Appendix ?:
IGSC Wet Weather Monitoring
Annual Results Summary
May 2012 – April 2013

1 Sampling Sites

1.1 *River Sites*

In accordance with Section 4 of the IGSC Monitoring Plan, the following sites within the Avon River were sampled during two wet weather events on the 14 October and 12 November 2012 (refer to main report for details of site locations):

Avon River at Manchester Street (AVON04)
Avon River at Mona Vale (AVON07)
Addington Stream (AVON09)
Dudley Creek (AVON10)
Avon River at Carlton Mill Corner (AVON12)
Avon River at Avondale Road (AVON13)

Rainfall for the 24- and 48-hours preceding the 14 October was 37 and 38 millimetres, respectively[1]. Rainfall for the 24- and 48-hour periods preceding the 12 November was 13 and 13 millimetres, respectively. Flow rates in the Avon River at the time of sampling are indicated in Figures 1 and 2.

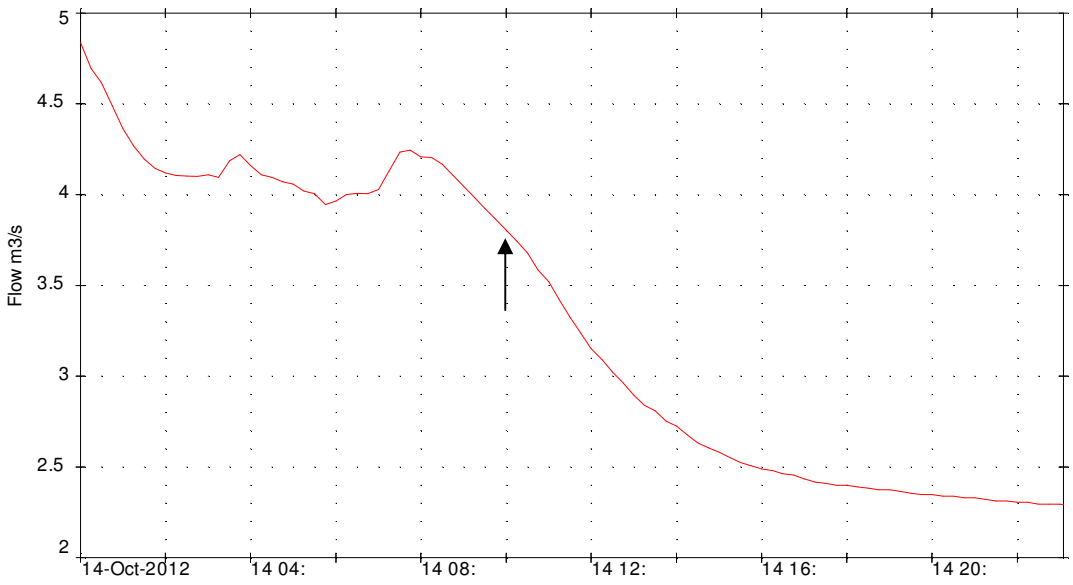


Figure 1 Flow rate in the Avon River at Gloucester Street, on the 14 October 2012. Wet weather samples were collected between 9.30 – 10.30am on this day, as indicated by the arrow on the graph.

[1] Recorded at the Botanic Gardens

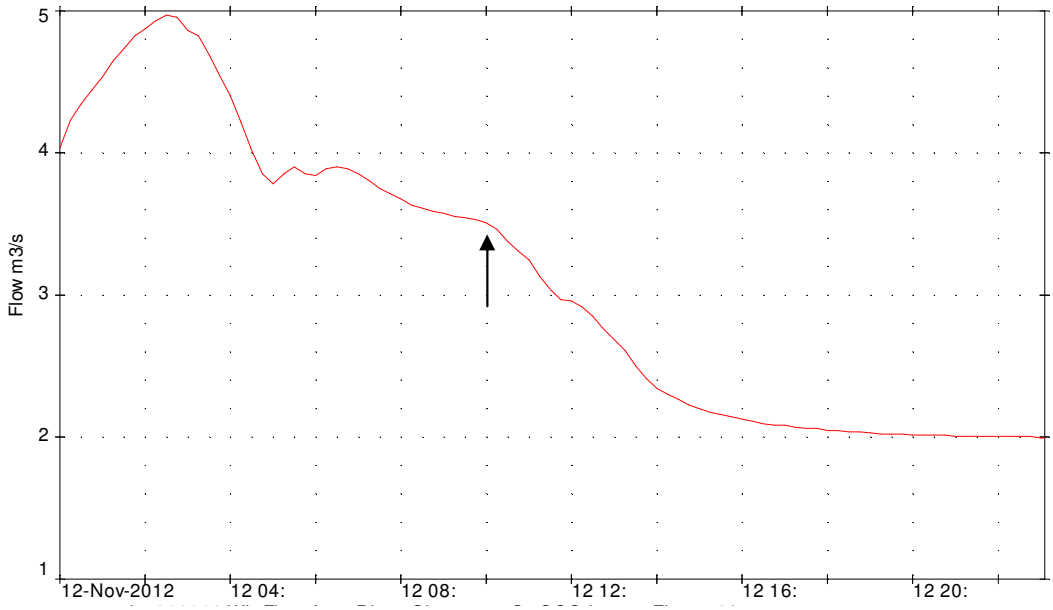


Figure 2 Flow rate in the Avon River at Gloucester Street, on the 12 November 2012. Wet weather samples were collected between 9.30 – 10.30am on this day, as indicated by the arrow on the graph.

1.2 Stormwater Outfall Sites

A number of stormwater outfall sites were also sampled during one wet weather event (over three time periods per event), in accordance with Section 3 of the monitoring plan. This is the first year monitoring results for stormwater outfalls have been presented. The sites sampled, their locations and the dates of sampling are detailed in Table 1. Rainfall[1] for the 24- and 48-hours preceding each of the sampling events is detailed with the water quality results in Table 4.

Table 1 Locations and dates of sampling for stormwater outfall wet weather monitoring

Site	Northing	Easting	Sampling Dates	Receiving Environment	Monthly Water Quality Sampling of Receiving Environment?
Waltham (manhole at Ontrack, 350 Waltham Road)	5740124	2482072	3 May 2013	Heathcote River	Yes
Bromley (Charlesworth Drain in manhole at 250 Dyers Road)	5740911	2486033	5 February 3 May 2013	Charlesworth Street Stream ↓ Estuary	No
Curletts Road Branch Drain (Adjacent to 65 Treffers Road)	5740038	2475645	18 May 2013	Haytons Stream ↓ Heathcote River	Yes
Westmorland (24 Penruddock Rise silt trap)	5736573	2477952	18 May 2013	Cashmere Stream ↓ Heathcote River	Yes

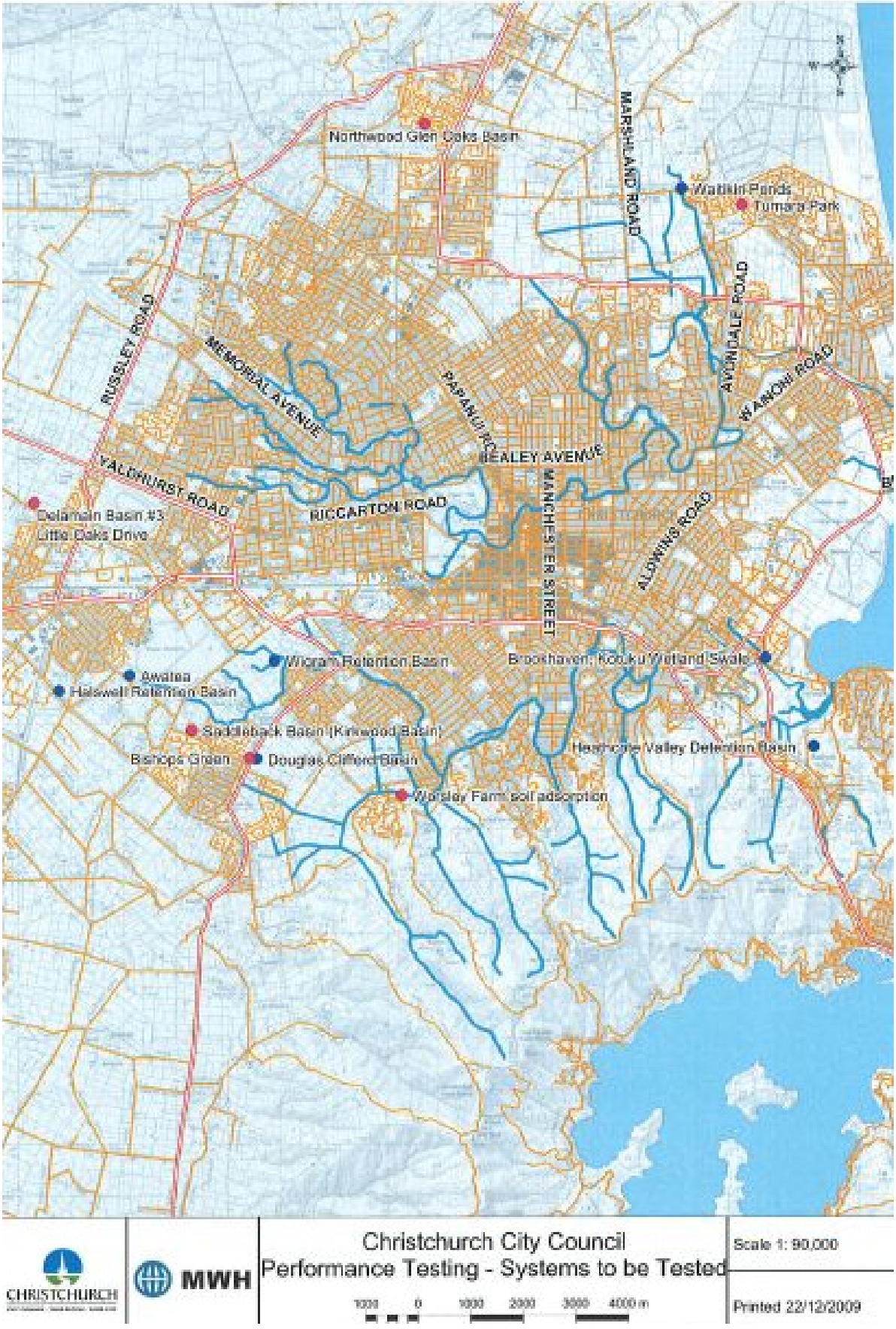
1.3 Infiltration Basin Sites

In accordance with Section 8 of the monitoring plan, the performance of a number of infiltration basins were also monitored by sampling the inlets and outlets of these basins during one wet weather event. This is the first year monitoring results for infiltration basins have been presented. This report presents data from this years monitoring, as well as initial testing in 2011. The sites sampled, their locations and the dates of sampling are detailed in Table 2 and Figure 3. Rainfall[1] for the 24- and 48-hours preceding each of the sampling events is detailed with the water quality results in Tables 5 and 6.

