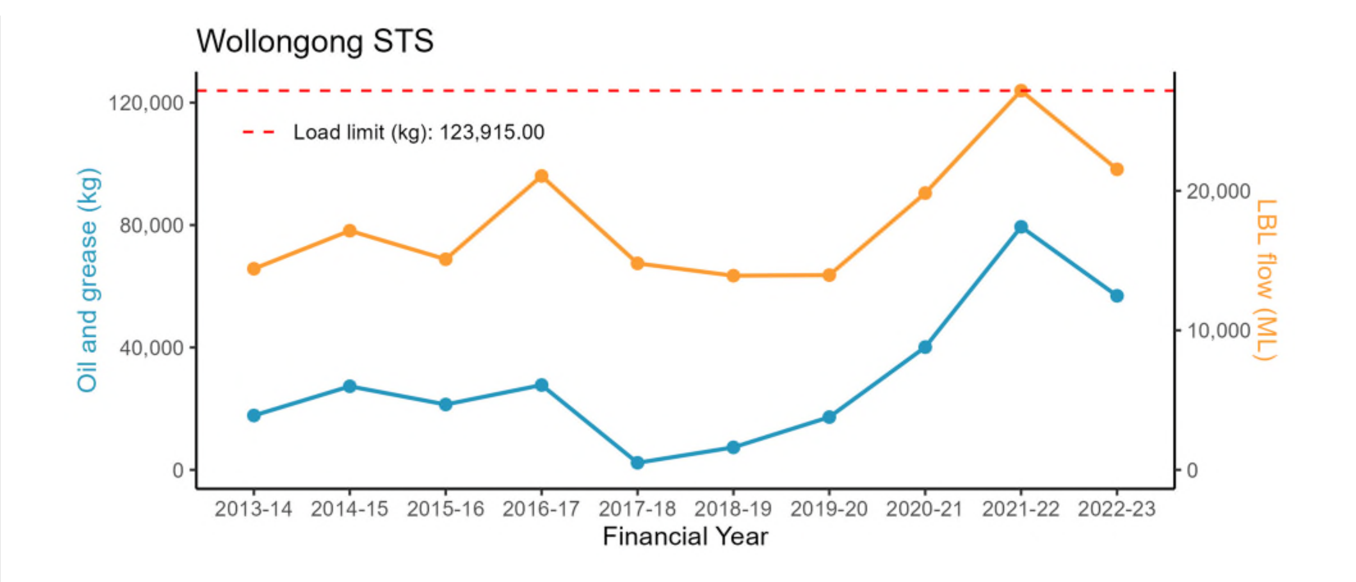
Nutrients

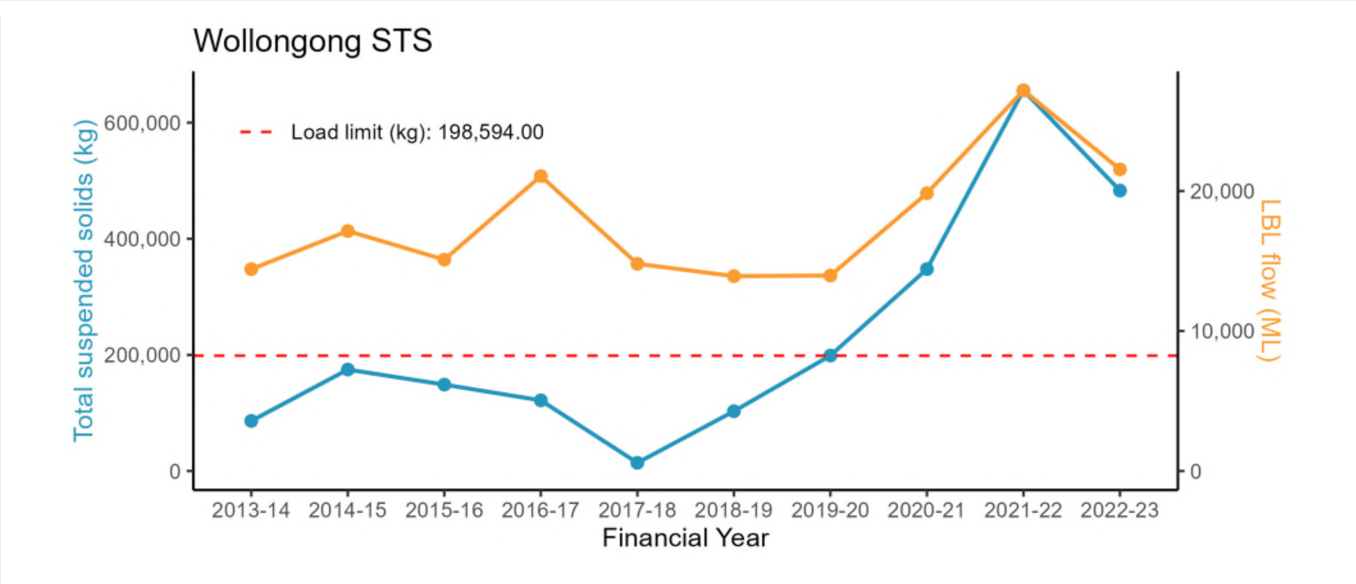




Major conventional analytes



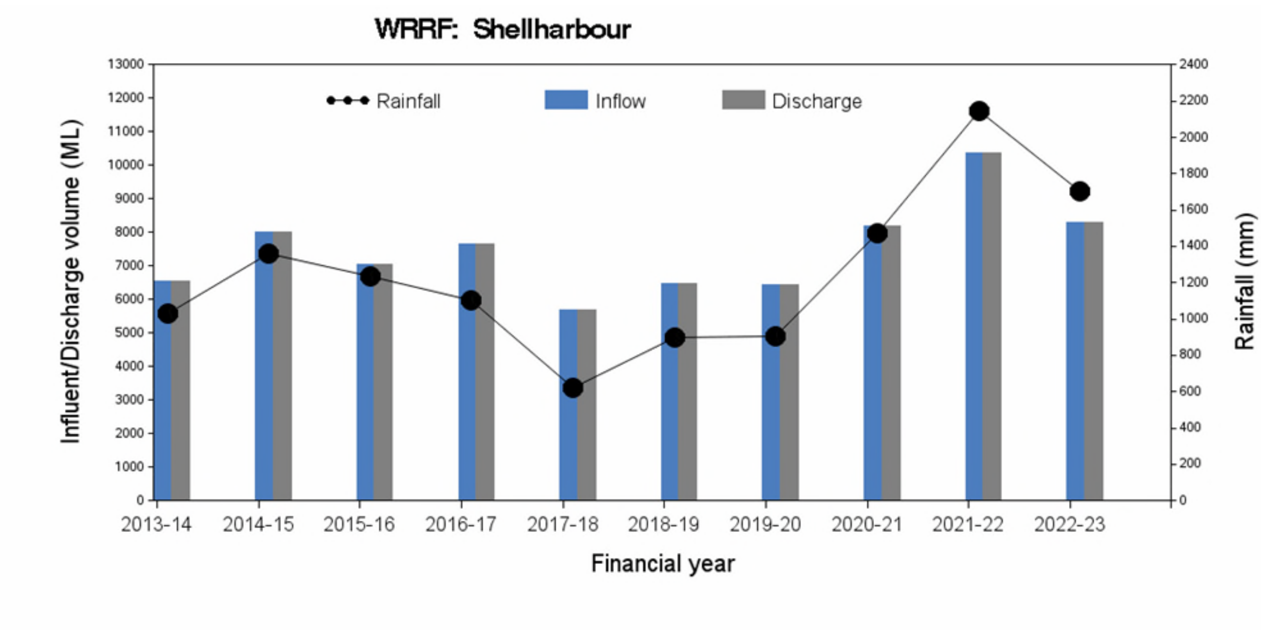

Wollongong STS
Load limit (kg): 123,915.00
Oil and grease (kg)
LBL flow (ML)
120,000
80,000
40,000
0
20,000
10,000
0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Financial Year


Wollongong STS
Load limit (kg): 198,594.00
Total suspended solids (kg)
LBL flow (ML)
600,000
400,000
200,000
0
20,000
10,000
0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Financial Year

D-5 Shellharbour WRRF

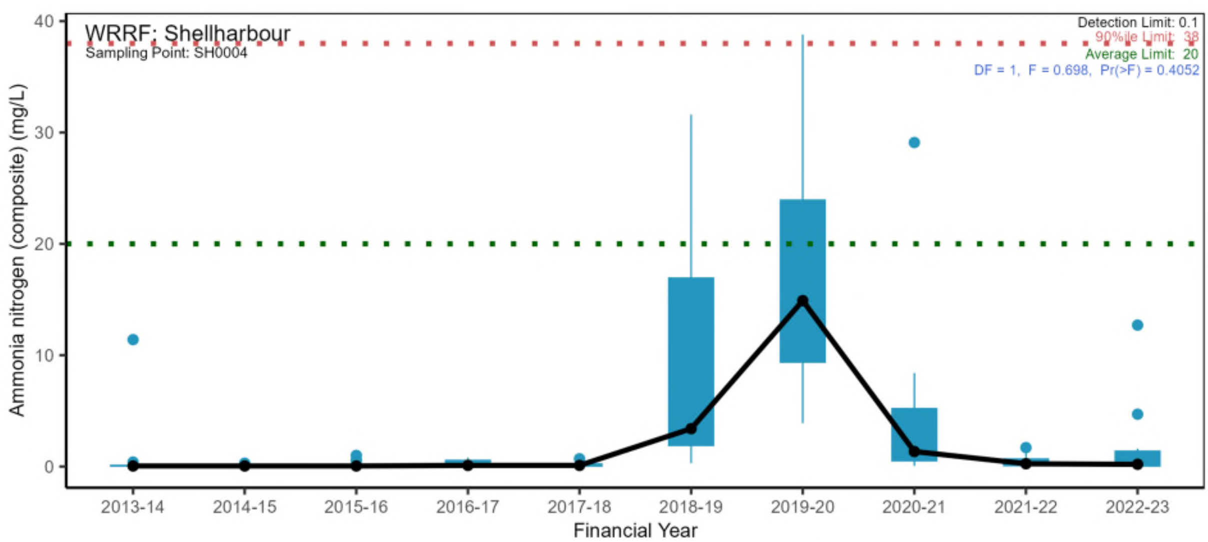
D-5.1 Pressure – Wastewater quantity

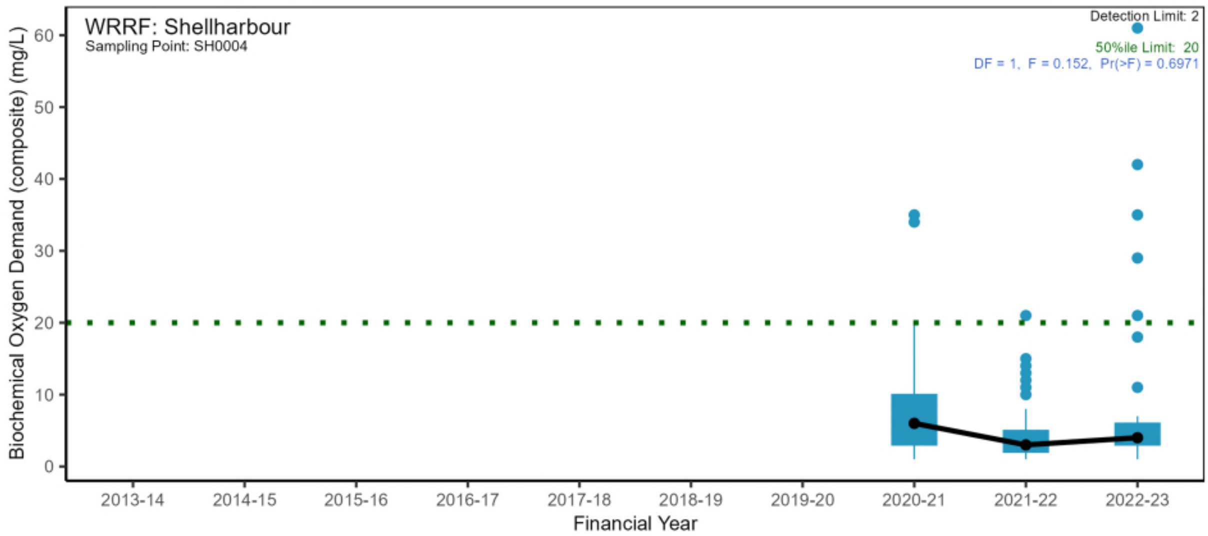
Inflow/ Discharge volume and rainfall

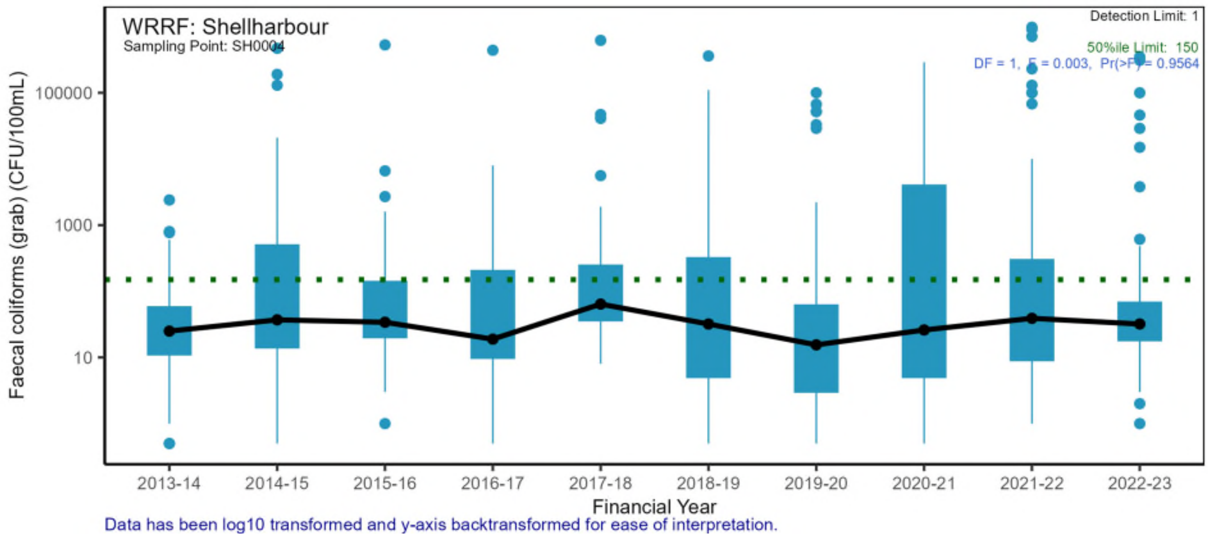


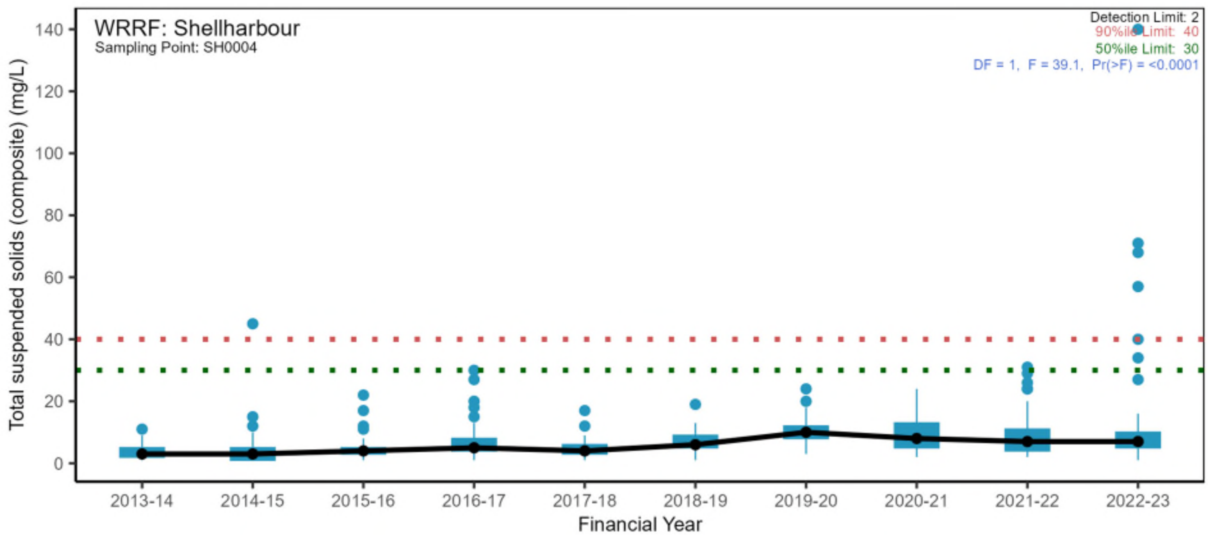
D-5.2 Pressure – Wastewater quality

Nutrients

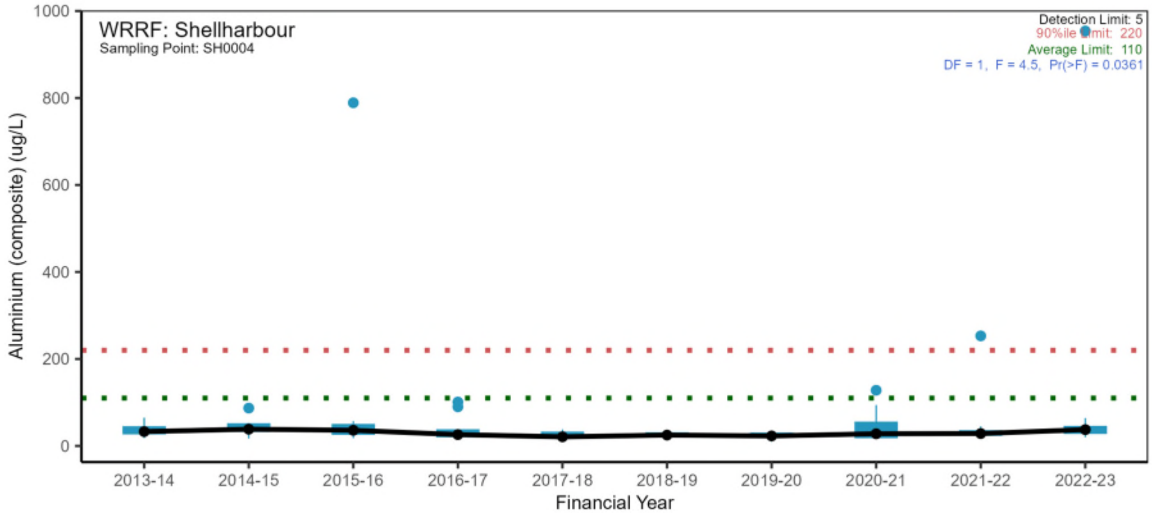


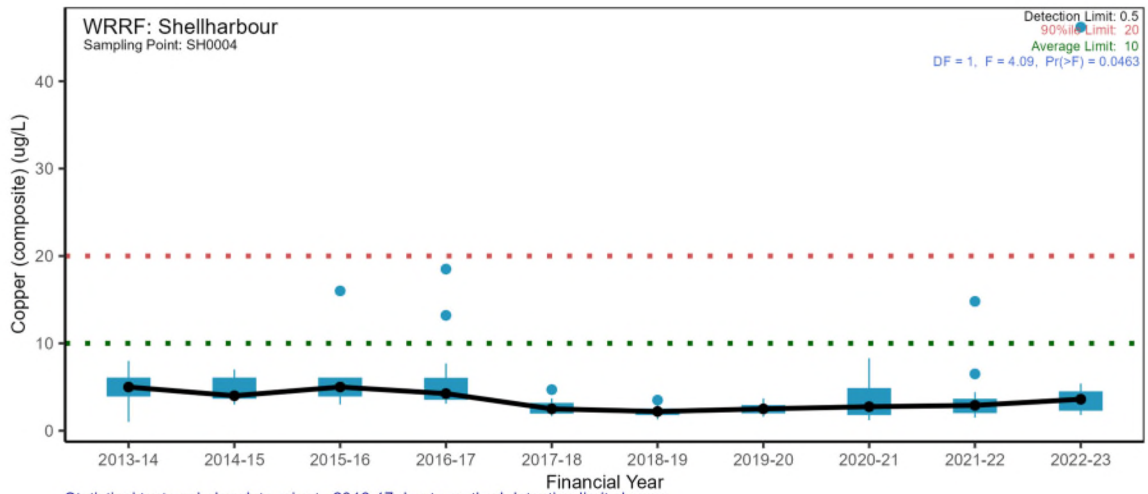

WRRF: Shellharbour
Sampling Point: SH0004
Detection Limit: 2
50%ile Limit: 20
DF = 1, F = 0.152, Pr(>F) = 0.6971
Biochemical Oxygen Demand (composite) (mg/L)
60
50
40
30
20
10
0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Financial Year


WRRF: Shellharbour
Sampling Point: SH0004
Detection Limit: 1
50%ile Limit: 150
DF = 1, F = 0.003, Pr(>F) = 0.9564
Faecal coliforms (grab) (CFU/100mL)
100000
1000
10
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Financial Year
Data has been log10 transformed and y-axis backtransformed for ease of interpretation.


WRRF: Shellharbour
Sampling Point: SH0004
Detection Limit: 2
90%ile Limit: 40
50%ile Limit: 30
DF = 1, F = 39.1, Pr(>F) = <0.0001
Total suspended solids (composite) (mg/L)
140
120
100
80
60
40
20
0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Financial Year

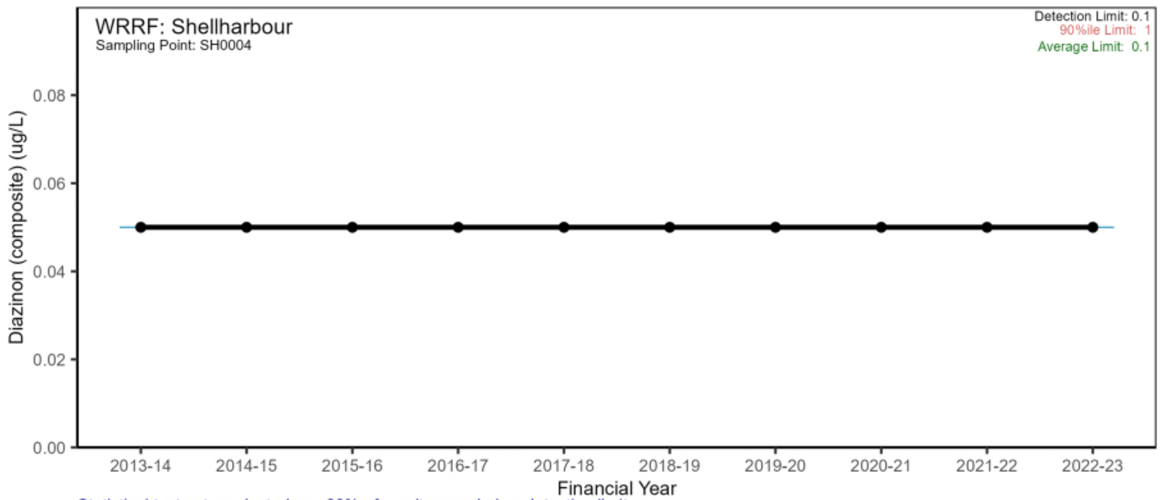
Trace metals



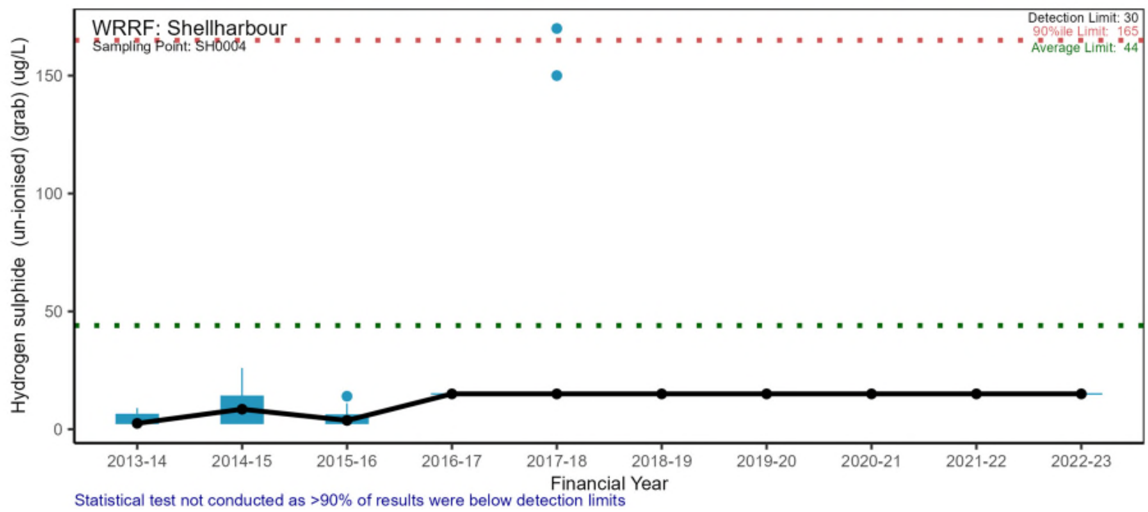


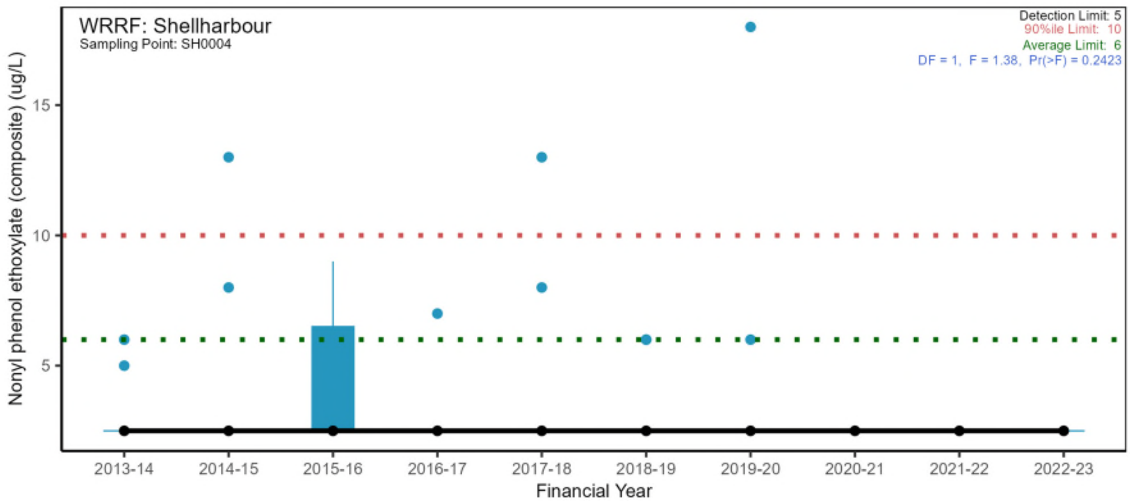
Statistical test excludes data prior to 2016-17 due to method detection limit change.

Other chemicals and organics (including pesticides)

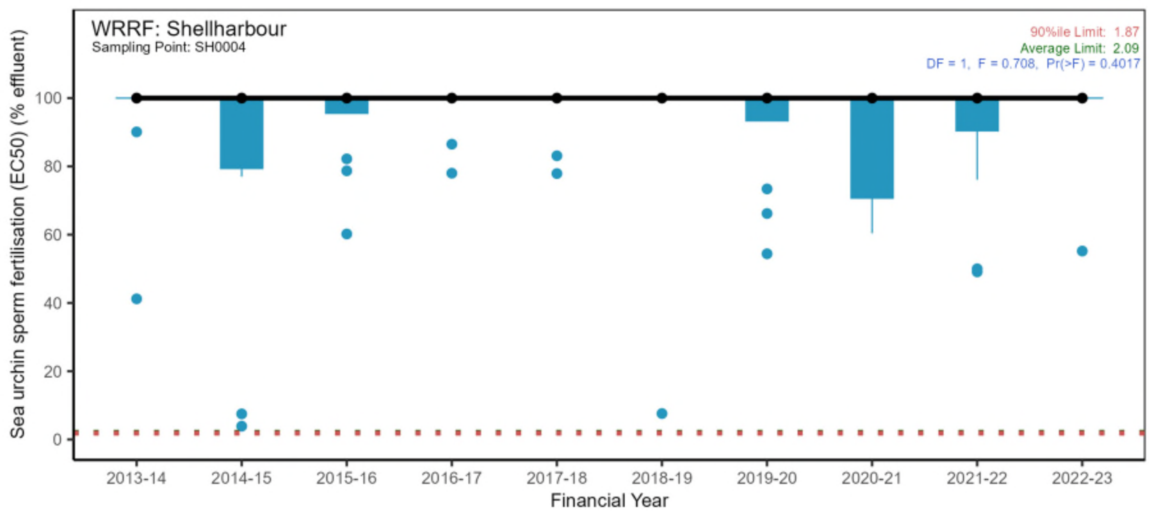


Statistical test not conducted as >90% of results were below detection limits



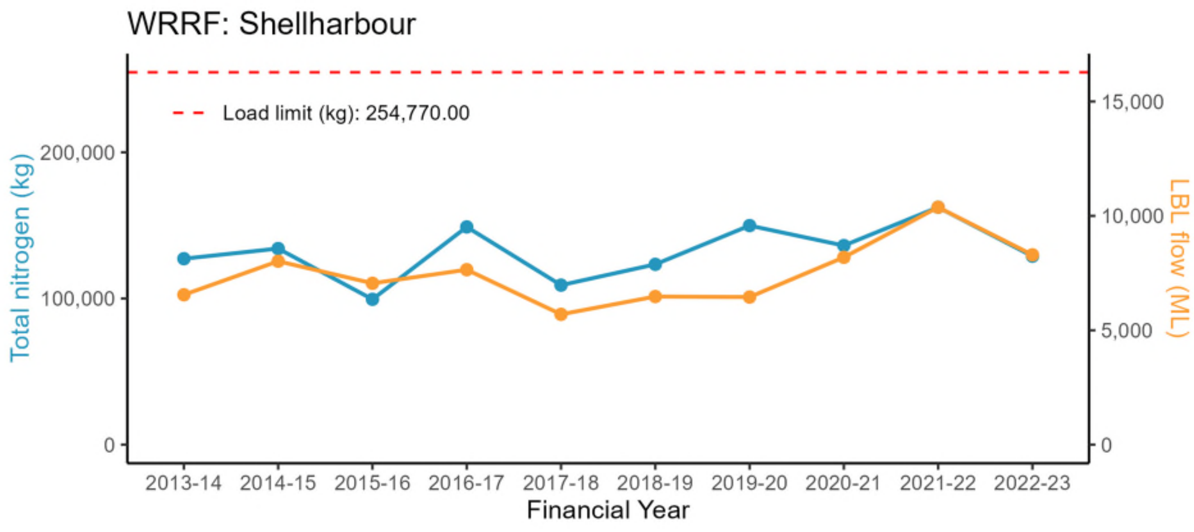


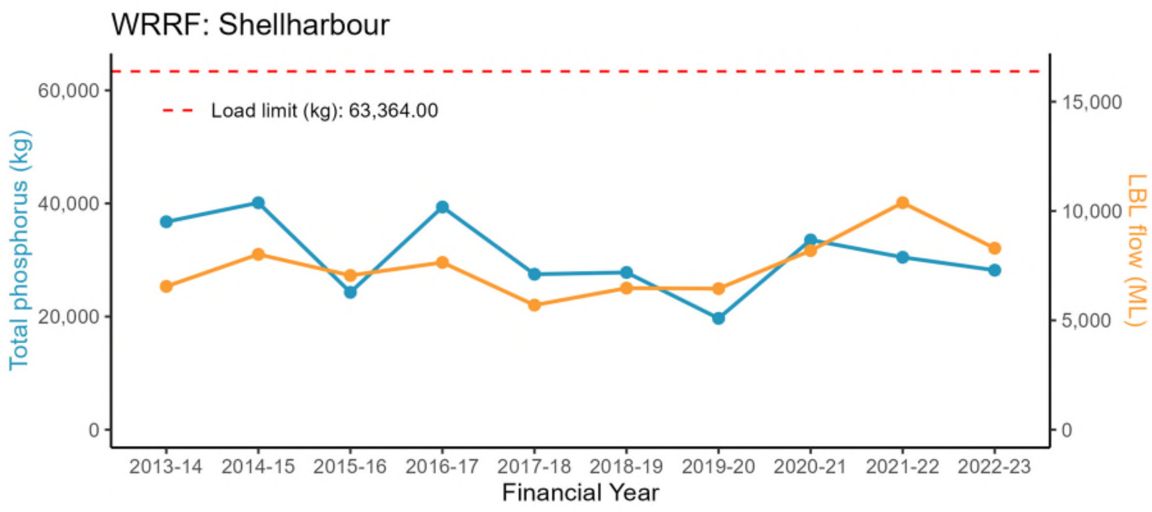
D-5.3 Pressure – Wastewater toxicity



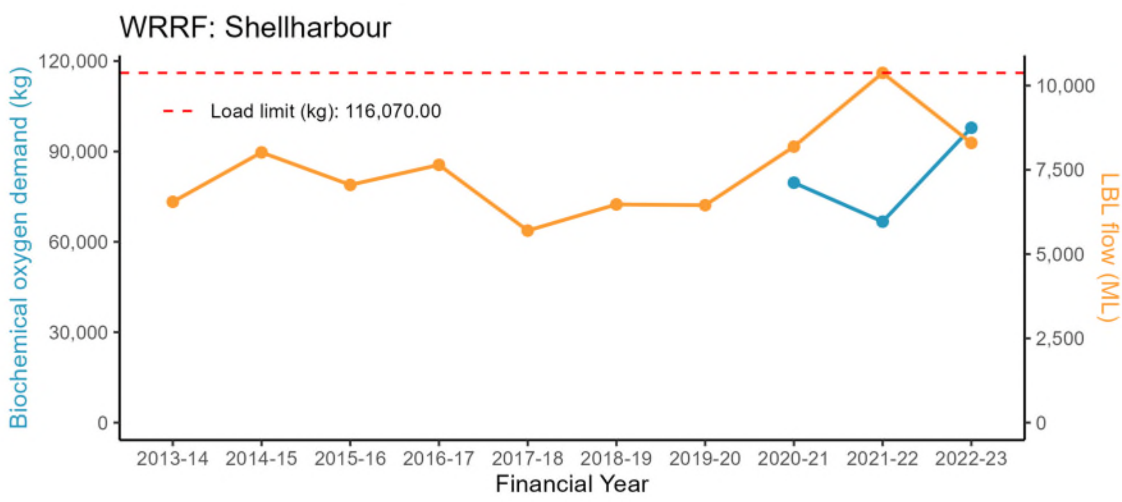
D-5.4 Pressure – Wastewater discharge load

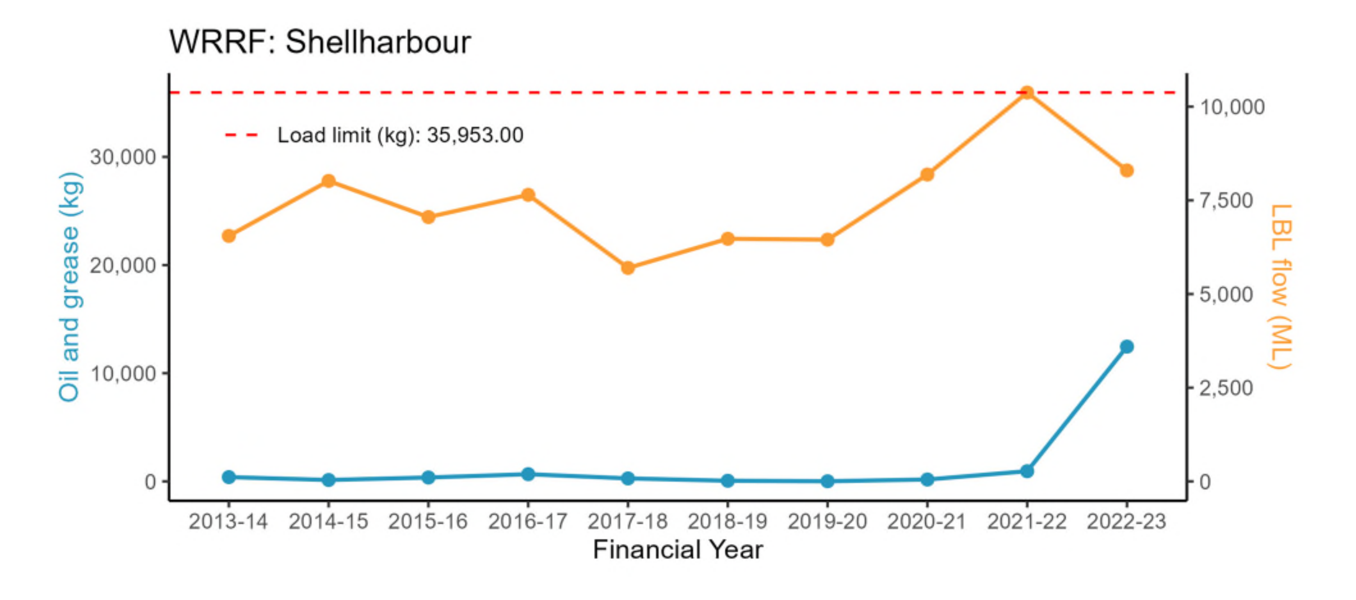
Nutrients

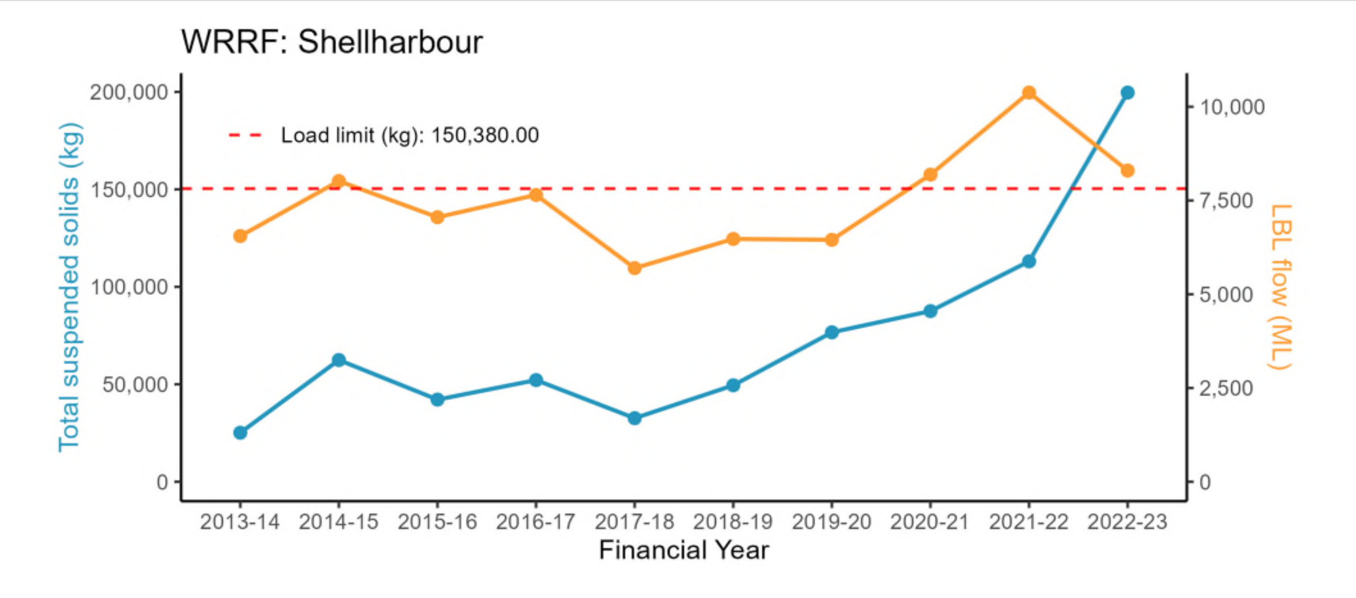




Major conventional analytes







D-5.5 Ecosystem receptor –Macro algae and invertebrates

Monitoring of the nearshore marine environment is currently limited to three sites for determining the impact of the Shellharbour WRRF outfall. No stressor indicators are monitored, only ecosystem receptor indicators are currently included. The revised program is in the process of include water quality analytes and expanding to 30 other sites, pending the outcomes of a feasibility study.

Monitoring of rocky-intertidal communities under the shoreline outfall program assesses the potential ecological impact from the Shellharbour WRRF which discharges to the nearshore ocean environment. The structures of natural communities (without anthropogenic impacts) from two control sites were used in assessment of the Shellharbour outfall (impact) site (Volume 1 Figure 2-7. The Shellharbour outfall site is situated about 2 km north of the two control sites. The control sites are situated about 400 m apart.

The taxonomic level recorded was based on morphological characteristics that could be seen with the naked eye and the level recorded is shown in the SIMPER 2021 output (Table D-2). Identification of macroinvertebrate taxa and macro algae was checked against taxonomic works of Edgar (1997) and Dakin (1987).

Shoreline outfall discharges with documented measurable impacts on intertidal community structure are typically limited in spatial extent from 100 to 300 m (Fairweather 1990). These intertidal community structures were dominated by extensive covers of green macro algae. A pictorial example of a localised spatial impact of about 50 m^2 (Figure D-2) was formerly seen at Barrack Point outfall in 2001. At that time, an extensive cover of green macro algae occurred with few invertebrates (EP Consulting 2003). This was prior to upgrade works conducted at the Shellharbour WRRF in the early to mid-2000's.

An asymmetrical permutational multivariate analysis of variance test (PERMANOVA) was conducted with 'Control and Impact' locations treated as a fixed factor. 'Sites' were nested within 'Control and Impact', with 'Sites' treated as a random factor. The outfall site was the only site under the Impact location and the two sites were under the Control locations. A fourth root transformation was applied to the data prior to a Bray-Curtis dissimilarity matrix being constructed. This matrix was the basis for PERMANOVA testing with 9999 permutations run under a reduced model, with conservative Type III sums of squares inspected to base hypothesis decisions upon.

Asymmetrical PERMANOVA indicated there was no significant difference between 'Control and Impact' locations for the 2022-23 survey (Table D-1).

SIMPER analysis for the 2022-23 period shows Green Algae to be the dominate taxa at both control site 1 and the outfall location, however only contributing 30.41% and 22.87% respectively (Table D-2). The remaining majority composition of these two sites is made up of a community structure dominated by invertebrates. Control site 2 similarly reflected a community structure dominated by invertebrates with a lesser contribution of macro algae. The picture of the outfall site in 2022-23 (Figure D-1) reflects these SIMPER results, which is different to the green algal dominance and low number of invertebrates recorded in 2001 prior to WRRF upgrade works (Figure D-2).

In summary the multivariate analyses of community structure of 2022-23 morphologically based intertidal rock platform community data suggested there was no measurable impact in the intertidal rock platform community near the outfall at Barrack Point from wastewater discharges from the Shellharbour WRRF. This outcome was supported by the differences apparent in the pictorial comparisons of 2001 and 2022-23. Context of 2022-23 data to the broader data collected back to 2008 is provided under the 2008 to 2022-23 data analysis below.

Table D-1 Asymmetrical PERMANOVA of 2022-23 intertidal assemblages

Permutational MANOVA
Sums of squares type: Type III (partial)
Fixed effects sum to zero for mixed terms
Permutation method: Permutation of residuals under a reduced model
Number of permutations: 9999

Factors

Name	Type	Levels
Control / Impact	Fixed	2
Site	Random	3

PERMANOVA table of results

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms	P(MC)
Control / Impact	1	7461.9	7461.9	0.90638		3	0.5308
Site(Control / Impact)	1	8232.6	8232.6	14.217	0.0001	9958	
Res	39	22584	579.08				
Total	41	38279					

Estimates of components of variation

Source	Estimate	Sq.root
S(Control / Impact)	-41.291	-6.4258
V(Site(Control / Impact))	546.68	23.381
V(Res)	579.08	24.064

Table D-2 SIMPER 2022-23 - intertidal assemblages by site

Control site-1 – 2022-23 Average sample similarity: 59%

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Green Algae (Chlorophyta)	2.62	18.01	1.18	30.41	30.41
Brown algae (Phaeophyta)	2.31	14.84	1.41	25.07	55.47
False limpets & rock limpets (Patellogastropoda)	1.65	12.93	2.07	21.83	77.31
Oyster Borer (Muricidae *Morula marginalba*)	0.89	5.80	1.22	9.79	87.09
Red Algae (Rhodophyta)	1.15	3.83	0.51	6.47	93.57
Zebra top shell (Trochidae *Austrocochlea*)	0.69	1.99	0.44	3.36	96.93
Conniwinks (Lottorinidae *Bembicium*)	0.48	0.82	0.25	1.39	98.32
Nerite (Nertidae *Nerita*)	0.32	0.61	0.26	1.03	99.35
Barnacles (Cirripedia)	0.35	0.39	0.18	0.65	100.00

Control site-2 – 2022-23 Average sample similarity: 77%

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Barnacles (Cirripedia)	6.40	30.89	6.97	39.91	39.91
Brown algae (Phaeophyta)	3.14	14.76	3.38	19.07	58.98
Green Algae (Chlorophyta)	2.39	9.61	1.93	12.42	71.40
False limpets & rock limpets (Patellogastropoda)	1.74	8.15	5.44	10.54	81.94
Zebra top shell (Trochidae *Austrocochlea*)	1.50	5.80	1.42	7.49	89.43
Red Algae (Rhodophyta)	1.24	3.46	0.77	4.47	93.90
Oyster Borer (Muricidae *Morula marginalba*)	0.80	2.03	0.64	2.62	96.51
Conniwinks (Lottorinidae *Bembicium*)	0.59	1.42	0.54	1.83	98.35
Encrusting tube worm (Serpilidae *Galeolaria caespitose*)	0.53	1.28	0.66	1.65	100.00

Outfall site – 2022-23 Average sample similarity: 64%

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Green Algae (Chlorophyta)	2.78	14.67	1.88	22.87	22.87
Conniwinks (Lottorinidae *Bembicium*)	2.41	13.64	4.39	21.28	44.15
Barnacles (Cirripedia)	2.04	9.81	2.28	15.29	59.44
False limpets & rock limpets (Patellogastropoda)	1.83	9.71	2.71	15.15	74.59
Red Algae (Rhodophyta)	1.77	6.52	1.10	10.17	84.76
Zebra top shell (Trochidae *Austrocochlea*)	1.05	3.41	0.78	5.32	90.08
Nerite (Nertidae *Nerita*)	0.79	2.26	0.65	3.52	93.60
Oyster Borer (Muricidae *Morula marginalba*)	0.68	1.73	0.53	2.69	96.30
Periwinkles (Littorinidae *Nodilitorina*)	0.71	1.11	0.33	1.74	98.03
Brown algae (Phaeophyta)	0.54	0.93	0.43	1.46	99.49
Encrusting tube worm (Serpilidae *Galeolaria caespitose*)	0.25	0.33	0.26	0.51	100.00

Figure D-1 Barrack Point with a healthy intertidal rock platform community in 2022-23

Figure D-2 Barrack Point (in 2001) with an unhealthy intertidal rock platform community impacted by wastewater discharges from the Shellharbour WRRF prior to upgrade in the early to mid-2000's

Intertidal communities Shellharbour 2008-09 to 2022-23

Inclusion of yearly replicate samples from 2008-09 to 2022-23 allowed the factor ‘Time’ to be included in the above asymmetrical permutational analysis of variance test (PERMANOVA). Time was comprised of 2008-09, 2009-10, 2010-11, 2011-12, 2012-13, 2013-14, 2014-15, 2015-16, 2016-17, 2017-18, 2018-19, 2019-20, 2020-21, 2021-22 and 2022-23 surveys, which were conducted at varying times through late winter to late spring.

Asymmetrical PERMANOVA indicated there was no significant difference between ‘Control and Impact’ locations for the 2008-09 to 2022-23 period (Table D-3). However, differences between sites through time were indicated as significant results were returned for the ‘Site (Control / Impact)’ and ‘Site (Control / Impact) x Time’ factors (Table D-3).

The non-metric multidimensional scaling (nMDS) ordination routine of PRIMER was used to produce a 3-dimensional ordination plot. In this plot the relative distance between samples is proportional to the relative similarity in taxonomic composition and abundance – the closer the points on the graph the more similar the community (Clarke 1993). That is, site samples with similar taxa lay closer together and site samples with a differing taxon composition lie farther apart. An unconstrained ordination procedure such as nMDS inevitably introduces distortion when trying to simultaneously represent the similarities between large numbers of samples in a few dimensions. The success of the procedure is measured by a stress value, which indicates the degree of distortion imposed. In the PRIMER software package, a stress value of below 0.2 indicates an acceptable representation of the original data, although lower values are desirable. Where stress values are just above 0.2, the patterns displayed should be confirmed with other techniques such as PERMANOVA. The returned 2-dimensional stress value was 0.23 and an improved lower stress value of 0.15 was observed for the 3-dimensional ordination plot.

To understand the context of 2022-23 site data to that of previous years (2008-09 to 2021-22), site sample data were colour coded as shown in Figure D-3. Data patterns displayed in this 3-dimensional nMDS ordination plot indicated widely dispersed 2008-09 to 2021-22 Control site-1 samples overlapped with 2008-09 to 2021-22 outfall site samples. The 2022-23 outfall samples also overlaid this mass of samples. While the Control site-1 and Control site 2 samples from 2022-23 were positioned on the edges of the agglomerations of their respective 2008-09 to 2021-22 samples reflecting significant ‘Site (Control / Impact) x Time’ term of PERMANOVA model outlined above.

Under the nMDS routine, due to rank ordering of dissimilarities some detail can be hidden. This detail may be seen using a Principal Coordinates Analysis (PCO) routine as PCO is based upon original dissimilarities being projected onto axes in the space of the chosen resemblance measure (Anderson et al. 2008). As a check for any additional dimensionality in the multivariate data cloud, a PCO ordination plot was raised based on a fourth root transformation of the data and a Bray-Curtis resemblance measure. No additional dimensionality was indicated as the patterns between nMDS (Figure D-3) and PCO ordination (Figure D-4) plots were very similar.

A Canonical Analysis of Principal Coordinates (CAP) ordination plot was also produced. The CAP routine is designed to ask, ‘Are there axes in the multivariate space that separate groups?’ CAP is designed to purposely seek out and find groups even if differences occur in obscure directions and may not have been apparent from nMDS or PCO plots that provide views of the multivariate data cloud as a whole (Anderson et al. 2008). A similar pattern to that in the nMDS (Figure D-3) and PCO (Figure D-4) ordination plots was displayed. This also suggested no hidden dimensionality, with good agreement between the nMDS, PCO and CAP ordination plots.

An additional run of the CAP routine was undertaken with placement of 2022-23 outfall samples onto the canonical axes of the existing CAP model from the initial run. Output from the second run indicated 2022-23 outfall samples were most similar to either the Outfall 2008-09 to 2021-22 samples or Control site 1 2008-09 to 2022-23 samples (Figure D-5). This result also reflected patterns displayed in the nMDS and PCO ordination plots (Figure D-3 and Figure D-4).

The trend of taxonomic differences between sites situated close together on shorelines is known to occur and accounts for the differences between Control site-1 that is only 400 m from Control site-2 on the shoreline. It is mentioned by Underwood and Chapman (1995) who cite Underwood (1981) who states, 'on exposed shores in New South Wales there are great differences in patterns of occupancy of space from one place to another not many metres away, even though these are not a function of gradients in wave action.'

In summary, a relatively stable equilibrium in rocky-intertidal community structure was indicated from these assessments of the 2008-09 to 2022-23 monitoring data at the 3 Shellharbour WRRF sites studied. These results also suggest over the 2008-09 to 2022-23 period, no measurable impact had developed in the intertidal rock platform community near the outfall at Barrack Point from wastewater discharges from the Shellharbour WRRF as the community assemblage of the outfall site was very similar to Control site-1 for the 2008-09 to 2021-22 period. Results from Control site-2 represent natural variation in rocky-intertidal community structure that has been demonstrated to occur for closely spaced shoreline sites.

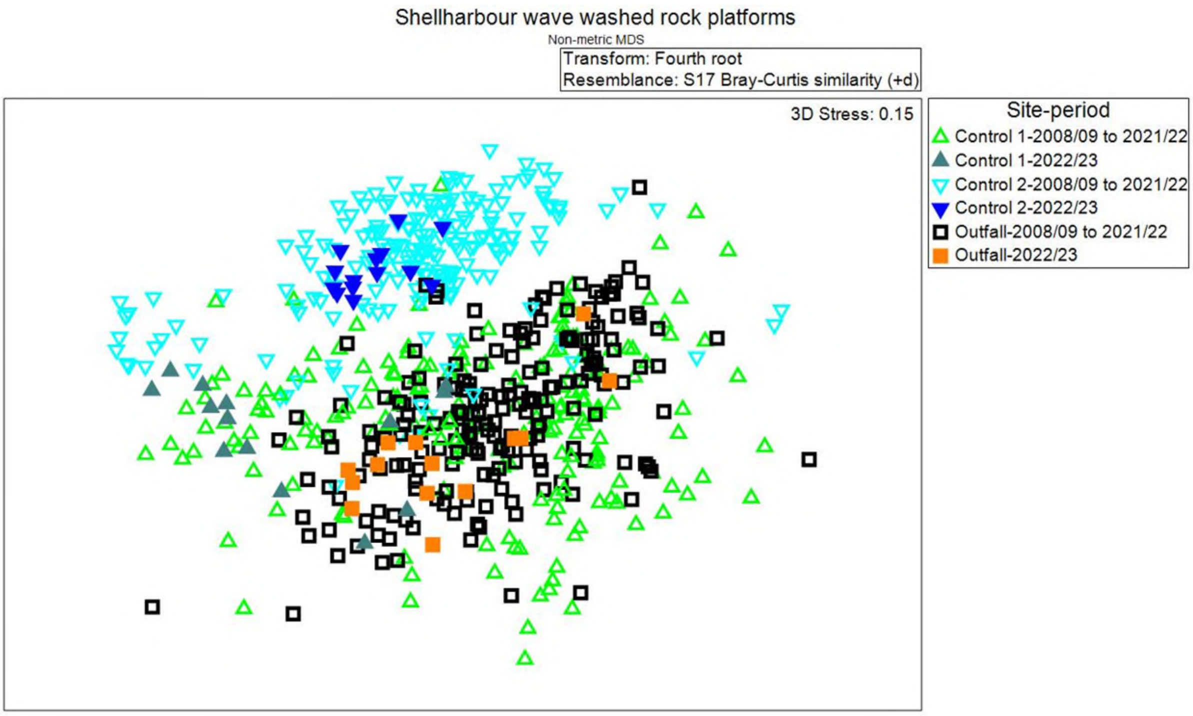


Figure D-3 Dimensions 1 and 2 of 3-dimensional nMDS ordination plot of 2008-09 to 2022-23 intertidal rock platform community data

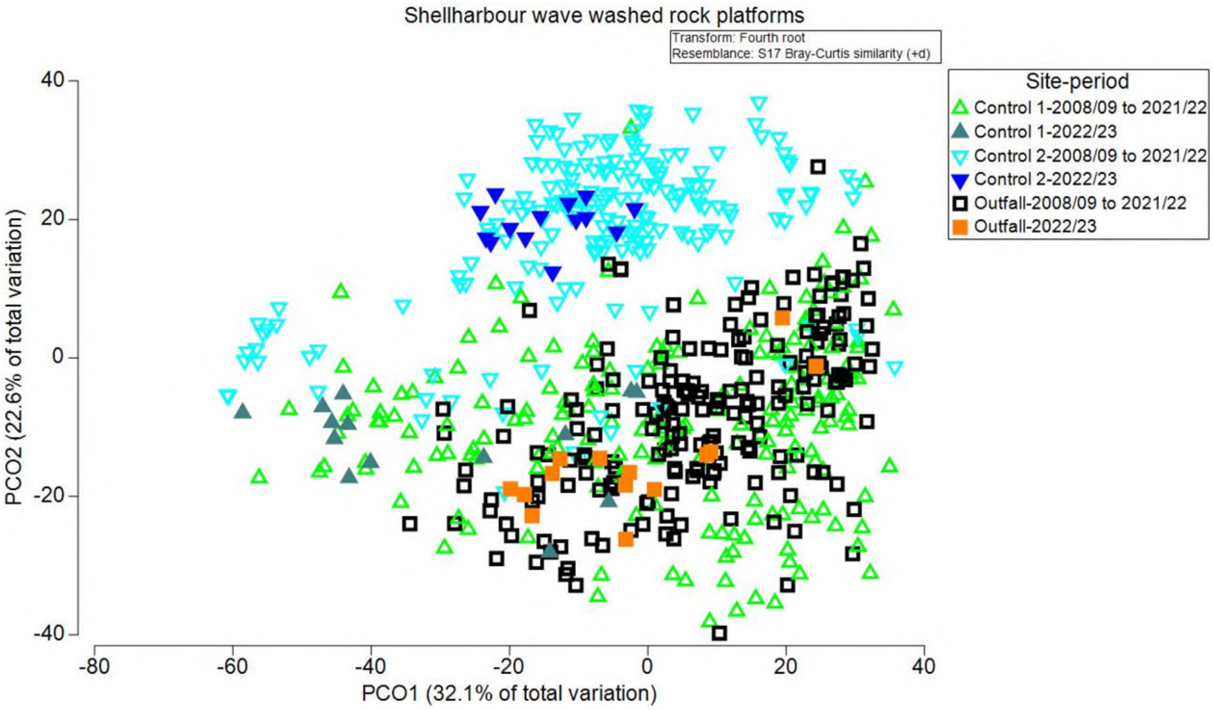


Figure D-4 PCO ordination plot of 2008-09 to 2022-23 intertidal rock platform community data - dimensional

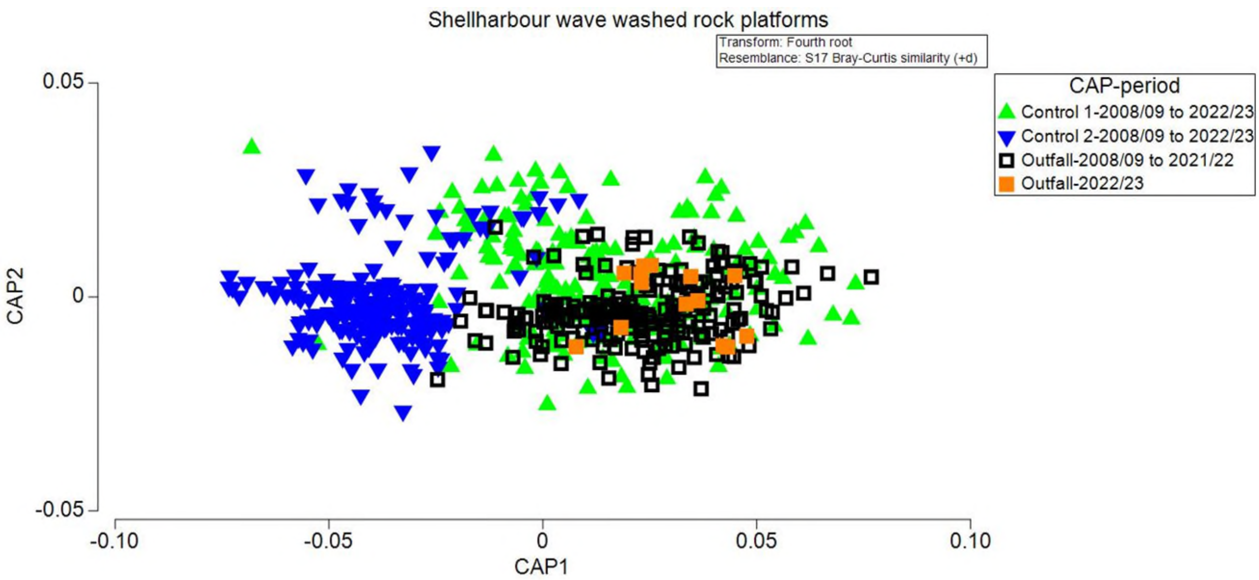


Figure D-5 CAP ordination plot of intertidal rock platform community data (2008-09 to 2022-23 for Control site 1 and Control site 2 and 2008-09 to 2021-22 outfall site) with 2022-23 outfall samples (orange squares) predicted

Table D-3 Asymmetrical PERMANOVA of 2008-09 to 2022-23 intertidal assemblages

Sums of squares type: Type III (partial)
Fixed effects sum to zero for mixed terms
Permutation method: Permutation of residuals under a reduced model
Number of permutations: 9999

Factors

Name	Type	Levels
Control / Impact	Fixed	2
Time	Fixed	15
Site	Random	3

PERMANOVA table of results

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms	P(MC)
Control / Impact	1	71622	71622	0.74658		3	0.5956
Time	14	94596	6756.8	1.2236	0.2065	9878	
Site(Control / Impact)	1	94580	94580	133.64	0.0001	9953	
Control / ImpactxTime	14	66343	4738.8	0.85869	0.7064	9985	
TimexSite(Control / Impact)	14	76403	5457.4	7.7115	0.0001	9873	
Res	583	4.1259E+05	707.69				
Total	627	8.3411E+05					

Estimates of components of variation

Source	Estimate	Sq.root
S(Control / Impact)	-86.743	-9.3136
S(Time)	33.064	5.7501
V(Site(Control / Impact))	452.97	21.283
S(Control / ImpactxTime)	-41.783	-6.464
V(TimexSite(Control / Impact))	343.12	18.523
V(Res)	707.69	26.603

Table D-4 CAP analysis of 2008-09 to 2021-22 intertidal assemblages with 2022-23 outfall site samples predicted

Factor for groups: CAP-period
Factor level for new samples group: Outfall-2022/23
Number of samples: 614
Choice of m: 3

CANONICAL ANALYSIS
Correlations

Eigenvalue	Correlation	Corr.Sq.
1	0.8196	0.6718
2	0.2575	0.0663

DIAGNOSTICS

m	prop.G	ssres	d_1^2	d_2^2	%correct
3	0.7089	1.2752	0.6718	0.0663	68.241

Cross Validation
Leave-one-out Allocation of Observations to Groups (for the choice of m: 3)

Orig. group	Classified Control 1-2008/09 to2022/23	Control 2-2008/09 to 2022/23	Outfall-2008/09 to 2021/22	Total	%correct
Control 1-2008/09 to 2022/23	99	19	92	210	47.143
Control 2-2008/09 to 2022/23	10	193	3	206	93.689
Outfall-2008/09 to 2021/22	64	7	127	198	64.141

Total correct: 419/614 (68.241%)
Mis-classification error: 31.759%

Individual samples that were mis-classified

Sample	Orig.group	Class.group
Control 1-2018-1	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
Control 1-2018-3	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
Control 1-2018-4	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
Control 1-2018-5	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
Control 1-2018-6	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
Control 1-2018-10	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
Control 1-2018-12	Control 1-2008/09 to 2022/23	Control 2-2008/09 to 2022/23
Control 1-2018-13	Control 1-2008/09 to 2022/23	Control 2-2008/09 to 2022/23
Control 1-2018-14	Control 1-2008/09 to 2022/23	Control 2-2008/09 to 2022/23
Control 1-2008-1	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
Control 1-2008-2	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
Control 1-2008-3	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
Control 1-2008-4	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
Control 1-2008-5	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
Control 1-2008-6	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
Control 1-2008-7	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
Control 1-2008-8	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
Control 1-2008-10	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
Control 1-2008-12	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
Control 1-2009-2	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
Control 1-2009-3	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
Control 1-2009-4	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
Control 1-2009-5	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
Control 1-2009-7	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
Control 1-2009-9	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
Control 1-2009-10	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
Control 1-2009-12	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22

Control 1-2009-13	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
Control 1-2009-14	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
Control 1-2010-1	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
Control 1-2010-2	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
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Control 1-2010-5	Control 1-2008/09 to 2022/23	Control 2-2008/09 to 2022/23
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Control 1-2010-11	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
Control 1-2010-12	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
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Control 1-2011-7	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
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Control 1-2011-12	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
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Control 1-2012-9	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
Control 1-2012-11	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
Control 1-2012-14	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
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Control 1-2014-4	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
Control 1-2014-5	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
Control 1-2014-7	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
Control 1-2014-8	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
Control 1-2014-10	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
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Control 1-2014-14	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
Control 1-2015-3	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
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Control 1-2015-8	Control 1-2008/09 to 2022/23	Control 2-2008/09 to 2022/23
Control 1-2015-10	Control 1-2008/09 to 2022/23	Control 2-2008/09 to 2022/23
Control 1-2015-11	Control 1-2008/09 to 2022/23	Control 2-2008/09 to 2022/23
Control 1-2015-14	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
Control 1-2016-1	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
Control 1-2016-2	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
Control 1-2016-7	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
Control 1-2016-12	Control 1-2008/09 to 2022/23	Control 2-2008/09 to 2022/23
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Control 1-2017-9	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
Control 1-2017-11	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
Control 1-2017-14	Control 1-2008/09 to 2022/23	Control 2-2008/09 to 2022/23
Control 1-2019-2	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22

Control 1-2019-5	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
Control 1-2019-6	Control 1-2008/09 to 2022/23	Control 2-2008/09 to 2022/23
Control 1-2019-7	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
Control 1-2019-8	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
Control 1-2019-9	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
Control 1-2019-10	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
Control 1-2019-12	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
control 1-2020-4	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
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control 1-2020-8	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
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Control 1-2021-7	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
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Control 1-2021-11	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
Control 1-2021-12	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
Control 1-2021-13	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
Control 1-2021-14	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
Control 1-2022/23-6	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
Control 1-2022/23-9	Control 1-2008/09 to 2022/23	Control 2-2008/09 to 2022/23
Control 1-2022/23-10	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
Control 1-2022/23-12	Control 1-2008/09 to 2022/23	Control 2-2008/09 to 2022/23
Control 1-2022/23-14	Control 1-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
Control 2-2008-2	Control 2-2008/09 to 2022/23	Control 1-2008/09 to 2022/23
Control 2-2008-6	Control 2-2008/09 to 2022/23	Control 1-2008/09 to 2022/23
Control 2-2008-7	Control 2-2008/09 to 2022/23	Control 1-2008/09 to 2022/23
Control 2-2008-10	Control 2-2008/09 to 2022/23	Control 1-2008/09 to 2022/23
Control 2-2008-13	Control 2-2008/09 to 2022/23	Control 1-2008/09 to 2022/23
Control 2-2008-14	Control 2-2008/09 to 2022/23	Control 1-2008/09 to 2022/23
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Control 2-2019-2	Control 2-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
Control 2-2019-3	Control 2-2008/09 to 2022/23	Outfall-2008/09 to 2021/22
Control 2-2019-4	Control 2-2008/09 to 2022/23	Control 1-2008/09 to 2022/23
Control 2-2019-7	Control 2-2008/09 to 2022/23	Control 1-2008/09 to 2022/23
Control 2-2019-8	Control 2-2008/09 to 2022/23	Control 1-2008/09 to 2022/23
Control 2-2019-9	Control 2-2008/09 to 2022/23	Control 1-2008/09 to 2022/23
Outfall-2018-1	Outfall-2008/09 to 2021/22	Control 1-2008/09 to 2022/23
Outfall-2018-2	Outfall-2008/09 to 2021/22	Control 1-2008/09 to 2022/23
Outfall-2018-3	Outfall-2008/09 to 2021/22	Control 1-2008/09 to 2022/23
Outfall-2018-5	Outfall-2008/09 to 2021/22	Control 1-2008/09 to 2022/23
Outfall-2018-6	Outfall-2008/09 to 2021/22	Control 1-2008/09 to 2022/23
Outfall-2018-7	Outfall-2008/09 to 2021/22	Control 1-2008/09 to 2022/23
Outfall-2018-9	Outfall-2008/09 to 2021/22	Control 1-2008/09 to 2022/23
Outfall-2018-11	Outfall-2008/09 to 2021/22	Control 1-2008/09 to 2022/23
Outfall-2018-12	Outfall-2008/09 to 2021/22	Control 1-2008/09 to 2022/23
Outfall-2018-13	Outfall-2008/09 to 2021/22	Control 1-2008/09 to 2022/23
Outfall-2018-14	Outfall-2008/09 to 2021/22	Control 1-2008/09 to 2022/23
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Outfall-2011-2	Outfall-2008/09 to 2021/22	Control 2-2008/09 to 2022/23
Outfall-2011-3	Outfall-2008/09 to 2021/22	Control 2-2008/09 to 2022/23
Outfall-2011-7	Outfall-2008/09 to 2021/22	Control 2-2008/09 to 2022/23
Outfall-2011-9	Outfall-2008/09 to 2021/22	Control 1-2008/09 to 2022/23
Outfall-2011-10	Outfall-2008/09 to 2021/22	Control 1-2008/09 to 2022/23
Outfall-2011-11	Outfall-2008/09 to 2021/22	Control 1-2008/09 to 2022/23

Outfall-2011-13	Outfall-2008/09 to 2021/22	Control 1-2008/09 to 2022/23
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Outfall-2012-2	Outfall-2008/09 to 2021/22	Control 1-2008/09 to 2022/23
Outfall-2012-4	Outfall-2008/09 to 2021/22	Control 1-2008/09 to 2022/23
Outfall-2012-11	Outfall-2008/09 to 2021/22	Control 1-2008/09 to 2022/23
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Outfall-2014-5	Outfall-2008/09 to 2021/22	Control 1-2008/09 to 2022/23
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Outfall-2015-8	Outfall-2008/09 to 2021/22	Control 1-2008/09 to 2022/23
Outfall-2015-13	Outfall-2008/09 to 2021/22	Control 1-2008/09 to 2022/23
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Outfall-2016-3	Outfall-2008/09 to 2021/22	Control 1-2008/09 to 2022/23
Outfall-2016-4	Outfall-2008/09 to 2021/22	Control 1-2008/09 to 2022/23
Outfall-2016-5	Outfall-2008/09 to 2021/22	Control 1-2008/09 to 2022/23
Outfall-2016-6	Outfall-2008/09 to 2021/22	Control 2-2008/09 to 2022/23
Outfall-2016-9	Outfall-2008/09 to 2021/22	Control 1-2008/09 to 2022/23
Outfall-2016-12	Outfall-2008/09 to 2021/22	Control 1-2008/09 to 2022/23
Outfall-2016-13	Outfall-2008/09 to 2021/22	Control 1-2008/09 to 2022/23
Outfall-2016-14	Outfall-2008/09 to 2021/22	Control 1-2008/09 to 2022/23
Outfall-2017-2	Outfall-2008/09 to 2021/22	Control 1-2008/09 to 2022/23
Outfall-2017-3	Outfall-2008/09 to 2021/22	Control 1-2008/09 to 2022/23
Outfall-2017-4	Outfall-2008/09 to 2021/22	Control 1-2008/09 to 2022/23
Outfall-2017-5	Outfall-2008/09 to 2021/22	Control 1-2008/09 to 2022/23
Outfall-2017-6	Outfall-2008/09 to 2021/22	Control 1-2008/09 to 2022/23
Outfall-2017-8	Outfall-2008/09 to 2021/22	Control 1-2008/09 to 2022/23
Outfall-2017-9	Outfall-2008/09 to 2021/22	Control 1-2008/09 to 2022/23
Outfall-2017-10	Outfall-2008/09 to 2021/22	Control 1-2008/09 to 2022/23
Outfall-2017-11	Outfall-2008/09 to 2021/22	Control 1-2008/09 to 2022/23
Outfall-2017-12	Outfall-2008/09 to 2021/22	Control 1-2008/09 to 2022/23
Outfall-2019-1	Outfall-2008/09 to 2021/22	Control 1-2008/09 to 2022/23
Outfall-2019-4	Outfall-2008/09 to 2021/22	Control 1-2008/09 to 2022/23
Outfall-2019-5	Outfall-2008/09 to 2021/22	Control 1-2008/09 to 2022/23
Outfall-2019-6	Outfall-2008/09 to 2021/22	Control 1-2008/09 to 2022/23
Outfall-2019-7	Outfall-2008/09 to 2021/22	Control 1-2008/09 to 2022/23
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Outfall-2020-7	Outfall-2008/09 to 2021/22	Control 1-2008/09 to 2022/23
Outfall-2020-10	Outfall-2008/09 to 2021/22	Control 1-2008/09 to 2022/23
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Outfall-2020-12	Outfall-2008/09 to 2021/22	Control 1-2008/09 to 2022/23
Outfall-2020-14	Outfall-2008/09 to 2021/22	Control 1-2008/09 to 2022/23
Outfall-2021-9	Outfall-2008/09 to 2021/22	Control 1-2008/09 to 2022/23
Outfall-2021-11	Outfall-2008/09 to 2021/22	Control 1-2008/09 to 2022/23
Outfall-2021-13	Outfall-2008/09 to 2021/22	Control 1-2008/09 to 2022/23
Outfall-2021-14	Outfall-2008/09 to 2021/22	Control 1-2008/09 to 2022/23

PERMUTATION TEST
trace statistic = (tr(Q_m'HQ_m))
first squared canonical correlation = (delta_1^2)

tr(Q_m'HQ_m): 0.73811 P: 0.0001
delta_1^2: 0.67182 P: 0.0001
No. of permutations used: 9999

NEW SAMPLES

Canonical coordinate scores for New Samples

Sample	CAP1	CAP2
Outfall-2022/23-1	0.0346	0.0047
Outfall-2022/23-2	0.0363	-0.0009
Outfall-2022/23-3	0.0254	0.0074
Outfall-2022/23-4	0.0432	-0.0117
Outfall-2022/23-5	0.0477	-0.0092
Outfall-2022/23-6	0.0235	0.0072
Outfall-2022/23-7	0.0421	-0.0114
Outfall-2022/23-8	0.019	0.0056
Outfall-2022/23-9	0.0078	-0.0117
Outfall-2022/23-10	0.0183	-0.0072
Outfall-2022/23-11	0.0335	-0.0017
Outfall-2022/23-12	0.0449	0.0049
Outfall-2022/23-13	0.0231	0.0034
Outfall-2022/23-14	0.0229	0.0053

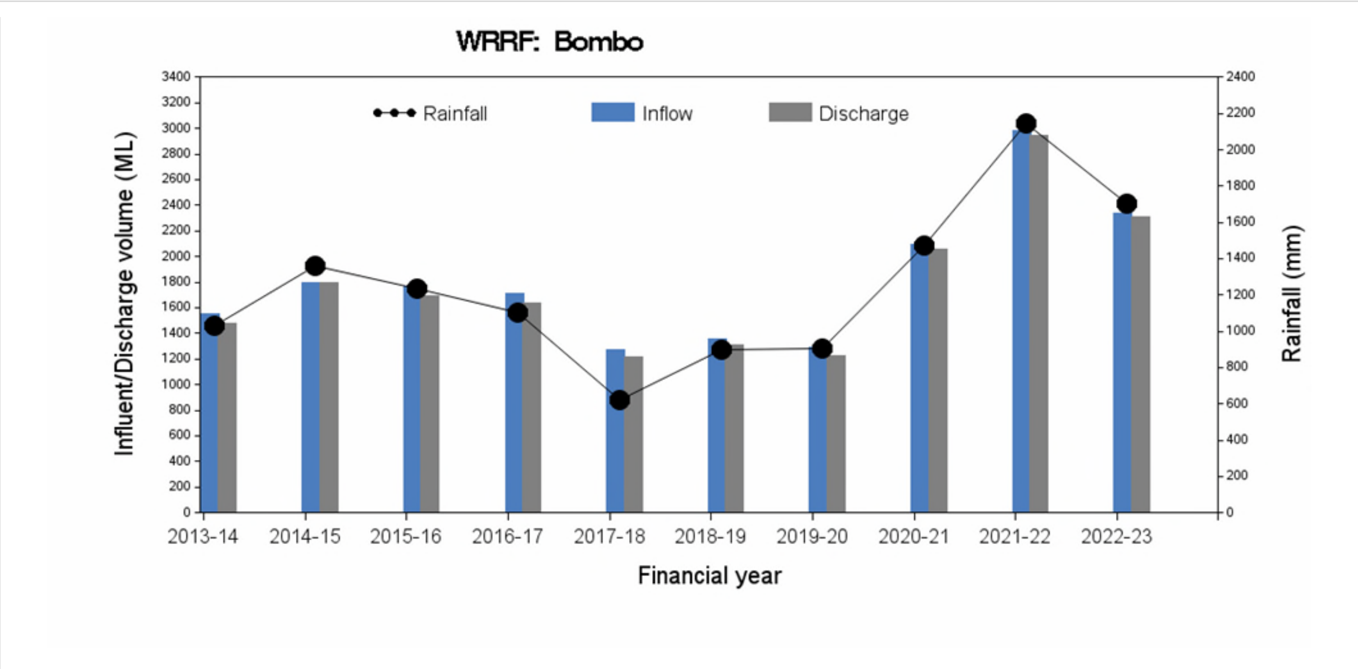
New sample classification

Sample	Group
Outfall-2022/23-1	Outfall-2008/09 to 2021/22
Outfall-2022/23-2	Outfall-2008/09 to 2021/22
Outfall-2022/23-3	Control 1-2008/09 to 2022/23
Outfall-2022/23-4	Outfall-2008/09 to 2021/22
Outfall-2022/23-5	Outfall-2008/09 to 2021/22
Outfall-2022/23-6	Control 1-2008/09 to 2022/23
Outfall-2022/23-7	Outfall-2008/09 to 2021/22
Outfall-2022/23-8	Control 1-2008/09 to 2022/23
Outfall-2022/23-9	Control 1-2008/09 to 2022/23
Outfall-2022/23-10	Outfall-2008/09 to 2021/22
Outfall-2022/23-11	Outfall-2008/09 to 2021/22
Outfall-2022/23-12	Outfall-2008/09 to 2021/22
Outfall-2022/23-13	Outfall-2008/09 to 2021/22
Outfall-2022/23-14	Control 1-2008/09 to 2022/23

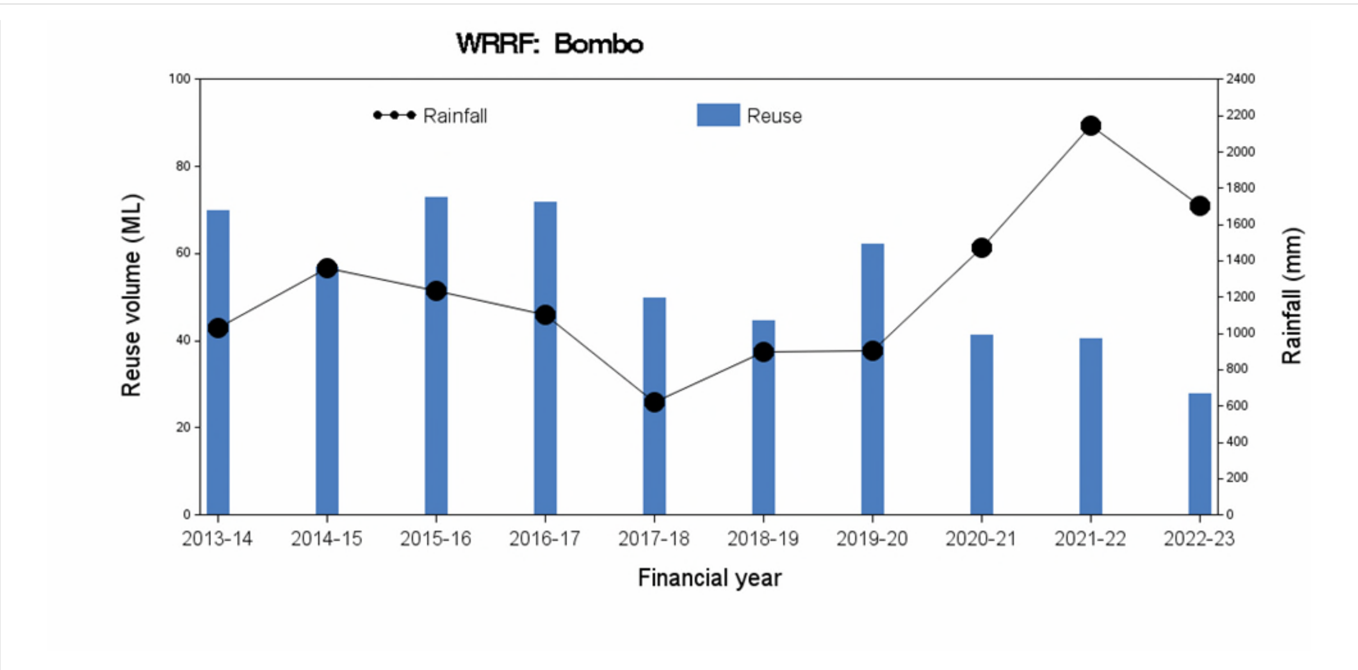
D-6 Bombo WRRF

D-6.1 Pressure – Wastewater quantity

Inflow/ Discharge volume and rainfall

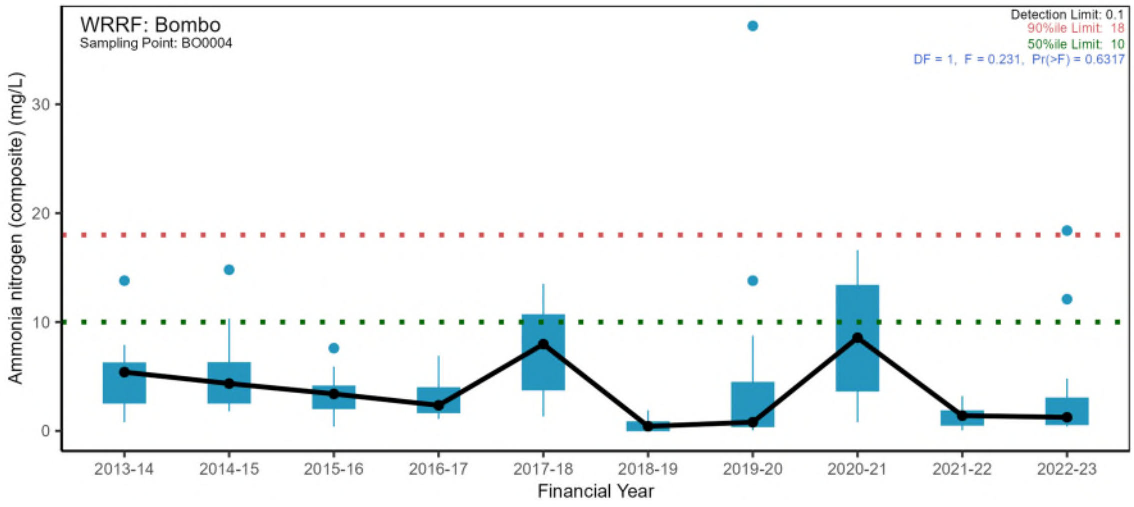


Reuse volume and rainfall

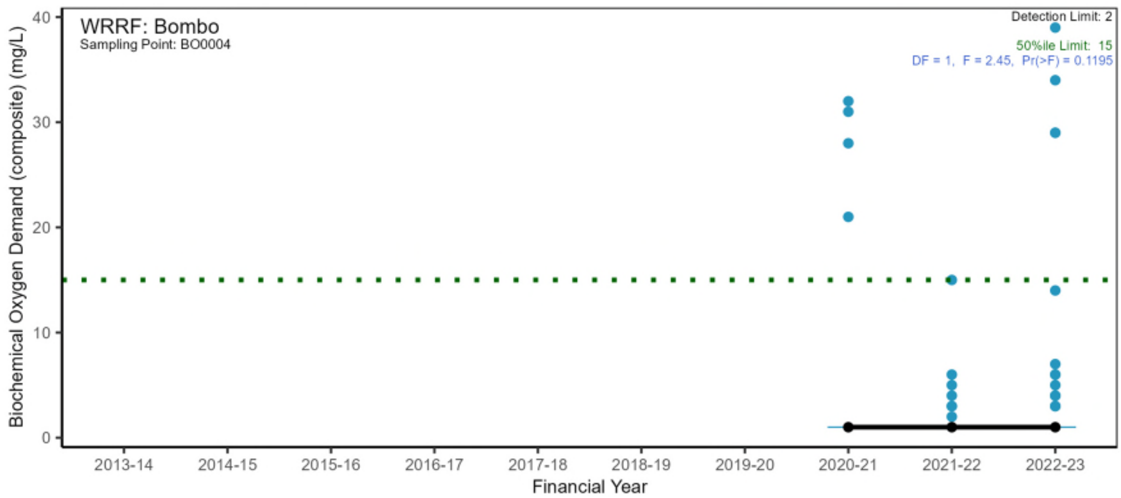


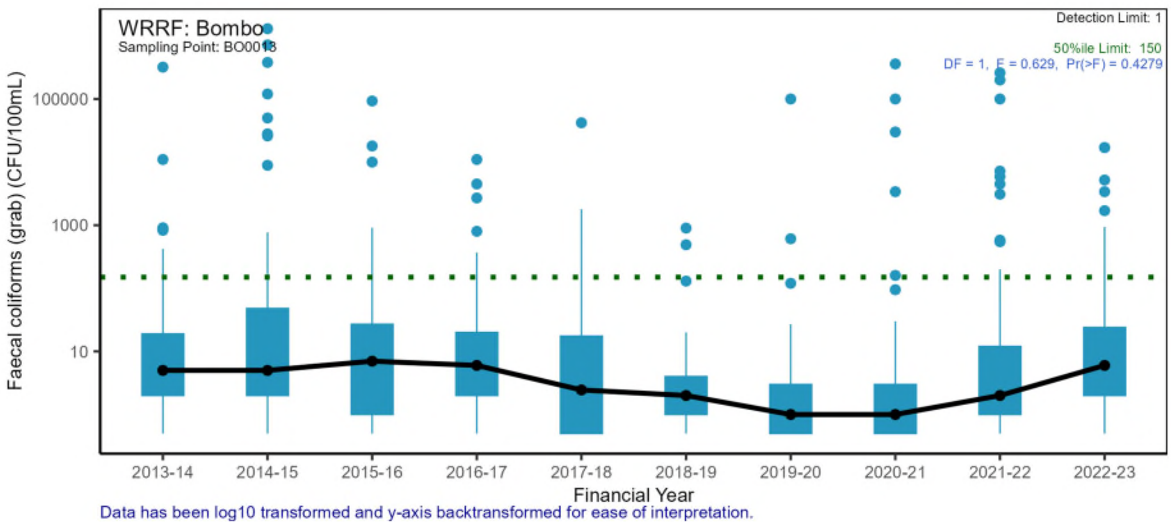
D-6.2 Pressure – Wastewater quality

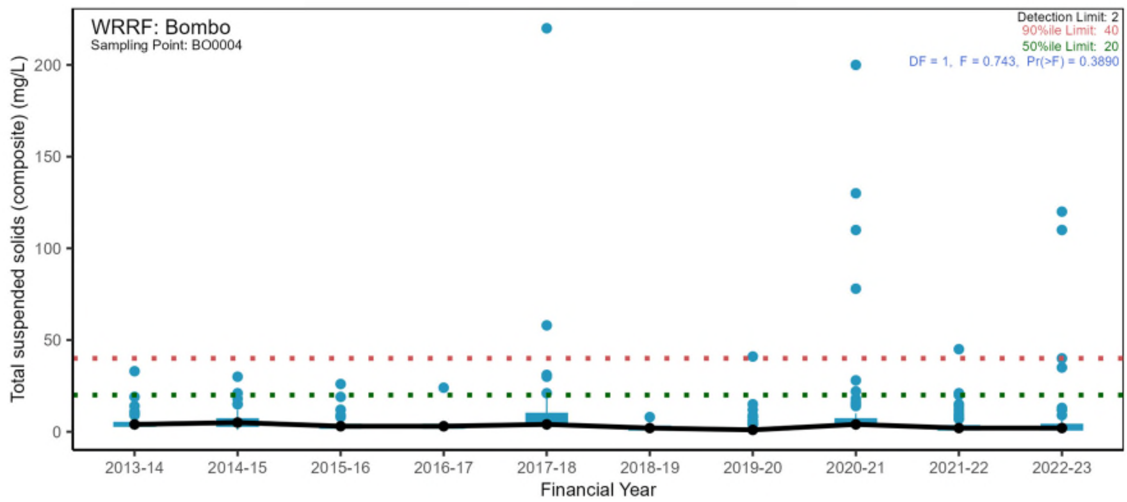
Nutrients



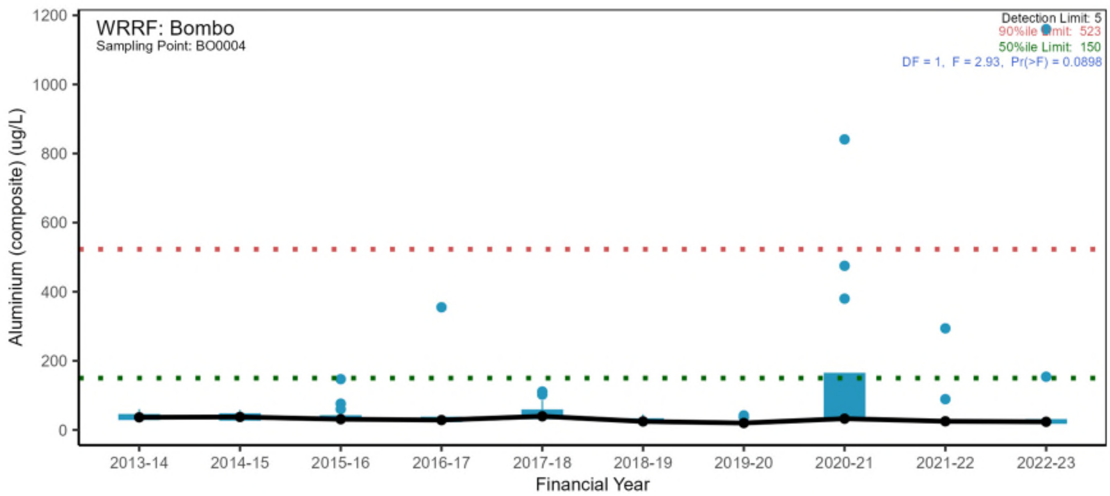
Major conventional analytes

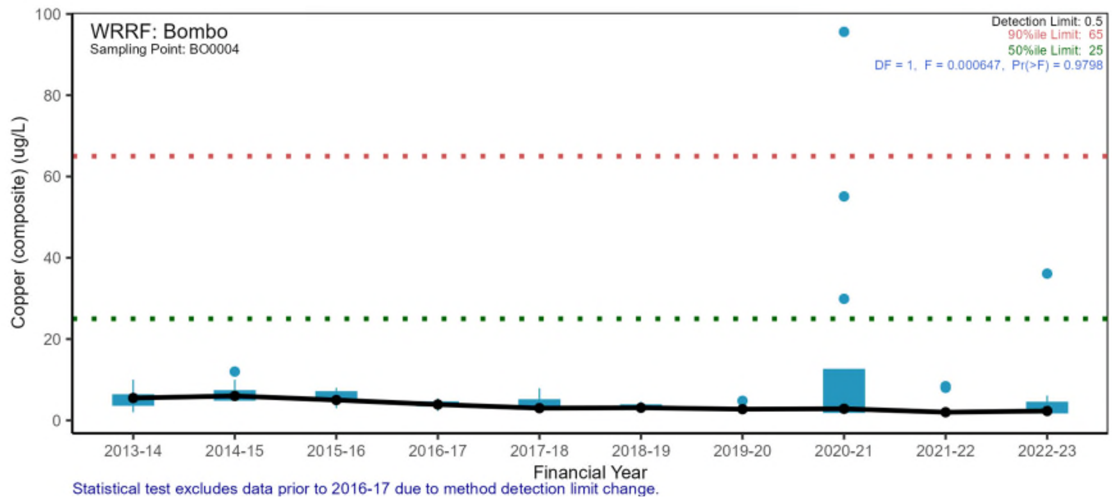




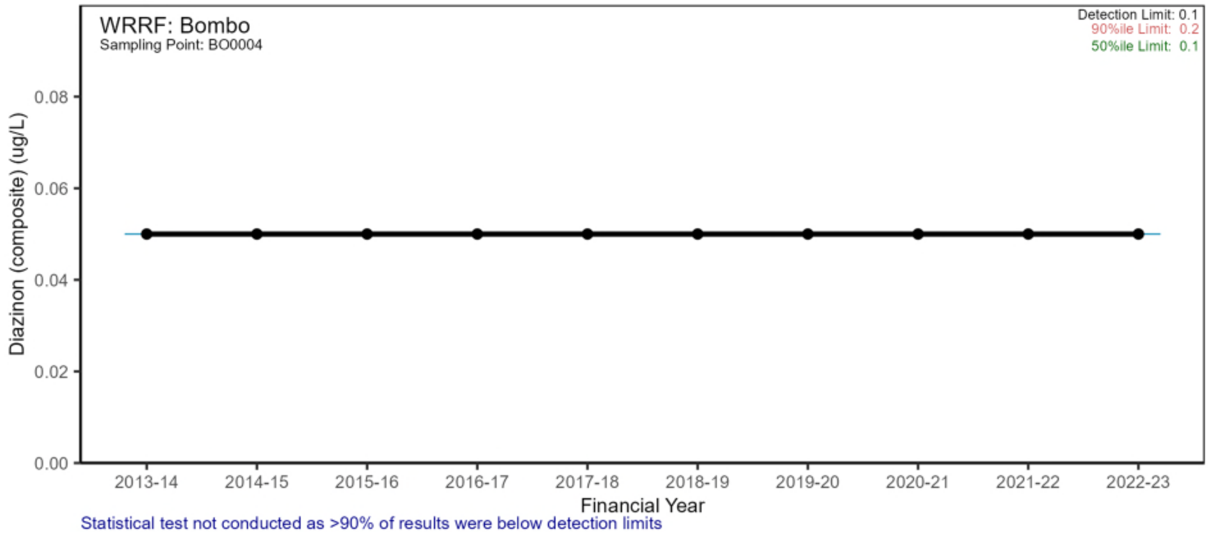


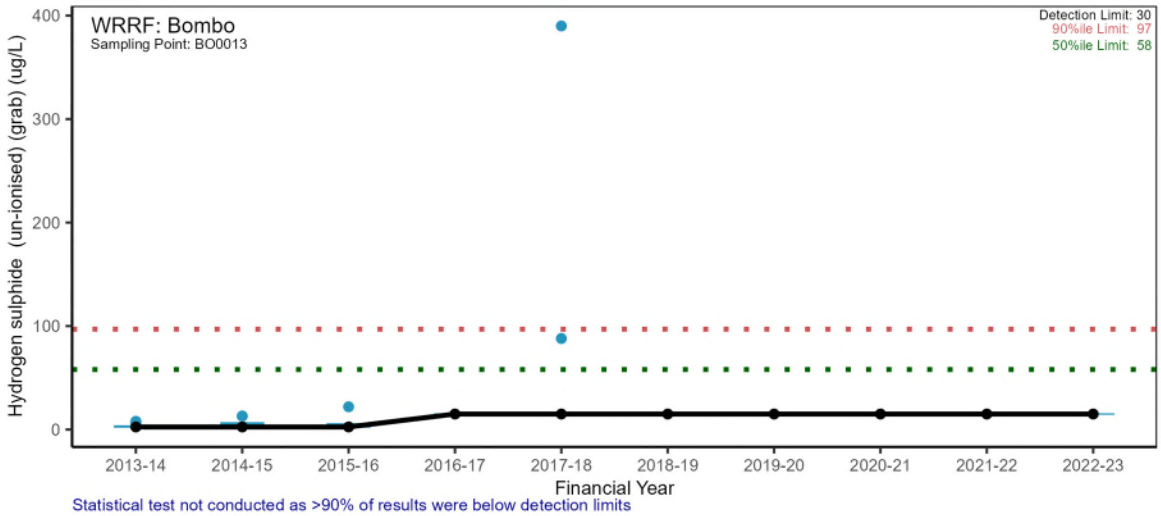
Trace metals

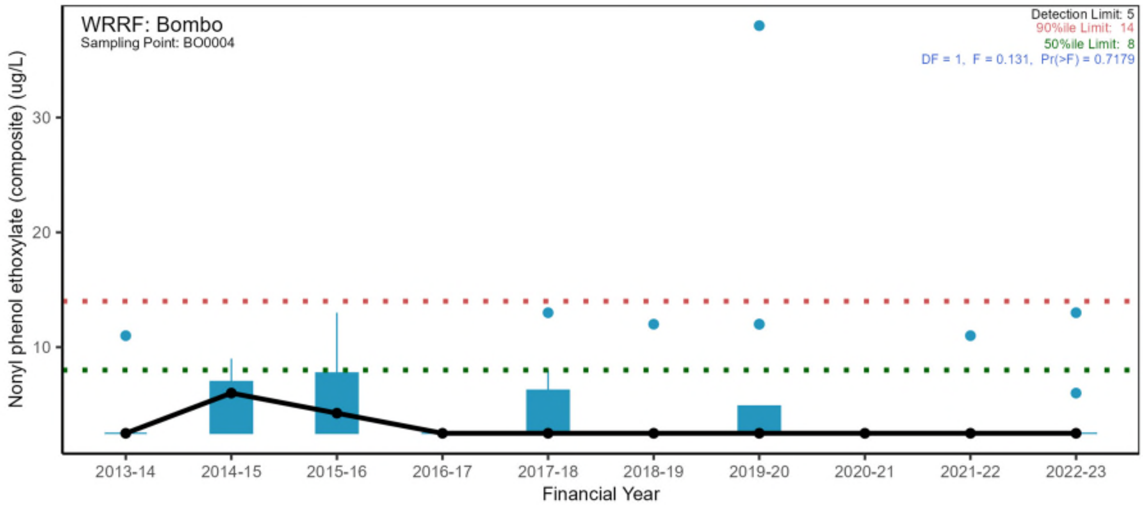




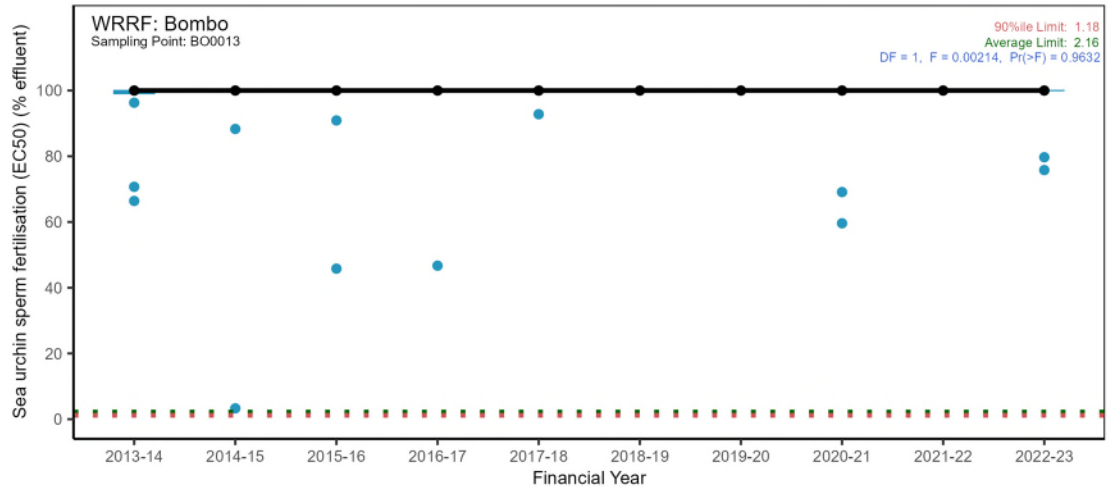
Other chemicals and organics (including pesticides)





