Interim Global Stormwater Consent

Wet Weather Monitoring Report for the period May 2014 – April 2015

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Interim Global Stormwater Consent

Wet Weather Surface Water Quality Monitoring Report for the period May 2013 – April 2014

1 Introduction

In accordance with the Interim Global Stormwater Consent (IGSC; CRC090292), this report summarises the results of the Christchurch City Council (CCC) wet weather surface water quality, stormwater devices and stormwater outfall monitoring for the period May 2014 to April 2015.

Section 3 of the IGSC monitoring plan details that stormwater outfall samples will be taken every year from eight sites with varying catchment influences of residential, commercial and industrial (Table 1; Figure 1). One storm event per site will be sampled, over three time periods for each event.

Under section 4.1 of the IGSC monitoring plan, surface water samples within different river catchments each monitoring year are required to be taken during two wet weather events. In accordance with these plans, three sites in the Heathcote River catchment were scheduled to be sampled this monitoring year (Table 2; Figure 2).

Section 8.2 of the IGSC monitoring plan also outlines that stormwater system performance sampling should be undertaken over the lifetime of the consent at thirteen basins. Monitoring has been undertaken so far at the following basins:

- Waitikiri Ponds (November 2010, October 2011, October 2012 and December 2012)
- Tumara Park (November 2010, October 2011 and December 2012)
- Northwood Glen Oaks Basin (November 2010 and October 2011)
- Douglas Clifford and Bishops Green (June 2013)
- Worsley Farm soil adsorption (June 2013)
- Halswell Retention Basin (monthly monitoring since 2007, presented in the annual water quality monitoring report; Margetts & Marshall, 2015)
- Wigram Retention Basin (November 2010)

Difficulties were encountered this monitoring year, due to insufficient rain events (i.e. not meeting the criteria specified in the methods) during this particularly dry year and logistics (e.g. health and safety issues limiting sampling to daylight hours). Therefore, only two stormwater outfall sites were able to be sampled this monitoring year. No river monitoring or basin monitoring was achieved. For the basin monitoring, as detailed above, this is required over the lifetime of the consent, not annually, and a significant amount of this sampling has already been undertaken. We will still carry out the river sampling and will make these results available to Environment Canterbury (ECan) as soon as we are able to achieve the required two monitoring events.

The majority of the IGSC wet weather monitoring conditions were included in the consent to allow collection of data to inform the developments of Stormwater Management Plans (SMP) and associated consents. It is considered enough information on stormwater quality has been collected by the CCC and others to allow the development of these plans, as shown by the detailed Avon SMP submitted with the Comprehensive Stormwater Network Discharge Consent (CSNDC) application to ECan. Because of this, it is not proposed to continue this type of monitoring under the CSNDC, with a greater focus on receiving environment monitoring. Device and stormwater outfall monitoring will still be undertaken as part of the Council's maintenance and implementation work, but this is not proposed to be included as consent conditions. This is in line with the latterly granted South-West and Styx SMPs.

The exception to this being the river wet weather monitoring, which is still proposed under the CSNDC and is present in the South-West and Styx SMPs. Therefore, practically we do not consider it is a large issue that not all wet weather monitoring was able to be achieved this monitoring year.

Table 1. Interim Global Stormwater Consent stormwater outfall monitoring site descriptions, GPS coordinates and receiving environments

Site Description	Easting	Northing	Receiving Environment
Waltham (manhole at Ontrack – Wilsons Road)	2482072	5740128	Heathcote River
South Central City (outfall at "Tiffanys" Oxford Terrace)	2480299	5741424	Avon River
Bromley (Charlesworth Drain in manhole at 250 Dyers Road)	2486033	5740911	Charlesworth Street Stream ↓ Estuary
Curletts Road Branch Drain (adjacent to 65 Treffers Road)	2475645	5740038	Haytons Stream ↓ Heathcote River
St Albans (Lower Frees Creek at Manchester Street outfall)	2480911	5742110	Avon River
Northwood Top Basin inlet	2478627	5749485	Styx River
Westmorland (24 Penruddock Rise silt trap)	2477952	5736573	Cashmere Stream ↓ Heathcote River
Avonhead (Norton Street)	2474275	5742736	Austins Stream ↓ Avon River