Table 2 Locations and dates of sampling for infiltration basin wet weather monitoring

Site	Sampling Dates
Waitikiri Ponds inlet and outlet	20 October 2011 23 October 2012 December 2012
Tumara Park inlet and outlet	20 October 2011 7 December 2012
Northwood inlet and outlet	20 October 2011
Bishops Green inlet	20 June 2013
Douglas Clifford inlet and outlet	20 June 2013
Worsleys inlet and outlet	20 June 2013

Figure 3 Location of infiltration basins (from Appendix E of IGSC Monitoring Plan)



2 Water Quality Results

2.1 *River Sites*

The results of the water quality sampling during the two wet weather events at each of the river sites is presented in Table 3. Parameters of importance to instream values are discussed in the following sections. Concentrations from the two wet weather events are compared to the annual means from the monthly sampling presented in the main report.

Table 3 Water quality results from Avon River catchment monitoring during two wet weather events per site

Parameter	Avon River at Manchester Street		Avon River at Mona Vale		Addington Stream		Dudley Creek		Avon River at Carlton Mill Corner[2]		Avon River at Avondale Road[2]	
Date	14/10/12	12/11/12	14/10/12	12/11/12	14/10/12	12/11/12	14/10/12	12/11/12	14/10/12	12/11/12	14/10/12	12/11/12
Ammonia Nitrogen (mg/L)	0.047	0.077	0.030	0.017	0.100	0.16	0.120	0.17	0.024	0.062	0.076	0.033
BOD_5 (mg/L)	1.1	1.3	<1	<1.0	1.4	1.8	1.6	2.8	<1	1.1	1.8	<1.0
Dissolved Cadmium (mg/L)	<0.00020	<0.0002	<0.00020	<0.0002	<0.00020	<0.0002	<0.00020	<0.0002				
Conductivity (µS/cm)	83.6	108	80.7	173	89.0	133	76.1	98.4	78.7	115	57.6	172
Dissolved Copper (mg/L)	0.0023	0.002	0.0120	<0.0020	0.0033	0.0027	0.0035	0.0031				
Dissolved Oxygen (%)	89	87	92	90	93	92	86	79	91	92	79	90
Dissolved Oxygen (mg/L)	10.2	9.4	10.3	9.7	10.6	10.1	10.1	8.6	10.2	9.9	8.9	9.2
Dissolved Organic Carbon (mg/L)	2.2	2.3	1.2	0.2	2.1	2.4	3.1	4.6				
Escherichia coli (CFU/100mL)	2400	4900	3200	700	3700	4600	4400	9800	1500	4100	2500	860
Faecal Coliforms (CFU/100mL)	2100	2900	3000	700	2300	2300	4600	8100	2300	4200	2000	420
Dissolved Lead (mg/L)	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015	0.0016				
Nitrate Nitrogen (mg/L)	0.70	0.6	1.10	2.3	0.45	0.45	0.44	<0.01	0.86	0.81	0.46	0.88
Nitrite Nitrogen (mg/L)	<0.0050	0.01	<0.0050	<0.01	0.0055	0.02	0.0058	0.81	<0.0050	<0.01	0.0071	0.01
Nitrate-Nitrite Nitrogen (mg/L)	0.70	0.61	1.10	2.3	0.45	0.46	0.44	7.2	0.86	0.81	0.47	0.89
pH	7.1	7.2	7.1	7.4	7.1	7.2	7.1	0.026	7.2	7.2	7.2	7.8
Dissolved Reactive Phosphorus (mg/L)	0.023	0.053	0.021	0.017	0.050	0.026	0.065	10	0.020	0.026	0.038	0.018
Total Phosphorus (mg/L)	0.035	0.1	0.022	0.036	0.079	0.1	0.097	12.1				
Total Suspended Solids (mg/L)	7	6	3	<3.0	8	13	10	25	6	10	9	<3.0
Temperature (℃)	9.7	12	10.0	12.4	9.5	11	8.7	12.2	10.0	12.1	10.1	14.7
Total Nitrogen (mg/L)	1.10	1.2	1.40	2.5	0.95	1.2	1.10	1.1				
Turbidity (NTU)	3.9	4.9	1.7	0.7	11.0	15	8.0	20				
Dissolved Zinc (mg/L)	0.078	0.056	0.096	0.016	0.160	0.15	0.150	0.084				

[2] Sites monitored for a reduced suite of parameters that exclude turbidity, total nitrogen, total phosphorus, metals and dissolved organic carbon

2.1.1 Nitrate-Nitrite Nitrogen (NNN)

The majority of sites recorded wet weather samples either lower or similar to the annual mean (Figure 4). The exception to this was Dudley Creek on the 12 November 2012, where a substantially higher value than any other site was recorded (7 mg/L), which was 16 times greater than the guideline value of 0.44 mg/L. consistent with the annual means, there was generally a downstream trend in concentrations during these wet weather events, but no differences between the mainstem and tributaries.

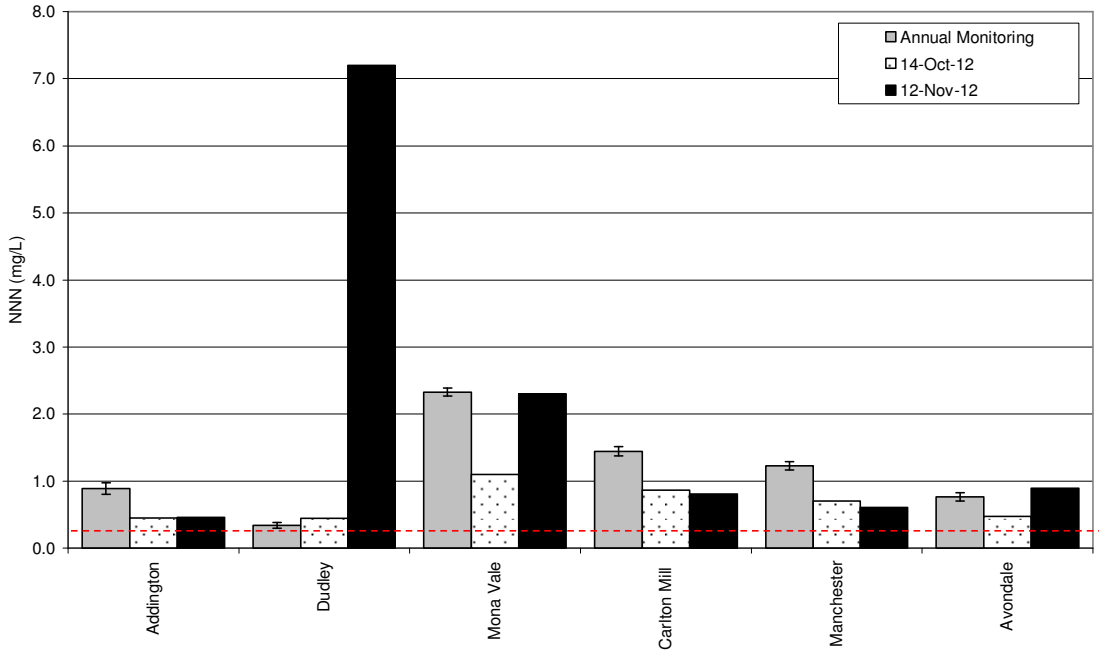


Figure 4 Nitrate-nitrite nitrogen concentrations for each of the monitoring sites within the Avon River catchment for two wet weather sampling events in 2012, compared to annual averages (± the standard error; May 2012 to April 2013). The guideline value of 0.444 mg/L is shown as a dotted line.

2.1.2 Dissolved Reactive Phosphorus (DRP)

A number of sites recorded DRP concentrations greater than the annual mean during both wet weather events (Figure 5). The largest difference between these events and the annual means was during the 14 October 2012 wet weather event in Addington Stream, the 12 November 2012 event at the Manchester Street site in the Avon River, and during both wet weather events in Dudley Creek. The Mona Vale site on the Avon River was the only site with an annual mean (including the upper standard error) below the guideline value of 0.016 mg/L; however, both wet weather events at this site exceeded this guideline. Wet weather concentrations generally increased downstream in the Avon River mainstem, and the tributaries generally recorded greater values than the mainstem. This is consistent to the trends observed for the annual means.

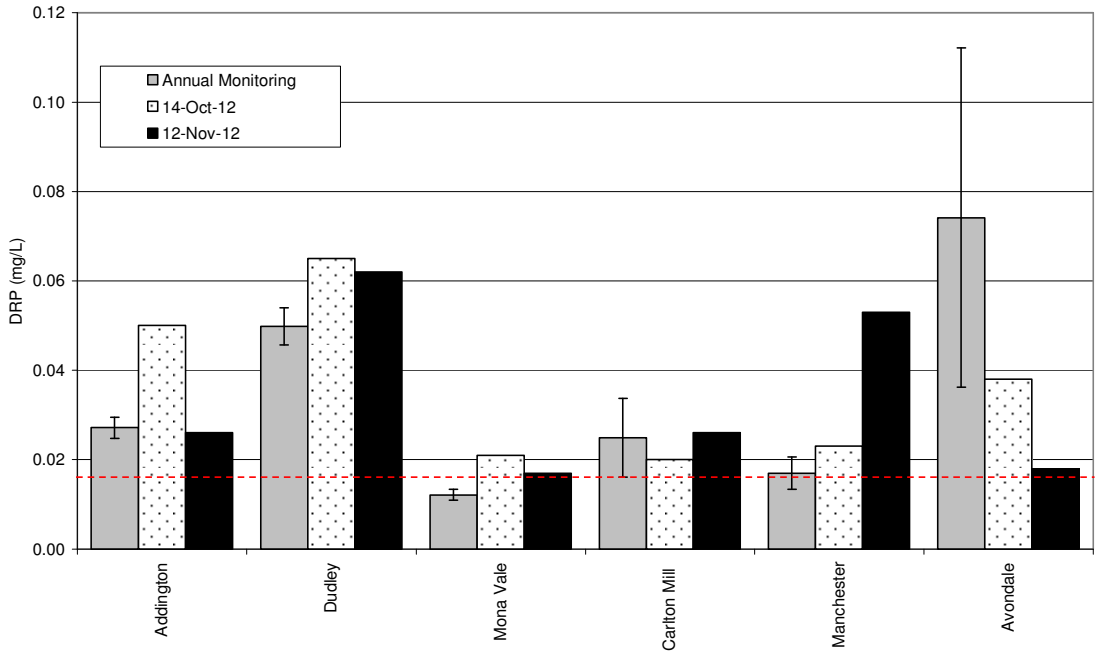


Figure 5 DRP concentrations for each of the monitoring sites within the Avon River catchment for two wet weather sampling events in 2012, compared to annual averages (± the standard error; May 2012 to April 2013). The dotted line represents the NRRP water quality standard of 0.016 mg/L.

2.1.3 Ammonia Nitrogen

Concentrations of ammonia nitrogen from all wet weather events at all sites were well below guideline levels (Figure 6). However, concentrations during the 12 November wet weather event were substantially higher than the annual means within Addington Stream, and the Avon River at Carlton Mill and Manchester Street. Consistent with the annual mean trends, wet weather concentrations generally increased downstream in the mainstem, and the tributaries recorded higher values than the mainstem.