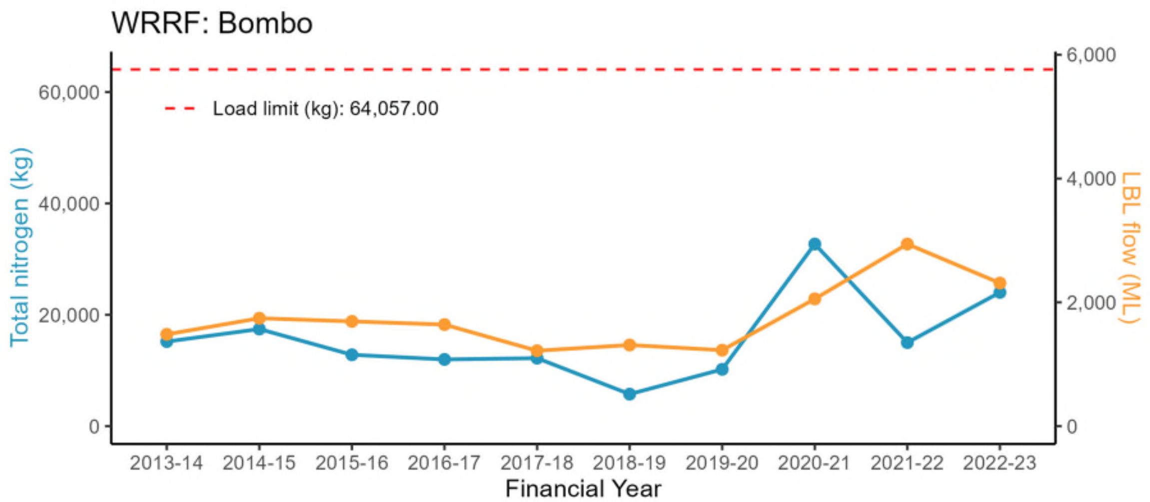


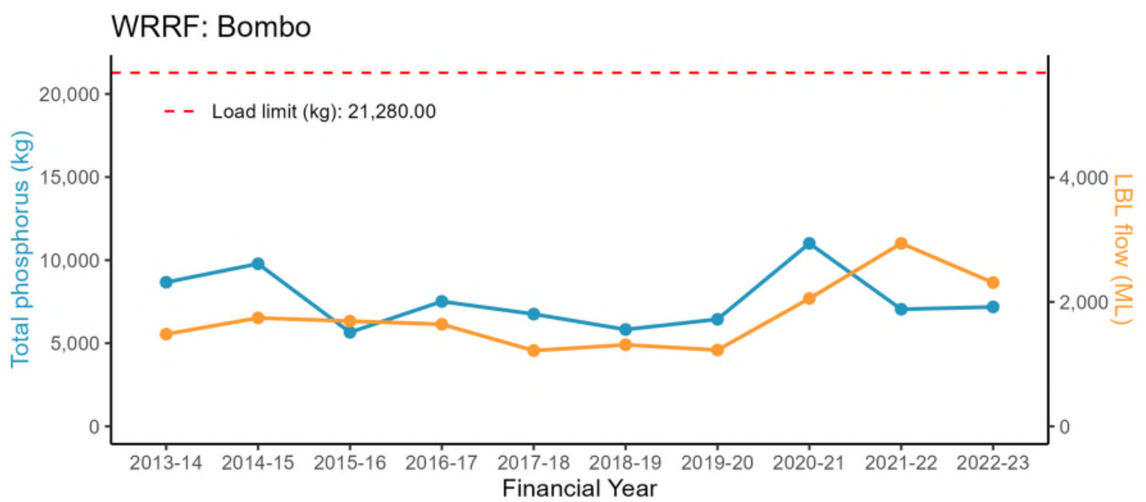
D-6.3 Pressure – Wastewater toxicity



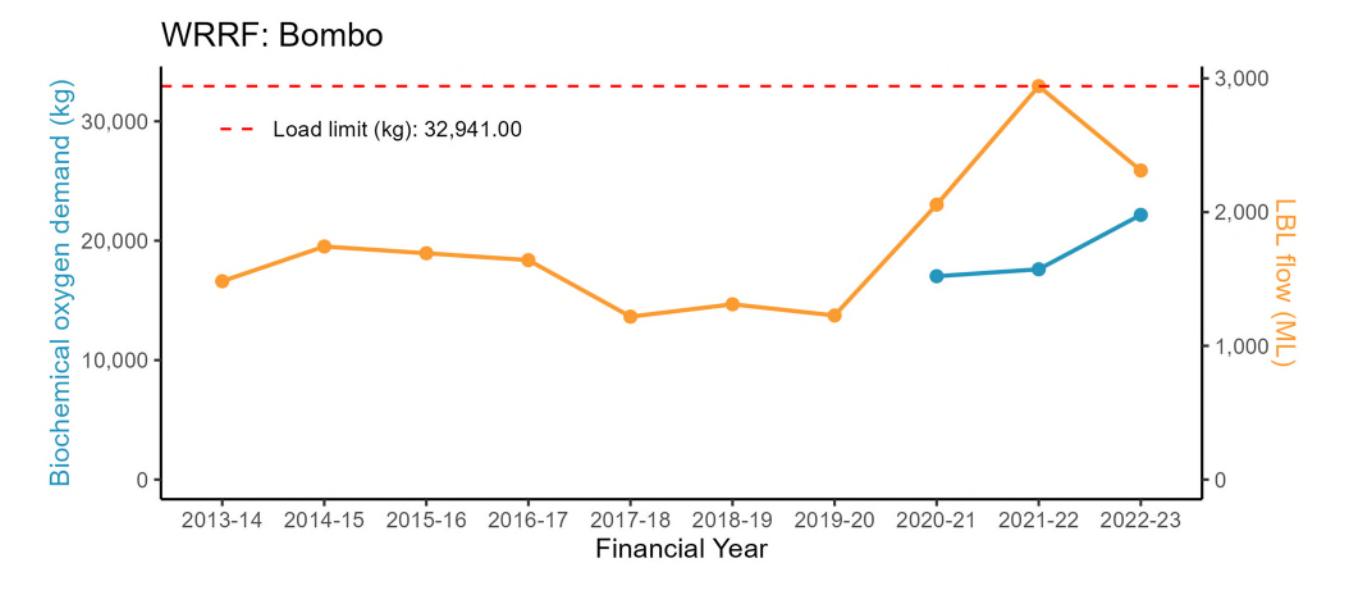
D-6.4 Pressure – Wastewater discharge load

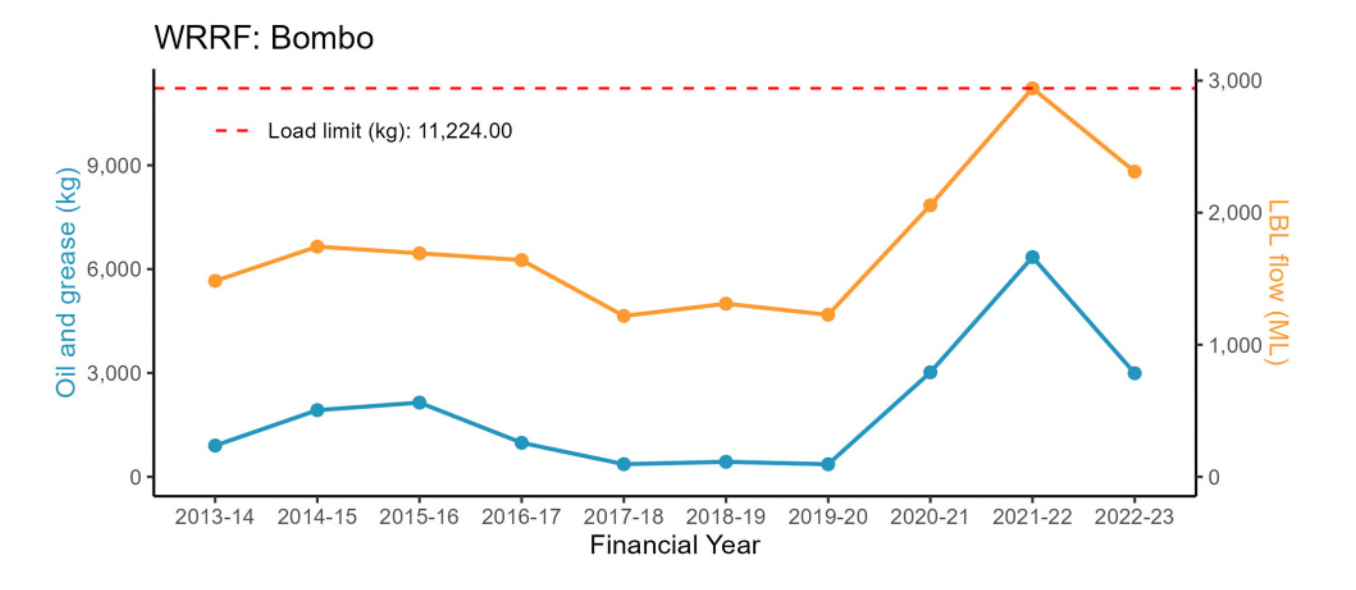
Nutrients

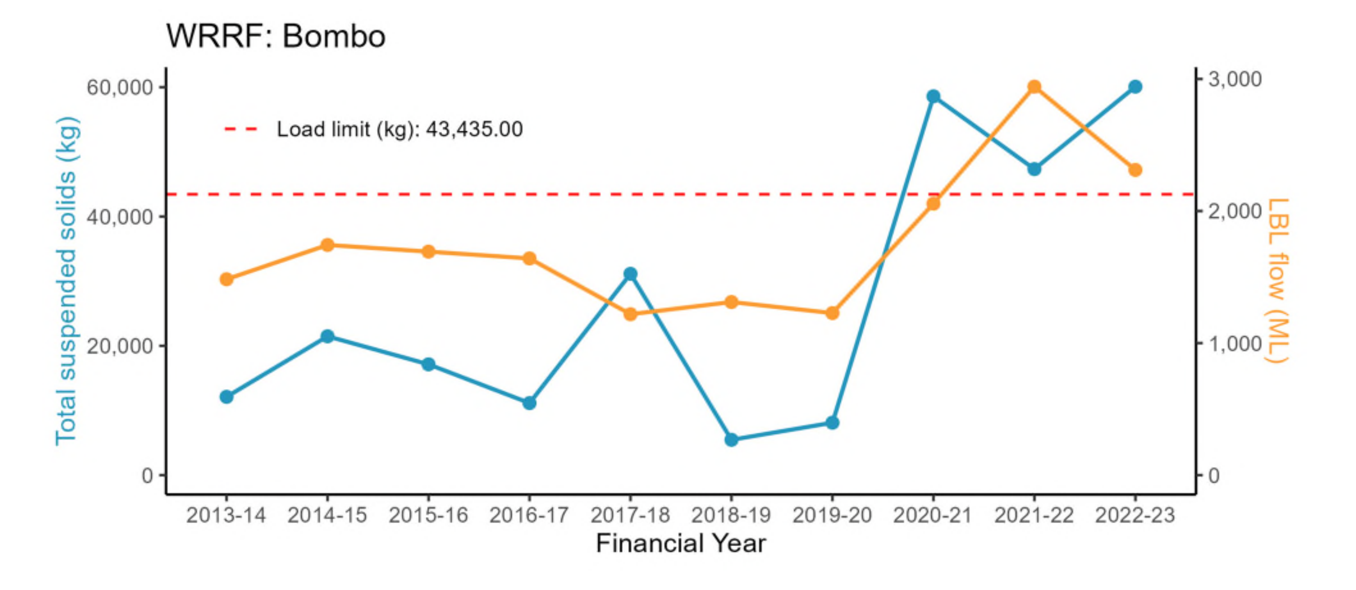




Major conventional analytes







D-7 EPL limits of Nearshore discharging WRRFs

Table D-5 EPL concentration limits for the Nearshore discharging WRRFs (2022-23)

WRRF	Sampling Points	Ammonia Nitrogen (mg/L)			Biochemical Oxygen Demand (mg/L)			Faecal Coliform (cfu/100mL)	Oil and Grease (mg/L)		Total Suspended Solids (mg/L)				Sea urchin fertilisation (EC50)	
		Average	50th %-ile	90th %-ile	50th %-ile	90th %-ile	100th %-ile	50th %-ile	50th %-ile	90th %-ile	50th %-ile	80th %-ile	90th %-ile	100th %-ile	Average	90th %-ile
Warriewood	WW0005 (C), (G)							200			30	40			6.7	4
Cronulla	CR0003 (C), CR0017 (G)	31		52	15	20		200	5	8	10		15		1.53	0.19
Wollongong	WO0005 (C), (G)				20						30		40			
Shellharbour	SH0004 (C), (G)	20		38	20			150			30		40		2.09(50%ile)	1.87
Bombo	BO0004 (C), BO0013 (G)		10	18	15			150			20		40		2.16	1.18

WRRF	Sampling Points	Aluminium (µg/L)			Copper (µg/L)			Zinc (µg/L)		Chlorpyrifos (µg/L)		Cyanide (µg/L)		Diazinon (µg/L)			Nonylphenol ethoxylate (µg/L)			Unionised H_2S (µg/L)		
		Average	50th %-ile	90th %-ile	Average	50th %-ile	90th %-ile	Average	90th %-ile	Average	90th %-ile	Average	90th %-ile	Average	50th %-ile	90th %-ile	Average	50th %-ile	90th %-ile	Average	50th %-ile	90th %-ile
Warriewood	WW0005 (C), (G)	80		150	15		30					17	30				11		22			
Cronulla	CR0003 (C), CR0017 (G)	100		383	50		500	55	100	0.09	1	5	10	0.2		2	8		11	38		70
Wollongong	WO0005 (C), (G)	120		430	40		80							0.1		0.5				30		60
Shellharbour	SH0004 (C), (G)	110		220	10		20							0.1		1	6		10	44		165
Bombo	BO0004 (C), BO0013 (G)		150	523		25	65								0.1	0.2		8	14		58	97

Table D-6 EPL load limits for the Nearshore discharging WRRFs (2022-23)

Load limits (in kg) 2022-23	Warriewood	Cronulla		Wollongong	Shellharbour	Bombo
Total Nitrogen	299,300	735,110		743,076	254,770	64,057
Total Phosphorus	74,460	243,090		74,319	63,364	21,280
Biological Oxygen Demand	135,050	319,010		198,535	116,070	32,941
Total Suspended Solids	175,200	305,000		198,594	150,380	43,435
Oil & Grease	41,975	110,000		123,915	35,953	11,224
Cadmium		28				
Chromium		76				
Copper		2,551				
Lead		138				
Mercury		5				
Selenium		356				
Zinc		2,956				
Pesticides		20				

Appendix E: Offshore marine environment

This Appendix includes graphical presentation of all monitoring data for the Offshore Marine catchment. Summary tables and detailed statistical analyses outcomes are also included where relevant.

The Water Resource Recovery Facilities (WRRFs) that are discharging into offshore marine environment are ordered from North (North Head) to South (Malabar).

Under each Offshore WRRF, **Pressure** indicator results are presented first following the **Pressure**, **Stressor** and **Ecosystem Receptor** (**P-S-ER**) causal pathway elements (E-1 to E-3).

Trend plots are included on wastewater quantity (discharge and inflow), quality, toxicity and discharge loads. Trends plots on other supplementary data are also included to improve our understanding on:

- weather condition ie catchment specific rainfall condition for each WRRF
- wastewater reuse/ recycling volume of relevant WRRF.

Wastewater quality and load plots are included in following four sub-groups, and then within each sub-group, analytes presented in alphabetical order:

- nutrients
- major conventional analytes
- trace metals
- other chemicals and organics (including pesticides)

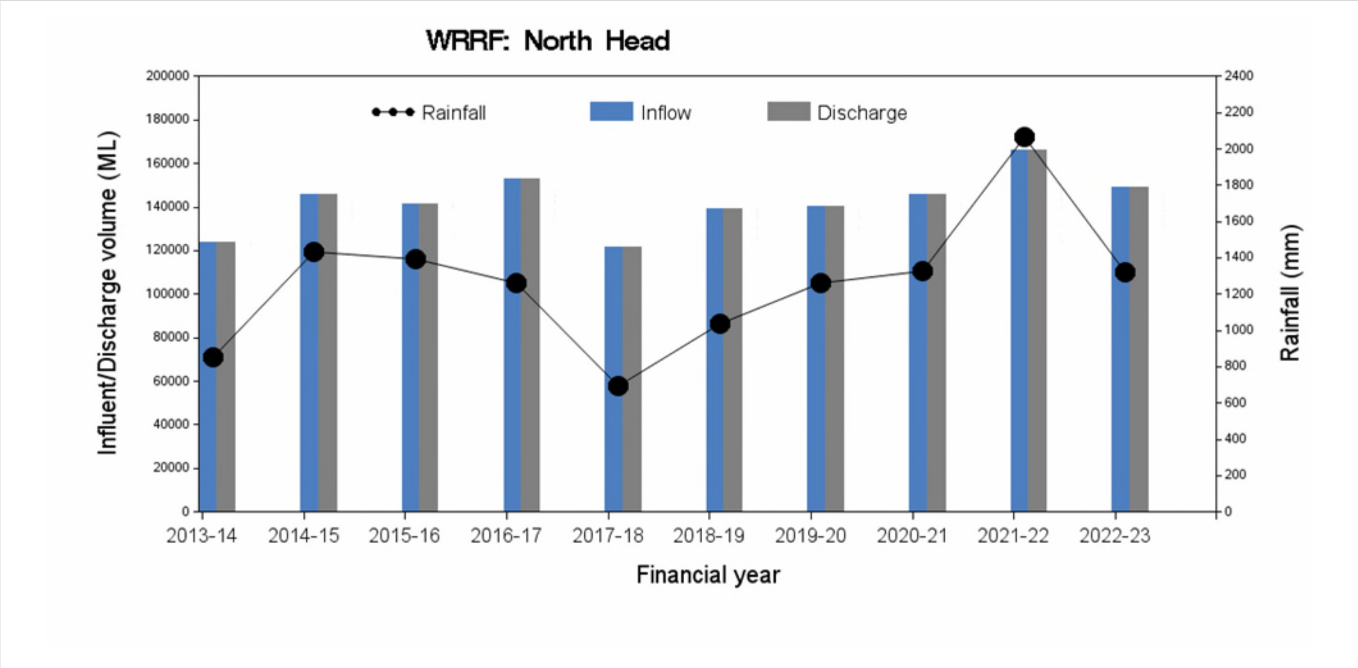
Tests conducted on wastewater are specified in the Environment Protection Licence (EPL) issued by the NSW EPA for each WRRF (E-4). Data for all these measured analytes that have EPL concentration and load limits are included.

For the **Stressor** and **Ecosystem Receptor** indicators data are presented together at the end for all three offshore WRRFs (E-5 and E-6).

E-1 North Head WRRF

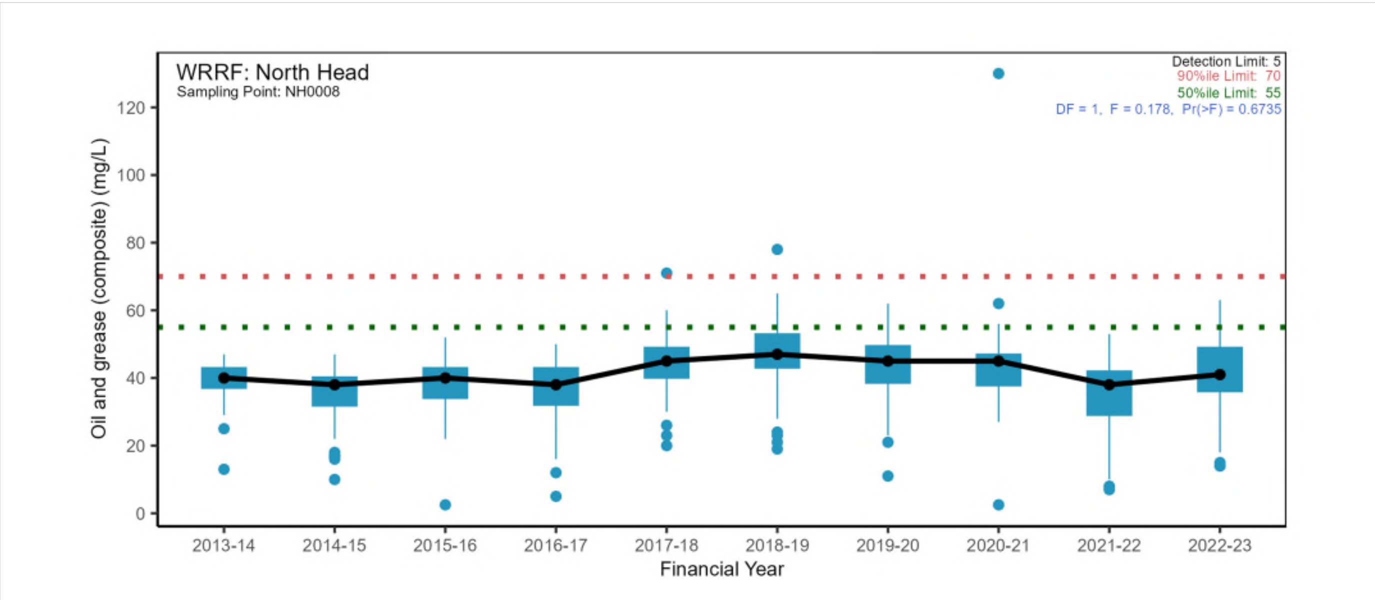
E-1.1 Pressure – Wastewater quantity

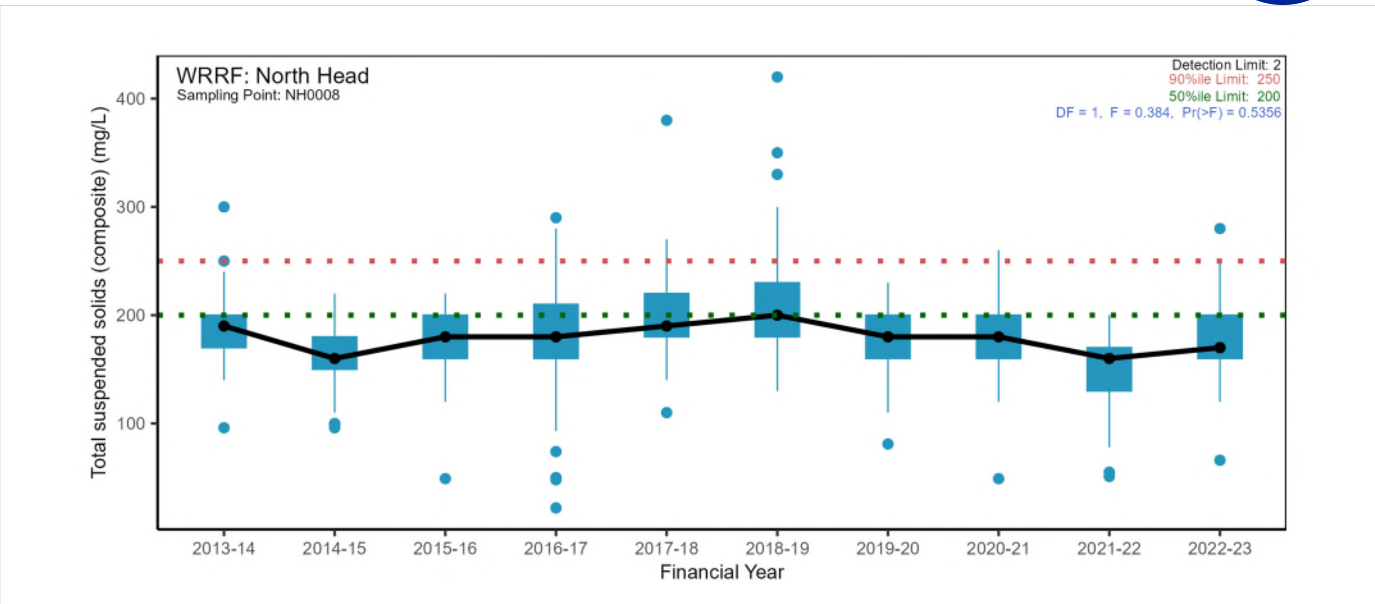
Inflow/ Discharge volume and rainfall



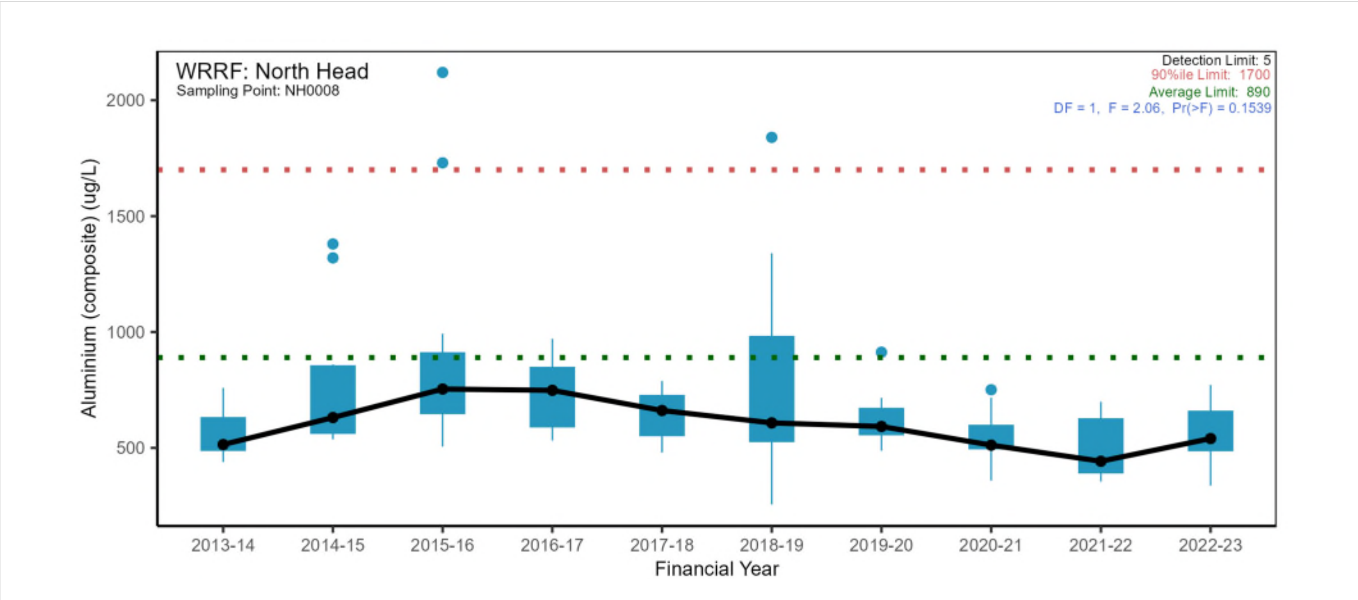
E-1.2 Pressure – Wastewater quality

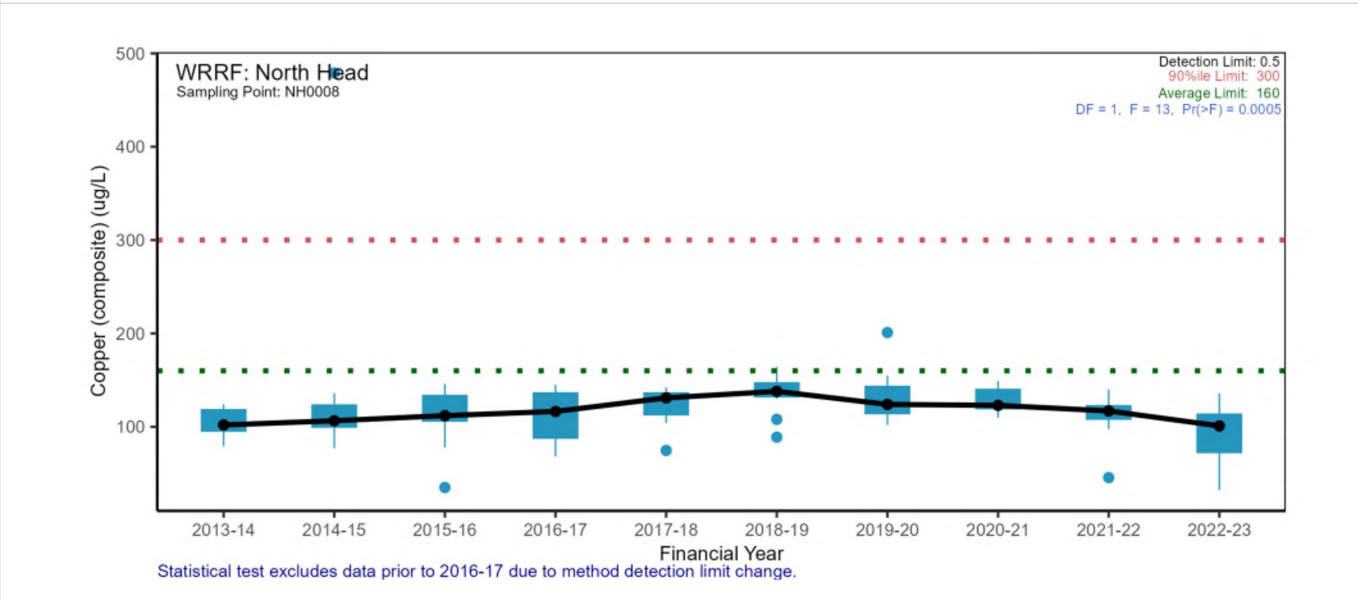
Major conventional analytes



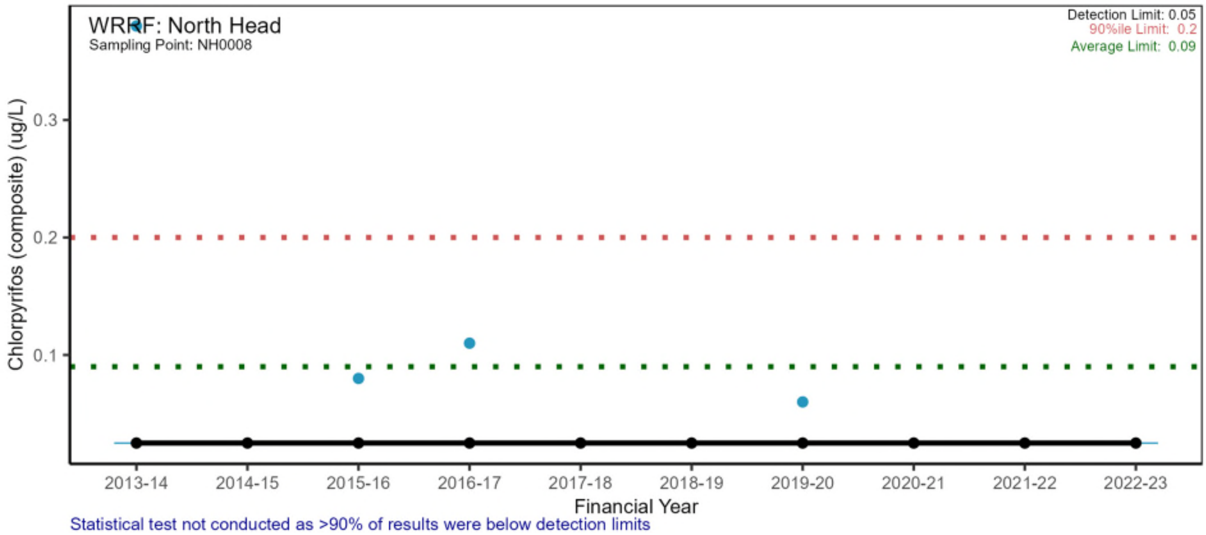


Trace metals

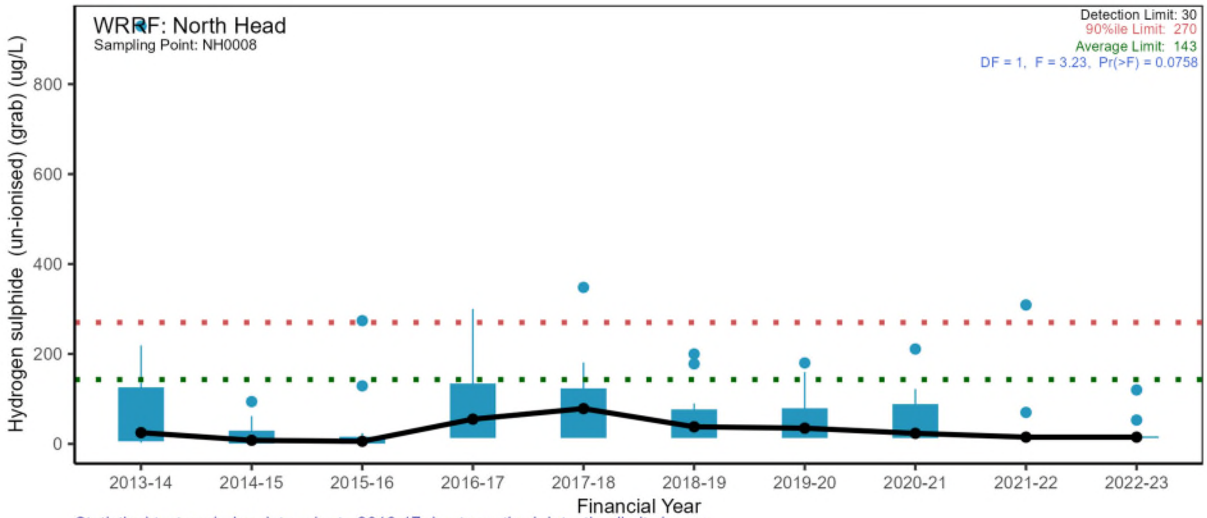




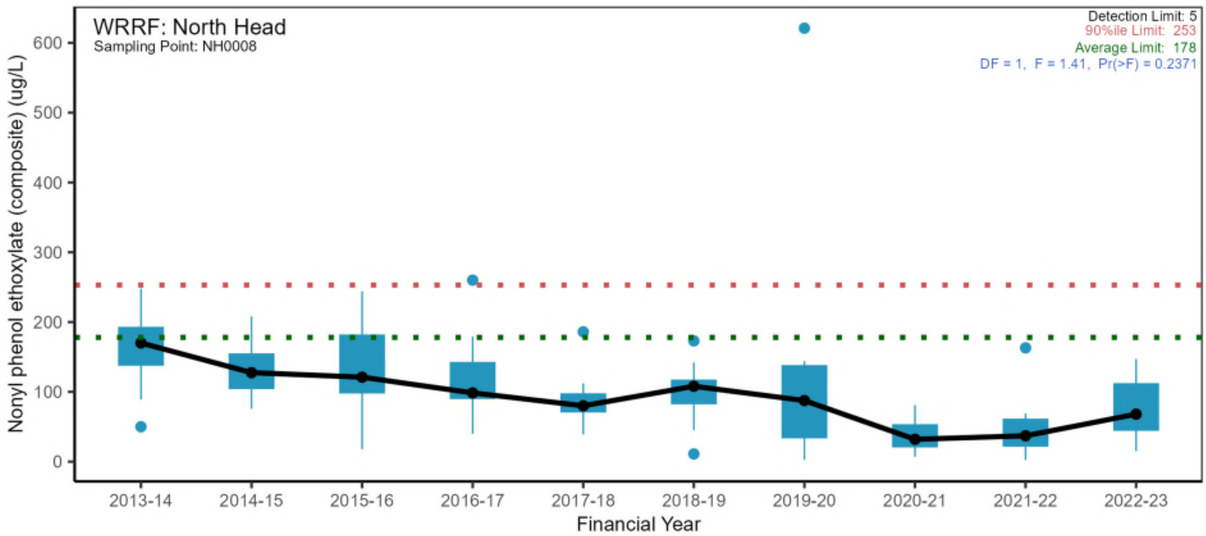
Other chemicals and organics (including pesticides)



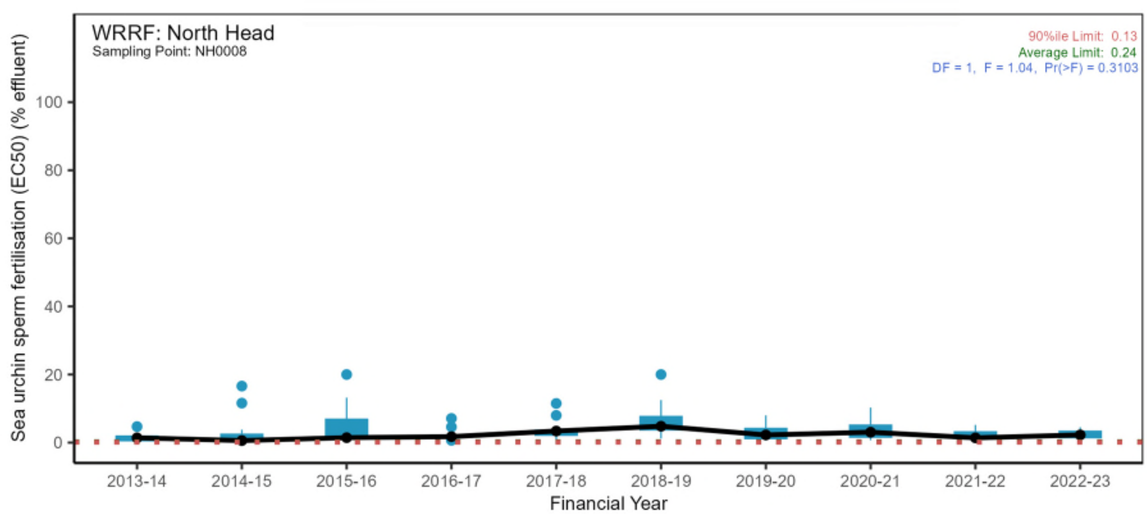
Statistical test not conducted as >90% of results were below detection limits



Statistical test excludes data prior to 2016-17 due to method detection limit change.

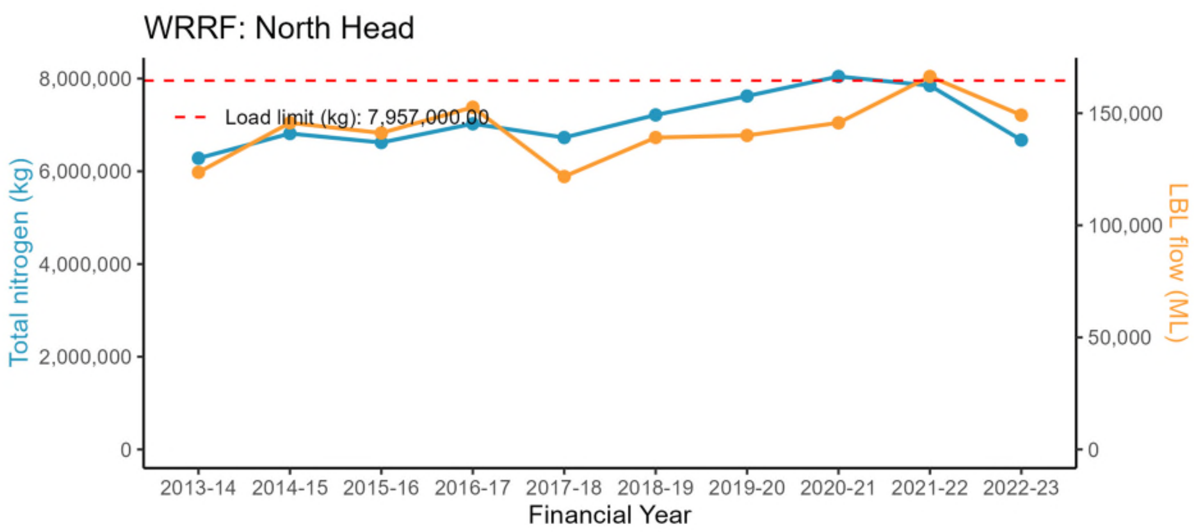


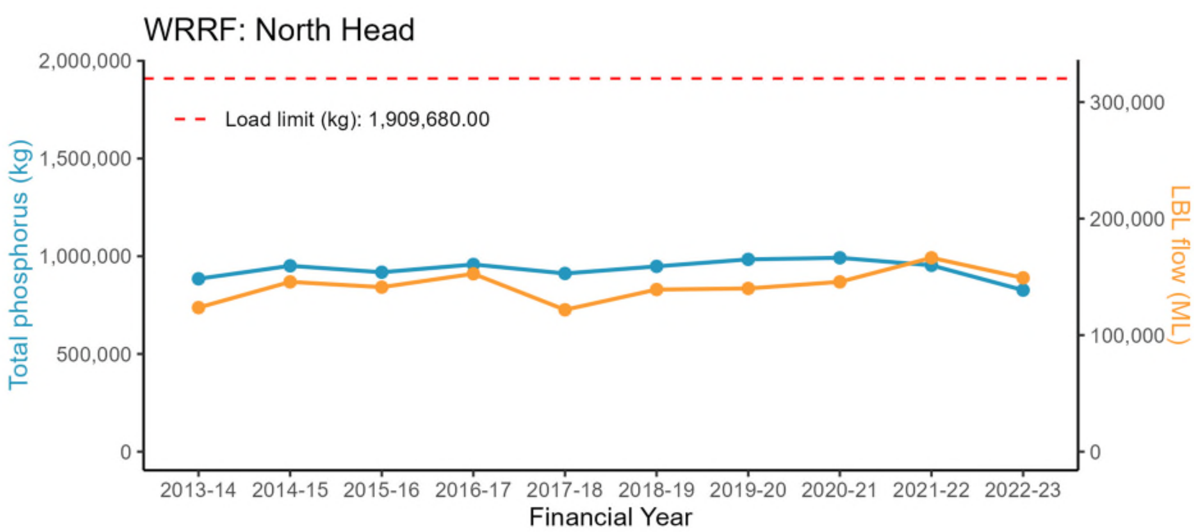
E-1.3 Pressure – Wastewater toxicity



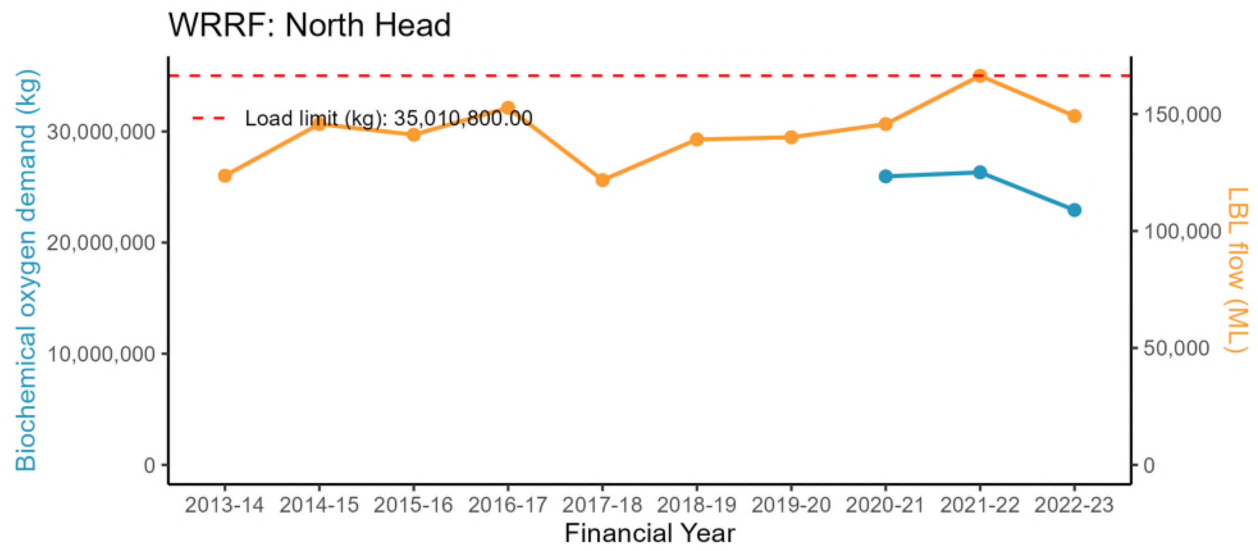
E-1.4 Pressure – Wastewater discharge load

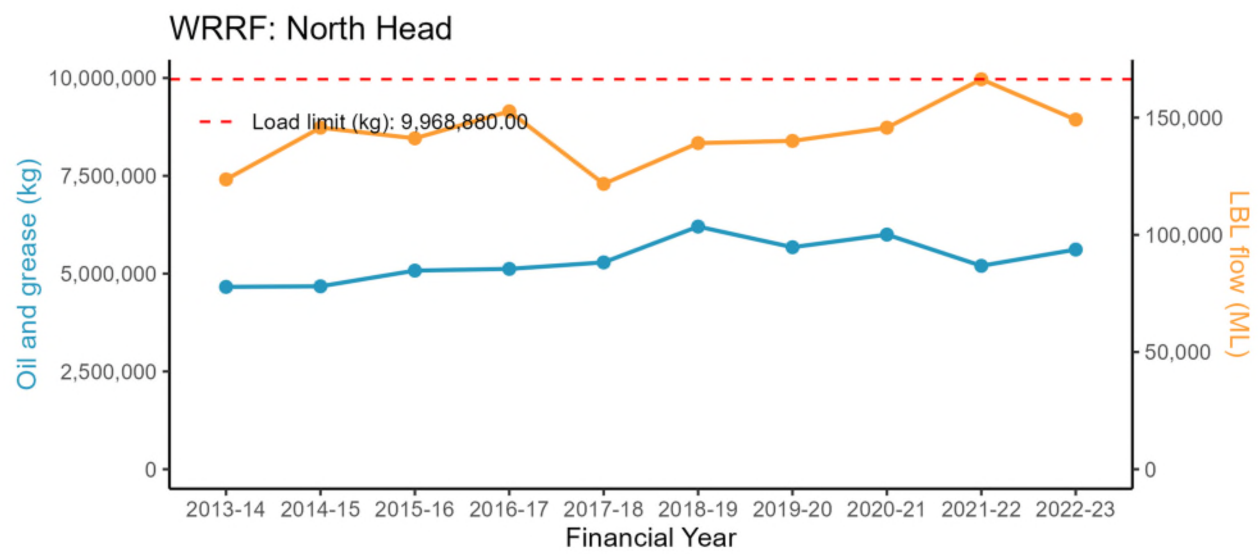
Nutrients

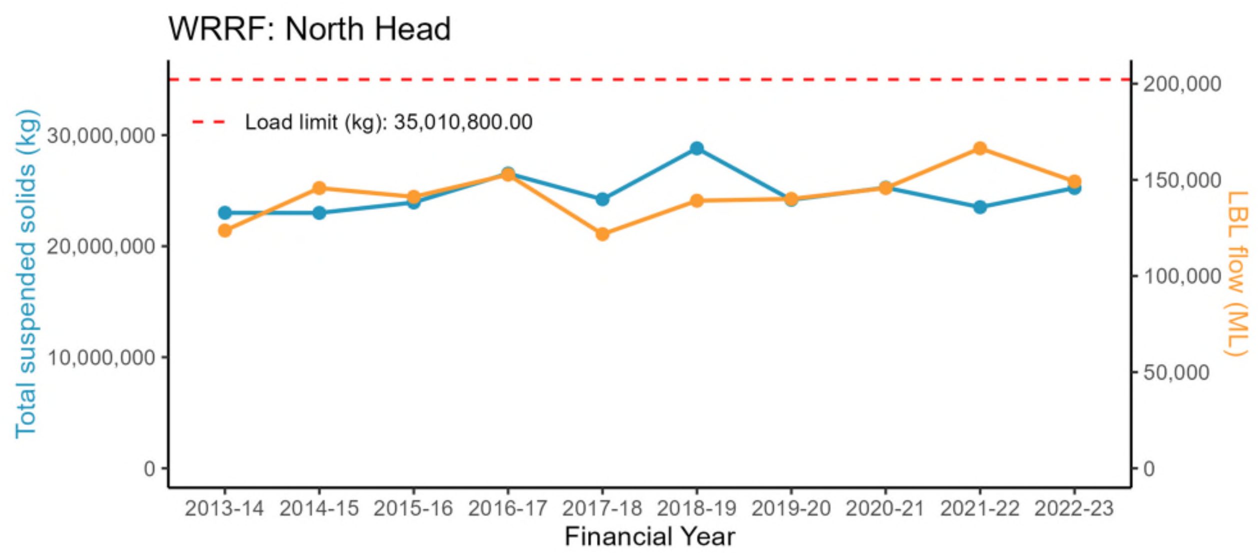




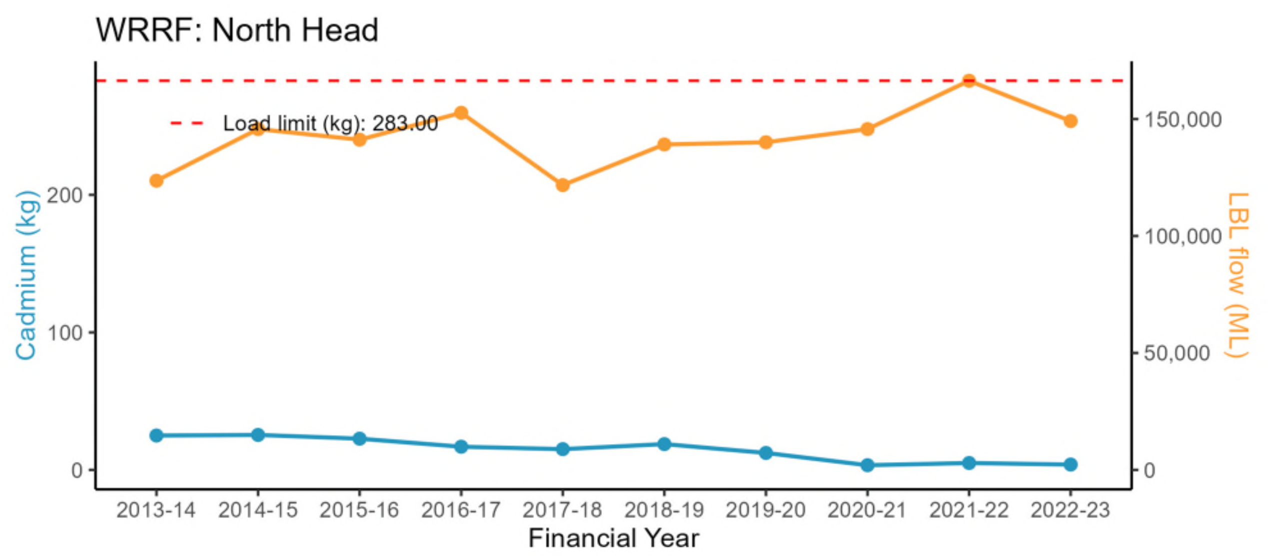
Major conventional analytes

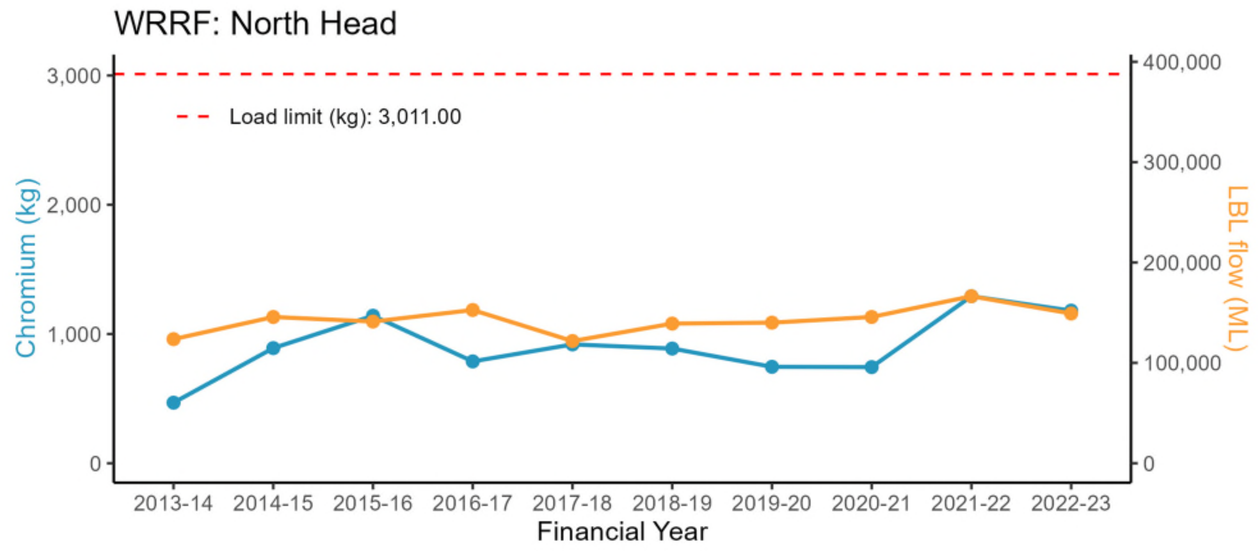


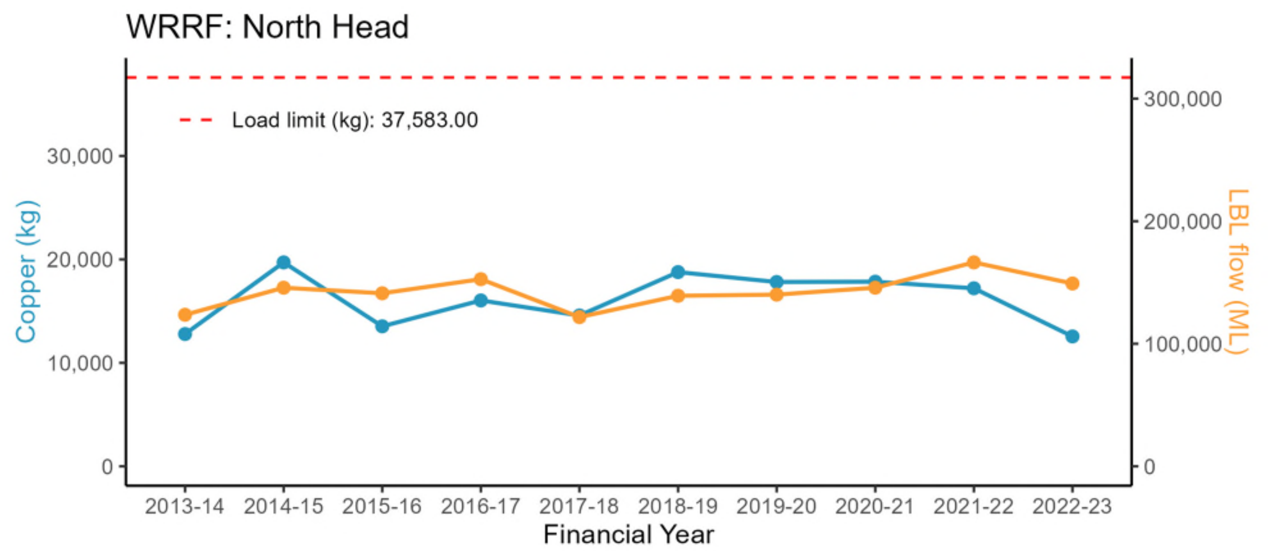


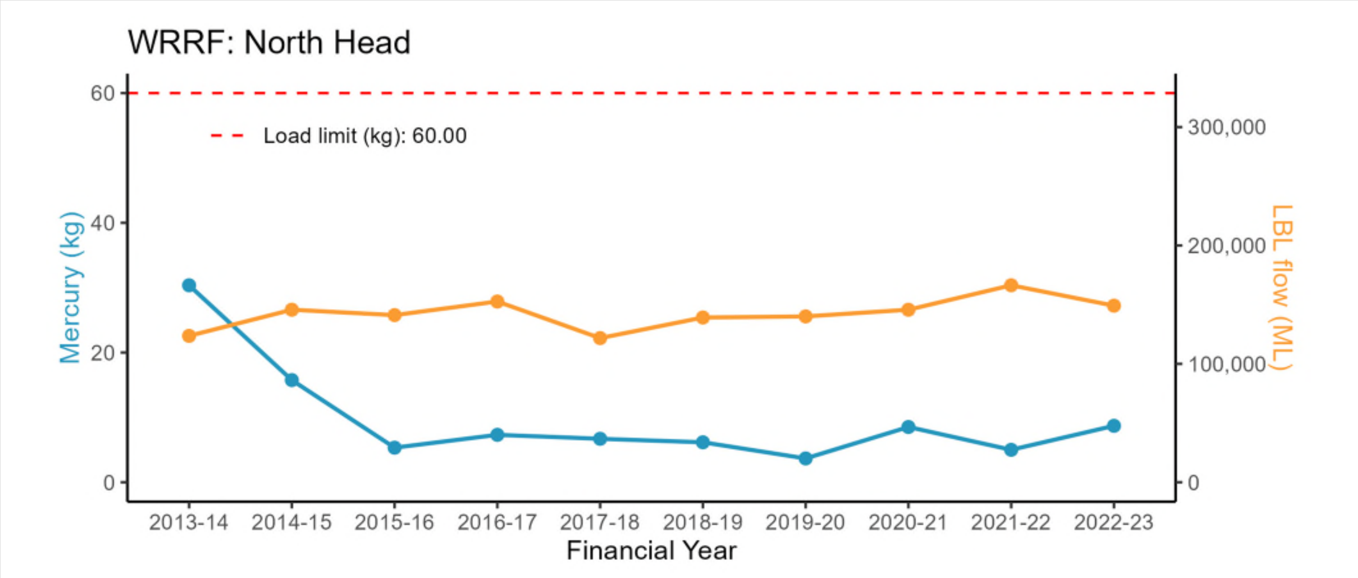


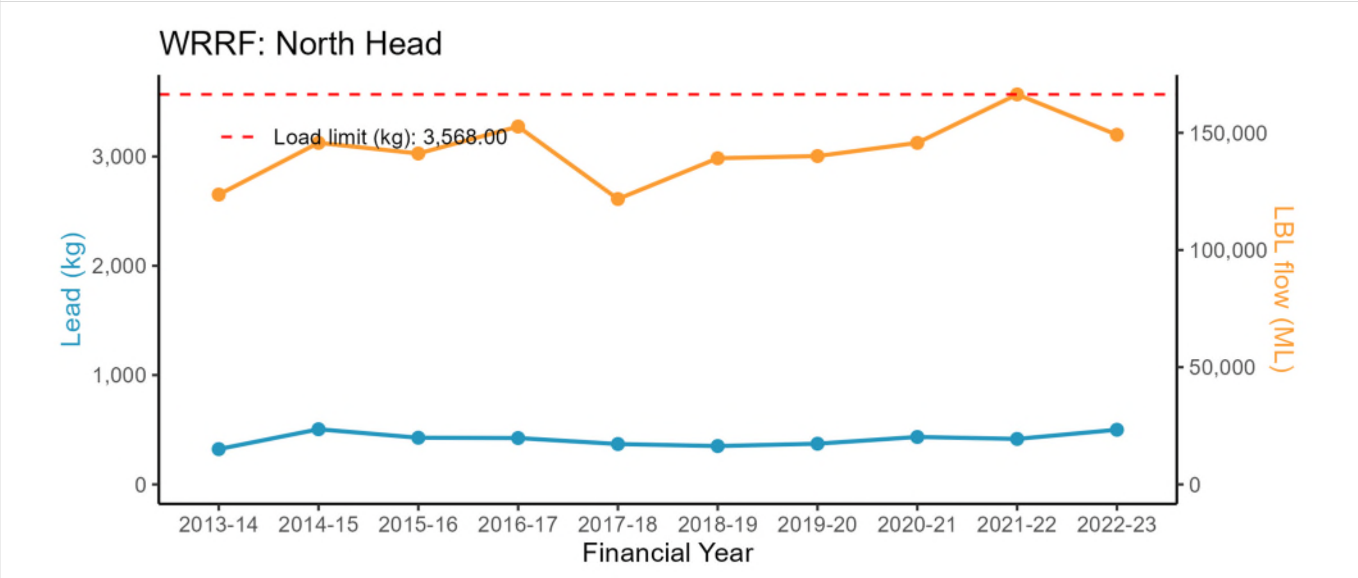
Trace metals

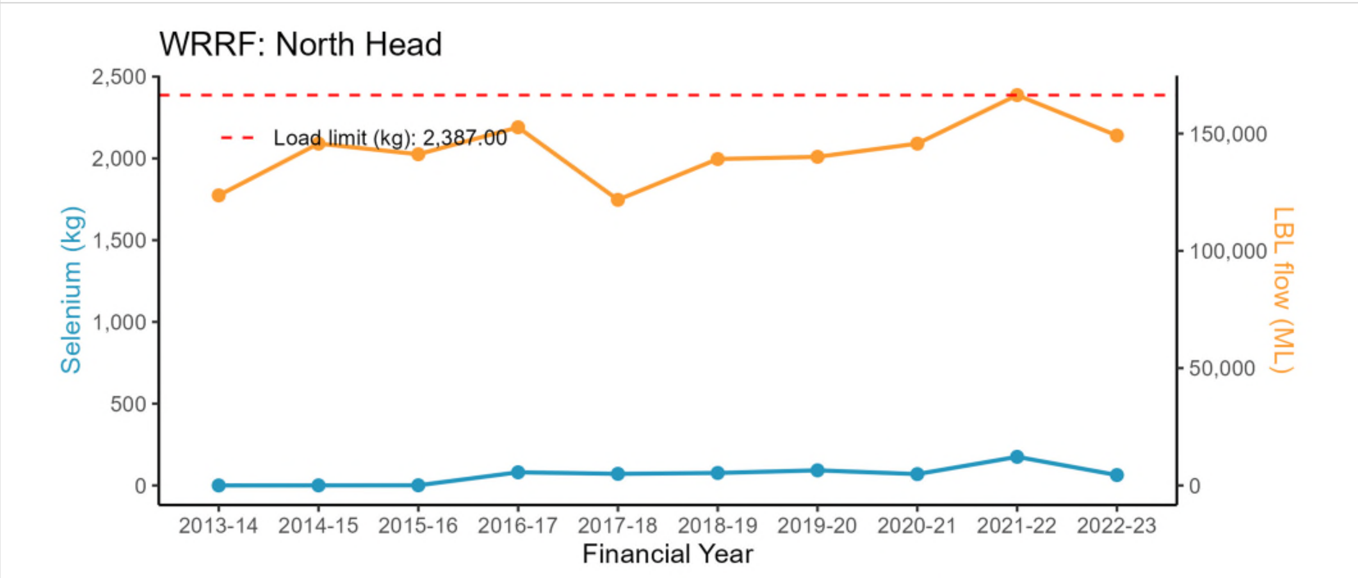


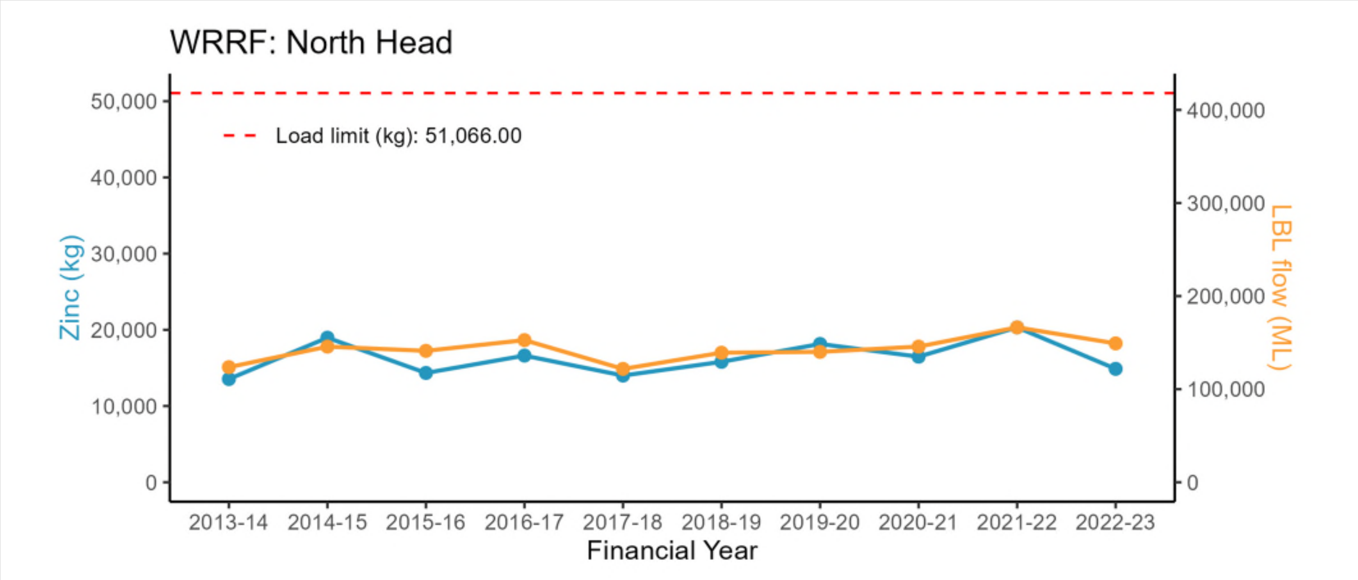




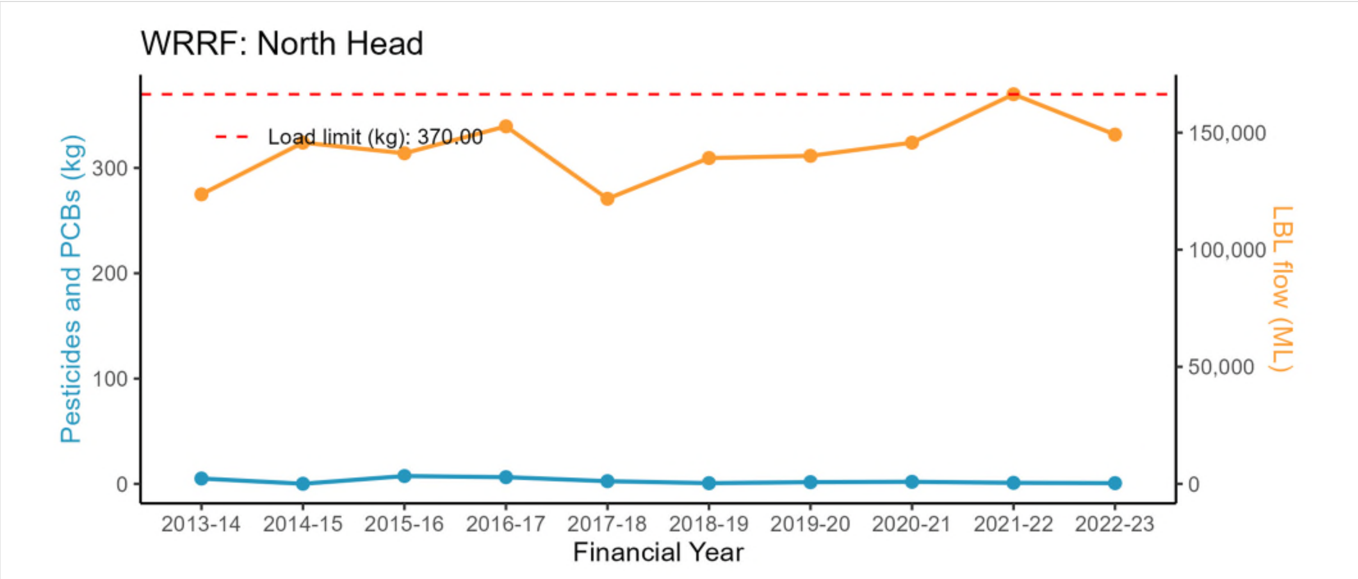

WRRF: North Head
Load limit (kg): 60.00
Mercury (kg)
LBL flow (ML)
60
40
20
0
300,000
200,000
100,000
0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Financial Year


WRRF: North Head
Load limit (kg): 3,568.00
Lead (kg)
LBL flow (ML)
3,000
2,000
1,000
0
150,000
100,000
50,000
0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Financial Year


WRRF: North Head
Load limit (kg): 2,387.00
Selenium (kg)
LBL flow (ML)
2,500
2,000
1,500
1,000
500
0
150,000
100,000
50,000
0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Financial Year



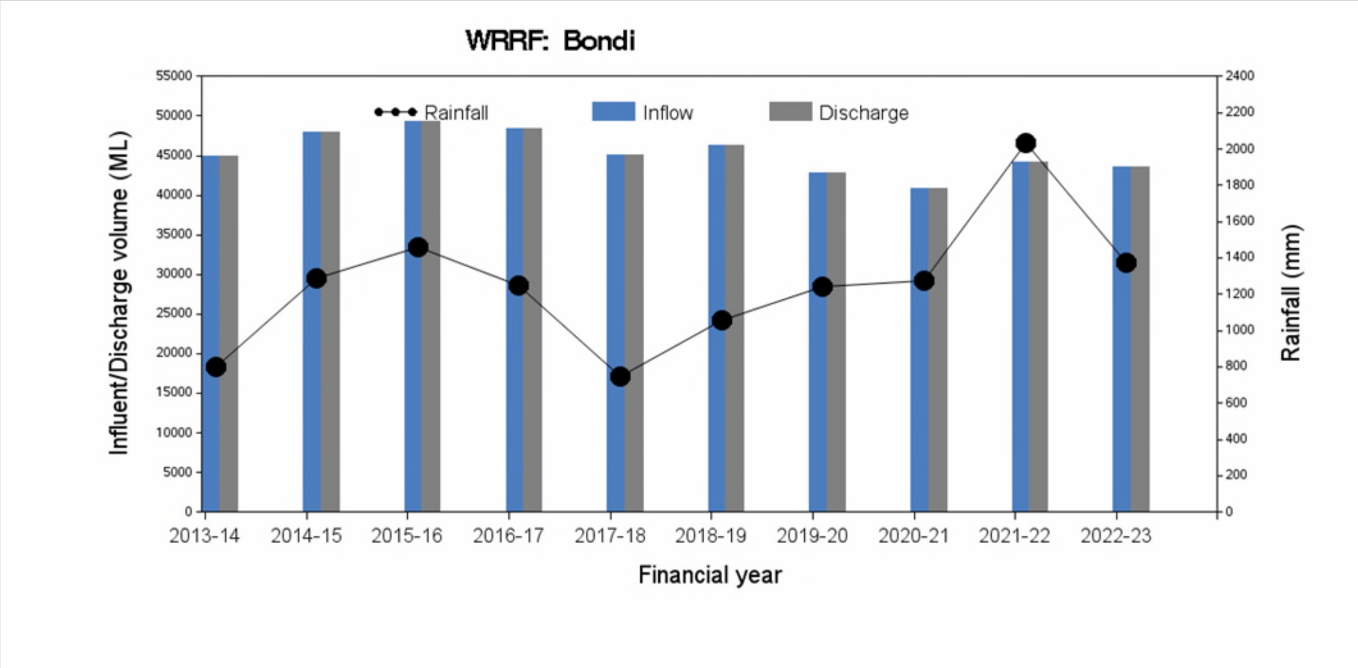
Other chemicals and organics (including pesticides)



E-2 Bondi WRRF

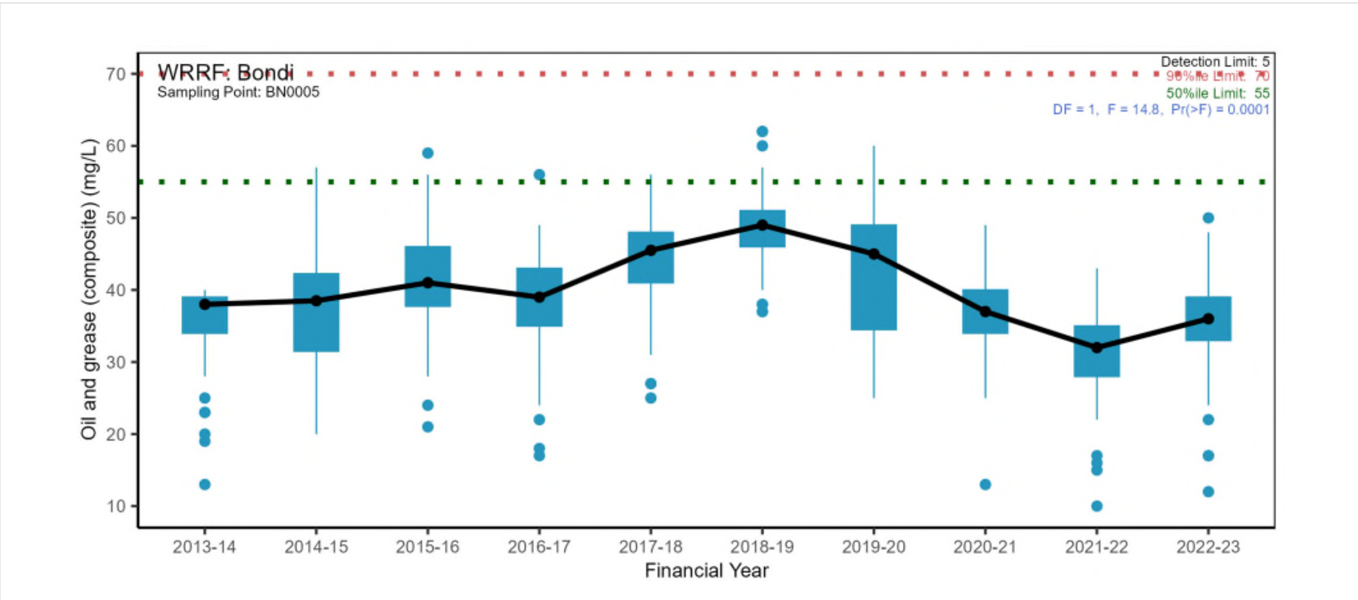
E-2.1 Pressure – Wastewater quantity

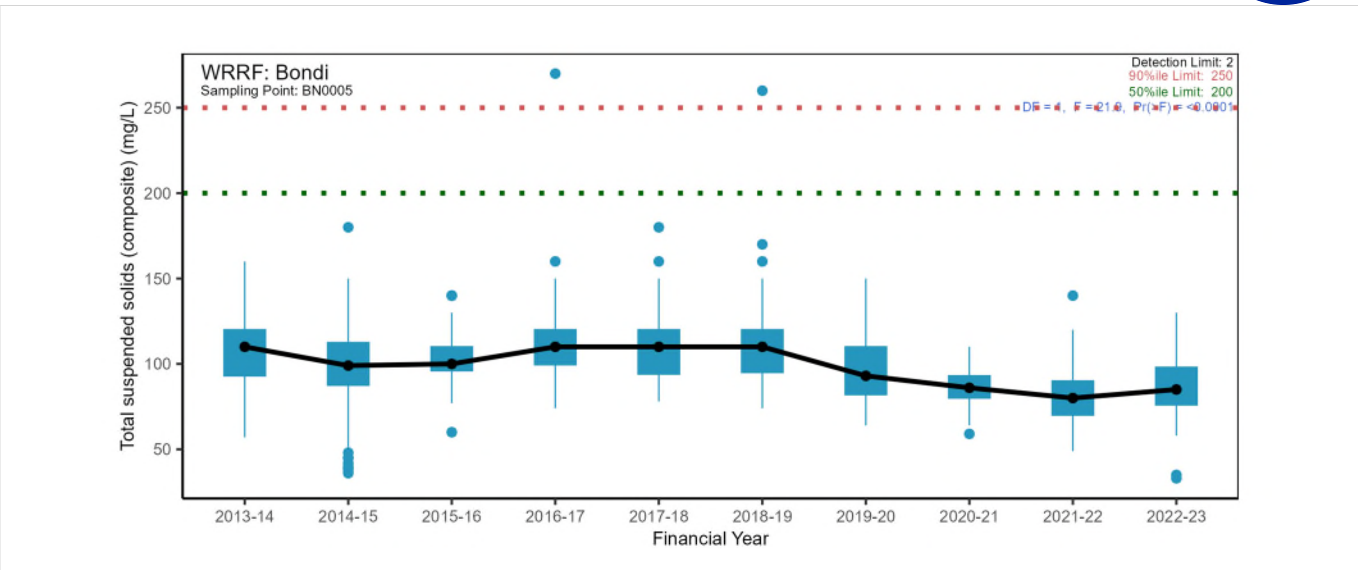
Inflow/ Discharge volume and rainfall



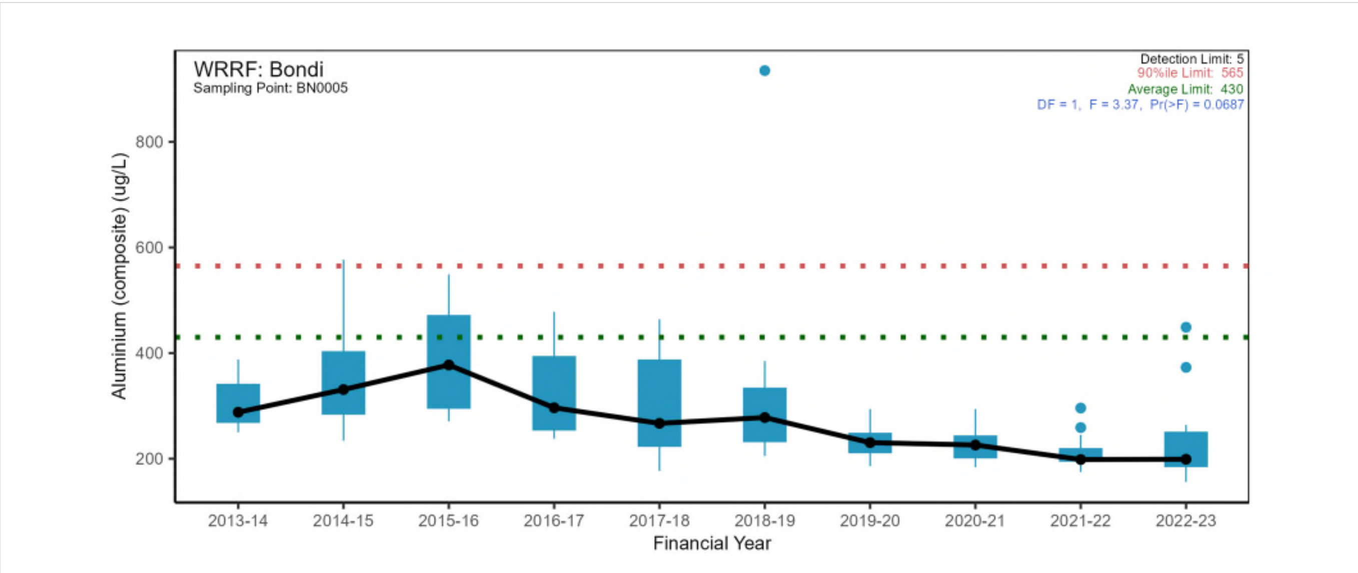
E-2.2 Pressure – Wastewater quality

Major conventional analytes

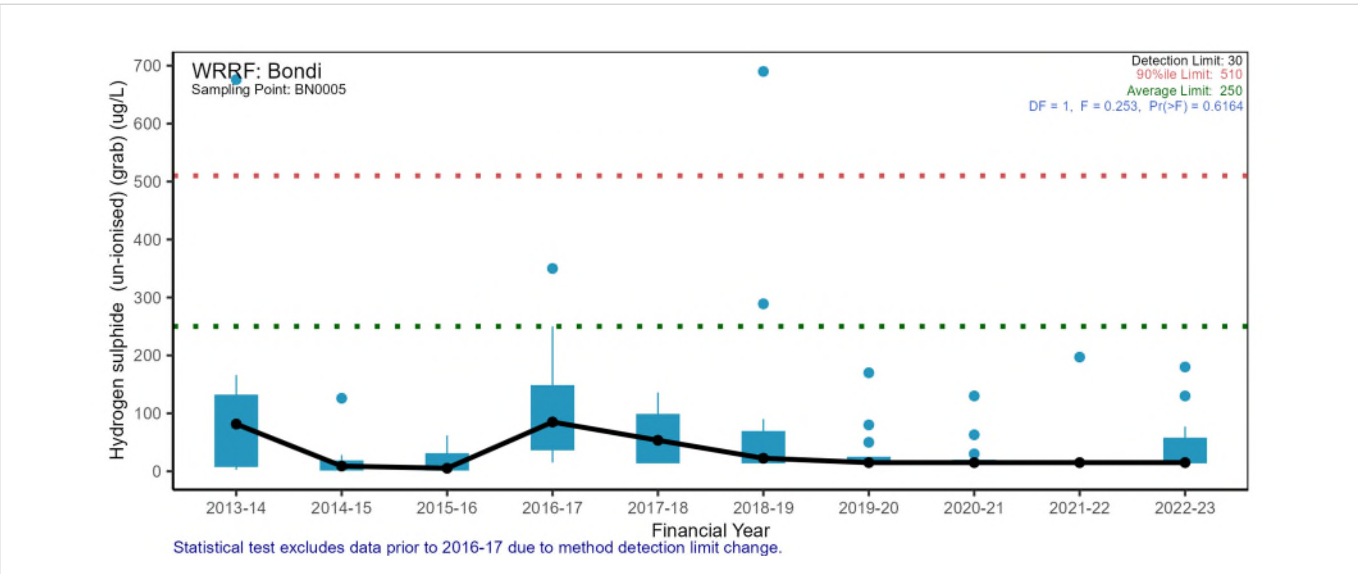


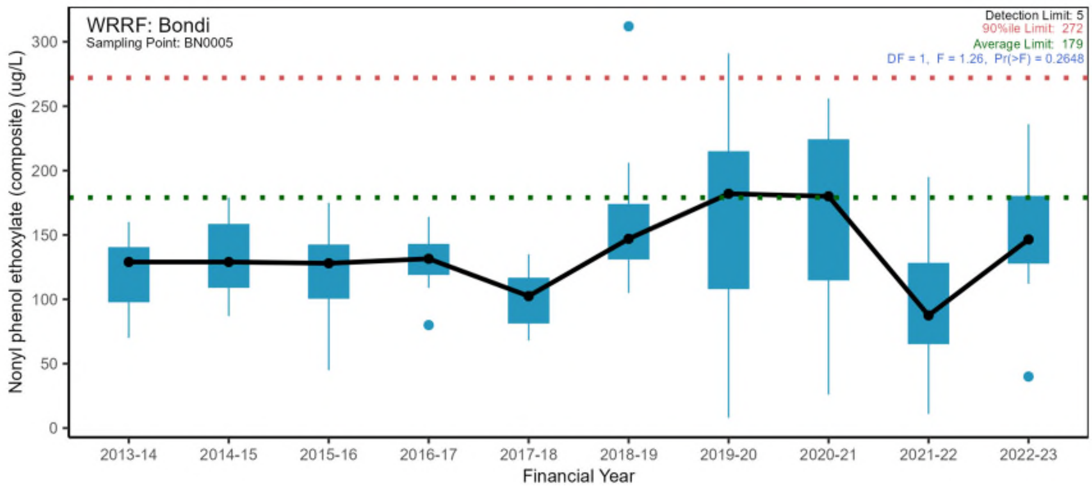


Trace metals

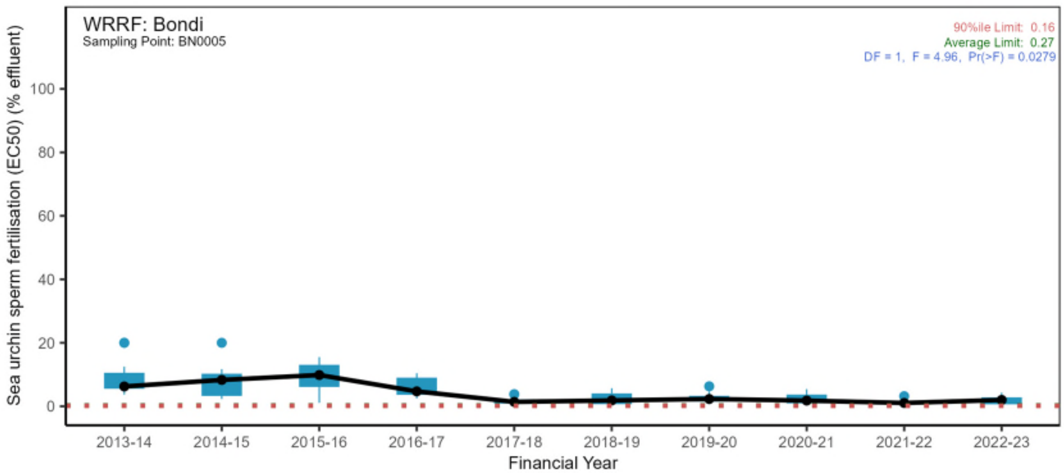


Other chemicals and organics (including pesticides)



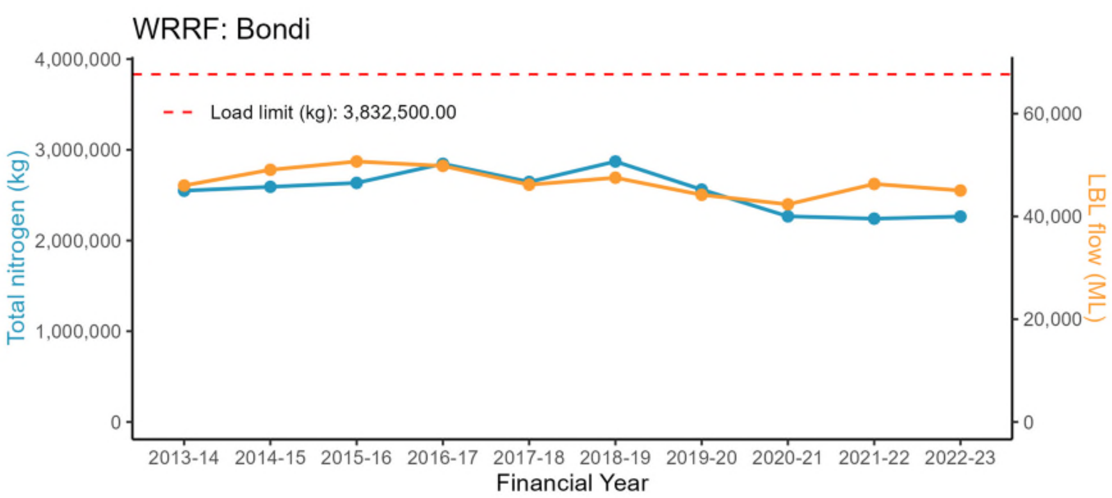


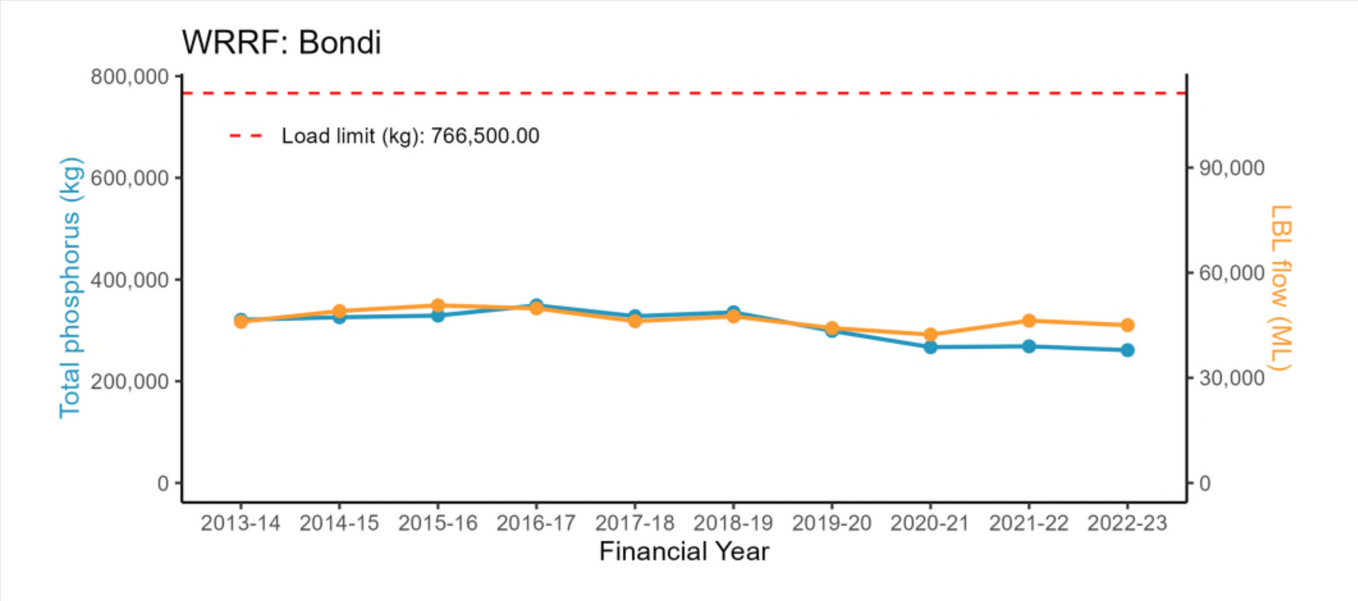
E-2.3 Pressure – Wastewater toxicity



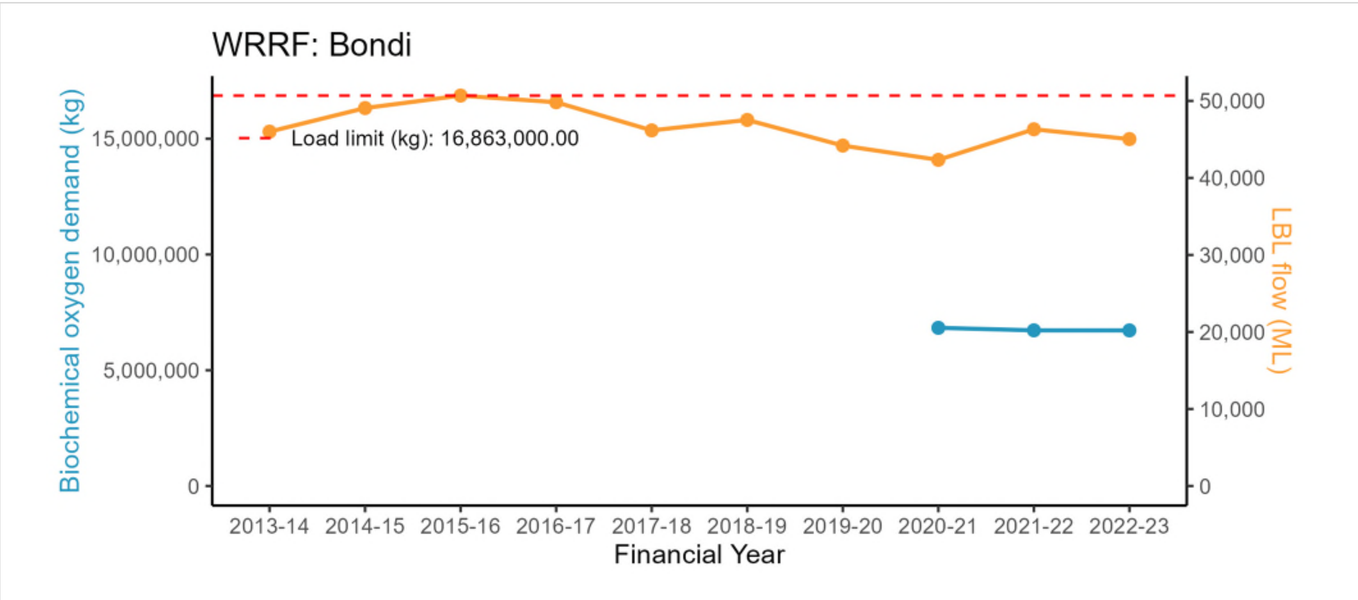
E-2.4 Pressure – Wastewater discharge load