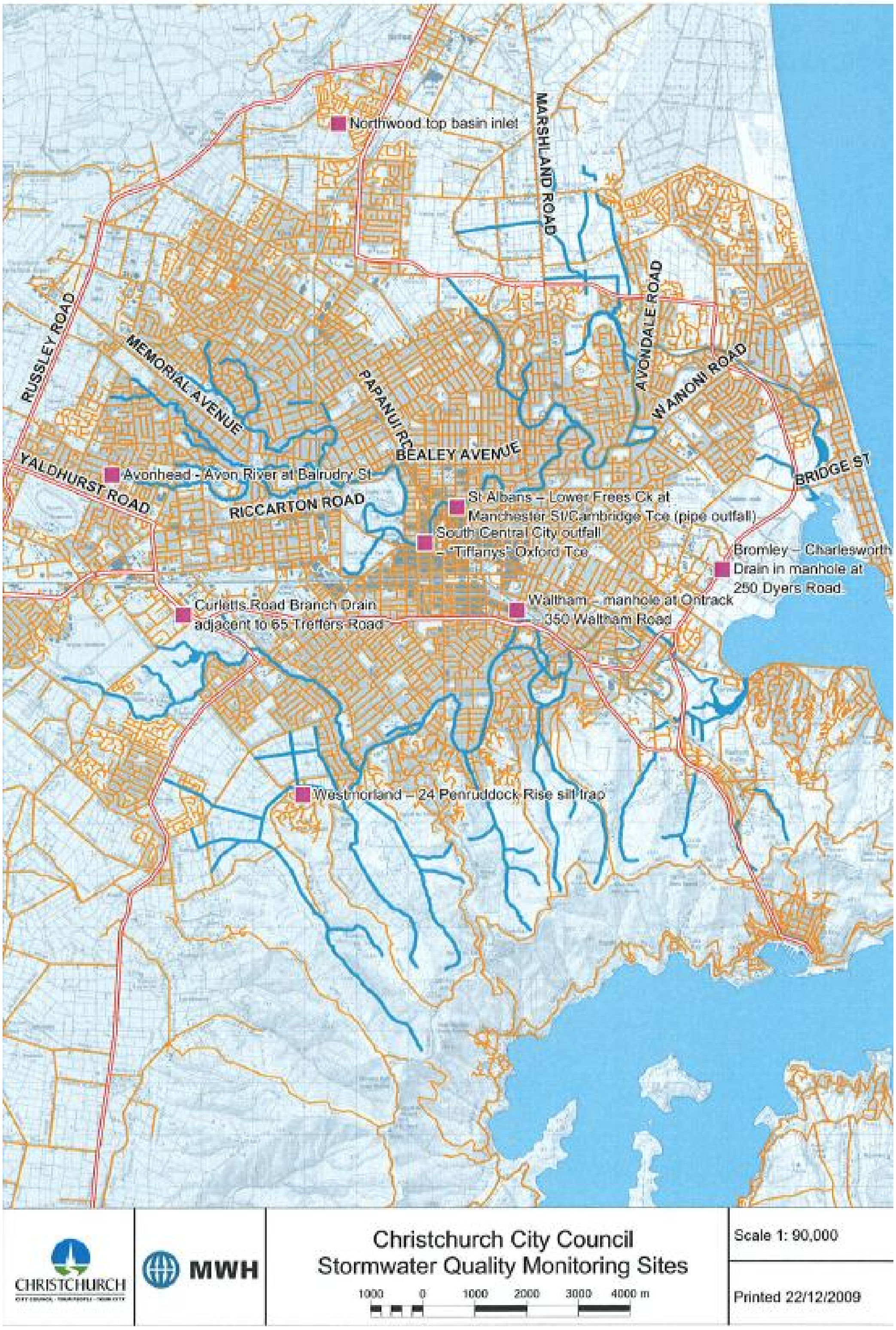

Figure 1. Location of Christchurch City Council Interim Global Stormwater Consent Stormwater Outfall monitoring sites

Table 2. Christchurch City Council wet weather surface water quality monitoring sites required under the Interim Global Stormwater Consent (pLWRP = proposed Land & Water Regional Plan)