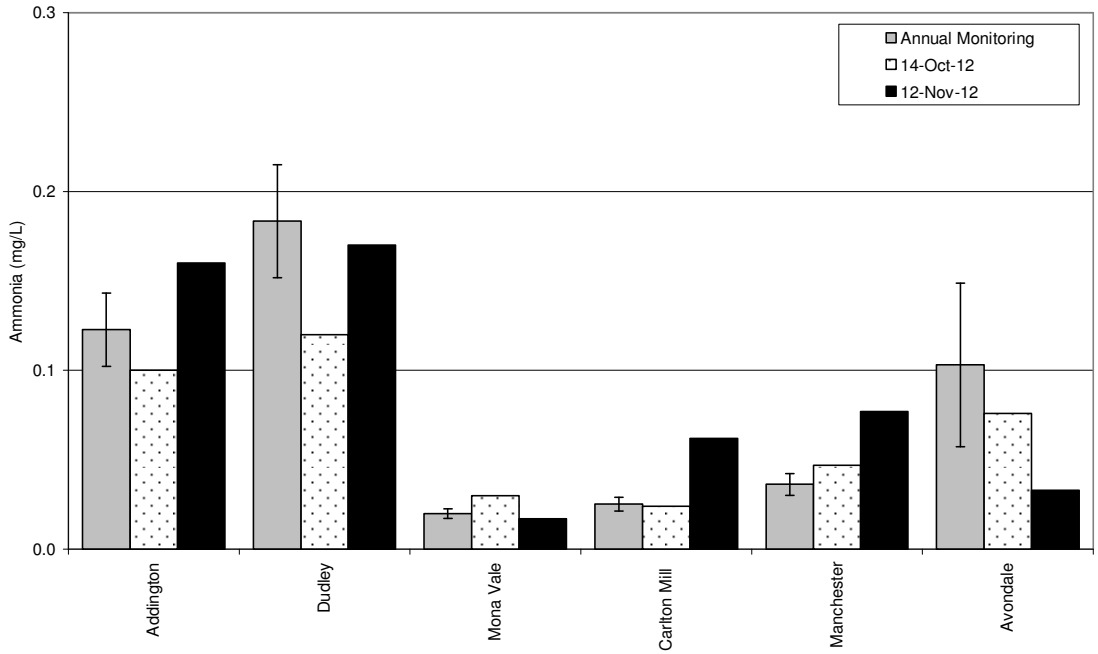


Figure 6 Ammonia nitrogen concentrations for each of the monitoring sites within the Avon River catchment for two wet weather sampling events in 2012, compared to annual averages (± the standard error; May 2012 to April 2013). The NRRP standard value of 1.61 mg/L is not shown on this graph because the scale does not extend that high.

2.1.4 Biochemical Oxygen Demand (BOD)

There were a number of sites than recorded wet weather concentrations greater than the annual means, but there were also some that recorded BOD concentrations below or similar to these means (Figure 7). Of particular note was BOD concentrations during the 12 November wet weather event in Dudley Creek (2.8 mg/L), which was substantially higher than the annual mean and all other sites, and the only concentration that was greater than the guideline value of 2 mg/L. There was generally a downstream increase in BOD in the mainstem, and the tributaries were generally higher than the mainstem. This is consistent with the annual mean trends.

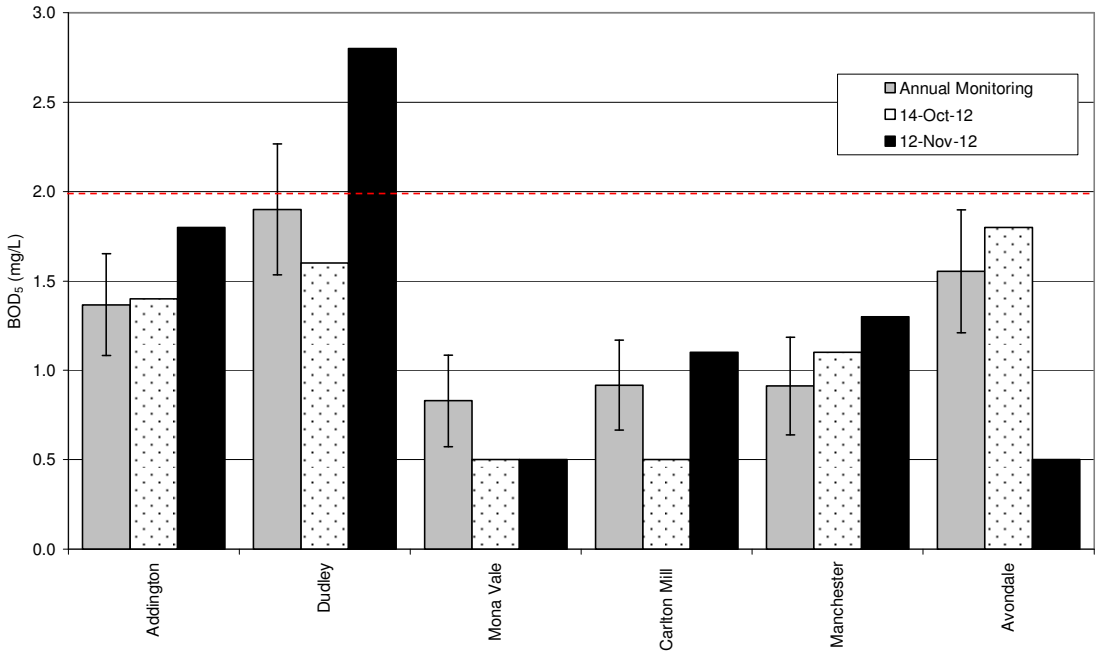


Figure 7 BOD_5 concentrations for each of the monitoring sites within the Avon River catchment for two wet weather sampling events in 2012, compared to annual averages (± the standard error; May 2012 to April 2013). The MfE guideline value of 2 mg/L is shown as a dotted line. Values less than the limit of detection (1 mg/L) are plotted as half this detection limit.

2.1.5 Total Suspended Solids (TSS)

The majority of sites recorded wet weather values greater than the annual mean (Figure 8). The largest concentration was recorded within Dudley Creek during the 12 November wet weather event; this concentration was equivalent to the guideline value of 25 mg/L and was the only value to come close to the guideline (including annual mean values). There was generally an increase in TSS concentration downstream in the mainstem, and the tributaries typically recorded values greater than the mainstem. This is consistent with the annual mean trends.

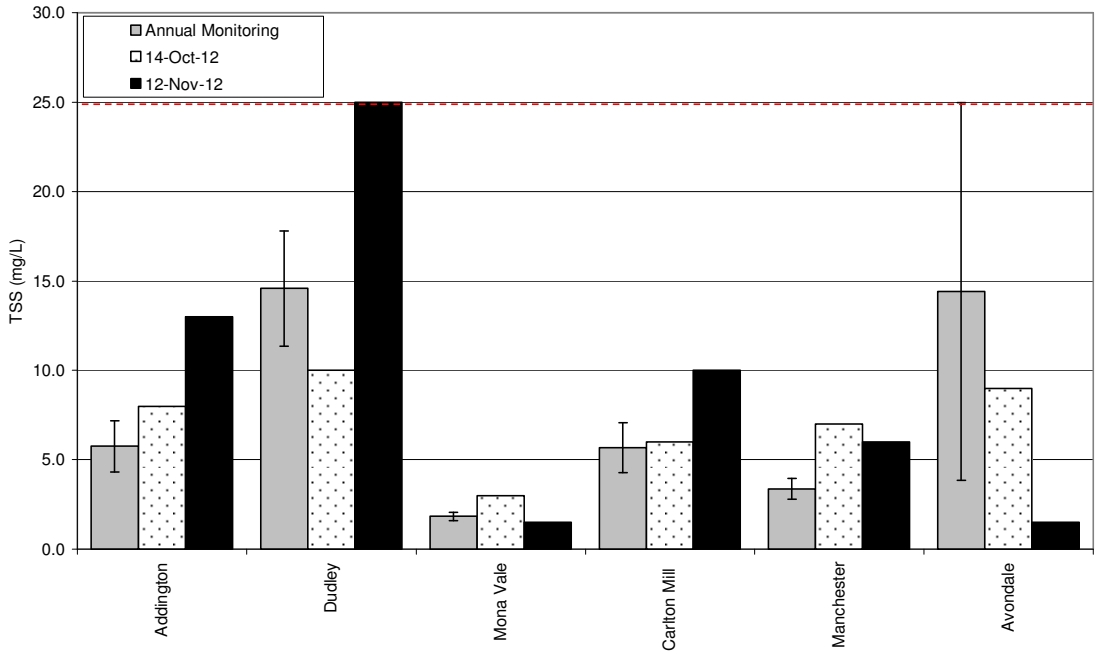


Figure 8 Total suspended solid concentrations for each of the monitoring sites within the Avon River catchment for two wet weather sampling events in 2012, compared to annual averages (± the standard error; May 2012 to April 2013). The guideline value of 25 mg/L is shown as a dotted line. Values less than the limit of detection (3 mg/L) are plotted as half this detection limit.

2.1.6 *Escherichia coli (E. coli)*

Both wet weather events recorded values substantially greater than the annual means at all of the sites (Figure 9). The highest *E. coli* concentration was recorded in Dudley Creek during the 12 November wet weather event (9800 *E. coli* per 100 mL). The Mona Vale and Avondale sites in the Avon River were the only two locations that recorded annual means below the guideline value of 550 *E. coli* per 100 mL; but this guideline value was exceeded during both wet weather events at both of these sites. As was the case with annual means, there were no apparent trends in wet weather concentrations downstream in the mainstem, or between the mainstem and the tributaries.