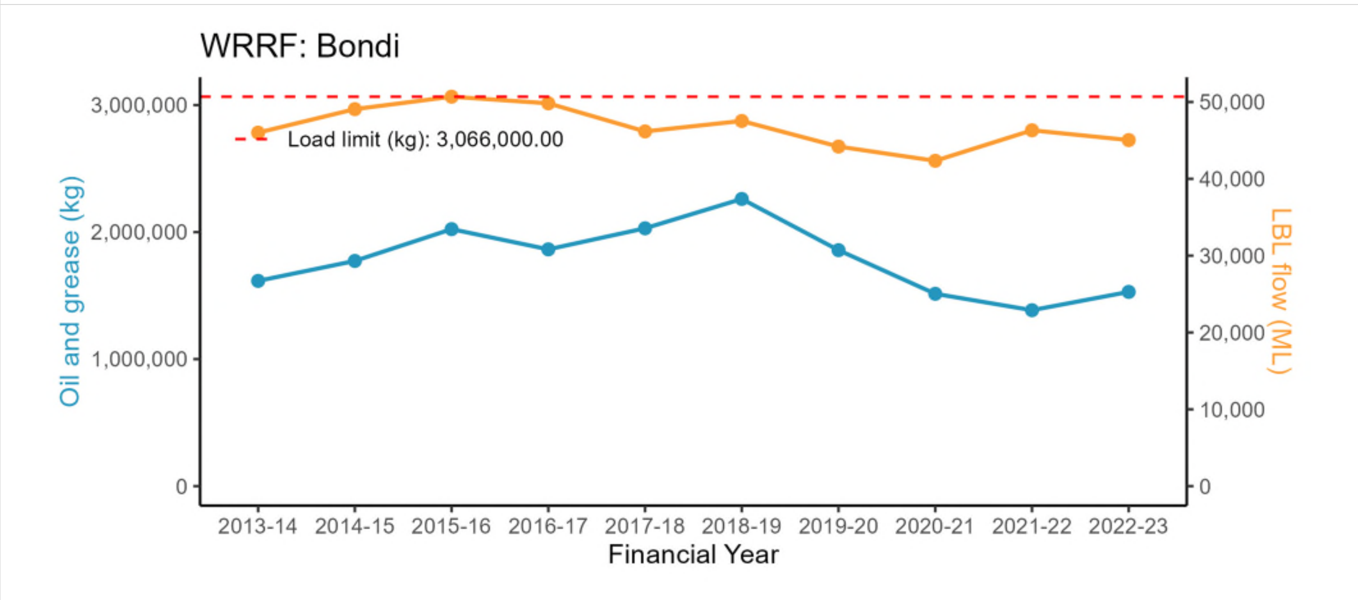
Nutrients

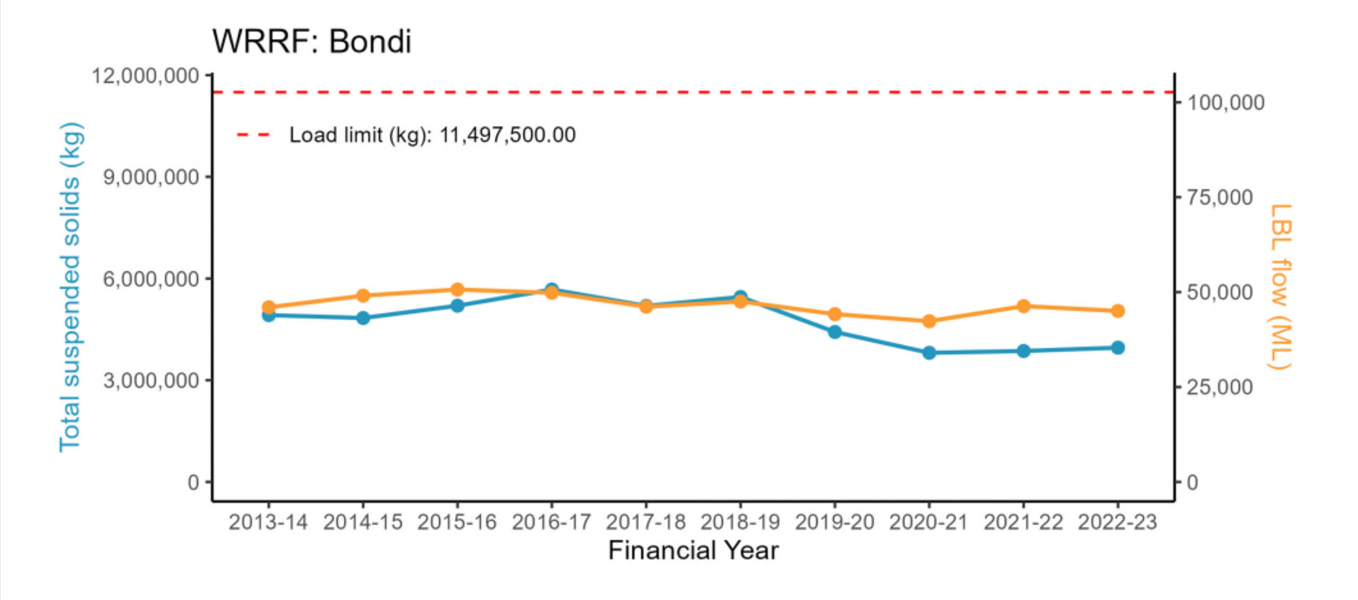




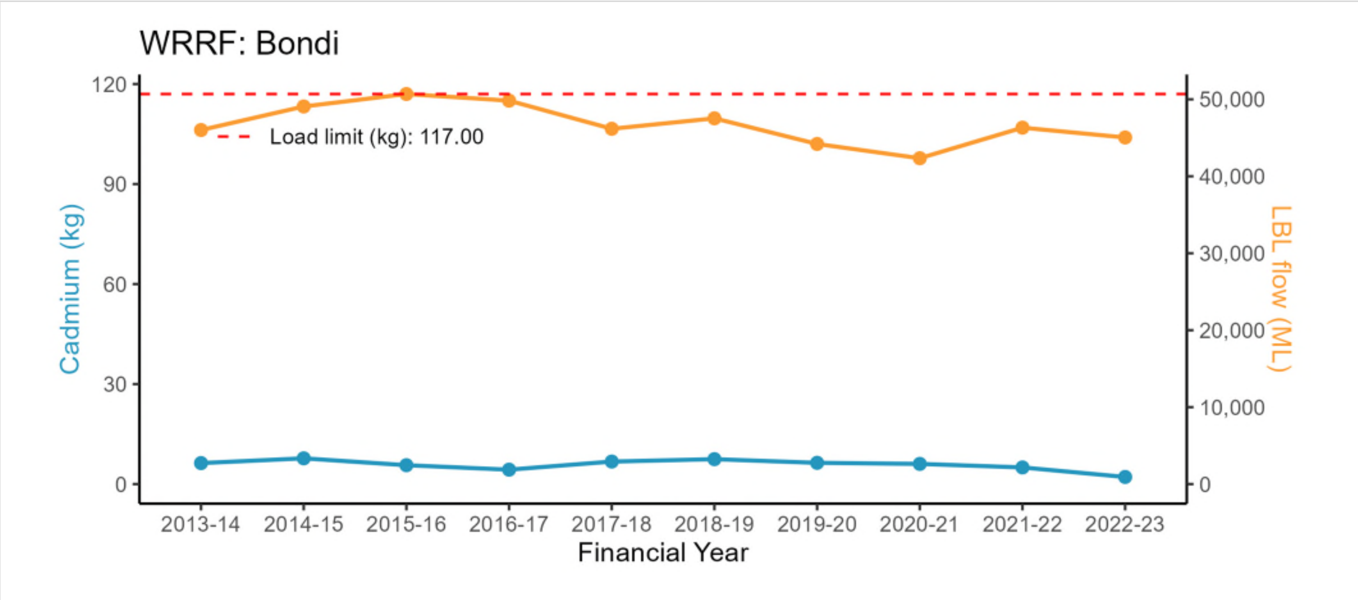
Major conventional analytes

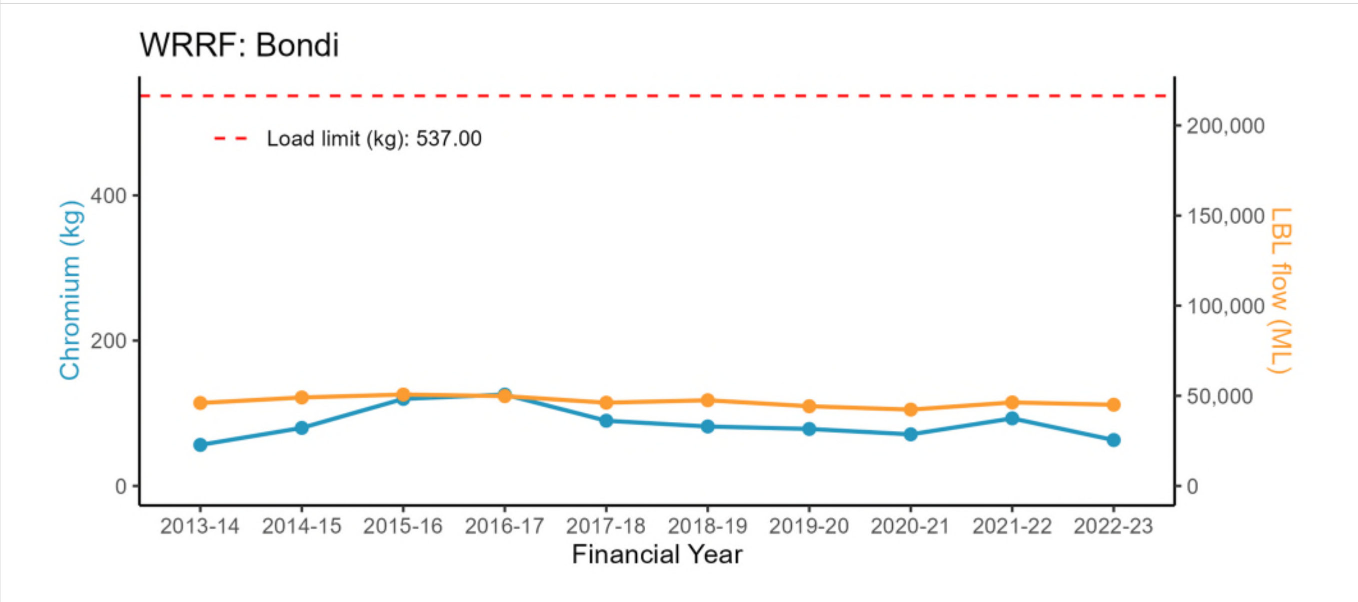


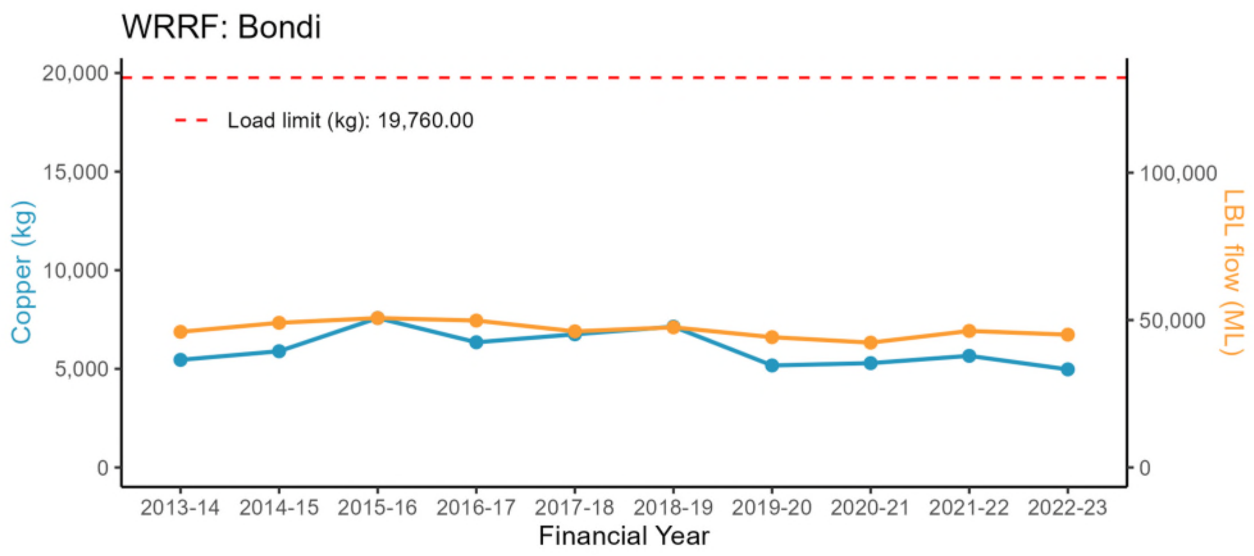


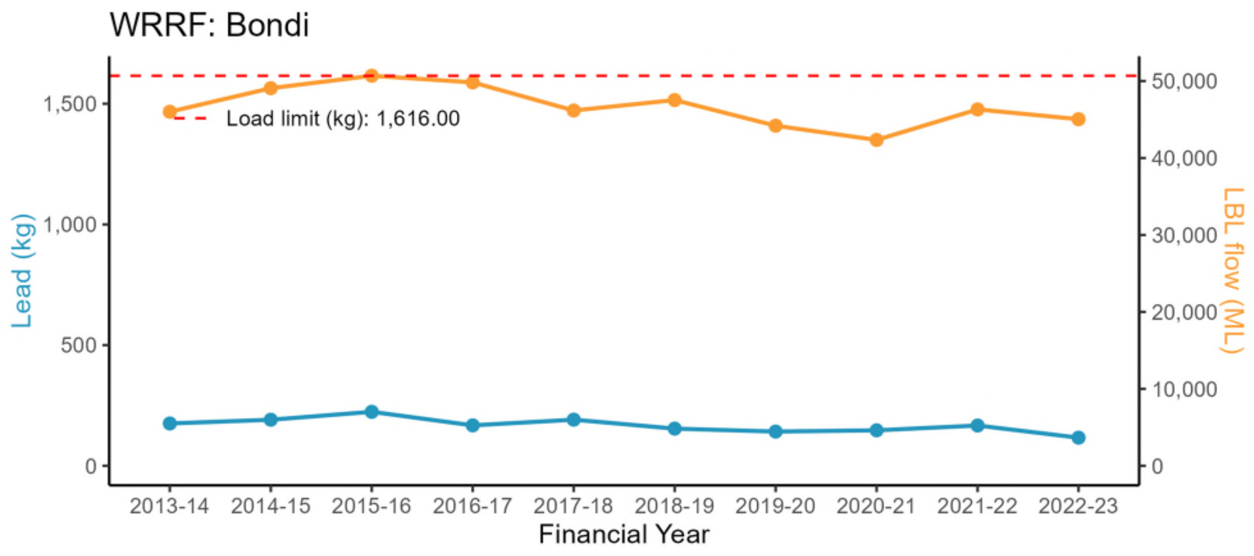


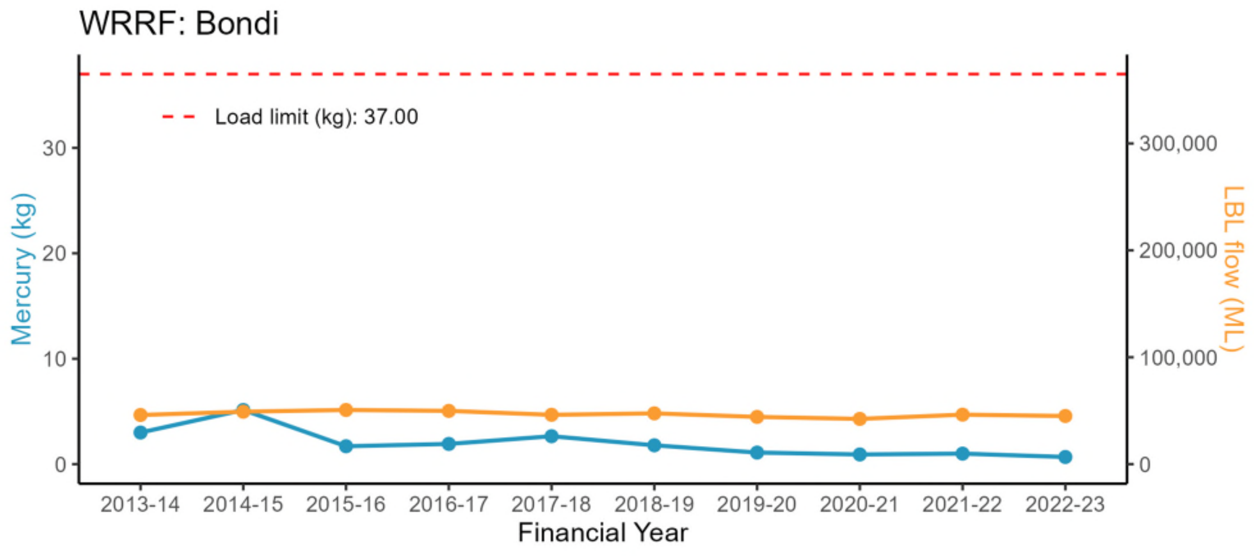
Trace metals

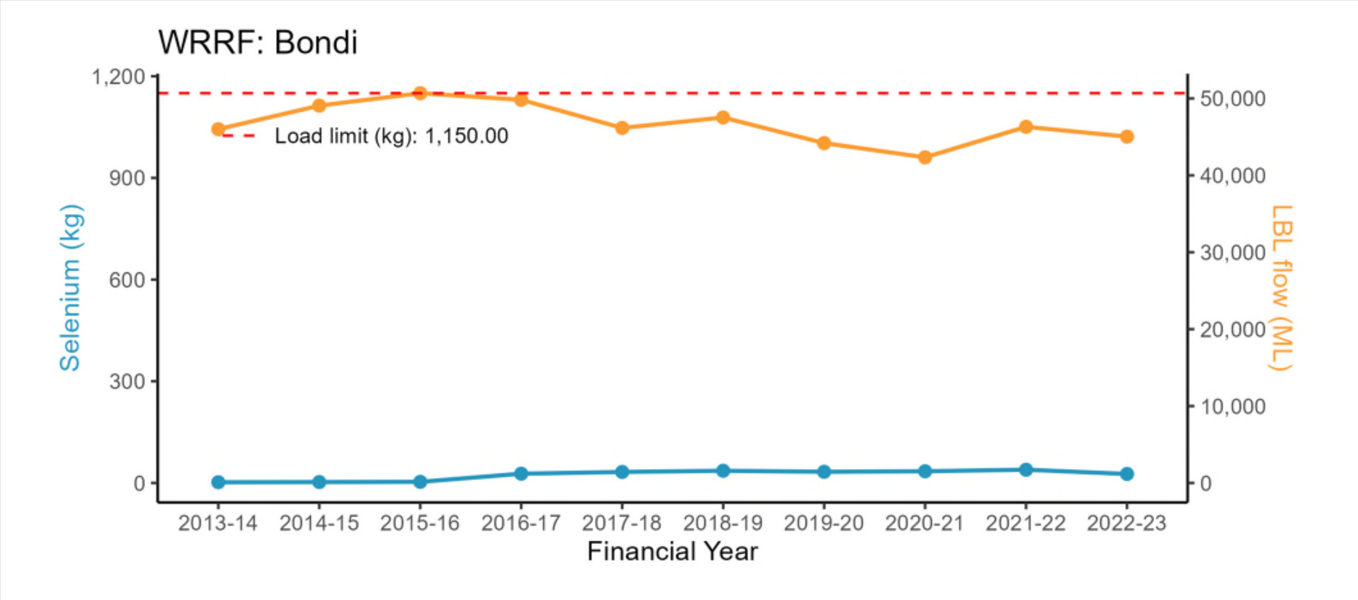


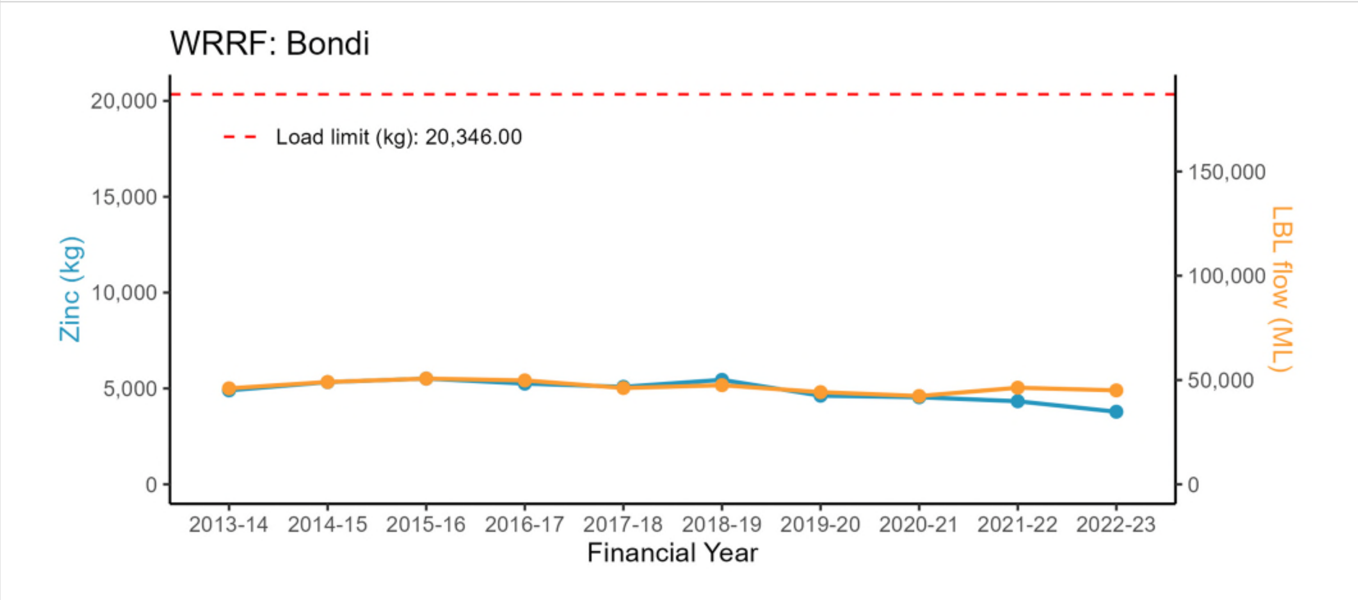



WRRF: Bondi
Load limit (kg): 19,760.00
Copper (kg)
LBL flow (ML)
20,000
15,000
10,000
5,000
0
100,000
50,000
0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Financial Year

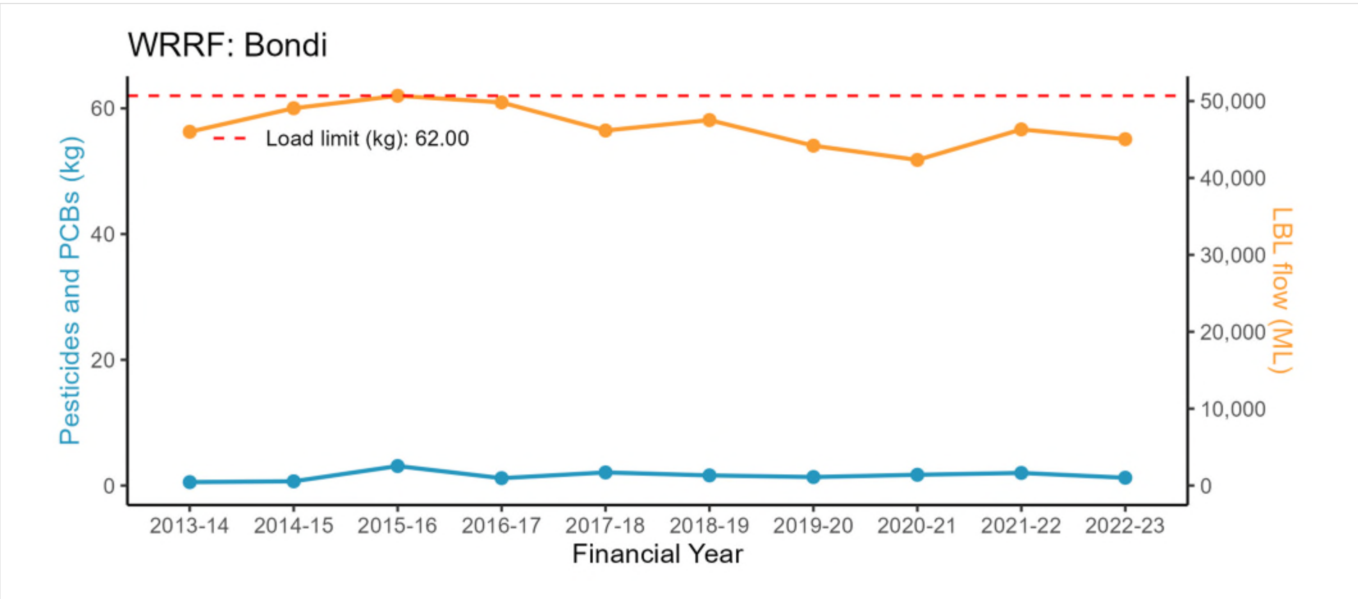

WRRF: Bondi
Load limit (kg): 1,616.00
Lead (kg)
LBL flow (ML)
1,500
1,000
500
0
50,000
40,000
30,000
20,000
10,000
0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Financial Year


WRRF: Bondi
Load limit (kg): 37.00
Mercury (kg)
LBL flow (ML)
30
20
10
0
300,000
200,000
100,000
0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Financial Year





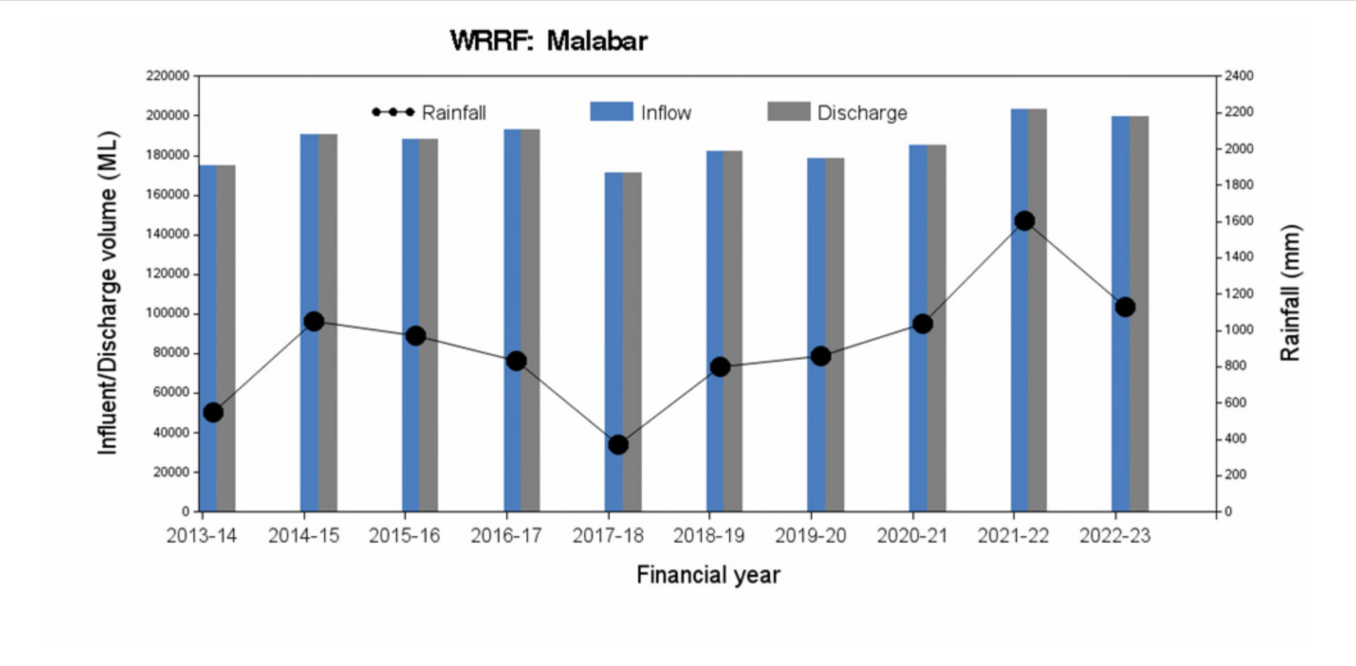
Other chemicals and organics (including pesticides)



E-3 Malabar WRRF

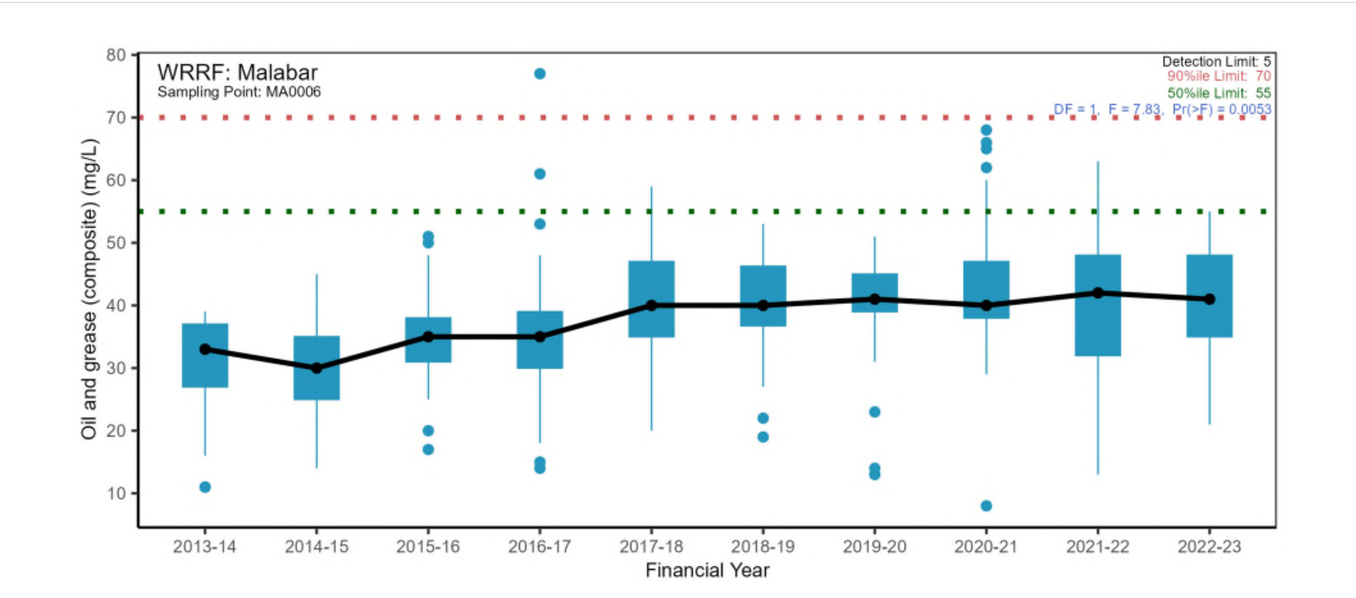
E-3.1 Pressure – Wastewater quantity

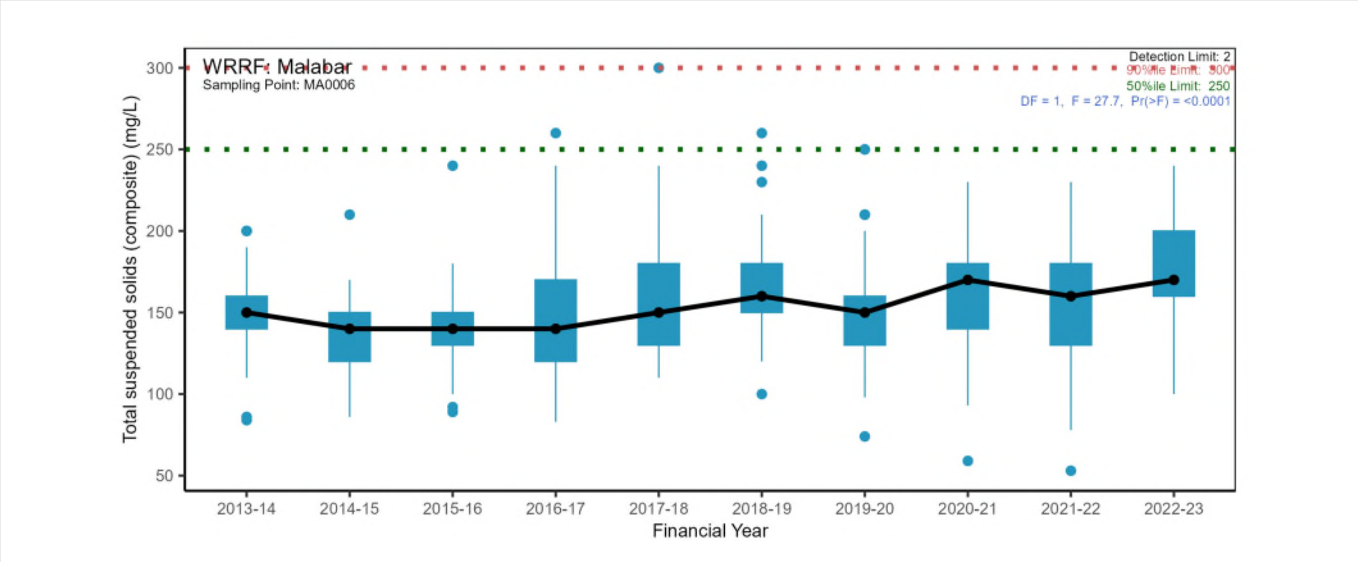
Inflow/ Discharge volume and rainfall



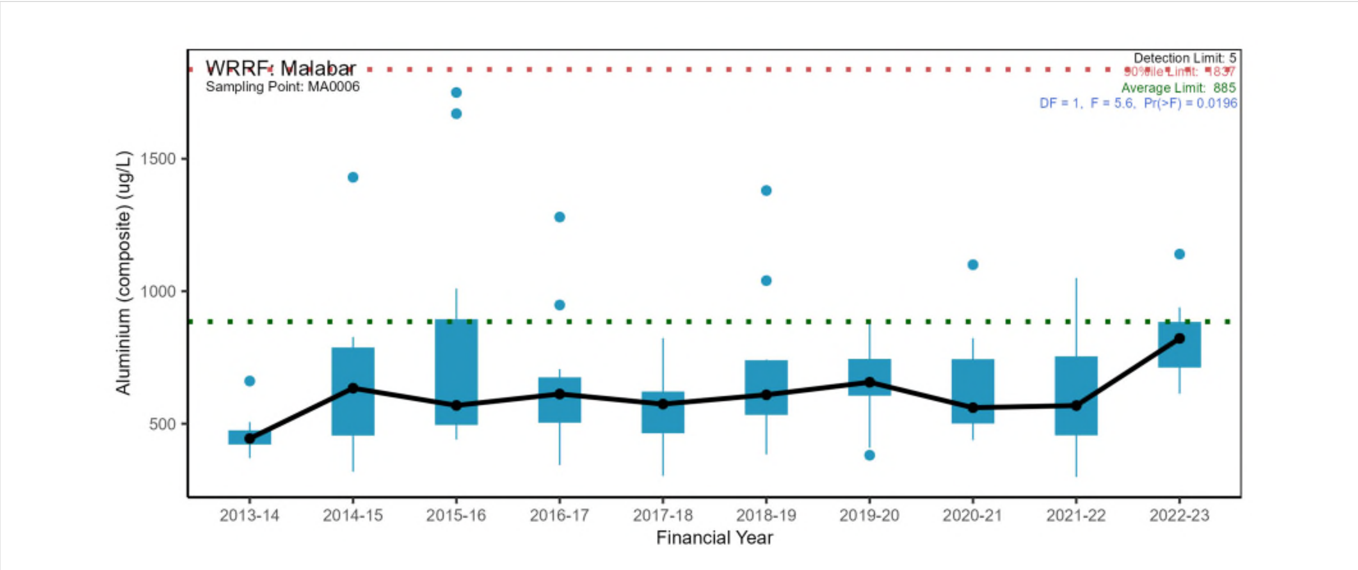
E-3.2 Pressure – Wastewater quality

Major conventional analytes

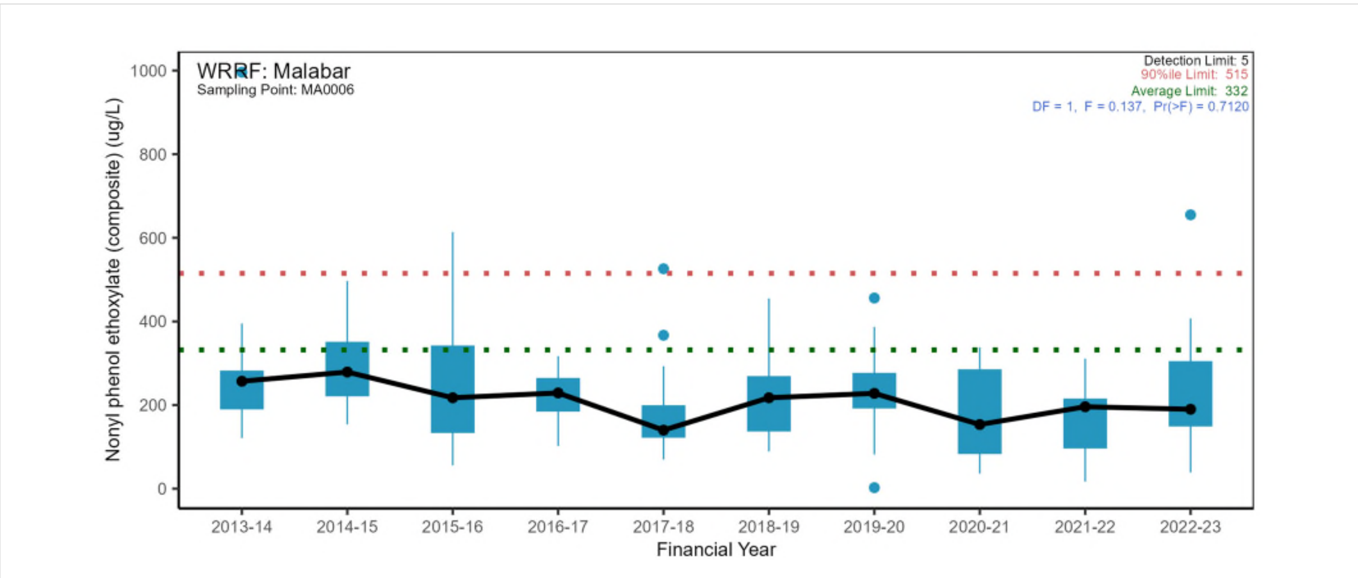


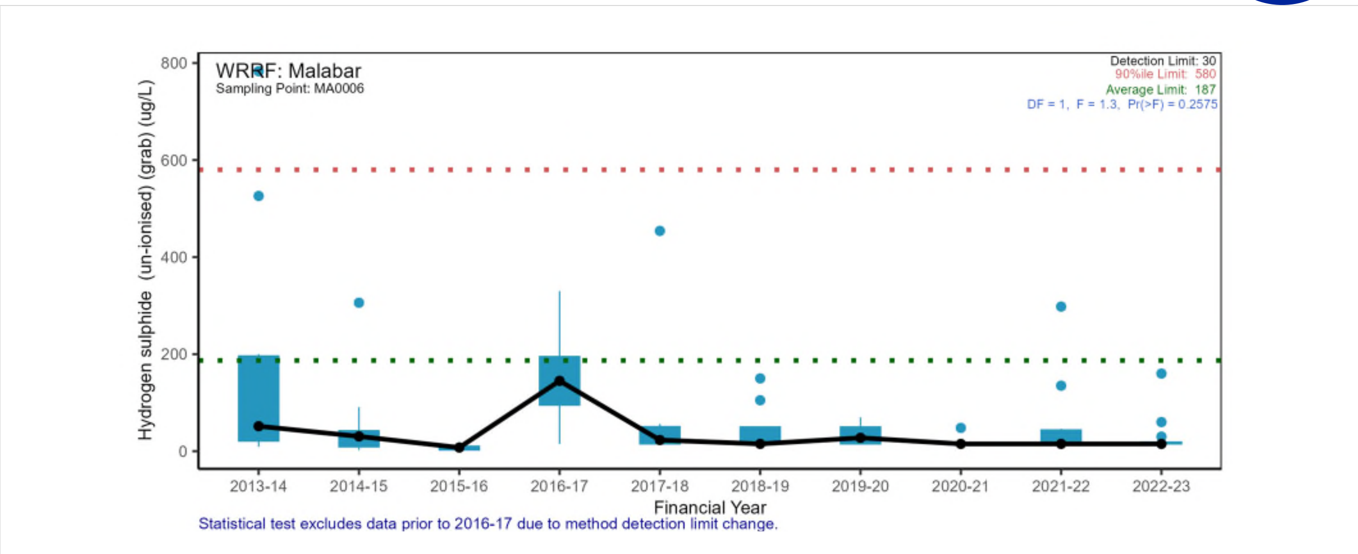


Trace metals

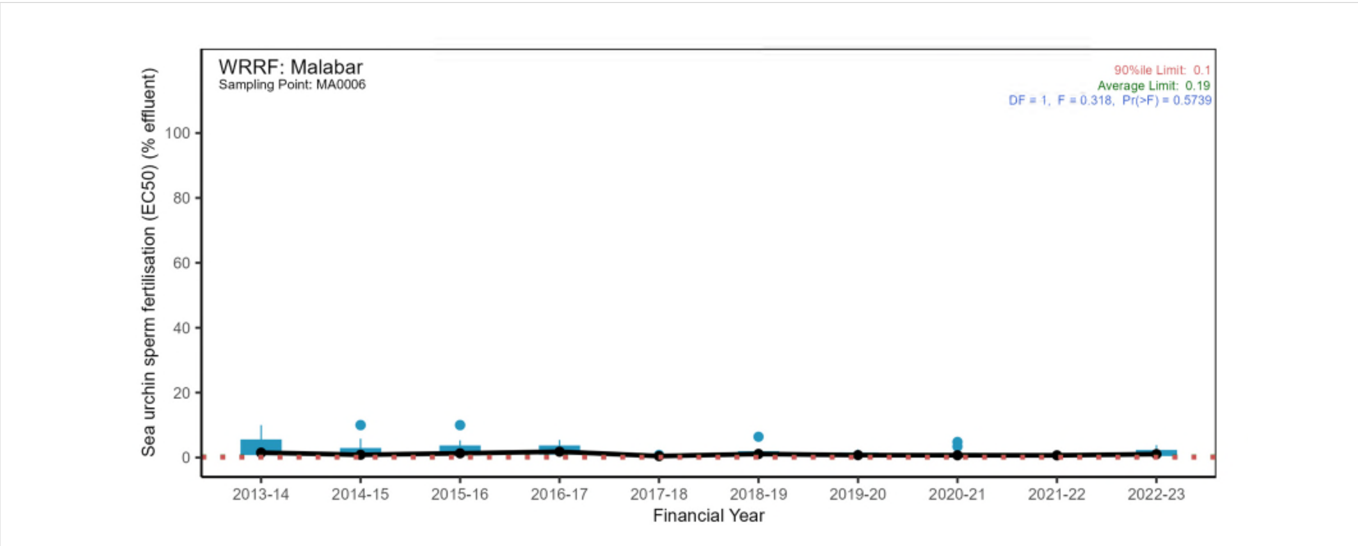


Other chemicals and organics (including pesticides)



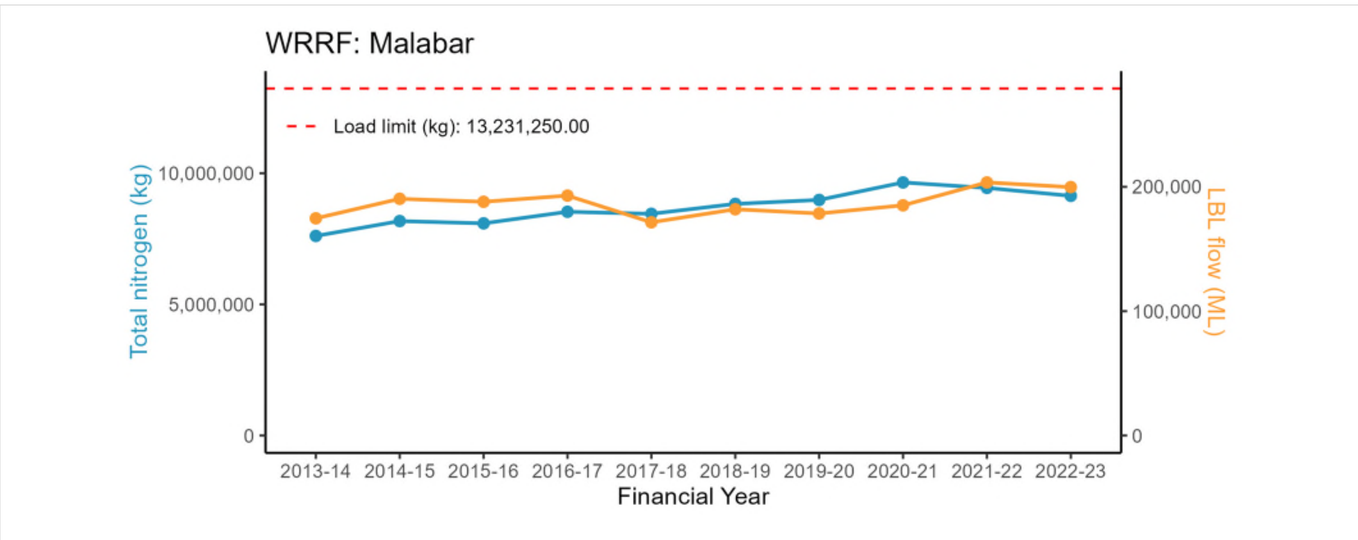


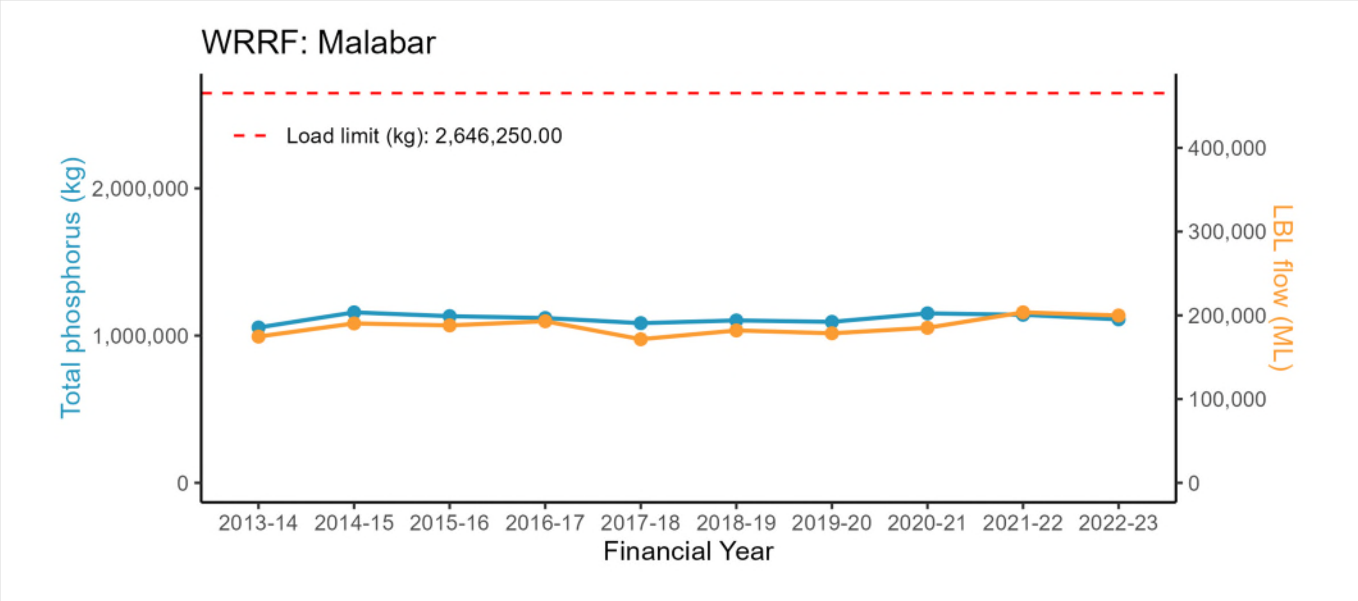
E-3.3 Pressure – Wastewater toxicity



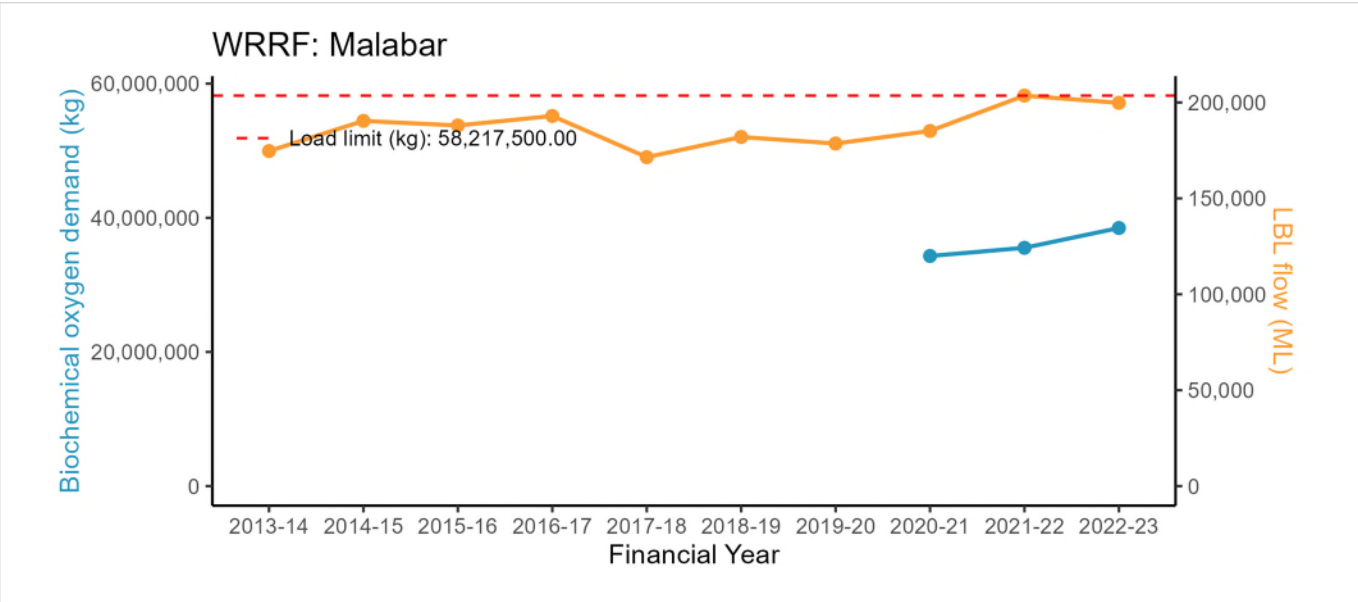
E-3.4 Pressure – Wastewater discharge load

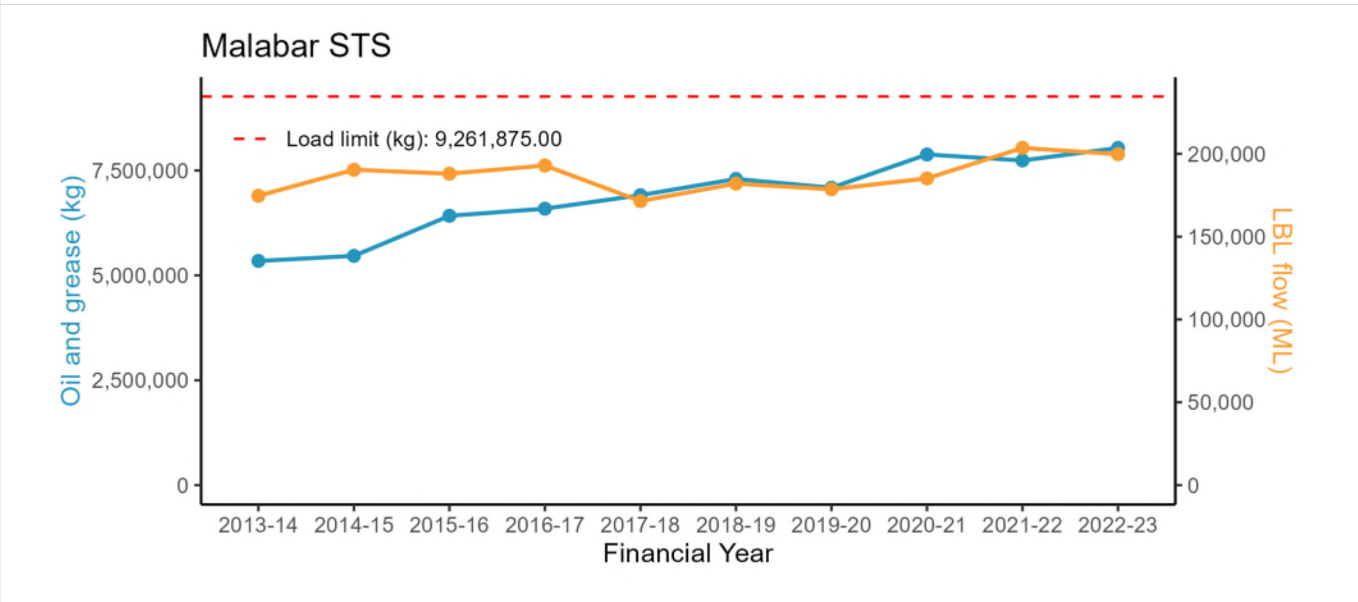
Nutrients

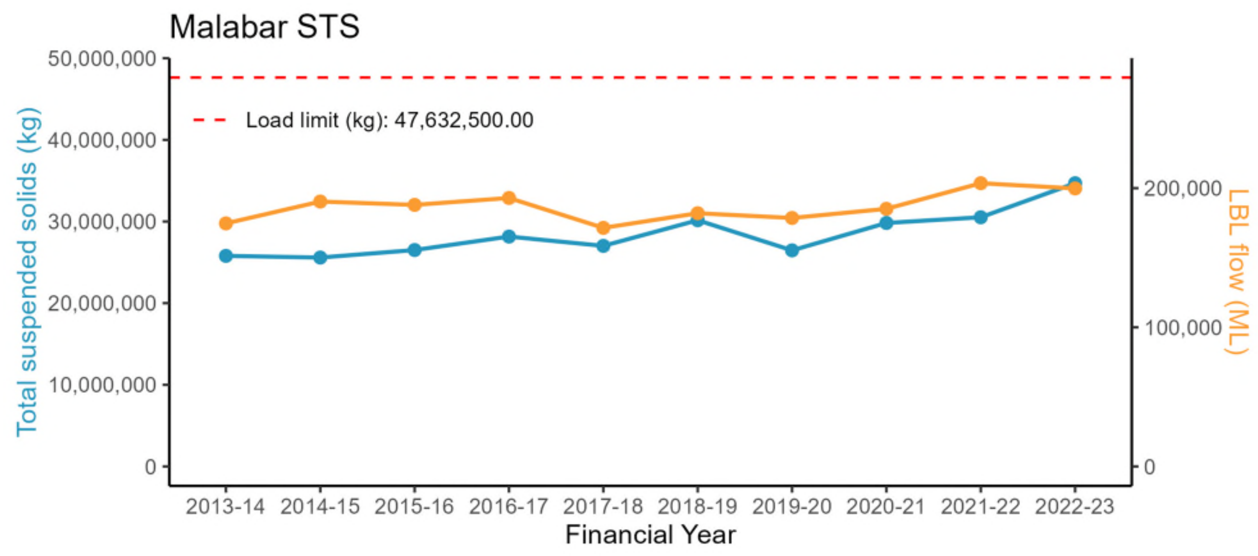




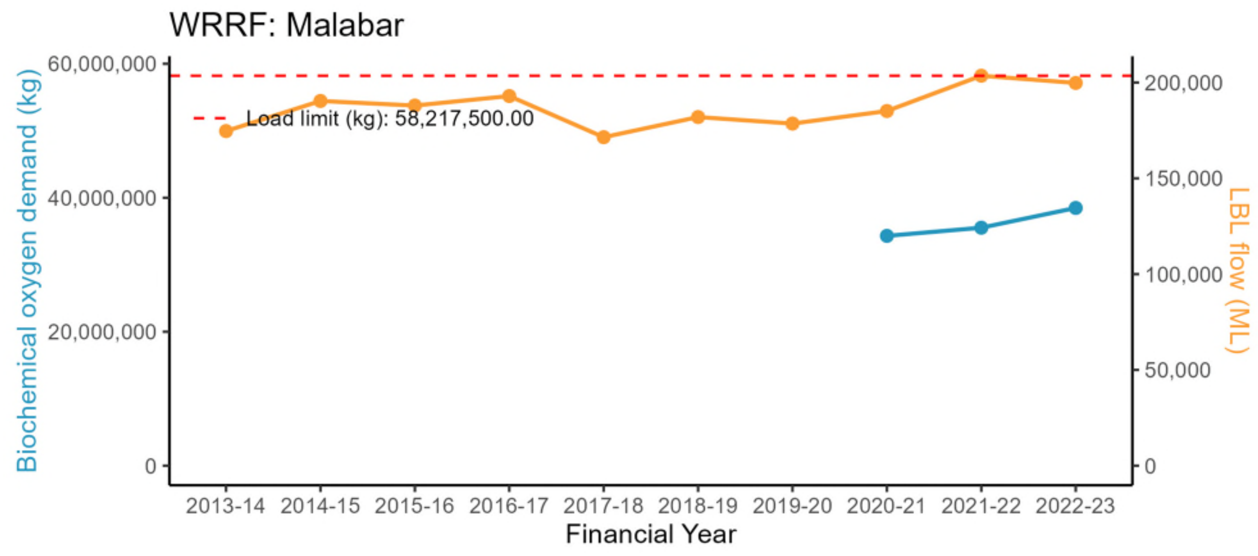
Major conventional analytes



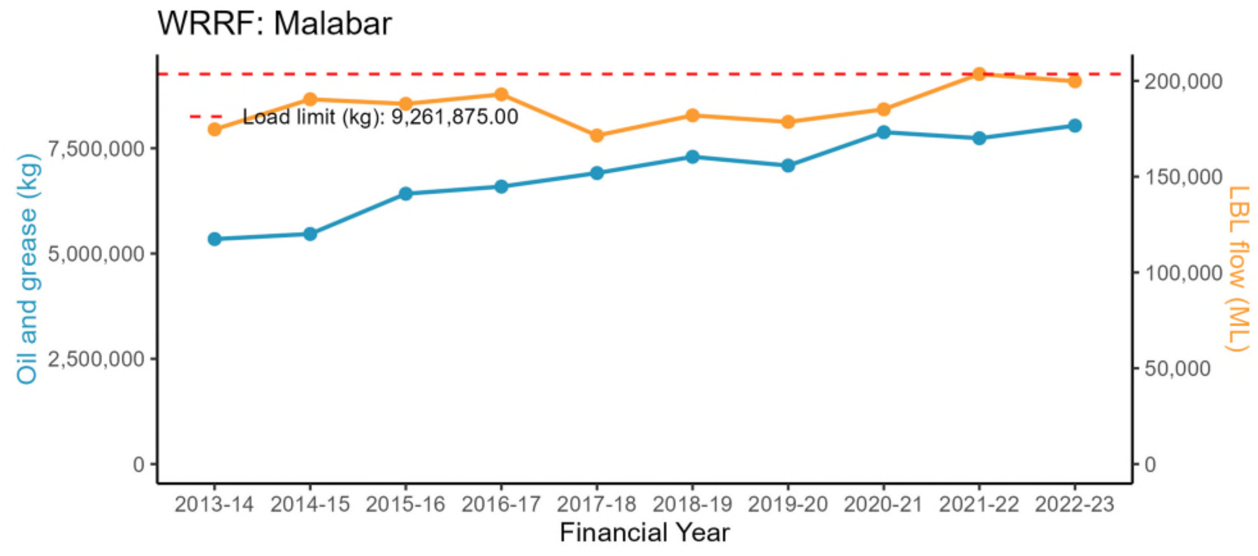




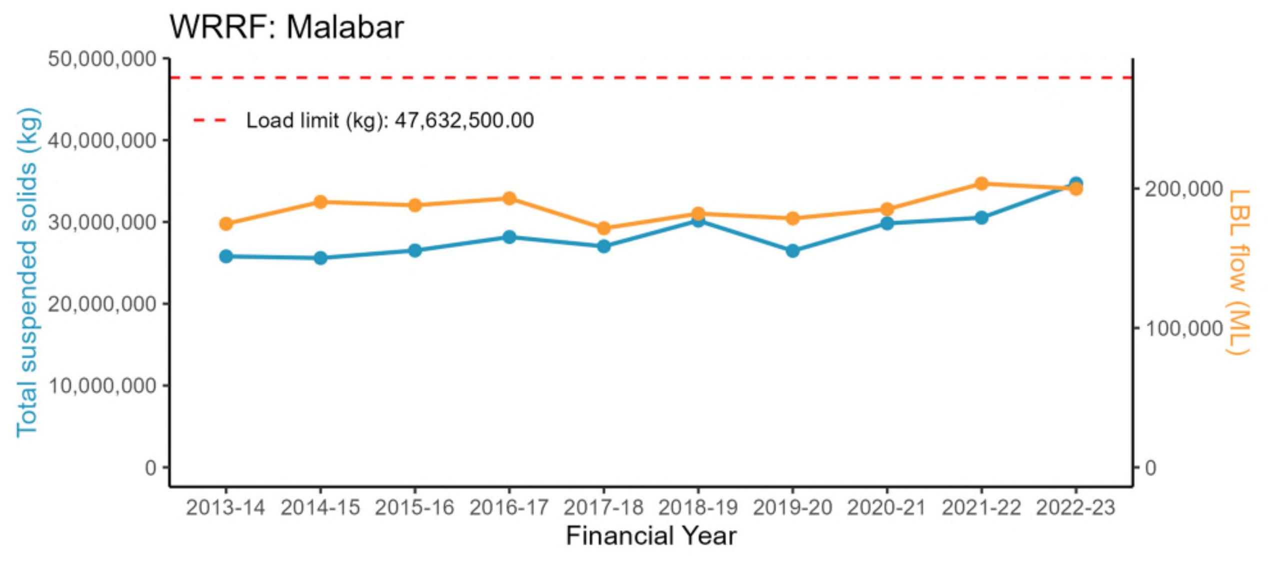
Malabar STS
Load limit (kg): 47,632,500.00
Total suspended solids (kg)
LBL flow (ML)
50,000,000
40,000,000
30,000,000
20,000,000
10,000,000
0
200,000
100,000
0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Financial Year



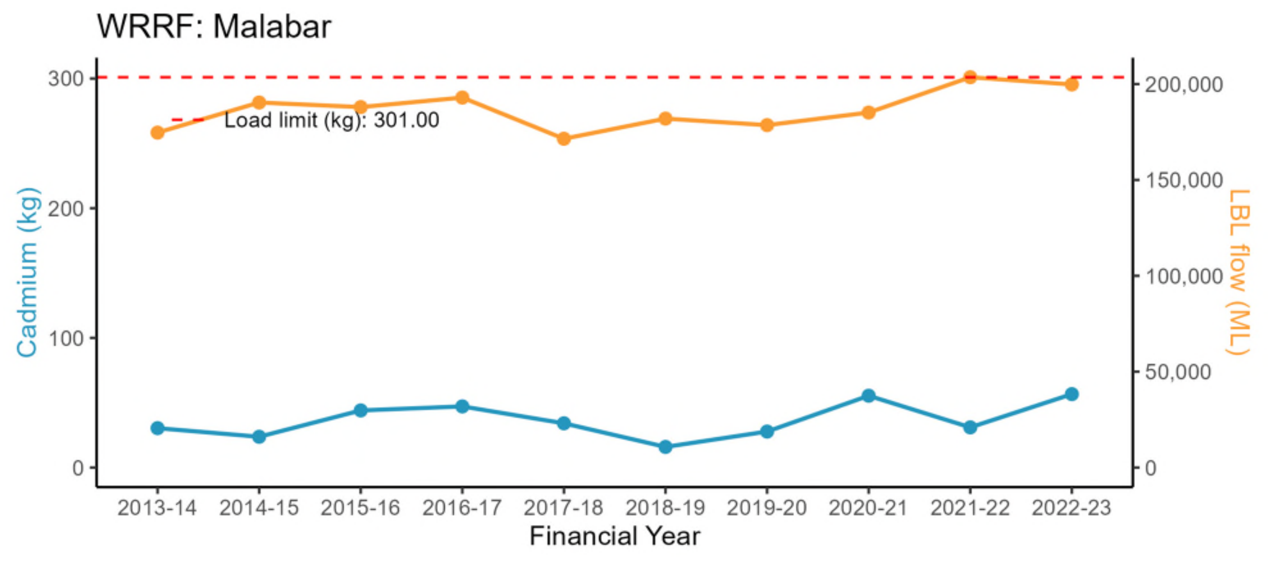
WRRF: Malabar
Load limit (kg): 58,217,500.00
Biochemical oxygen demand (kg)
LBL flow (ML)
60,000,000
40,000,000
20,000,000
0
200,000
150,000
100,000
50,000
0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Financial Year

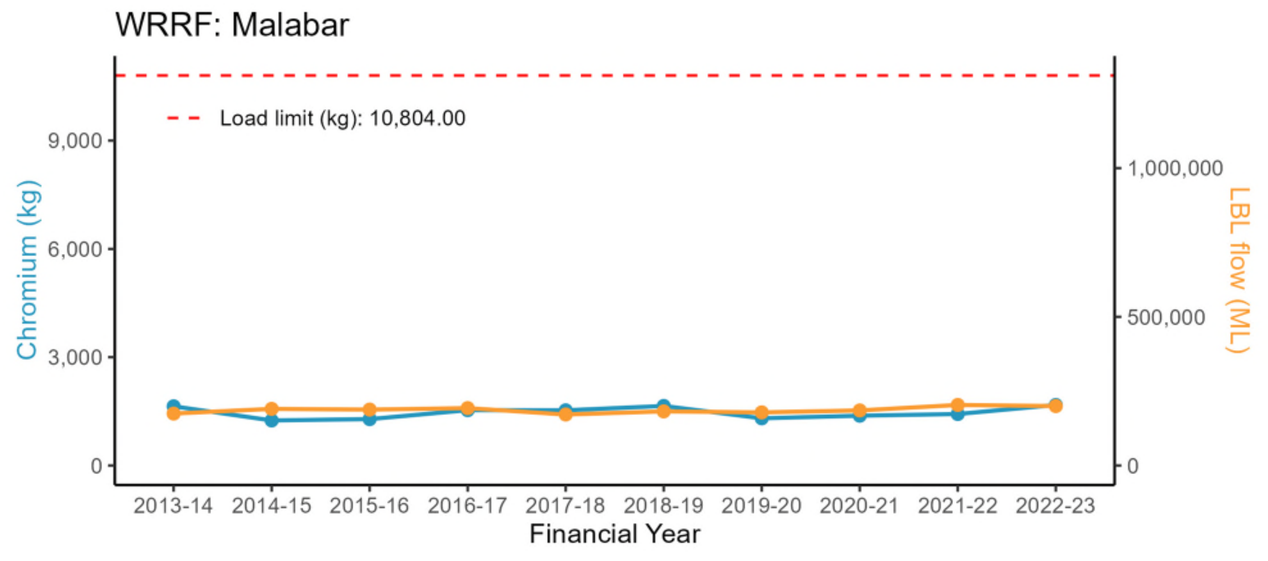


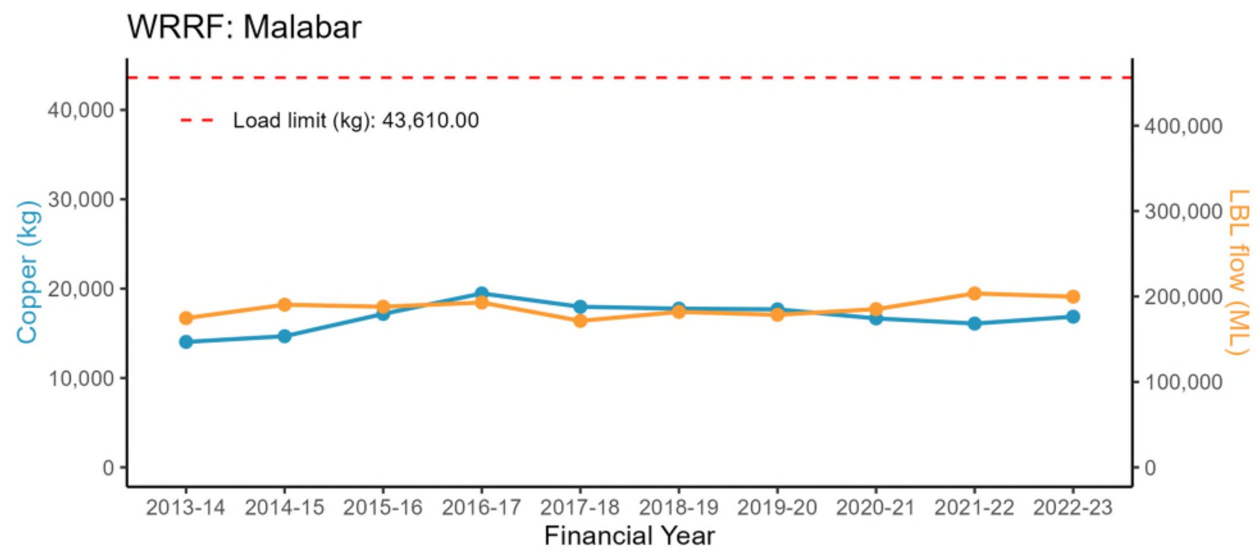
WRRF: Malabar
Load limit (kg): 9,261,875.00
Oil and grease (kg)
LBL flow (ML)
7,500,000
5,000,000
2,500,000
0
200,000
150,000
100,000
50,000
0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Financial Year

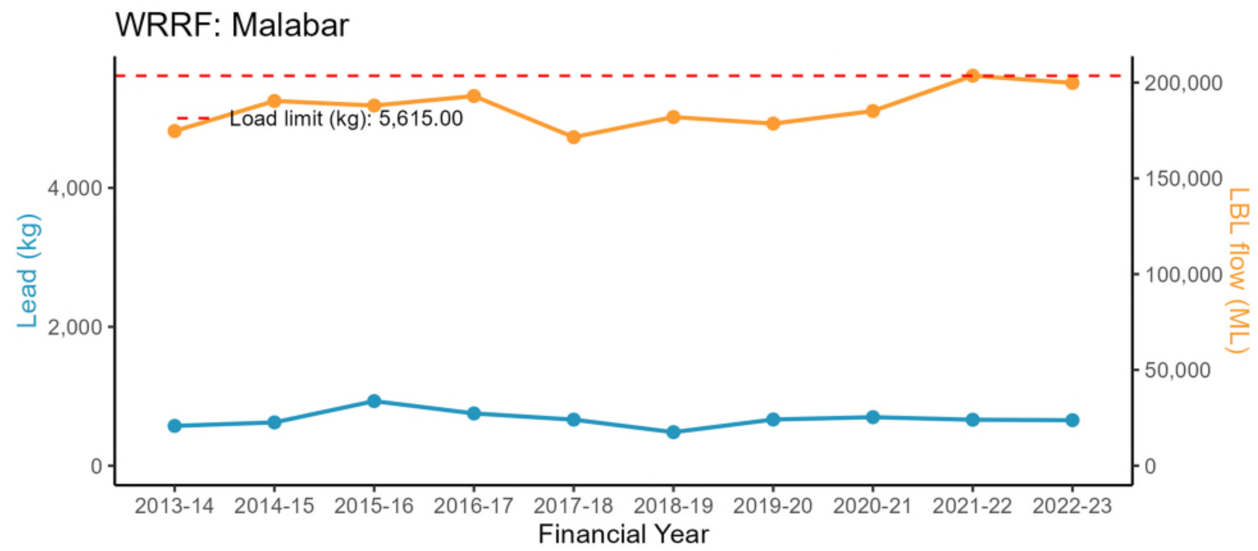


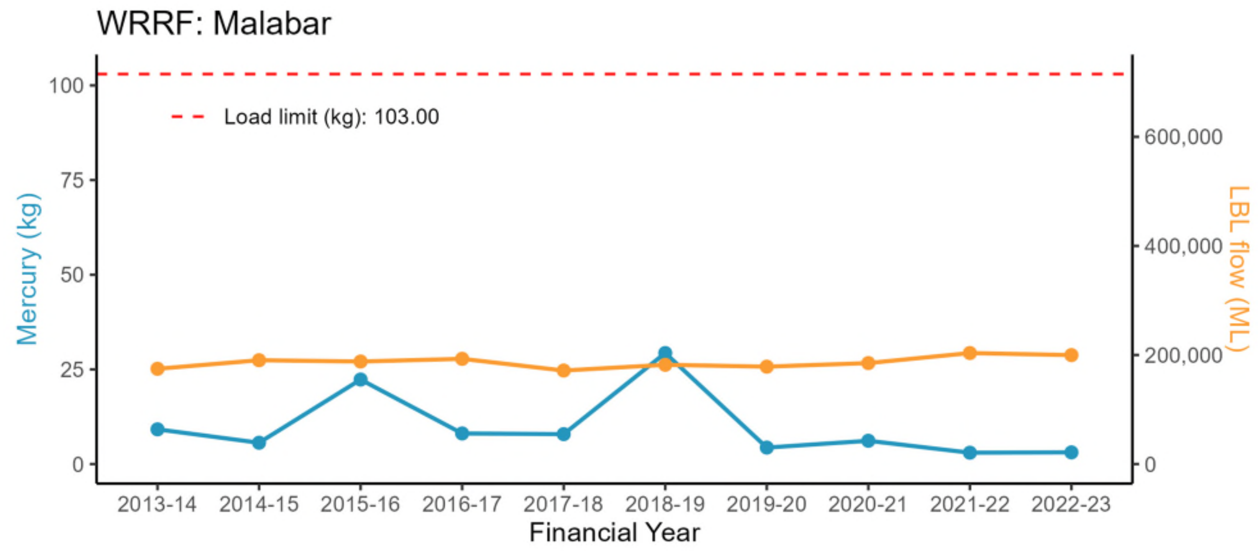
Trace metals

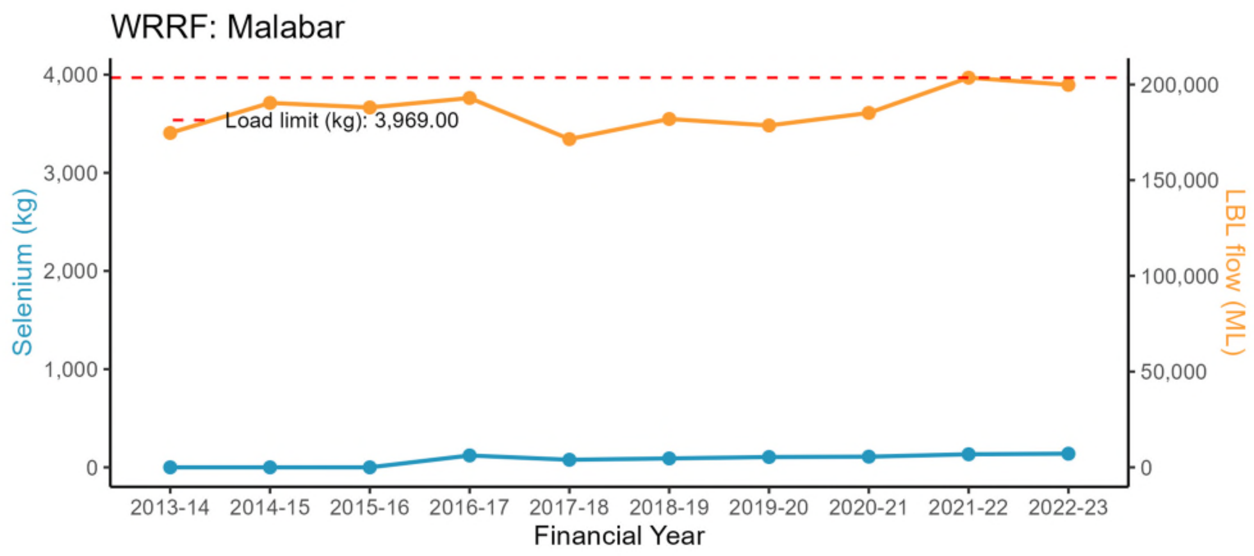


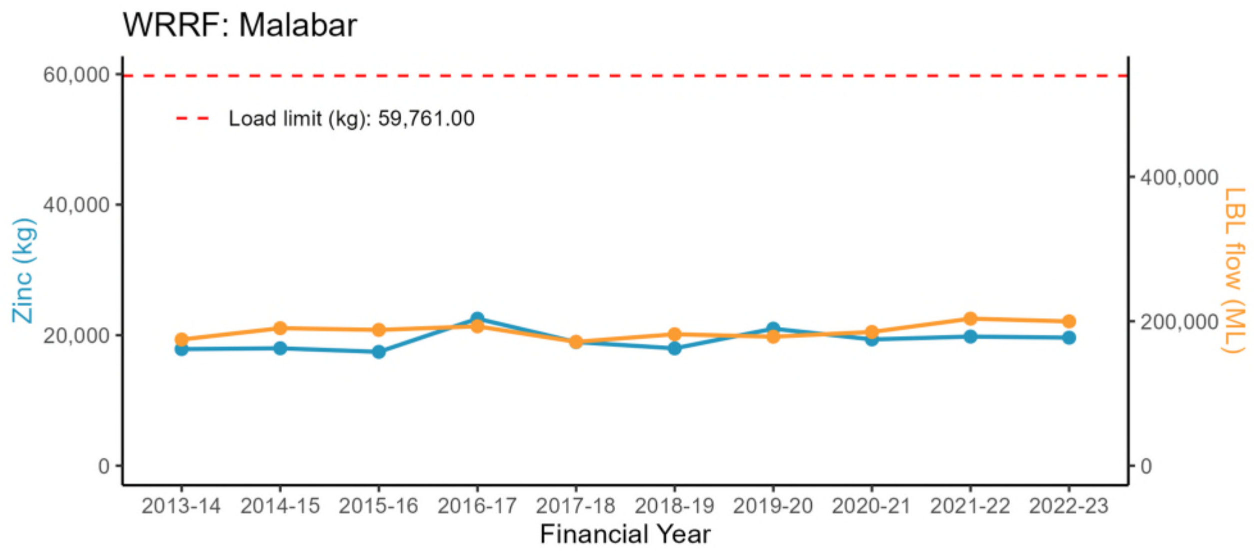



WRRF: Malabar
Load limit (kg): 43,610.00
Copper (kg)
LBL flow (ML)
40,000
30,000
20,000
10,000
0
400,000
300,000
200,000
100,000
0
2013-14 2014-15 2015-16 2016-17 2017-18 2018-19 2019-20 2020-21 2021-22 2022-23
Financial Year

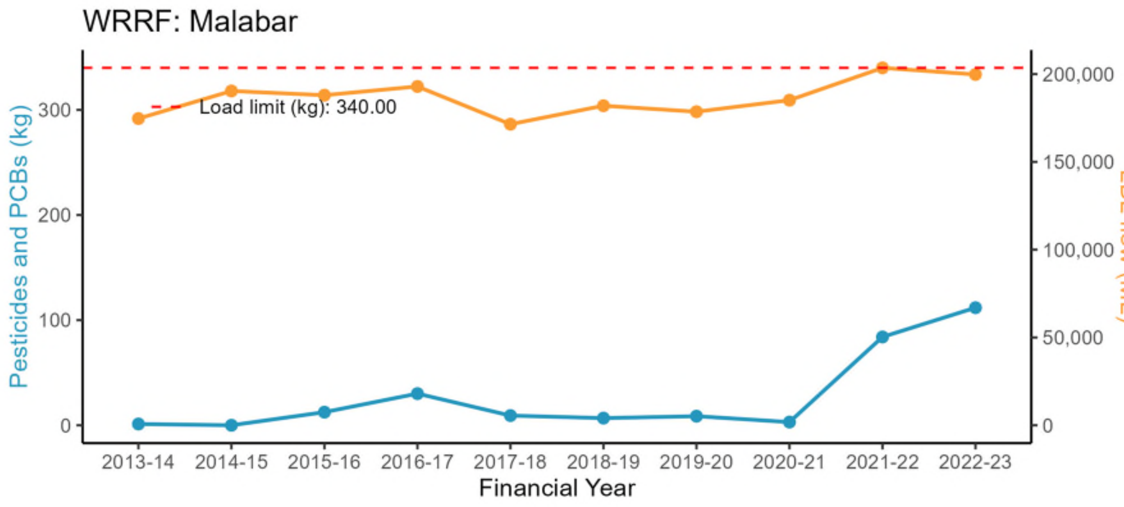

WRRF: Malabar
Load limit (kg): 5,615.00
Lead (kg)
LBL flow (ML)
4,000
2,000
0
200,000
150,000
100,000
50,000
0
2013-14 2014-15 2015-16 2016-17 2017-18 2018-19 2019-20 2020-21 2021-22 2022-23
Financial Year


WRRF: Malabar
Load limit (kg): 103.00
Mercury (kg)
LBL flow (ML)
100
75
50
25
0
600,000
400,000
200,000
0
2013-14 2014-15 2015-16 2016-17 2017-18 2018-19 2019-20 2020-21 2021-22 2022-23
Financial Year





Other chemicals and organics (including pesticides)



E-4 EPL limits of Offshore discharging WRRFs

Table E-1 EPL concentration limits for the Offshore discharging WRRFs (2022-23)

WRRF	Sampling Points	Oil and Grease (mg/L)		Total Suspended Solids (mg/L)		Sea urchin fertilisation (EC50)	
		50th %-ile	90th %-ile	50th %-ile	90th %-ile	Average	90th %-ile
North Head	NH0008 (C), (G)	55	70	200	250	0.24	0.13
Bondi	BN0005 (C), (G)	55	70	200	250	0.27	0.16
Malabar	MA0006 (C), (G)	55	70	250	300	0.19	0.1

WRRF	Sampling Points	Aluminium (µg/L)		Copper (µg/L)		Chlorpyrifos (µg/L)		Nonylphenol ethoxylate (µg/L)		Unionised H_2S (µg/L)	
		Average	90th %-ile	Average	90th %-ile	Average	90th %-ile	Average	90th %-ile	Average	90th %-ile
North Head	NH0008 (C), (G)	890	1700	160	300	0.09	0.2	178	253	143	270
Bondi	BN0005 (C), (G)	430	565					179	272	250	510
Malabar	MA0006 (C), (G)	885	1837					332	515	187	580

Table E-2 EPL load limits for the Offshore discharging WRRFs (2022-23)

Load limits (in kg) 2022-23	North Head	Bondi	Malabar
Total Nitrogen	7,957,000	3,832,500	13,231,250
Total Phosphorus	1,909,680	766,500	2,646,250
Biological Oxygen Demand	35,010,800	16,863,000	58,217,500
Total Suspended Solids	35,010,800	11,497,500	47,632,500
Oil & Grease	9,968,880	3,066,000	9,261,875
Cadmium	283	117	301
Chromium	3,011	537	10,804
Copper	37,583	19,760	43,610
Lead	3,568	1,616	5,615
Mercury	60	37	103
Selenium	2,387	1,150	3,969
Zinc	51,066	20,346	59,761
Pesticides	370	62	340

E-5 Ocean receiving water quality

E-5.1 Summary of modelled chemical concentrations near deepwater ocean outfalls

Out of eight chemicals assessed in 2022-23, only modelled copper concentrations in the receiving waters in the initial dilution zones of North Head and Malabar deepwater ocean outfalls exceeded the ANZECC (2000) guideline of 1.3 ug/L for protection of 95% of marine species (Table E-3 to Table E-5).

Table E-3 Comparison of modelled chemical concentrations near the deepwater ocean outfalls for the STSIMP (financial years) to ANZECC (2000) guideline values for North Head WRRF

North Head		Chemical concentration (µg/L)							
		cadmium	chromium	copper	mercury	lead	zinc	endosulphan	chlorpyrifos
Guideline 95th %ile for protection of marine species		5.5	27.4	1.3	0.4	4.4	15	0.01	0.009
2022-23 undiluted wastewater average value		0.1	7.9	95	0.06	3.3	99	0.01	0.05
Dilution exceeded 98% of time	75:1	0.001	0.1	1.3	0.0008	0.04	1.3	0.0001	0.0007
Dilution exceeded 10% of time	847:1	0.0001	0.009	0.1	0.00007	0.004	0.1	0.00001	0.00006
2021-22 undiluted wastewater average value		<0.1	7.8	112	0.03	2.4	124	0.01	0.05
Dilution exceeded 98% of time	65:1	0.002	0.12	1.7	0.0005	0.04	1.9	0.0002	0.0008
Dilution exceeded 10% of time	773:1	0.0001	0.01	0.1	0.00004	0.003	0.2	0.00001	0.00006
2020-21 undiluted wastewater average value		<0.1	5.9	128	0.06	2.9	116	<0.01	<0.05
Dilution exceeded 98% of time	64:1	0.002	0.09	2.0	0.0009	0.05	1.8	0.0002	0.0008
Dilution exceeded 10% of time	727:1	0.0001	0.008	0.2	0.00008	0.004	0.2	0.00001	0.00007
2019-20 undiluted wastewater average value		<0.1	5.4	132	0.03	2.6	129	<0.01	<0.05
Dilution exceeded 98% of time	78:1	0.001	0.07	1.7	0.0004	0.03	1.7	0.0001	0.0006
Dilution exceeded 10% of time	649:1	0.0002	0.008	0.2	0.00005	0.004	0.2	0.00002	0.00008
2018-19 undiluted wastewater average value		0.1	6.3	135	0.04	2.5	114	<0.01	<0.05
Dilution exceeded 98% of time	69:1	0.002	0.09	1.9	0.0006	0.04	1.6	0.0001	0.0007
Dilution exceeded 10% of time	685:1	0.0002	0.009	0.2	0.00006	0.004	0.2	0.00001	0.00007
2017-18 undiluted wastewater average value		0.1	7.4	123	0.05	3.0	115	<0.01	<0.05
Dilution exceeded 98% of time	92:1	0.001	0.08	1.3	0.0005	0.03	1.3	0.0001	0.0005
Dilution exceeded 10% of time	1245:1	0.00008	0.006	0.1	0.00004	0.002	0.1	0.00001	0.00004
2016-17 undiluted wastewater average value		0.1	5.3	111	0.05	2.8	109	<0.01	<0.05
Dilution exceeded 98% of time	68:1	0.002	0.1	1.6	0.0007	0.040	1.6	0.0001	0.0007
Dilution exceeded 10% of time	712:1	0.0002	0.007	0.2	0.00007	0.004	0.2	0.00001	0.00007

North Head		Chemical concentration (µg/L)							
		cadmium	chromium	copper	mercury	lead	zinc	endosulphan	chlorpyrifos
Guideline 95th %ile for protection of marine species		5.5	27.4	1.3	0.4	4.4	15	0.01	0.009
2015-16 undiluted wastewater average value		0.2	8.8	111	0.04	2.9	102	<0.01	<0.05
Dilution exceeded 98% of time	71:1	0.002	0.1	1.6	0.0006	0.04	1.4	0.0001	0.0007
Dilution exceeded 10% of time	421:1	0.0004	0.02	0.3	0.0001	0.007	0.2	0.00002	0.0001
2014-15 undiluted wastewater average value		0.2	6.3	138	0.1	3.5	127	<0.01	<0.05
Dilution exceeded 98% of time	85:1	0.002	0.07	1.6	0.001	0.04	1.5	0.0001	0.0006
Dilution exceeded 10% of time	873:1	0.0002	0.007	0.2	0.0001	0.004	0.15	0.00001	0.00006
2013-14 undiluted wastewater average value		0.2	3.8	104	0.2	2.6	109	<0.01	<0.05
Dilution exceeded 98% of time	72:1	0.003	0.05	1.4	0.003	0.04	1.5	0.0001	0.0007
Dilution exceeded 10% of time	690:1	0.0003	0.01	0.2	0.0004	0.004	0.16	0.00001	0.00007
2012-13 undiluted wastewater average value		0.2	6.3	101	0.08	3.7	115	<0.01	<0.05
Dilution exceeded 98% of time	84:1	0.002	0.08	1.2	0.001	0.04	1.4	0.0001	0.0006
Dilution exceeded 10% of time	713:1	0.0004	0.01	0.1	0.0001	0.005	0.2	0.00001	0.0001
2011-12 undiluted wastewater average value		0.4	4.1	79	0.09	3.6	109	<0.01	<0.05
Dilution exceeded 98% of time	81:1	0.005	0.05	1.0	0.001	0.04	1.3	0.0001	0.0006
Dilution exceeded 10% of time	818:1	0.0005	0.005	0.1	0.0001	0.004	0.1	0.00001	0.00006
2010-11 undiluted wastewater average value		0.4	5.3	96	0.2	3.6	130	<0.01	<0.05
Dilution exceeded 98% of time	73:1	0.006	0.07	1.3	0.003	0.05	1.8	0.0001	0.0007
Dilution exceeded 10% of time	595:1	0.0006	0.009	0.2	0.0003	0.006	0.2	0.00002	0.00008
2009-10 undiluted wastewater average value		0.4	6.2	99	0.2	4.6	122	<0.01	<0.05
Dilution exceeded 98% of time	68:1	0.006	0.09	1.4	0.003	0.07	1.8	0.0001	0.0007
Dilution exceeded 10% of time	798:1	0.0005	0.008	0.1	0.0003	0.006	0.2	0.00001	0.00006
2008-09 undiluted wastewater average value		0.4	5.8	96	0.1	4.9	121	<0.01	<0.05
Dilution exceeded 98% of time	82:1	0.005	0.07	1.2	0.001	0.06	1.5	0.0001	0.0006

North Head		Chemical concentration (μg/L)							
		cadmium	chromium	copper	mercury	lead	zinc	endosulphan	chlorpyrifos
Guideline 95th %ile for protection of marine species		5.5	27.4	1.3	0.4	4.4	15	0.01	0.009
Dilution exceeded 10% of time	774:1	0.0005	0.007	0.1	0.0001	0.006	0.2	0.00001	0.00006

* high reliability trigger value for chromium VI
Blue shading indicates value exceeds ANZECC (2000) guideline value

Table E-4 Comparison of modelled chemical concentrations near the deepwater ocean outfalls for the STSIMP (financial years) to ANZECC (2000) guideline values for Bondi WRRF

Bondi		Chemical concentration (µg/L)							
		cadmium	chromium	copper	mercury	lead	zinc	endosulphan	chlorpyrifos
Guideline 95th %ile for protection of marine species		5.5	27.4	1.3	0.4	4.4	15	0.01	0.009
2022-23 undiluted wastewater average value		0.1	1.2	110	0.01	2.3	82	0.01	0.05
Dilution exceeded 98% of time	101:1	0.001	0.01	1.1	0.0001	0.02	0.8	0.0001	0.0005
Dilution exceeded 10% of time	1510:1	0.00007	0.0008	0.07	0.000007	0.002	0.05	0.000007	0.00003
2021-22 undiluted wastewater average value		0.1	1.8	124	0.02	3.1	90	0.01	0.05
Dilution exceeded 98% of time	92:1	0.001	0.02	1.3	0.0002	0.03	1.0	0.0001	0.0005
Dilution exceeded 10% of time	1271:1	0.0001	0.001	0.1	0.00002	0.002	0.1	0.00001	0.00004
2020-21 undiluted wastewater average value		0.1	1.5	127	0.02	3.1	105	<0.01	<0.05
Dilution exceeded 98% of time	89:1	0.001	0.02	1.4	0.0002	0.03	1.2	0.0001	0.0006
Dilution exceeded 10% of time	1323:1	0.0001	0.001	0.1	0.00002	0.002	0.1	0.00001	0.00004
2019-20 undiluted wastewater average value		<0.1	1.6	118	0.02	2.9	101	<0.01	<0.05
Dilution exceeded 98% of time	105:1	0.001	0.02	1.1	0.0002	0.03	1.0	0.0001	0.0005
Dilution exceeded 10% of time	978:1	0.0001	0.002	0.1	0.00002	0.003	0.1	0.00001	0.00005
2018-19 undiluted wastewater average value		0.1	1.58	152	0.03	3.0	113	<0.01	<0.05
Dilution exceeded 98% of time	93:1	0.001	0.02	1.6	0.0004	0.03	1.2	0.0001	0.0005
Dilution exceeded 10% of time	1007:1	0.0001	0.002	0.2	0.00003	0.003	0.1	0.00001	0.00005
2017-18 undiluted wastewater average value		0.1	1.83	148	0.05	3.98	109	<0.01	<0.05
Dilution exceeded 98% of time	114:1	0.0009	0.02	1.3	0.0004	0.03	1.0	0.0001	0.0004
Dilution exceeded 10% of time	1711:1	0.00006	0.001	0.1	0.00003	0.002	0.06	0.00001	0.00003
2016-17 undiluted wastewater average value		<0.1	2.4	130	0.04	3.1	105	<0.01	<0.05
Dilution exceeded 98% of time	89:1	0.001	0.03	1.5	0.0004	0.03	1.2	0.0001	0.001
Dilution exceeded 10% of time	1018:1	0.0001	0.002	0.1	0.00004	0.003	0.1	0.00001	0.00005
2015-16 undiluted wastewater average value		0.1	2.3	152	0.03	4.1	108	<0.01	<0.05
Dilution exceeded 98% of time	92:1	0.001	0.02	1.6	0.0004	0.04	1.2	0.0001	0.0005
Dilution exceeded 10% of time	623:1	0.0002	0.004	0.2	0.00005	0.007	0.2	0.00002	0.00008

Bondi		Chemical concentration (µg/L)							
		cadmium	chromium	copper	mercury	lead	zinc	endosulphan	chlorpyrifos
Guideline 95th %ile for protection of marine species		5.5	27.4	1.3	0.4	4.4	15	0.01	0.009
2014-15 undiluted wastewater average value		0.2	1.5	121	0.1	3.6	108	<0.01	<0.05
Dilution exceeded 98% of time	111:1	0.001	0.01	1.1	0.001	0.03	1.0	0.00009	0.0005
Dilution exceeded 10% of time	1522:1	0.0001	0.001	0.08	0.00007	0.002	0.07	0.000007	0.00003
2013-14 undiluted wastewater average value		0.1	1.1	120	0.07	3.6	106	<0.01	<0.05
Dilution exceeded 98% of time	89:1	0.001	0.01	1.3	0.001	0.04	1.2	0.0001	0.0006
Dilution exceeded 10% of time	943:1	0.0001	0.001	0.1	0.0001	0.004	0.1	0.00001	0.00005
2012-13 undiluted wastewater average value		0.3	2.3	125	0.09	5.4	123	<0.01	<0.05
Dilution exceeded 98% of time	102:1	0.003	0.02	1.2	0.001	0.05	1.2	0.0001	0.0005
Dilution exceeded 10% of time	1033:1	0.0003	0.002	0.1	0.0001	0.005	0.1	0.00001	0.0001
2011-12 undiluted wastewater average value		0.2	1.6	110	0.06	5.1	102	<0.01	<0.05
Dilution exceeded 98% of time	104:1	0.002	0.02	1.1	0.001	0.05	1.0	0.0001	0.0005
Dilution exceeded 10% of time	1353:1	0.0001	0.001	0.08	0.00004	0.004	0.08	0.00001	0.00004
2010-11 undiluted wastewater average value		0.1	1.8	113	<0.1	3.5	104	<0.01	<0.05
Dilution exceeded 98% of time	93:1	0.001	0.02	1.2	0.001	0.04	1.1	0.0001	0.0005
Dilution exceeded 10% of time	917:1	0.0001	0.002	0.1	0.0001	0.004	0.1	0.00001	0.00005
2009-10 undiluted wastewater average value		0.2	1.8	110	<0.1	4.4	102	<0.01	<0.05
Dilution exceeded 98% of time	86:1	0.002	0.02	1.3	0.001	0.05	1.2	0.0001	0.0006
Dilution exceeded 10% of time	1233:1	0.0002	0.001	0.1	0.00008	0.004	0.08	0.000008	0.00004
2008-09 undiluted wastewater average value		0.1	2.3	118	<0.1	4.7	106	<0.01	<0.05
Dilution exceeded 98% of time	108:1	0.001	0.02	1.1	0.001	0.04	1.0	0.0001	0.0005
Dilution exceeded 10% of time	1271:1	0.00008	0.002	0.09	0.00008	0.004	0.08	0.000008	0.00004

* High reliability trigger value for chromium VI

Blue shading indicates value exceeds ANZECC (2000) guideline value

Table E-5 Comparison of modelled chemical concentrations near the deepwater ocean outfalls for the STSIMP (financial years) to ANZECC (2000) guideline values for Malabar WRRF

Malabar		Chemical concentration (µg/L)							
		cadmium	chromium	copper	mercury	lead	zinc	endosulphan	Chlorpyrifos
Guideline 95th %ile for protection of marine species		5.5	27.4	1.3	0.4	4.4	15	0.01	0.009
2022-23 undiluted wastewater average value		0.3	8.5	85	0.02	3.3	98	0.01	0.4
Dilution exceeded 98% of time	65:1	0.004	0.1	1.3	0.0002	0.05	1.5	0.0002	0.006
Dilution exceeded 10% of time	632:1	0.0005	0.01	0.1	0.00002	0.005	0.2	0.00002	0.0007
2021-22 undiluted wastewater average value		0.2	6.9	79	0.02	3.2	97	0.01	0.07
Dilution exceeded 98% of time	58:1	0.003	0.12	1.4	0.0003	0.06	1.7	0.0002	0.0012
Dilution exceeded 10% of time	575:1	0.0003	0.012	0.1	0.00003	0.006	0.2	0.00002	0.00012
2020-21 undiluted wastewater average value		0.3	7.3	90	0.04	3.7	103	<0.01	0.08
Dilution exceeded 98% of time	61:1	0.005	0.12	1.5	0.0007	0.06	1.7	0.0002	0.0013
Dilution exceeded 10% of time	589:1	0.0005	0.012	0.2	0.00007	0.006	0.2	0.00002	0.00014
2019-20 undiluted wastewater average value		0.2	7.4	100	0.02	3.6	116	<0.01	<0.05
Dilution exceeded 98% of time	70:1	0.003	0.11	1.4	0.0003	0.05	1.7	0.0001	0.0007
Dilution exceeded 10% of time	426:1	0.0005	0.017	0.2	0.00005	0.008	0.3	0.00002	0.00012
2018-19 undiluted wastewater average value		0.1	9.1	98	0.2	2.7	99	<0.01	<0.05
Dilution exceeded 98% of time	64:1	0.002	0.1	1.5	0.003	0.04	1.6	0.0002	0.0008
Dilution exceeded 10% of time	470:1	0.0002	0.02	0.2	0.0003	0.006	0.2	0.00002	0.0001
2017-18 undiluted wastewater average value		0.2	9.0	105	0.05	3.9	111	<0.01	<0.05
Dilution exceeded 98% of time	68:1	0.003	0.1	1.5	0.0007	0.06	1.6	0.0001	0.0007
Dilution exceeded 10% of time	824:1	0.0002	0.01	0.1	0.00006	0.005	0.1	0.00001	0.00006
2016-17 undiluted wastewater average value		0.3	8.1	103	0.04	4.0	118	<0.01	0.124
Dilution exceeded 98% of time	56:1	0.004	0.1	1.8	0.0008	0.07	2.1	0.0002	0.002
Dilution exceeded 10% of time	515:1	0.0005	0.02	0.2	0.0001	0.008	0.2	0.00002	0.0002
2015-16 undiluted wastewater average value		0.2	6.8	91	0.13	4.8	92	<0.01	<0.05
Dilution exceeded 98% of time	55:1	0.004	0.1	1.7	0.002	0.09	1.7	0.0002	0.0009
Dilution exceeded 10% of time	244:1	0.0009	0.03	0.4	0.0005	0.02	0.4	0.00004	0.0002

Malabar		Chemical concentration (µg/L)							
		cadmium	chromium	copper	mercury	lead	zinc	endosulphan	Chlorpyrifos
Guideline 95th %ile for protection of marine species		5.5	27.4	1.3	0.4	4.4	15	0.01	0.009
2014-15 undiluted wastewater average value		0.1	6.5	78	0.03	3.3	94	<0.01	<0.05
Dilution exceeded 98% of time	70:1	0.002	0.09	1.1	0.0004	0.05	1.3	0.0001	0.0007
Dilution exceeded 10% of time	665:1	0.0002	0.01	0.1	0.00005	0.005	0.1	0.00002	0.00008
2013-14 undiluted wastewater average value		0.2	9.3	80	0.05	3.3	102	<0.01	<0.05
Dilution exceeded 98% of time	56:1	0.004	0.17	1.4	0.001	0.06	1.8	0.0002	0.0009
Dilution exceeded 10% of time	478:1	0.0004	0.02	0.2	0.0001	0.01	0.2	0.00002	0.0001
2012-13 undiluted wastewater average value		0.2	6.0	74	0.07	4.3	97	<0.01	<0.05
Dilution exceeded 98% of time	65:1	0.003	0.09	1.1	0.001	0.07	1.5	0.0002	0.0008
Dilution exceeded 10% of time	507:1	0.0003	0.01	0.1	0.0001	0.01	0.2	0.00002	0.0001
2011-12 undiluted wastewater average value		0.2	7.8	74	0.06	4.2	107	<0.01	<0.05
Dilution exceeded 98% of time	68:1	0.003	0.11	1.1	0.001	0.06	1.6	0.0001	0.0007
Dilution exceeded 10% of time	578:1	0.0003	0.01	0.1	0.0001	0.007	0.2	0.00002	0.00009
2010-11 undiluted wastewater average value		0.1	7.8	59	<0.1	2.7	86	<0.01	<0.05
Dilution exceeded 98% of time	55:1	0.002	0.14	1.1	0.002	0.05	1.6	0.0002	0.0009
Dilution exceeded 10% of time	448:1	0.0002	0.02	0.1	0.0002	0.006	0.2	0.00002	0.0001
2009-10 undiluted wastewater average value		0.3	10.2	67	<0.1	13.3	86	<0.01	<0.05
Dilution exceeded 98% of time	55:1	0.005	0.19	1.2	0.002	0.24	1.6	0.0002	0.0009
Dilution exceeded 10% of time	551:1	0.0005	0.02	0.1	0.0002	0.02	0.2	0.00002	0.00009
2008-09 undiluted wastewater average value		0.2	7.0	68	<0.1	4.1	90	<0.01	<0.05
Dilution exceeded 98% of time	67:1	0.003	0.10	1.0	0.001	0.06	1.3	0.0001	0.0007
Dilution exceeded 10% of time	550:1	0.0004	0.01	0.1	0.0002	0.007	0.2	0.00002	0.00009

* High reliability trigger value for chromium VI

Blue shading indicates value exceeds ANZECC (2000) guideline value

E-6 Ocean sediment quality and ecosystem health

Approximately 80% of Sydney's wastewater is treated at the North Head, Bondi and Malabar WWTPs and discharged through three deepwater ocean outfalls located between 2 and 4 km offshore, in waters between 65-80 m deep. As a general description, these deepwater ocean outfalls discharge wastewater through multiple diffusers that spread it over 500 to 750 m, which achieves rapid dilution that approximately ranges from design targets of 300:1 to 500:1, depending on oceanographic conditions and the diffuser field. The purpose of the diffusers is to release wastewater into the ocean at concentrations that are unlikely to be toxic once mixing has occurred. The distance from the discharge point to the boundary of the initial dilution zone varies considerably, depending on ocean and discharge conditions. It is defined to occur when the vertical momentum and buoyancy of the wastewater are the same as that of the surrounding water. The initial dilution zone is also referred to as the initial mixing zone or the end of the near-field.