Site Description	Easting	Northing	Environment Canterbury pLWRP Waterway Classification
Heathcote at Bowenvale Avenue (HEATH04)	2481198	5737390	Spring-fed – plains – urban
Heathcote at Catherine Street (HEATH11)	2484415	5739494	Spring-fed – plains – urban
Cashmere Stream at Sutherlands Road (HEATH16)	2476084	5735598	Not classified[1]

[1] But considered a Banks Peninsula waterway, as per the lower reaches

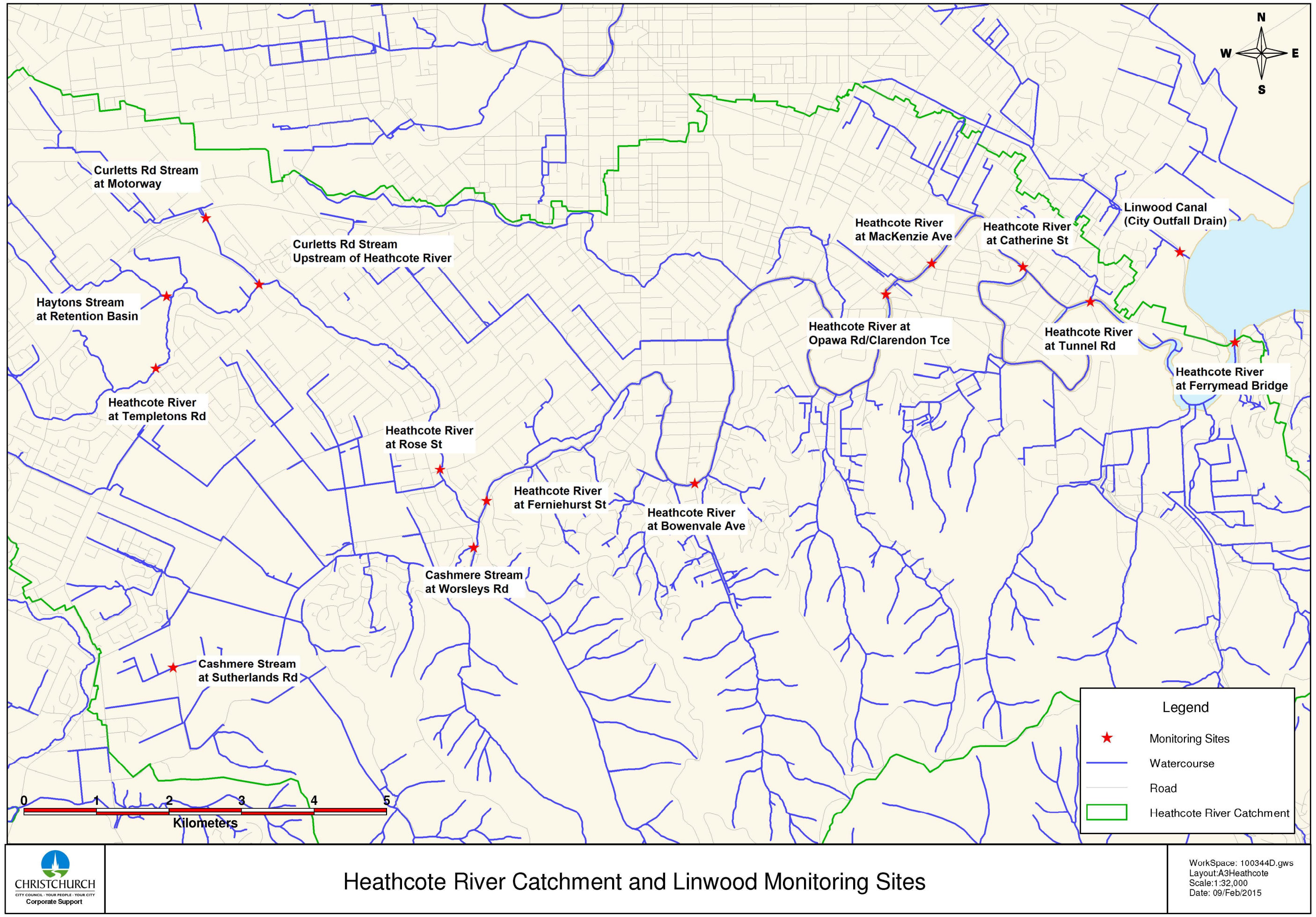

Figure 2. Location of Christchurch City Council Heathcote River catchment surface water quality monitoring sites, including the three wet weather sampling sites

2 Methods

Stormwater outfall samples were collected at the two sites, Bromley and Northwood Top Basin, by the Christchurch City Council laboratory, according to the protocol in the monitoring plan. Samples were collected during a single, continuous wet weather event starting on the 13th April 2015. Autosamplers took samples over three time periods of the event.