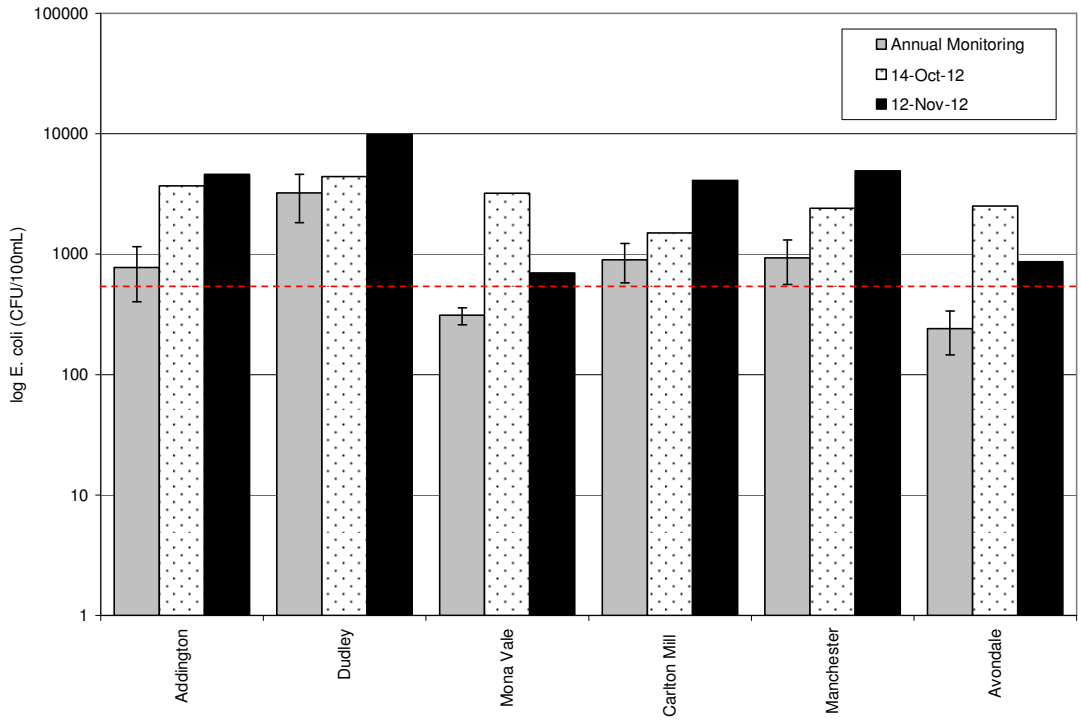


Figure 9 *E. coli* concentrations for each of the monitoring sites within the Avon River catchment for two wet weather sampling events in 2012, compared to annual averages (± the standard error; May 2012 to April 2013). The MfE guideline value of 550 *E. coli* per 100 mL is shown as a dotted line.

2.1.7 Dissolved Copper

Wet weather concentrations were generally greater than the annual means at all sites (Figure 10). As was the case with annual means, wet weather concentrations were all below the guideline value of 3.56 µg/L. The exception to this was the Mona Vale site in the Avon River, which recorded a concentration of 12 µg/L during the 14 October wet weather event, which is approximately three times greater than this guideline. In line with the annual means, there were no apparent trends downstream in the mainstem, although this is difficult to establish with only two sites being analysed for this parameter. Concentrations of copper were similar between the mainstem and the tributaries, which is consistent with that recorded for the annual means.

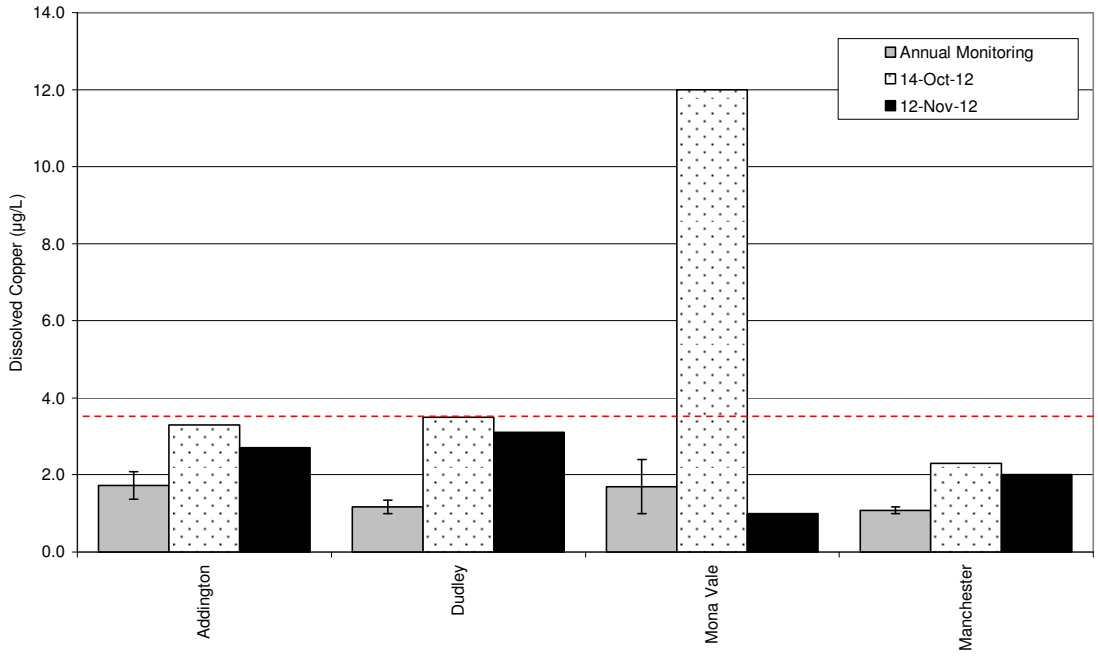


Figure 10 Dissolved copper concentrations for each of the monitoring sites within the Avon River catchment for two wet weather sampling events in 2012, compared to annual averages (± the standard error; May 2012 to April 2013). The ANZECC (2000) hardness modified trigger value of 3.56 µg/L (for 90% species protection) is displayed as a dotted line on the graph. Values less than the limit of detection (2 µg/L) are plotted as half this detection limit. The Carlton Mill and Avondale sites were not monitored for this parameter.

2.1.8 Dissolved Lead

All wet weather concentrations at all sites were less than or similar to the annual means, with all values below the limit of detection of 1.5 µg/L (Figure 11). The exception to both of these was the 12 November wet weather concentration in Dudley Creek (1.6 µg/L). All wet weather values and annual means were well below the guideline value of 15.54 µg/L. There were no apparent trends downstream in the mainstem; however, as discussed this is difficult to establish with only two sites being analysed for this parameter. Lead concentrations were similar between the mainstem and the tributaries.

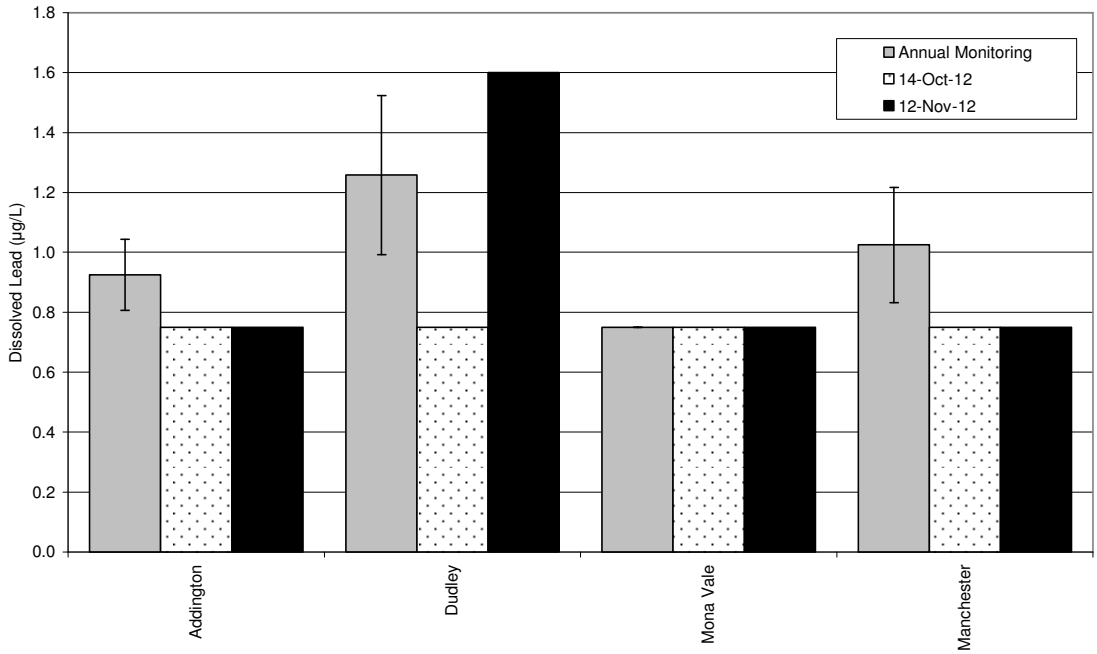


Figure 11 Dissolved lead concentrations for each of the monitoring sites within the Avon River catchment for two wet weather sampling events in 2012, compared to annual averages (± the standard error; May 2012 to April 2013). The ANZECC (2000) hardness modified trigger value of 15.54 µg/L is not shown on this graph as the scale does not extend to that value. The annual mean with no standard error reflects a lack of variability in the dataset, due to all sampling events recording levels below the limit of detection. Values less than the limit of detection (1.5 µg/L) are plotted as half this detection limit. The Carlton Mill and Avondale sites were not monitored for this parameter.

2.1.9 Dissolved Zinc

Wet weather concentrations were substantially greater than the annual means at all of the sites, with the exception of Dudley Creek (Figure 12). The highest wet weather values recorded were within Dudley Creek and Addington Stream, which is in line with that recorded for the annual means. The annual means only exceeded the guideline value (29.7 µg/L) in Addington Stream and Dudley Creek; however, all concentrations at all sites during both wet weather events exceeded this guideline value. The exception to this was the Mona Vale site in the Avon River during the 12 November wet weather event. The tributaries recorded substantially greater wet weather zinc levels than the mainstem, consistent with that recorded for the annual means.

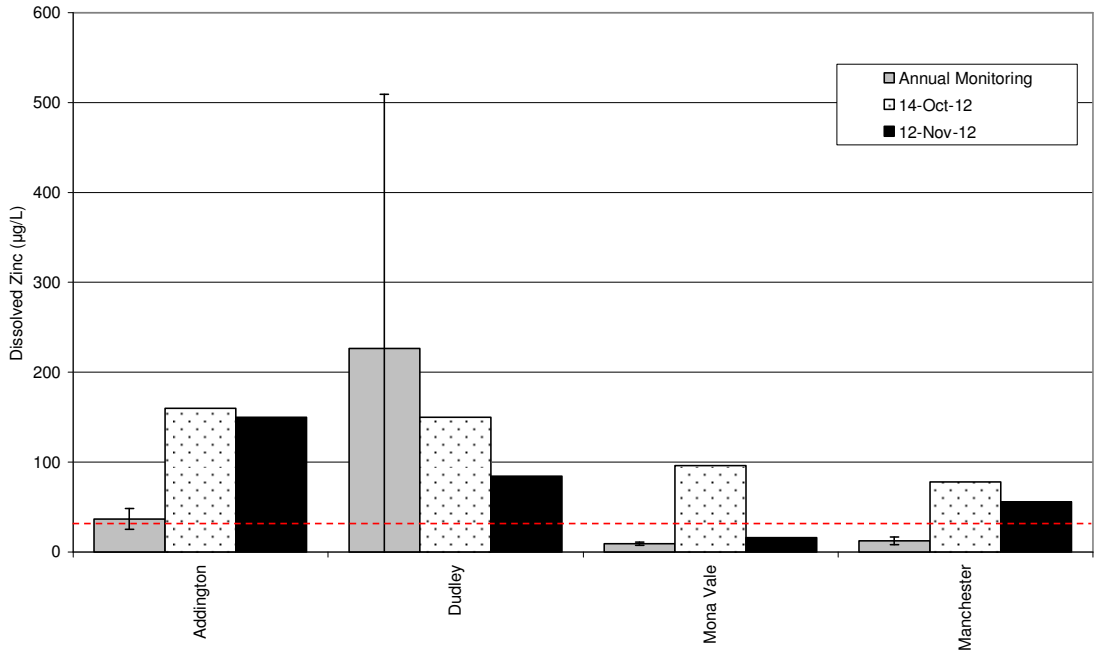


Figure 12 Dissolved zinc concentrations for each of the monitoring sites within the Avon River catchment for two wet weather sampling events in 2012, compared to annual averages (± the standard error; May 2012 to April 2013). The ANZECC (2000) default trigger value of 29.7 µg/L for 90% species protection is displayed as a dotted line on the graph.