E-6.1 Offshore marine sediment quality

For the 2022-23 'surveillance' year, results were obtained from the analytes measured at both sites (1 and 2) of the three locations listed in Table E-6.

Table E-6 Locations and analytes measured in 2022-23

Sites 1 and 2 of locations	Analytes measured
Malabar 0 km	Total Organic Carbon Sediment Grain Size Benthic macrofauna
Bondi and North Head	Total Organic Carbon Sediment Grain Size

Coordinates for the grid centre for each site of the nine locations of the study are provided in Table E-13. Actual geographical coordinates of each sample collected in the 2022-23 surveillance year from sites 1 and 2 for each of the three locations are listed in Table E-14.

Sediment grain size analyses were undertaken on sediment samples from all sites. Results for sediment granulometry size classes were calculated for <0.063 mm (%), >0.063 mm (%) and >2.0 mm (%) categories. Summary statistics including mean and standard deviation are presented in Table E-7 with all raw data presented in Table E-8. Levels were similar to those seen in past years (Figure E-1).

Table E-7 Summary statistics of TOC and sediment grain size measured in 2022-23

Sites	TOC %		<0.063mm		>0.063mm		>2.0mm	
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
North Head 1	0.7	0.1	3.4	1.1	90.3	11.8	6.3	11
North Head 2	0.5	0.2	3.2	0.8	93.5	3.1	3.3	2.8
Bondi 1	0.4	0.1	2.9	0.4	96.4	0.7	0.6	0.4
Bondi 2	0.4	0.2	3.5	1.9	95.3	3.2	1.2	2.4
Malabar 0km 1	0.6	0.2	4.9	2.6	92.8	3	2.4	1.2
Malabar 0km 2	0.8	0.1	7.9	1.3	90.9	1.4	1.3	0.6

Table E-8 TOC and sediment grain size for each sample measured in 2022-23

Site description		TOC	<0.063 mm	>0.063 mm	>2.0 mm
	Replicate	%	%	%	%
North Head 1	1	0.60	2.26	96.4	1.35
North Head 1	2	0.62	2.82	94.9	2.24
North Head 1	3	0.70	2.66	96.3	1
North Head 1	4	0.81	4.24	94.7	1.02
North Head 1	5	0.67	4.81	69.3	25.9
North Head 2	1	0.27	2.3	91.6	6.14
North Head 2	2	0.50	4.57	88.9	6.54
North Head 2	3	0.63	3.34	96	0.69
North Head 2	4	0.74	3.2	94.9	1.94
North Head 2	5	0.43	2.82	96	1.18
Bondi 1	1	0.31	2.81	96.2	0.98
Bondi 1	2	0.43	3.12	96.4	0.45
Bondi 1	3	0.51	2.86	96.9	0.2
Bondi 1	4	0.58	3.4	95.5	1.06
Bondi 1	5	0.29	2.39	97.2	0.37
Bondi 2	1	0.44	3.11	96.8	0.12
Bondi 2	2	0.25	2.06	97.7	0.21
Bondi 2	3	0.61	6.5	93.4	0.1
Bondi 2	4	0.16	1.86	98	0.17
Bondi 2	5	0.34	3.83	90.7	5.51
Malabar 0 km 1	1	0.52	4.16	94.7	1.15
Malabar 0 km 1	2	0.94	9.47	87.4	3.08
Malabar 0 km 1	3	0.29	2.74	93.5	3.81

Site description	Replicate	TOC %	<0.063 mm %	>0.063 mm %	>2.0 mm %
Malabar 0 km 1	4	0.48	3.72	93.6	2.69
Malabar 0 km 1	5	0.70	4.4	94.6	1.05
Malabar 0 km 2	1	0.82	6.56	91.5	1.97
Malabar 0 km 2	2	0.85	9.34	89.8	0.87
Malabar 0 km 2	3	0.72	8.4	90.4	1.2
Malabar 0 km 2	4	0.66	8.58	89.8	1.65
Malabar 0 km 2	5	0.72	6.44	93	0.6

In 2022-23, the TOC % content for all ten samples collected from the Malabar 0 km location were less than the NSW EPA specified 99th percentile trigger value of 1.2%. No specific trigger value has been set for either Bondi or North Head.

TOC % content was also less than 1.2% for all ten samples collected from North Head and Bondi. Over the 2001 to 2023 period, 23 TOC values were recorded from a total of 1527 samples to exceed 1.2% across a few of the nine locations (Table E-9). The most recent exceedance was in 2020. This suggests the values recorded in previous years may be examples of the higher variability seen from time to time, rather than an indication of TOC build up and subsequent anoxic conditions around this deepwater outfall. High anoxia conditions would be more likely to impact benthic community structure.

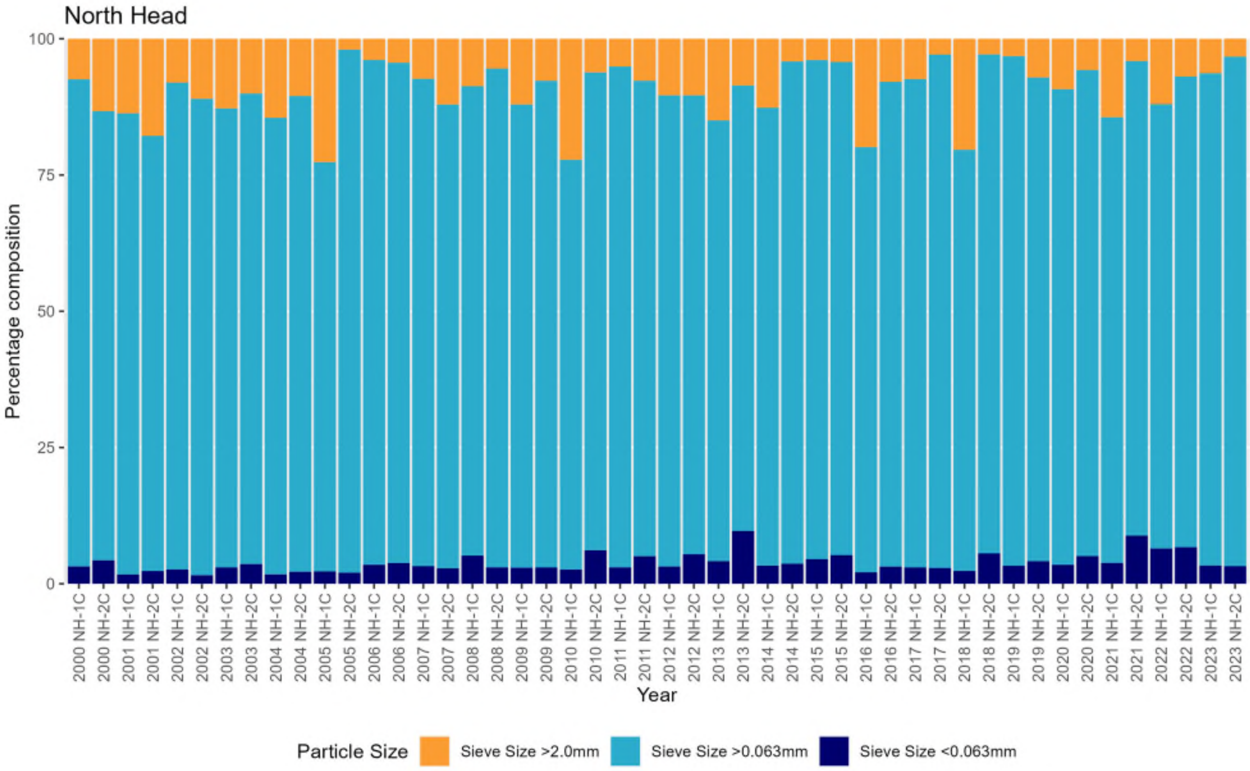
These TOC results suggest the prevailing currents that induce sediment movement and also move effluent plumes away from the diffuser arrays, have contributed to the low anoxia conditions in the benthic sediments around the diffuser arrays.

The average levels of fine sediments observed in 2022-23 were similar to those seen in past years, with no apparent build-up of fine particles (<0.063 mm) (Figure E-1). This suggests that metal concentrations in the sediment were unlikely to have increased at the North Head, Bondi and Malabar 0 km deepwater outfall locations.

With high levels of anoxia unlikely, together with the probable lack of build-up in chemical concentrations in the fine sediments, the benthic community structure of the Malabar 0 km location was unlikely to have changed beyond the levels recorded in past assessment years. A check of the 2022-23 benthic community structure was made next to see if it was similar to past assessment years.

Table E-9 TOC % replicate values equal or above 1.2% content from 2001 to 2023

Year	Location	TOC %
2002	North Head outfall	1.5
2002	North Head outfall	1.9
2002	Long Reef reference	4.4
2003	North Head outfall	1.3
2003	Long Reef reference	1.5
2003	Long Reef reference	1.3
2005	Long Reef reference	1.9
2005	Long Reef reference	1.6
2005	Long Reef reference	1.8
2006	Bondi outfall	1.5
2006	Malabar 7 km	1.8
2007	North Head outfall	1.4
2009	Malabar 7 km	3.5
2011	North Head outfall	3.5
2016	Malabar 0 km outfall	1.2
2015	Bondi outfall	2.0
2017	North Head outfall	1.7
2017	North Head outfall	1.6
2018	North Head outfall	1.2
2018	North Head outfall	1.4
2020	Long Reef reference	1.4
2020	Malabar 5 km	1.9
2020	Malabar 7 km	1.2


North Head
Percentage composition
100
75
50
25
0
2000 NH-1C
2000 NH-2C
2001 NH-1C
2001 NH-2C
2002 NH-1C
2002 NH-2C
2003 NH-1C
2003 NH-2C
2004 NH-1C
2004 NH-2C
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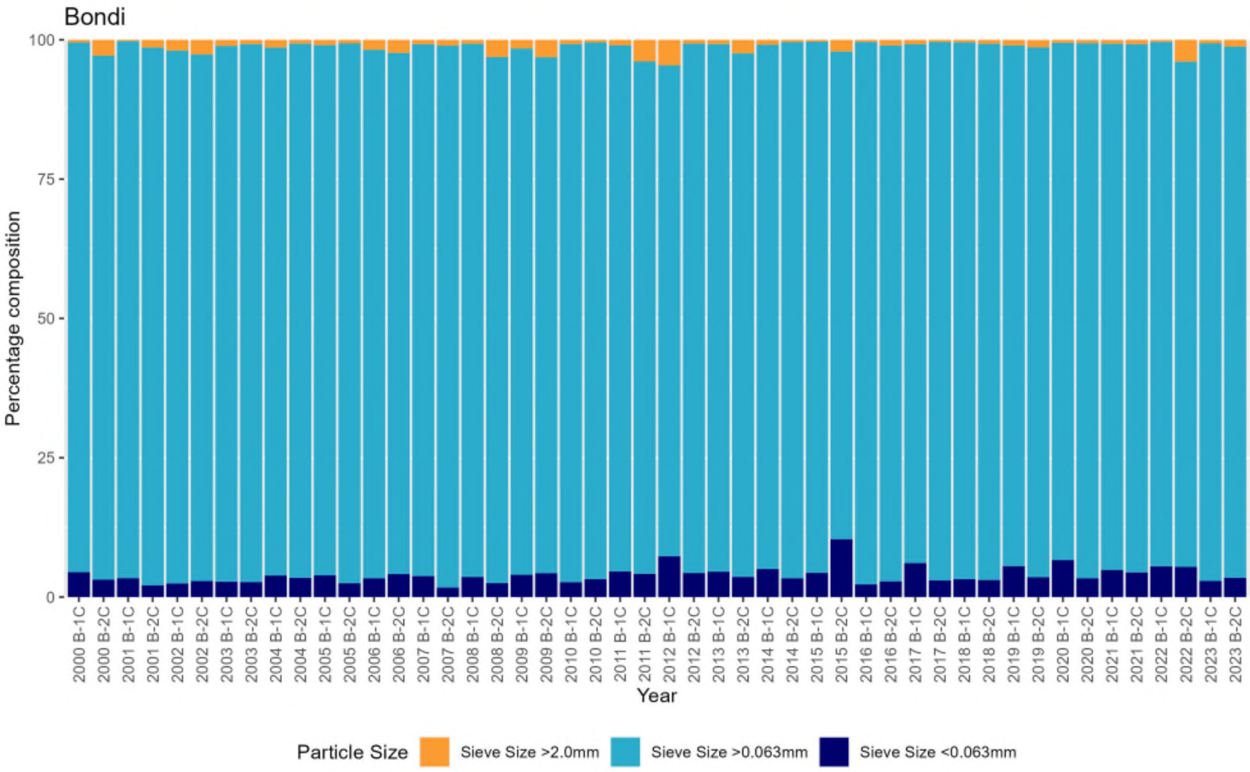
2019 NH-2C
2020 NH-1C
2020 NH-2C
2021 NH-1C
2021 NH-2C
2022 NH-1C
2022 NH-2C
2023 NH-1C
2023 NH-2C
Year
Particle Size
Sieve Size >2.0mm
Sieve Size >0.063mm
Sieve Size <0.063mm


Bondi
Percentage composition
100
75
50
25
0
2000 B-1C
2000 B-2C
2001 B-1C
2001 B-2C
2002 B-1C
2002 B-2C
2003 B-1C
2003 B-2C
2004 B-1C
2004 B-2C
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2020 B-2C
2021 B-1C
2021 B-2C
2022 B-1C
2022 B-2C
2023 B-1C
2023 B-2C
Year
Particle Size
Sieve Size >2.0mm
Sieve Size >0.063mm
Sieve Size <0.063mm

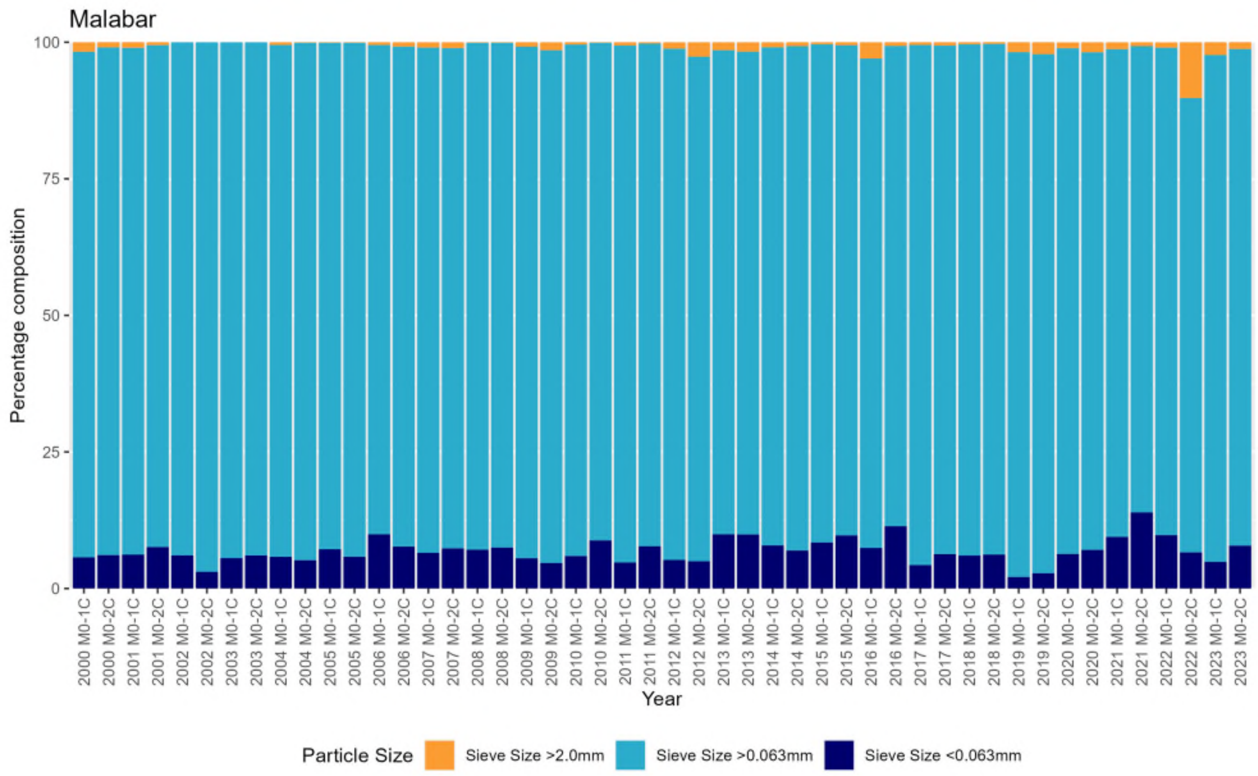


Figure E-1 Cumulative sediment particle size composition by three size classes for: top North Head; middle Bondi; and bottom Malabar 0 km 2000 to 2022-23

E-6.2 Offshore marine sediment fauna communities

A summary of the benthic macrofauna data from the Malabar 0 km location is presented in Table E-10. In 2022-23, the most common fauna types (taxa) were Polychaete worms, which also had the highest abundances out of all groups. Other taxa groups such as Crustaceans had less animal types and lower abundances (Table E-10). While abundances and the exact number of taxa varied between years, this year's taxonomic structure was typical of other years except for 2012 where Crustacean individuals outnumbered Polychaete worm individuals (Figure E-2).

The detailed benthic community dataset collected in 2022-23 is provided in Table E-15. The Polychaete worm of the family Maldanidae was the most abundant taxon, which was collected in all 20 samples representing 35% of the total Polychaete worms collected in 2022-23 (Table E-10). Maldanidae is described as an indicator of low organic input conditions (Dean, 2008). Contributing approximately 14% of all polychaete worms collected, Spionidae was found in all Malabar 0 km samples collected during 2022-23.

Table E-10 Summary of benthic macrofauna at Malabar 0 km location in 2022-23

Summary statistics based on taxa	Sum	% Contribution
Total number of taxa	110	100
Number of Polychaete taxa	46	41.8
Number of Crustacean taxa	30	27.3
Number of Mollusc taxa	22	20
Number of Echinoderm taxa	5	4.5
Number of other worm phyla taxa	4	3.6
Number of other phyla taxa	3	2.7
Summary statistics based on abundance	**Sum**	**% Contribution**
Total number of individuals	4684	100
Number of Polychaetes	2948	62.94
Number of Crustaceans	1201	25.64
Number of Molluscs	396	8.45
Number of Echinoderms	88	1.88
Number of other worm phyla	44	0.94
Number of other phyla	7	0.15

The composition of the Polychaeta, Crustacea, Mollusca and Echinodermata has been observed to vary up and down in both number of taxa and in number of individuals over the 2000 to 2023 period (Figure E-2). While the total number of individuals was lower than the previous year (2021-22), there has not been a sustained decline or increase in any of these four taxonomic groups over the 23 years of monitoring.

In addition to the above coarse check of the taxonomic structure, a finer comparison of the taxonomic structure at the Malabar 0 km location was made against that from past 'assessment' years to see if it was typical of that seen in the past. This was done by placing the 2023 samples from the Malabar outfall location onto the canonical axes of the existing Canonical Analysis of

Principal coordinates (CAP) model of interpretive-year data (2002, 2005, 2008, 2011, 2014, 2016, 2020) with the outputted sample allocations inspected for fit of 2023 samples to past samples.

A first pass of the CAP routine was run and after viewing diagnostic statistics an 'm' value of 17 was chosen to make the second pass. The second pass indicated a 60% allocation success and the first squared canonical correlation was reasonably large ($\delta_1^2 = 0.85$). The Pillar's trace statistic was significant (2.43274, $p = 0.0001$) and indicated there was more than one group of samples in multivariate space. The Cross Validation Leave-one-out Allocation of Observations to Groups statistic reflected a number of overlapped and mixed groups of samples with no one location having all of its samples being allocated solely to it. Rather, miss-classified samples were mostly assigned to locations immediately north or south of that location or nearby locations (Table E-12). The allocation based on taxonomic structure of the 20 samples collected in 2022-23 from the Malabar 0 km location was to either the Malabar 0 km location or to other nearby locations with a similar allocation as seen in the base 7-year assessment data analysis. The resultant CAP plot is shown in Figure E-3.

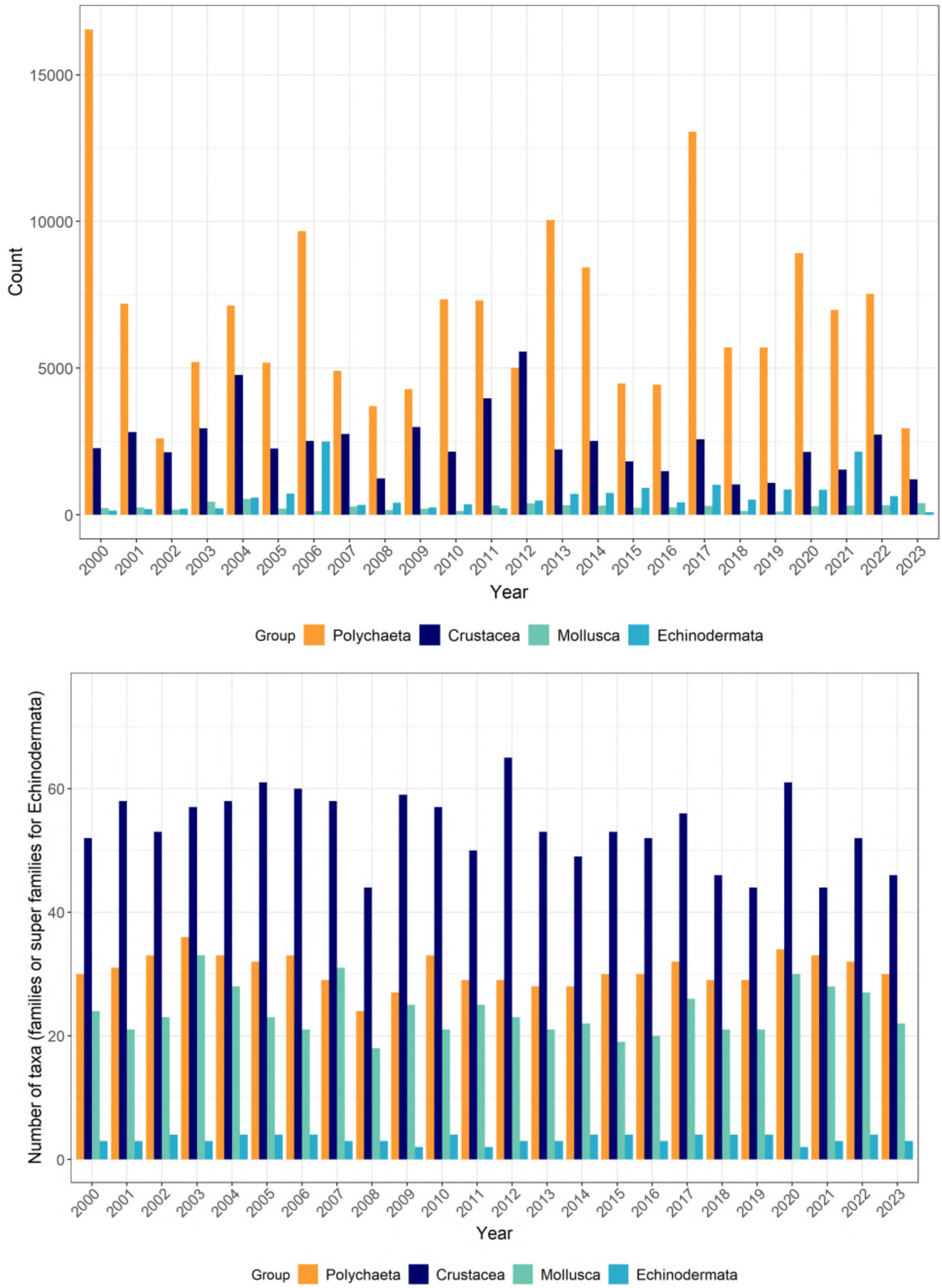


Figure E-2 Counts and number of taxa at Malabar 0 km location each year from 2000 to 2023

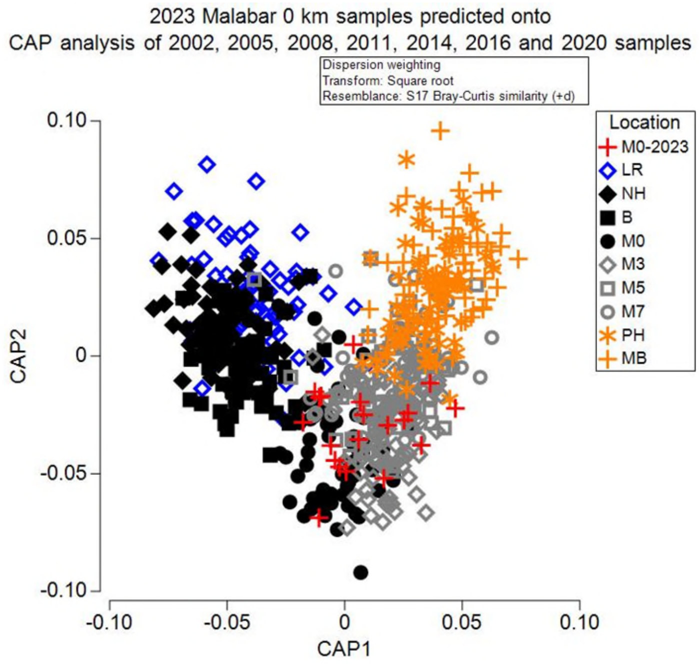


Figure E-3 CAP plot with Malabar 0 km location 2023 sample prediction compared to past assessment years

OSP Summary for 2022-2023

TOC % content results suggested elevated levels of anoxia were unlikely to have built-up in benthic sediment in 2022-2023. There also appeared to be a lack of build-up of fine sediment particles, which in turn suggests sedimentary metal concentrations have not increased in 2022-2023. Without changes in those sediment characteristics, the benthic community structure at the Malabar deepwater ocean outfall location was unlikely to have changed beyond the levels recorded in past 'assessment' years. The check of the 2022-23 benthic community structure to past 'assessment' years also suggested community structure was within ranges seen in the past 'assessment' years.

Table E-11 Allocated location group for Malabar 0 km samples of 2023 which were predicted onto the base CAP analysis of samples collected from all nine locations in 2002, 2005, 2008, 2011, 2014, 2016 and 2020 assessment years

2023 Malabar 0 km site and replicate sample number	Allocated location group
M01C-1	M7
M01C-2	M0
M01C-3	M0
M01C-4	M0
M01C-5	M0
M01C-6	M0
M01C-7	M3
M01C-8	M0
M01C-9	M0
M01C-10	M0
M02C-1	M5
M02C-2	M7
M02C-3	M5
M02C-4	M5
M02C-5	M0
M02C-6	M3
M02C-7	M3
M02C-8	M3
M02C-9	M0
M02C-10	M0

Table E-12 Statistics from the cross-validation leave-one-out allocation of samples to location groups of 2002, 2005, 2008, 2011, 2014, 2016 and 2020 from base CAP analysis

Original group	LR	NH	B	M0	M3	M5	M7	PH	MB	Total samples	% correct
LR	49	14	4	1	0	1	1	0	0	70	70
NH	10	51	8	1	0	0	0	0	0	70	73
B	4	8	57	1	0	0	0	0	0	70	81
M0	3	3	3	49	7	3	2	0	0	70	70
M3	1	0	0	8	44	13	3	1	0	70	63
M5	2	0	0	6	15	22	19	4	2	70	31
M7	1	0	1	4	9	16	28	9	2	70	40
PH	0	0	0	0	1	8	12	25	24	70	36
MB	0	0	0	0	0	0	4	16	50	70	71

Table E-13 EPA sampling site coordinate grid centres

Sites of location	Easting (grid centre)	Northing (grid centre)	Latitude (S)	Longitude (E)	Easting (converted to represent 0 co-ord, x value)	Northing (converted to represent 0 co-ord, y value)
Long Reef 1	349791.41	6266903.05	33º43.630'	151º22.720'	349666.41	6266778.05
Long Reef 2	349315.23	6264892.50	33º44.707'	151º22.393'	349190.23	6264767.50
North Head 1	347436.95	6257934.94	33º48.460'	151º21.100'	347311.95	6257809.94
North Head 2	347463.41	6256056.66	33º49.470'	151º21.100'	347338.41	6255931.66
Bondi 1	343415.85	6248226.10	33º53.670'	151º18.400'	343290.85	6248101.10
Bondi 2	344024.31	6250792.20	33º52.300'	151º18.820'	343899.31	6250667.20
Malabar 0 km 1	342807.40	6238966.99	33º58.680'	151º17.900'	342682.40	6238841.99
Malabar 0 km 2	343468.76	6239125.72	33º58.600'	151º18.325'	343343.76	6239000.72
Malabar 3 km 1	341378.85	6236506.71	34º00.000'	151º16.950'	341253.85	6236381.71
Malabar 3 km 2	341590.48	6236612.53	33º59.945'	151º17.085'	341465.48	6236487.53
Malabar 5 km 1	340638.12	6234628.44	34º01.000'	151º16.450'	340513.12	6234503.44
Malabar 5 km 2	340902.67	6234469.71	34º01.100'	151º16.615'	340777.67	6234344.71
Malabar 7 km 1	339527.03	6233041.16	34º01.860'	151º15.705'	339402.03	6232916.16
Malabar 7 km 2	339394.75	6232723.70	34º02.030'	151º15.615'	339269.75	6232598.70
Port Hacking 1	336749.29	6228649.70	34º04.200'	151º13.850'	336624.29	6228524.70
Port Hacking 2	336749.29	6228411.60	34º04.334'	151º13.845'	336624.29	6228286.60
Marley 1	331643.55	6221348.22	34º08.105'	151º10.450'	331518.55	6221223.22
Marley 2	331722.92	6221163.04	34º08.205'	151º10.500'	331597.92	6221038.04

Table E-14 Actual sub-sampling coordinates from collection of 2022-23 samples from sites 1 and 2 of 3 locations with replicate samples numbers

Location	Easting (grid centre)	Northing (grid centre)	Easting (converted to represent 0 co-ord, x value)	Northing (converted to represent 0 co-ord, y value)	Random number x co-ord (0-5)	Random number y co-ord (0-5)	Grid Easting	Grid Northing
North Head site 1								
Replicate 1	347436.95	6257934.94	347311.95	6257809.94	1	1	347370.72	6257865.79
Replicate 2	347436.95	6257934.94	347311.95	6257809.94	3	4	347451.61	6257997.44
Replicate 3	347436.95	6257934.94	347311.95	6257809.94	3	3	347460.68	6257955.41
Replicate 4	347436.95	6257934.94	347311.95	6257809.94	5	5	347559.33	6258053.52
Replicate 5	347436.95	6257934.94	347311.95	6257809.94	1	2	347347.26	6257908.28
North Head site 2								
Replicate 1	347463.41	6256056.66	347338.41	6255931.66	4	1	347539.14	6255966.89
Replicate 2	347463.41	6256056.66	347338.41	6255931.66	3	5	347504.63	6256165.40
Replicate 3	347463.41	6256056.66	347338.41	6255931.66	5	2	347585.50	6256024.11
Replicate 4	347463.41	6256056.66	347338.41	6255931.66	1	2	347404.10	6256053.56
Replicate 5	347463.41	6256056.66	347338.41	6255931.66	3	3	347493.44	6256085.04
Bondi site 1								
Replicate 1	343415.85	6248226.10	343290.85	6248101.1	2	2	343386.71	6248188.22
Replicate 2	343415.85	6248226.10	343290.85	6248101.1	3	0	343461.90	6248124.98
Replicate 3	343415.85	6248226.10	343290.85	6248101.1	4	0	343479.22	6248117.70
Replicate 4	343415.85	6248226.10	343290.85	6248101.1	1	2	343319.11	6248180.55
Replicate 5	343415.85	6248226.10	343290.85	6248101.1	5	4	343534.00	6248296.55

Location	Easting (grid centre)	Northing (grid centre)	Easting (converted to represent 0 co-ord, x value)	Northing (converted to represent 0 co-ord, y value)	Random number x co-ord (0-5)	Random number y co-ord (0-5)	Grid Easting	Grid Northing
Bondi site 2								
Replicate 1	344024.31	6250792.20	343899.31	6250667.2	1	2	343927.17	6250770.88
Replicate 2	344024.31	6250792.20	343899.31	6250667.2	2	1	343990.08	6250715.75
Replicate 3	344024.31	6250792.20	343899.31	6250667.2	1	2	343941.36	6250779.85
Replicate 4	344024.31	6250792.20	343899.31	6250667.2	4	4	344105.34	6250850.43
Replicate 5	344024.31	6250792.20	343899.31	6250667.2	0	4	343904.38	6250884.76
Malabar 0 km site 1								
Replicate 1	342807.40	6238966.99	342682.4	6238841.99	3	1	342828.99	6238884.48
Replicate 2	342807.40	6238966.99	342682.4	6238841.99	1	3	342715.77	6238972.45
Replicate 3	342807.40	6238966.99	342682.4	6238841.99	5	5	342921.42	6239076.93
Replicate 4	342807.40	6238966.99	342682.4	6238841.99	2	5	342795.92	6239082.92
Replicate 5	342807.40	6238966.99	342682.4	6238841.99	1	2	342708.12	6238945.19
Replicate 6	342807.40	6238966.99	342682.4	6238841.99	3	1	342849.19	6238907.34
Replicate 7	342807.40	6238966.99	342682.4	6238841.99	4	0	342890.47	6238852.40
Replicate 8	342807.40	6238966.99	342682.4	6238841.99	2	4	342798.05	6239053.46
Replicate 9	342807.40	6238966.99	342682.4	6238841.99	0	2	342683.94	6238933.83
Replicate 10	342807.40	6238966.99	342682.4	6238841.99	3	4	342844.27	6239024.35
Malabar 0 km site 2								
Replicate 1	343468.76	6239125.72	343343.76	6239000.72	3	2	343487.37	6239077.77
Replicate 2	343468.76	6239125.72	343343.76	6239000.72	3	0	343474.67	6239025.65

Location	Easting (grid centre)	Northing (grid centre)	Easting (converted to represent 0 co-ord, x value)	Northing (converted to represent 0 co-ord, y value)	Random number x co-ord (0-5)	Random number y co-ord (0-5)	Grid Easting	Grid Northing
Replicate 3	343468.76	6239125.72	343343.76	6239000.72	3	0	343485.08	6239003.47
Replicate 4	343468.76	6239125.72	343343.76	6239000.72	3	3	343517.89	6239156.05
Replicate 5	343468.76	6239125.72	343343.76	6239000.72	3	3	343489.76	6239144.47
Replicate 6	343468.76	6239125.72	343343.76	6239000.72	4	1	343522.74	6239041.15
Replicate 7	343468.76	6239125.72	343343.76	6239000.72	5	2	343588.97	6239120.52
Replicate 8	343468.76	6239125.72	343343.76	6239000.72	2	0	343446.25	6239005.36
Replicate 9	343468.76	6239125.72	343343.76	6239000.72	3	1	343483.14	6239039.92
Replicate 10	343468.76	6239125.72	343343.76	6239000.72	1	0	343399.22	6239008.63

Table E-15 Invertebrate data from the Malabar 0 km location in 2021 from sites 1 and 2

Phylum	Class	Order	Family	M01	M01	M01	M01	M01	M01	M01	M01	M01	M01	M02	M02	M02	M02	M02	M02	M02	M02	M02	M02
			Replicate	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10
Annelida	Clitellata	Oligochaeta	Indeterminate							1	1												
Annelida	Polychaeta	Amphinomida	Amphinomidae																	1			
Annelida	Polychaeta	Eunicida	Dorvilleidae								2												
Annelida	Polychaeta	Eunicida	Eunicidae				1	1															
Annelida	Polychaeta	Eunicida	Lumbrineridae		16	17	6	7	5	9	8	3	2	17	8	7	11	23	111	41	11	21	26
Annelida	Polychaeta	Eunicida	Oenonidae					3						1			1		1		1		
Annelida	Polychaeta	Eunicida	Onuphidae	5		12	14		6	2	5	1		2			1	1					
Annelida	Polychaeta	Phyllodocida	Glyceridae		2								1			1							
Annelida	Polychaeta	Phyllodocida	Nephtyidae									1		1		2		1					
Annelida	Polychaeta	Phyllodocida	Nereididae	1	73	39	9	4	8	11	4	43	5	1		1	1	1	1	3	1	1	1
Annelida	Polychaeta	Phyllodocida	Phyllodocidae		1					1			1		1								
Annelida	Polychaeta	Phyllodocida	Polynoidae		1	1	1	2		2	1					1					1		1
Annelida	Polychaeta	Phyllodocida	Sigalionidae			1				2							1			1	1		
Annelida	Polychaeta	Phyllodocida	Goniadidae		1	2	1			3		1		1	1			2			2	1	
Annelida	Polychaeta	Phyllodocida	Syllidae	5	31	13	28	22	15	31	35	18	2		1	3	2	1	2	5	1	3	13
Annelida	Polychaeta	Sabellida	Sabellidae		7	1		3				3		10	10	5	4	7	15	8	3	10	19
Annelida	Polychaeta	Sabellida	Serpulidae		1																		
Annelida	Polychaeta	Sabellida	Oweniidae		1				4							2		1	1	2			
Annelida	Polychaeta	Scolecida	Capitellidae				3			1	2					1	1	1		1		1	
Annelida	Polychaeta	Scolecida	Maldanidae	8	61	6	98	35	14	98	104	36	3	41	20	36	96	40	85	49	17	77	102
Annelida	Polychaeta	Scolecida	Paraonidae	1	1	1	9	1		6	5			1	2		1		1	1			4
Annelida	Polychaeta	Scolecida	Scalibregmatidae					1															
Annelida	Polychaeta	Scolecida	Opheliidae		1					1	1			2			1	1	2	1	3		
Annelida	Polychaeta	Scolecida	Orbiniidae	1	19	9	15	12	7	10	9	17	3	2		4	1	3	6	2	5	2	3
Annelida	Polychaeta	Spionida	Poecilochaetidae			2			1		1												
Annelida	Polychaeta	Spionida	Spionidae	2	16	8	12	8	10	13	16	10	2	76	28	32	20	32	33	16	18	32	40
Annelida	Polychaeta	Spionida	Chaetopteridae	1	60				2	2		55					2	1	3				
Annelida	Polychaeta	Terebellida	Ampharetidae	7	1	2	2	6	30	3	3	1			3	2	1		3	3		3	15
Annelida	Polychaeta	Terebellida	Cirratulidae		8	3	9	2	2	2	5	4	1	2	1				1	3	1	1	1
Annelida	Polychaeta	Terebellida	Pectinariidae	3	3	1	4	3	3	3	4		2										
Annelida	Polychaeta	N/A	Unknown					1															
Annelida	Polycheata	Terebellida	Trichobranchidae/ Terebellidae		1							3				3		1			1		2
Arthropoda	Malacostraca	Amphipoda	Ampeliscidae	3		2		5	2	3	1		1				1	2	1			1	
Arthropoda	Malacostraca	Amphipoda	Aoridae/Isaeidae/ Photidae/Unciolidae	6	21	10	13		11	4	10	6	18	4	2	2	6		2	1	2	4	1
Arthropoda	Malacostraca	Amphipoda	Atylidae	1																			
Arthropoda	Malacostraca	Amphipoda	Caprellidae														2						2
Arthropoda	Malacostraca	Amphipoda	Eusiridae						1														
Arthropoda	Malacostraca	Amphipoda	Iciliidae		2							1	3				1						
Arthropoda	Malacostraca	Amphipoda	Ischyroceridae			2			1	1			2	1		1	18	2	1			1	4
Arthropoda	Malacostraca	Amphipoda	Liljeborgiidae			1	2						1	1	1	2	1		2			1	1
Arthropoda	Malacostraca	Amphipoda	Lysianassidae	8	17	6	37	22	8	15	23	26	11	4	2	2	4	5	2		1	2	8
Arthropoda	Malacostraca	Amphipoda	Maeridae		35				1			15											
Arthropoda	Malacostraca	Amphipoda	Melitidae		1									1	2	1			2	2			

Phylum	Class	Order	Family	M01	M01	M01	M01	M01	M01	M01	M01	M01	M01	M02	M02	M02	M02	M02	M02	M02	M02	M02	M02
			Replicate	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10
Arthropoda	Malacostraca	Amphipoda	Oedicerotidae		3		4		1	1	2	3						1					
Arthropoda	Malacostraca	Amphipoda	Phoxocephalidae	4	16	7	4		2	2	3	5	1	3	1		4	6	5	1	2		4
Arthropoda	Malacostraca	Amphipoda	Podoceridae		6						1	1											
Arthropoda	Malacostraca	Amphipoda	Unknown amphipod	1		3																	
Arthropoda	Malacostraca	Amphipoda	Urothoidae								2		1										
Arthropoda	Malacostraca	Cumacea	Bodotriidae/ Nannastacidae				1																
Arthropoda	Malacostraca	Cumacea	Diastylidae/ Gynodiastylidae			1																	
Arthropoda	Malacostraca	Decapoda	Alpheidae														1						
Arthropoda	Malacostraca	Decapoda	Callianassidae				1	1						1		4	3		1		3		
Arthropoda	Malacostraca	Decapoda	Crab Larvae (megalopa, zoea)				1																
Arthropoda	Malacostraca	Decapoda	Diogenidae					1															
Arthropoda	Malacostraca	Decapoda	Galatheidae		1							1											
Arthropoda	Malacostraca	Decapoda	Goneplacidae																			1	
Arthropoda	Malacostraca	Decapoda	Hexapodidae		1	3		2	1	2	1				6	1	2	1		2	1		
Arthropoda	Malacostraca	Decapoda	Paguridae				4				1	1											
Arthropoda	Malacostraca	Decapoda	Paguroidea	1	3	2				2	3	1			1	2			1	1			
Arthropoda	Malacostraca	Decapoda	Pasiphaeidae								1			1					1				
Arthropoda	Malacostraca	Decapoda	Pilumnidae		1							1											
Arthropoda	Malacostraca	Decapoda	Raninidae											1									
Arthropoda	Malacostraca	Isopoda	Antarcturidae									1											
Arthropoda	Malacostraca	Isopoda	Anthuridae		2	1		1		1	1		1			4						1	
Arthropoda	Malacostraca	Isopoda	Arcturidae					1									4						2
Arthropoda	Malacostraca	Isopoda	Cirolanidae		1					1				1				1					
Arthropoda	Malacostraca	Isopoda	Leptanthuridae	1	1	1	1				1							3					
Arthropoda	Malacostraca	Isopoda	Paranthuridae	3	3	4	8	2	1	10	9	1		3	1		2	3		1	4	3	3
Arthropoda	Malacostraca	Isopoda	Serolidae										1										
Arthropoda	Malacostraca	Isopoda	Sphaeromatidae		1		2					2											
Arthropoda	Malacostraca	Nebaliacea	Nebaliidae										1										
Arthropoda	Malacostraca	Tanaidacea	Apseudidae		2	1	1	1			8	1	1				1			2		2	
Arthropoda	Malacostraca	Tanaidacea	Leptocheliidae	2	67	14	55	13	6	24	53	64	6	4			1		2	4			5
Arthropoda	Malacostraca	Tanaidacea	Neotanaidae/ Leptocheliidae		2	2	2				6	1	2						1				
Arthropoda	Malacostraca	Tanaidacea	Paratanaidae	1	4		2	2	2	5	11	4	1	1	1	1		2		1			
Arthropoda	Maxillopoda	Cyclopoida	Cyclopoida									6											
Arthropoda	Ostracoda	Myodocopida	Cylindroleberididae	2	29		4		3	1	3		1	2	1	1							
Arthropoda	Ostracoda	Myodocopida	Cypridinidae/ Rutidermatidae	2		1	2				2		1		1								
Arthropoda	Ostracoda	Myodocopida	Sarsiellidae				1			2	1	1			1								
Arthropoda	Ostracoda	Podocopida	Podocopida											1									1
Arthropoda	Pycnogonida	Unknown	Pycnogonida		1							1											
Bryozoa	Indeterminate	Indeterminate	Indeterminate									1											
Chordata	Actinopterygii	Anguilliformes	Anguillidae								1												

Phylum	Class	Order	Family	M01	M01	M01	M01	M01	M01	M01	M01	M01	M01	M02	M02	M02	M02	M02	M02	M02	M02	M02	M02
			Replicate	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10
Cnidaria	Anthozoa	Actinaria	O. Actiniaria								1												
Echinodermata	Asteroidea	Indeterminate	Indeterminate							1													
Echinodermata	Echinoidea	Indeterminate	Indeterminate																			1	
Echinodermata	Ophiuroidea	Indeterminate	Indeterminate		17	6	3	7	10	1	2	14	5	1	2	1	1	5	1	1	2		7
Mollusca	Aplacophora	Chaetodermatida	Chaetodermatidae				1	3		1	2	1			2	4		2	1	2	1	3	1
Mollusca	Bivalva	Arcoida	Philobryidae					9															
Mollusca	Bivalva	Lucinoida	Lucinidae	3					2					1	1	2	1	1	2	2		3	2
Mollusca	Bivalva	Lucinoida	Thyasiridae											1									
Mollusca	Bivalva	Mytiloida	Mytilidae		1					1		1					1	1	1				
Mollusca	Bivalva	Nuculida	Nuculanidae									1											
Mollusca	Bivalva	Nuculida	Nuculidae	2			1				1	2	1				2		1				
Mollusca	Bivalva	Solemyoida	Solemyidae			1		1		1		1				1		1	2			1	3
Mollusca	Bivalva	Veneroida	Cardiidae								1												
Mollusca	Bivalva	Veneroida	Galeommatidae			3	1		1				1										
Mollusca	Bivalva	Veneroida	Trapeziidae		1							5											
Mollusca	Bivalva	Veneroida	Ungulinidae								2	2											
Mollusca	Gastropoda	Littorinimorpha	Anabathridae							1													
Mollusca	Gastropoda	N/A	Skeneidae	1																			
Mollusca	Gastropoda	Neogastropoda	Marginellidae			1			1				3			1							
Mollusca	Gastropoda	Neogastropoda	Nassariidae	33	53	14	31	19	28	13	10	22	13	11	13	4	1		3			3	
Mollusca	Gastropoda	Neogastropoda	Olividae										1										
Mollusca	Gastropoda	Neogastropoda	Turridae			1		1				1				1							
Mollusca	Gastropoda	Neogastropoda	Volutomitridae												1								
Mollusca	Gastropoda	(unassigned) Heterobranchia	Acteonidae					2	2	1		1											1
Mollusca	Gastropoda	(unassigned) Heterobranchia	Pyramidellidae				1								1								
Mollusca	Gastropoda	N/A	Unknown							1		1											
Mollusca	Scaphopoda	Dentaliida	Laevidentaliidae	1											1								
Nematoda	Indeterminate	Indeterminate	Indeterminate				2							9	4				1	3	1		2
Nemertea	Indeterminate	Indeterminate	Indeterminate					2		2	1	3					1	1		1	1	1	1
Platyhelminthes	Indeterminate	Indeterminate	Indeterminate						1														
Porifera	Indeterminate	Indeterminate	Indeterminate		3							1											
Sipuncula	Indeterminate	Indeterminate	Indeterminate		1				2		2												

Appendix F: Wastewater overflows

F-1 Wet weather overflows

Table F-1 Trend in wet weather wastewater overflow frequency and volumes for inland WWTPs wastewater system (2016-17 to 2022-23)

Wastewater system	2016-17		2017-18		2018-19		2019-20		2020-21		2021-22		2022-23	
	MOF	SOV (ML)	MOF	SOV (ML)	MOF	SOV (ML)	MOF	SOV (ML)	MOF	SOV (ML)	MOF	SOV (ML)	MOF	SOV (ML)
Picton	0	0	0	0	0	0	1	7.5	3	1	4	18.4	7	16.2
West Camden	3	3	0	0	2	1.0	1	65.1	4	105	5	287.2	6	128.6
Wallacia	5	11	0	0	3	2.2	4	28.6	9	34	7	69.3	2	15.8
Penrith	4	0.3	0	0	4	12.2	6	173.0	5	126	11	241.6	8	88.9
Winmalee	0	0	0	0	1	0.1	2	98.0	1	35	3	15.6	2	16.7
North Richmond	8	11	0	0	2	0.4	3	15.6	3	37	2	42.5	2	9.8
Richmond	0	0	0	0	0	0	1	2.1	1	0	3	10.6	1	0
St Marys	5	38	0	0	10	71.7	6	399.7	6	445	11	864.5	5	473.1
Quakers Hill	10	162	1	12.2	8	280.0	4	538.2	8	853	11	1378.0	7	487.4
Riverstone	3	3.5	0	0	2	0.5	1	34.9	3	142	5	235.8	5	95.5
Castle Hill	2	1	0	0	4	4.6	2	75.5	3	63	4	124.8	3	40.3
Rouse Hill	3	0.3	0	0	2	8.1	1	111.9	0	124	4	242.0	1	72.0
Hornsby Heights	0	0	0	0	0	0	1	1.1	1	0	4	0.4	0	0
West Hornsby	2	11	0	0	8	42.9	2	91.8	3	60	5	103.0	2	34.0
Brooklyn-Danger Island	0	0	0	0	0	0	0	0.0	0	0	0	0.0	0	0
All inland systems	**45**	**241**	**1**	**12.2**	**46**	**423.7**	**15**	**1643**	**50**	**2025**	**79**	**3633.6**	**51**	**1478.3**

F-2 MOF: Maximum overflow frequency

F-3 SOV: System overflow volume

Table F-2 Trend in wet weather wastewater overflow frequency and volumes for ocean WWTPs wastewater system (2016-17 to 2022-23)

Wastewater system	2016-17		2017-18		2018-19		2019-20		2020-21		2021-22		2022-23	
	MOF	SOV (ML)	MOF	SOV (ML)	MOF	SOV (ML)	MOF	SOV (ML)	MOF	SOV (ML)	MOF	SOV (ML)	MOF	SOV (ML)
Warriewood	3	0.5	1	3.5	2	4.8	5	157.7	2	95	6	247.4	5	23.1
North Head / Northern suburbs	23	4,000	16	279.9	23	3,801.0	16	9,861.0	26	9,300	29	21,127.9	38	3,697.8
Bondi	20	94	5	11.7	10	179.5	12	489.1	14	302	18	693.0	20	281.3
Malabar/Southern suburbs	29	5,328	20	2,415.0	28	6,586.5	18	15,593.2	38	13,207	47	37973.0	41	16,866.8
Cronulla	13	94	-	0.03	8	28.0	9	659.7	7	361	15	1281.0	12	1,147.2
Wollongong	8	86	2	0.2	5	25.0	2	59.3	6	34	10	189.3	8	217.9
Bellambi	22	234	1	0.0	19	46.2	4	159.8	8	70	10	340.5	23	1,387.7
Port Kembla	8	159	2	0.7	4	6.7	2	142.4	9	113	13	348.7	19	475.6
Shellharbour	4	146	1	1.5	4	2.6	1	106.3	7	167	16	302.1	9	561.8
Kiama/Bombo	8	72	4	2.5	6	4.1	2	3.0	9	173	13	452.7	14	288.7
All ocean systems	**138**	**10,213.5**	**52**	**2,715.0**	**109**	**10,684.4**	**71**	**27,232**	**126**	**23,821**	**177**	**62,955.6**	**189**	**26,426.2**

MOF: Maximum overflow frequency

SOV: System overflow volume

F-2 Dry weather overflows that reach waterways

Table F-3 Trend in dry weather wastewater overflow that reach waterways, frequency and volumes for inland wastewater systems (2016-17 to 2022-23)

Wastewater system	2016-17		2017-18		2018-19		2019-20		2020-21		2021-22		2022-23	
	Frequency	Volume (KL)	Frequency	Volume (KL)	Frequency	Volume (KL)	Frequency	Volume (KL)	Frequency	Volume (KL)	Frequency	Volume (KL)	Frequency	Volume (KL)
Picton	5	188	2	22	3	45	4	28	0	0	1	1	2	3
West Camden	4	35	7	1,079	1	7	3	35	4	29	9	287	4	41
Wallacia	2	3	1	13	1	9	0	0	1	21	0	0	0	0
Penrith	6	194	11	287	3	73	10	180	4	210	7	303	4	86
Winmalee	11	441	11	580	8	180	5	99	23	364	9	304	4	66
North Richmond	0	0	0	0	2	14	1	6	0	0	0	0	0	0
Richmond	0	0	0	0	0	0	0	0	0	0	1	5	1	1
St Marys	2	62	0	0	4	170	8	192	4	111	4	45	6	59
Quakers Hill	2	109	5	123	10	866	4	130	5	85	12	167	1	14
Riverstone	0	0	1	87	1	57	2	36	0	0	2	60	2	3
Castle Hill	2	312	4	74	8	213	2	20	3	61	8	235	2	16
Rouse Hill	6	72	1	10	9	318	8	163	8	78	3	51	3	33
Hornsby Heights	6	43	3	2	4	37	9	147	12	99	10	35	4	38
West Hornsby	8	123	6	27	9	391	5	100	9	319	11	292	8	517
Brooklyn-Danger Island	0	0	0	0	0	0	0	0	0	0	0	0	1	1
All inland systems	**54**	**1,582**	**52**	**2,304**	**63**	**2,380**	**61**	**1,138**	**73**	**1,377**	**77**	**1,785**	**42**	**878**

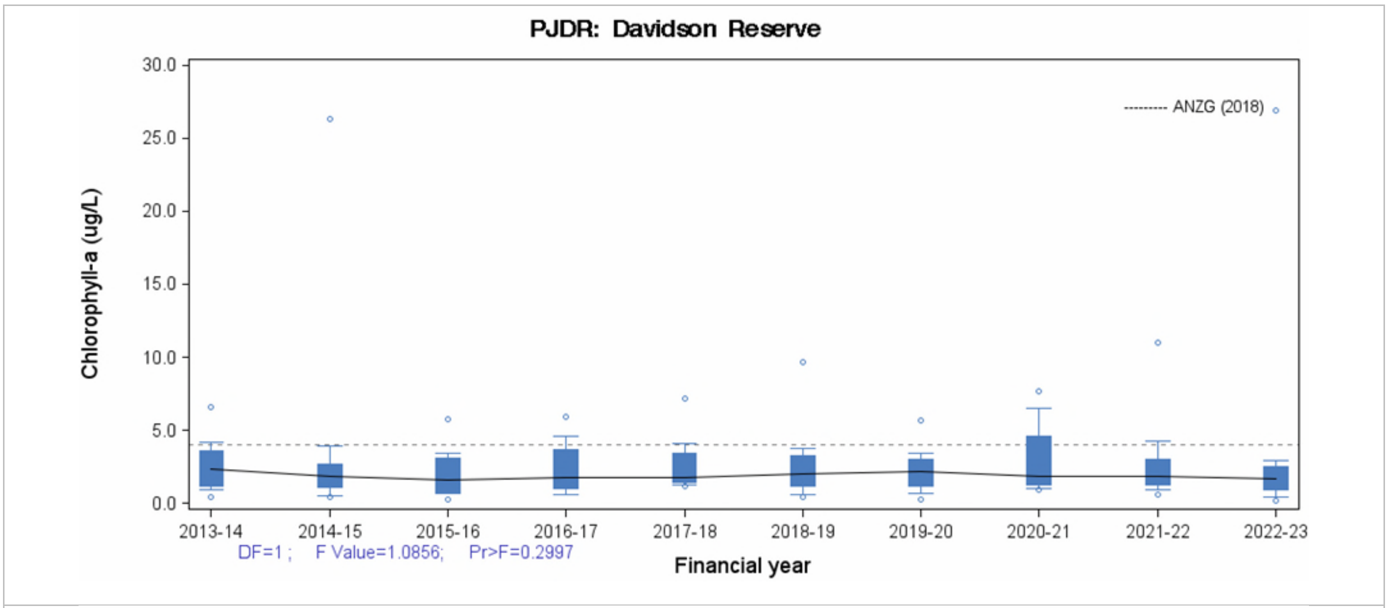
Table F-4 Trend in dry weather wastewater overflow that reach waterways, frequency and volumes for coastal WWTPs wastewater system (2016-17 to 2022-23)

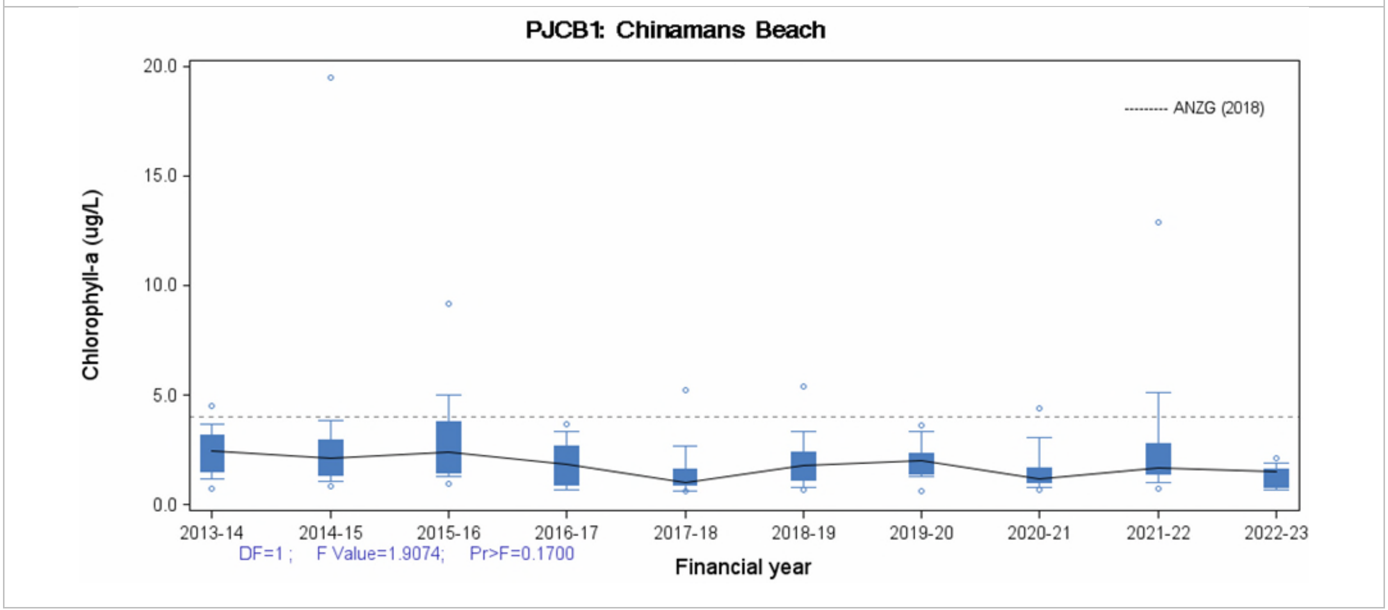
Wastewater system	2016-17		2017-18		2018-19		2019-20		2020-21		2021-22		2022-23	
	Frequency	Volume (KL)	Frequency	Volume (KL)	Frequency	Volume (KL)	Frequency	Volume (KL)	Frequency	Volume (KL)	Frequency	Volume (KL)	Frequency	Volume (KL)
Warriewood	6	99	6	39	3	27	7	55	9	87	16	189	9	47
North Head / Northern suburbs	98	6,547	147	10,197	170	16,151	176	7,948	155	6,215	103	2,850	88	2,958
Bondi	24	1,017	16	960	30	1,424	22	1,480	28	2,599	26	1,223	28	2,752
Malabar/Southern suburbs	76	8,098	75	6,112	79	6,853	133	9,530	133	11,072	82	7,614	80	7,033
Cronulla	30	1,030	42	2,205	54	2,279	41	693	29	311	26	522	18	334
Wollongong	9	174	11	132	28	551	27	649	26	276	23	1,011	14	163
Port Kembla	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Shellharbour	2	75	3	387	3	42	4	172	5	527	5	51	5	28
Kiama/Bombo	1	142	1	7	2	34	2	39	3	39	4	99	0	0
All ocean systems	**246**	**17,182**	**301**	**20,039**	**369**	**27,361**	**412**	**20,567**	**388**	**21,126**	**285**	**13,559**	**242**	**13,315**

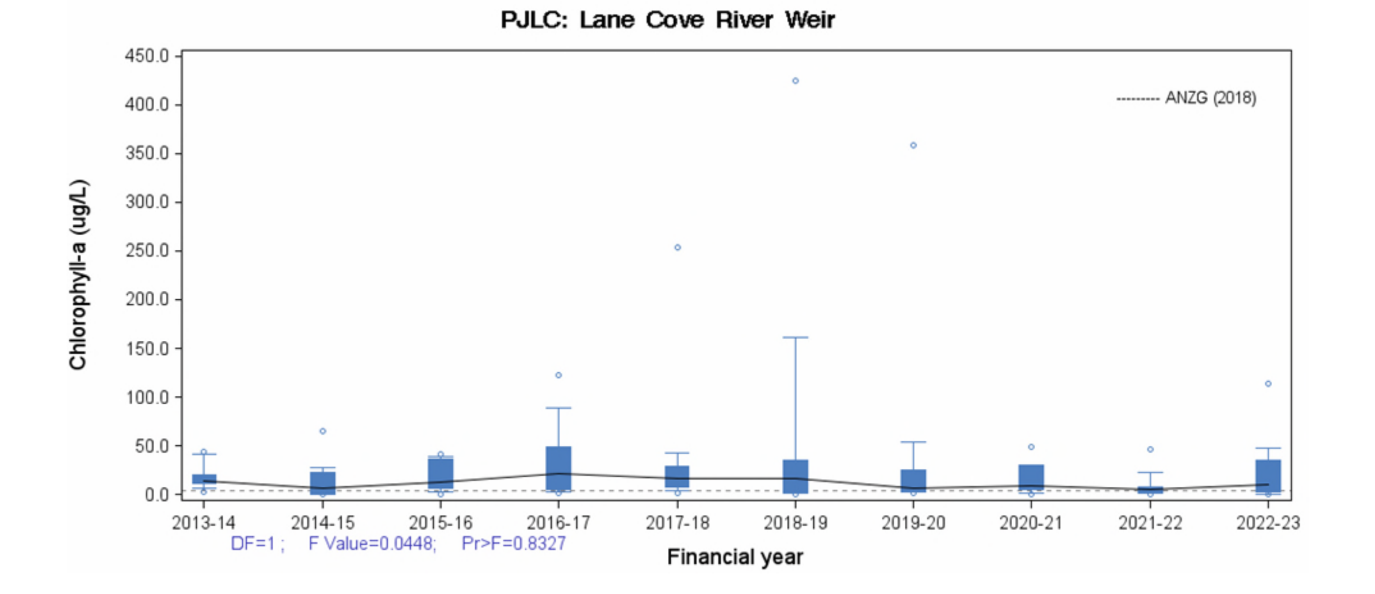
Appendix G: Other monitoring – Estuary, lagoon and beaches

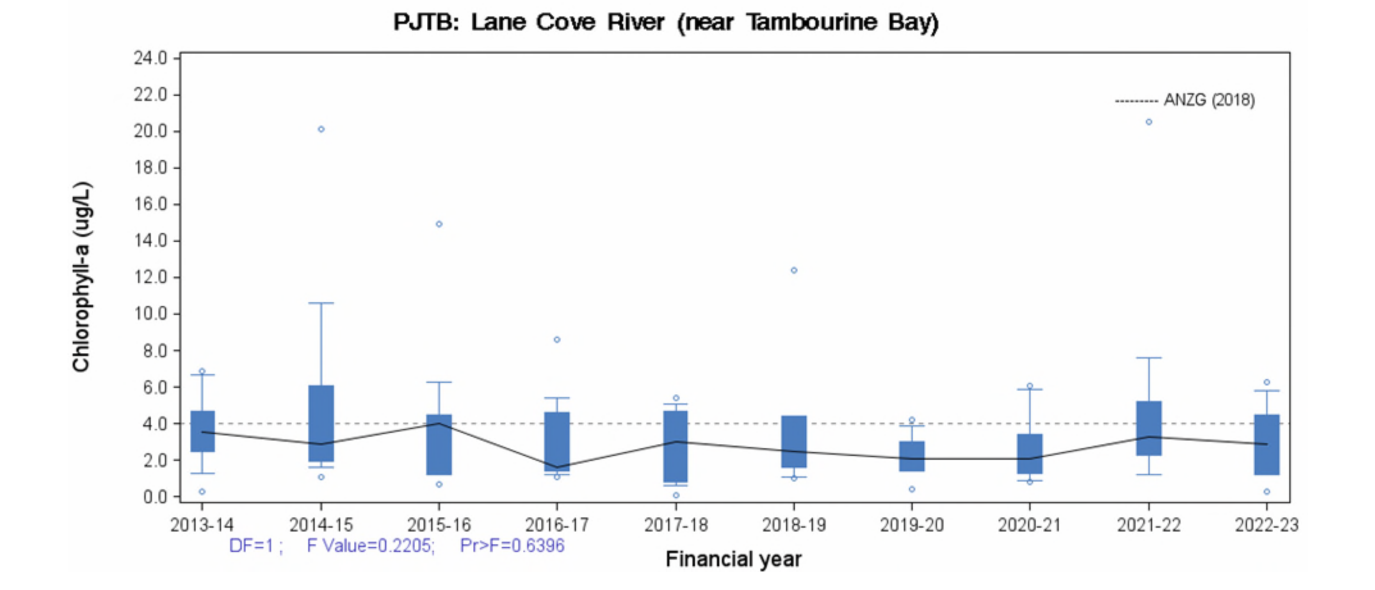
G-1 Chlorophyll-a in estuarine sites

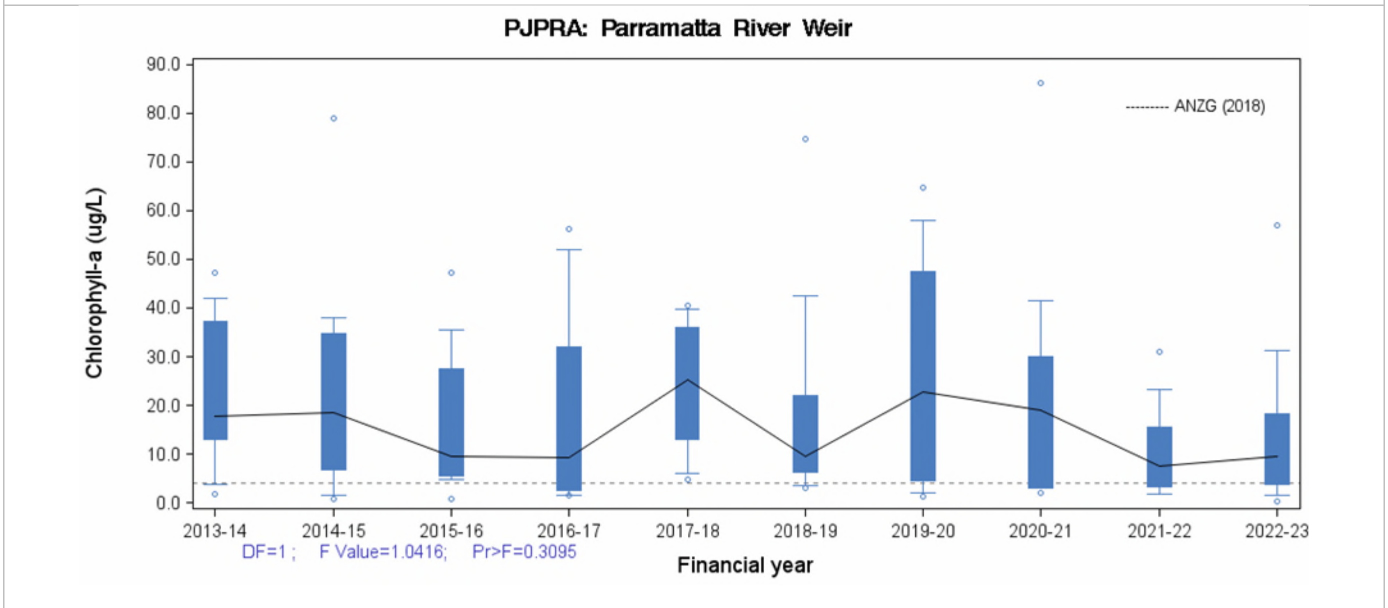
Port Jackson

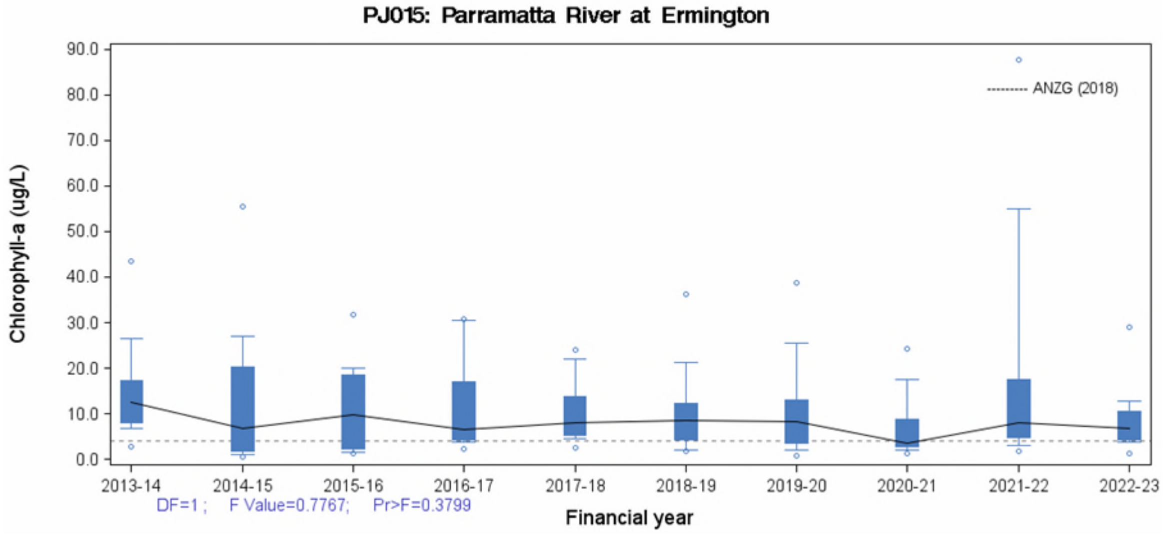


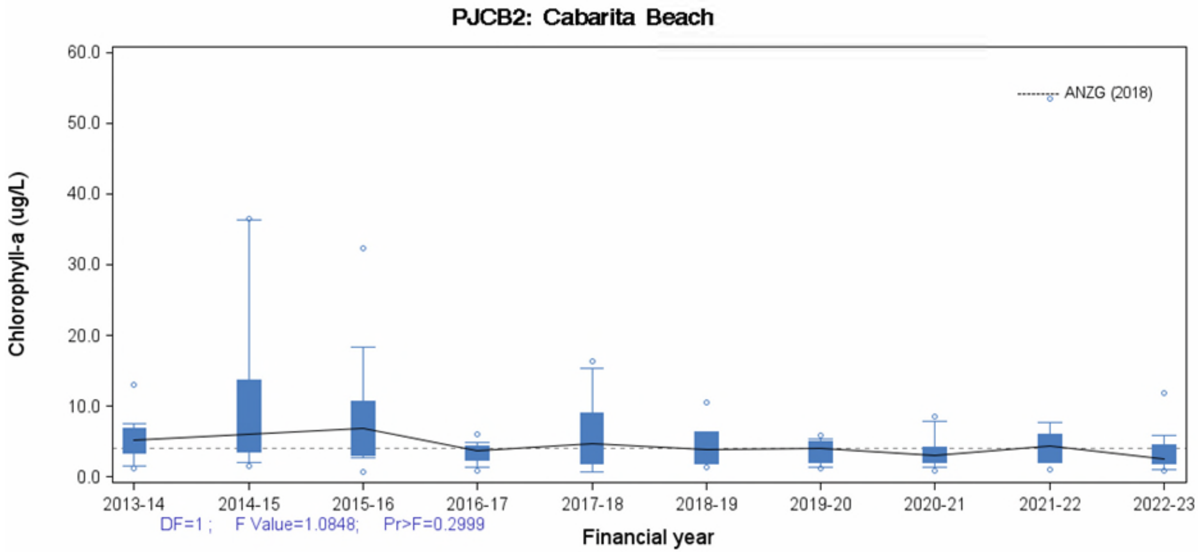


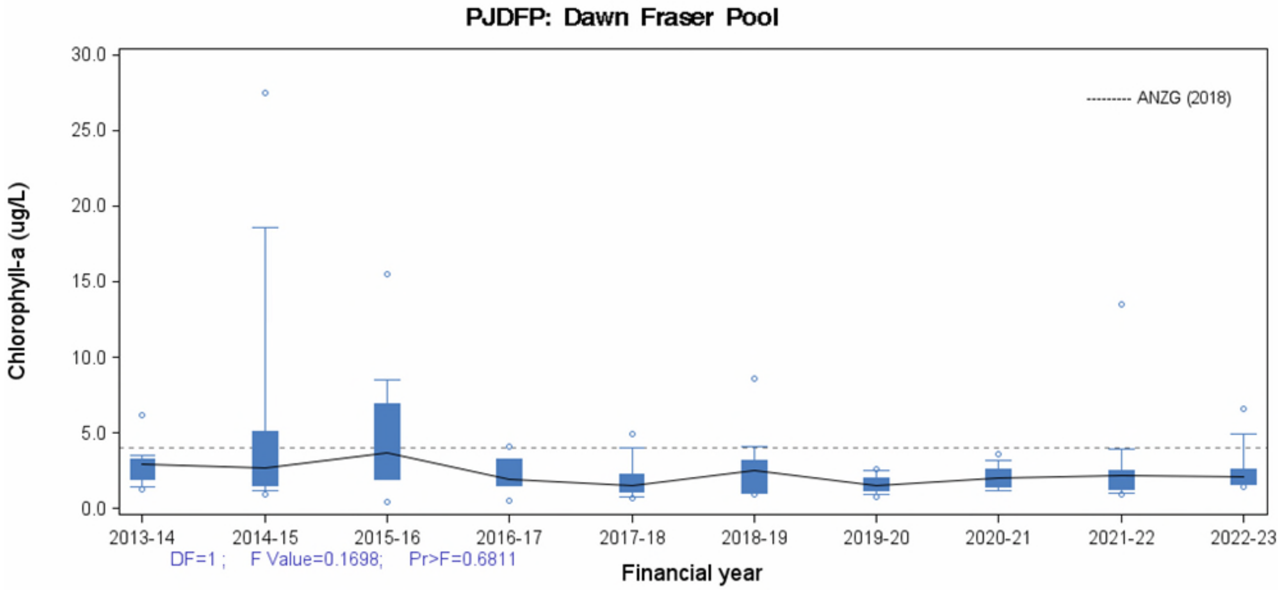

PJLC: Lane Cove River Weir
ANZG (2018)
Chlorophyll-a (ug/L)
450.0
400.0
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=0.0448; Pr>F=0.8327
Financial year


PJTB: Lane Cove River (near Tambourine Bay)
ANZG (2018)
Chlorophyll-a (ug/L)
24.0
22.0
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=0.2205; Pr>F=0.6396
Financial year

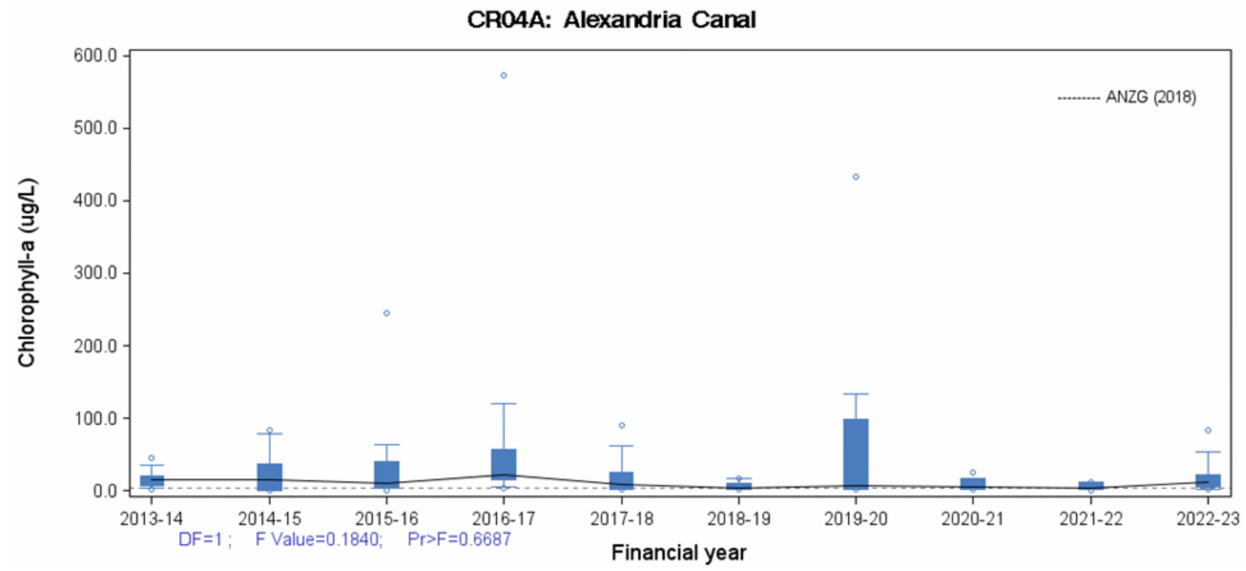

PJPRA: Parramatta River Weir
ANZG (2018)
Chlorophyll-a (ug/L)
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=1.0416; Pr>F=0.3095
Financial year

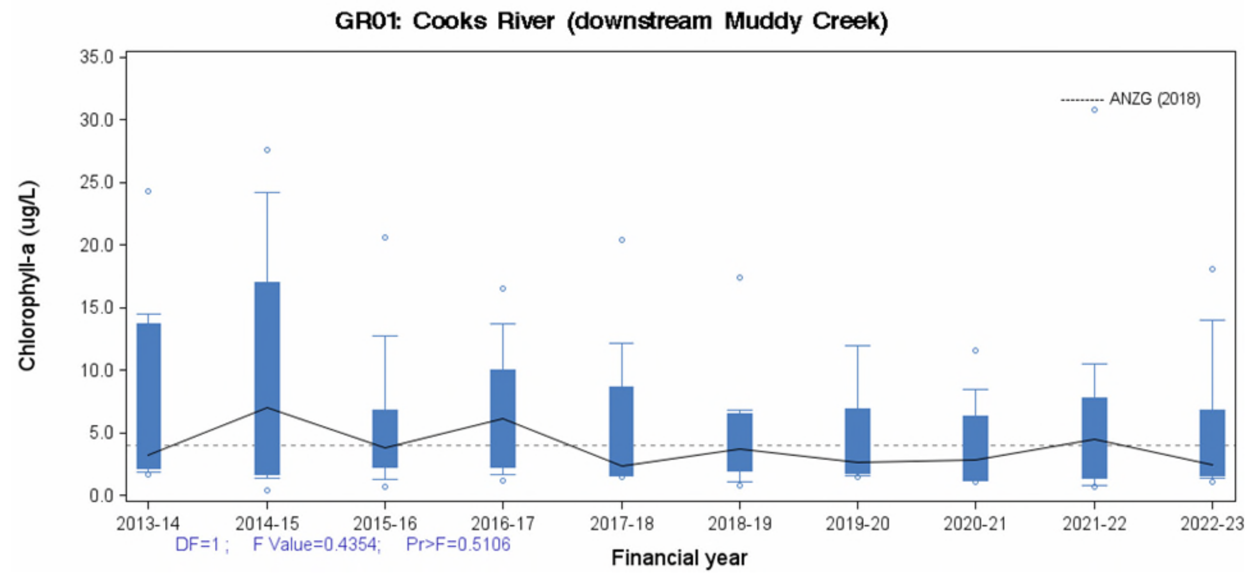

PJ015: Parramatta River at Ermington
Chlorophyll-a (ug/L)
ANZG (2018)
Financial year
DF=1 ; F Value=0.7767; Pr>F=0.3799

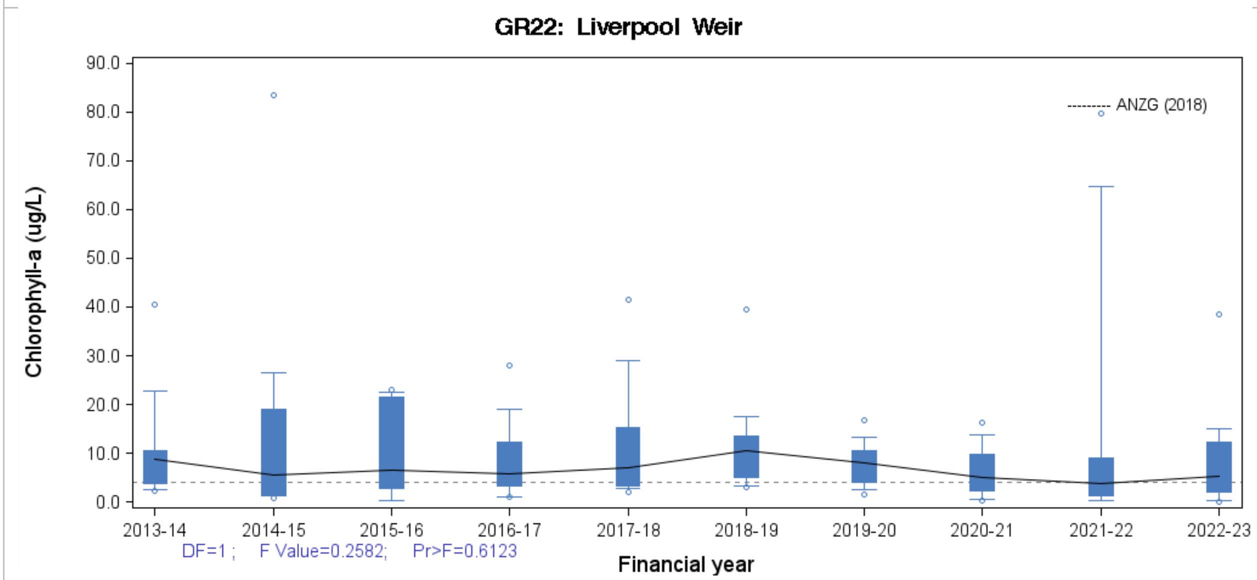

PJCB2: Cabarita Beach
Chlorophyll-a (ug/L)
ANZG (2018)
Financial year
DF=1 ; F Value=1.0848; Pr>F=0.2999

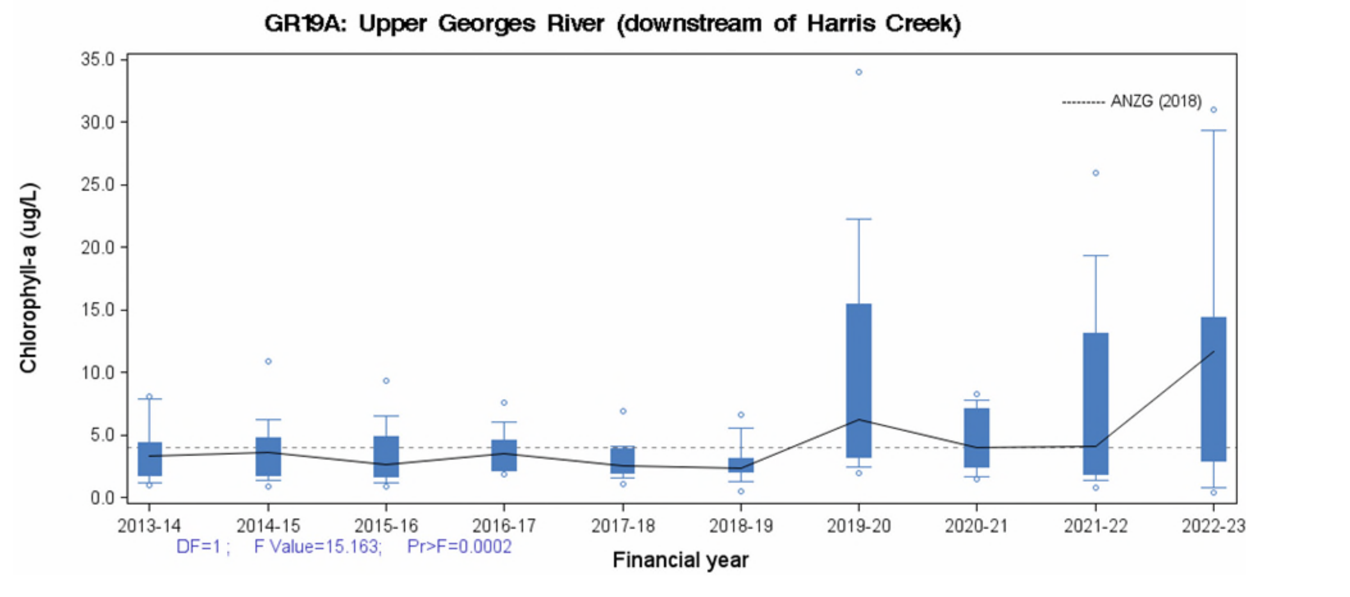

PJDFP: Dawn Fraser Pool
Chlorophyll-a (ug/L)
ANZG (2018)
Financial year
DF=1 ; F Value=0.1698; Pr>F=0.6811

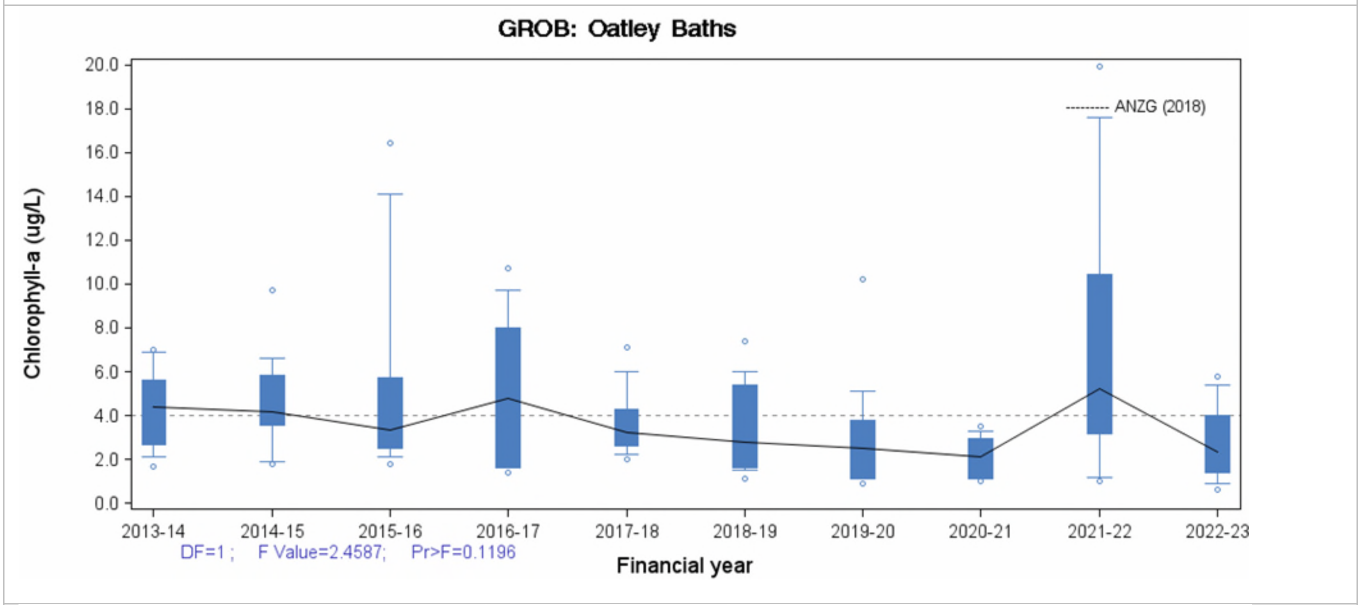
Botany Bay

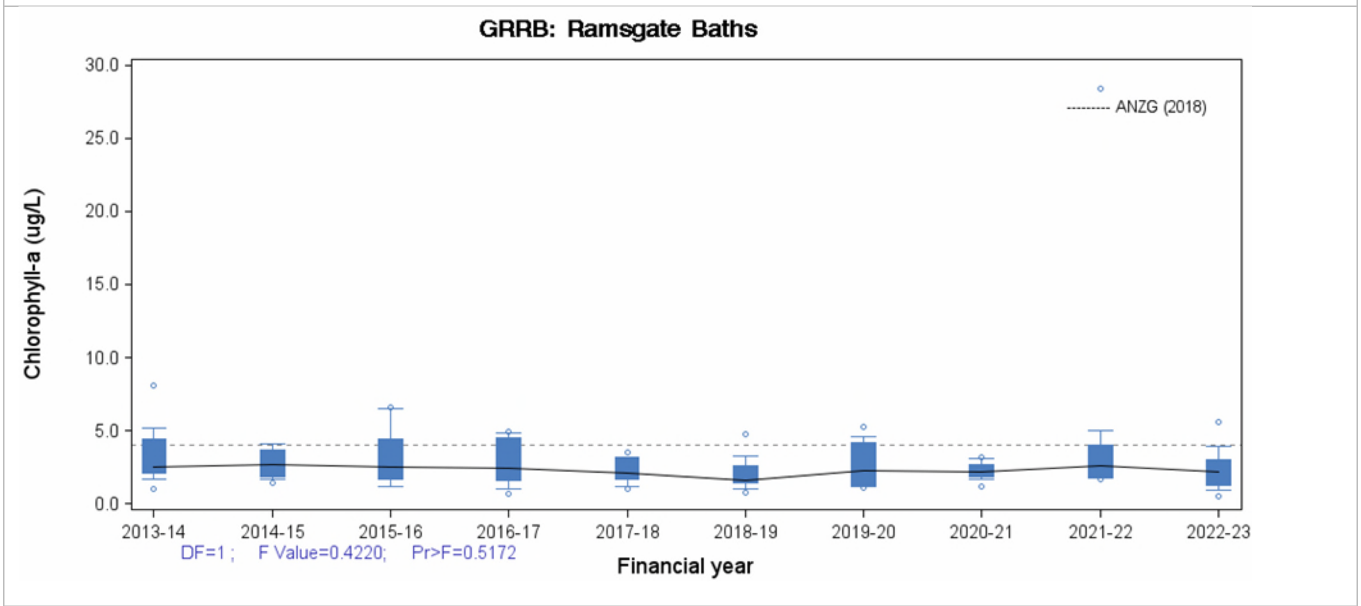

CR04A: Alexandria Canal
Chlorophyll-a (ug/L)
600.0
500.0
400.0
300.0
200.0
100.0
0.0
--------- ANZG (2018)
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=0.1840; Pr>F=0.6687
Financial year