Stormwater outfall samples were tested at the laboratory for a range of different water quality parameters, as outlined in Table 3. However, for the Bromley sample, there was insufficient stormwater to sample every constituent during every time series. Biochemical Oxygen Demand (BOD_5) and Total Petroleum Hydrocarbons (TPH) were therefore unable to be analysed at this site during all three time periods. Rainfall gauges at Tunnel Road and the Botanic Gardens were assessed to determine the characteristics of the rainfall event at Bromley and Northwood, respectively.

The receiving environments for the Bromley and Northwood Top Basin outfalls are Charlesworth Street Stream and the Styx River, respectively. Charlesworth Street Stream is not classified under the proposed Land & Water Regional Plan (pLWRP), but is considered a 'spring-fed – plains – urban' waterway in this report (similar to the Avon and Heathcote Rivers). The Styx River is classified as 'spring-fed – plains' under the pLWRP.

The results of this sampling are compared in this report to guideline levels for these relevant receiving waters, to give an indication of the effects of stormwater on water quality. As these are stormwater outfall samples though, further dilution is expected in the receiving environment. However, it is useful to see what parameters are likely to be of concern, based on the initial concentrations in stormwater (i.e. potentially only those that are above guideline levels in stormwater). A brief discussion of the main parameters sampled, their importance and relevant guideline levels are included in the following paragraphs.

Metals, in particular, *arsenic, cadmium, copper*, *lead* and *zinc*, can be toxic to aquatic organisms, negatively affecting such things as fecundity, maturation, respiration, physical structure and behaviour (Harding, 2005). The toxicity of metals in freshwater, and therefore the risk of adverse biological effects, alters depending on the hardness, pH and alkalinity of the water, with a positive relationship between toxicity and water hardness (ANZECC 2000). Therefore, trigger levels should be calculated with consideration of water hardness (ANZECC 2000). For this monitoring report, this is relevant for dissolved copper, lead and zinc. The Council has previously calculated Hardness Modified Trigger Values (HMTV) for metals in Christchurch Rivers in accordance with ANZECC (2000) methodology (see Appendix A). For this report, the Avon River values were used for the Bromley sample and the Styx River values were used for the Northwood sample.

pH is a measure of acidity or alkalinity, on a scale from 0 to 14; a pH value of seven is neutral, less than seven is acidic and greater than seven is alkaline. Appropriate pH levels are essential for the physiological functions of biota, such as respiration and excretion (Environment Canterbury, 2009). Aquatic species typically have tolerances for certain pH levels and alteration of pH can result in changes in the composition of fish and invertebrate communities, with generally a positive relationship between pH and the number of species present (Collier et al. 1990). The guidelines in the pLWRP for all waterways have a lower limit of 6.5 and an upper limit of 8.5.

Conductivity is a measure of how well water conducts an electrical current. Pure water has very low conductivity, but dissolved ions in the water (e.g. contaminants such as metals and nutrients) increase conductivity. Traditionally, conductivity has been compared to the guideline value of <175 µS/cm recommended by Biggs (1988) to avoid excessive periphyton growth. However, this guideline may be less relevant in urban waterways, where other contaminants that will not encourage periphyton growth may be contributing to high conductivity, such as metals. It is also noted that ECan do not consider this guideline value is useful, due to natural variations in levels (Abigail Bartram, ECan, personal communication). They instead consider that analysis of trends is more useful.

Elevated levels of suspended sediment (*Total Suspended Solids*, TSS) in the water column decrease the clarity of the water and can adversely affect aquatic plants, invertebrates and fish (Crowe & Hay, 2004; Ryan, 1991). For example, sediment can affect photosynthesis of plants and therefore primary productivity within streams, interfere with feeding through the smothering of food supply, and can clog suitable habitat for species (Crowe & Hay, 2004; Ryan, 1991). A guideline level for TSS is not provided in the pLWRP. Ryan (1991) recommends a guideline value of 25 mg/L to ensure protection of aesthetic and ecological values, and therefore this guideline is used in this monitoring report.