2.2 Stormwater Outfall Sites

The water quality of the stormwater outfall samples taken during three time periods of one wet weather event are presented in Table 4. Parameters of importance to instream values are discussed in the following sections, with graphs presented that compare concentrations to guideline values. However, it is noted that these guideline values are for receiving environments and not stormwater itself. These concentrations are also discussed in relation to levels recorded in the receiving environment for the outfalls (see Table 1), which were presented in the main body of this report. For all parameters there were no apparent trends in concentrations across the three time periods. However, this may be due to variations in sampling times, as there was no standardised timing for the three periods.

Table 4 Water quality results from stormwater outfall sampling during one wet weather event per site (over three time periods per event)

Parameter	Bromley[3] (Event 1)	Waltham			Bromley (Event 2)			Curletts			Westmorland		
Date	05/02/13	03/05/13	03/05/13	03/05/13	03/05/13	03/05/13	03/05/13	18/05/13	18/05/13	18/05/13	18/05/13	18/05/13	18/05/13
Time of sample collection	2300	0100	1300	2100	0100	2100	2300	0200	2200	2400	0200	2200	2400
24 hr rainfall (mm)[4]	7	3	3	3	3	3	2	8	5	4	8	5	4
48 hr rainfall (mm)[4]	17	4	4	4	4	4	4	8	9	9	8	9	9
Ammonia Nitrogen (mg/L)	0.27	0.24	0.26	0.24	0.25	0.39	0.27	0.083	0.32	0.39	2.5	0.26	0.1
Total Arsenic (mg/L)	0.0022	0.0041	0.0025	0.0022	0.0029	0.0046	0.0022	0.0036	0.0027	0.0029	0.016	0.002	0.022
BOD_5 (mg/L)	3	7.8	8.2	7.2	5	3.1	3	2.3	2.6	2.6	3.4	2.3	1.6
Total Cadmium (mg/L)	0.00017	0.0015	0.0006	0.00039	0.00012	0.00032	0.00017	<0.00020	<0.0002	<0.00020	<0.00020	<0.00020	<0.0002
Conductivity (µS/cm)	112	213	131	146	140	208	112	92.6	91.7	71.5	235	46.2	204
Total Copper (mg/L)	0.021	0.64	0.23	0.18	0.019	0.049	0.021	0.0038	0.014	0.011	0.031	0.01	0.043
Dissolved Organic Carbon (mg/L)	5.8	24	12	11	7.4	16	5.8	2.7	5.1	4.7	20	4.3	9.9
Escherichia coli (CFU/100mL)	1300	490	1800	2600	1400	4400	1300	14000	9800	18000	>240000	16000	2400
Faecal Coliforms (CFU/100mL)	1600	10	130	<100	1700	4100	1600	570	440	9000	82000	4200	1800
Total Lead (mg/L)	0.024	0.24	0.11	0.13	0.018	0.03	0.024	0.0018	<0.0017	<0.0017	0.008	<0.0017	0.057
Nitrate Nitrogen (mg/L)	0.39	0.28	0.43	0.72	0.46	0.94	0.39	0.2	0.38	0.3	<0.050	0.32	1.1
Nitrite Nitrogen (mg/L)	0.13	0.097	0.065	0.097	0.16	0.35	0.13	<0.0050	0.045	0.017	0.026	0.016	0.028
NNN (mg/L)	0.52	0.377	0.495	0.817	0.62	1.29	0.52	0.2	0.425	0.317	0.026	0.336	1.128
pH	7.7	7.3	7.4	7.4	7.8	7.6	7.7	7.4	7.3	7.5	7.5	7.4	7.8
Dissolved Reactive Phosphorus (mg/L)	0.069	0.004	0.078	0.021	0.078	0.12	0.069	0.043	0.057	0.056	<0.0030	0.042	0.061
Total Phosphorus (mg/L)	0.085	0.1	0.091	0.031	0.1	0.14	0.085	0.045	0.11	0.054	0.11	0.06	0.09
Total Suspended Solids (mg/L)	32	24	30	56	23	100	32	5	15	12	820	24	730
Total Nitrogen (mg/L)	1.3	2.6	2.7	1.7	1.5	3	1.3	0.69	1.8	2.6	8.2	1.9	2
Total Petroleum Hydrocarbons (TPH) (mg/L)	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7
TPH (S) Band C10-C14 (mg/L)	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
TPH (S) Band C15-C36 (mg/L)	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
TPH (S) Band C7-C9 (mg/L)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Turbidity (NTU)	62	39	35	62	50		62	4	14	6	1500	31	1600
Total Zinc (mg/L)	0.15	1.7	1.2	1.2	0.14	0.4	0.15	0.14	0.75	0.68	0.35	0.65	0.43

[3] This site was only measured for one time period
[4] Recorded at the Botanic Gardens

2.2.1 Nitrate-Nitrite Nitrogen (NNN)

The highest NNN concentrations were recorded at Bromley (Event 2) during the second time period and Westmorland during the third time period (Figure 13). Curletts was the only site that recorded concentrations below the guideline value for receiving waters (0.444 mg/L). In contrast, the mean annual values for Haytons Stream (the receiving environment for the Curletts stormwater outfall) were above this guideline level (see main report). The receiving environment for all the other outfalls, with the exception of the receiving environment for Bromley which is not monitored (Charlesworth Street Stream), also recorded concentrations above this guideline level.

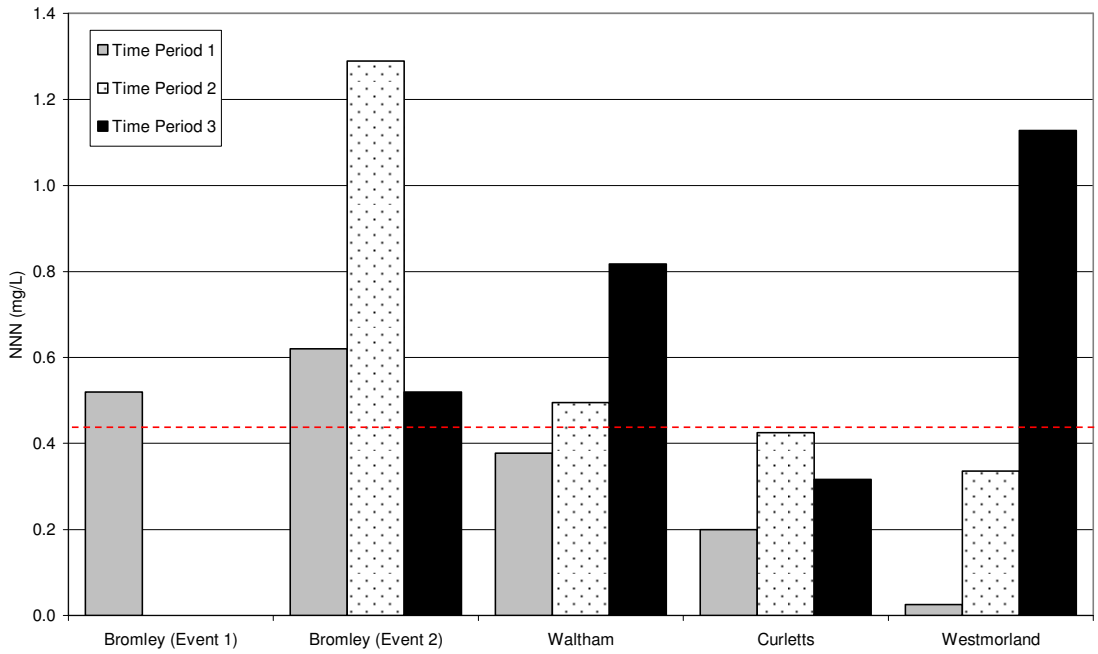


Figure 13 Nitrate-nitrite nitrogen concentrations for each of the stormwater outfall sites across three time periods of one wet weather event during the 2012 monitoring period. The guideline value for receiving waters of 0.444 mg/L is shown as a dotted line.

2.2.2 Dissolved Reactive Phosphorus (DRP)

Bromley recorded the highest DRP concentrations of all the sites (Figure 14). All sites recorded levels well above the guideline value for the receiving environment (0.016 mg/L). Exceptions to this were the first time periods for Waltham and Westmorland, where concentrations were below the laboratory limit of detection, indicating that contaminants had not yet reached these outfalls. These results are line with the annual river monitoring, which also recorded levels above the guideline value for the receiving environments of these outfalls.

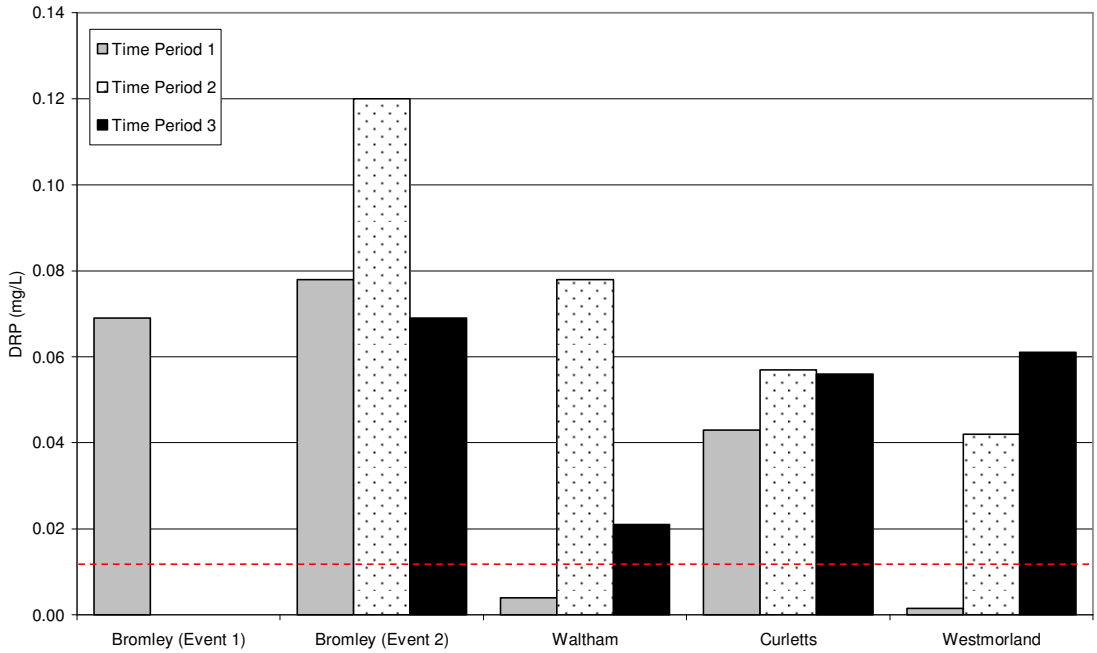


Figure 14 Dissolved reactive phosphorus concentrations for each of the stormwater outfall sites across three time periods of one wet weather event during the 2012 monitoring period. The NRRP water quality standard for receiving waters of 0.016 mg/L is displayed as a dotted line on the graph. Values less than the limit of detection (0.0030 mg/L) are plotted as half this detection limit.