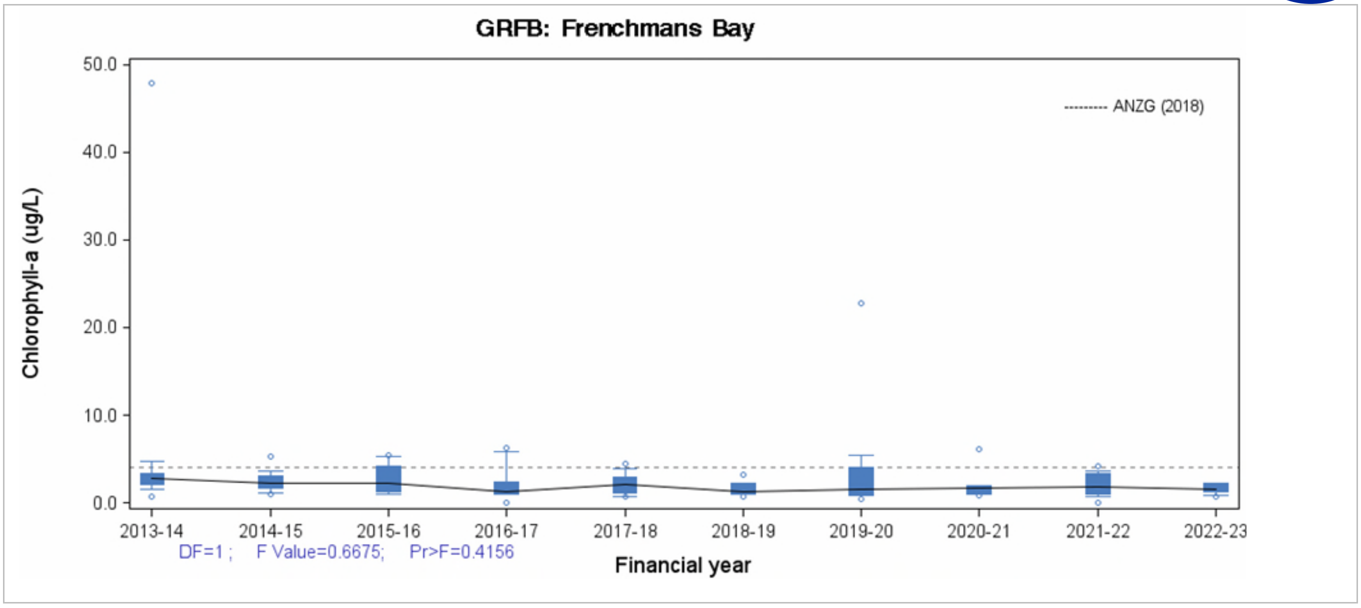

GR01: Cooks River (downstream Muddy Creek)
Chlorophyll-a (ug/L)
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
--------- ANZG (2018)
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=0.4354; Pr>F=0.5106
Financial year


GR22: Liverpool Weir
Chlorophyll-a (ug/L)
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
--------- ANZG (2018)
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=0.2582; Pr>F=0.6123
Financial year

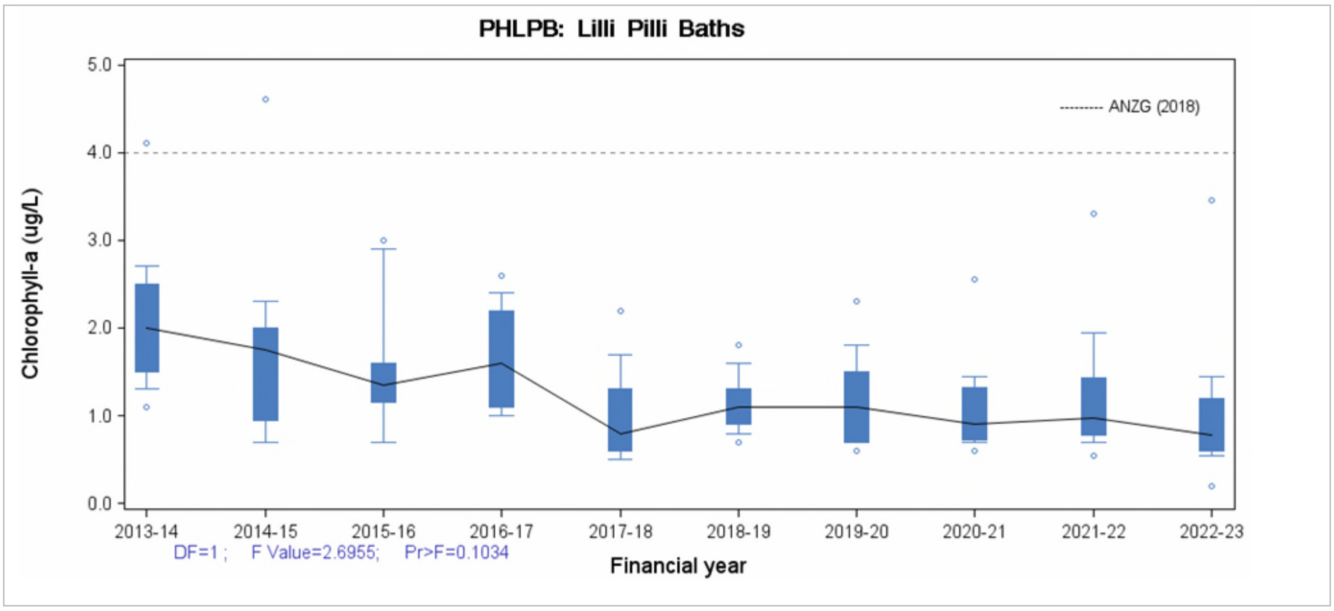

GR19A: Upper Georges River (downstream of Harris Creek)
Chlorophyll-a (ug/L)
ANZG (2018)
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=15.163; Pr>F=0.0002
Financial year


GROB: Oatley Baths
Chlorophyll-a (ug/L)
ANZG (2018)
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=2.4587; Pr>F=0.1196
Financial year

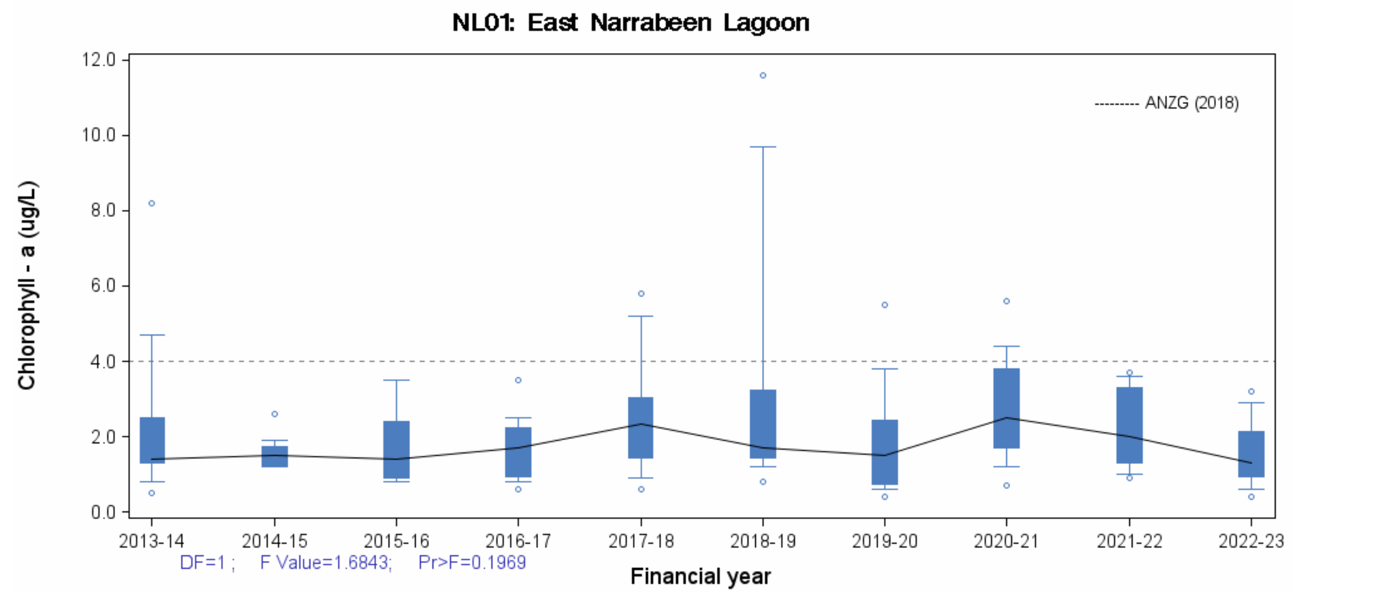

GRRB: Ramsgate Baths
Chlorophyll-a (ug/L)
ANZG (2018)
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=0.4220; Pr>F=0.5172
Financial year

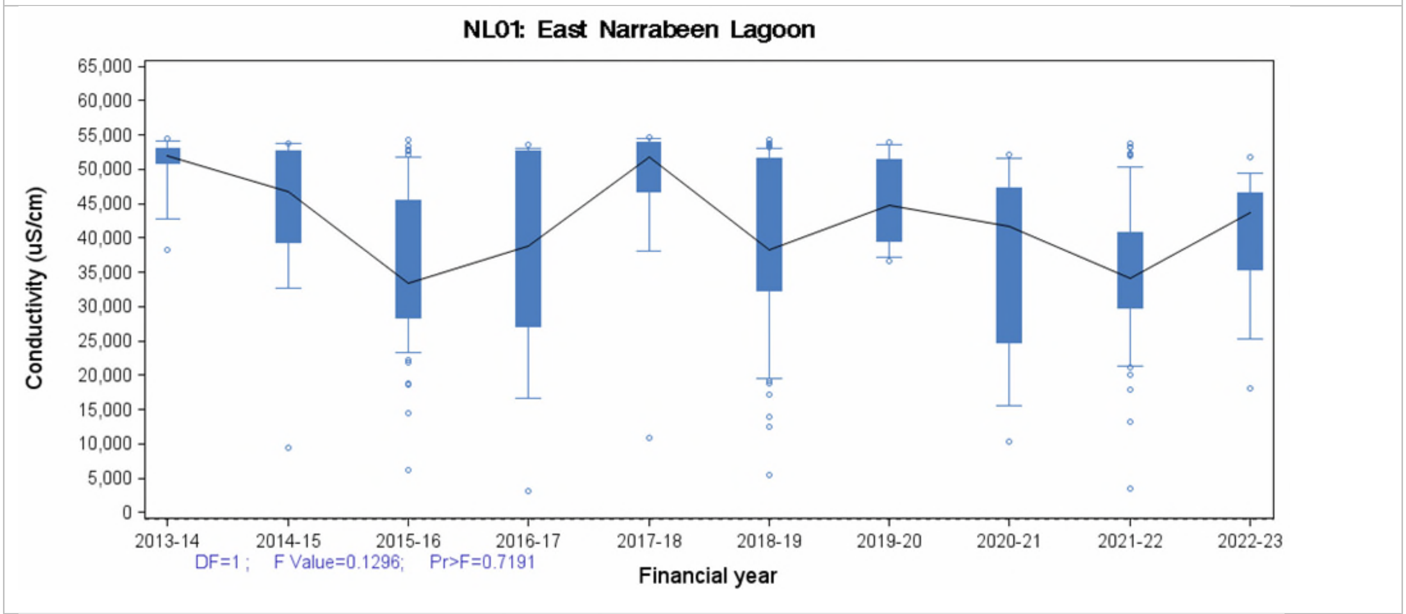


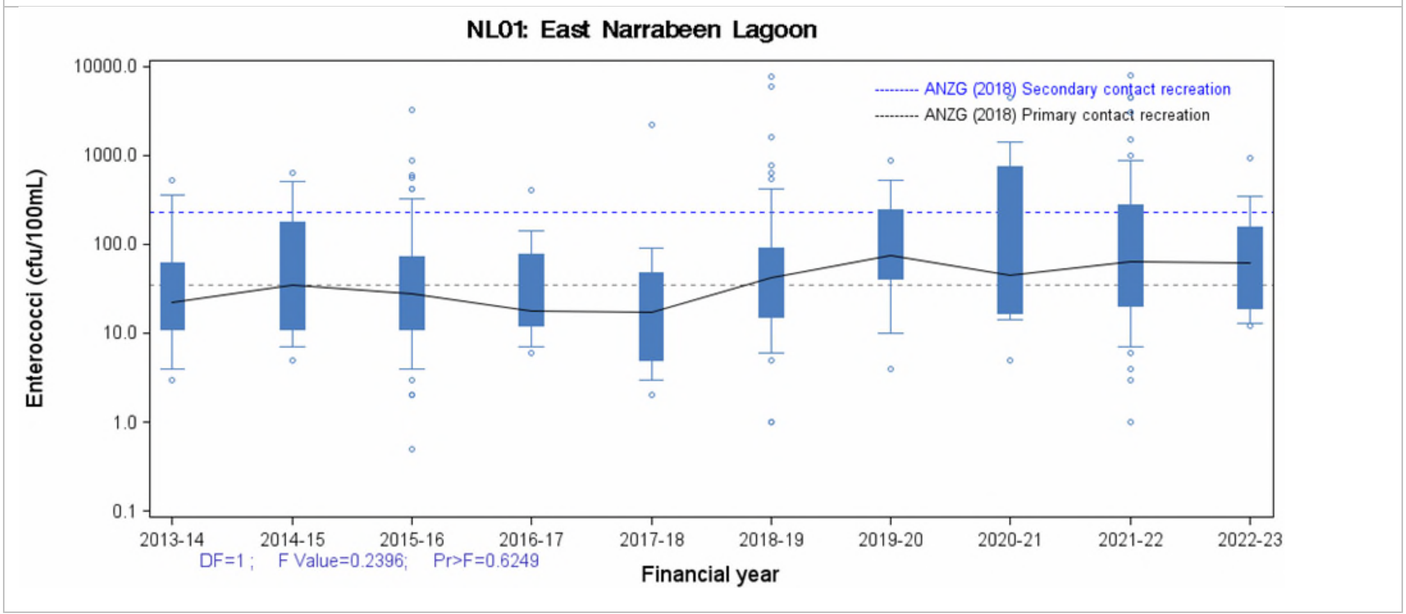
Port Hacking

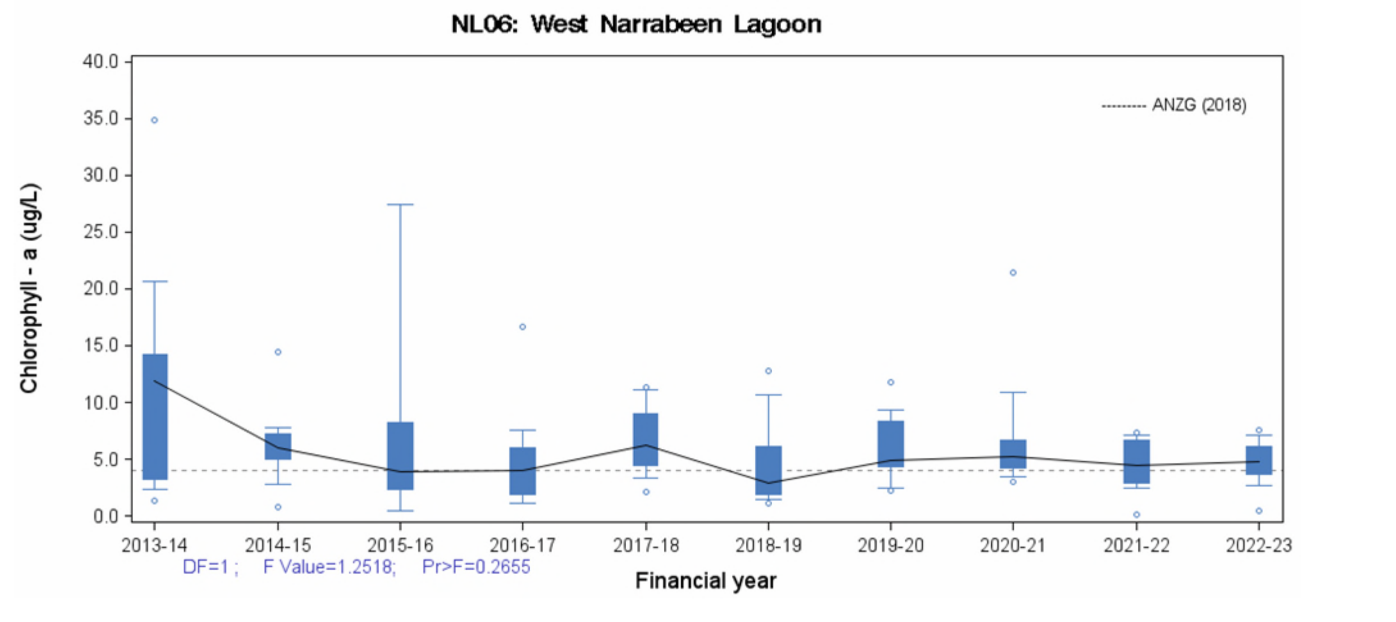


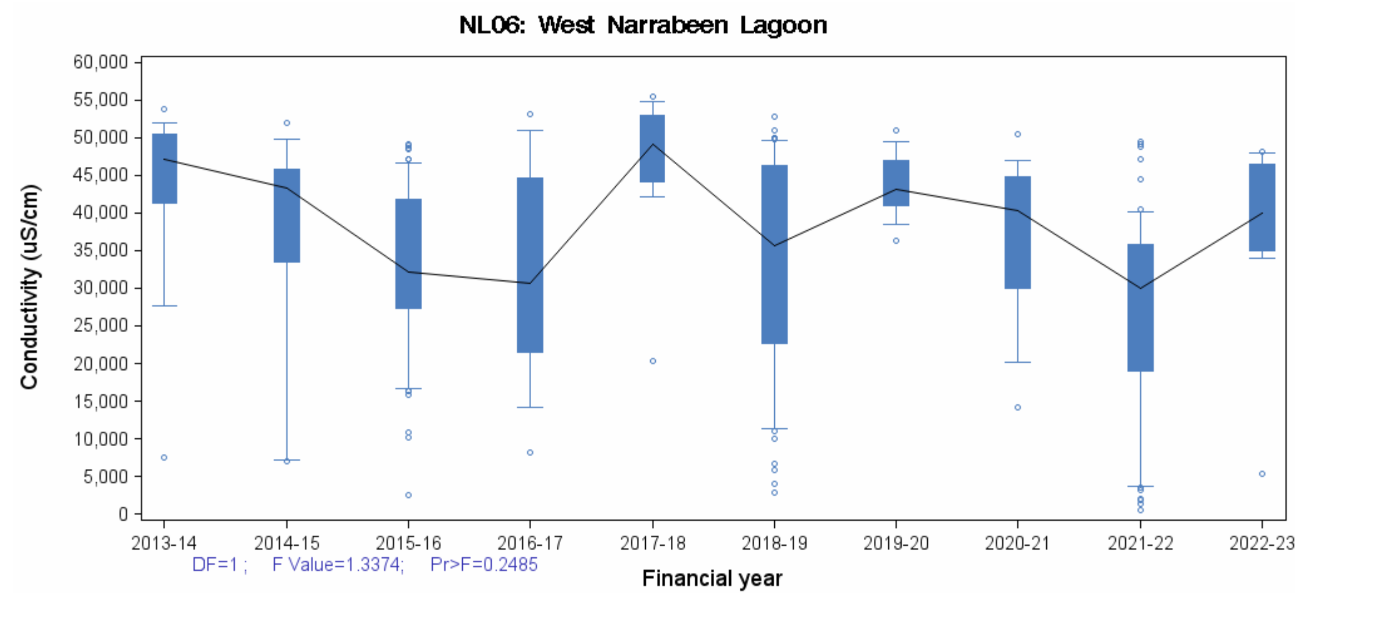
G-2 Water quality in lagoons

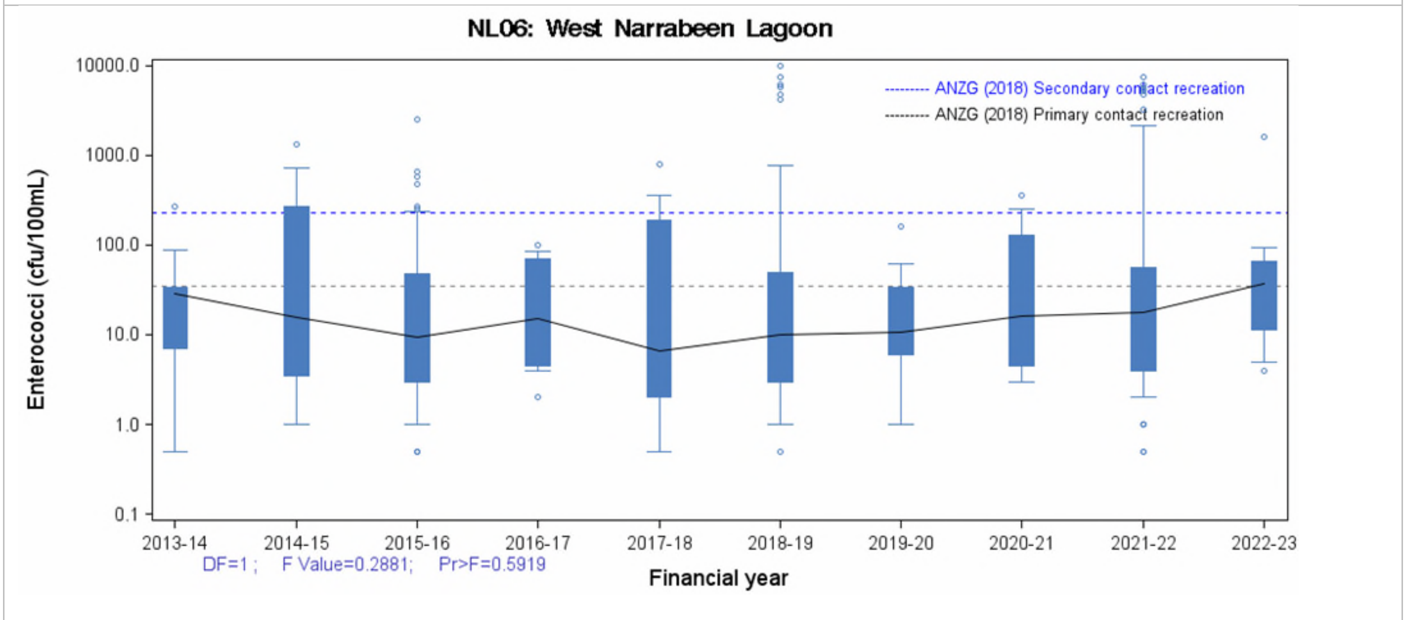


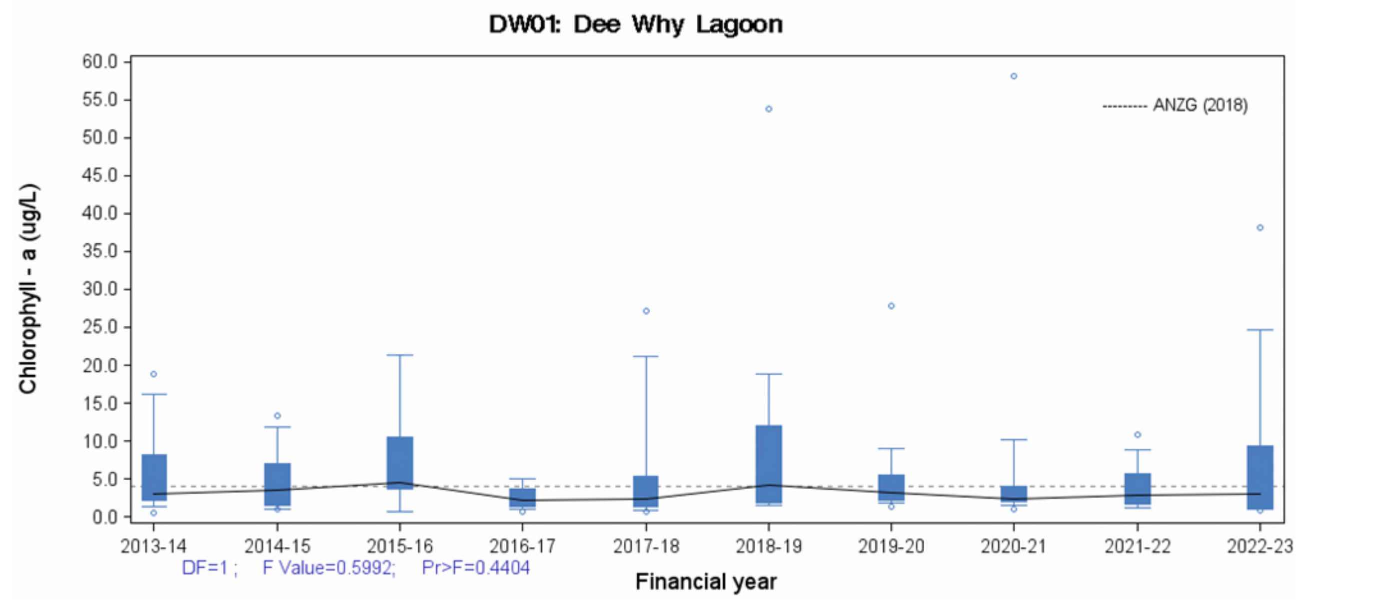


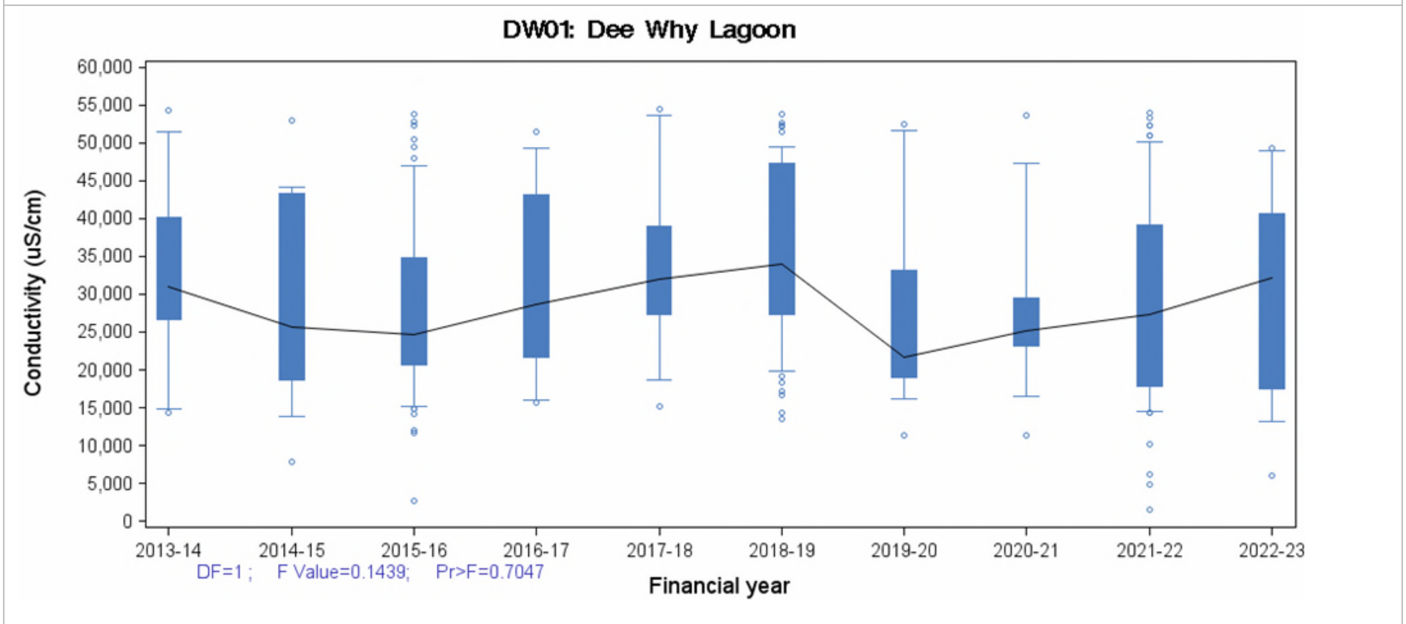


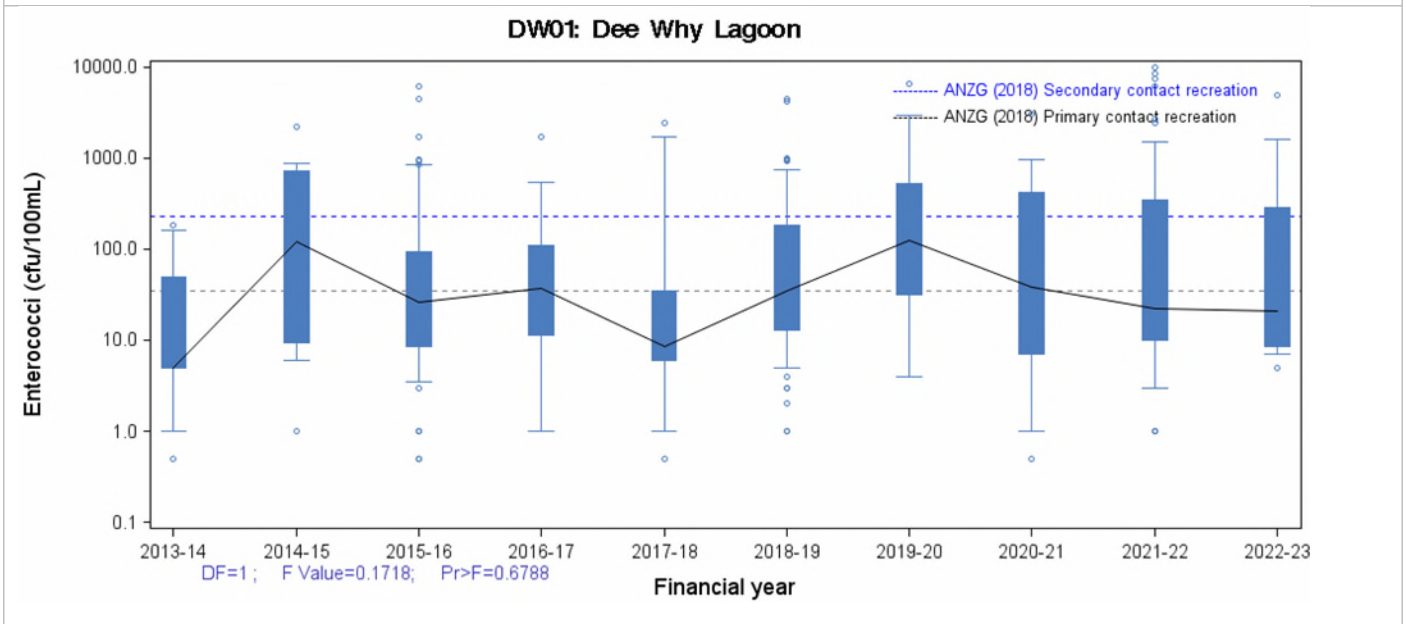

NL06: West Narrabeen Lagoon
Chlorophyll - a (ug/L)
ANZG (2018)
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=1.2518; Pr>F=0.2655
Financial year

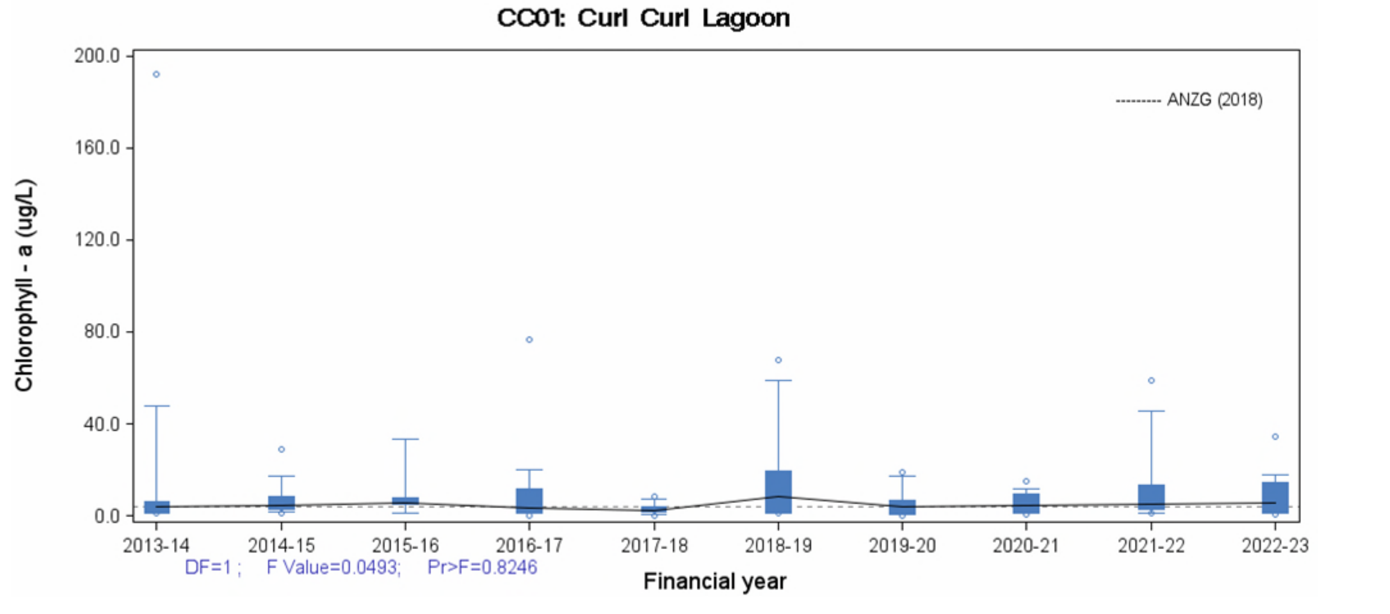

NL06: West Narrabeen Lagoon
Conductivity (uS/cm)
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=1.3374; Pr>F=0.2485
Financial year

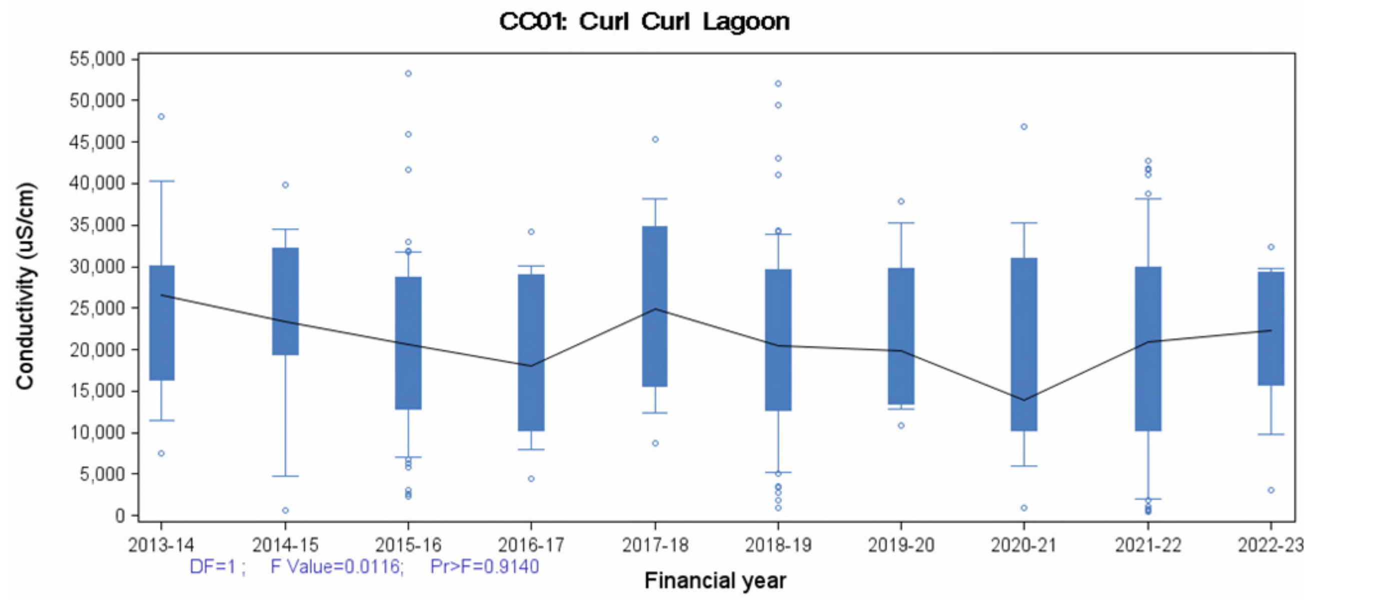

NL06: West Narrabeen Lagoon
Enterococci (cfu/100mL)
ANZG (2018) Secondary contact recreation
ANZG (2018) Primary contact recreation
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=0.2881; Pr>F=0.5919
Financial year

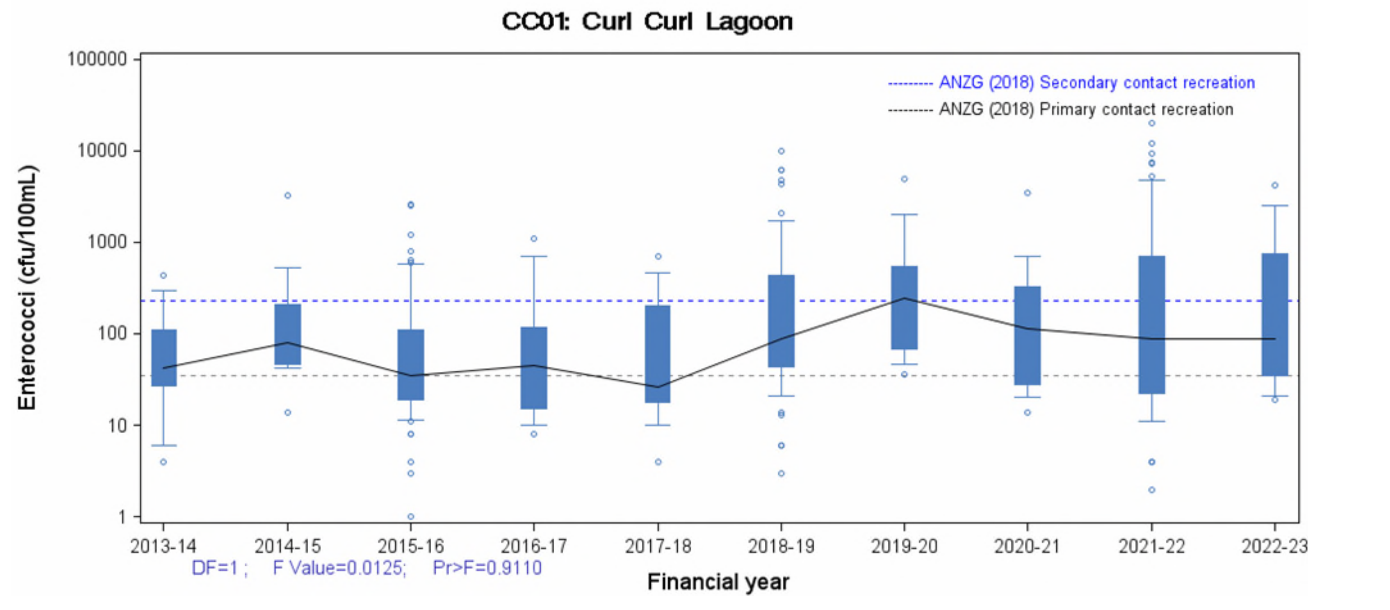

DW01: Dee Why Lagoon
ANZG (2018)
Chlorophyll - a (ug/L)
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
55.0
60.0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=0.5992; Pr>F=0.4404
Financial year

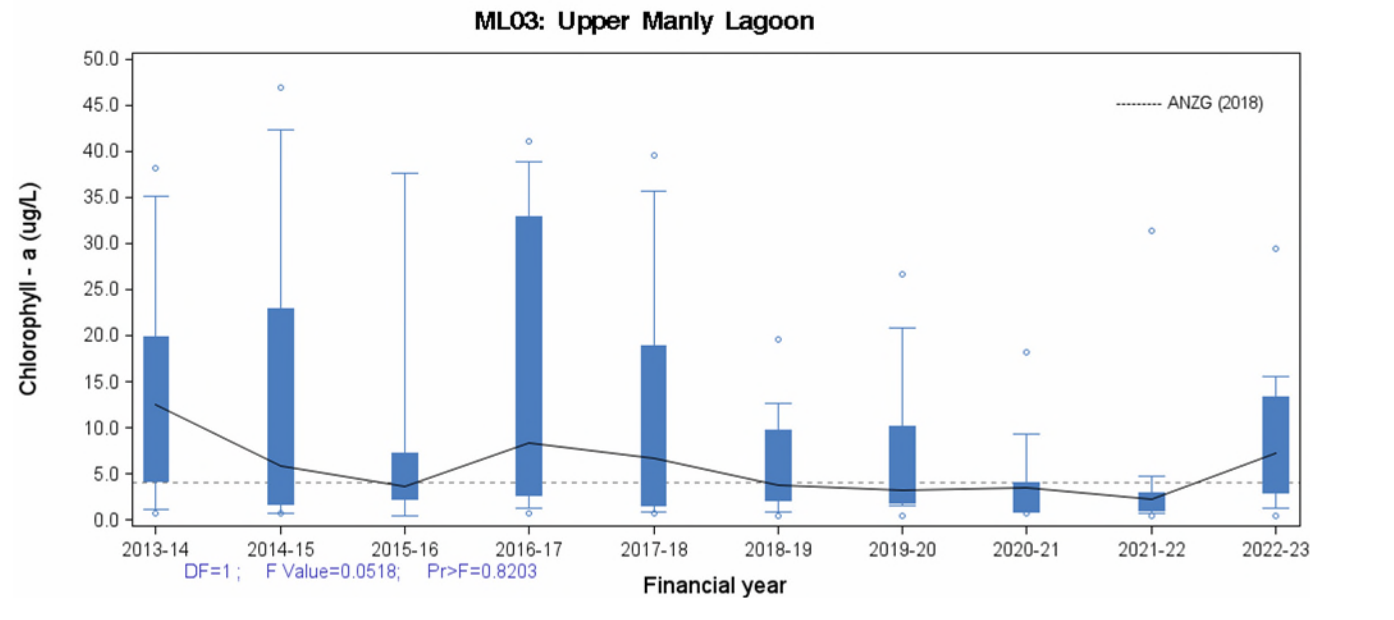

DW01: Dee Why Lagoon
Conductivity (uS/cm)
0
5,000
10,000
15,000
20,000
25,000
30,000
35,000
40,000
45,000
50,000
55,000
60,000
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=0.1439; Pr>F=0.7047
Financial year

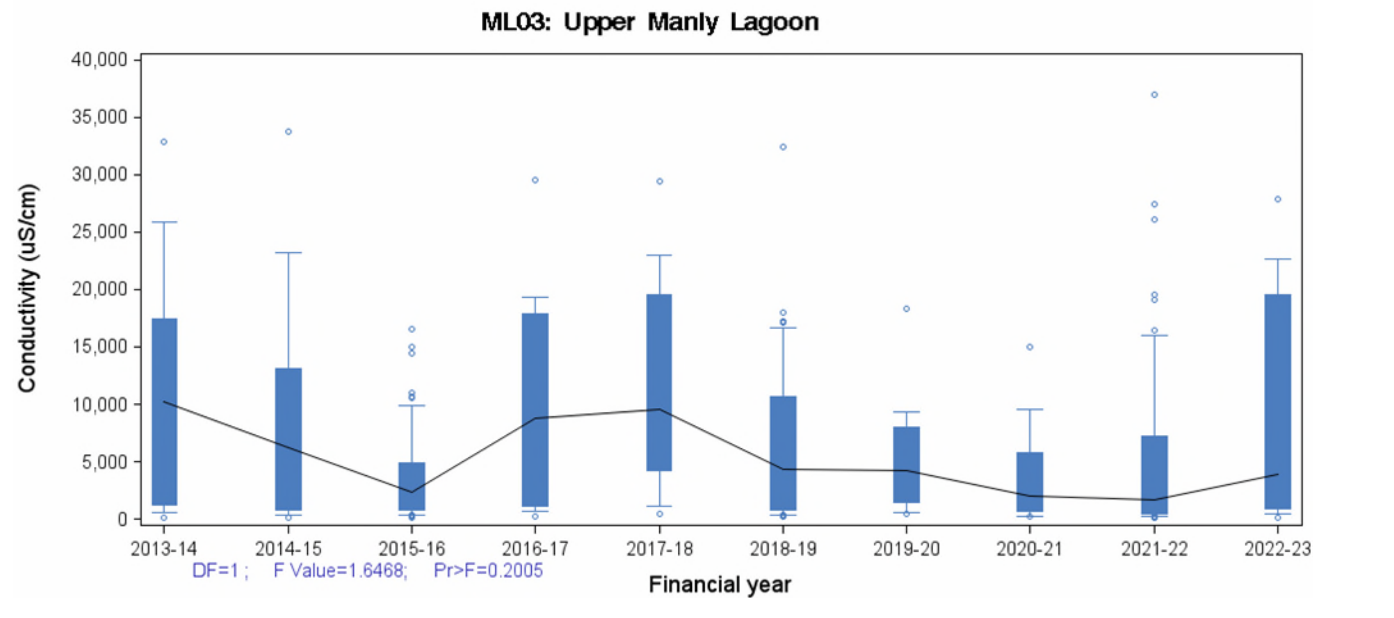

DW01: Dee Why Lagoon
ANZG (2018) Secondary contact recreation
ANZG (2018) Primary contact recreation
Enterococci (cfu/100mL)
0.1
1.0
10.0
100.0
1000.0
10000.0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=0.1718; Pr>F=0.6788
Financial year

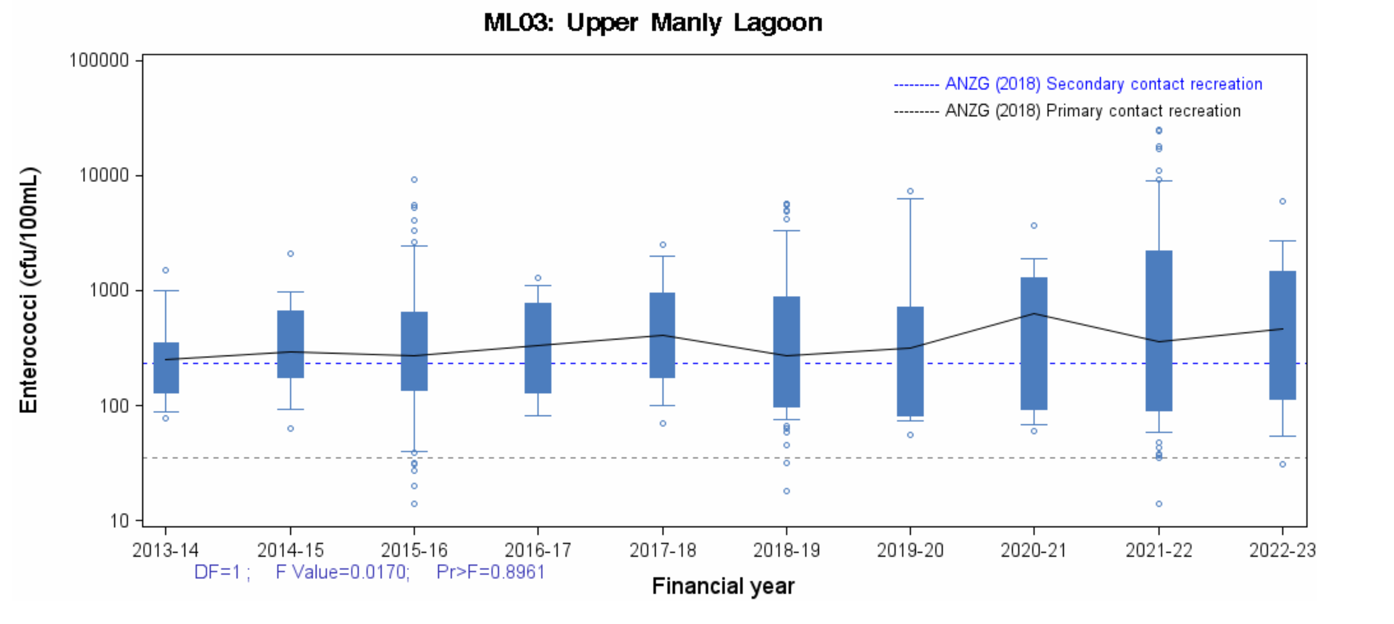

CC01: Curl Curl Lagoon
ANZG (2018)
Chlorophyll - a (ug/L)
200.0
160.0
120.0
80.0
40.0
0.0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=0.0493; Pr>F=0.8246
Financial year

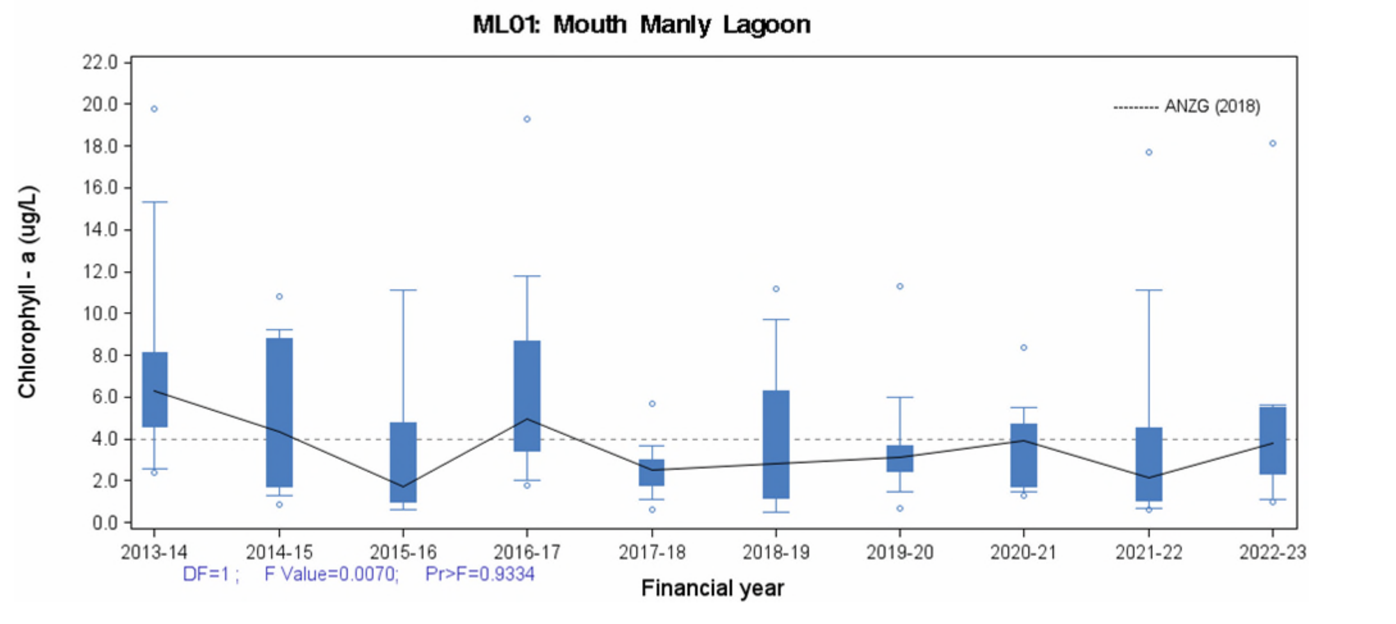

CC01: Curl Curl Lagoon
Conductivity (uS/cm)
55,000
50,000
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=0.0116; Pr>F=0.9140
Financial year

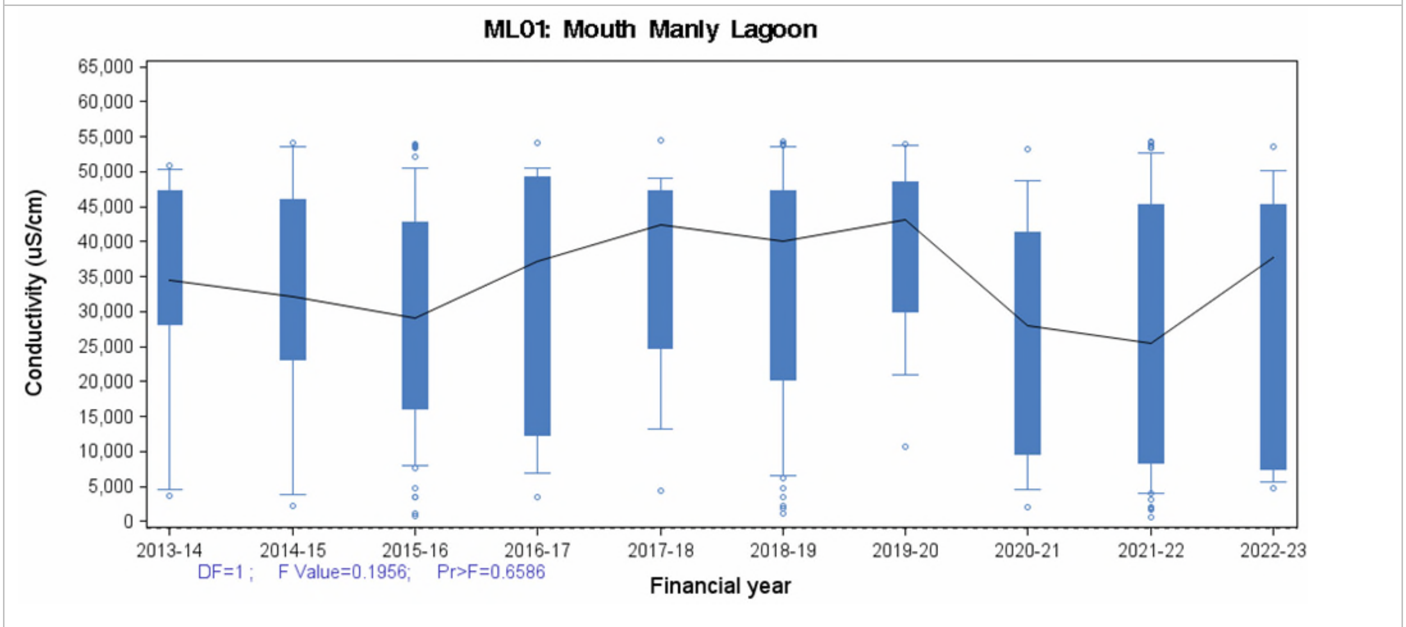

CC01: Curl Curl Lagoon
ANZG (2018) Secondary contact recreation
ANZG (2018) Primary contact recreation
Enterococci (cfu/100mL)
100000
10000
1000
100
10
1
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=0.0125; Pr>F=0.9110
Financial year

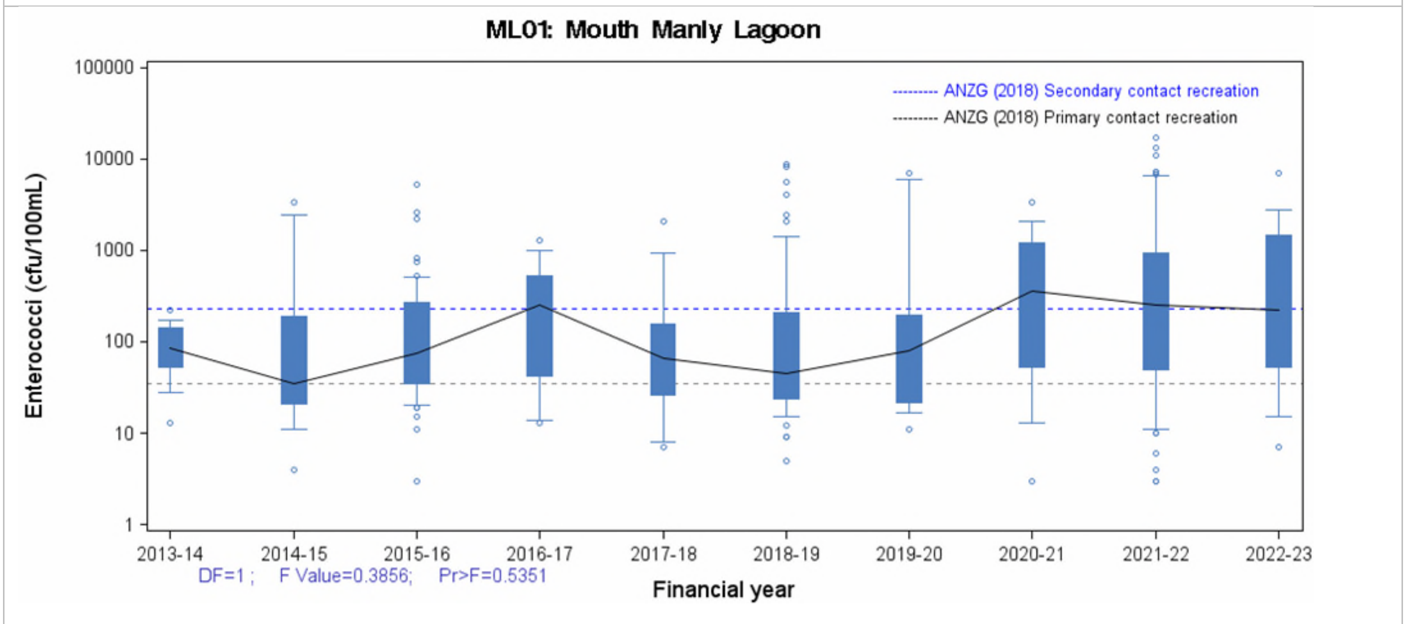

ML03: Upper Manly Lagoon
ANZG (2018)
Chlorophyll - a (ug/L)
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=0.0518; Pr>F=0.8203
Financial year

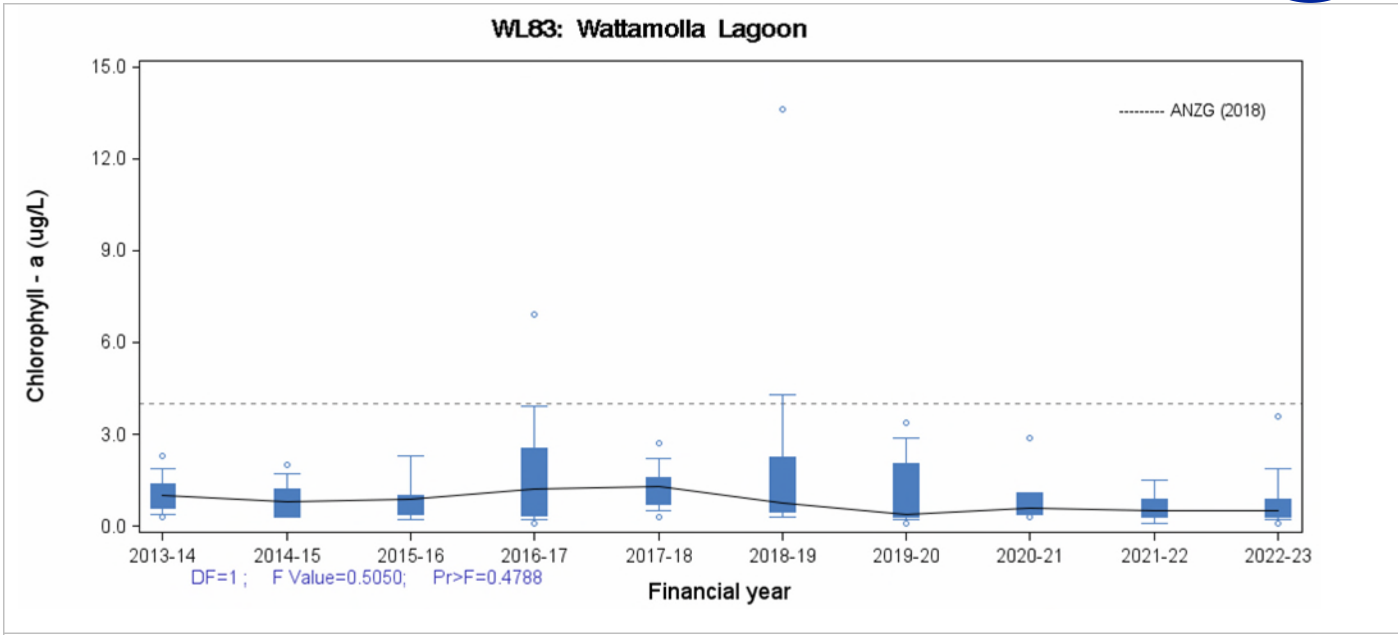

ML03: Upper Manly Lagoon
Conductivity (uS/cm)
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=1.6468; Pr>F=0.2005
Financial year

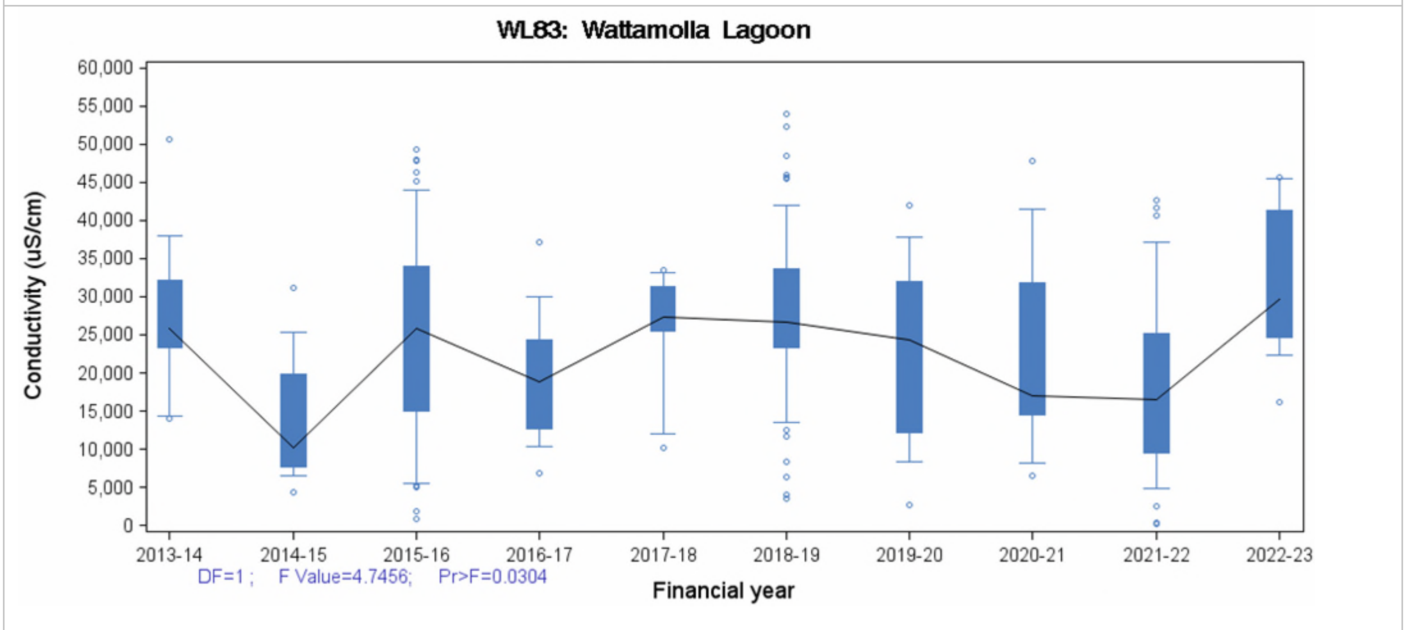

ML03: Upper Manly Lagoon
ANZG (2018) Secondary contact recreation
ANZG (2018) Primary contact recreation
Enterococci (cfu/100mL)
100000
10000
1000
100
10
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=0.0170; Pr>F=0.8961
Financial year

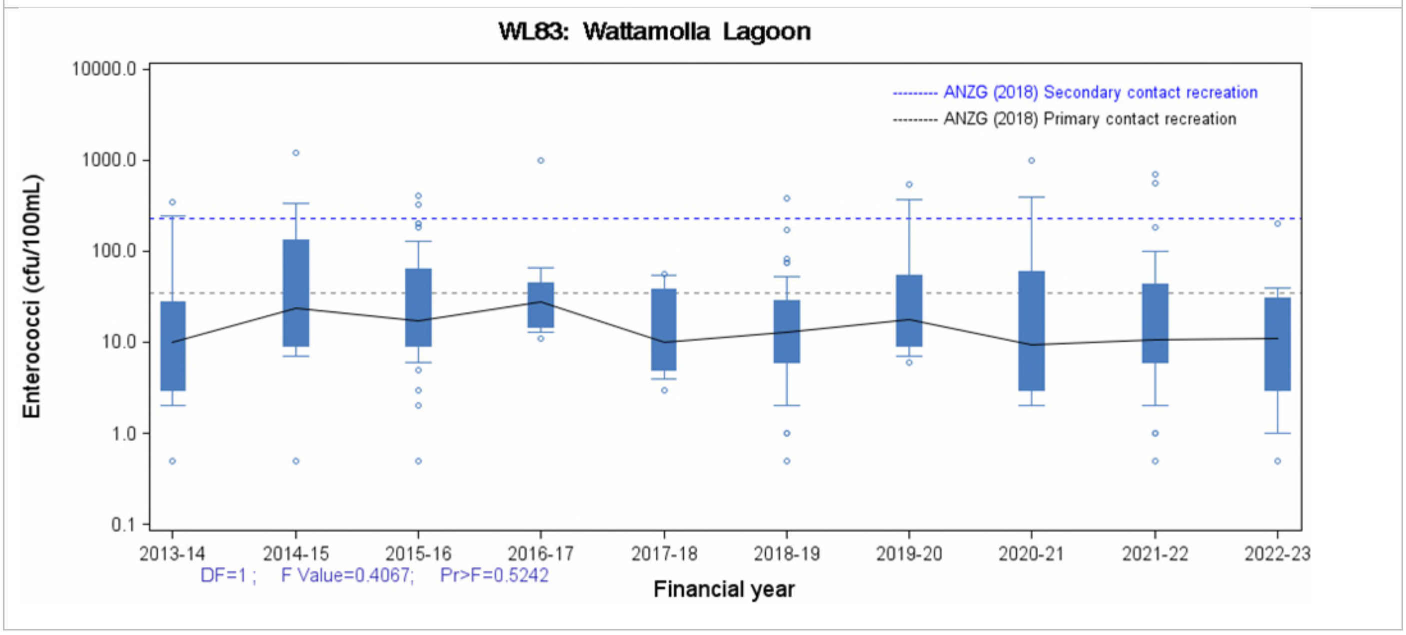

ML01: Mouth Manly Lagoon
Chlorophyll - a (ug/L)
ANZG (2018)
Financial year
DF=1 ; F Value=0.0070; Pr>F=0.9334


ML01: Mouth Manly Lagoon
Conductivity (uS/cm)
Financial year
DF=1 ; F Value=0.1956; Pr>F=0.6586


ML01: Mouth Manly Lagoon
Enterococci (cfu/100mL)
ANZG (2018) Secondary contact recreation
ANZG (2018) Primary contact recreation
Financial year
DF=1 ; F Value=0.3856; Pr>F=0.5351


WL83: Wattamolla Lagoon
ANZG (2018)
Chlorophyll - a (ug/L)
15.0
12.0
9.0
6.0
3.0
0.0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=0.5050; Pr>F=0.4788
Financial year


WL83: Wattamolla Lagoon
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=4.7456; Pr>F=0.0304
Financial year


WL83: Wattamolla Lagoon
ANZG (2018) Secondary contact recreation
ANZG (2018) Primary contact recreation
Enterococci (cfu/100mL)
10000.0
1000.0
100.0
10.0
1.0
0.1
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
DF=1 ; F Value=0.4067; Pr>F=0.5242
Financial year

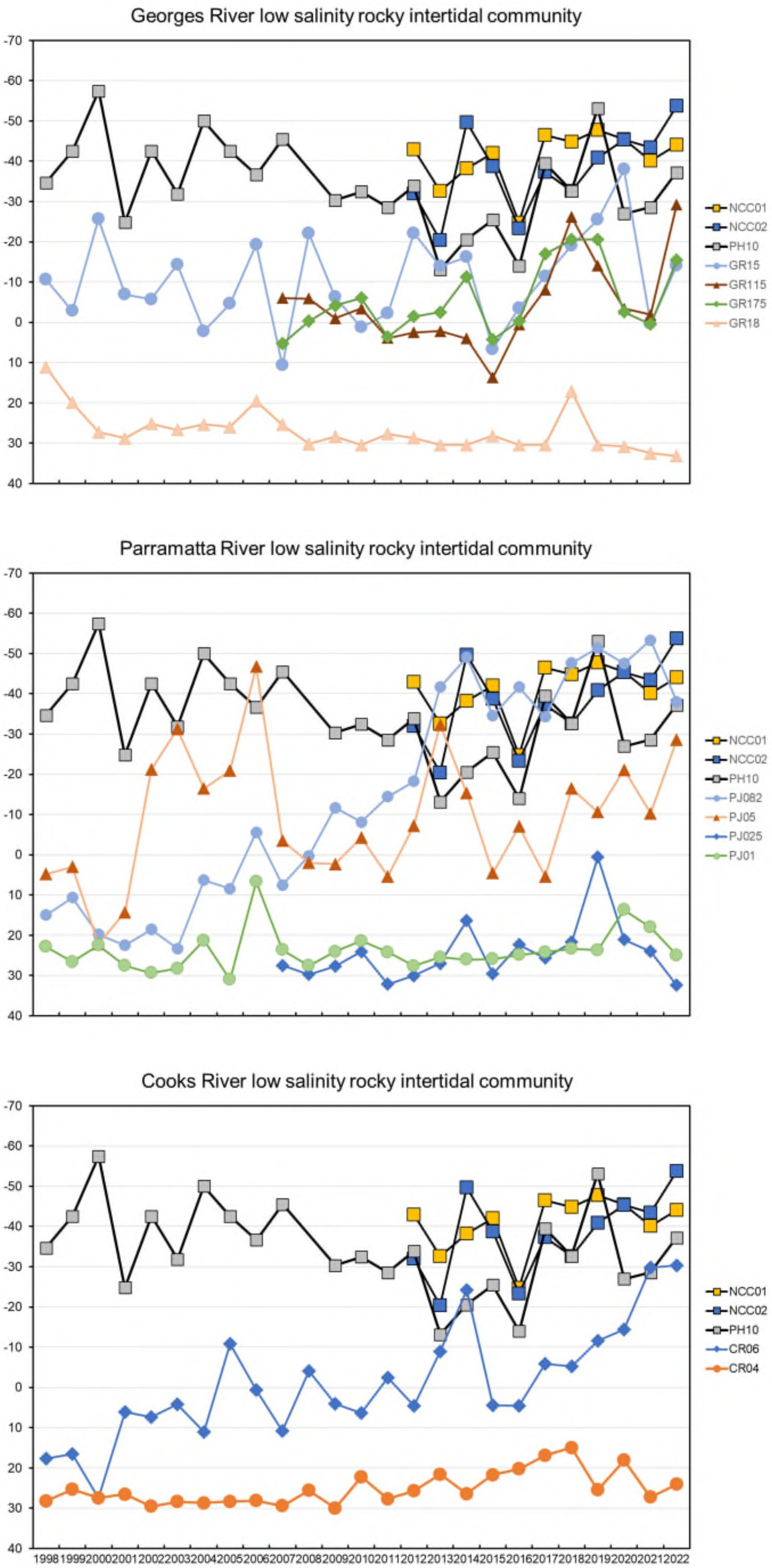
G-3 Intertidal communities – Sydney estuaries

Intertidal rock platform communities

As a check of potential change in community structure of intertidal rock platforms at test sites, a comparison was made between control sites and other sites situated below urban catchments. This check was conducted under Principal Coordinates Analysis (PCO). PCO is an ordination technique that projects point onto axes that minimise the residual variation in the space of a chosen dissimilarity measure (Anderson et al. 2008). The user chooses the number of axes to be included in the output, but usually the first 2 or 3 axes contain most of the percent variation explained. In the analysis presented here, PCO was based on a Bray-Curtis distance measure matrix. The Bray-Curtis resemblance measure is focused on compositional changes in taxa identities (Anderson and Walsh 2013). The choice of this measure is considered appropriate as a change in taxonomic composition was recorded after remediation of the wastewater system (Sydney Water 2012). A separate analysis was conducted for each salinity zone.

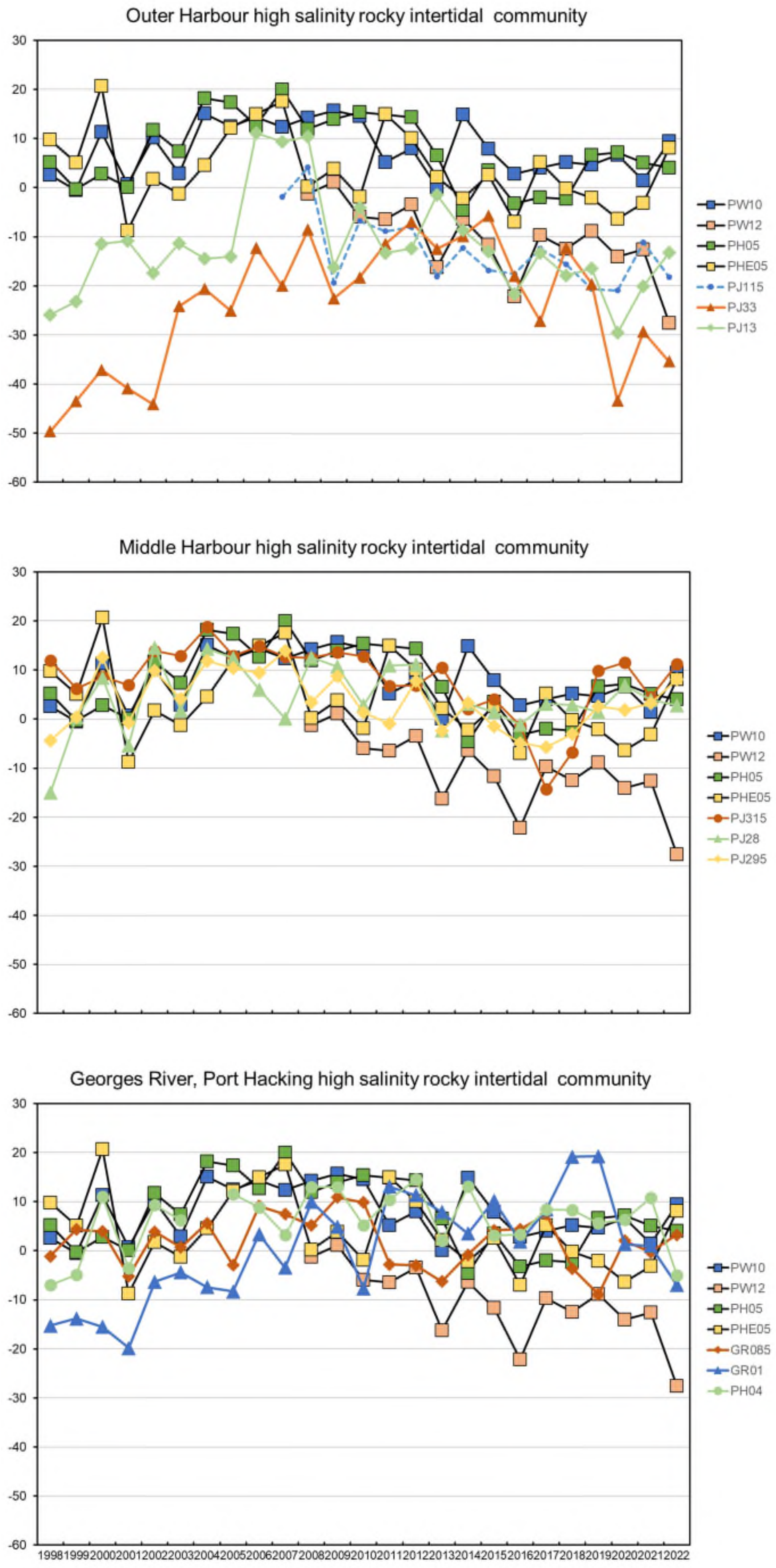
The PCO output allowed control chart style visualisation of centroids in Bray-Curtis space for each site by plotting output for PCO axis 1 against year. This explained about 60% of the variation for the low salinity zone and about 27% of the variation for the high salinity zone. This indicated the low salinity analysis described more variation in data of low salinity sites (81% of variation explained by the first 2 PCO axes) compared with that for the high salinity sites (48% of variation explained by the first 2 PCO axes) (Figure G-1 and Figure G-2) over the 1998 to 2022 period.

Most test sites within the higher salinity zones in 2022 were grouped near or within the range of variation recorded for higher salinity control sites with the exception of a downward trend at Rushcutters Bay (PJ33) that sits below the control site range. However, those in the lower salinity zone were well separated, particularly in the Parramatta River and Cooks River, from the recorded range of variation for the lower salinity control sites with the exception being an improvement in the trend for the Hawthorn Canal arm within Iron Cove (PJ082), Wolli Creek Cooks River (CR06) and at Woolwich Baths Lane Cove River (PJ05). In contrast, test sites within the Georges River (Como Woronora River GR15; Kyle Bay Georges River GR115; Edith Bay Georges River GR175), with the exception of Salt Pan Creek GR18, now sit within or just below the range of control sites. This suggests the 2022 community structure in the lower salinity zone was impaired at four sites of Kissing Point Bay Parramatta River PJ025; Silverwater Bridge Parramatta River PJ01; Salt Pan Creek Georges River GR18; and Alexandra Canal Cooks River CR04.



Black line colour represents control sites: other line colours represent test sites

Figure G-1 Relatively lower salinity zone with year plotted against Principal Coordinates Analysis axis 1 of distance among centroids for sites



Black line colour represents control sites: other line colours represent test sites

Figure G-2 Relatively higher salinity zone with year plotted against Principal Coordinates Analysis axis 1 of distance among centroids for sites

Settlement panels

Settlement panels were used to supplement intertidal rock platform measurements and provide a focus on colonisation of intertidal larvae from the swimming juvenile life stages. Settlement panels were deployed at a number of sites that each included a large muddy intertidal area with mangroves. These areas of the estuaries did not have regular wave activity. The settlement panels consisted of weathered hardwood fence palings (weathered to remove tannins) that were vertically hammered into the mud at an intertidal height just below the lowest growing mangroves, and were left for four months to allow intertidal organisms to settle. After that time, they were removed and measured for the area covered by barnacles. Panels were deployed twice a year, during late spring and late autumn.

Barnacles were the dominant animal that settled and were a mixture of small types like Elminius and Chamaesipho, as well as some larger animals like Balanus. The relatively short deployment time of approximately four months, was inadequate for taxa such as snails (Mollusca) to develop to a sufficient size compared to barnacles that developed in a relatively shorter time where conditions were suitable for barnacle settlement. Previous analysis by Sydney Water (2012) showed reductions in barnacle cover (for example Rushcutters Bay PJ33) following sewer remediation suggesting higher levels of barnacle cover to be a possible indicator of wastewater overflows in wave-sheltered areas of the estuaries around Sydney.

In wave exposed areas of the coast and outer estuaries where there is regular wave occurrence, barnacles naturally grow on hard substrates and are not an indicator of the presence of wastewater. An estimate of barnacle cover was formed by multiplying the average size of barnacles with measured abundance.

Analysis of variance (ANOVA) indicated significant differences between sites situated in relatively higher salinity waters of the outer estuaries of Sydney (df = 8, MS = 1251.103, F = 9.19, p <0.0001). A multiple mean (SNK) comparison indicated two sites being significantly different from the remaining overlapping group of sites (Figure G-3).

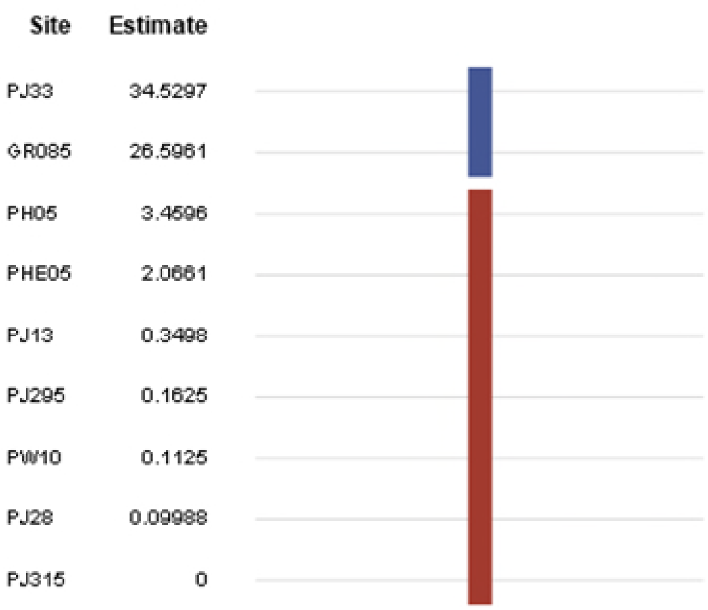


Figure G-3 Multiple mean comparison groupings of relatively high salinity locations for 2022-23 (means covered by the same bar are not significantly different)

ANOVA indicated significant differences between sites situated in relatively lower salinity waters of the inner estuaries of Sydney (df = 11, MS = 6966.293, F = 35.23, p <0.0001). A multiple mean (SNK) comparison test indicated three Georges River sites at Como (GR15), Edith Bay (GR175) and Kyle Bay (GR115) were significantly different from the remaining groups of sites (Figure G-4).

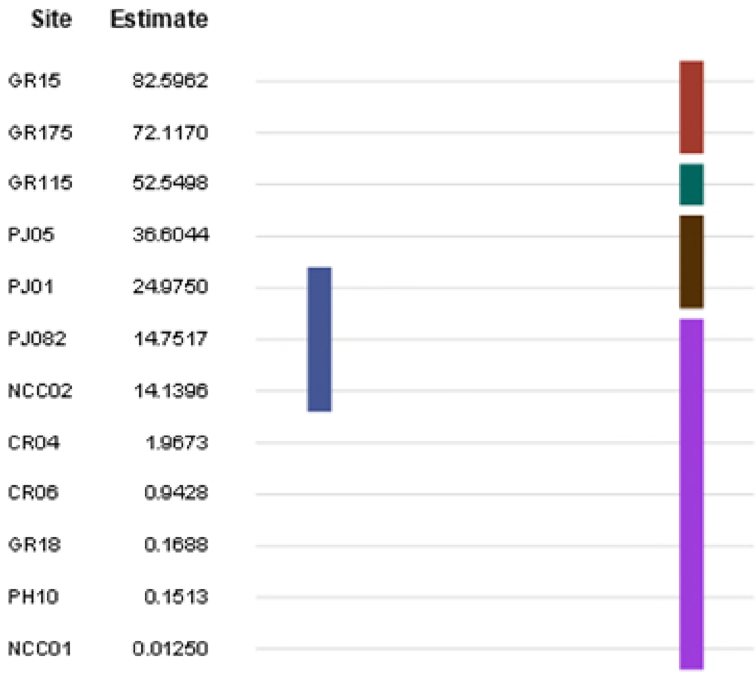


Figure G-4 Multiple mean comparison groupings of relatively lower salinity locations for 2022-23 (means covered by the same bar are not significantly different)

G-4 Recreational water quality – Harbour and beaches

The analysis of the Beachwatch data has been designed to identify potential wastewater overflows or leakage under dry weather conditions. Overflows or leakage reaching the waterways during dry weather conditions pose a risk to public health. The wet weather public health risk for recreational activities in waterways (harbour and beaches) are well known.

Assumptions behind the data for Beachwatch analysis:

- *Enterococci* results without a respective conductivity value were excluded. Conductivity results for various sites were not available mainly due to instrument failures at the time of collecting samples. Conductivity data is required to separate dry weather data from wet weather data.
- Only dry weather results were included in these plots. *Enterococci* results associated with conductivity below 30,000 µS/cm were considered wet weather and not included in these plots.
- Data labels: Maximum *Enterococci* values for each financial year were labelled where *Enterococci* values ≥ 230 cfu/100mL, which is the secondary contact recreation guideline (ANZECC 2000).

The Beachwatch results are presented in the following order similar to monitoring programs and sub-catchments as stated in the method section of Volume 1:

Sydney Beaches

- Northern Sydney
- Central Sydney
- Southern Sydney

Illawarra Beaches

- Wollongong
- Shellharbour
- Bombo

Harbours

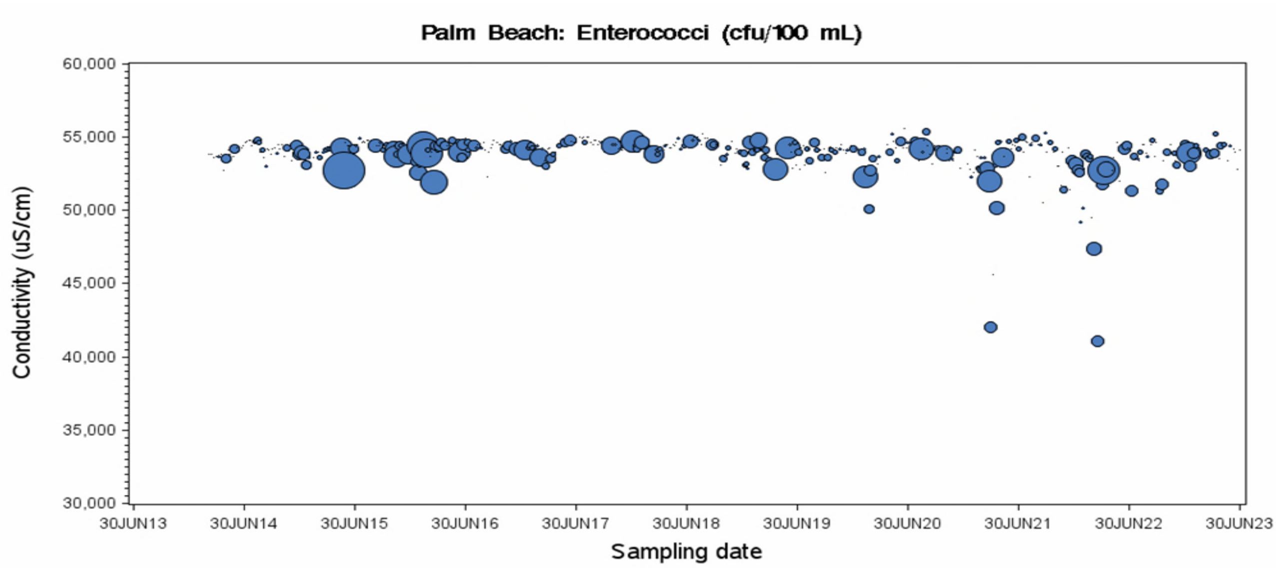
- Botany Bay and Georges River
- Port Hackings
- Port Jackson
- Middle Harbour
- Pittwater

The sites under each sub-catchment are presented in the order from north coast to south coast. When the sub-catchment is a harbour with sites on both coasts then sites on south coasts were stated first and then following clockwise direction to the north coast.

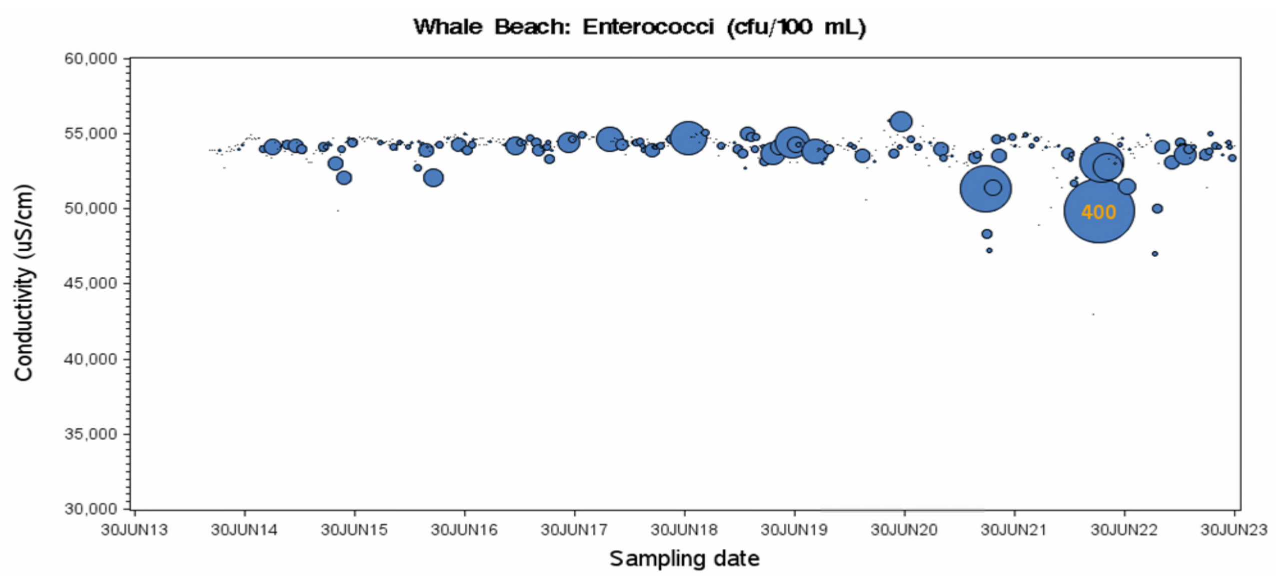
Note: The size of the bubble can't be compared between plots precisely due to software limitations. The bubble size for each site varied based on maximum value for that site using the following ranges, which helped in adjusting the size of bubble for comparison between plots.

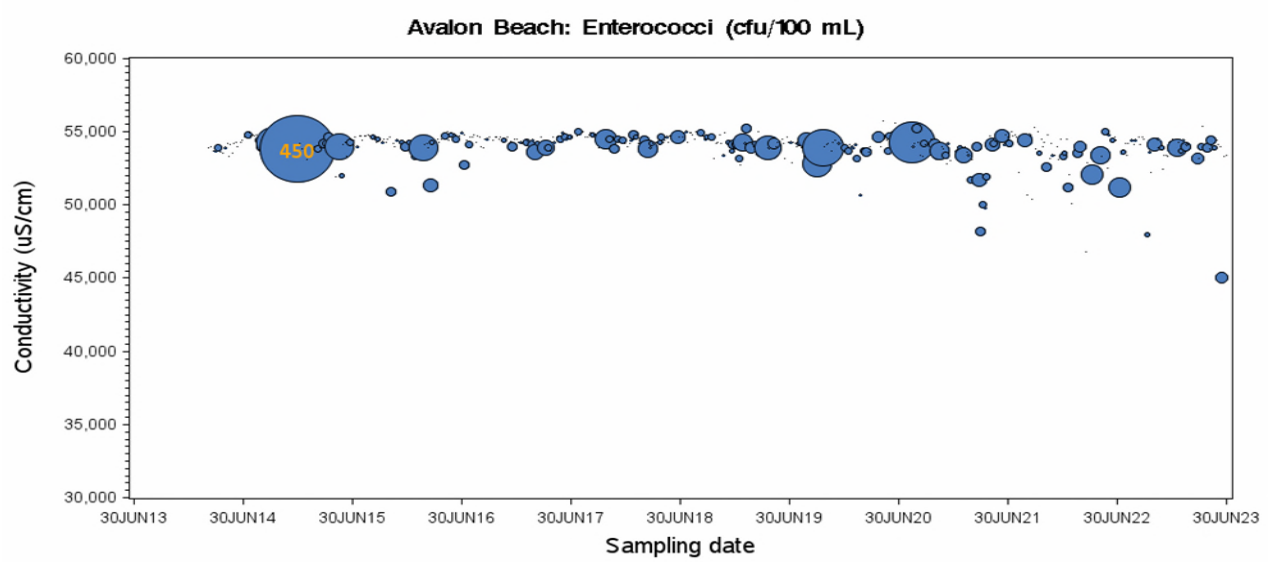
Bubble size	Range of maximum *Enterococci* value (cfu/100mL)
9	<35
10	35 to 230
11	231 to 499
12	500 to 999
13	1000 to 4999
14	5000 to 9999
15	10000 or more

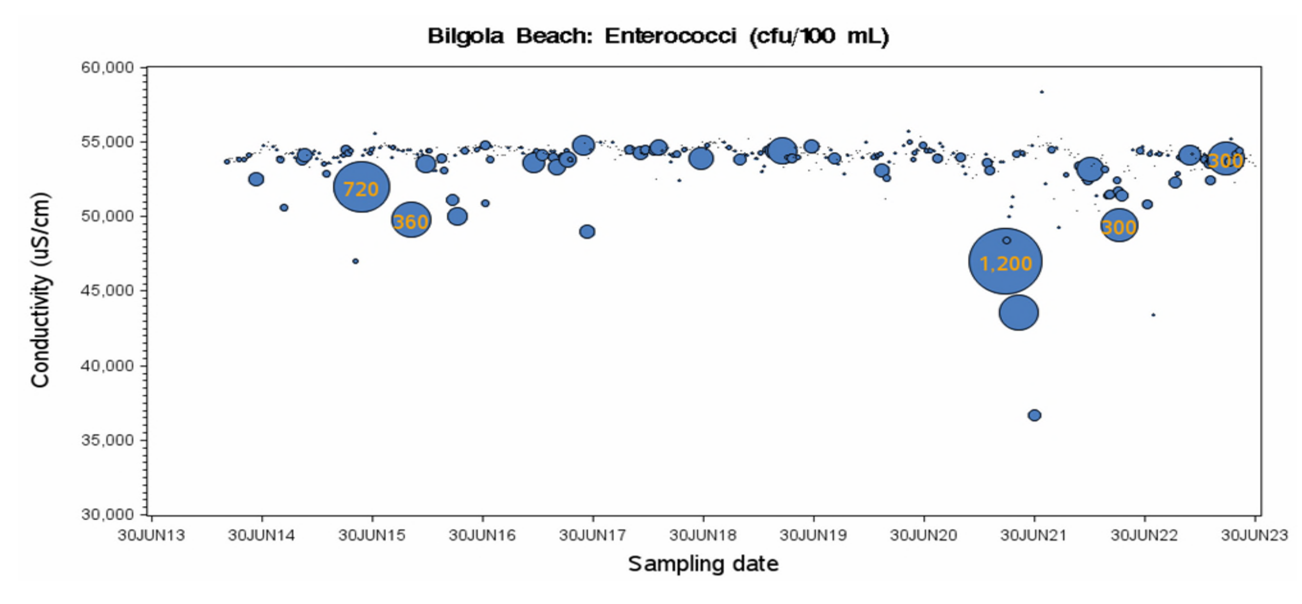
Sydney Beaches: Northern Sydney

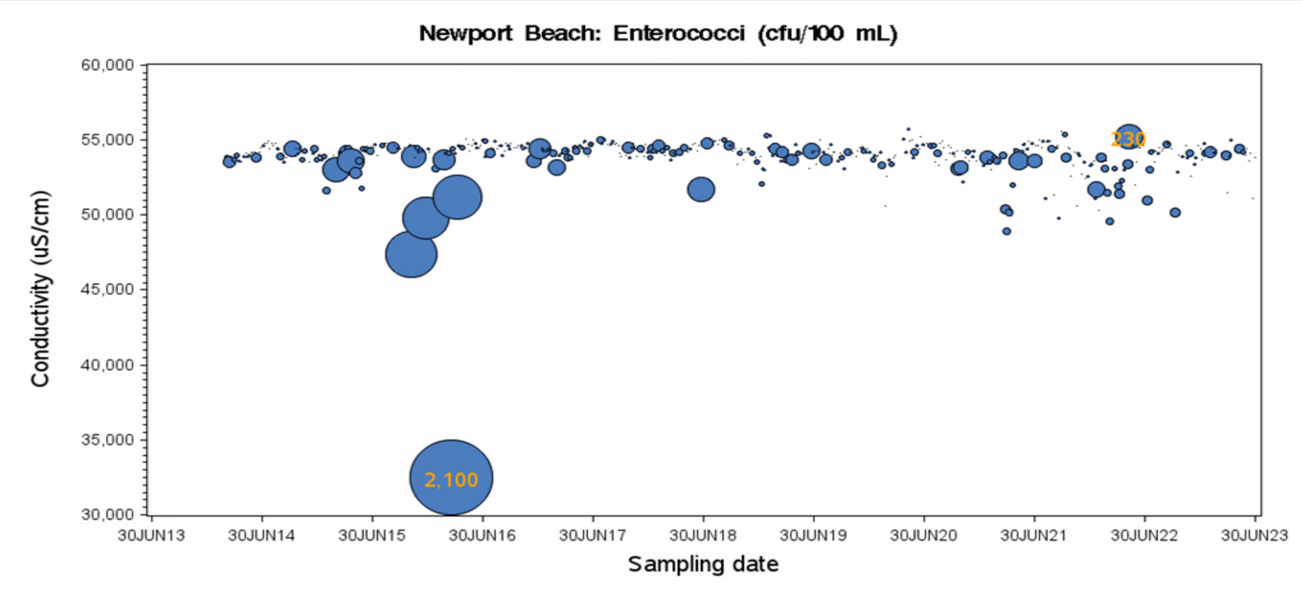


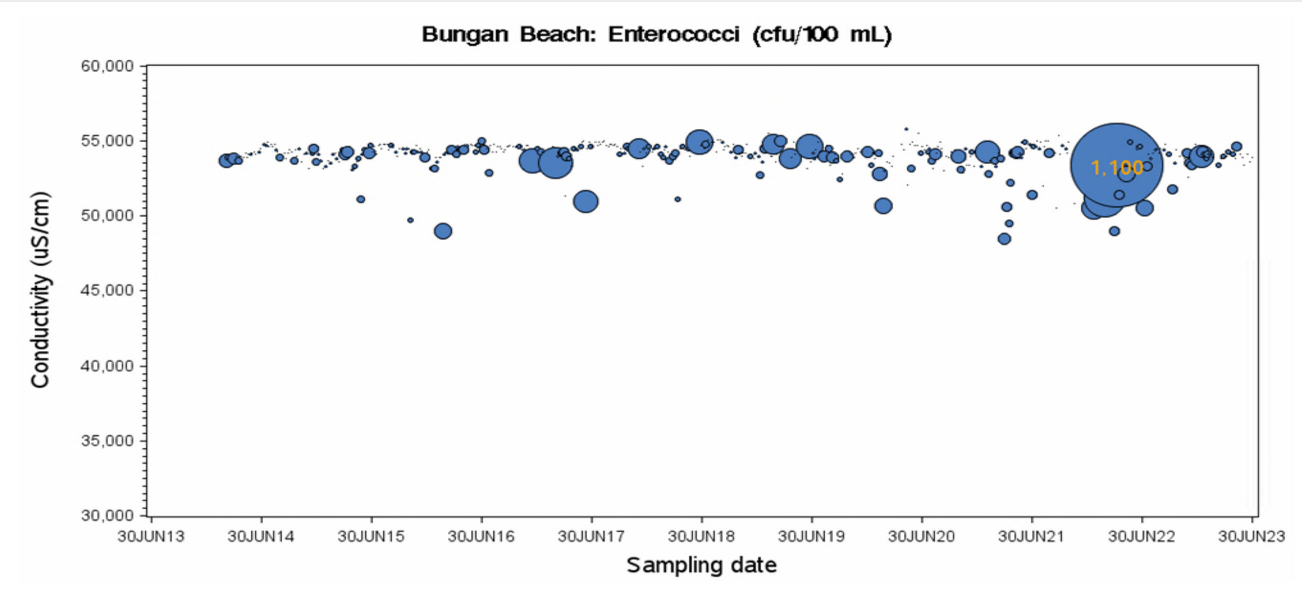
No *Enterococci* values ≥ 230 cfu/100mL for last ten years.