Turbidity is a measure of the transmission of light through water. Suspended matter in the water column causes light to be scattered or absorbed as is travels through the water. As for TSS, turbidity decreases the clarity of the water and can negatively affect stream biota (Ryan, 1991). A guideline level for this parameter is not provided in the pLWRP. ANZECC (2000) provides a guideline of 5.6 Nephelometric Turbidity Units (NTU) for lowland rivers.

Dissolved Oxygen (DO) is the concentration of oxygen dissolved or freely available in water and is commonly expressed as percent saturation. Adequate DO levels are essential for aquatic animals, such as fish and invertebrates, and can be influenced by many factors, including temperature, velocity, decomposition of organic material, and the photosynthesis and respiration of aquatic plants. The pLWRP details a minimum DO level of 70% for 'spring-fed – plains – urban' and 'spring-fed – plains' waterways.

High *water temperature* can affect aquatic biota, with some studies showing that the presence of sensitive macroinvertebrates decreases with increasing temperature (Wahl et al., 2013). The pLWRP water quality standard for temperature for all waterways is a maximum of 20°C.

Biochemical Oxygen Demand (BOD_5) is an indicator of the amount of biodegradable organic material in the water and the amount of oxygen required by bacteria to break down this material. High BOD_5 values are due to plant matter, nitrogen and phosphorus, and indicate the potential for bacteria to deplete oxygen levels in the water. The pLWRP does not have a guideline level for this parameter. The Ministry for the Environment (1992) guideline level is 2 mg/L.

Total ammonia (ammoniacal nitrogen) is typically a minor component of the nitrogen available for plant growth, but at high levels can have toxic effects on aquatic ecosystems. The toxicity of ammonia varies with pH (ANZECC, 2000). Therefore, the pLWRP water quality standards also vary depending on pH, ranging from 2.57 mg/L at pH 6 to 0.18 mg/L at pH 9 (Environment Canterbury, 2012). For this report, the water quality standard was adjusted based on the median pH levels for the two sampled stormwater sites (7.5, resulting in an ammonia standard of 1.61 mg/L).

Nitrate can also be toxic to stream biota and specific guidelines for this parameter have recently been developed to protect freshwater species (Hickey, 2013). Guidelines are available for different species protection levels: 99% (pristine environment with high biodiversity and conservation values), 95% (environments which are subject to a range of disturbances from human activities, but with minor effects), 90% (environments which have naturally seasonally elevated concentrations for significant periods of the year (1-3 months)), 80% (environments which are measurably degraded and which have seasonally elevated concentrations for significant periods of the year (1-3 months)), and acute (environments which are significantly degraded; probable chronic effects on multiple species). To be conservative, the 90% species protection was chosen as the guideline level for the two sites in this report. Within this 90% level of species protection there are two guideline values: the ‘grading’ guideline (3.8 mg/L) that provides for ecosystem protection for average long-term exposure (measured against medians) and the ‘surveillance’ guideline (5.6 mg/L) that assesses seasonal maximum concentrations (measured against annual 95% percentiles).

Elevated concentrations of *Nitrate Nitrite Nitrogen* (NNN) can lead to the proliferation of aquatic plants and algae, because nitrate and nitrite are oxidised forms of nitrogen that are readily available to plants. The pLWRP does not have a guideline value for this parameter, but the ANZECC (2000) water quality guidelines provide a trigger value of 0.444 mg/L for lowland rivers to avoid excessive plant growth.

Dissolved Inorganic Nitrogen (DIN), which is the sum of ammonia, nitrite and nitrate, provides a measure of the risk of eutrophication and toxicity (Environment Canterbury, 2012). The pLWRP details a value of 1.5 mg/L for 'spring-fed – plains – urban' and 'spring-fed – plains' waterways.

Dissolved Reactive Phosphorus (DRP) is a soluble form of phosphorus that is readily available for use by plants. Phosphorus is an essential nutrient for plant growth and can limit primary production at low levels, but can cause proliferation of algae and aquatic plants at high levels. The pLWRP standard for ‘spring-fed – plains – urban' and 'spring-fed – plains' waterways is 0.016 mg/L.