2.2.3 Ammonia Nitrogen

Westmorland recorded substantially higher ammonia nitrogen concentrations during the first time period compared to all other sites (Figure 15). This value (2.5 mg/L) was the only concentration that was above the guideline value for receiving waters of 1.61 mg/L. The Cashmere Stream, which is the receiving environment for this outfall, recorded ammonia values well below this guideline level during the years river monitoring.

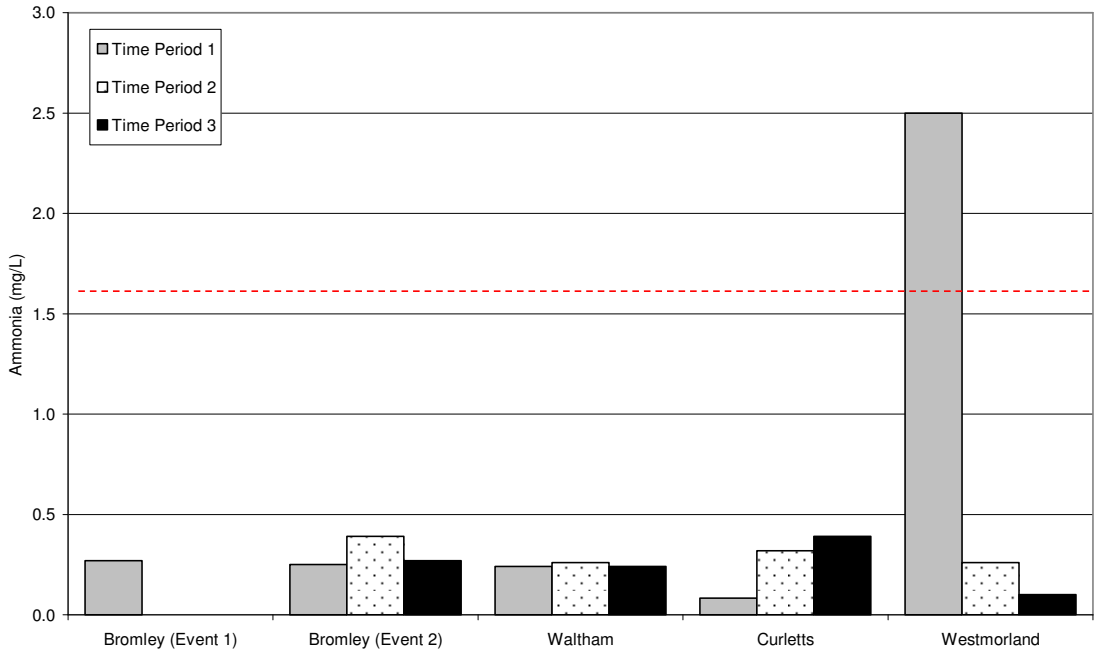


Figure 15 Ammonia nitrogen concentrations for each of the stormwater outfall sites across three time periods of one wet weather event during the 2012 monitoring period. The NRRP water quality standard for receiving waters of 1.61 mg/L is displayed as a dotted line on the graph.

2.2.4 Biochemical Oxygen Demand (BOD)

Waltham recorded substantially higher BOD concentrations that the other outfall sites (Figure 16). All sites recorded concentrations above the guideline value for waterways of 2 mg/L. The receiving environment for the Curletts Road outfall, Haytons Stream, was the only waterway that recorded annual BOD levels above this guideline level during the 2012-2013 monitoring period.

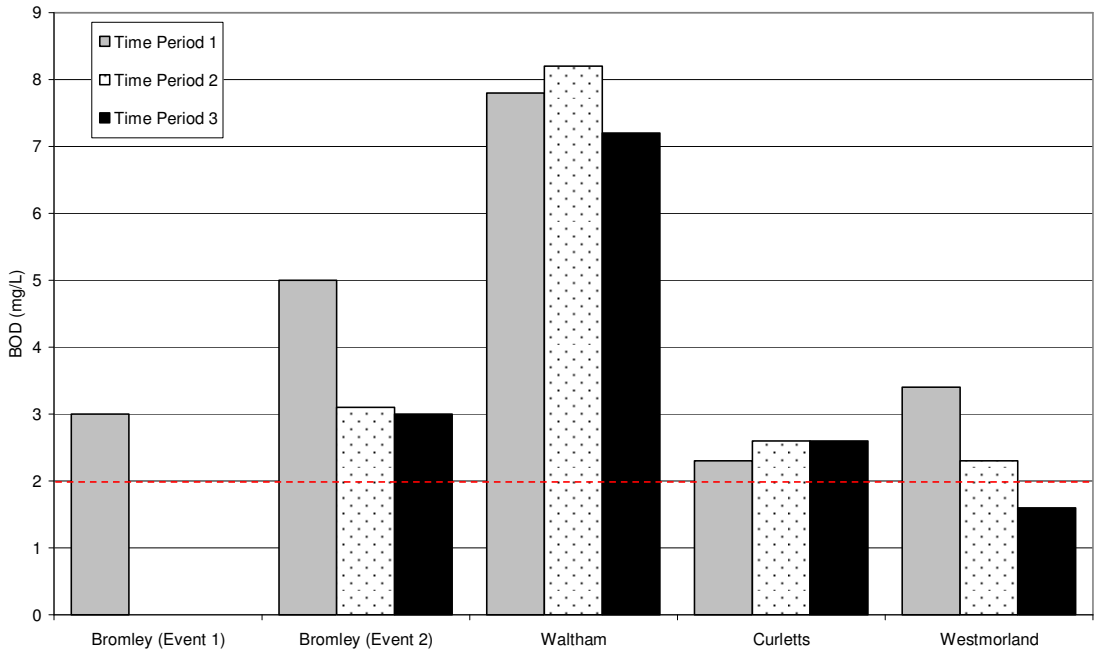


Figure 16 Biochemical oxygen demand concentrations for each of the stormwater outfall sites across three time periods of one wet weather event during the 2012 monitoring period. The MfE guideline value for receiving waters of 2 mg/L is shown as a dotted line.

2.2.5 Total Suspended Solids (TSS)

TSS levels were substantially higher at the Westmorland site compared to all other sites (Figure 17). All sites recorded levels higher than the guideline value for receiving environments (25 mg/L) during at least one time period, with the exception of the Curletts Road site. However, Haytons Stream (the receiving environment for this site), was the only waterway that recorded TSS above this guideline level during the annual river monitoring.

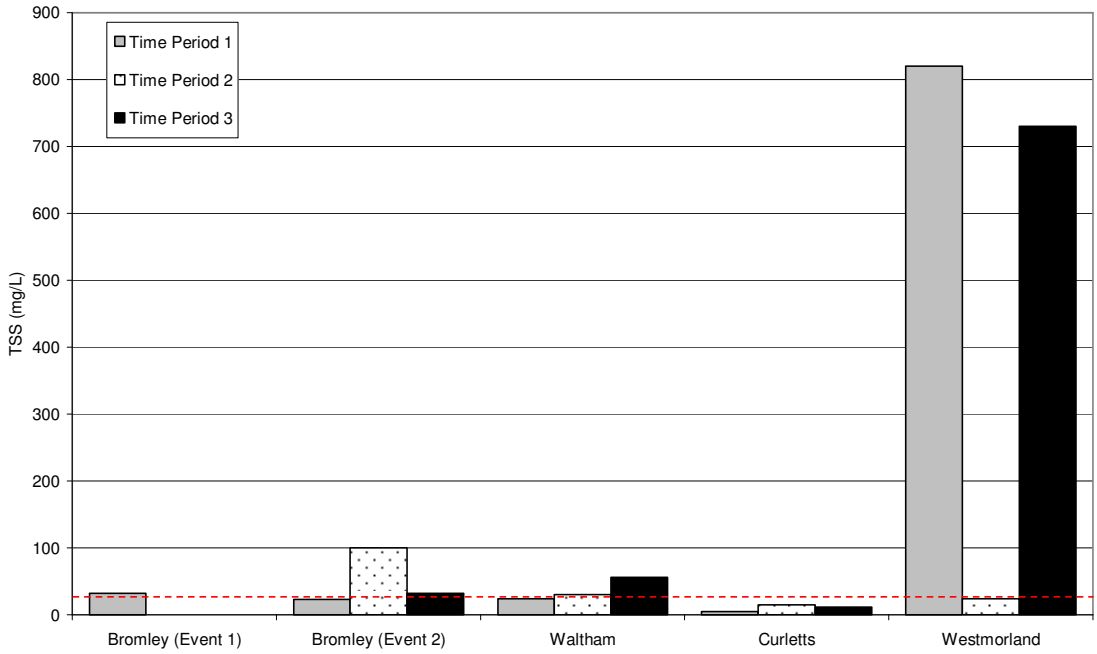


Figure 17 Total suspended solid concentrations for each of the stormwater outfall sites across three time periods of one wet weather event during the 2012 monitoring period. The guideline value of 25 mg/L for receiving waters is shown as a dotted line.

2.2.6 *Escherichia coli* (*E. coli*)

Curletts Road and Westmorland recorded much higher concentrations of *E. coli* than the other two sites (Figure 18). All sites recorded levels above the guideline value of 550 *E. coli* per 100 mL. The Heathcote River (the receiving environment for the Waltham outfall) generally recorded mean *E. coli* concentrations above this guideline level during the annual river monitoring, but Haytons Stream (the receiving environment for the Curletts outfall) and Cashmere Stream (the receiving environment for the Westmorland outfall) did not.