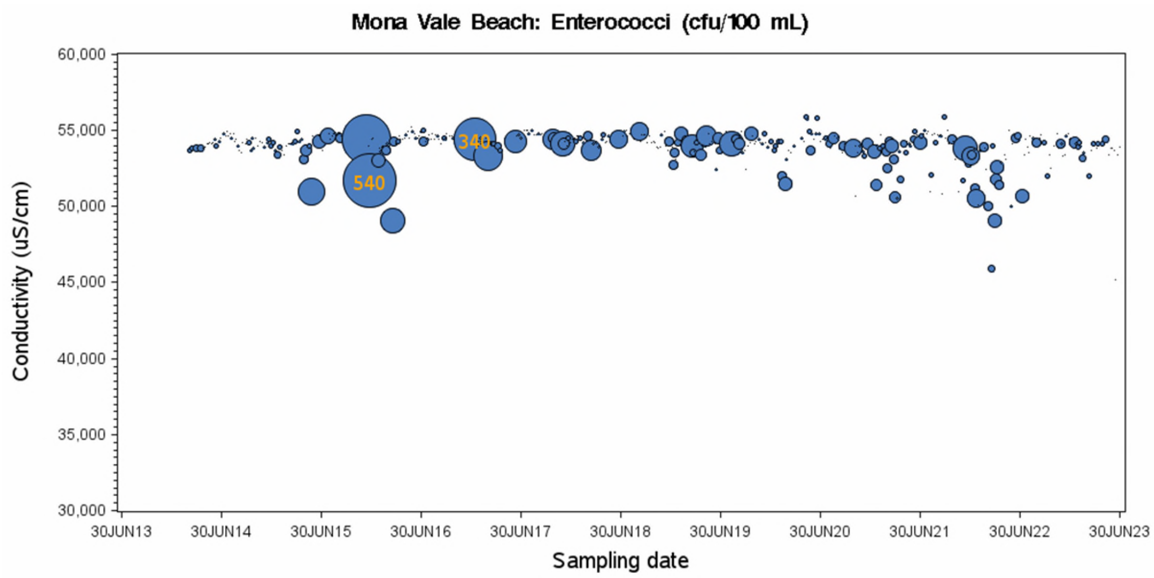


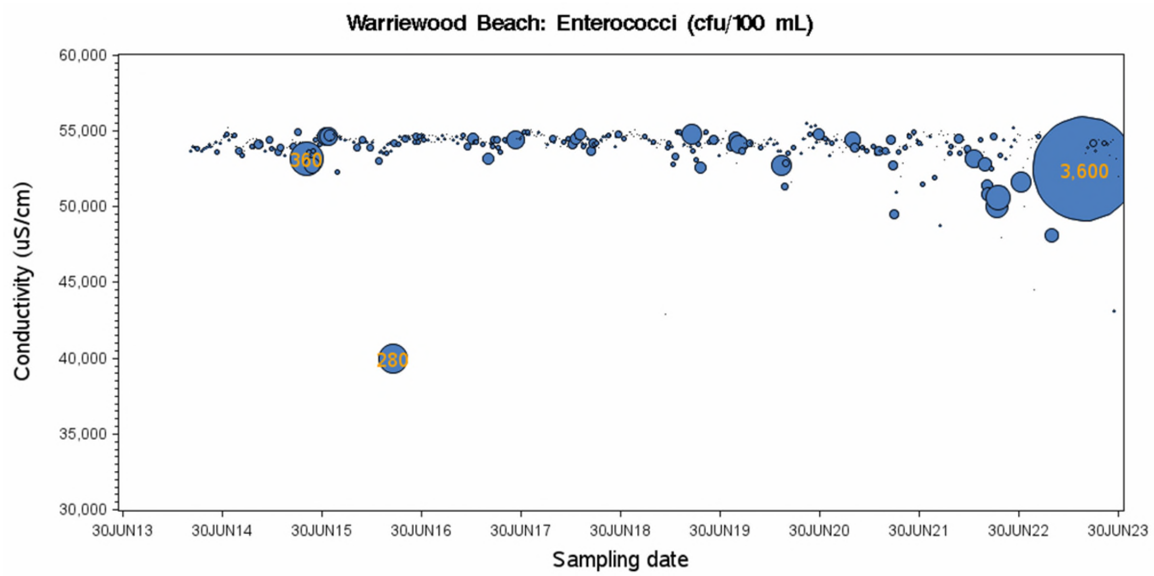


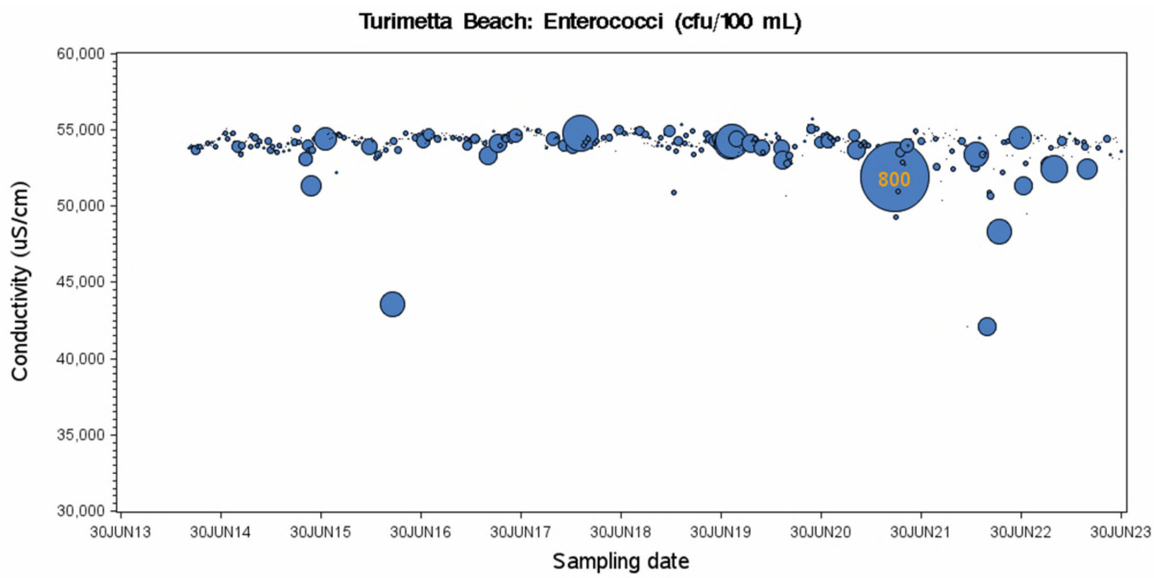

Bilgola Beach: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date
720
360
1,200
300
300

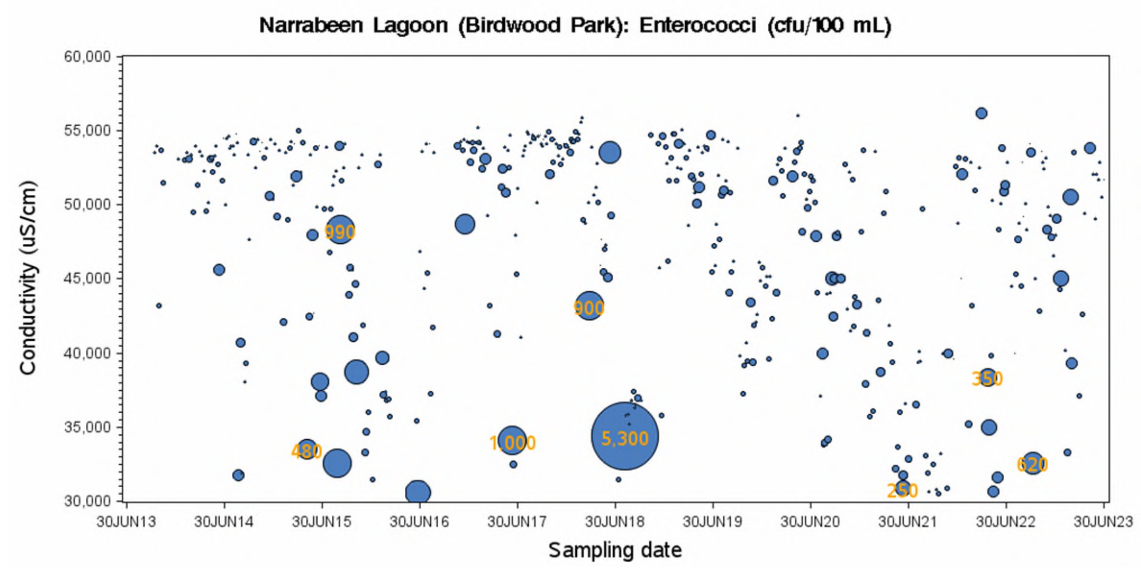

Newport Beach: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date
2,100
230

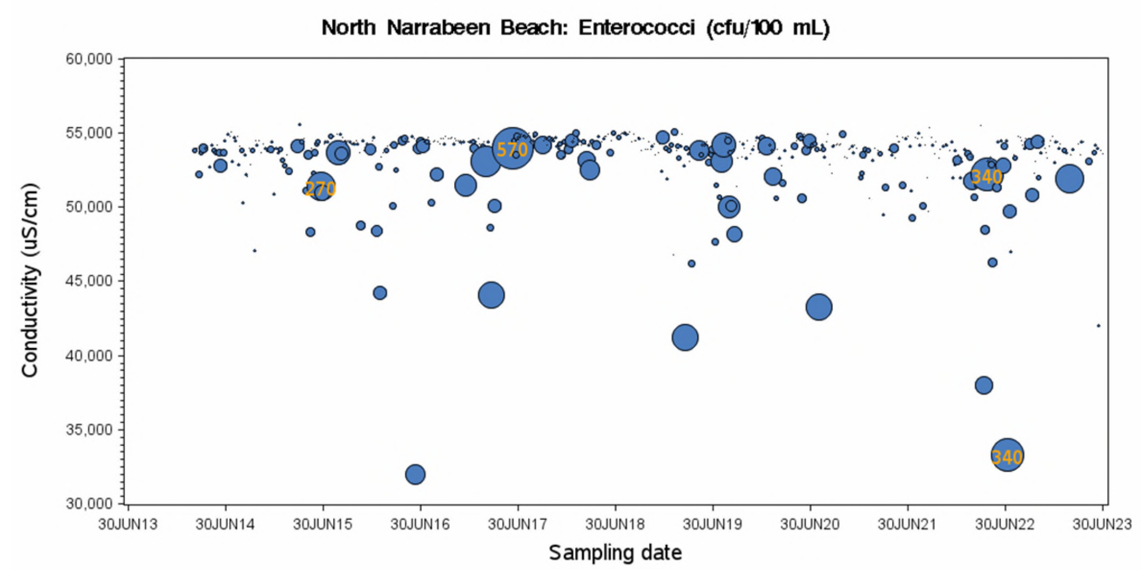

Bungan Beach: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date
1,100

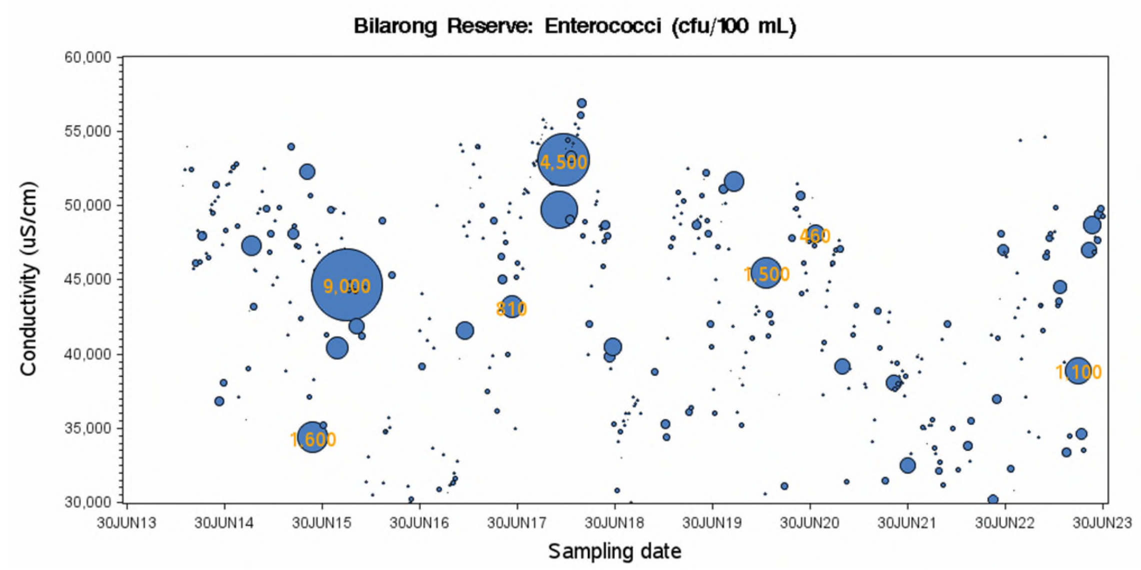

Mona Vale Beach: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
340
540
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date

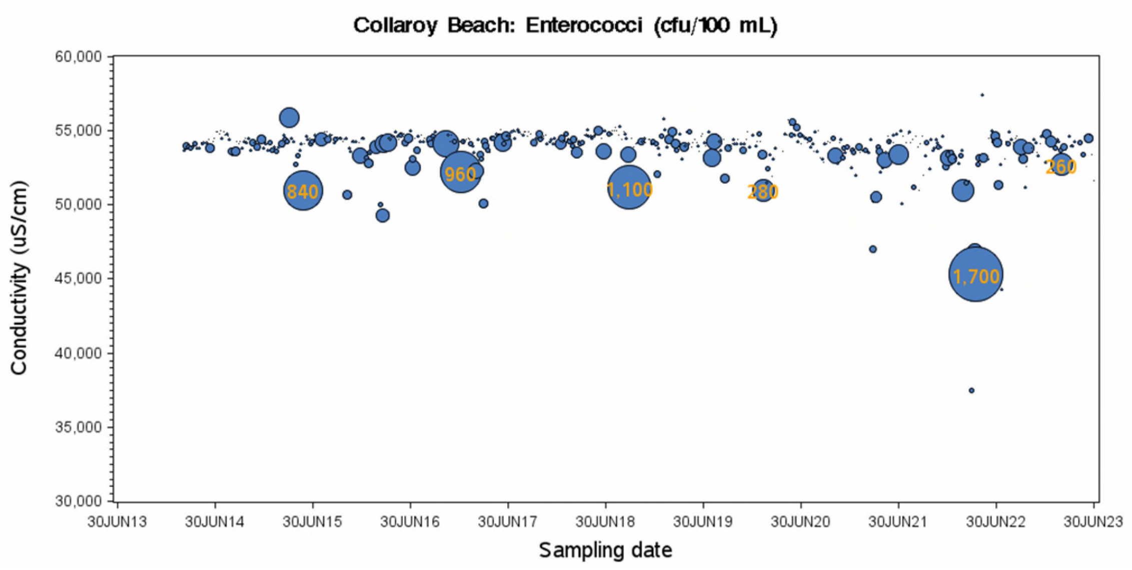

Warriewood Beach: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
360
280
3,600
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date

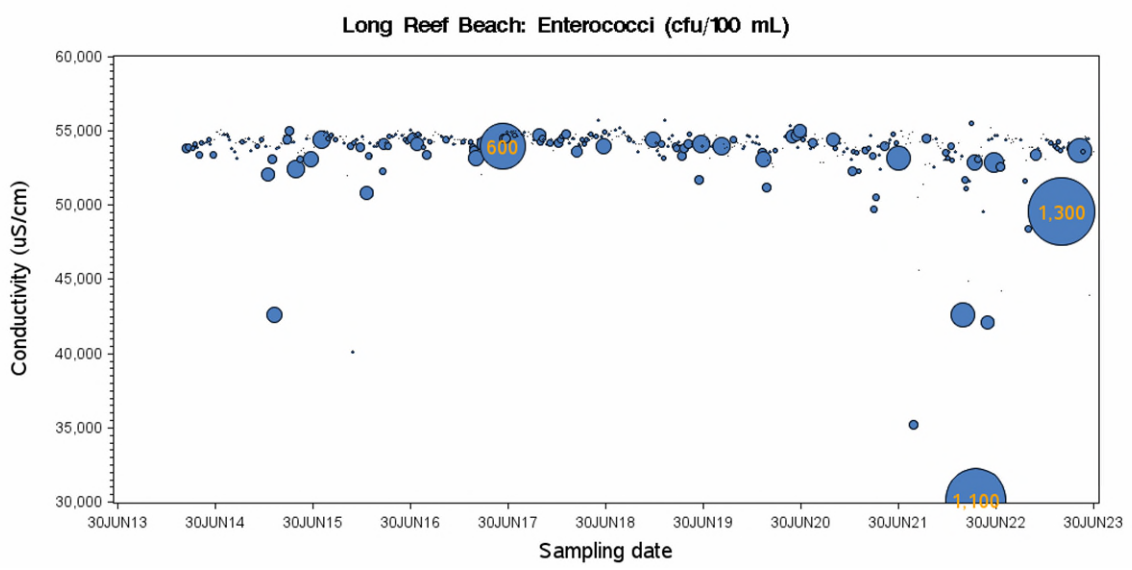

Turimetta Beach: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
800
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date

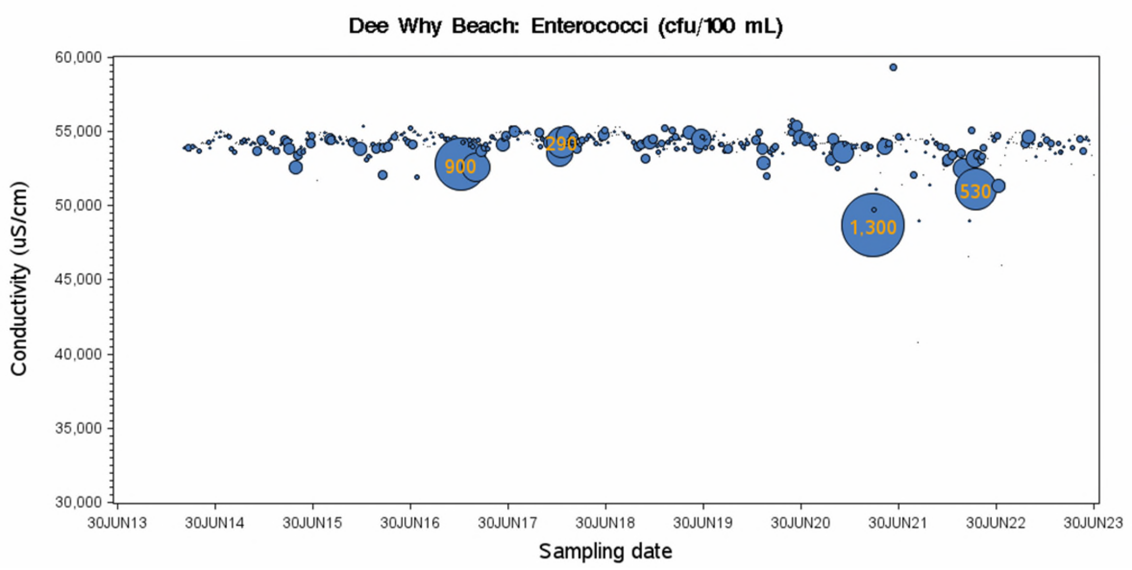

Narrabeen Lagoon (Birdwood Park): Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
990
900
350
480
1,000
5,300
620
250
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date

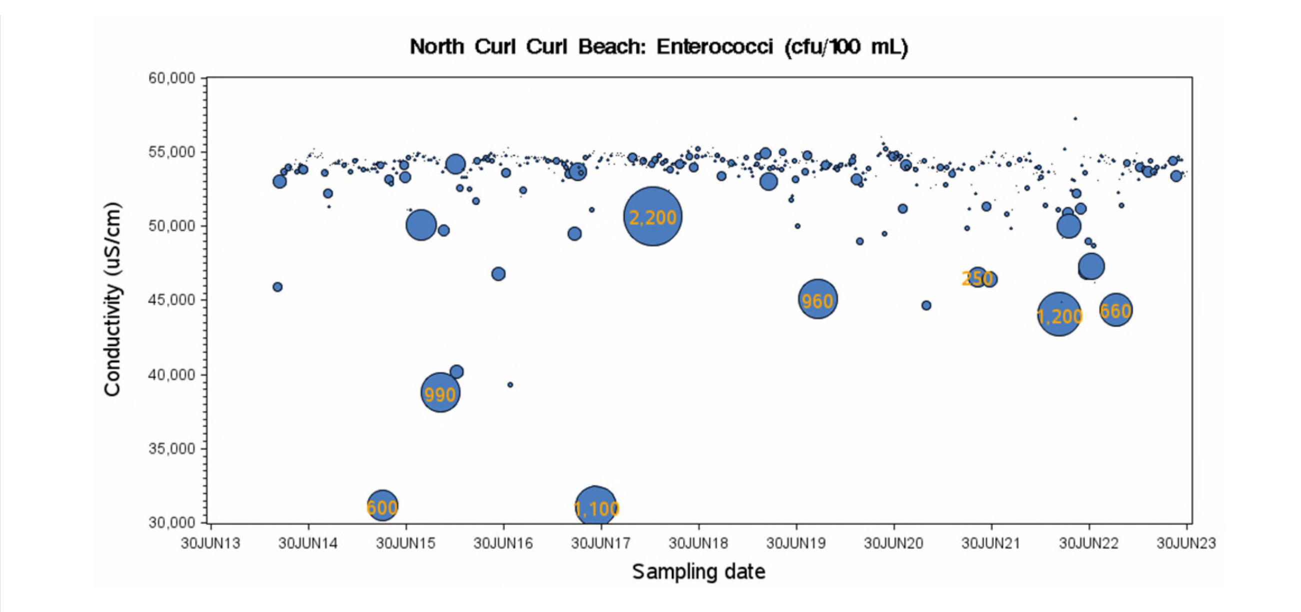

North Narrabeen Beach: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
570
270
340
340
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date

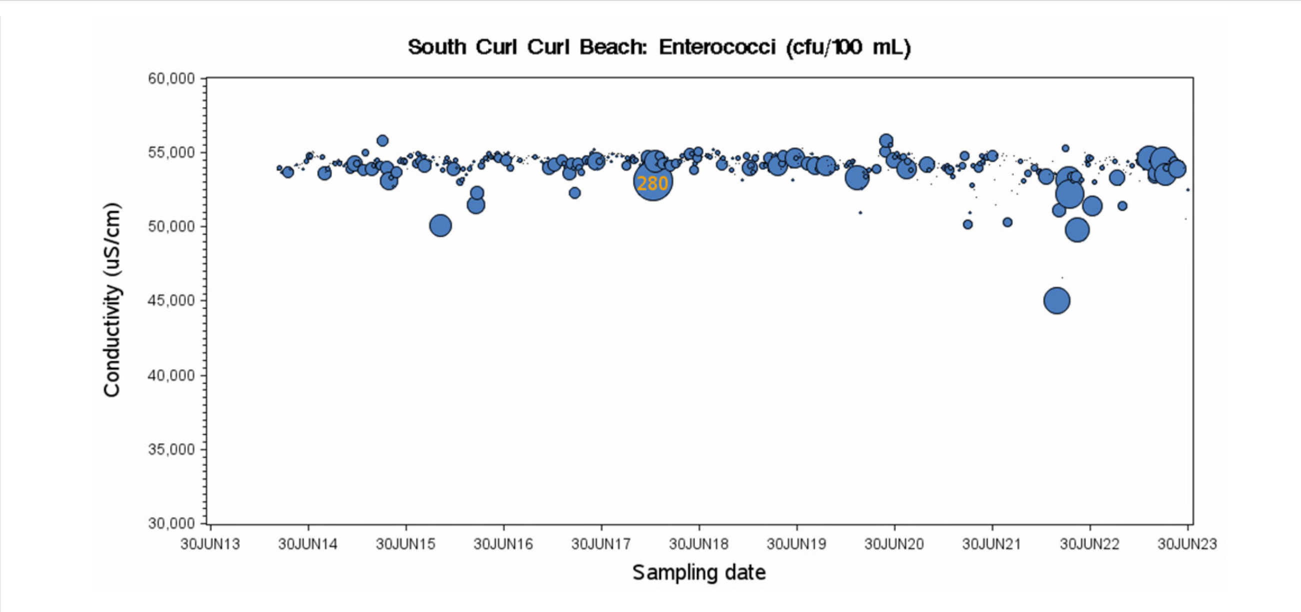

Bilarong Reserve: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
4,500
480
9,000
1,500
810
1,100
1,600
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date

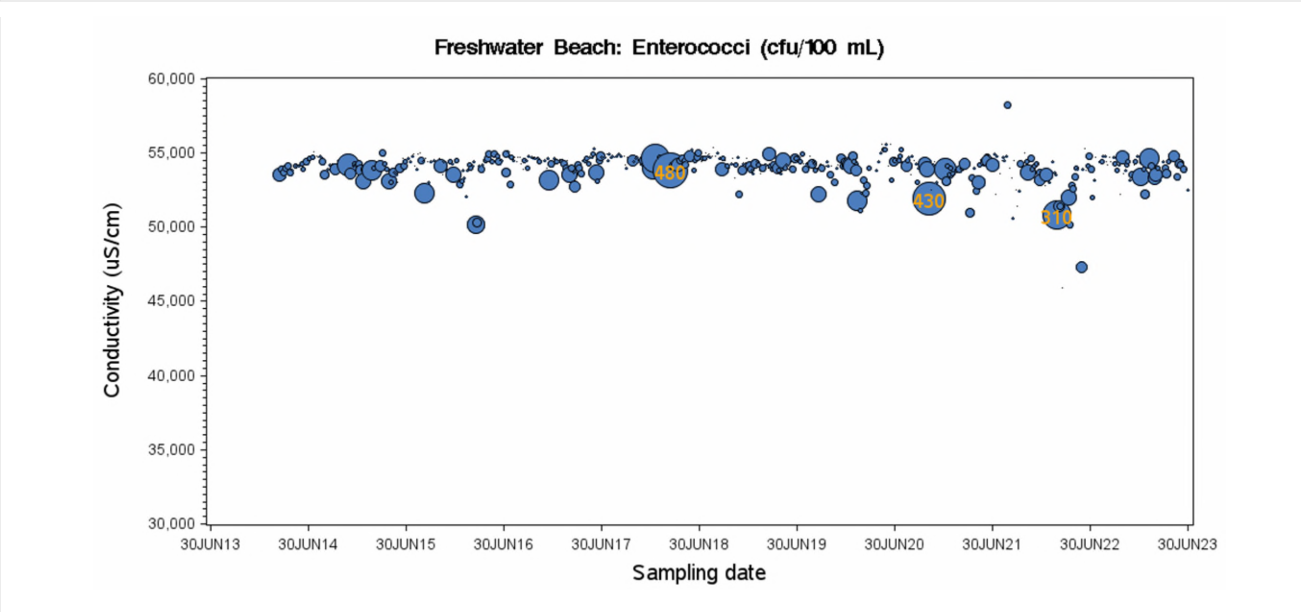

Collaroy Beach: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
Sampling date
60,000
55,000
50,000
45,000
40,000
35,000
30,000
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
840
960
1,100
280
1,700
260

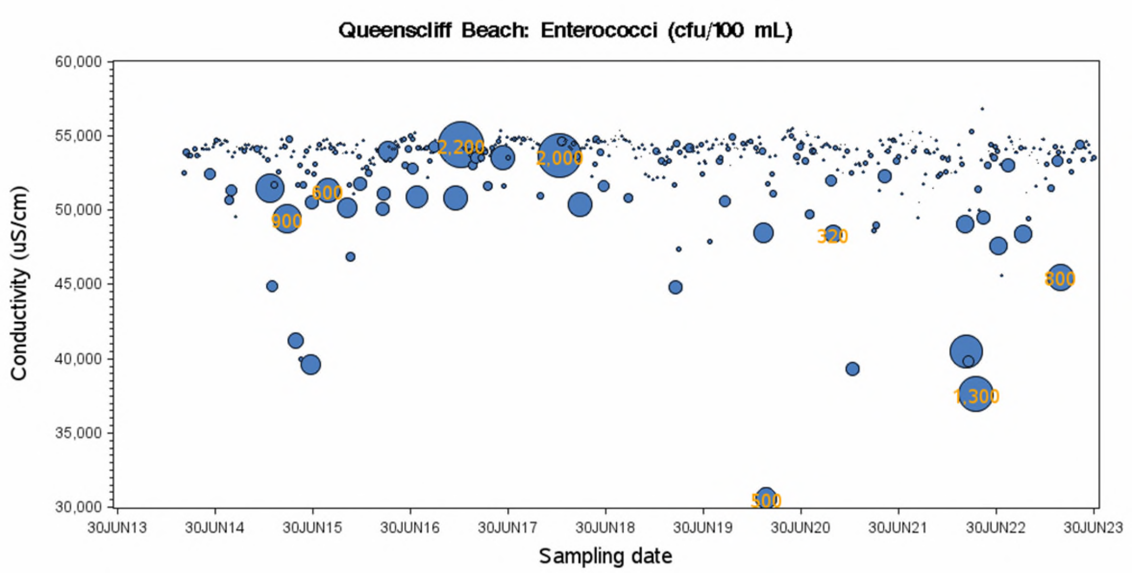

Long Reef Beach: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
Sampling date
60,000
55,000
50,000
45,000
40,000
35,000
30,000
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
600
1,300
1,100

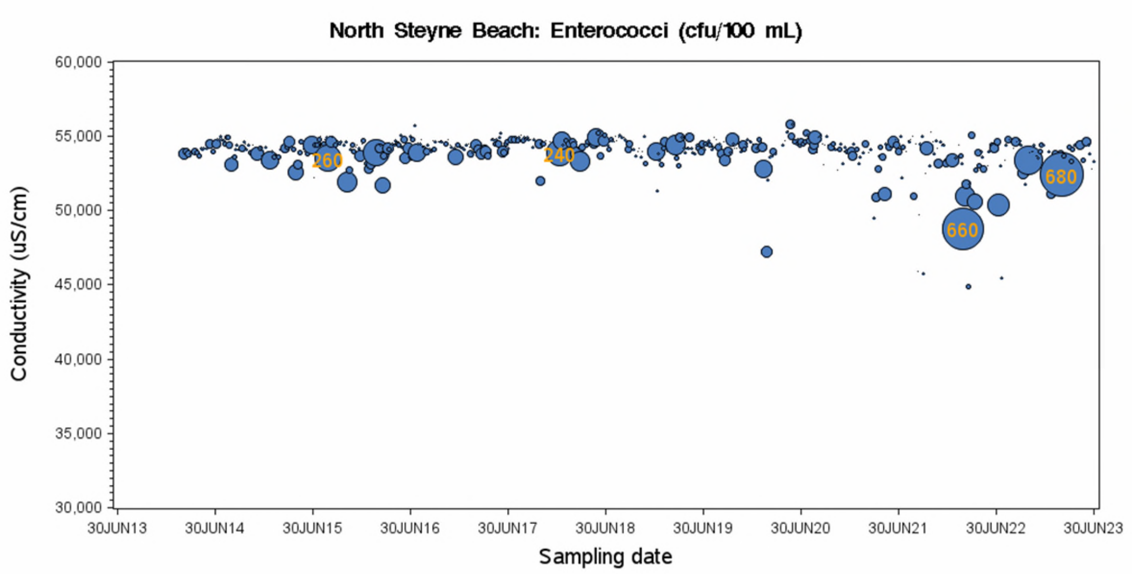

Dee Why Beach: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
Sampling date
60,000
55,000
50,000
45,000
40,000
35,000
30,000
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
900
290
530
1,300

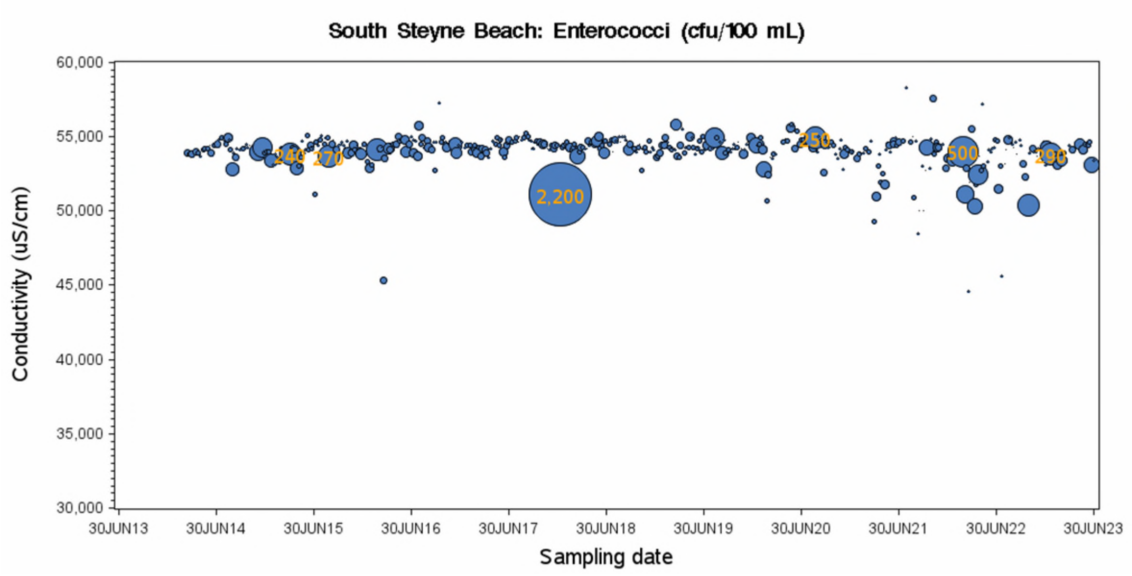

North Curl Curl Beach: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
2,200
990
960
250
1,200
660
600
1,100
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date


South Curl Curl Beach: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
280
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date


Freshwater Beach: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
480
430
310
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date


Queenscliff Beach: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
Sampling date
60,000
55,000
50,000
45,000
40,000
35,000
30,000
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
2,200
2,000
600
900
320
800
1,300
500


North Steyne Beach: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
Sampling date
60,000
55,000
50,000
45,000
40,000
35,000
30,000
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
260
240
680
660


South Steyne Beach: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
Sampling date
60,000
55,000
50,000
45,000
40,000
35,000
30,000
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
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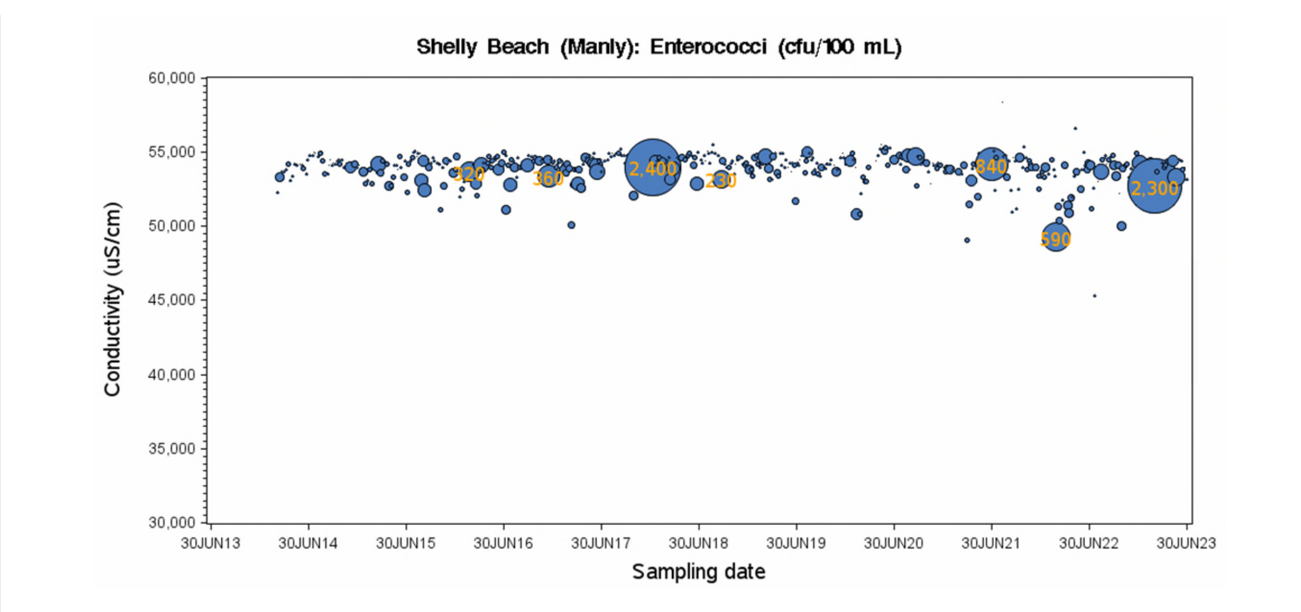
30JUN23
240
270
2,200
250
500
290


Shelly Beach (Manly): Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
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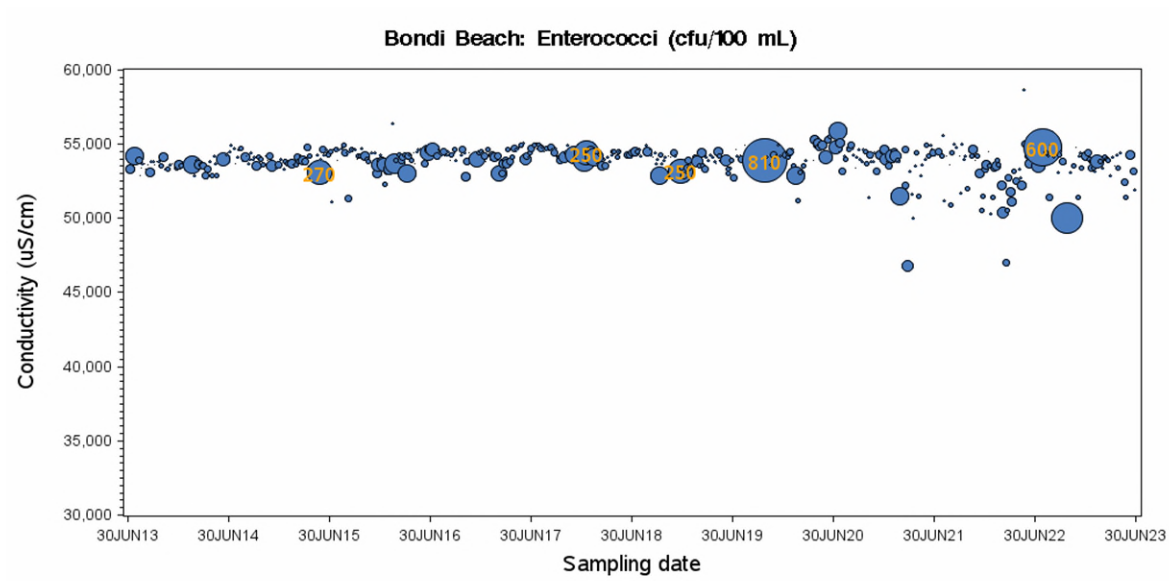
30JUN21
30JUN22
30JUN23
Sampling date
320
360
2,400
230
840
590
2,300


Bondi Beach: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
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30JUN20
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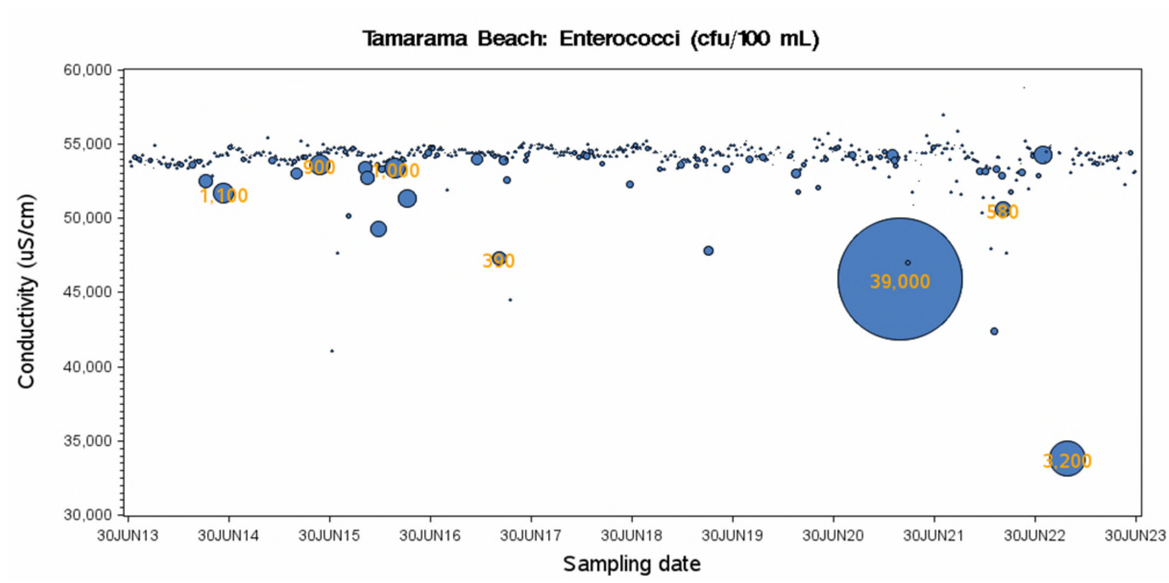
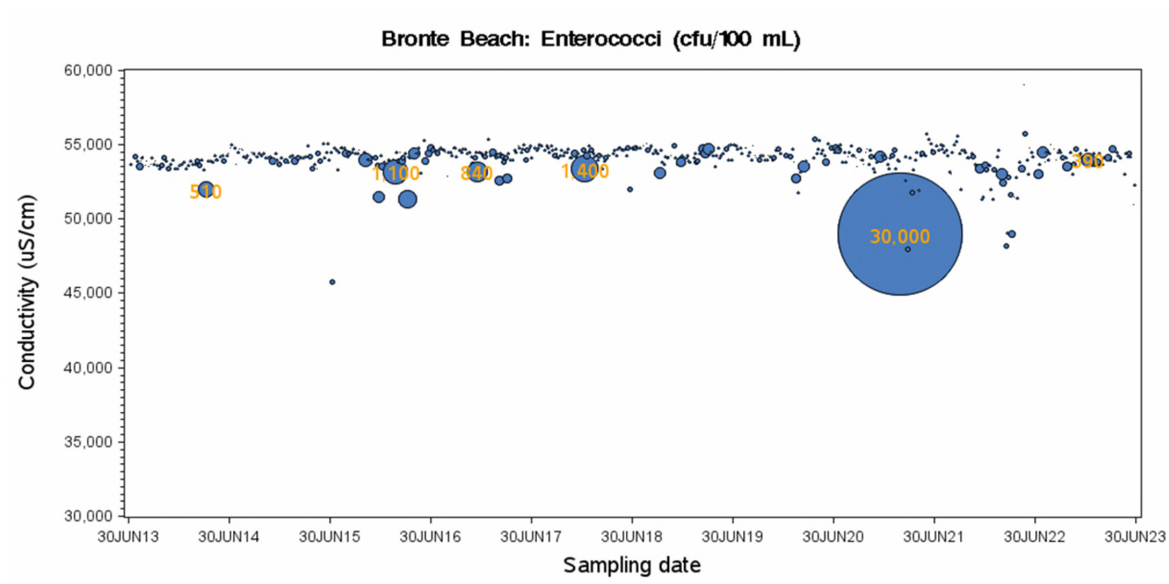
30JUN22
30JUN23
Sampling date
270
250
250
810
600


Tamarama Beach: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date
1,100
900
1,000
39,000
580
3,200


Bronte Beach: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
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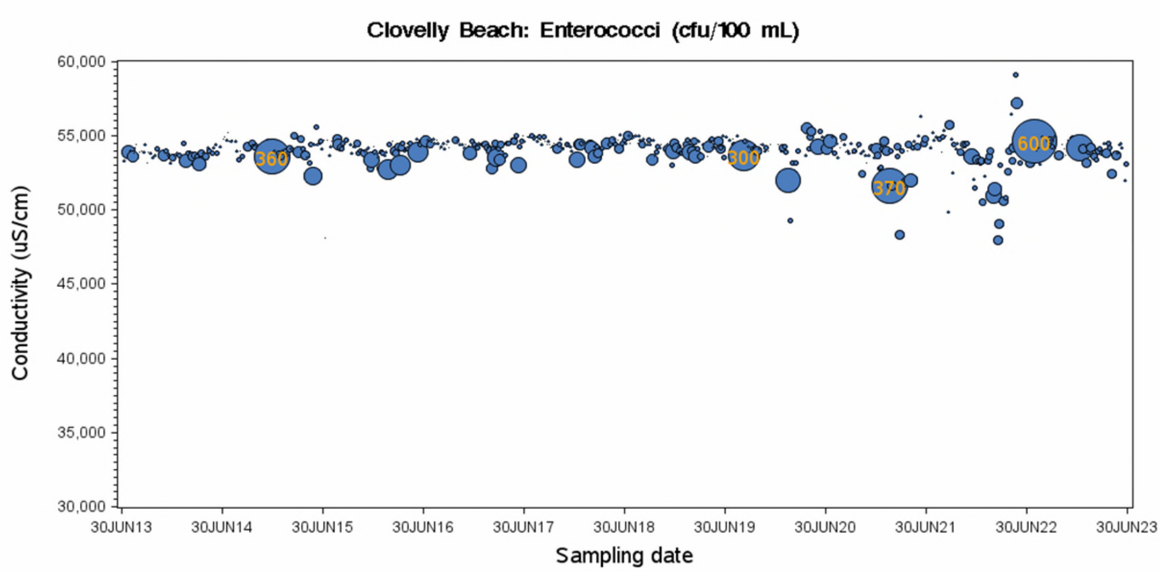
30JUN23
Sampling date
510
1,100
840
1,400
30,000


Clovelly Beach: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
Sampling date
60,000
55,000
50,000
45,000
40,000
35,000
30,000
30JUN13
30JUN14
30JUN15
30JUN16
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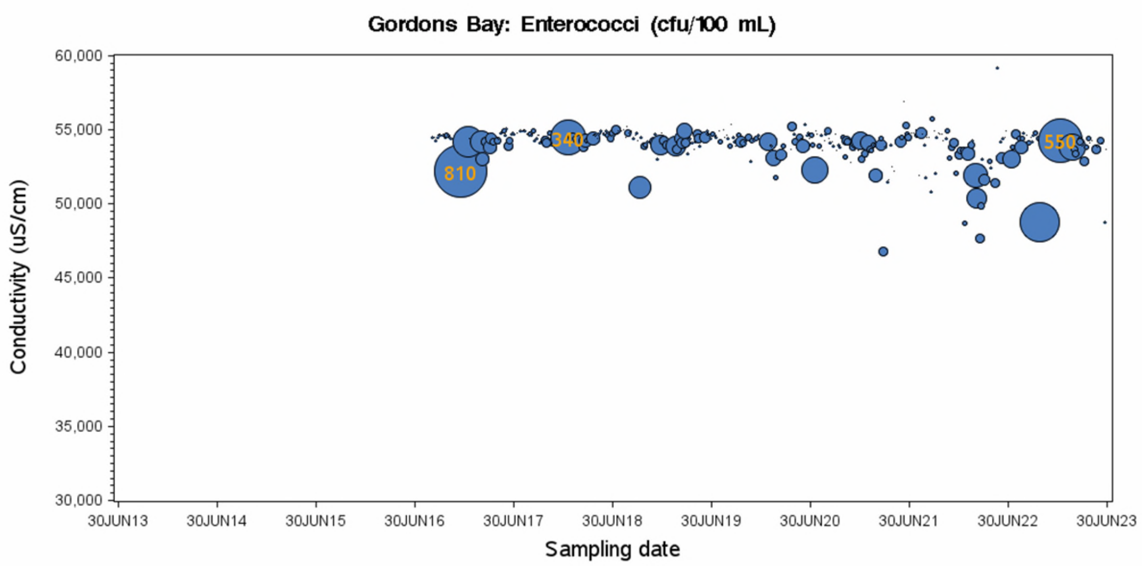
30JUN22
30JUN23
360
300
370
600


Gordons Bay: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
Sampling date
60,000
55,000
50,000
45,000
40,000
35,000
30,000
30JUN13
30JUN14
30JUN15
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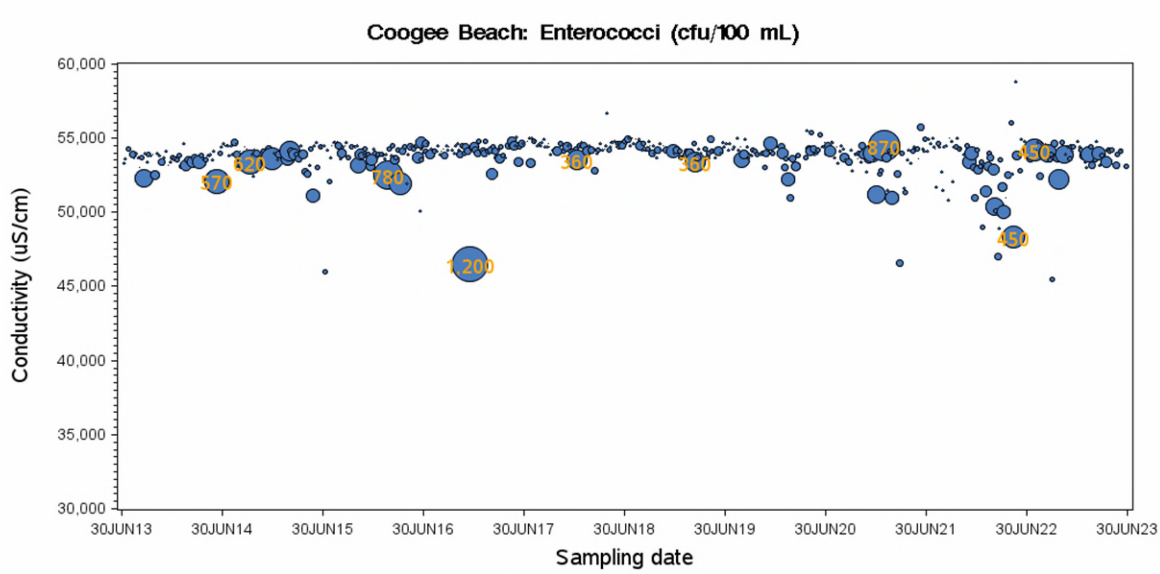
30JUN22
30JUN23
810
340
550


Coogee Beach: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
Sampling date
60,000
55,000
50,000
45,000
40,000
35,000
30,000
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
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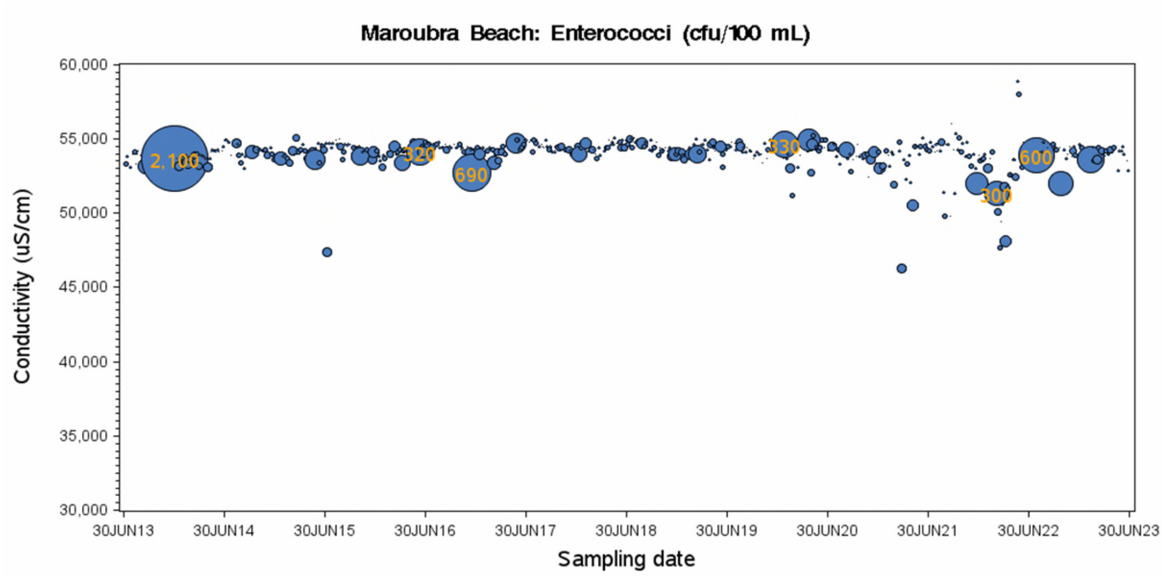
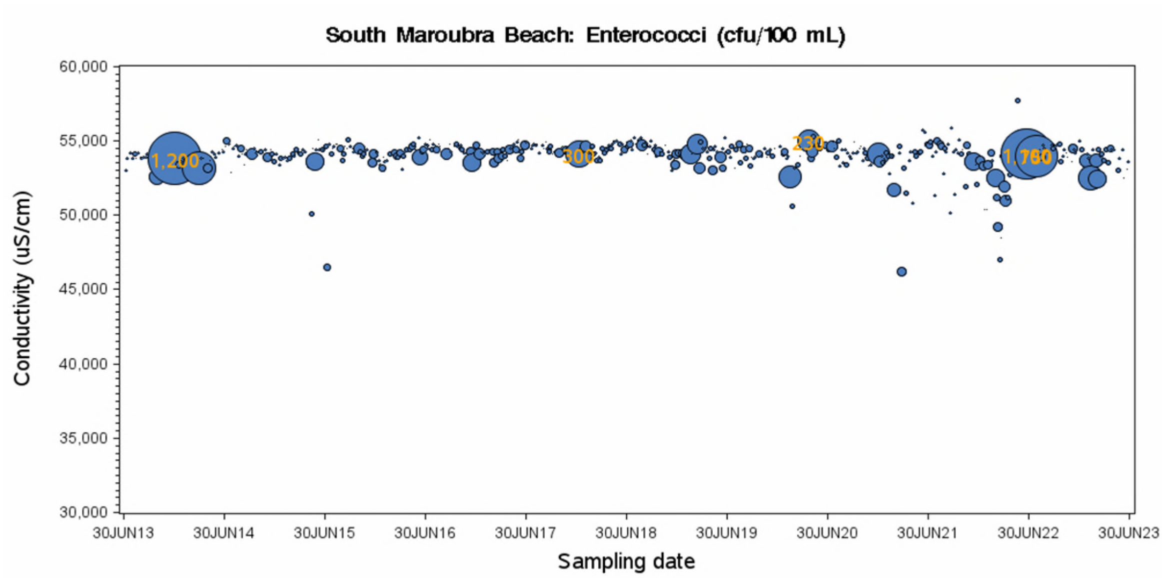
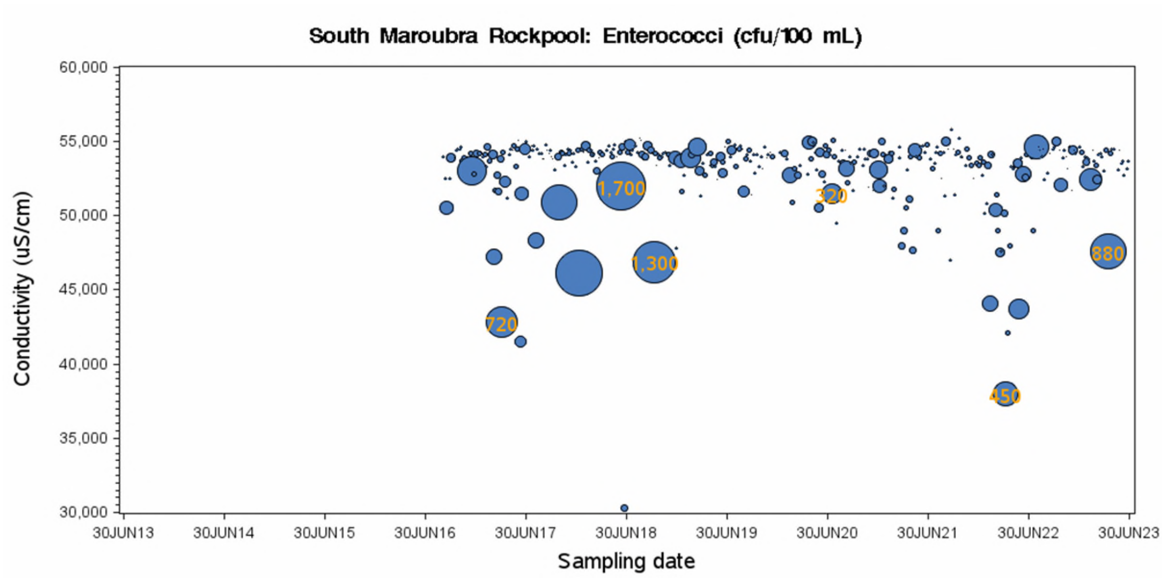
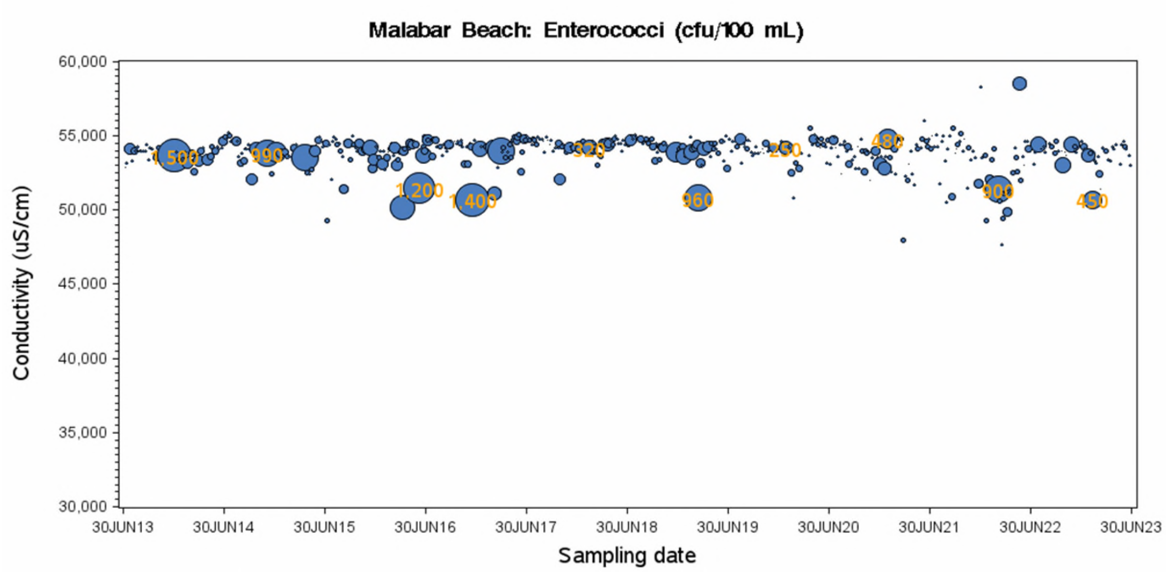
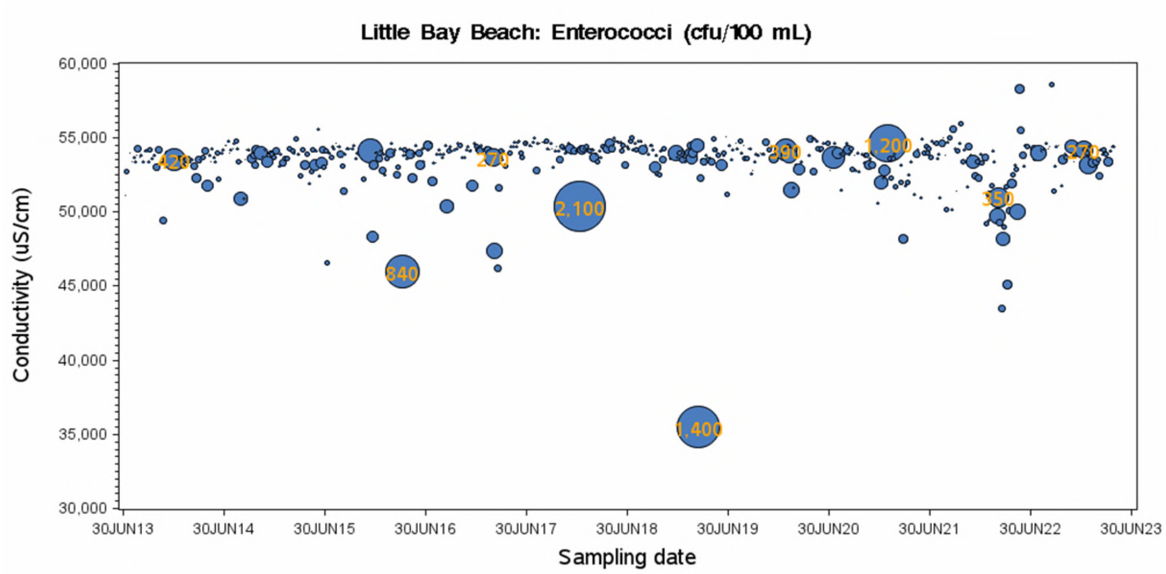
30JUN22
30JUN23
570
620
780
1,200
360
360
870
450
450


Maroubra Beach: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date
2,100
320
690
330
600
300

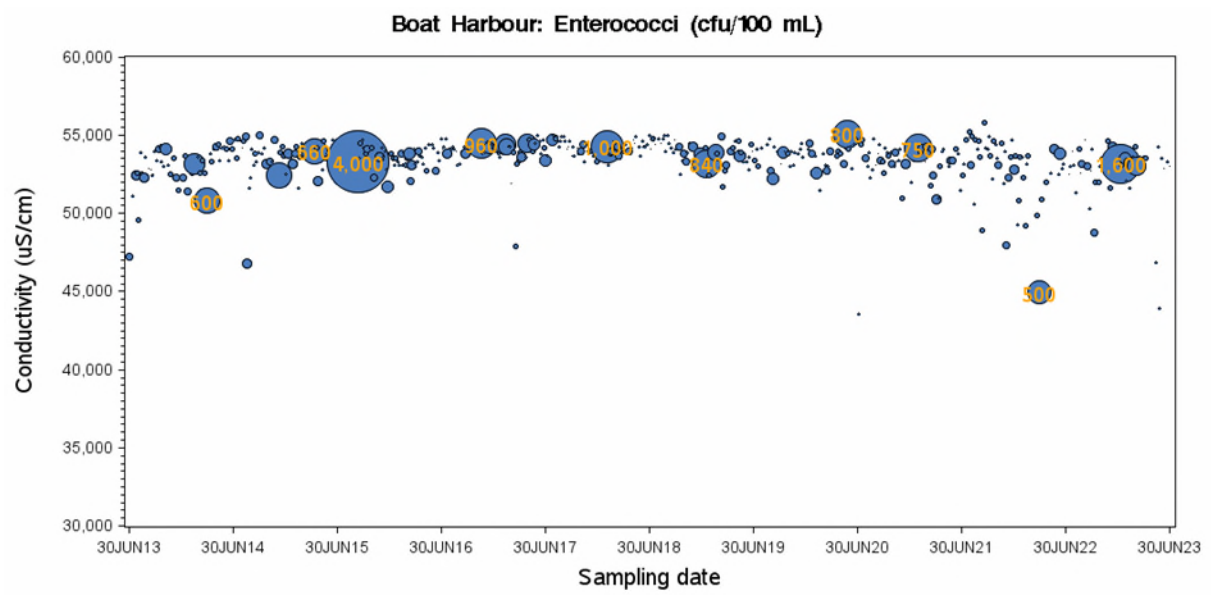

South Maroubra Beach: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date
1,200
300
230

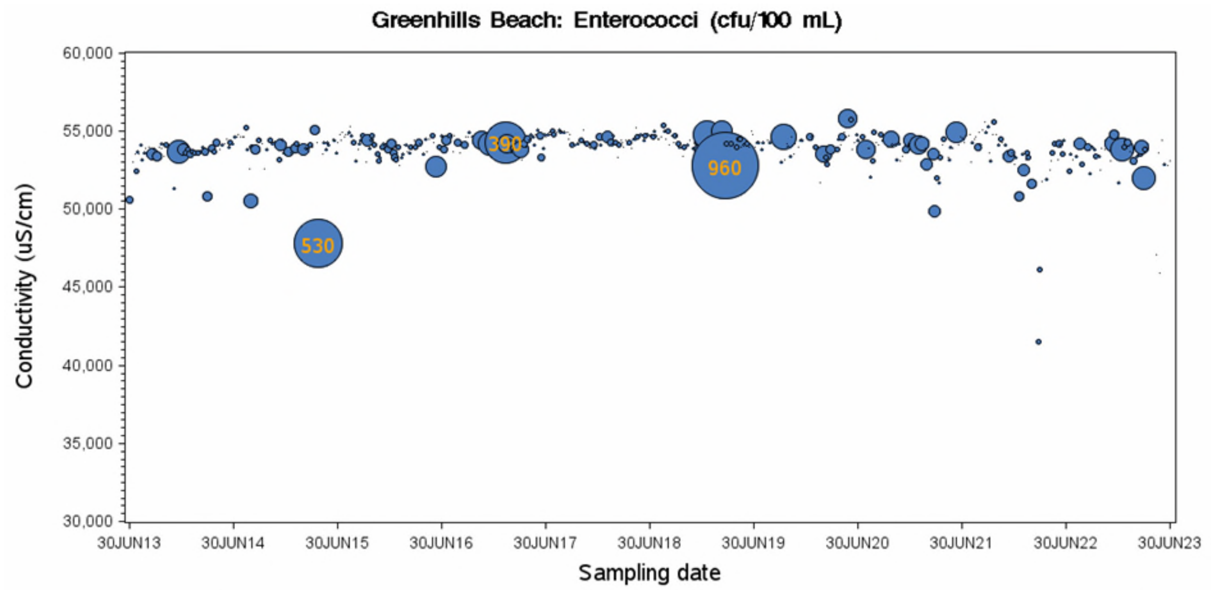

South Maroubra Rockpool: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date
1,700
320
1,300
720
880
450

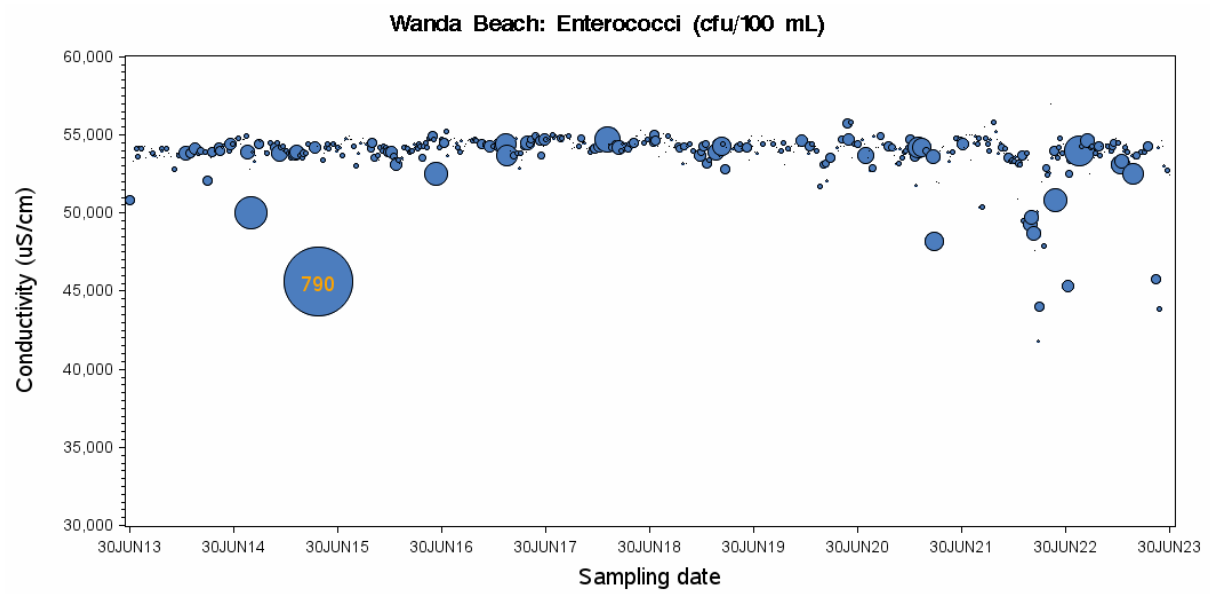

Malabar Beach: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date
1,500
990
1,200
1,400
320
960
250
480
900
450

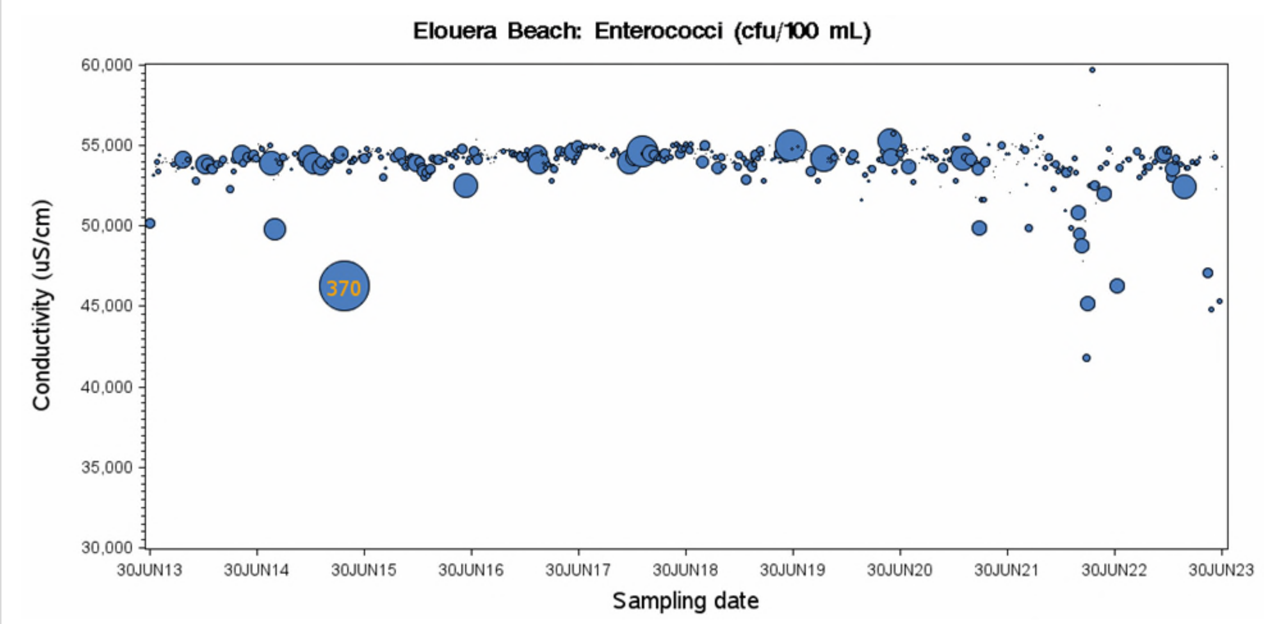

Little Bay Beach: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date
420
270
840
2,100
1,400
390
1,200
350
270

Sydney Beaches: Southern Sydney








Elouera Beach: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
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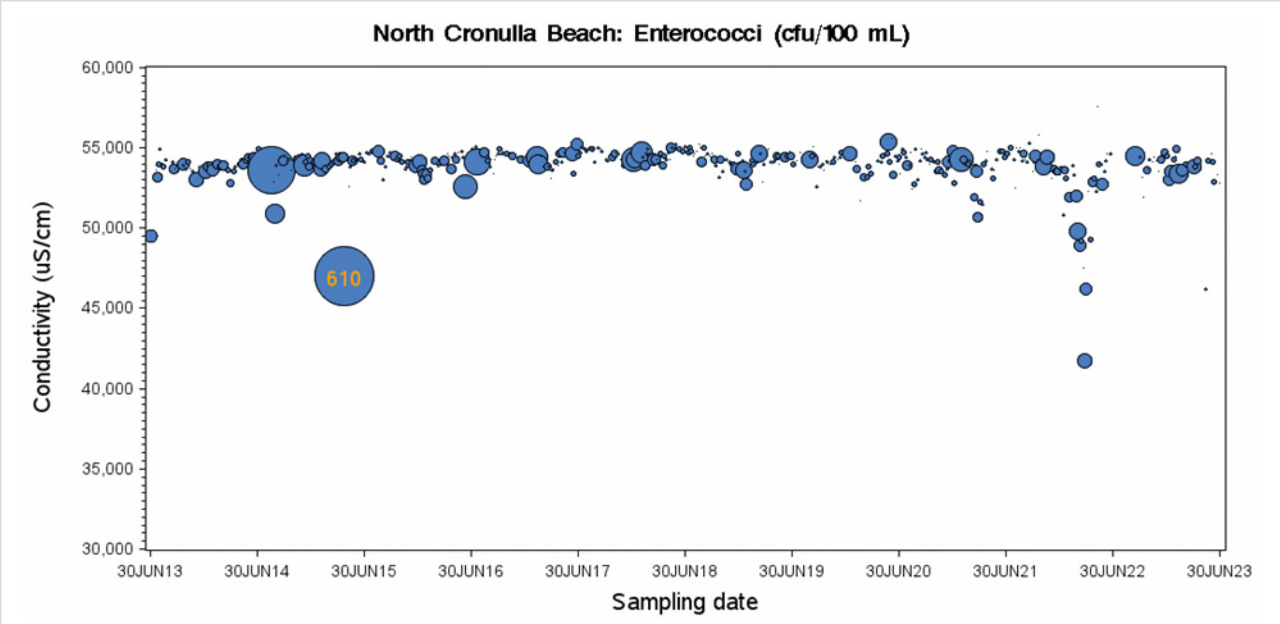
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date
370


North Cronulla Beach: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
30JUN13
30JUN14
30JUN15
30JUN16
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30JUN18
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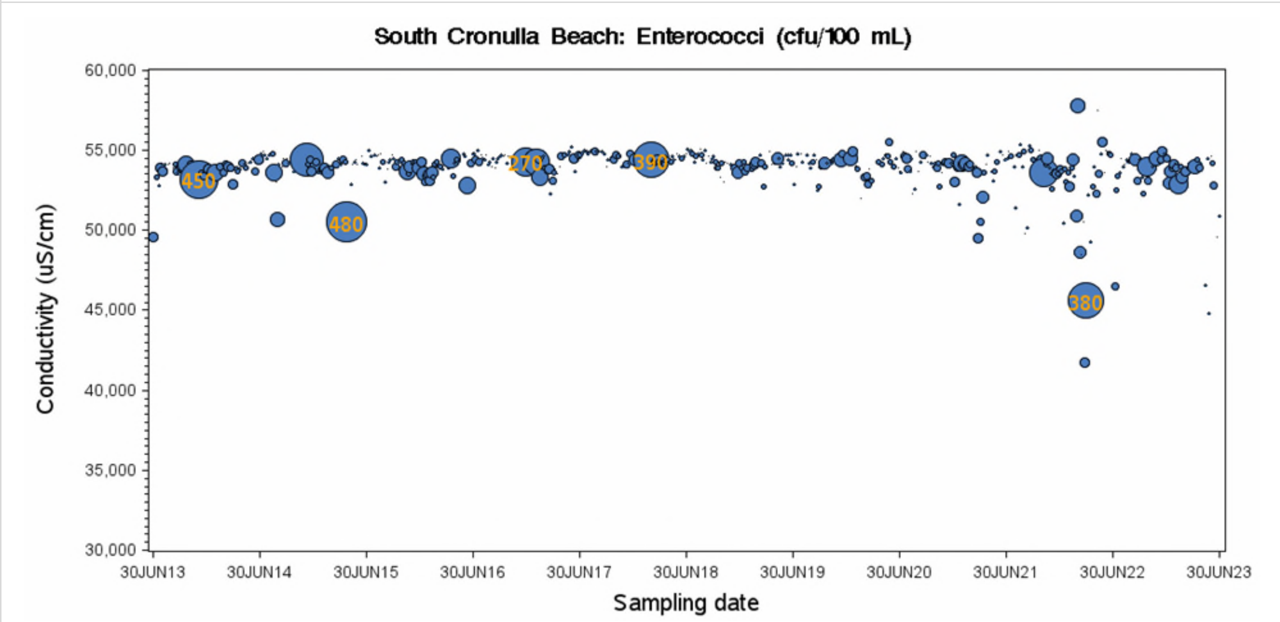
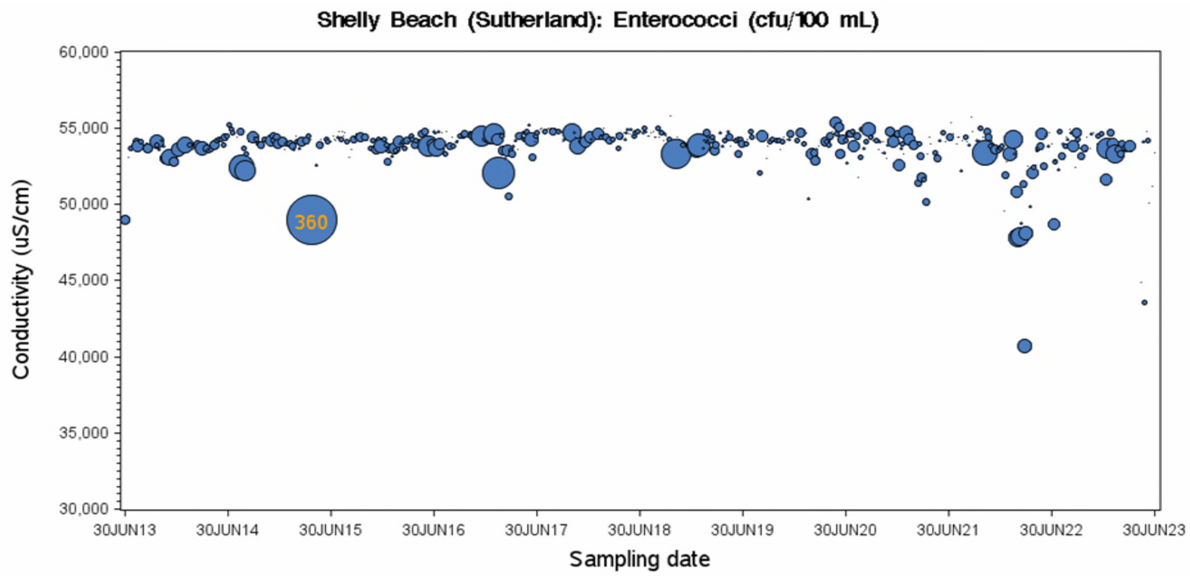
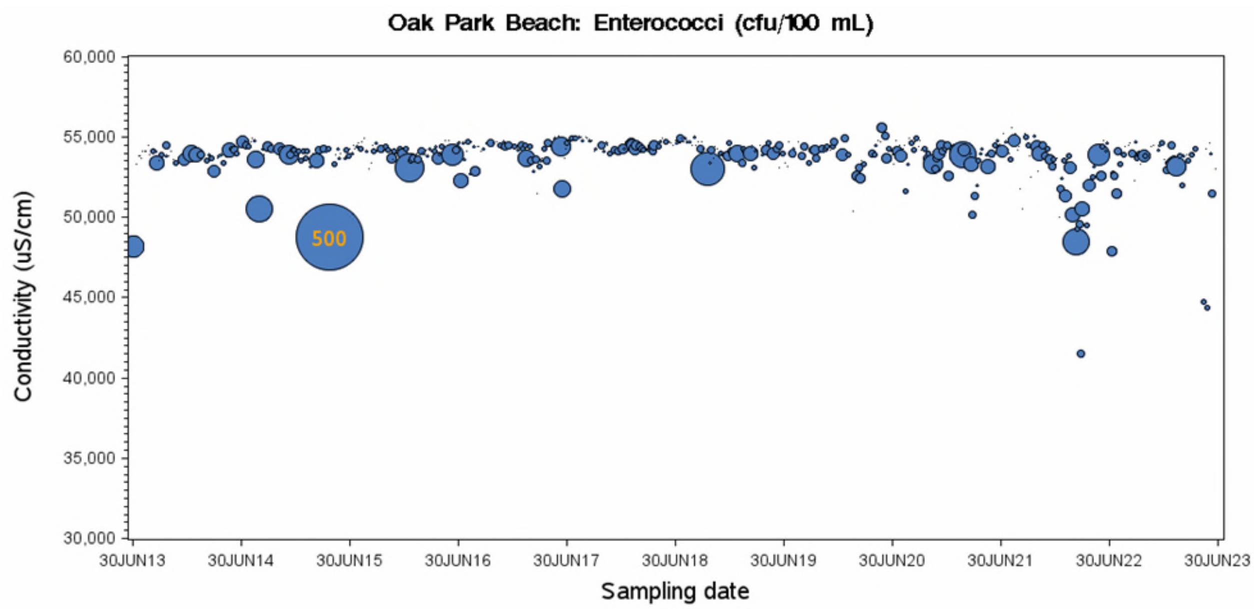
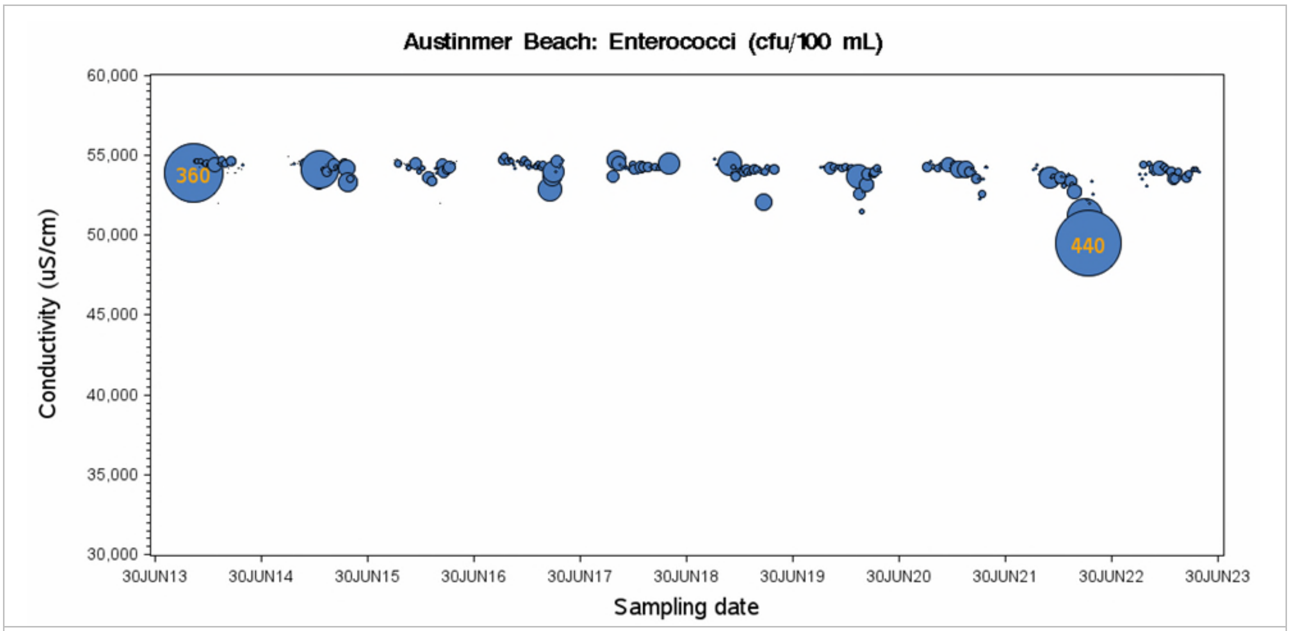
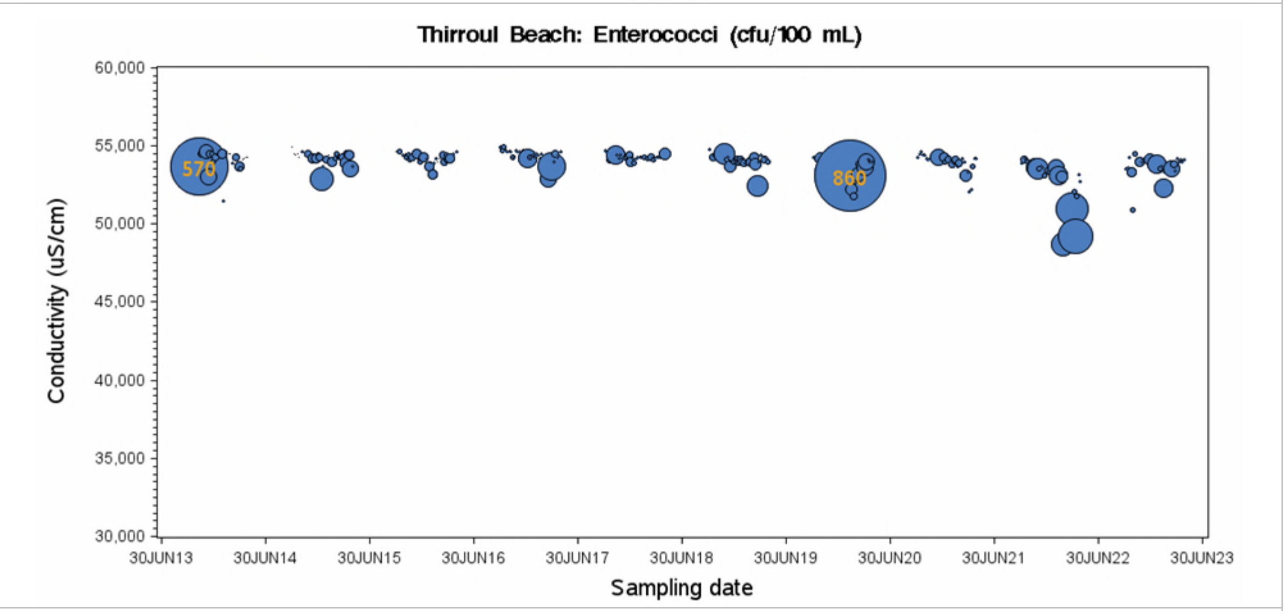
30JUN21
30JUN22
30JUN23
Sampling date
610

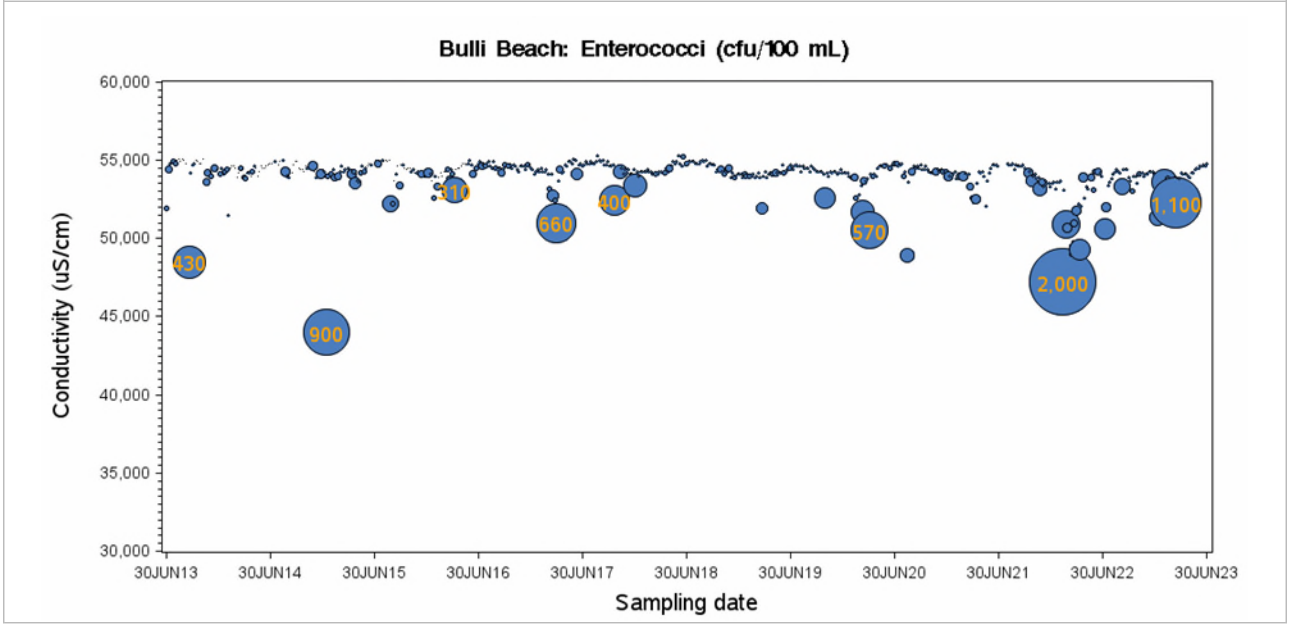

South Cronulla Beach: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date
450
480
270
390
380

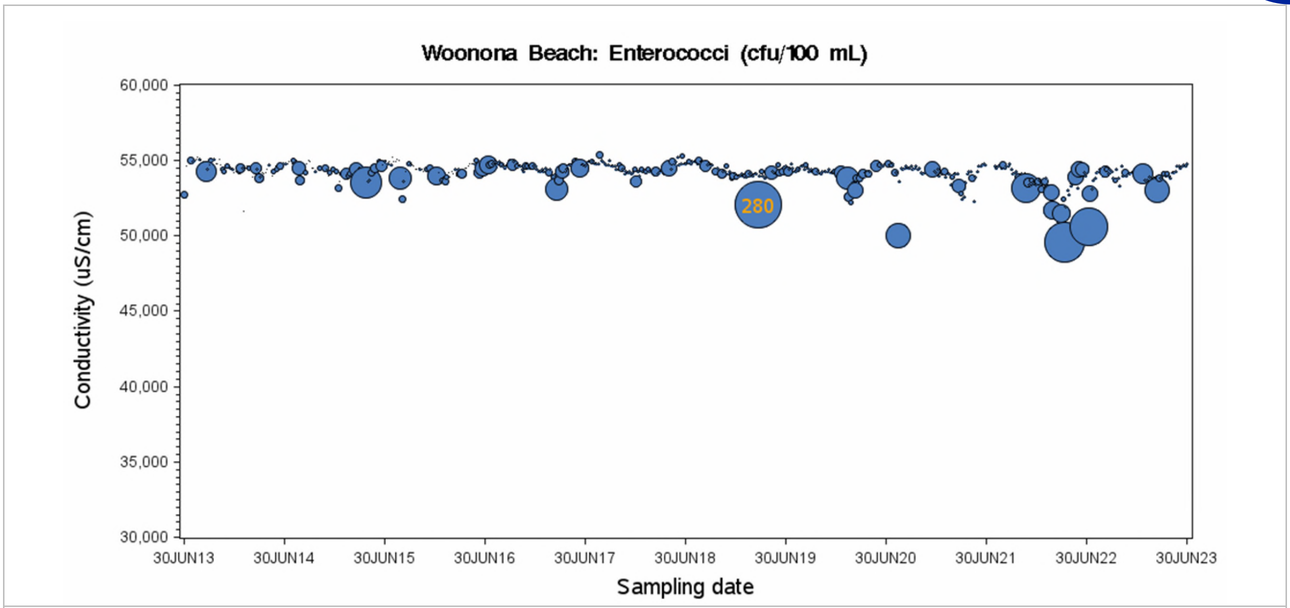

Shelly Beach (Sutherland): Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
360
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date

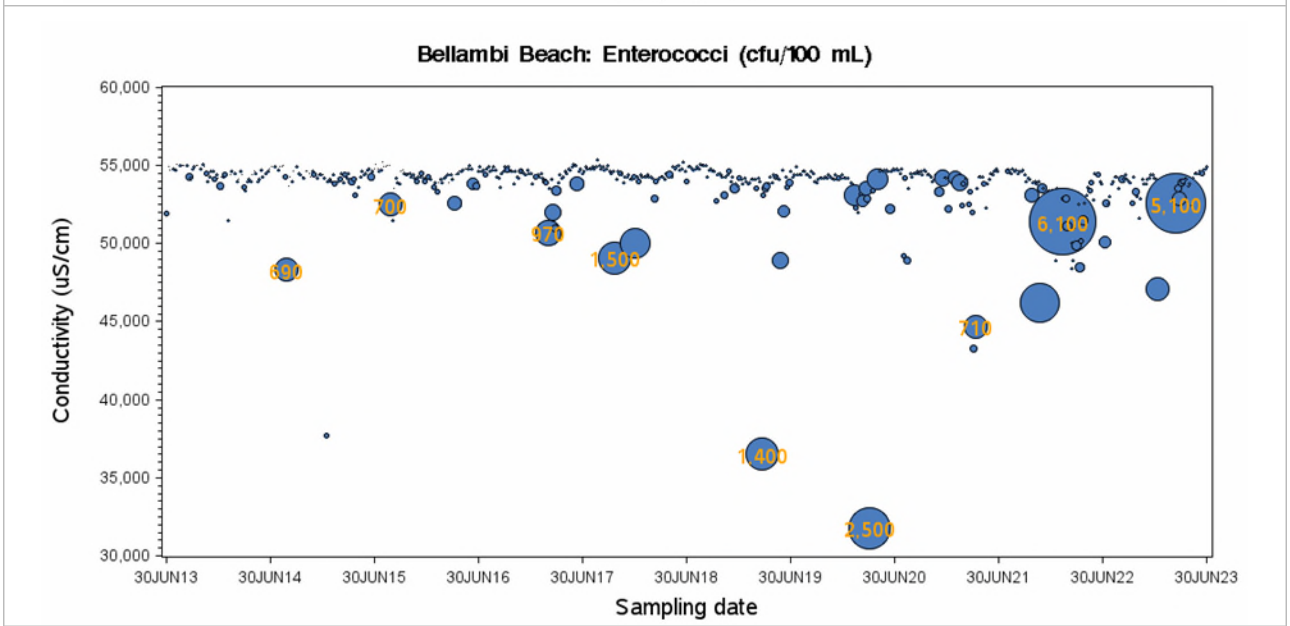

Oak Park Beach: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
500
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date

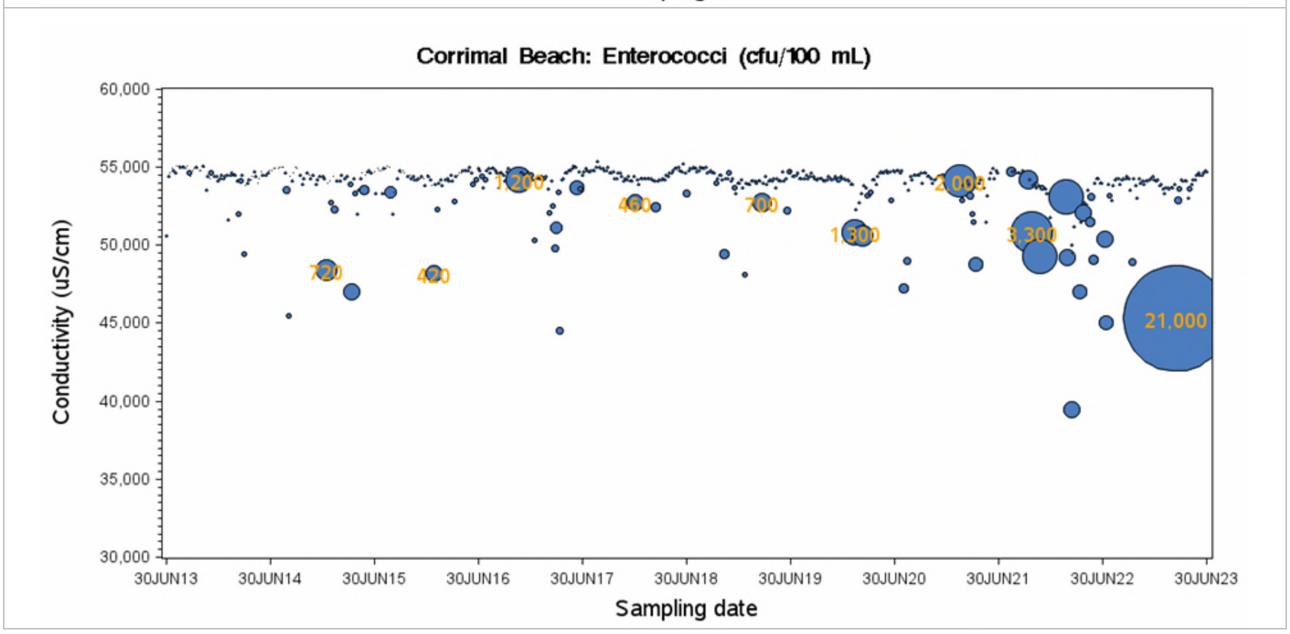

Austinmer Beach: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date
360
440

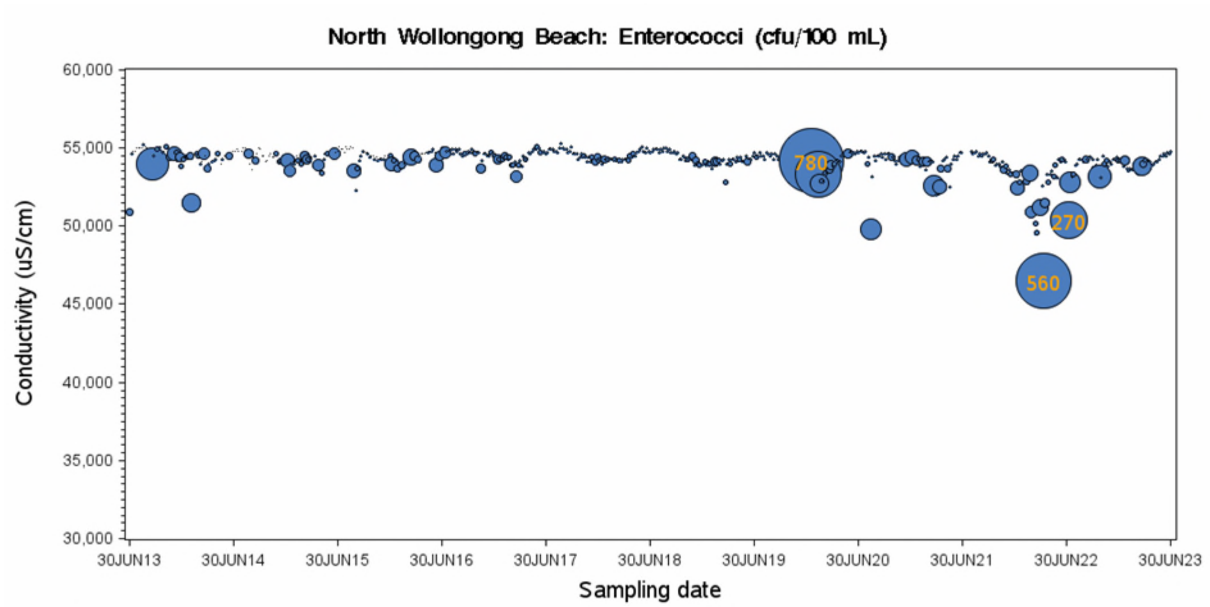

Thirroul Beach: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date
570
860

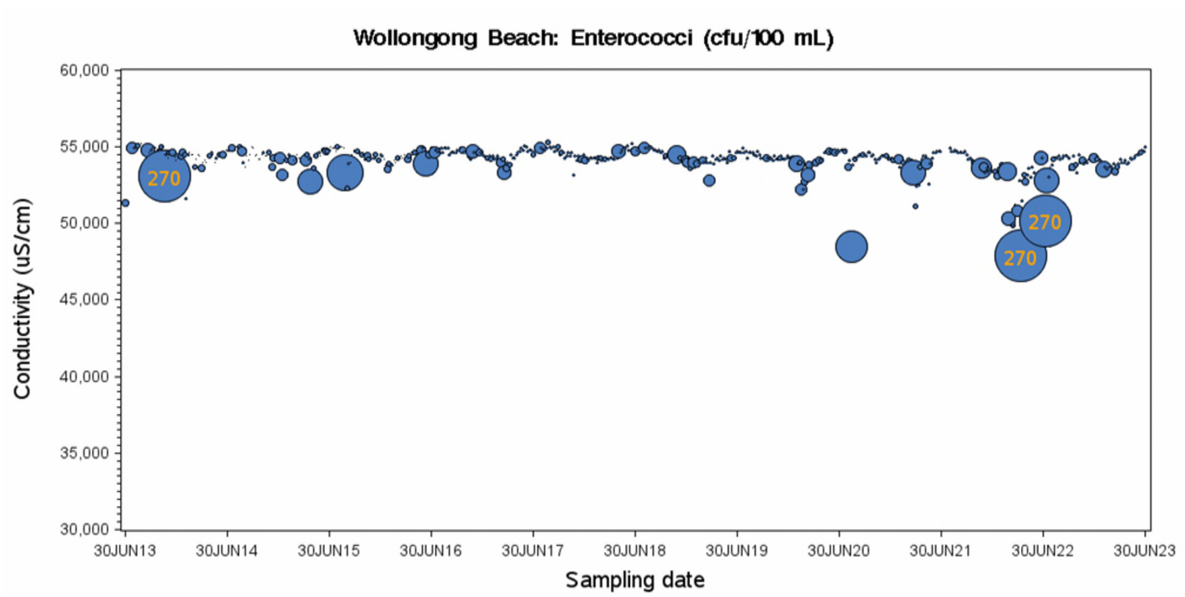

Bulli Beach: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date
430
900
310
660
400
570
2,000
1,100

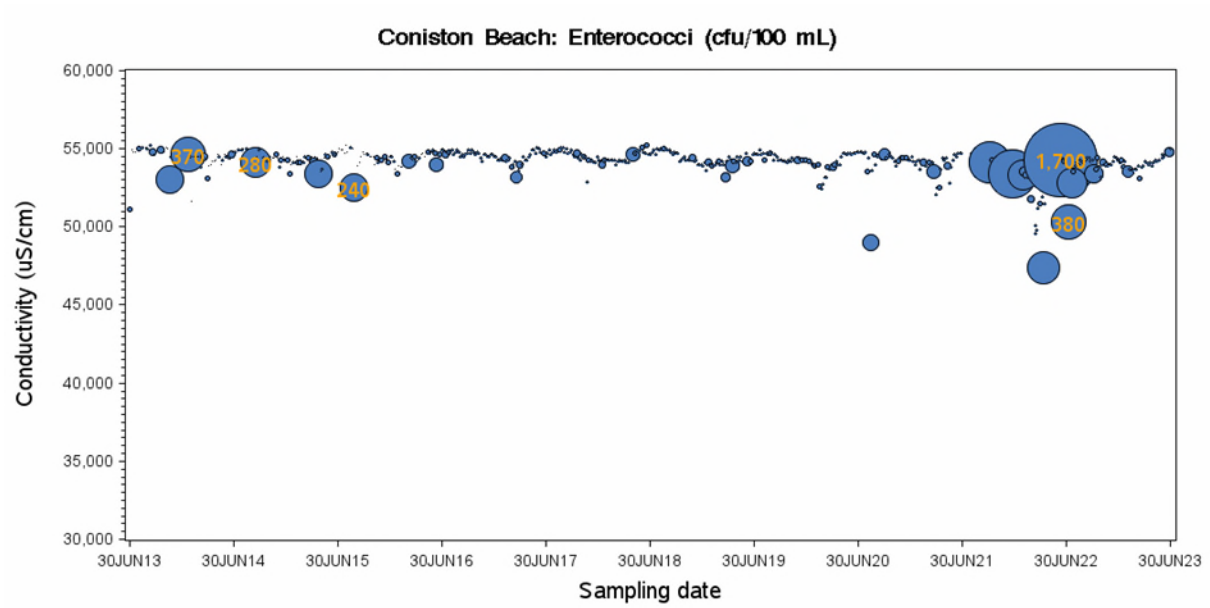

Woonona Beach: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
280
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date

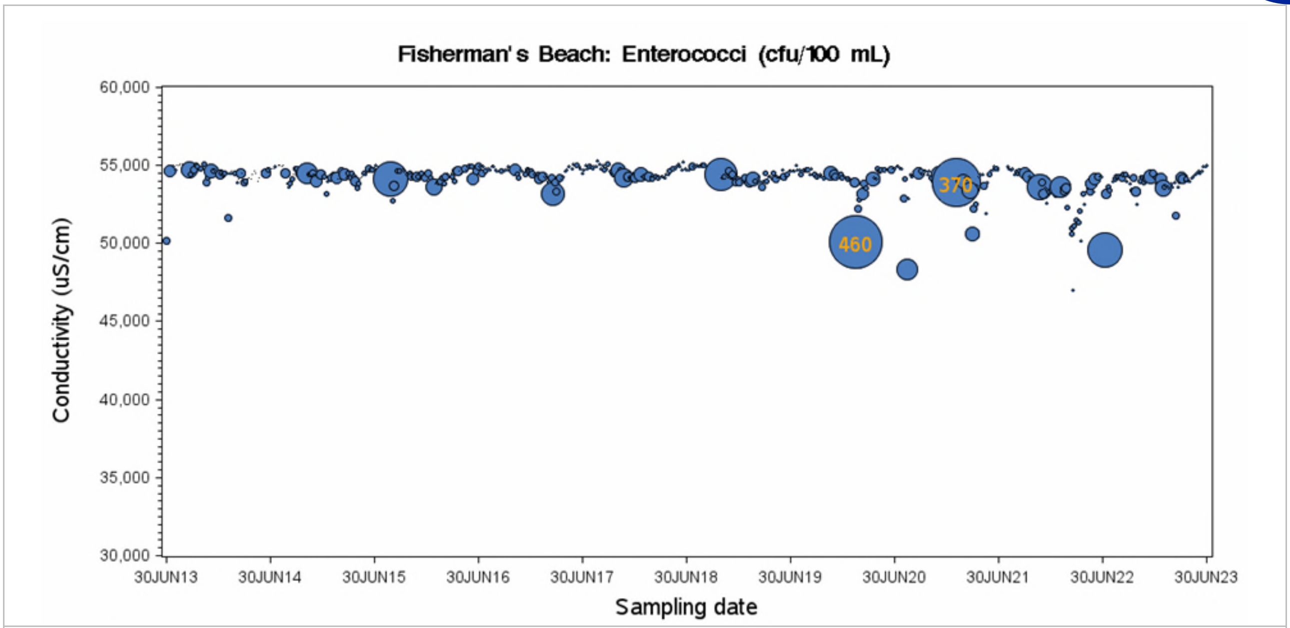

Bellambi Beach: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
700
970
690
1,500
6,100
5,100
710
1,400
2,500
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date


Corrimal Beach: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
1,200
2,000
460
700
1,300
3,300
720
420
21,000
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date

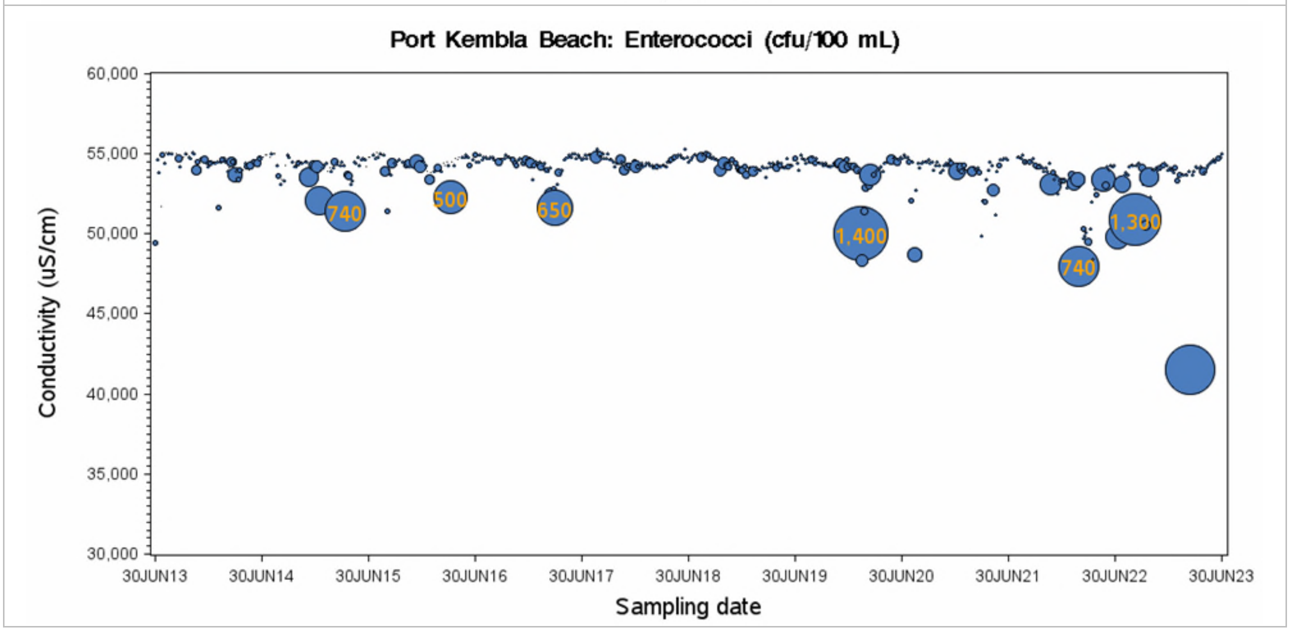

North Wollongong Beach: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
780
270
560
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date


Wollongong Beach: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
270
270
270
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date


Coniston Beach: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
370
280
240
1,700
380
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date

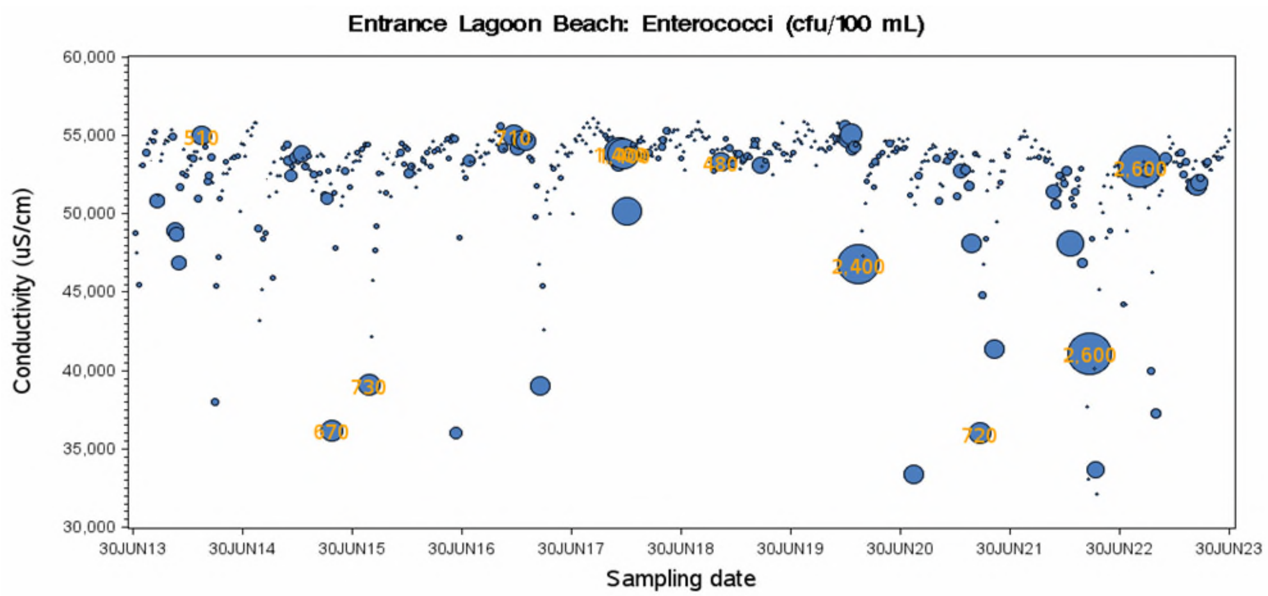


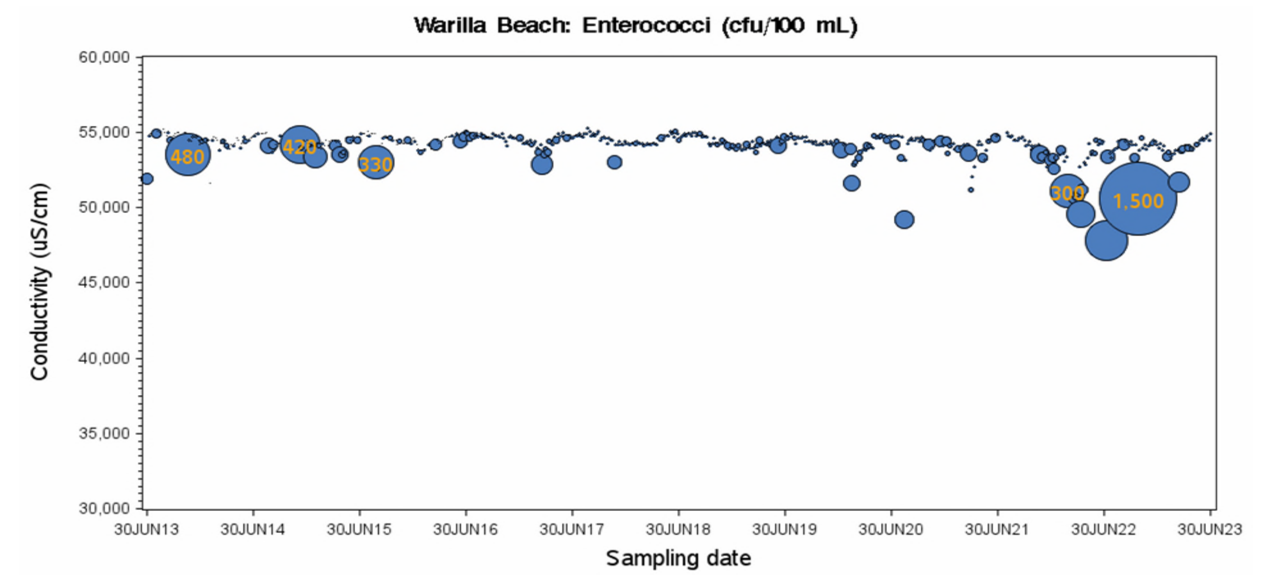
Fisherman's Beach: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date
460
370

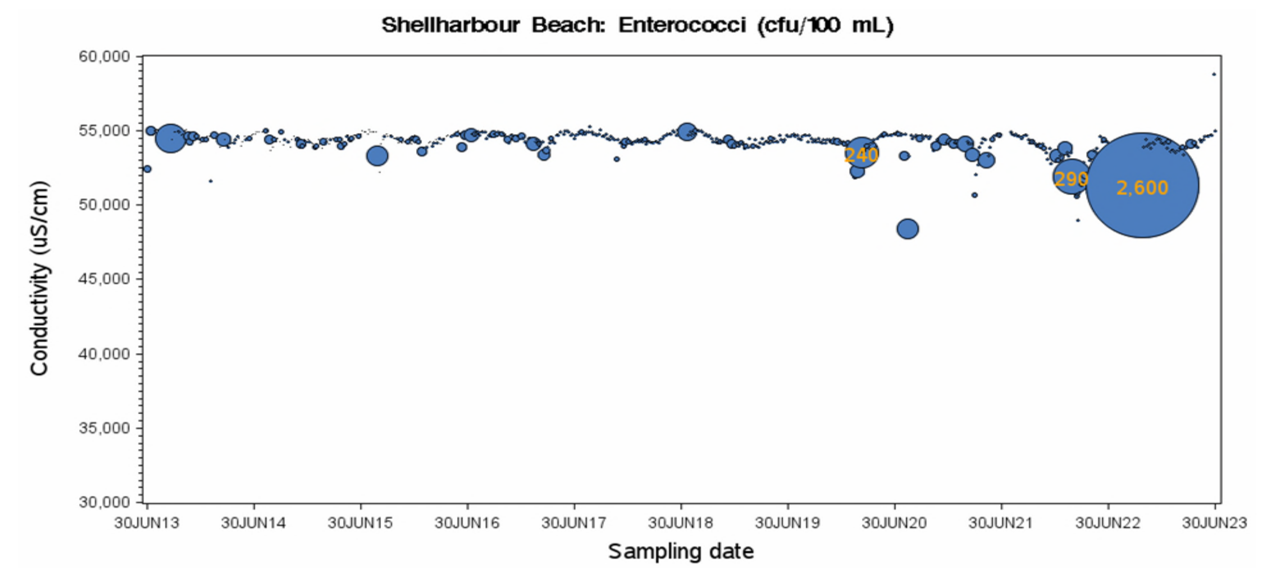


Port Kembla Beach: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date
740
500
650
1,400
740
1,300

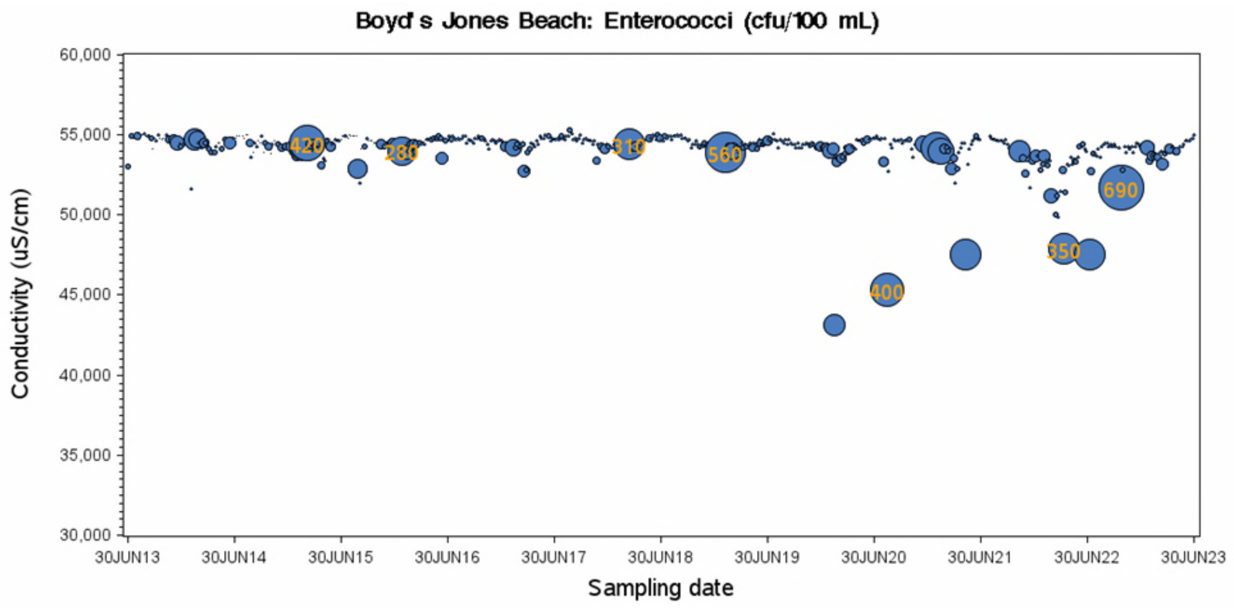
Illawarra Beaches: Shellharbour

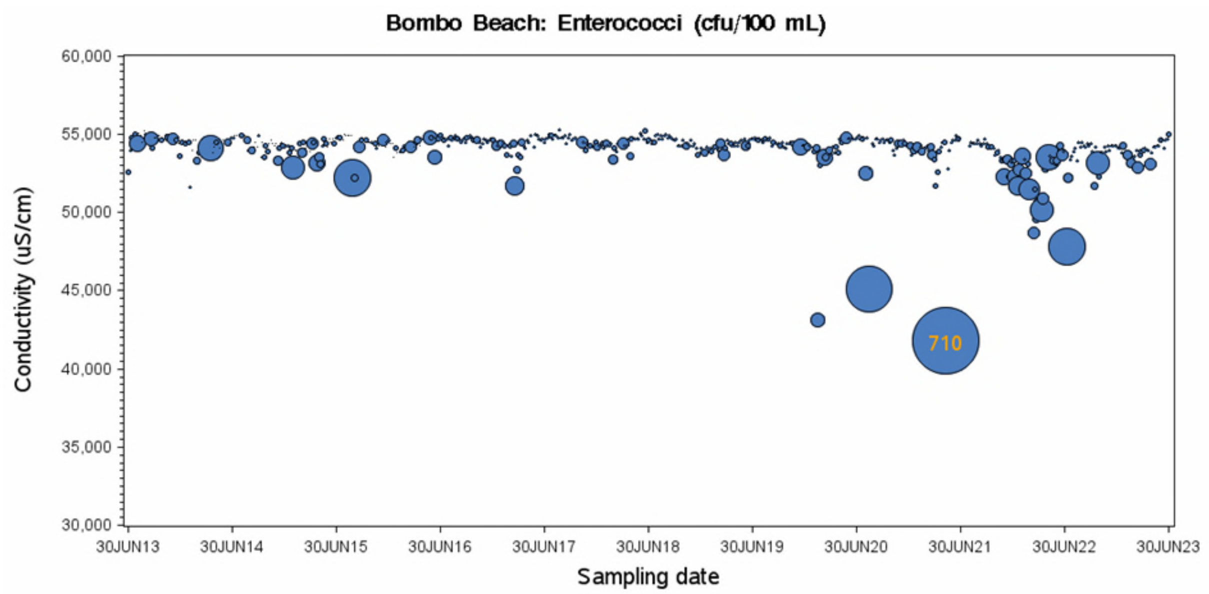


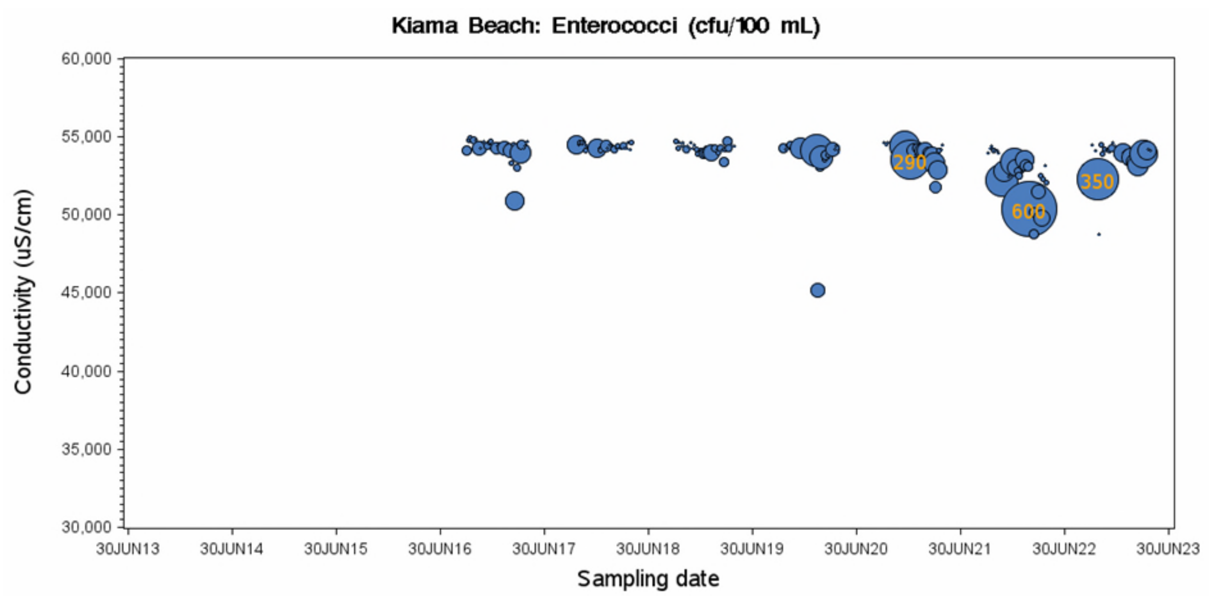


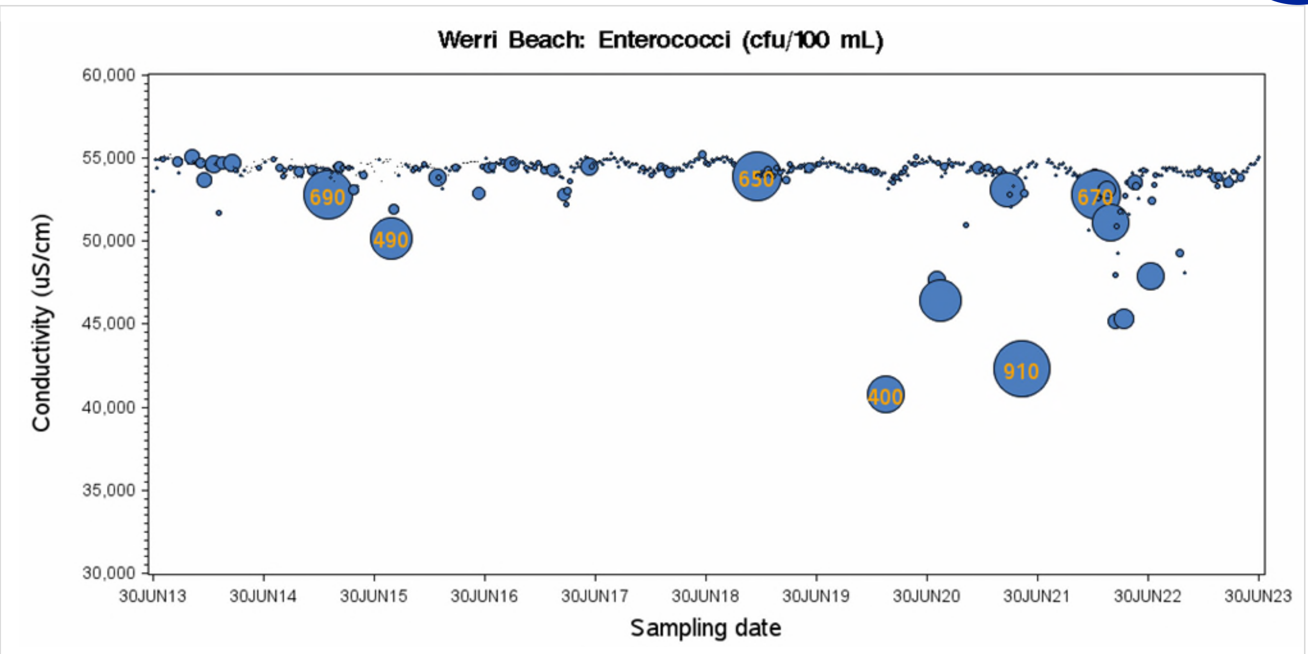


Illawarra Beaches: Bombo

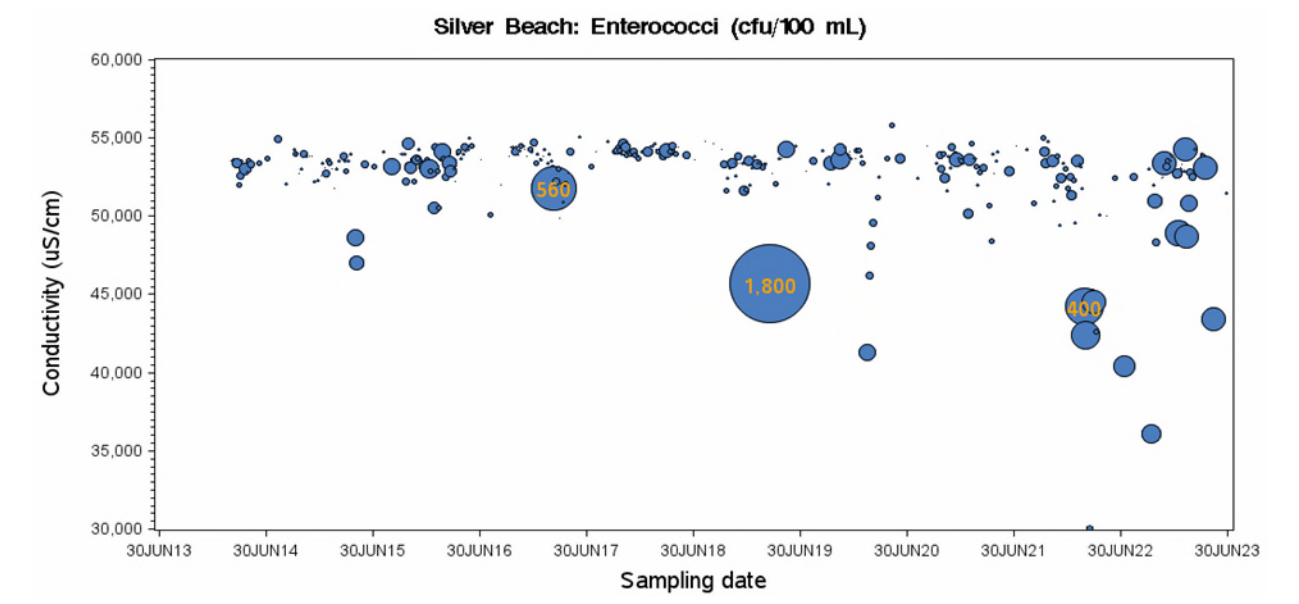


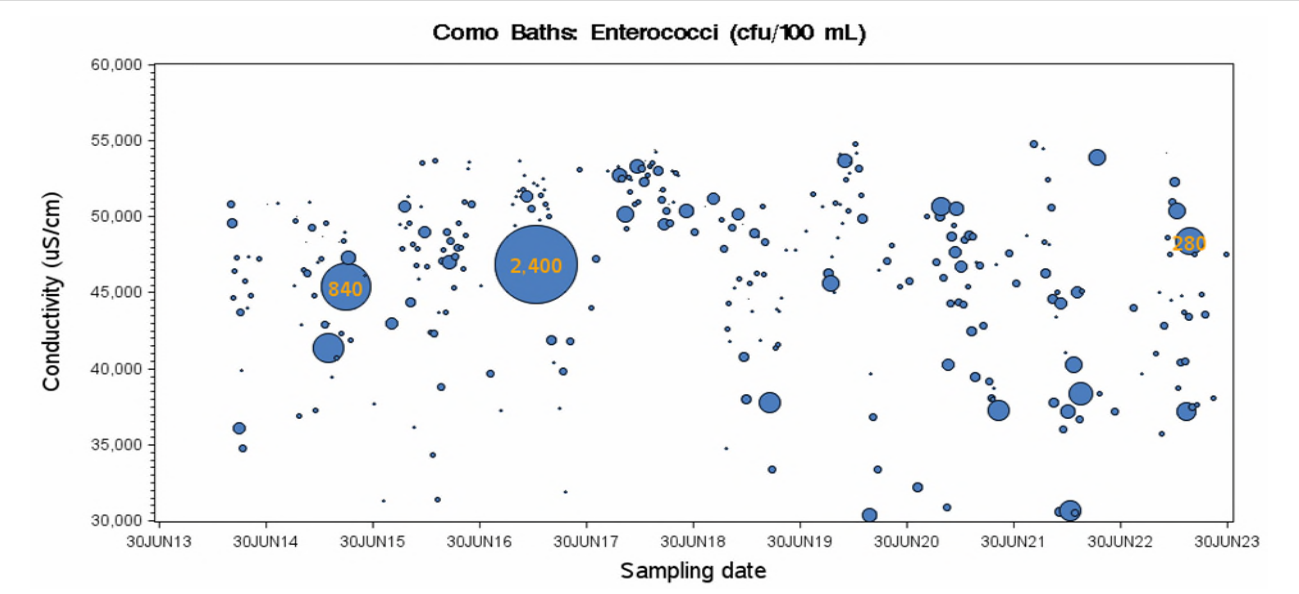


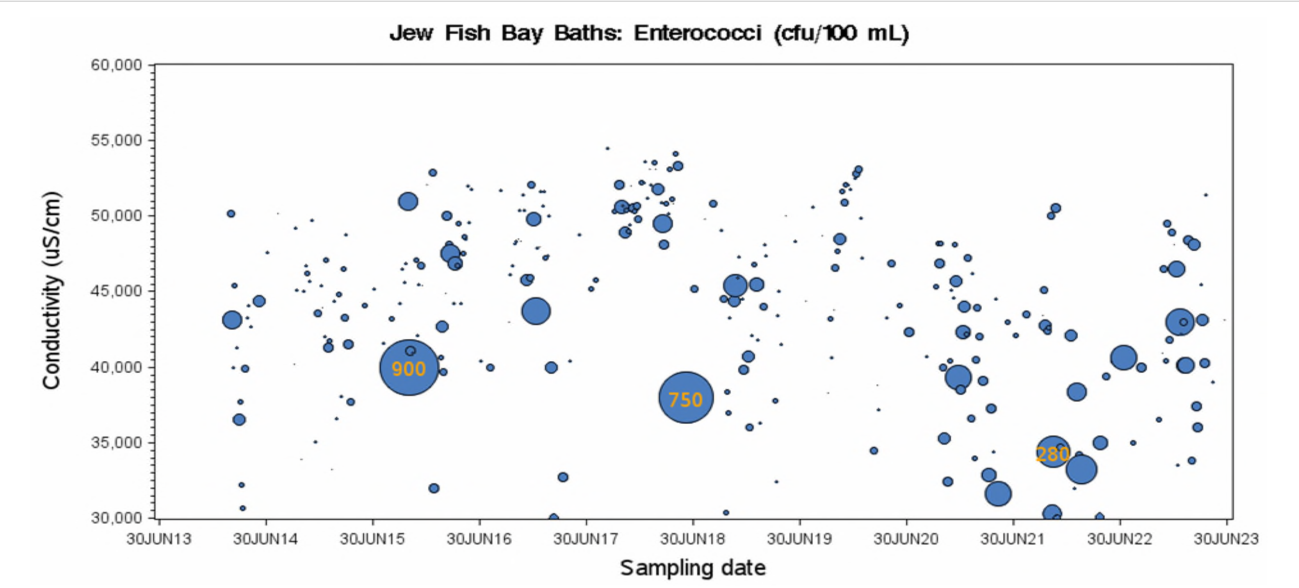


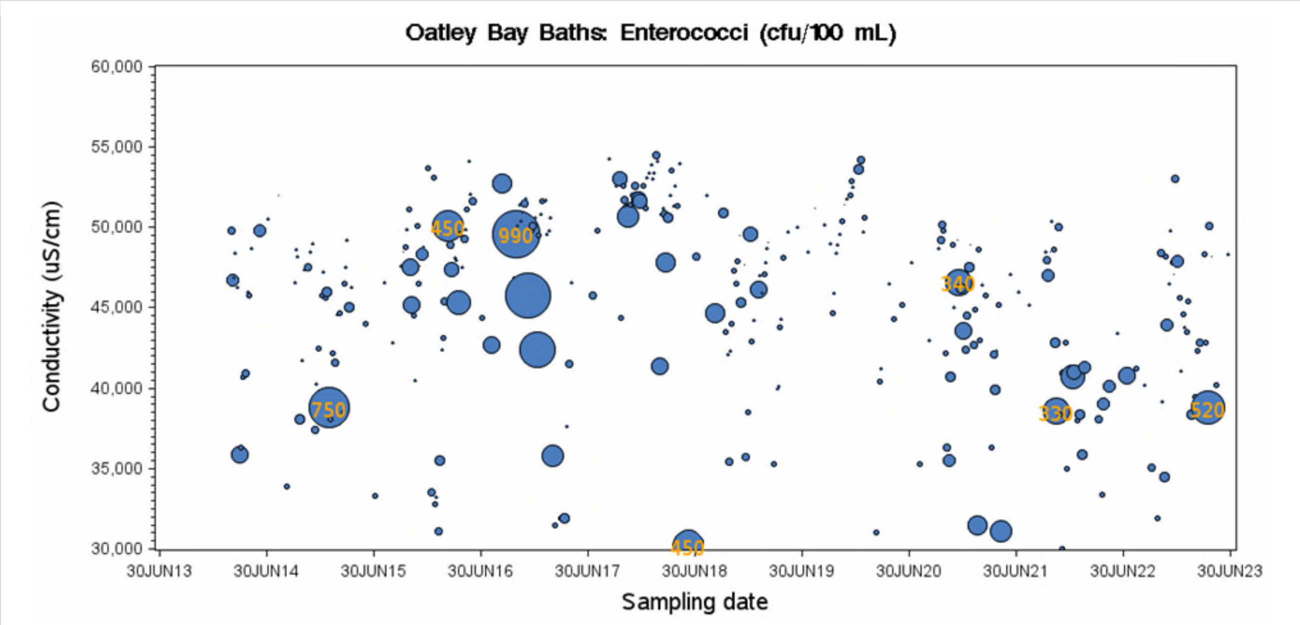

Werri Beach: Enterococci (cfu/100 mL)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
Conductivity (uS/cm)
690
490
650
400
910
670
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date

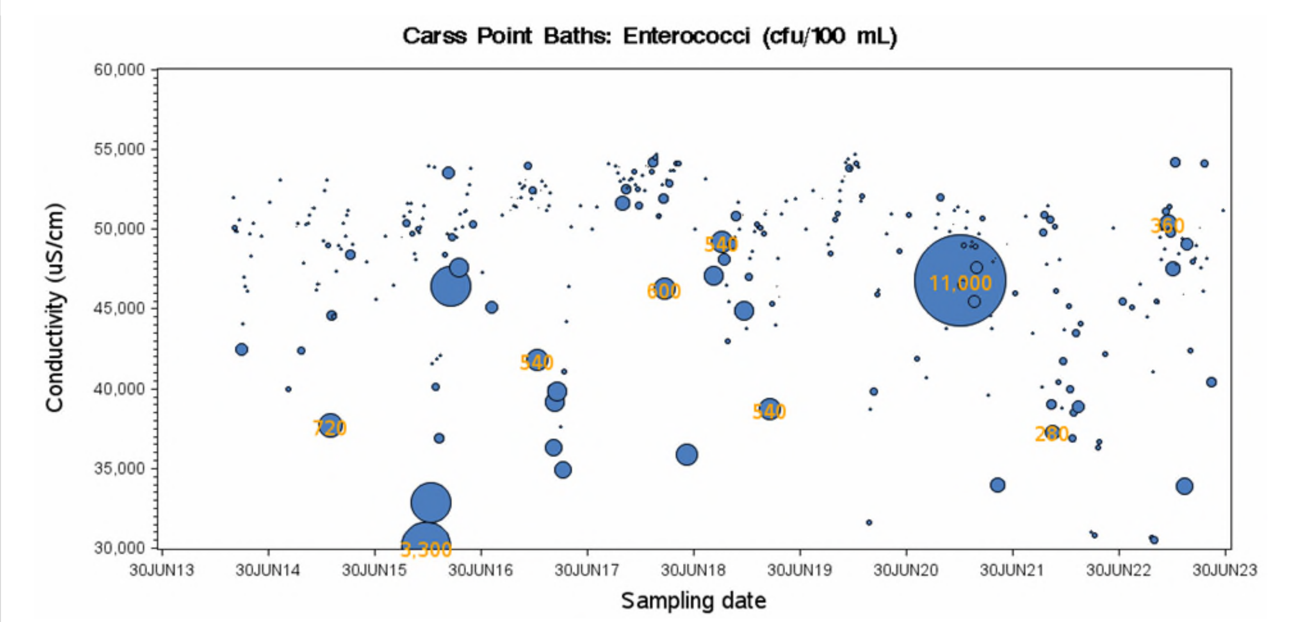
Sydney Harbour and Estuaries: Botany Bay and Georges River








Oatley Bay Baths: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date
450
990
750
340
330
520
450


Carss Point Baths: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
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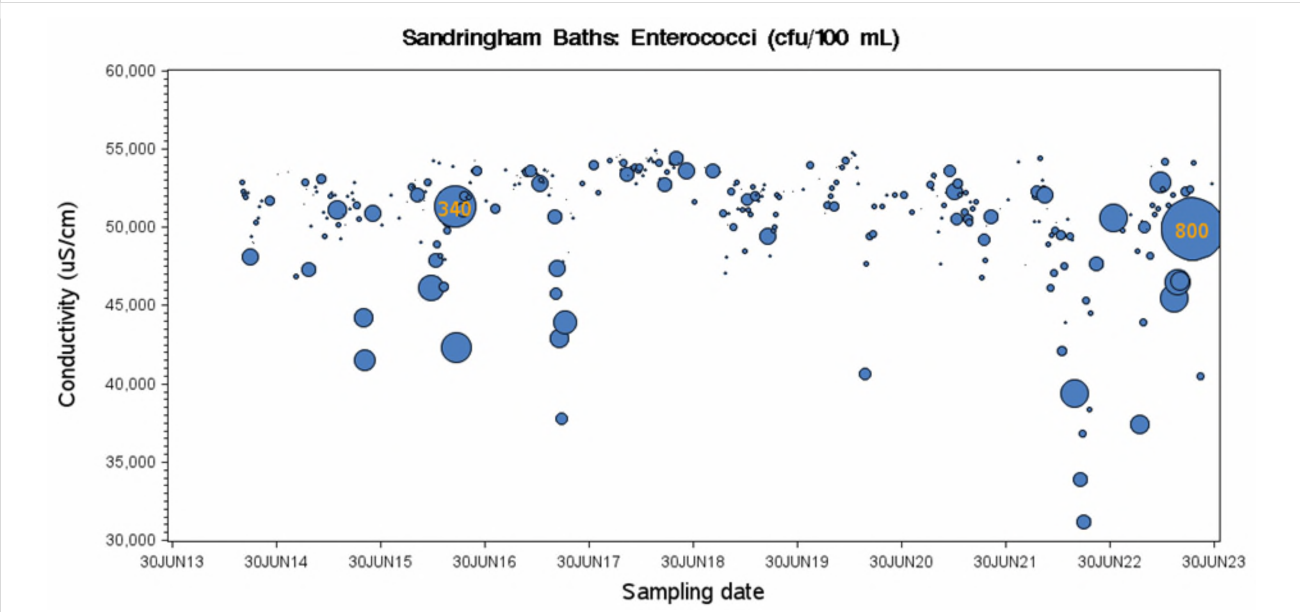
30JUN21
30JUN22
30JUN23
Sampling date
540
600
11,000
360
540
720
540
280


Sandringham Baths: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
30JUN13
30JUN14
30JUN15
30JUN16
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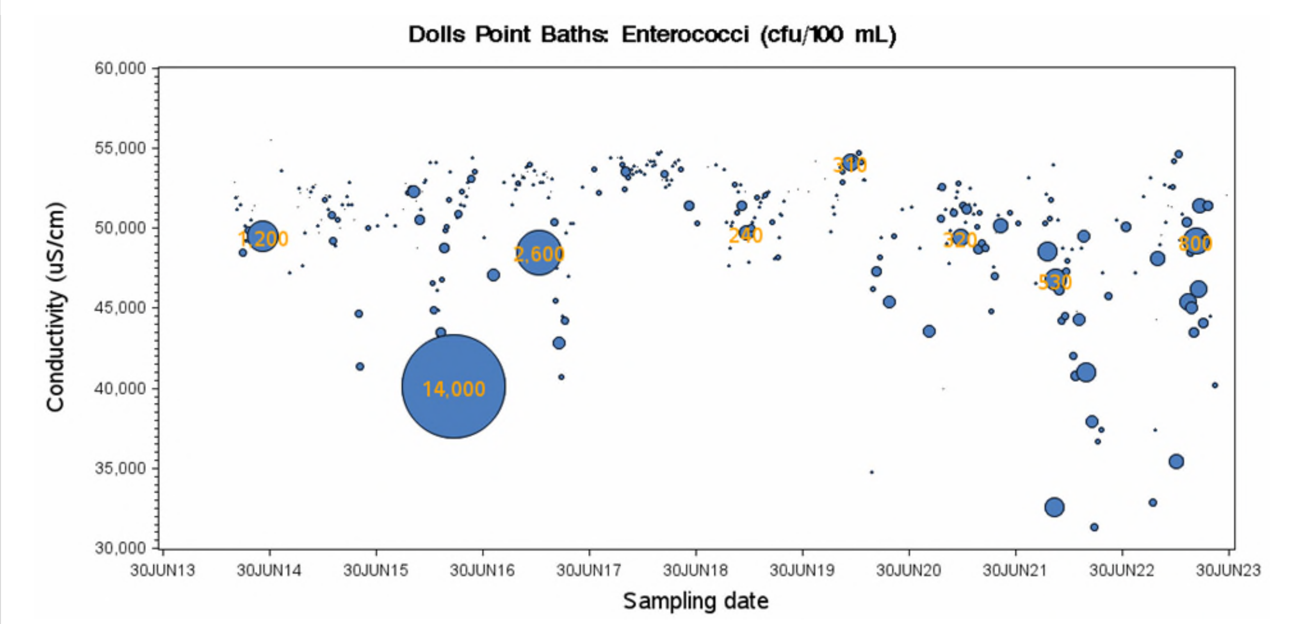
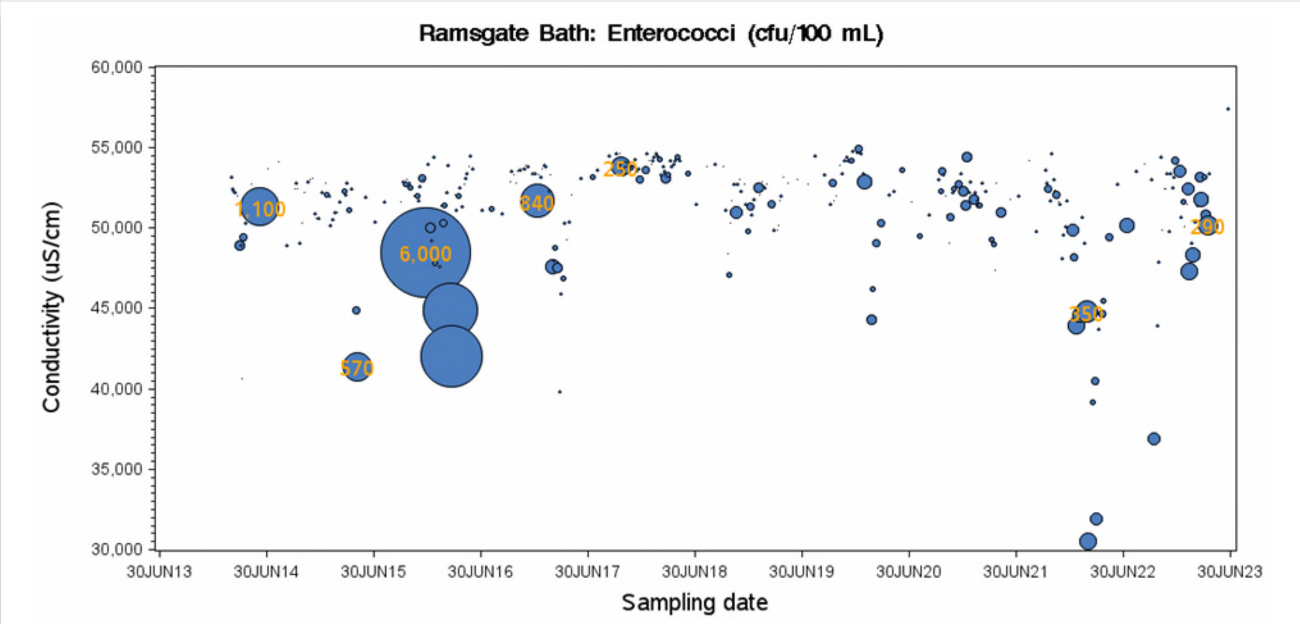
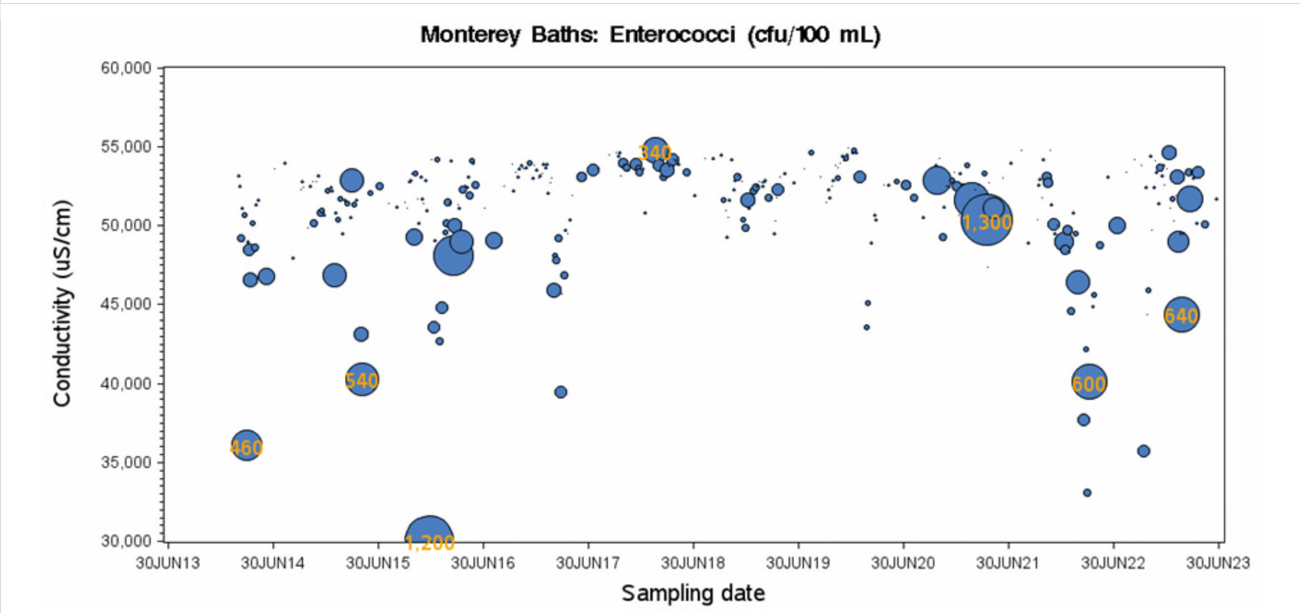
30JUN22
30JUN23
Sampling date
340
800


Dolls Point Baths: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date
1,200
14,000
2,600
240
310
320
530
300


Ramsgate Bath: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date
1,100
6,000
570
840
250
350
290


Monterey Baths: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
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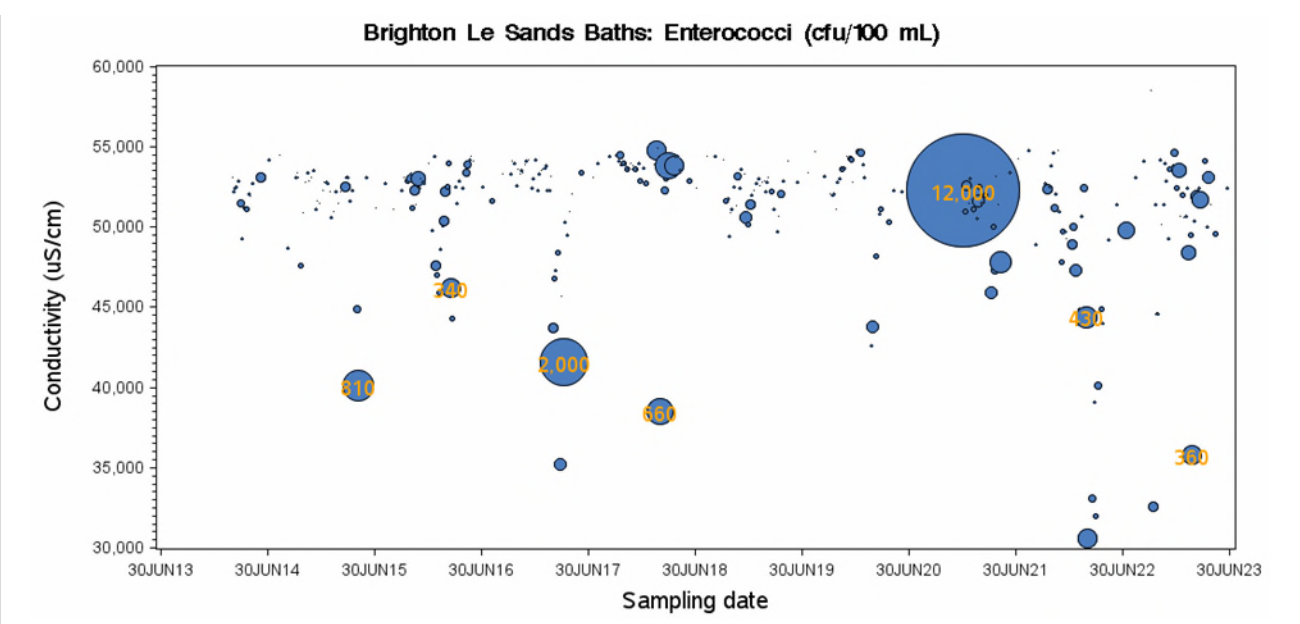
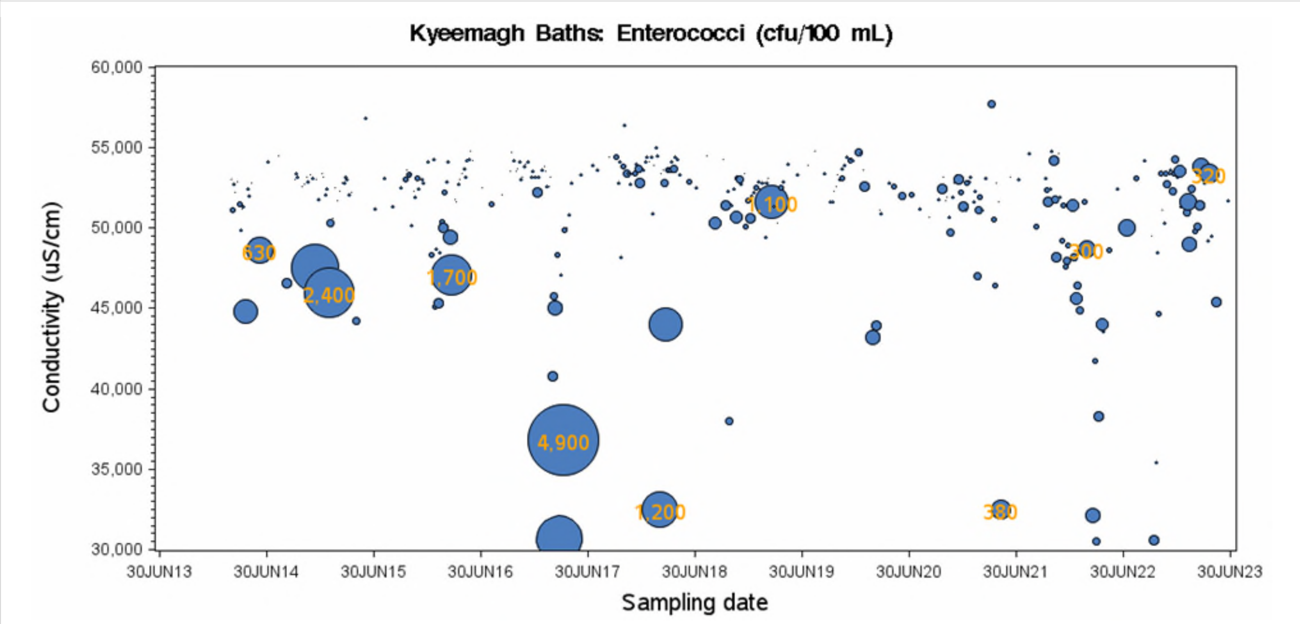
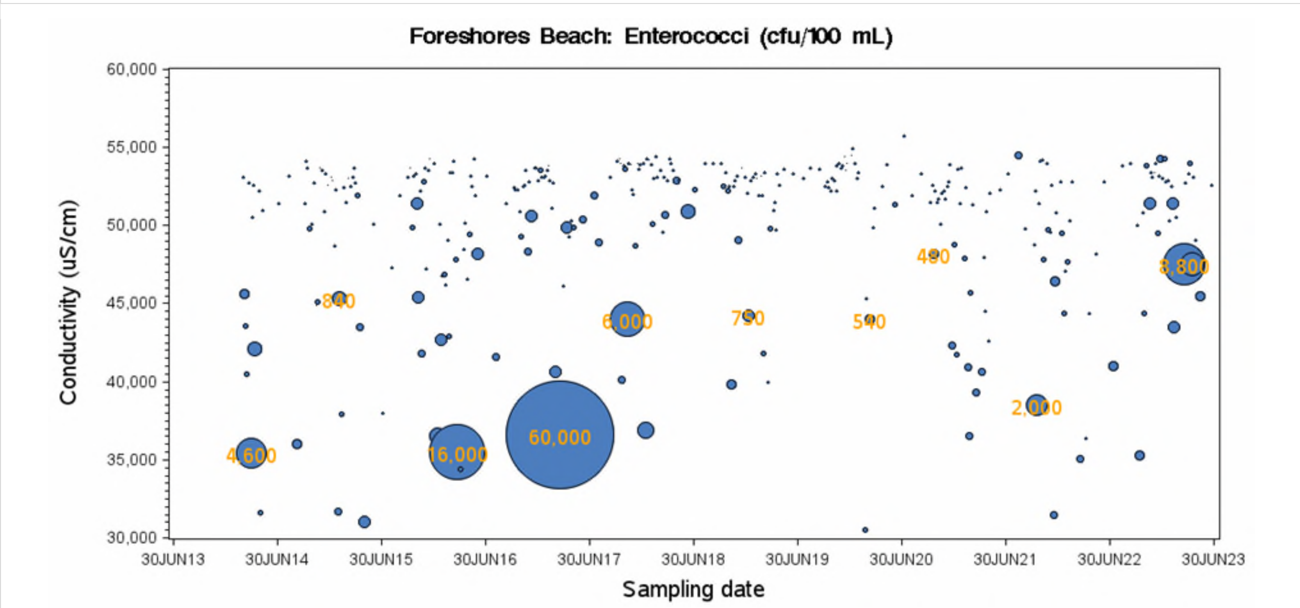
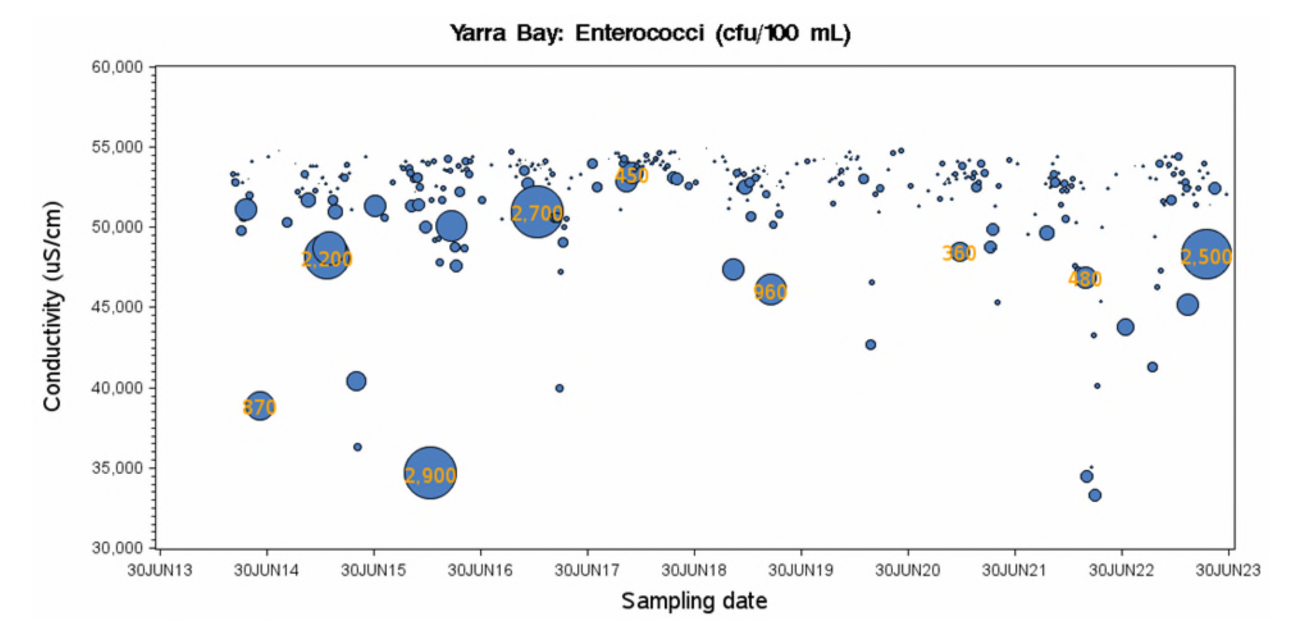
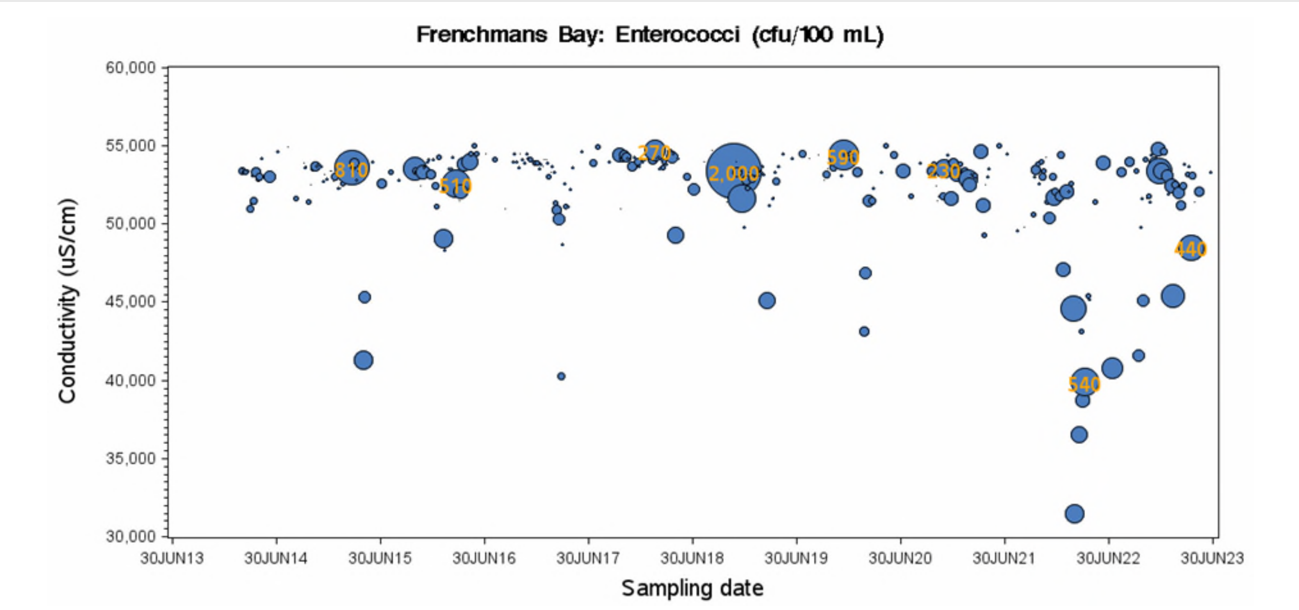
30JUN21
30JUN22
30JUN23
Sampling date
460
540
1,200
340
1,300
600
640

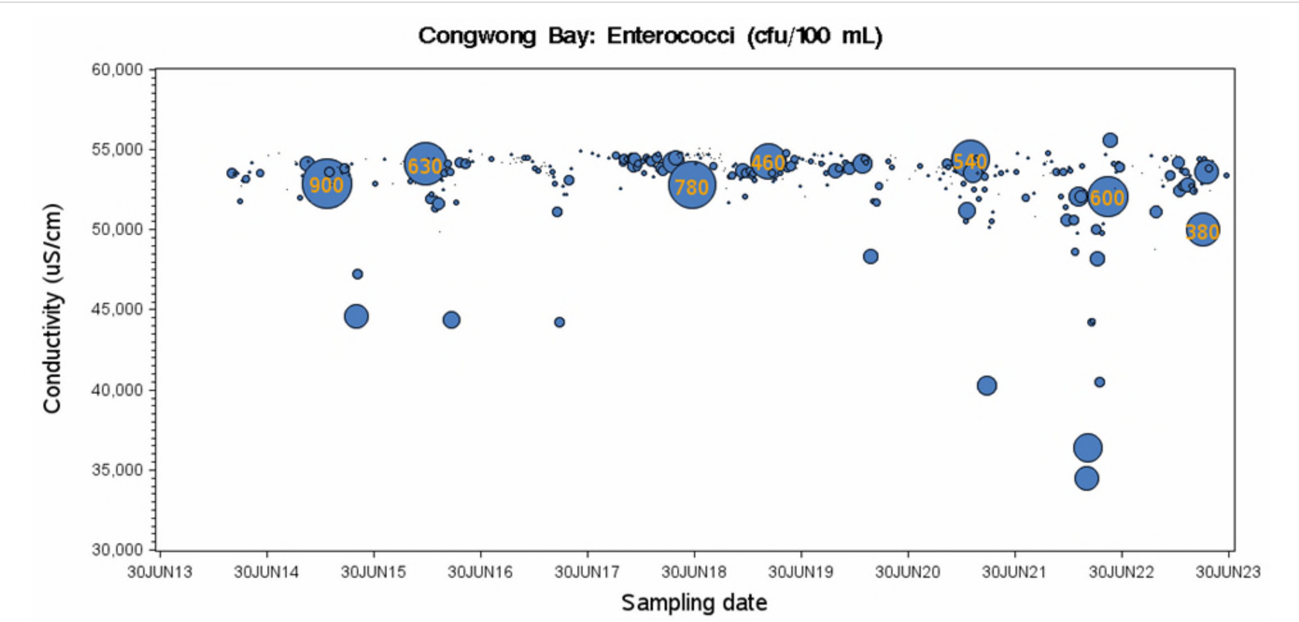

Brighton Le Sands Baths: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
30JUN13 30JUN14 30JUN15 30JUN16 30JUN17 30JUN18 30JUN19 30JUN20 30JUN21 30JUN22 30JUN23
Sampling date
12,000
240
310
2,000
560
430
360


Kyeemagh Baths: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
30JUN13 30JUN14 30JUN15 30JUN16 30JUN17 30JUN18 30JUN19 30JUN20 30JUN21 30JUN22 30JUN23
Sampling date
630
2,400
1,700
4,900
1,200
1,100
380
300
320


Foreshores Beach: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
30JUN13 30JUN14 30JUN15 30JUN16 30JUN17 30JUN18 30JUN19 30JUN20 30JUN21 30JUN22 30JUN23
Sampling date
4,600
840
16,000
60,000
6,000
790
540
480
2,000
3,800


Yarra Bay: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date
2,200
370
2,900
2,700
450
960
360
480
2,500


Frenchmans Bay: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date
810
510
370
2,000
590
230
540
440


Congwong Bay: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
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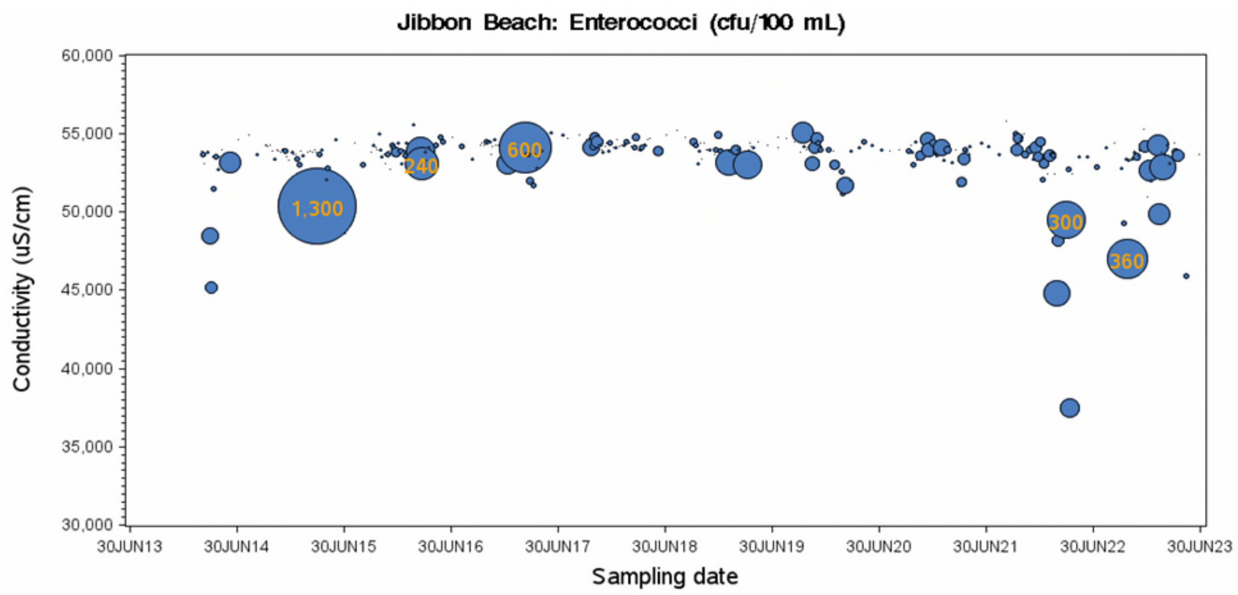
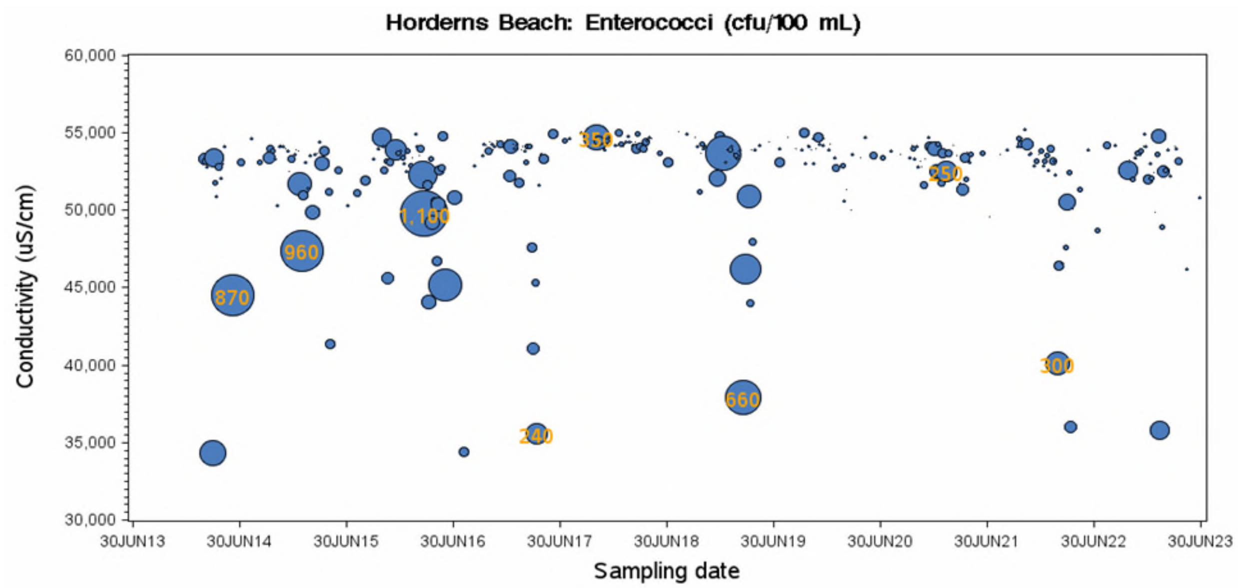
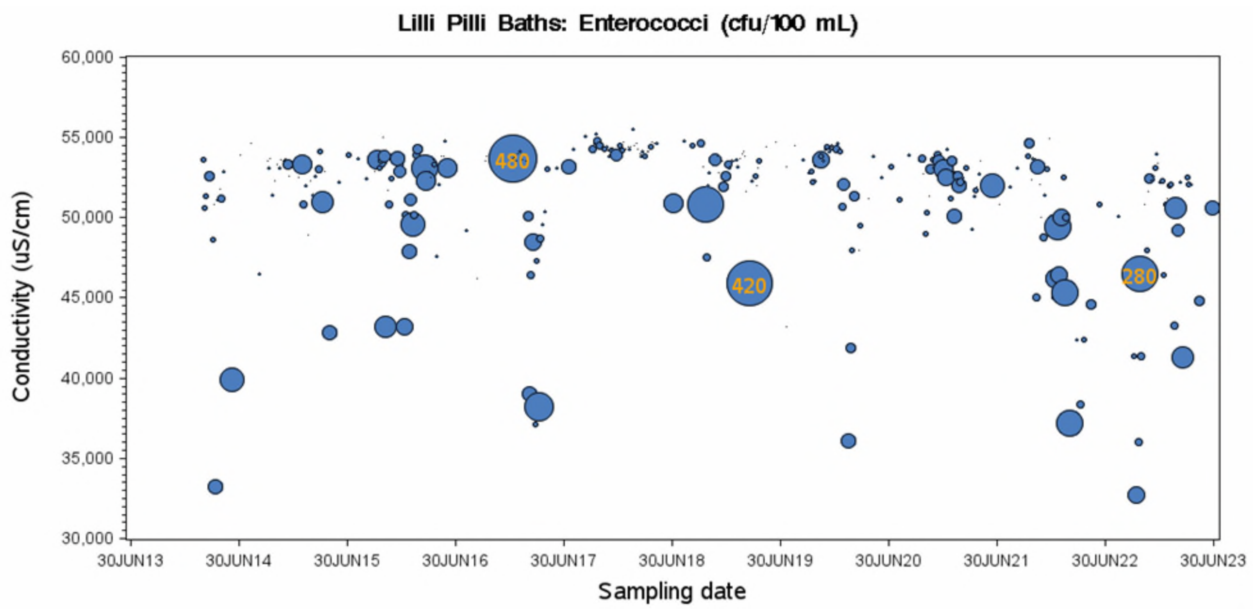
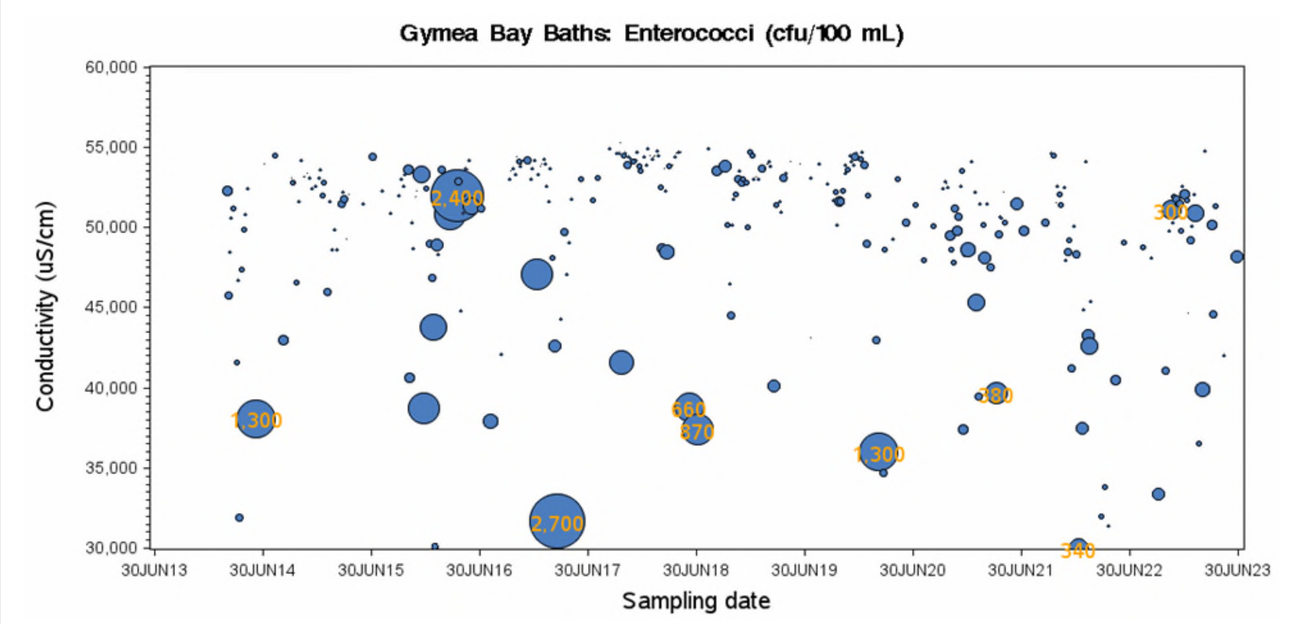
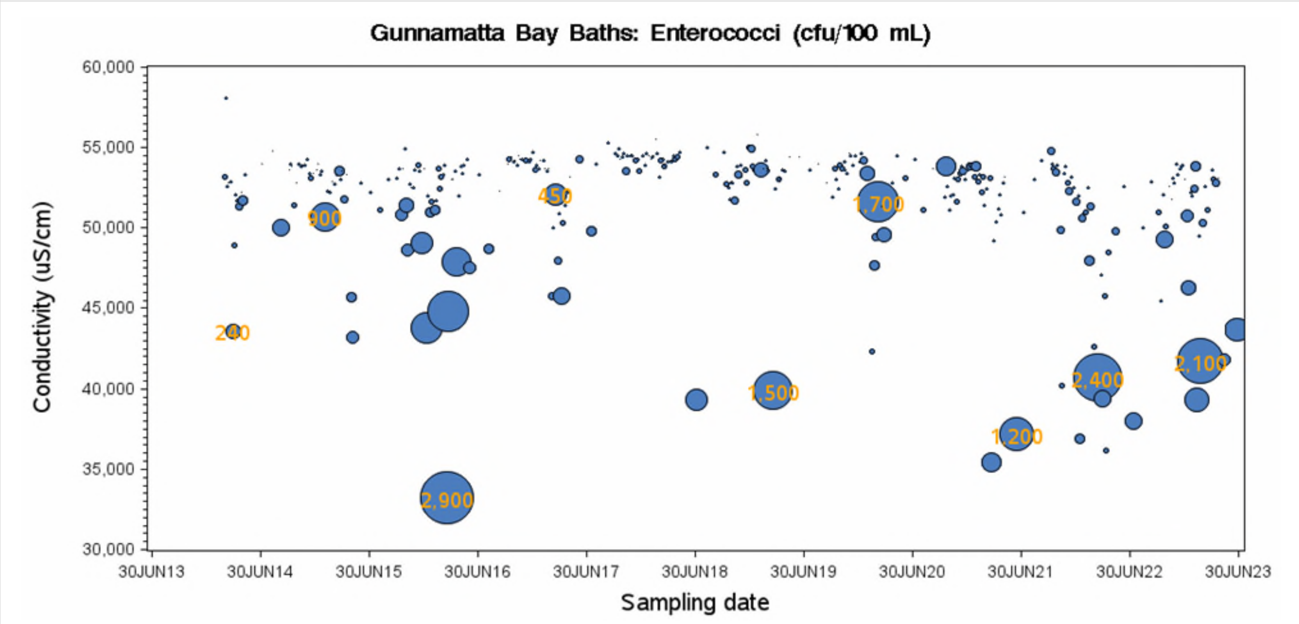
30JUN21
30JUN22
30JUN23
Sampling date
900
630
780
460
540
600
380


Jibbon Beach: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
1,300
600
240
300
360
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date

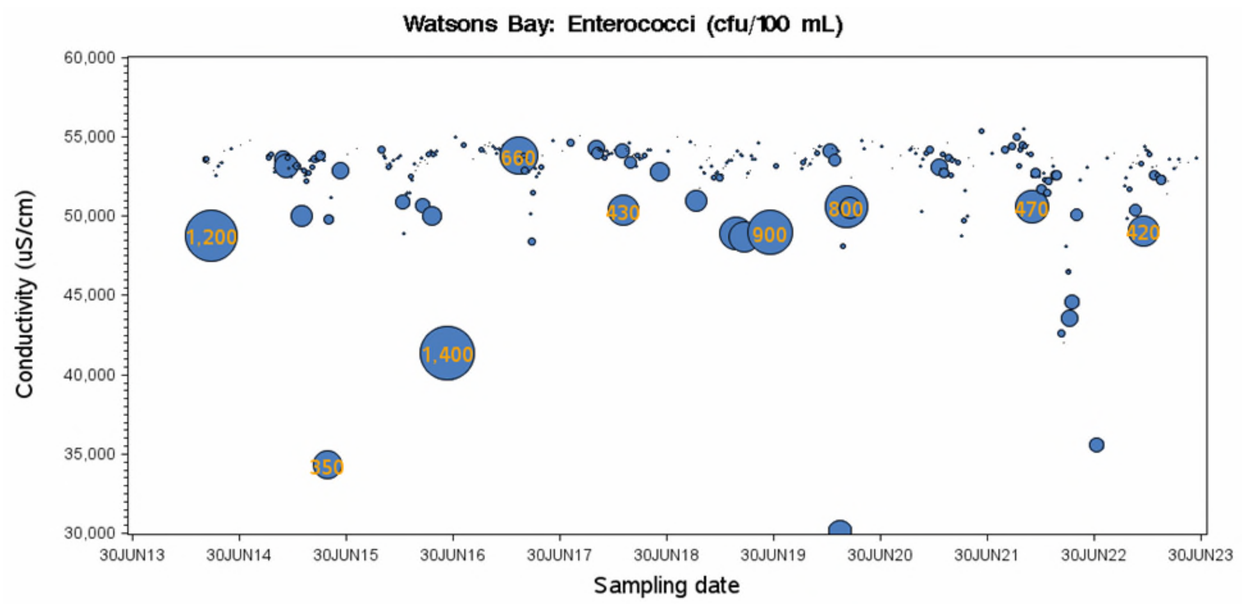

Horderns Beach: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
350
250
1,100
960
870
660
300
240
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date

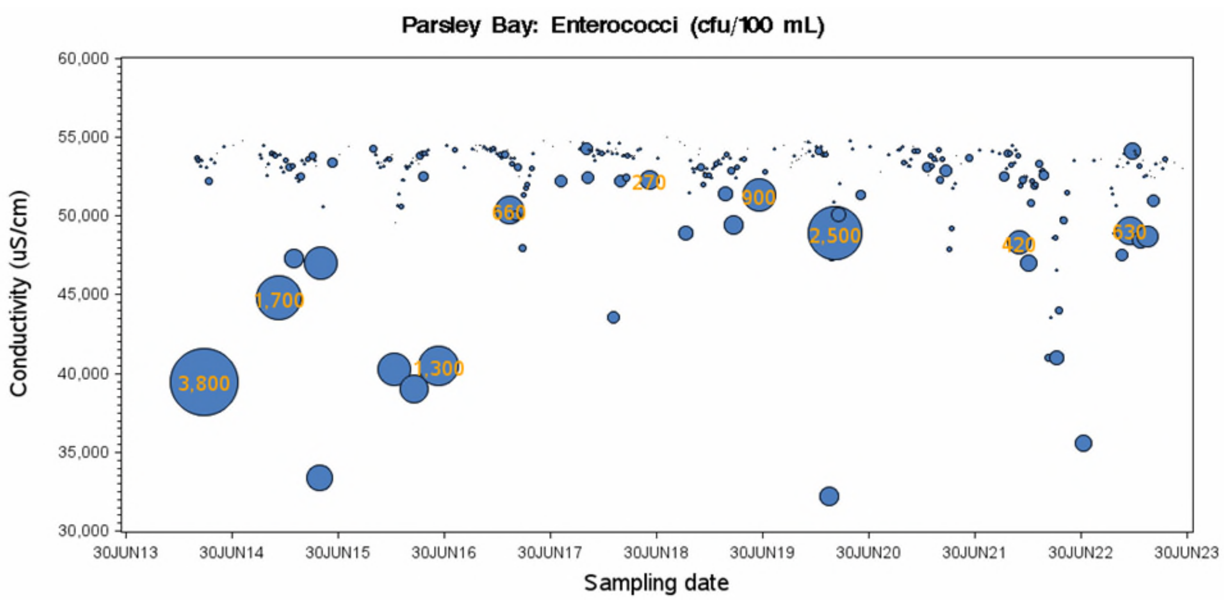

Lilli Pilli Baths: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
480
420
280
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date

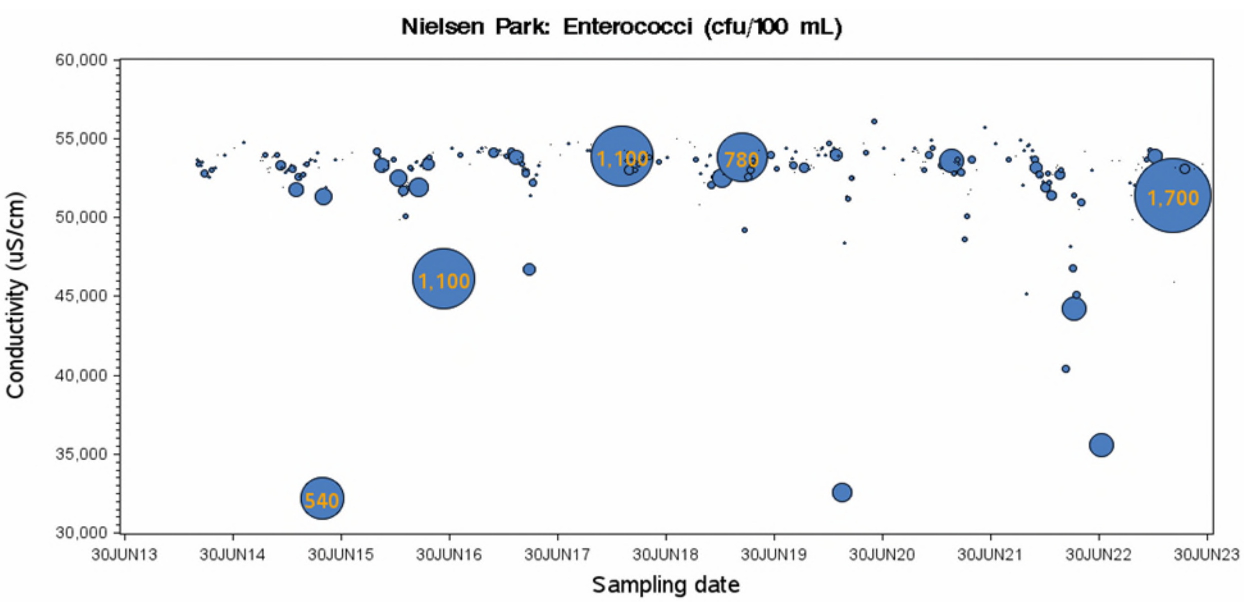

Gymea Bay Baths: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date
2,400
1,300
2,700
660
870
1,300
380
340
300

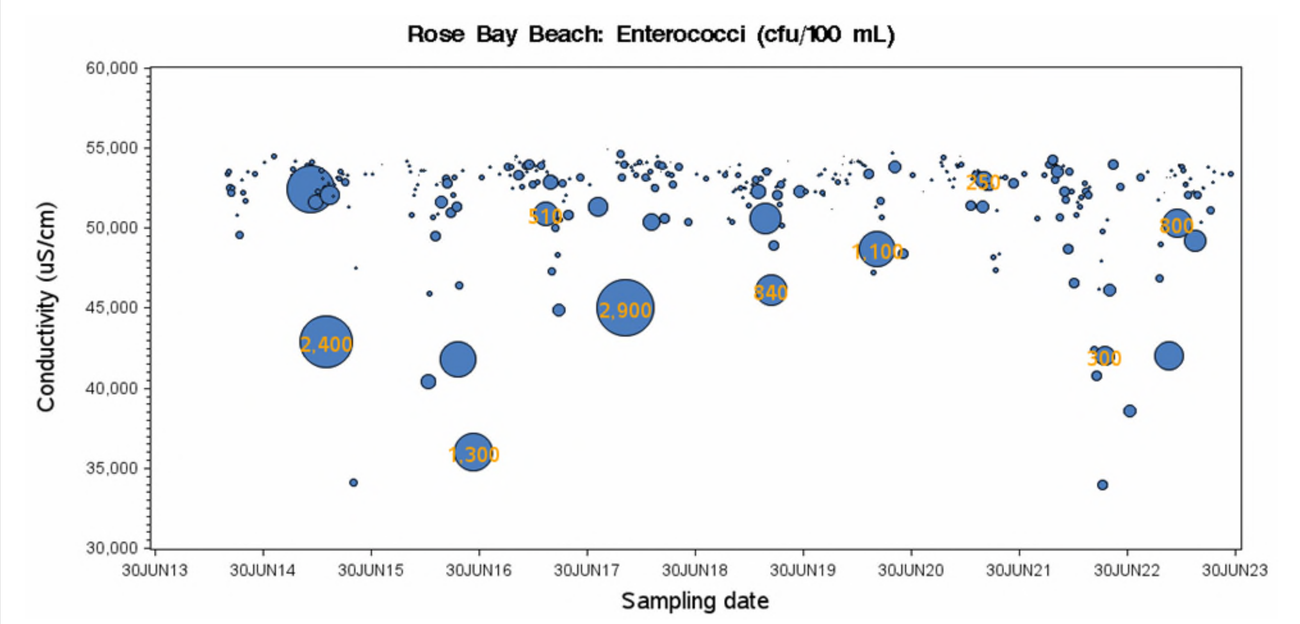

Gunnamatta Bay Baths: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date
240
900
450
2,900
1,500
1,700
1,200
2,400
2,100