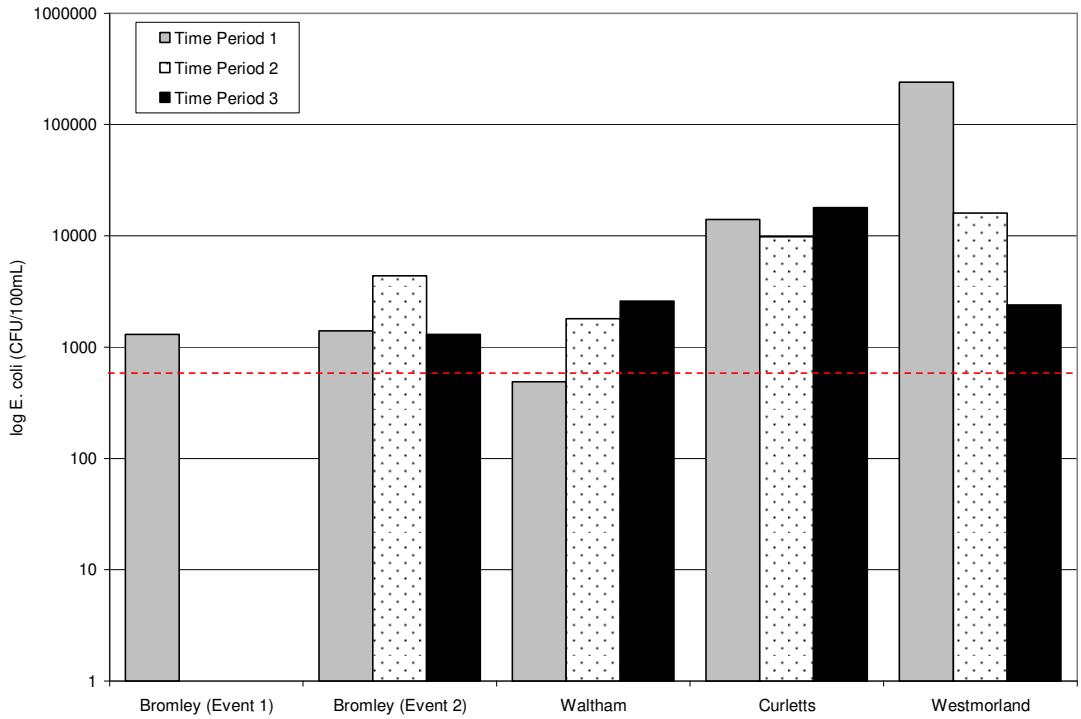


Figure 18 *Escherichia coli* concentrations for each of the stormwater outfall sites across three time periods of one wet weather event during the 2012 monitoring period. The MfE guideline value for receiving waters of 550 *E. coli* per 100 mL is shown as a dotted line. The Westmorland Time Period 1 value reached the maximum limit of detection (240000 *E. coli* per 100 mL) – this maximum value is used as the concentration in this graph.

2.2.7 Total Metals

The Waltham outfall recorded substantially higher levels of copper, lead and zinc compared to the other three sites (Figures 19 – 21). Concentrations at all sites for these three metals were above the guideline values for the receiving environment during at least one time period. The exception to this was lead for the Curletts Road outfall. The receiving environments for all these outfalls recorded annual values well below the guideline levels for all three metals during the 2012-2013 river monitoring.

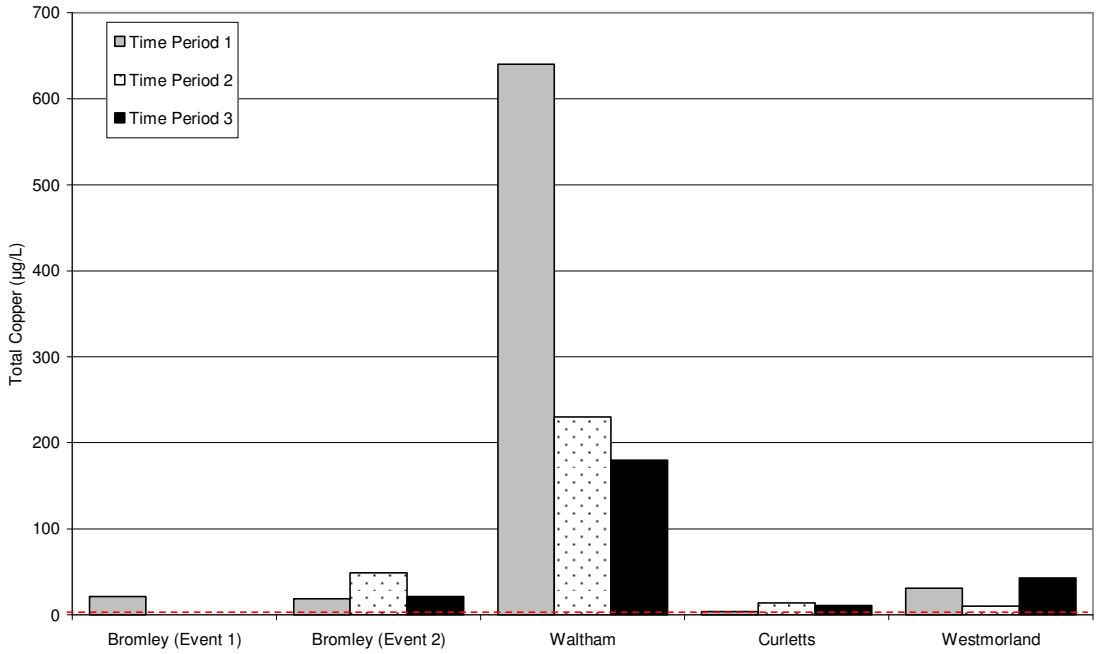


Figure 19 Total copper concentrations for each of the stormwater outfall sites across three time periods of one wet weather event during the 2012 monitoring period. The ANZECC (2000) hardness modified copper trigger value for receiving waters of 3.56 µg/L (for 90% species protection) is displayed as a dotted line on the graph.

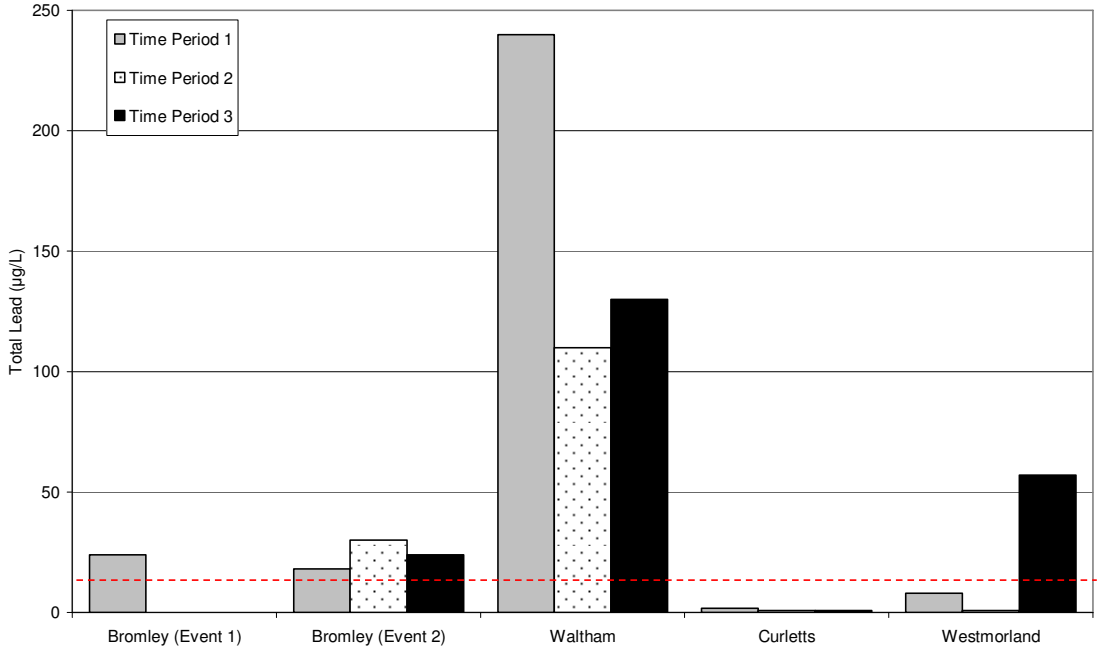


Figure 20 Total lead concentrations for each of the stormwater outfall sites across three time periods of one wet weather event during the 2012 monitoring period. The ANZECC (2000) hardness modified lead trigger value for receiving waters of 15.54 µg/L (for 90% species protection) is displayed as a dotted line on the graph. Values less than the limit of detection (0.0017µg/L) are plotted as half this detection limit.

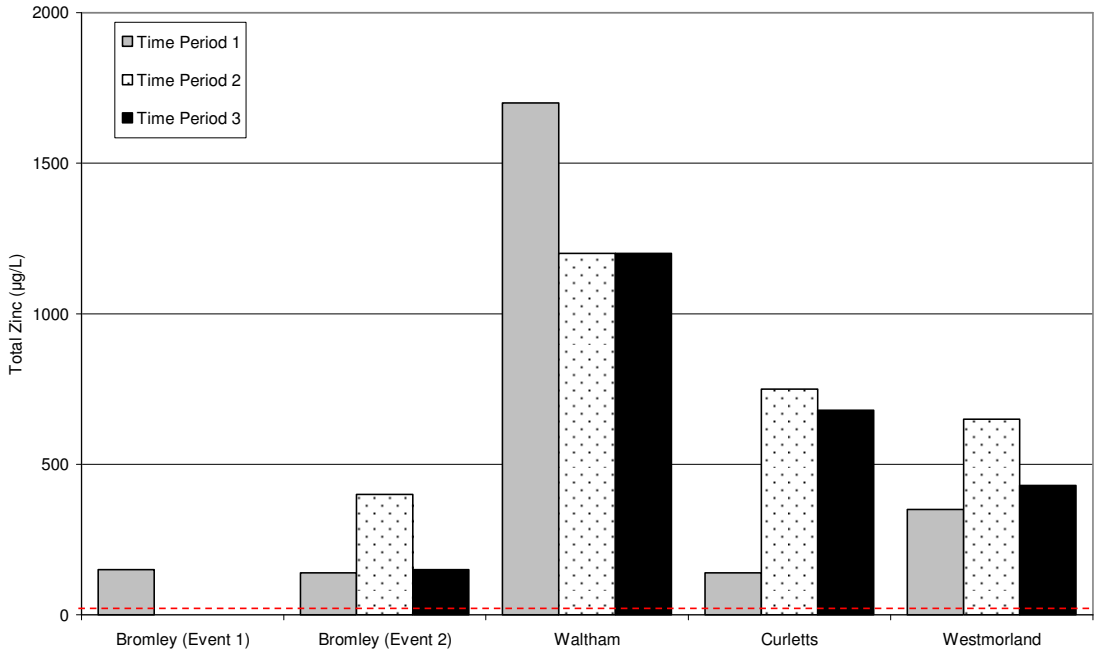


Figure 21 Total zinc concentrations for each of the stormwater outfall sites across three time periods of one wet weather event during the 2012 monitoring period. The ANZECC (2000) hardness modified zinc trigger value for receiving waters of 29.7 µg/L (for 90% species protection) is displayed as a dotted line on the graph.

2.3 Infiltration Basin Sites

The majority of contaminants reduced in concentration following treatment by the basins (Tables 5 and 6). However, there were a number that increased in concentration by greater than 50%, as follows:

- Ammonia nitrogen (Bishops Green/Douglas Clifford and Waitikiri)
- BOD (Bishops Green/Douglas Clifford)
- Cadmium (Tumara Park and Northwood)
- Copper (Tumara Park and Northwood)
- Dissolved oxygen (Waitikiri)
- DRP (Waitikiri)
- Faecal coliforms (Worsleys)
- Lead (Bishops Green/Douglas Clifford and Waitikiri)
- Nitrate (Waitikiri)
- Nitrite (Bishops Green/Douglas Clifford)
- Total Petroleum Hydrocarbons (Waitikiri)

However, these percent reductions should be viewed with caution, as sampling of the inlets and outlets were conducted simultaneously, and may not represent actual relative concentrations before and after treatment. Further dilution will also be provided by the receiving environment.

Table 5 Water quality results from infiltration basin sampling in 2011 during one wet weather event per site, with percent change in contaminant levels between the inlets and the outlets[5]. Values with a percent increase of greater than 50% are shown in bold.

Parameter	Waitikiri Ponds Inlet	Waitikiri Ponds Outlet	Waitikiri Ponds % Change	Tumara Park Inlet	Tumara Park Outlet	Tumara Park % Change	Northwood Inlet	Northwood Outlet	Northwood Outlet % Change
Date	20/10/11	20/10/11	-	20/10/11	20/10/11	-	20/10/11	20/10/11	-
Time of sample collection	1005	1020	-	0923	0940	-	1110	1120	-
24 hr rainfall (mm)[6]	28	28	-	28	28	-	28	28	-
48 hr rainfall (mm)[3]	48	48	-	48	48	-	48	48	-
Ammonia Nitrogen (mg/L)	0.11	0.11	0.0%	0.66	0.025	-96.2%	0.14	0.022	-84.3%
Total Arsenic (mg/L)	0.0087	0.0038	-56.3%	0.0068	0.002	-70.6%	0.0045	0.0043	-4.4%
BOD_5 (mg/L)	6	6.1	1.7%	2.5	1.7	-32.0%	2.4	1.5	-37.5%
Total Cadmium (mg/L)	<0.0002	<0.0002	0.0%	<0.0002	0.0012	**1100.0%**	<0.0002	0.0034	**3300.0%**
Conductivity (µS/cm)	599	314	-47.6%	373	60.9	-83.7%	167	46.8	-72.0%
Total Copper (mg/L)	0.0035	<0.002	-71.4%	<0.002	0.0021	**110.0%**	0.0034	0.0055	**61.8%**
Dissolved Organic Carbon (mg/L)	44	12	-72.7%	23	3.3	-85.7%	2.9	3.9	34.5%
Dissolved Oxygen (mg/L)	6.6	7.8	18.2%	9.5	7	-26.3%	8.8	8.7	-1.1%
Dissolved Oxygen (%)	58	70	20.7%	83	62	-25.3%	83	80	-3.6%
Escherichia coli (CFU/100mL)	16000	4700	-70.6%	2500	2600	4.0%	730	450	-38.4%
Faecal Coliforms (CFU/100mL)	23000	3600	-84.3%	2700	3800	40.7%	820	91	-88.9%
Total Lead (mg/L)	0.0029	<0.0015	-74.1%	0.0038	<0.0015	-80.3%	<0.0015	0.0036	380.0%
Nitrate Nitrogen (mg/L)	0.29	0.44	**51.7%**	0.38	0.24	-36.8%	1.5	0.14	-90.7%
Nitrite Nitrogen (mg/L)	0.059	0.018	-69.5%	0.06	0.005	-91.7%	0.027	<0.005	-90.7%
NNN (mg/L)	0.349	0.458	31.2%	0.44	0.245	-44.3%	1.527	0.14	-99.8%
pH	6.9	7.3	5.8%	7.8	6.3	-19.2%	7	6.5	-7.1%
Dissolved Reactive Phosphorus (mg/L)	0.05	0.048	-4.0%	0.11	0.072	-34.5%	0.067	0.052	-22.4%
Total Phosphorus (mg/L)	0.23	0.088	-61.7%	0.32	0.11	-65.6%	0.26	0.31	19.2%
Total Suspended Solids (mg/L)	17	9	-47.1%	17	3	-82.4%	22	<3	-93.2%
Temperature - water (Cº)	9.9	10.9	10.1%	9.4	9.5	1.1%	12.8	11.5	-10.2%
Total Nitrogen (mg/L)	4.7	1.2	-74.5%	3.3	0.28	-91.5%	1.4	0.097	-93.1%
Total Petroleum Hydrocarbons (mg/L)	<0.3	0.3	**100.0%**	0.3	0.3	0.0%	0.3	<0.3	0.0%
Turbidity (NTU)	16	12	-25.0%	26	5.3	-79.6%	13	3.9	-70.0%
Total Zinc (mg/L)	0.0088	0.013	47.7%	0.0063	0.011	74.6%	0.033	0.0075	-77.3%

[5] Where values are below the laboratory limit of detection (indicated by values with a '<'), half this value is used in the percent change calculations
[6] Recorded at the Botanic Gardens

Table 6 Water quality results from infiltration basin sampling in 2012 during one wet weather event per site, with percent change in contaminant levels between the inlets and the outlets[7]. Values with a percent increase of greater than 50% are shown in bold.

Parameter	Waitikiri Ponds Inlet	Waitikiri Ponds Outlet	Waitikiri % Change	Waitikiri Ponds Inlet	Waitikiri Ponds Outlet	Waitikiri % Change	Tumara Park Inlet	Tumara Park Outlet	Tumara % Change	Bishops Green Inlet	Douglas Clifford Inlet (Dunbars Drain)	Douglas Clifford Outlet	Bishops Green/ Douglas Clifford % Change[8]	Worsleys Inlet	Worsleys Outlet	Worsley % Change
Date	23/10/12	23/10/12	-	07/12/12	07/12/12	-	07/12/12	07/12/12	-	20/06/13	20/06/13	20/06/13	-	20/06/13	20/06/13	-
Time of sample collection	1140	1155	-	1620	Not recorded	-	1550	1600	-	0940	0930	1000	-	1040	1025	-
24 hr rainfall (mm)[9]	4	4	-	28	28	-	28	28	-	18	18	18	-	18	18	-
48 hr rainfall (mm)[3]	13	13	-	28	28	-	28	28	-	18	18	18	-	18	18	-
Ammonia Nitrogen (mg/L)	0.022	0.047	**113.6%**	0.065	0.046	-29.2%	0.11	0.074	-32.7%	0.026	0.15	0.051	**96.2%**	0.068	0.065	-4.4%
Total Arsenic (mg/L)	0.0079	0.0035	-55.7%	0.0049	0.0033	-32.7%	<0.0018	<0.0018	0.0%	0.0091	0.01	0.0068	-25.3%	0.0042	0.003	-28.6%
BOD_5 (mg/L)	3.3	<1	-84.8%	1.3	1.5	15.4%	1.4	<1	-64.3%	<1.0	1	1	**100.0%**	1.5	1.5	0.0%
Total Cadmium (mg/L)	<0.0001	<0.0001	0.0%	<0.0001	<0.0001	0.0%	<0.0001	<0.0001	0.0%	<0.00010	<0.00010	<0.00010	0.0%	<0.00010	<0.00010	0.0%
Conductivity (µS/cm)	480	268	-44.2%	253	282	11.5%	17.4	12.7	-27.0%	106	121	150	41.5%	241	227	-5.8%
Total Copper (mg/L)	0.0023	0.0018	-21.7%	0.017	0.0028	-83.5%	0.0029	0.0023	-20.7%	0.0039	0.0055	0.0041	5.1%	0.0097	0.0094	-3.1%
Dissolved Organic Carbon (mg/L)	19	11	-42.1%	10	12	20.0%	3.1	1.6	-48.4%							
Dissolved Oxygen (mg/L)	10.3	10.2	-1.0%	8.2	66.1	**706.1%**	9.3	9.7	4.3%	9.3	9.1	7.7	-17.2%	11.2	10.7	-4.5%
Dissolved Oxygen (%)	93	97	4.3%	83	6.4	-92.3%	90	93	3.3%	79	79	66	-16.5%	96	94	-2.1%
Escherichia coli (CFU/100mL)	30	<10	-83.3%	20000	2500	-87.5%	3100	1000	-67.7%	660	2400	910	37.9%	880	810	-8.0%
Faecal Coliforms (CFU/100mL)	50	40	-20.0%	13000	600	-95.4%	1600	50	-96.9%	550	2000	460	-16.4%	1000	1700	**70.0%**
Total Lead (mg/L)	<0.0017	0.002	**135.3%**	0.0077	<0.0017	-89.0%	<0.0017	<0.0017	0.0%	<0.0017	<0.0017	0.0031	**264.7%**	0.013	0.011	-15.4%
Nitrate Nitrogen (mg/L)	<0.05	<0.05	0.0%	0.16	0.055	-65.6%	5.6	0.053	-99.1%	0.91	1	0.95	4.4%			
Nitrite Nitrogen (mg/L)	<0.005	<0.005	0.0%	<0.005	<0.005	0.0%	<0.005	<0.005	0.0%	<0.0050	0.006	0.018	**620.0%**	0.016	0.018	12.5%
NNN (mg/L)	<0.05	<0.05	0.0%	0.16	0.055	-65.6%	5.6	0.053	-100.0%	0.91	1.006	0.968	6.4%	0.016	0.018	12.5%
pH	7.6	7.8	2.6%	7.5	7.6	1.3%	6.8	6.8	0.0%	7.3	7.3	7.3	0.0%	7.2	7.3	1.4%
Dissolved Reactive Phosphorus (mg/L)	0.03	0.042	40.0%	0.034	0.084	**147.1%**	0.11	0.077	-30.0%	0.11	0.15	0.1	-9.1%	0.033	0.037	12.1%
Total Phosphorus (mg/L)	0.4	0.049	-87.8%	0.11	0.14	27.3%	0.14	0.11	-21.4%	0.13	0.17	0.12	-7.7%	0.13	0.16	23.1%
Total Suspended Solids (mg/L)	10	4	-60.0%	16	3	-81.3%	<3	<3	0.0%	7	16	8	14.3%	260	190	-26.9%
Temperature - water (Cº)	11.7	13.1	12.0%	15.4	15.8	2.6%	13.6	13	-4.4%	5.4	7.5	5.4	0.0%	7.7	8.2	6.5%
Total Nitrogen (mg/L)	1	0.2	-80.0%	1.6	1.9	18.8%	8.5	1.1	-87.1%	1.5	1.8	1.6	6.7%	11	9.3	-15.5%
Total Petroleum Hydrocarbons (mg/L)	1.3	0.36	-72.3%	17	0.52	-96.9%	1.6	<0.3	-6.3%	<0.7	<0.7	<0.7	0.0%	<0.7	<0.7	0.0%
Turbidity (NTU)	4.3	4.3	0.0%	12	2.1	-82.5%	1.9	2.2	15.8%	14	18	13	-7.1%	420	320	-23.8%
Total Zinc (mg/L)	0.004	0.003	-25.0%	0.01	0.006	-40.0%	0.019	0.014	-26.3%	0.11	0.11	0.054	-50.9%	0.083	0.061	-26.5%

[7] Where values are below the laboratory limit of detection (indicated by values with a '<'), half this value is used in the percent change calculations
[8] From Bishops Green Inlet
[9] Recorded at the Botanic Gardens