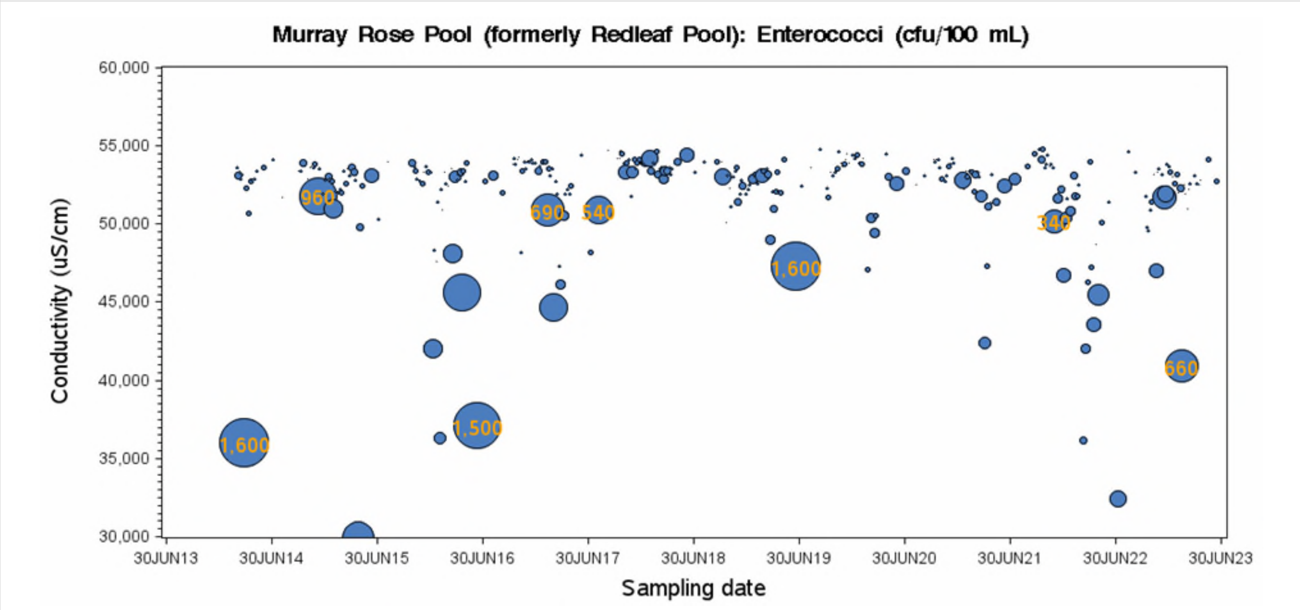
Sydney Harbour and Estuaries: Port Jackson

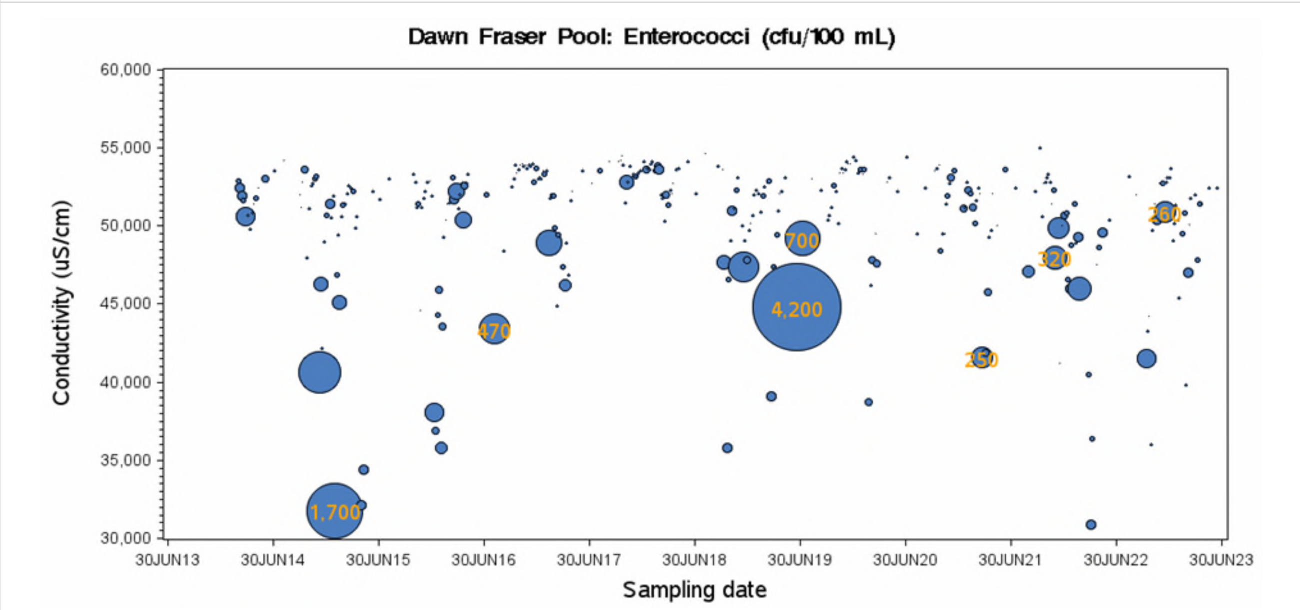


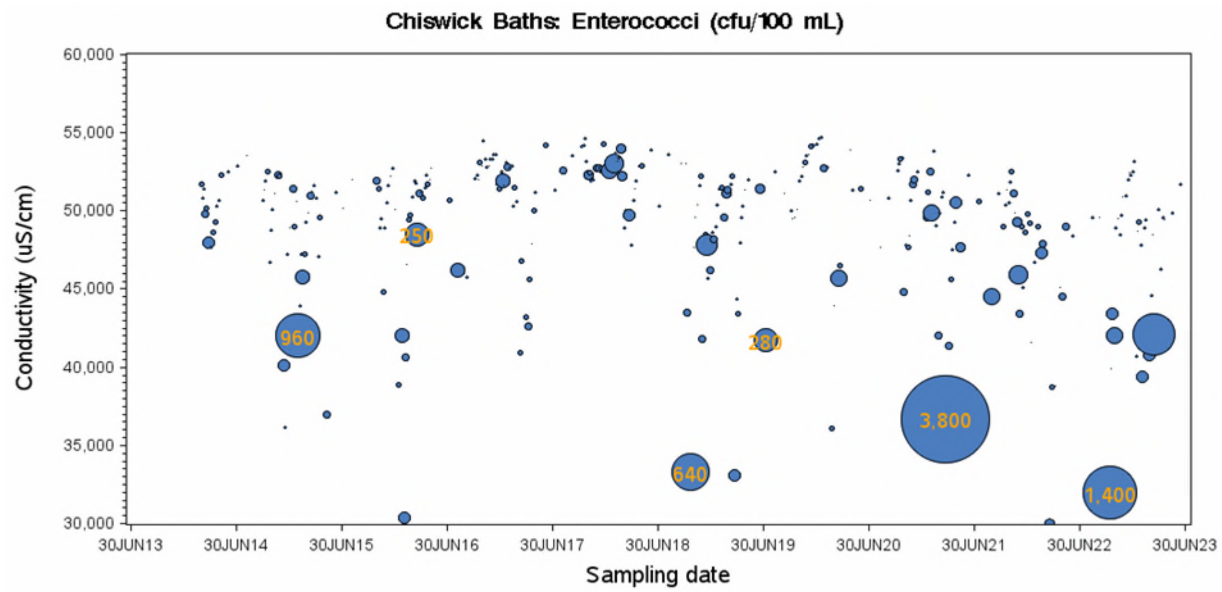


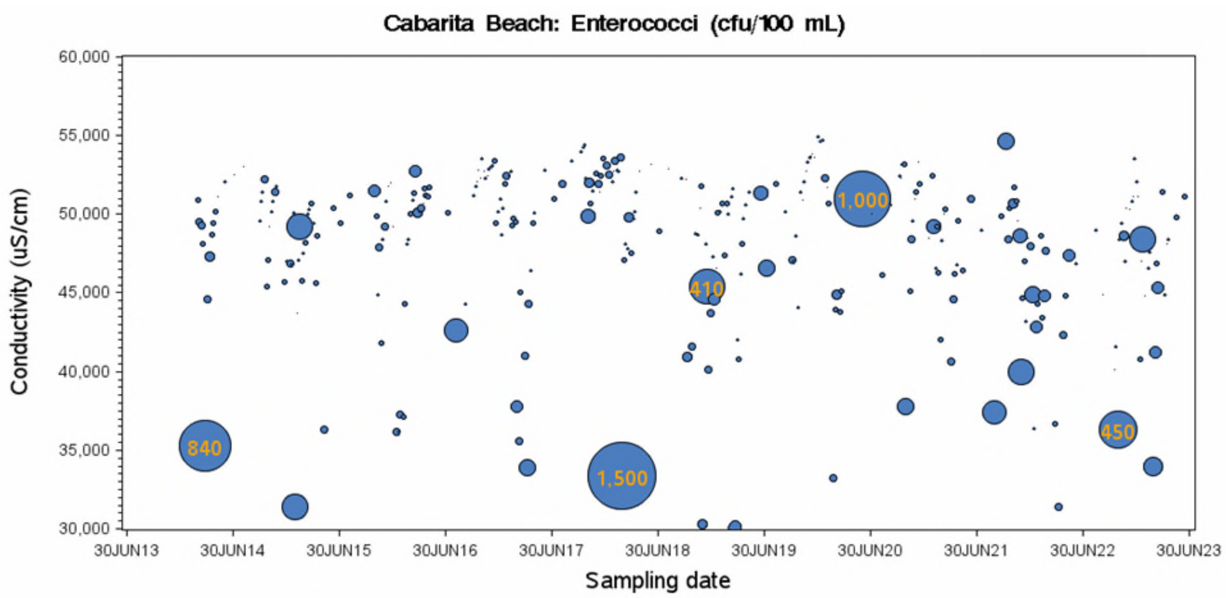


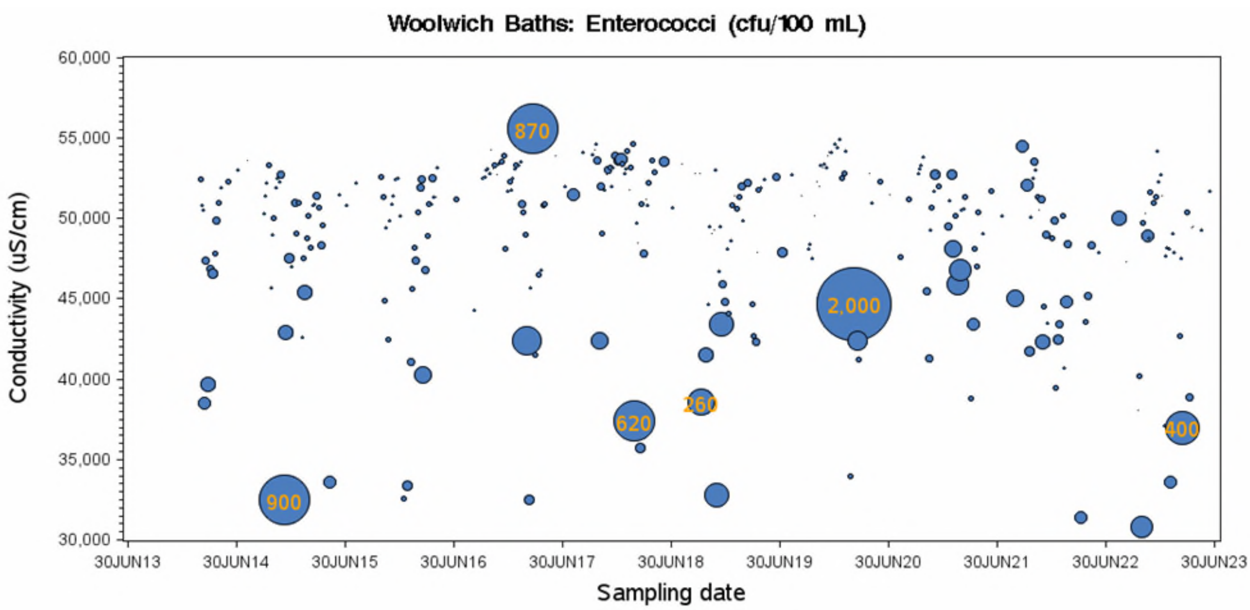

Rose Bay Beach: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date
2,400
1,300
510
2,900
840
1,100
250
300
800

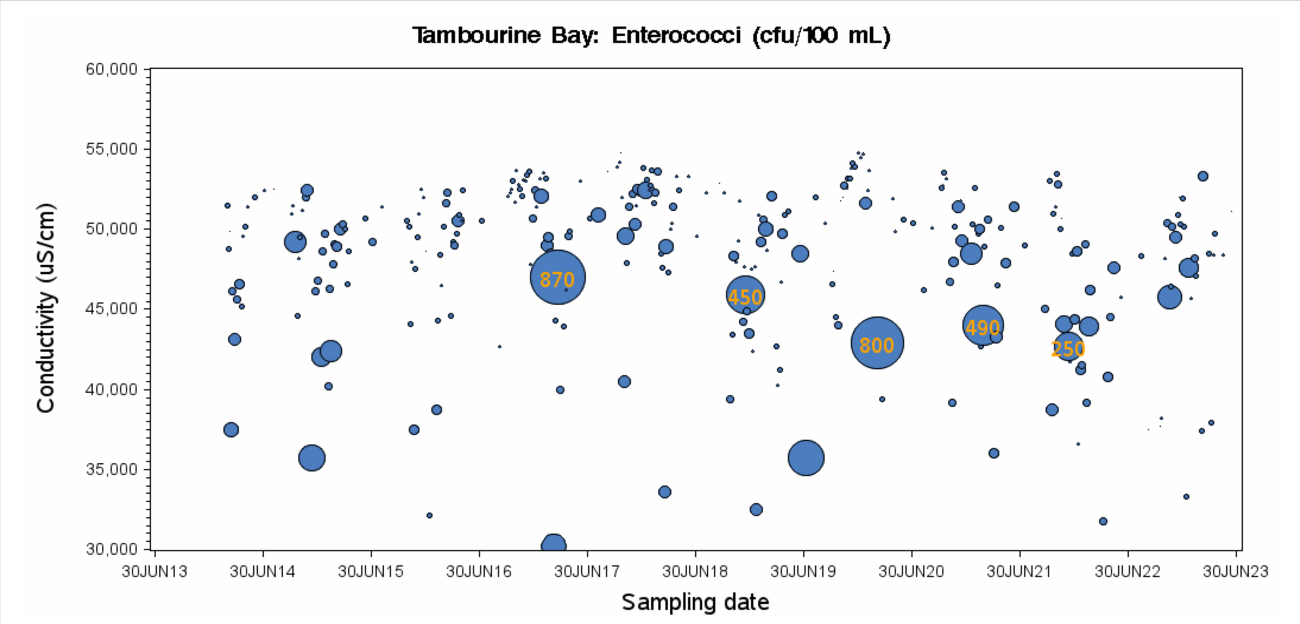

Murray Rose Pool (formerly Redleaf Pool): Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date
1,600
960
1,500
690
540
1,600
340
660

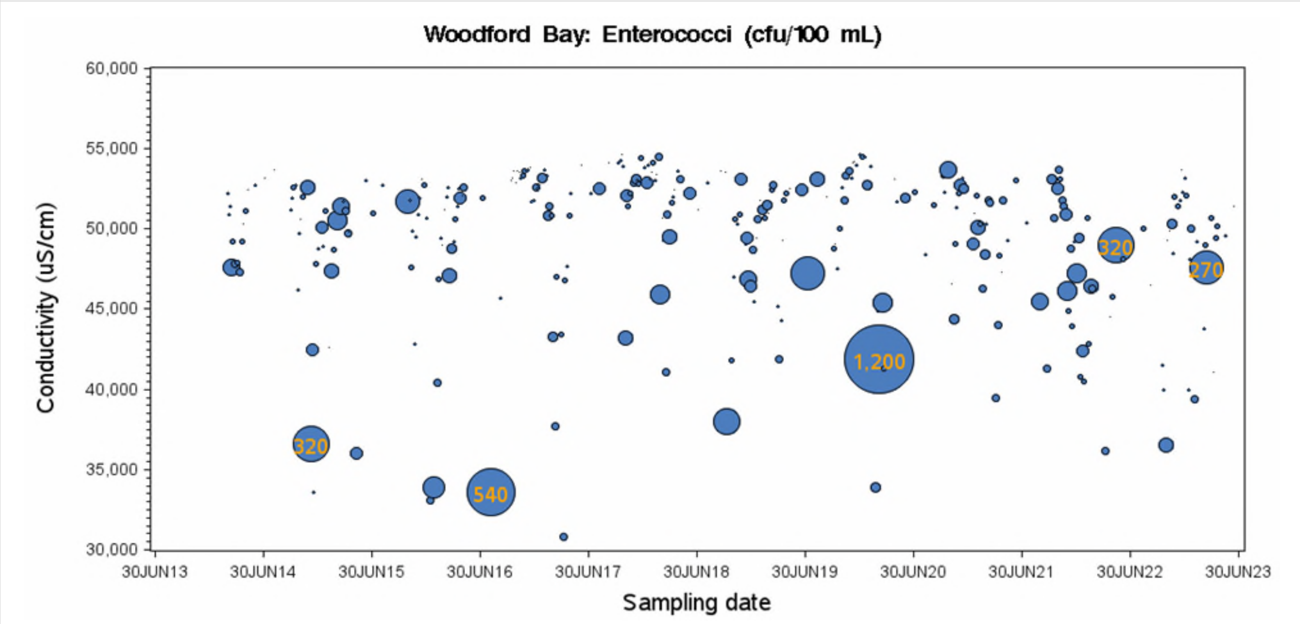

Dawn Fraser Pool: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date
1,700
470
700
4,200
250
320
260

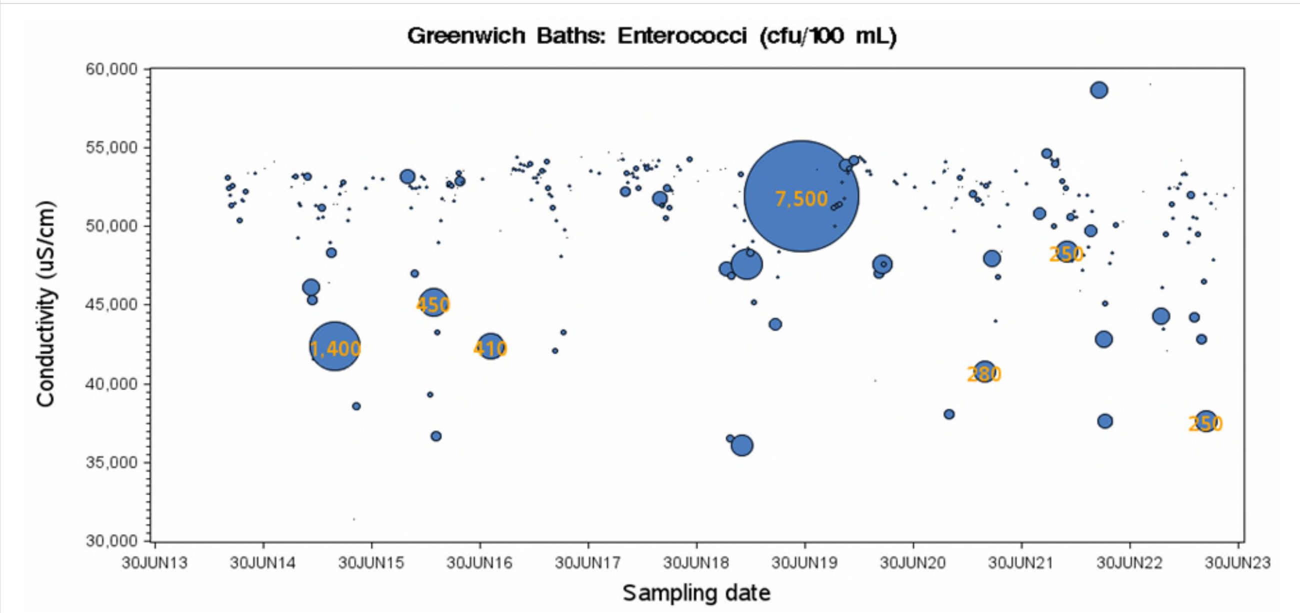

Chiswick Baths: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date
250
960
280
640
3,800
1,400

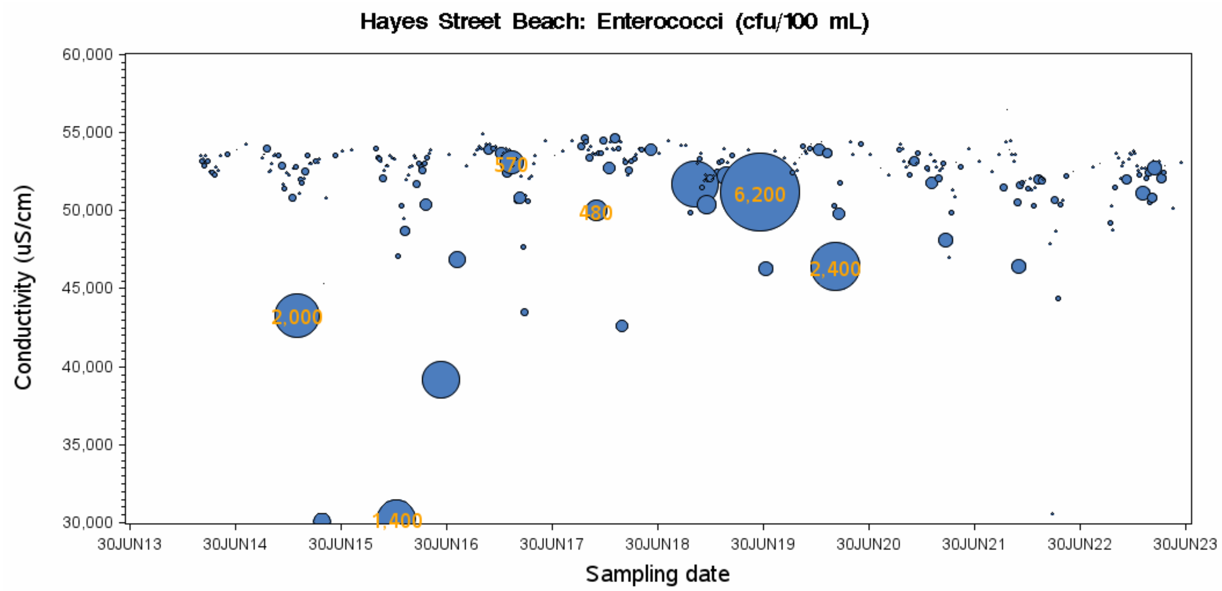

Cabarita Beach: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date
1,000
410
840
1,500
450


Woolwich Baths: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date
870
2,000
260
620
400
900

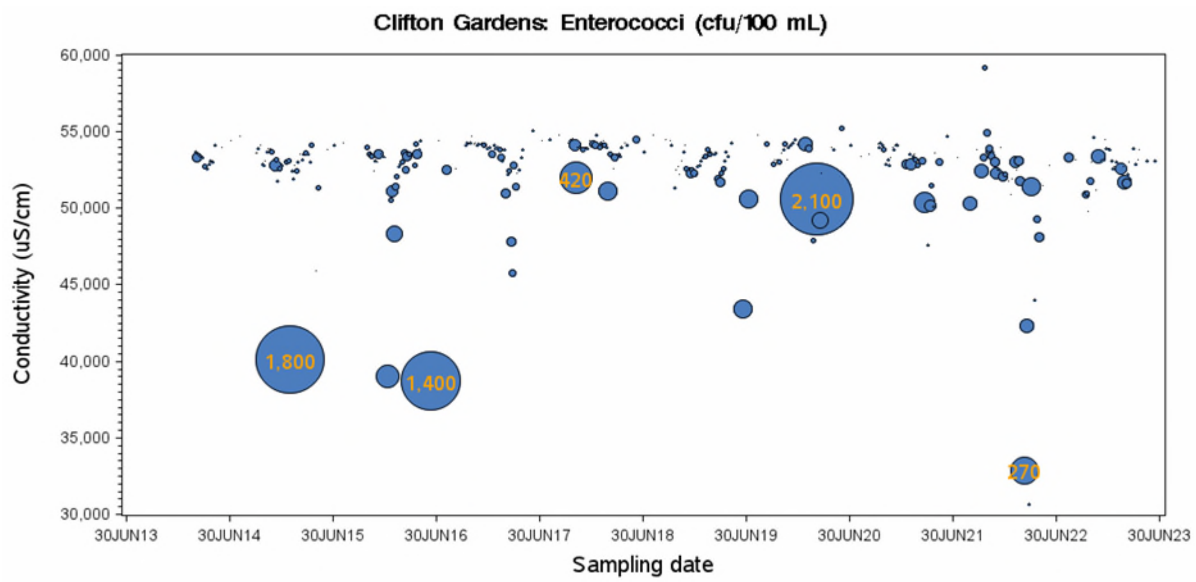

Tambourine Bay: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date
870
450
800
490
250


Woodford Bay: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date
320
270
1,200
320
540

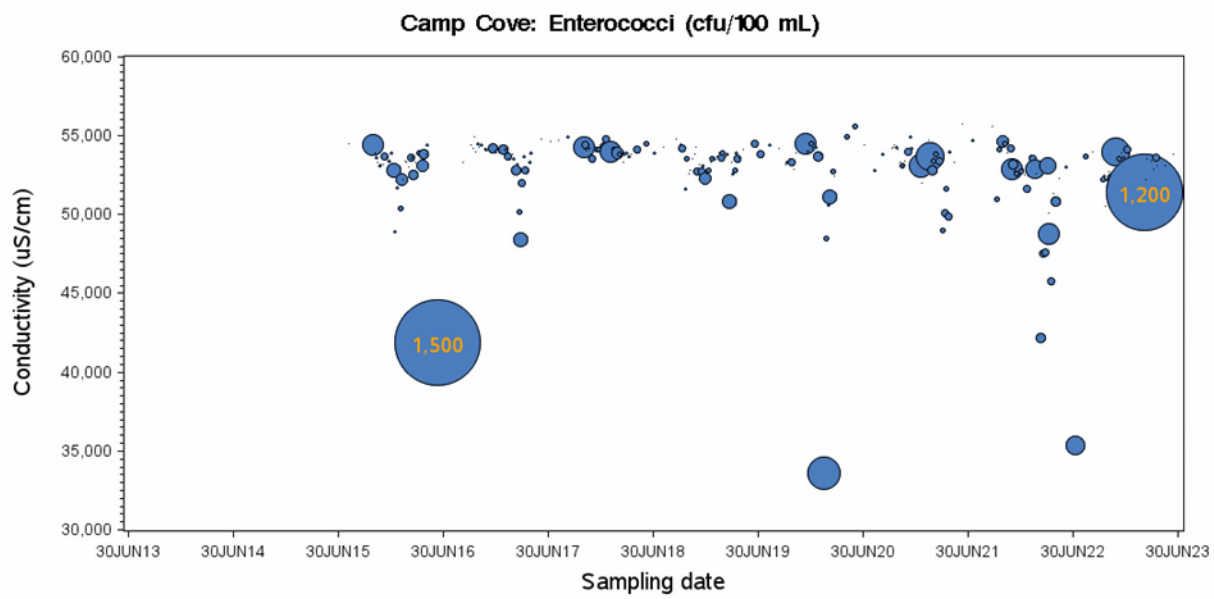

Greenwich Baths: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date
7,500
250
450
1,400
410
380
250



Hayes Street Beach: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
570
480
6,200
2,400
2,000
1,400
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date

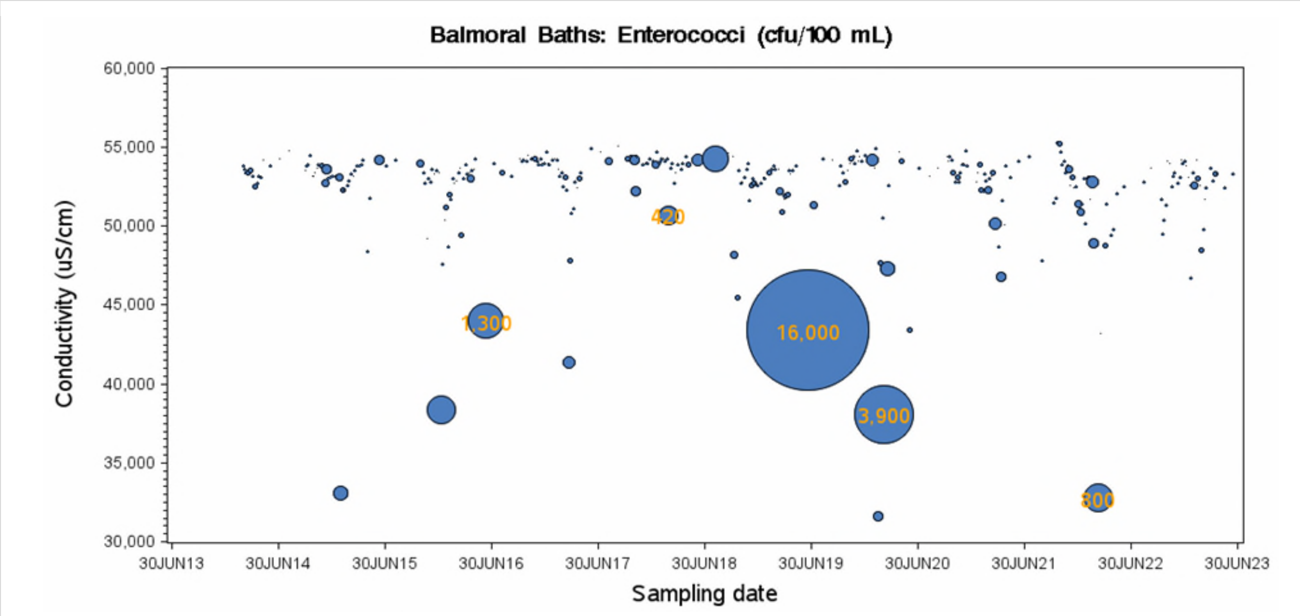


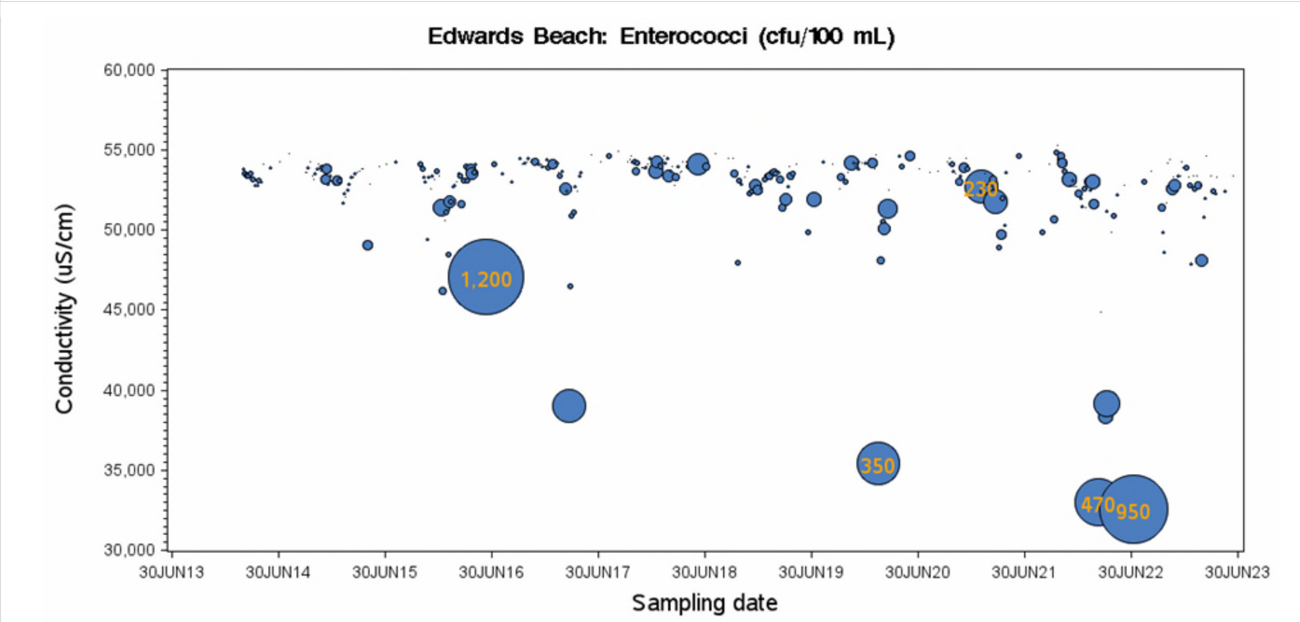
Clifton Gardens: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
420
2,100
1,800
1,400
270
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date

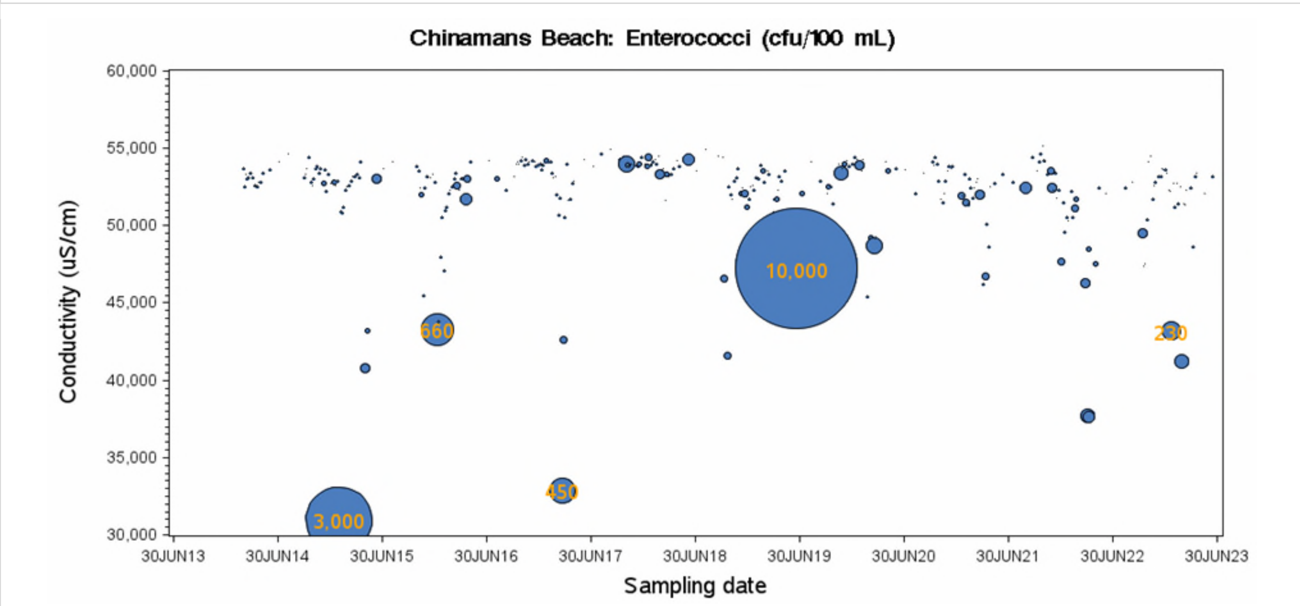


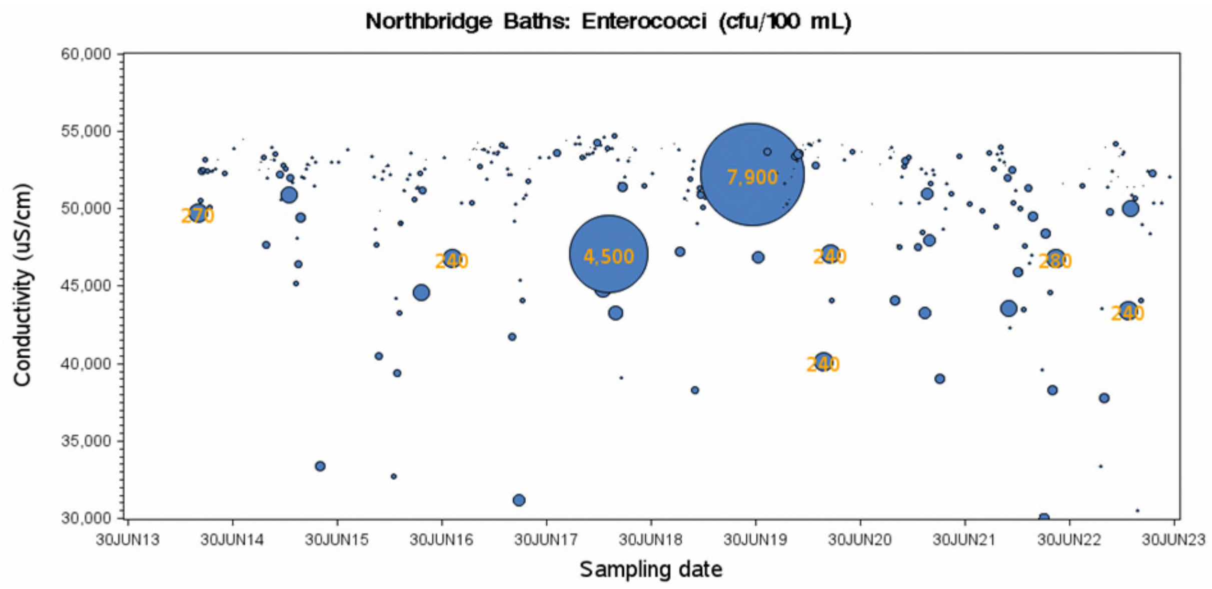
Camp Cove: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
1,200
1,500
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date

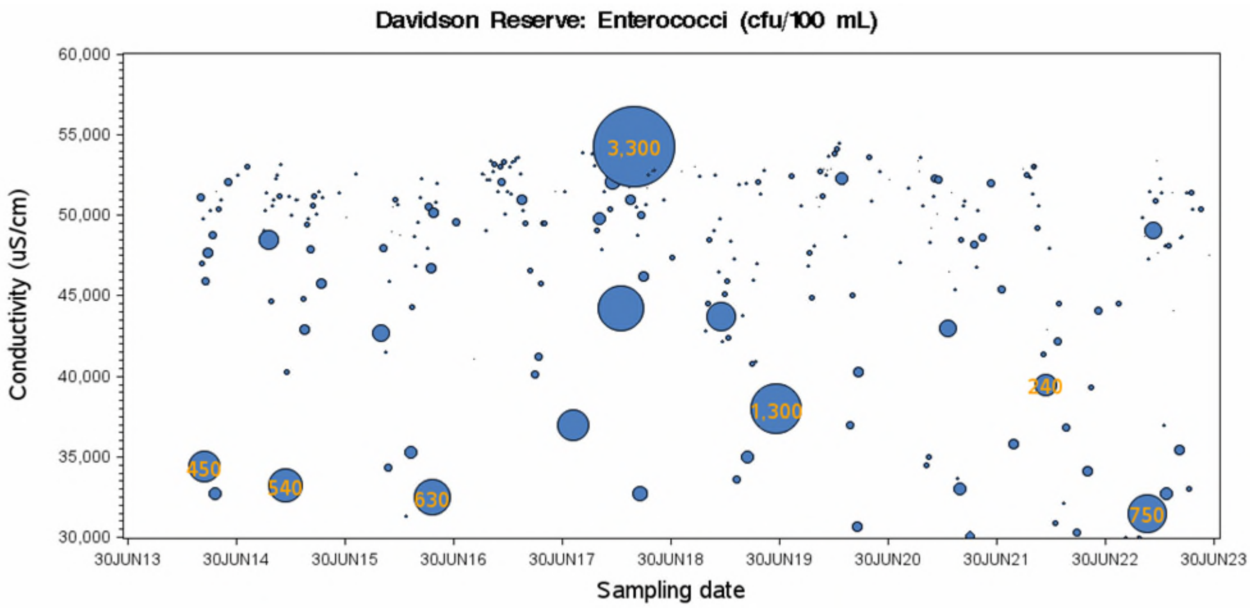
Sydney Harbour and Estuaries: Middle Harbour

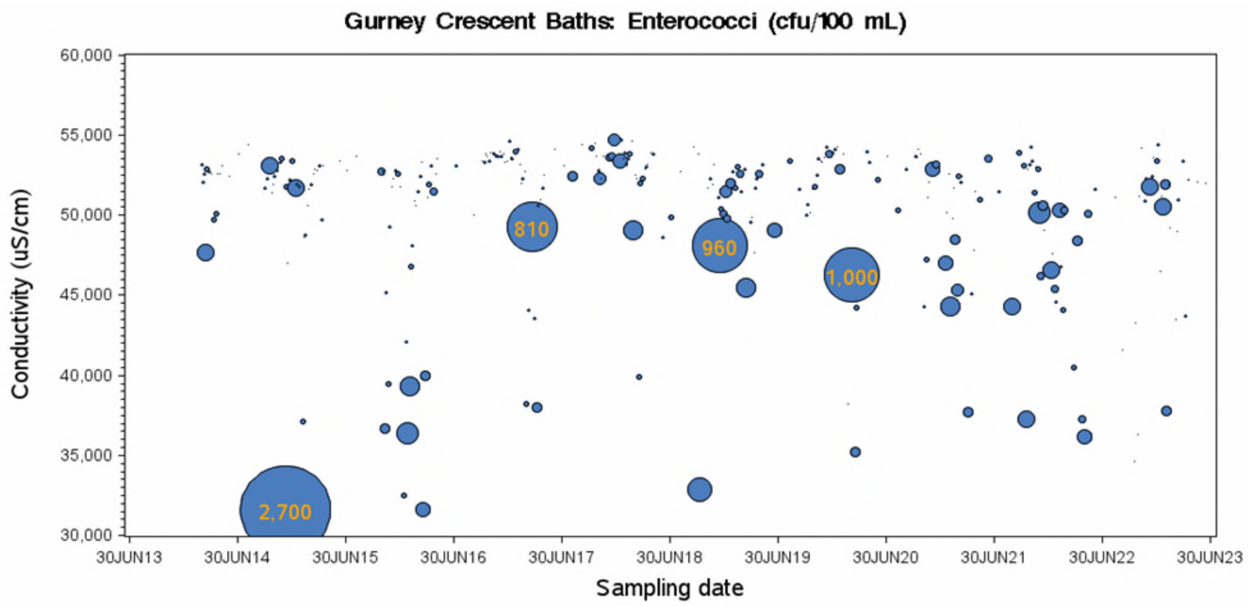


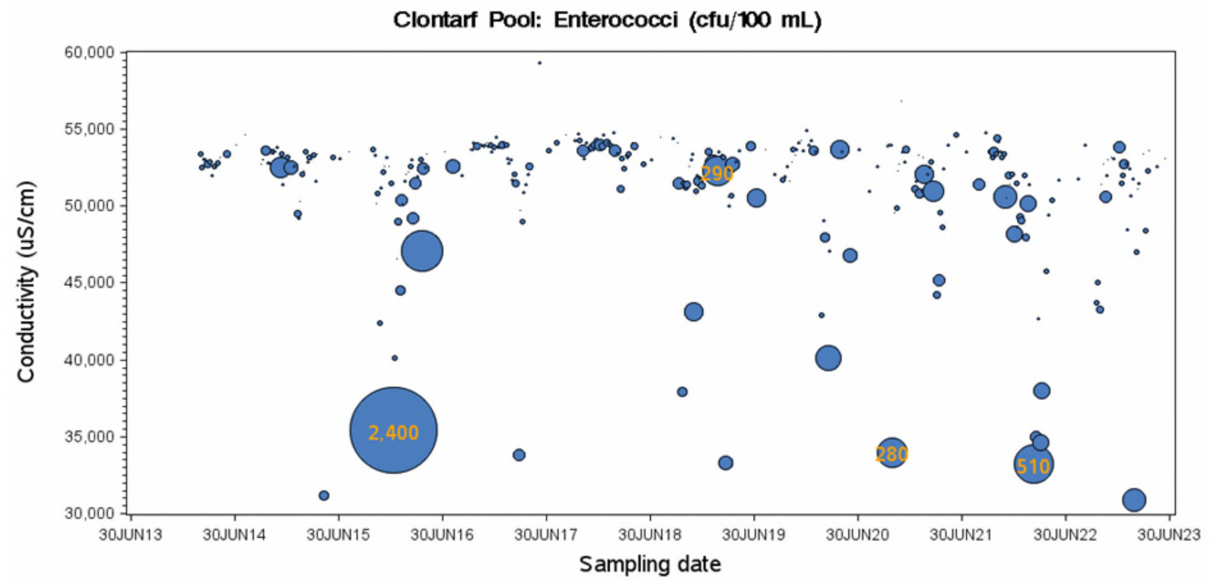


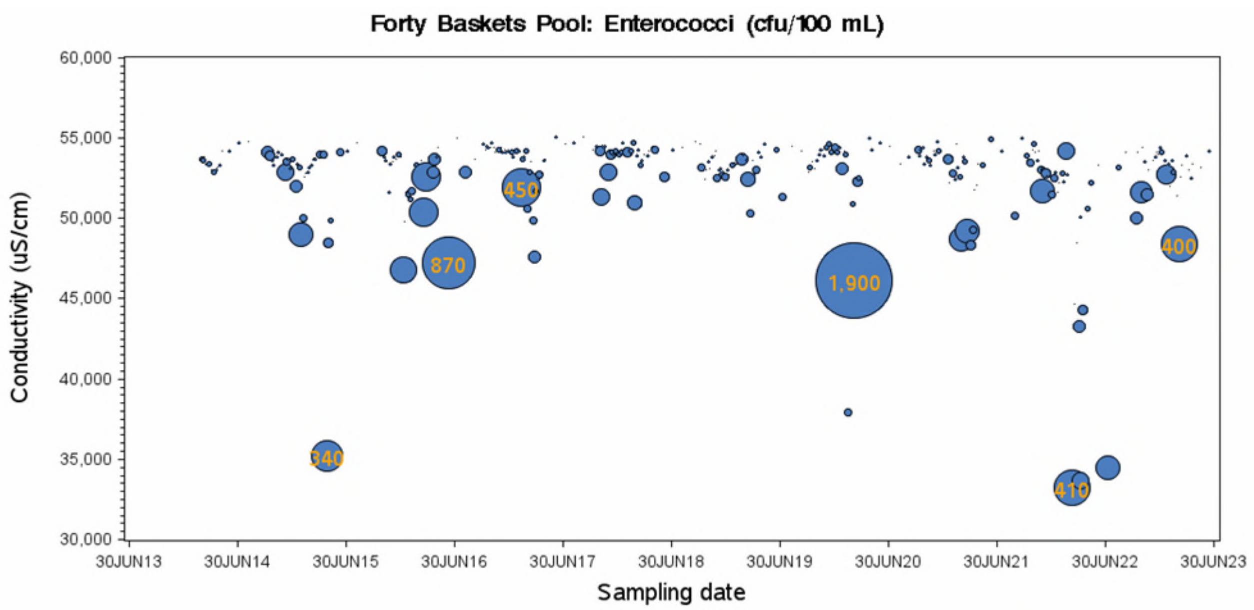


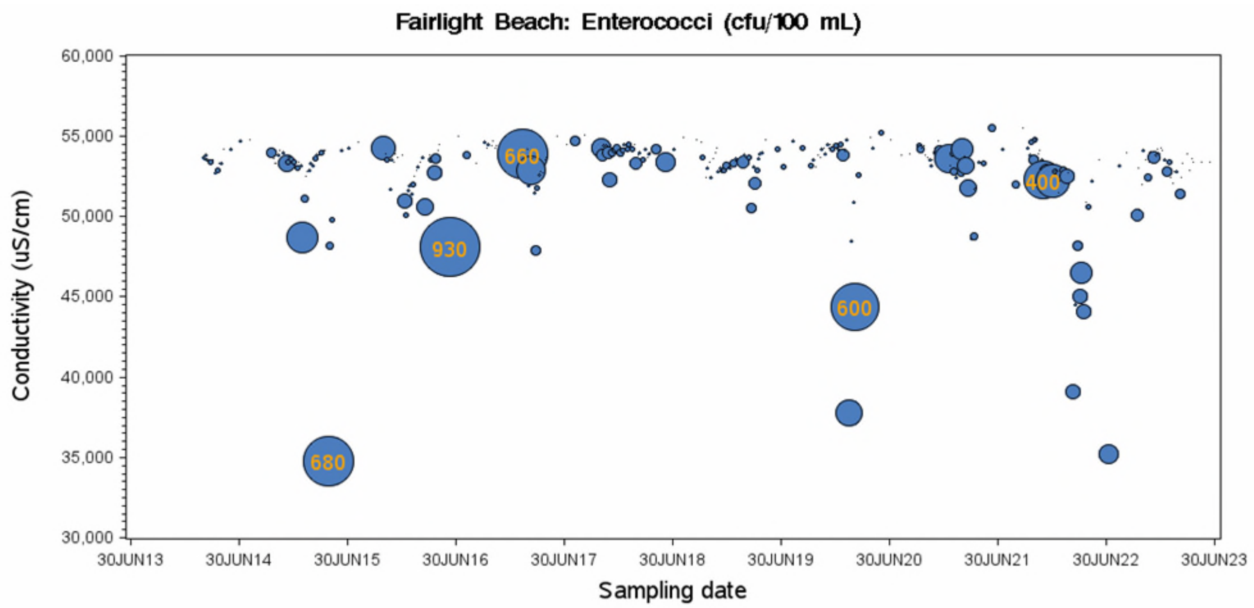

Northbridge Baths: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
Sampling date
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
270
240
4,500
7,900
240
280
240
240

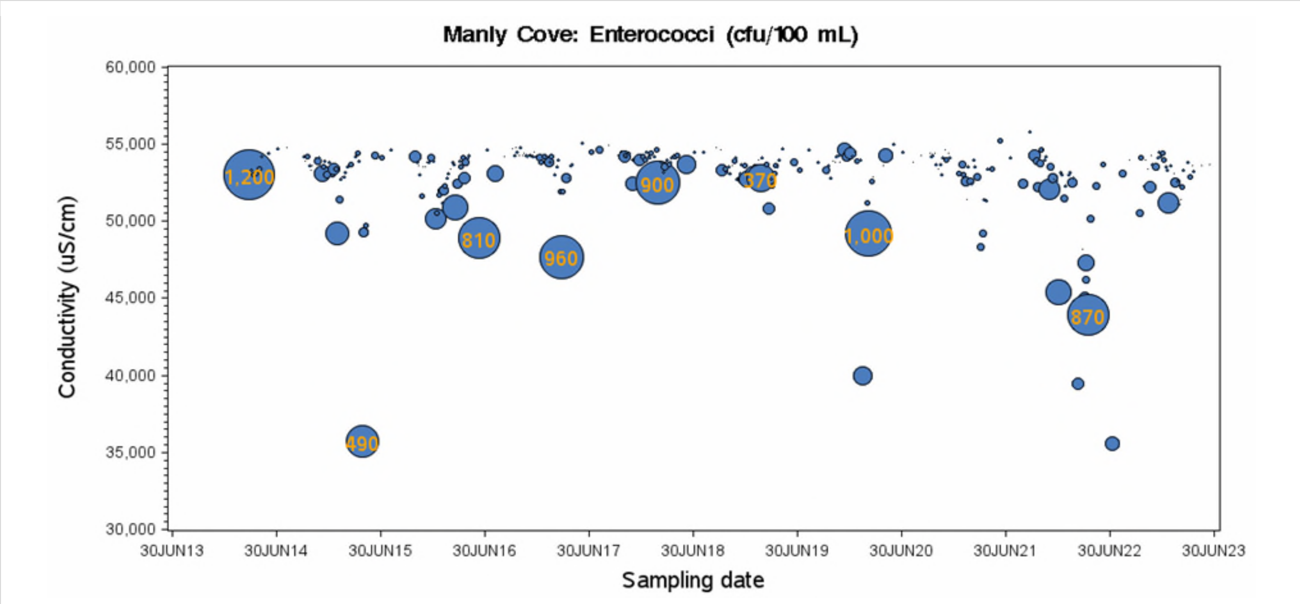

Davidson Reserve: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
Sampling date
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
3,300
1,300
240
450
540
630
750

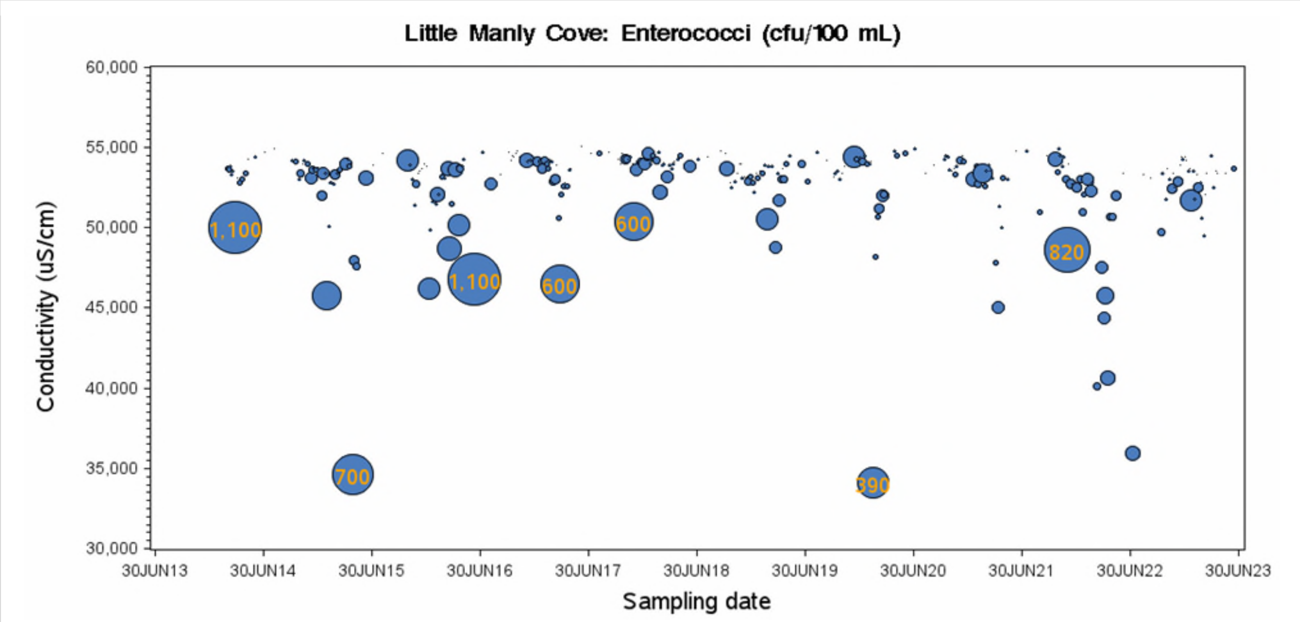

Gurney Crescent Baths: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
Sampling date
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
810
960
1,000
2,700


Clontarf Pool: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
2,400
290
280
510
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date

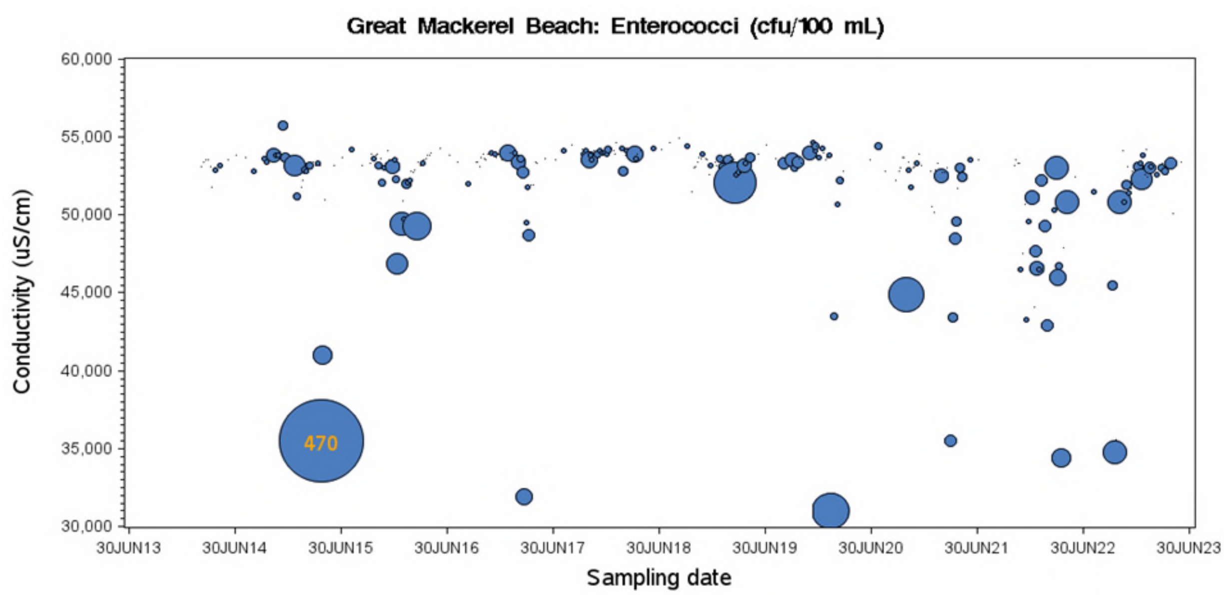

Forty Baskets Pool: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
450
870
1,900
400
340
410
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date

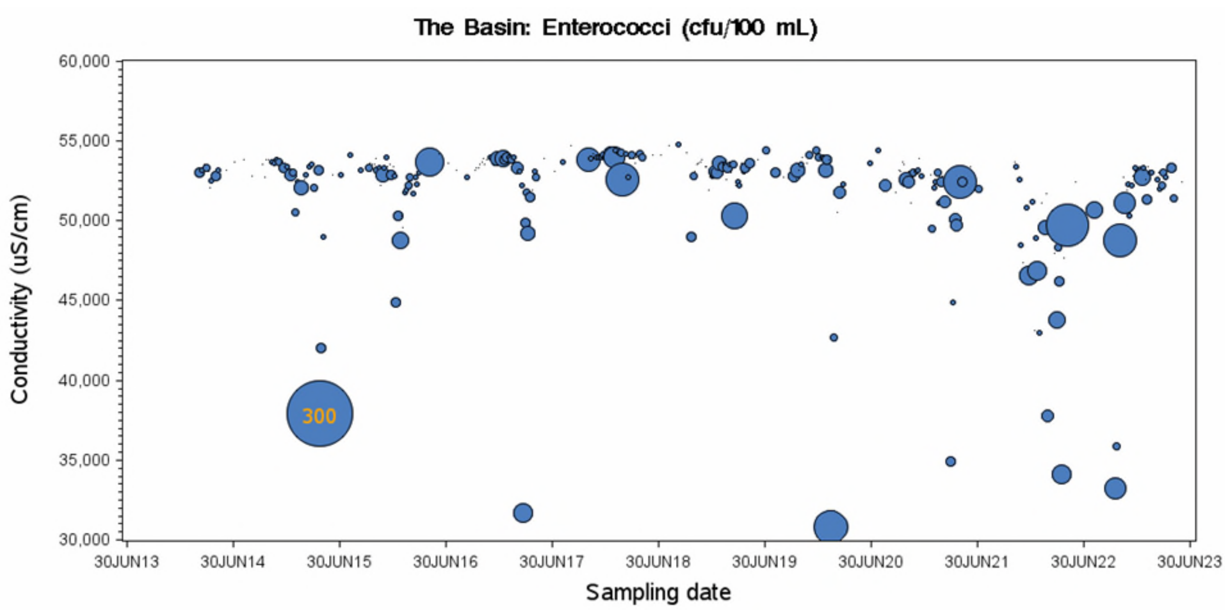

Fairlight Beach: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
660
400
930
600
680
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date

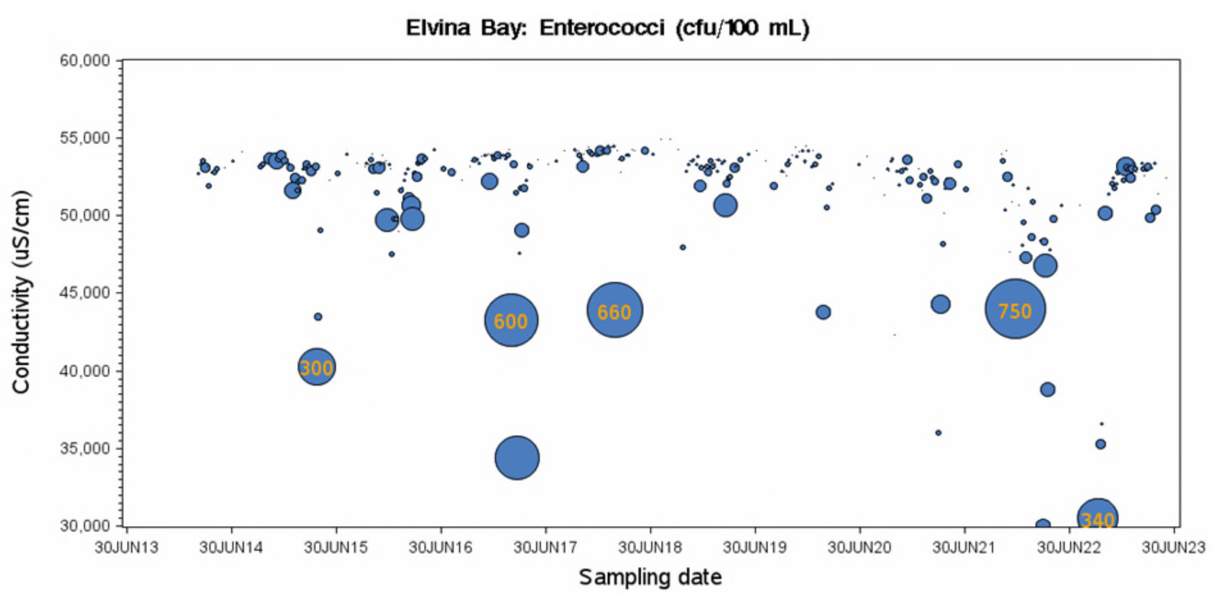

Manly Cove: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
Sampling date
60,000
55,000
50,000
45,000
40,000
35,000
30,000
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
1,200
490
810
960
900
870
1,000
870

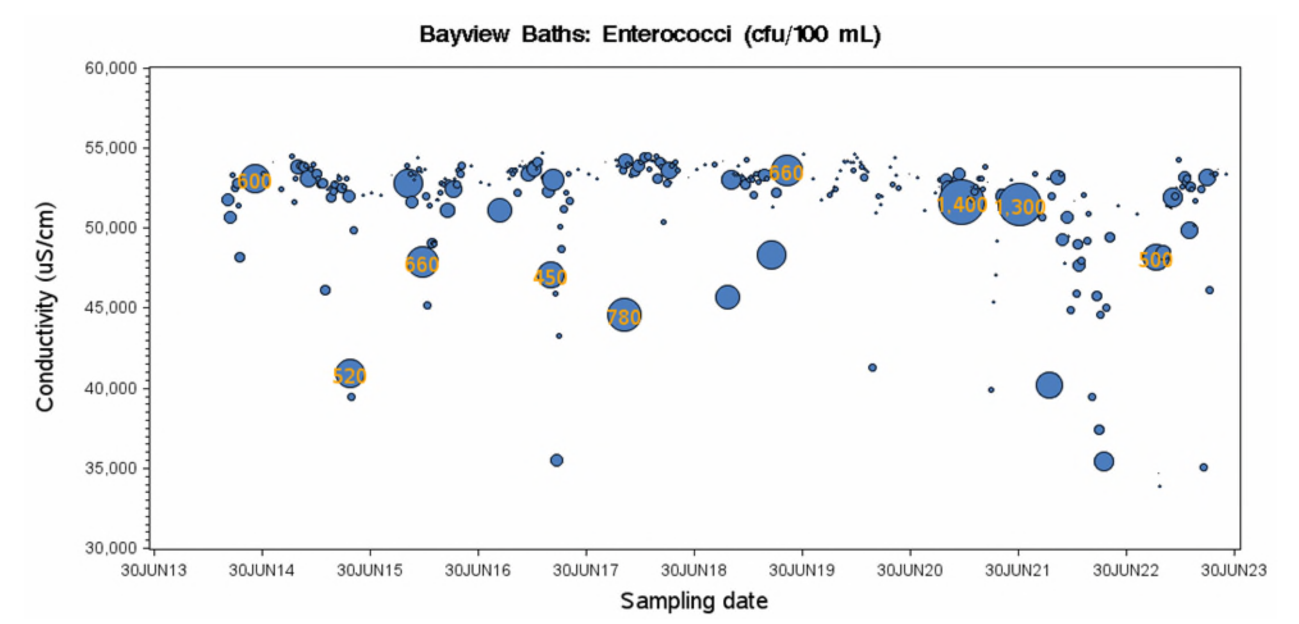

Little Manly Cove: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
Sampling date
60,000
55,000
50,000
45,000
40,000
35,000
30,000
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
1,100
700
1,100
600
600
390
820

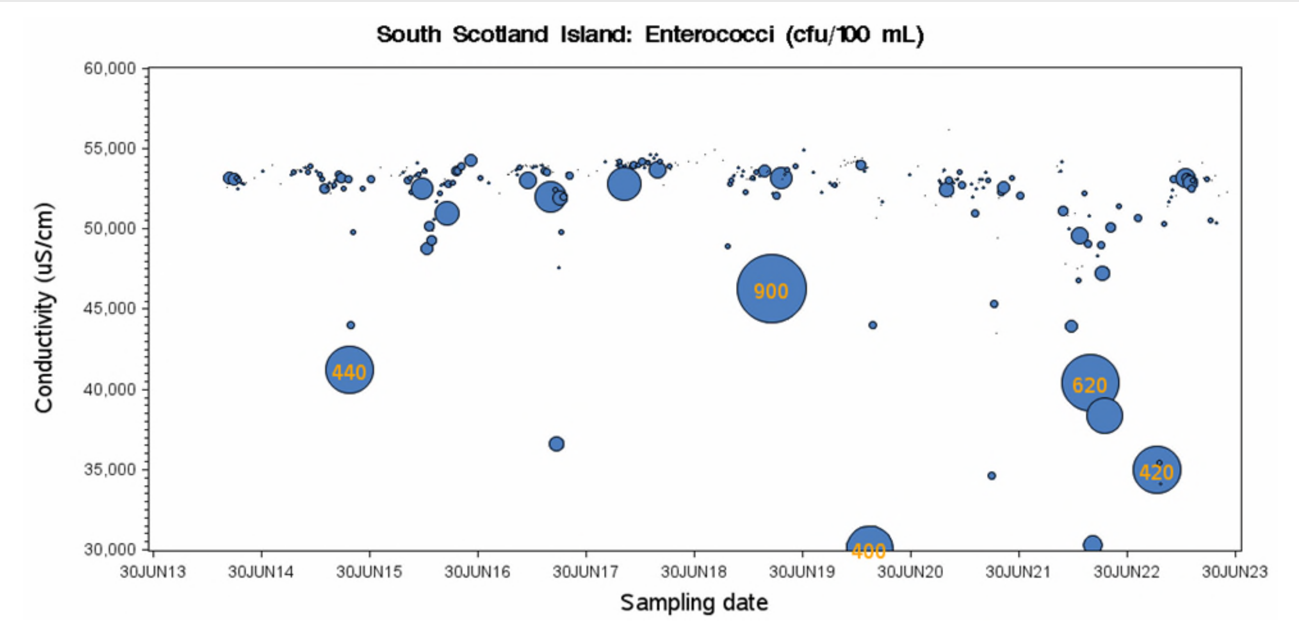
Sydney Harbour and Estuaries: Pittwater

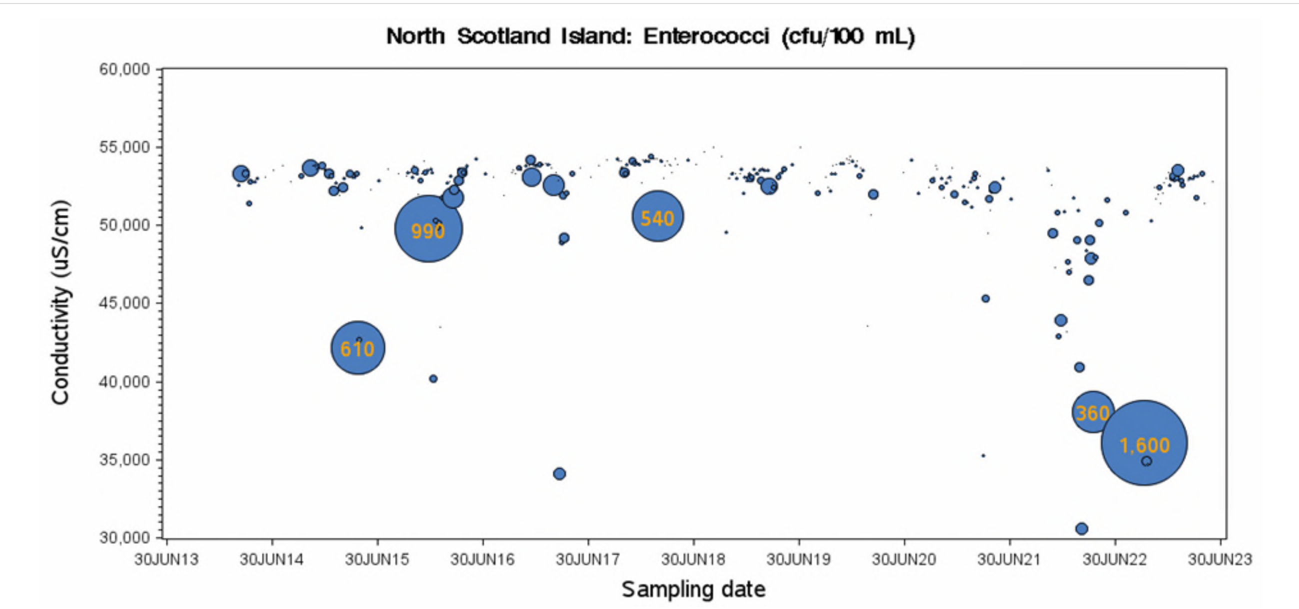


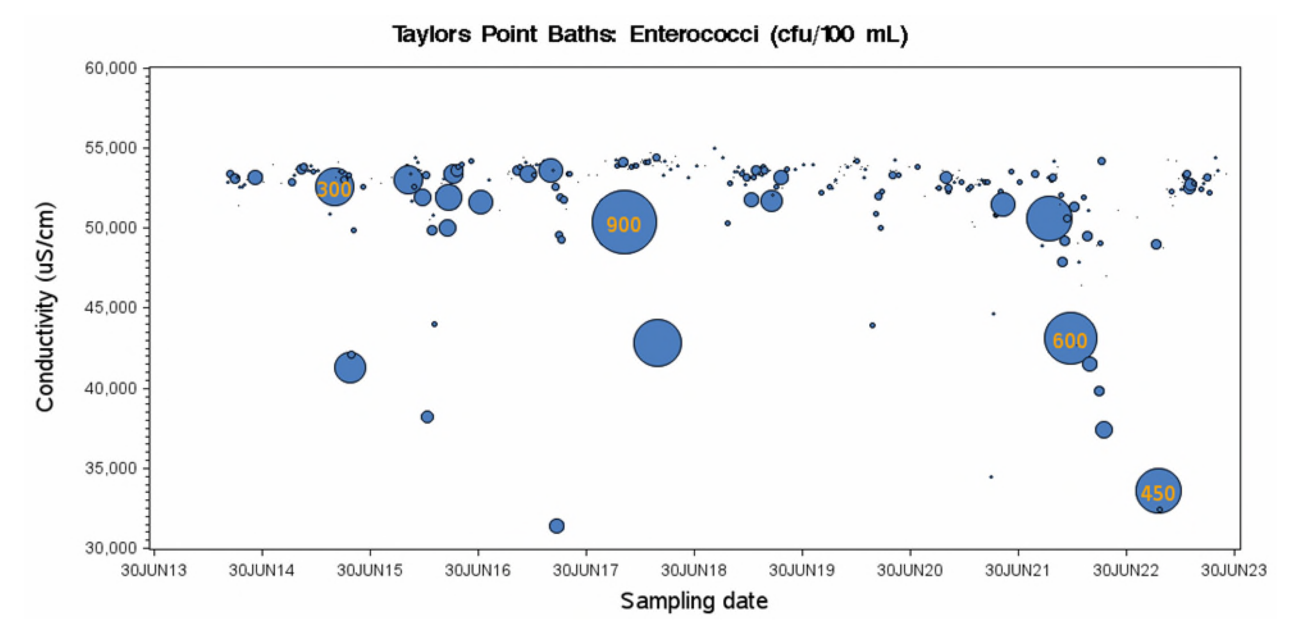




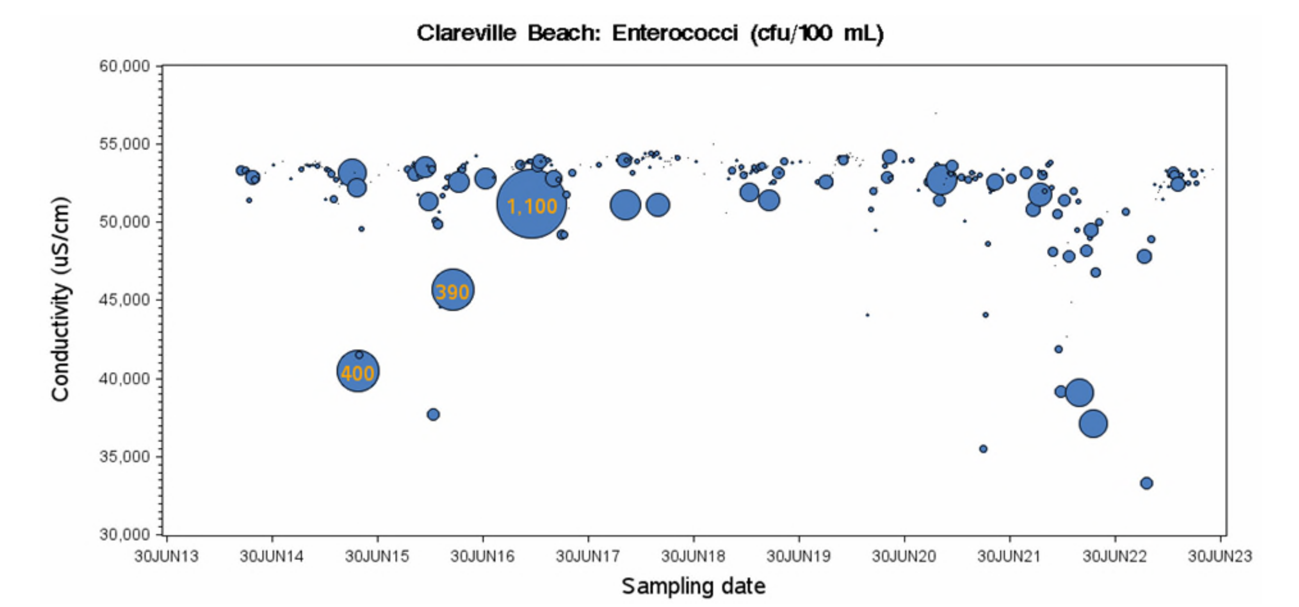

Bayview Baths: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
600
660
450
780
520
660
1,400
1,300
500
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date


South Scotland Island: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
900
440
620
420
400
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date

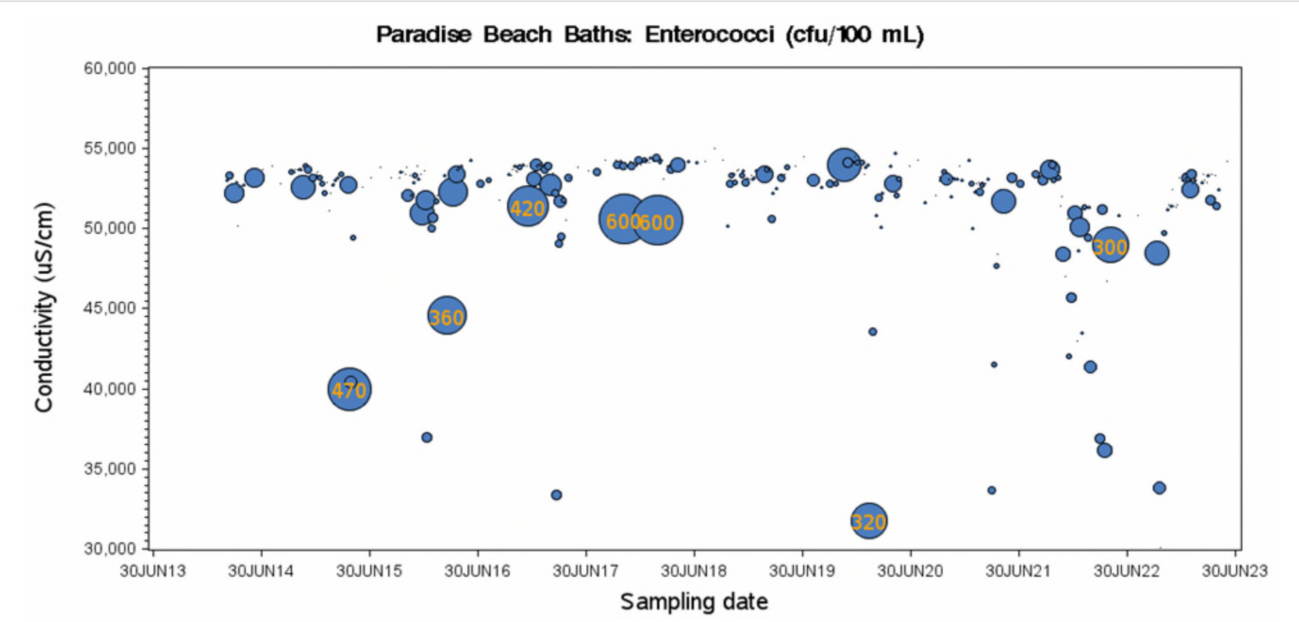

North Scotland Island: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
990
540
610
360
1,600
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date



Taylors Point Baths: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
300
900
600
450
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date



Clareville Beach: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
1,100
390
400
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date



Paradise Beach Baths: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
420
600
600
300
360
470
320
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date

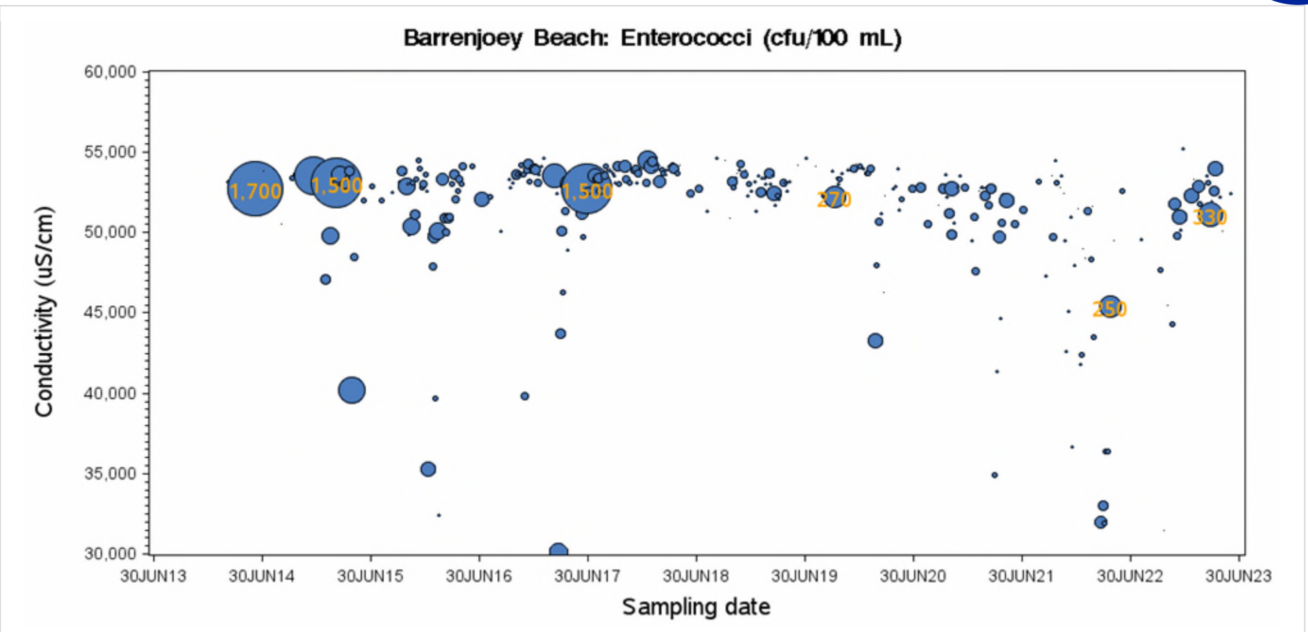

Barrenjoey Beach: Enterococci (cfu/100 mL)
Conductivity (uS/cm)
60,000
55,000
50,000
45,000
40,000
35,000
30,000
1,700
1,500
1,500
270
250
330
30JUN13
30JUN14
30JUN15
30JUN16
30JUN17
30JUN18
30JUN19
30JUN20
30JUN21
30JUN22
30JUN23
Sampling date

Table G-1. Short-listed dry weather *Enterococci* exceptions data (≥35 cfu/100mL) based on catchment rainfall condition (2022-23) (72hr rain ≤ 2mm)

Name	Date	Enterococci (cfu/100mL)	Conductivity (µS/cm)	72 hours rain(mm)	Station Number	Rainfall Station Name
Barrenjoey Beach	23-Nov-22	82	51800	0	66141	Mona Vale Golf Club
	23-Mar-23	330	51100	0.8	66141	
	11-Apr-23	140	54000	0	66141	
Bayview Baths	31-Oct-22	130	48500	0	66141	Mona Vale Golf Club
	02-Dec-22	240	51900	0	66141	
	13-Jan-23	46	52900	0.4	66141	
	23-Mar-23	74	53000	0.8	66141	
Bellambi Beach	20-Mar-23	61	53500	0.4	68228	Bellambi AWS
	01-Apr-23	61	53900	2	68228	
	12-Jun-23	41	54500	0	68228	
Bilarong Reserve	13-Jan-23	66	43600	0	66126	Collaroy (Long Reef Golf Club)
	11-Apr-23	180	34600	0	66126	
	26-May-23	40	46900	0	66126	
	14-Jun-23	110	49400	0.6	66126	
	20-Jun-23	90	49800	0	66126	
Bilgola Beach	23-Nov-22	120	54100	0	66141	Mona Vale Golf Club
	23-Mar-23	300	53900	0.8	66141	
Boat Harbour	13-Sep-22	35	53000	0	66058	Sans Souci (Public School)
	09-Dec-22	70	54300	0	66058	
	05-Jan-23	1600	53203	2	66058	
	02-Feb-23	62	53300	2	66058	
Bondi Beach	09-Jun-23	37	54300	1	66098	Rose Bay (Royal Sydney Golf Club)
Boyd's Beach	07-Apr-23	38	54100	0.2	68242	Kiama (Bombo Headland)
Brighton Le Sands Baths	09-Mar-23	130	51900	0	66037	Sydney Airport AMO
	21-Mar-23	240	51700	0.4	66037	
	18-Apr-23	110	53100	0.2	66037	
Bronte Beach	22-Mar-23	110	54100	0.6	66052	Randwick (Randwick St)
Cabarita Beach	03-Mar-23	48	41200	0.6	66048	Concord (Brays Rd)
Camp Cove	24-Nov-22	160	54000	0	66098	Rose Bay (Royal Sydney Golf Club)
Carss Point Baths	25-Nov-22	41	50100	0	66058	Sans Souci (Public School)
	07-Dec-22	70	51100	2	66058	
	23-Dec-22	110	49800	1	66058	
	30-Dec-22	300	47500	0	66058	
	06-Jan-23	100	54200	2	66058	
	16-Feb-23	200	49100	0	66058	
	27-Feb-23	46	42400	0	66058	
	18-Apr-23	90	54100	0	66058	
Chiswick Baths	14-Mar-23	900	42100	1.9	66034	Abbotsford (Blackwall Point Rd)

Name	Date	Enterococci (cfu/100mL)	Conductivity (µS/cm)	72 hours rain(mm)	Station Number	Rainfall Station Name
Clifton Gardens	24-Nov-22	62	53400	0	66006	Sydney Botanic Gardens
Clontarf Pool	04-Jan-23	43	53800	1	66011	Chatswood Bowling Club
Congwong Bay	11-Jan-23	56	52400	0	66037	Sydney Airport AMO
Coniston Beach	17-Jul-22	270	52800	0	68228	Bellambi AWS
Coogee Beach	13-Sep-22	330	54000	1.4	66052	Randwick (Randwick St)
	10-Nov-22	290	53900	0	66052	
	13-Apr-23	120	53400	0.8	66052	
Corrimal Beach	20-Mar-23	70	52900	0.4	68228	Bellambi AWS
Dawn Fraser Pool	12-Dec-22	260	50900	0.2	66214	Sydney (Observatory Hill)
Dolls Point Baths	23-Dec-22	39	54200	1	66058	Sans Souci (Public School)
	30-Dec-22	270	35400	0	66058	
	06-Jan-23	88	54600	2	66058	
	03-Feb-23	120	50400	0	66058	
	16-Feb-23	68	48500	0	66058	
	27-Feb-23	100	43500	0	66058	
	09-Mar-23	800	49200	0	66058	
	21-Mar-23	230	51400	0	66058	
	31-Mar-23	130	44100	2	66058	
	18-Apr-23	110	51400	0	66058	
Elouera Beach	09-Dec-22	46	54400	0	66058	Sans Souci (Public School)
	11-Jan-23	35	53500	0	66058	
	21-Feb-23	92	52400	2	66058	
Elvina Bay	31-Oct-22	46	50200	0	66141	Mona Vale Golf Club
Foreshores Beach	23-Dec-22	220	54300	0.8	66037	Sydney Airport AMO
	03-Feb-23	630	51400	0	66037	
	27-Feb-23	250	48200	0.8	66037	
	09-Mar-23	38	47300	0	66037	
	18-Apr-23	46	53100	0.2	66037	
Frenchmans Bay	07-Sep-22	50	54000	1	66037	Sydney Airport AMO
	23-Dec-22	420	53400	0.8	66037	
	18-Jan-23	78	53100	0	66037	
	03-Feb-23	140	52400	0	66037	
	27-Feb-23	80	52000	0.8	66037	
	09-Mar-23	66	51200	0	66037	
	18-Apr-23	38	53100	0.2	66037	
Freshwater Beach	06-Feb-23	150	54600	0	66126	Collaroy (Long Reef Golf Club)
Great Mackerel Beach	13-Oct-22	35	34800	1.2	66141	Mona Vale Golf Club
	31-Oct-22	38	50800	0	66141	
Greenhills Beach	09-Dec-22	49	54200	0	66058	Sans Souci (Public School)
	11-Jan-23	120	53800	0	66058	
	22-Mar-23	46	54000	0	66058	
	28-Mar-23	120	52000	13	66058	

Name	Date	Enterococci (cfu/100mL)	Conductivity (µS/cm)	72 hours rain(mm)	Station Number	Rainfall Station Name
	14-Mar-23	250	37600	0.6	66214	
Gunnamatta Bay Baths	06-Jan-23	170	50770	2	66058	Sans Souci (Public School)
	12-Jan-23	200	46300	0	66058	
	30-Jan-23	48	52400	0	66058	
	03-Feb-23	110	53800	0	66058	
	27-Feb-23	42	50300	0	66058	
	12-Apr-23	46	52800	0	66058	
Gymea Bay Baths	01-Dec-22	42	51800	0	66176	Audley (Royal National Park)
	30-Dec-22	62	52100	2	66176	
	03-Feb-23	210	50900	0	66176	
	27-Feb-23	150	39900	1	66176	
	06-Apr-23	39	44600	2	66176	
Hayes Street Beach	14-Mar-23	200	52700	0.6	66214	Sydney (Observatory Hill)
Horderns Beach	30-Dec-22	51	52000	2	66176	Audley (Royal National Park)
	03-Feb-23	100	54800	0	66176	
Jew Fish Bay Baths	18-Jan-23	200	43000	0	66148	Peakhurst Golf Club
	03-Feb-23	72	40100	0	66148	
Jibbon Beach	03-Feb-23	100	54300	0	66176	Audley (Royal National Park)
Kiama Beach	20-Mar-23	44	53700	0.6	68252	Kiama (Brighton St)
Kyeemagh Baths	25-Nov-22	55	52700	0	66037	Sydney Airport AMO
	23-Dec-22	50	54300	0.8	66037	
	03-Feb-23	300	51600	0	66037	
	16-Feb-23	48	52400	1.4	66037	
	09-Mar-23	58	50100	0	66037	
	21-Mar-23	250	53800	0.4	66037	
	18-Apr-23	320	53400	0.2	66037	
Lake Illawarra Entrance Lagoon	10-Oct-22	74	40000	0	68246	Blackbutt (Tammar Place)
	26-Nov-22	170	53500	0	68246	
	13-Jan-23	43	53100	0	68246	
	06-Feb-23	65	53300	0	68246	
	18-Feb-23	92	51600	0	68246	
	20-Mar-23	460	52000	0	68246	
Little Bay Beach	22-Nov-22	140	54400	0.8	66037	Sydney Airport AMO
Malabar Beach	22-Nov-22	350	54400	0.8	66052	Randwick (Randwick St)
	05-Dec-22	37	54300	1.2	66052	
	17-Jan-23	70	53900	0.6	66052	
Monterey Baths	06-Jan-23	86	54600	2	66058	Sans Souci (Public School)
	03-Feb-23	110	53100	0	66058	
	21-Mar-23	350	51700	0	66058	
	18-Apr-23	64	53400	0	66058	
Murray Rose Pool	12-Dec-22	330	51700	1	66098	Rose Bay (Royal Sydney Golf Club)
	16-Dec-22	200	51900	1.2	66098	

Name	Date	Enterococci (cfu/100mL)	Conductivity (µS/cm)	72 hours rain(mm)	Station Number	Rainfall Station Name
	08-Feb-23	37	52300	1.2	66098	
Narrabeen Lagoon (Birdwood Park)	02-Mar-23	130	39300	1.2	66141	Mona Vale Golf Club
Nielsen Park	04-Jan-23	56	53900	2	66098	Rose Bay (Royal Sydney Golf Club)
North Cronulla Beach	13-Sep-22	66	54500	0	66058	Sans Souci (Public School)
North Curl Curl Beach	06-Feb-23	78	53700	0	66126	Collaroy (Long Reef Golf Club)
North Wollongong Beach	20-Mar-23	64	53800	0.4	68228	Bellambi AWS
Oatley Bay Baths	25-Nov-22	74	43900	0	66148	Peakhurst Golf Club
	30-Dec-22	66	47900	2	66148	
	16-Feb-23	44	38400	0	66148	
Parsley Bay	12-Dec-22	630	49100	1	66098	Rose Bay (Royal Sydney Golf Club)
	21-Dec-22	200	54100	5.4	66098	
Port Kembla Beach	10-Oct-22	39	50500	0	68246	Blackbutt (Tammar Place)
Ramsgate Baths	06-Jan-23	110	53500	2	66058	Sans Souci (Public School)
	03-Feb-23	96	52400	0	66058	
	21-Mar-23	140	51800	0	66058	
	14-Oct-22	62	46900	1.8	66098	Rose Bay (Royal Sydney Golf Club)
	12-Dec-22	800	50300	1	66098	
	20-Feb-23	60	52100	2	66098	
Sandringham Baths	23-Dec-22	86	52900	1	66058	Sans Souci (Public School)
	27-Feb-23	68	46600	0	66058	
Shelly Beach (Sutherland)	11-Jan-23	56	53700	0	66058	Sans Souci (Public School)
Silver Beach	25-Nov-22	150	53400	0	66058	Sans Souci (Public School)
	12-Jan-23	200	48900	0	66058	
	03-Feb-23	160	54300	0	66058	
	16-Feb-23	78	50800	0	66058	
	12-Apr-23	150	53100	0	66058	
South Cronulla Beach	13-Sep-22	46	54400	0	66058	Sans Souci (Public School)
	22-Nov-22	61	54500	0	66058	
	05-Jan-23	42	52941	2	66058	
	11-Jan-23	41	53700	0	66058	
	21-Feb-23	40	53300	2	66058	
	06-Apr-23	68	54000	1	66058	
South Curl Curl Beach	06-Feb-23	100	54600	0	66126	Collaroy (Long Reef Golf Club)
South Maroubra Beach	05-Dec-22	40	54500	1.2	66052	Randwick (Randwick St)
South Maroubra Rockpool	05-Dec-22	57	54400	1.2	66052	Randwick (Randwick St)
	13-Apr-23	880	47600	0.8	66052	
South Steyne Beach	20-Jun-23	130	53100	0	66126	Collaroy (Long Reef Golf Club)

Name	Date	Enterococci (cfu/100mL)	Conductivity (µS/cm)	72 hours rain(mm)	Station Number	Rainfall Station Name
Taylors Point Baths	13-Oct-22	450	33600	1.2	66141	Mona Vale Golf Club
The Basin	31-Oct-22	80	48800	0	66141	Mona Vale Golf Club
Wanda Beach	16-Aug-22	140	54000	0	66058	Sans Souci (Public School)
	05-Jan-23	52	53117	2	66058	
	21-Feb-23	68	52500	2	66058	
Watsons Bay	12-Dec-22	420	49100	1	66098	Rose Bay (Royal Sydney Golf Club)
Whale Beach	13-Jan-23	37	53600	0.4	66141	Mona Vale Golf Club
Woolwich Baths	14-Mar-23	400	37000	1.9	66034	Abbotsford (Blackwall Point Rd)
Yarra Bay	03-Feb-23	43	52400	0	66037	Sydney Airport AMO

Appendix H: Electronic appendices

Multiple data and data summary files are provided as electronic appendices under the following three categories and type of data/ monitoring programs. Further details on this data and any other supporting data (historical) including metadata can be provided on request.

H-1 Descriptive statistics

Data summaries on descriptive statistics for all metrics for the key monitoring programs are provided in electronic appendices as Microsoft excel files. The criteria to prepare the files includes:

- Presenting each summary statistic within a column to the same level of precision (ie with the same number of decimal places) - easier to compare.
- Presenting the percentiles, minimum and maximum summary statistics with the precision of the scale of measurement.
- Present the mean at one level of precision more than the scale of measurement and the standard deviation at one level of precision more than the mean.

The number of variables presented in these summary statistics files varied by the type of data analysed and their significance to improve our understanding. List of files provided as electronic appendices by each type of data/ monitoring programs are provided below.

Table H-1 List of electronic appendix files on descriptive statistics

Data	File name
Wastewater	EA_WW_01 Yearly WWRF catchment rainfall, wastewater inflow, discharge, reuse volume
	EA_WW_02 Yearly WWRF LBL flow and load summary
	EA_WW_03 Yearly WWRF discharge concentration summary
Wastewater overflows	No additional data provided on dry and wet weather overflows summary
	EA_WWO_01 DWLP SCAMPs results for each EPL, 2022-23
Receiving water quality and ecosystem health (phytoplankton)	EA_WQ&EH_01 Yearly Hawkesbury-Nepean River – water quality and phytoplankton data summary
	EA_WQ_01 Yearly Chlorophyll-a at estuarine sites, data summary
	EA_WQ_02 Yearly Lagoons – water quality data summary
Ecosystem health (macroinvertebrates and other biota)	No additional data summary provided as electronic appendices

H-2 Statistical model details and outputs

No data provided as electronic appendices this year for this category

H-3 Analysis datasets

Analysis datasets for the key monitoring programs are provided in electronic appendices as Microsoft excel files. List of files provided as electronic appendices for each type of data are provided below.

Table H-2 List of electronic appendix files on analysis datasets

Data	File name
Wastewater	No additional data provided as electronic appendices
Wastewater overflows	No additional data provided as electronic appendices
Receiving water quality and ecosystem health (phytoplankton)	EA_WQ&EH_02 Hawkesbury-Nepean River – water quality and phytoplankton 2013-23
	EA_WQ_03 Chlorophyll-a at estuarine sites 2013-23
	EA_WQ_04 Lagoons – water quality 2013-23
Ecosystem health (macroinvertebrates and other biota)	EA_EH_01 Freshwater ecology indicator data 2022-23
	EA_EH_02 Intertidal community data 2022-23
	EA_EH_03 Shellharbour community data 2022-23
	EA_EH_04 Ocean sediment program indicator data 2022-23