Escherichia coli is a bacterium that is commonly used as an indicator of faecal contamination in freshwater and therefore health risk from contact recreation (Ministry for the Environment, 2003). The guideline level in the pLWRP for 'spring-fed – plains – urban' and 'spring-fed – plains' waterways is 550 *E. coli* per 100ml (for 95% of samples).

Table 3. Parameters analysed in wet weather stormwater outfall samples taken in accordance with the Interim Global Stormwater Consent

Parameter	Units of measurement
Total & dissolved arsenic	mg/L
Total & dissolved copper	mg/L
Total & dissolved lead	mg/L
Total & dissolved zinc	mg/L
pH	
Electrical conductivity	µS/cm
Total Suspended Solids (TSS)	mg/L
Turbidity	NTU
Dissolved Oxygen (DO)	mg/L and % saturation
Water temperature	°C
Biochemical Oxygen Demand (BOD_5)	mg/L
Total ammonia (ammoniacal nitrogen)	mg/L
Nitrate nitrogen	mg/L
Nitrite nitrogen	mg/L
Nitrate-Nitrite-Nitrogen (NNN)	mg/L
Dissolved Inorganic Nitrogen (DIN)	mg/L
Total nitrogen	mg/L
Dissolved Reactive Phosphorus (DRP)	mg/L
Total phosphorus	mg/L
Escherichia coli	CFU/100 mL
Total petroleum hydrocarbons	mg/L

3 Stormwater Outfall Results

Appendix B of this report presents the raw wet weather stormwater outfall results over the three time periods, along with the rainfall prior to each sampling event. Parameters of importance to instream values are discussed in the following sections, with graphs presented that compare concentrations to the receiving water guidelines outlined in the methods.

3.1 *Rainfall*

The Bromley rain event started slightly sooner than the Northwood event and recorded much higher rainfall depth (Figure 3). The Bromley samples taken during all three time periods were at a depth approximately 3 mm less than that of Northwood. All three samples for Bromley were within the building time of the storm and therefore the first flush is expected to have been sampled. For the Northwood samples, the first two are predicted to have intercepted the first flush, but the final one was likely taken within the tail end of the storm.

3.2 *Dissolved Copper*

Dissolved copper levels in the outfalls were generally above the respective receiving water quality guideline of 0.00212 mg/L (for Styx/Northwood) and 0.00356 mg/L (for Avon/Bromley), except for the second time period at Bromley and the first time period at Northwood (
Figure 4). Concentrations varied between time periods and sites, with Bromley generally recording higher values than Northwood. The higher first and third concentrations in the Bromley sample is likely reflective of the variable nature of stormwater and indicative of all three samples being taken during the first flush (i.e. a drop off was not shown). Northwood's pattern of highest concentration during the middle time period may be due to the peak of contaminants only just reaching the outfall at this time period; this is also in line with the rainfall data that suggests the third time period was taken outside of the first flush.

3.3 *Dissolved Lead*

All sites recorded dissolved lead levels below the LOD for all samples, which also meant that all samples were below their respective receiving water quality guidelines of 0.01554 mg/L (Avon/Bromley) and 0.00634 mg/L (Styx/Northwood) (
Figure 5).

3.4 *Dissolved Zinc*

All sites and all samples exceeded their respective receiving water quality guidelines of 0.02970 mg/L (Avon/Bromley) and 0.01214 mg/L (Styx/Northwood) (Figure 6). The first time period for Northwood recorded a much higher concentration compared to the other samples at both Northwood and Bromley. The Bromley site increased levels of zinc over time, again indicative of all three samples being taken during the first flush. In contrast, the Northwood sites decreased zinc concentrations over time, likely also indicative of the final samples being towards the tail end of the storm.

3.5 *pH*

All pH levels were within the receiving water quality guidelines of 6.5 to 8.5 (Figure 7). There was little change between sites, or within sites over time.

3.6 *Conductivity*

Conductivity levels varied between time periods and sites (Figure 8). There was no obvious trend in concentrations at Bromley, likely related to all samples being taken during the first flush. However, concentrations decreased over time at Northwood, potentially due to the latter samples being taken outside the first flush of the storm.

3.7 *TSS*

All time periods at Bromley recorded TSS concentrations above the receiving water quality guideline of 25 mg/L, while all time periods at Northwood recorded TSS concentrations below (Figure 9). The Bromley and Northwood sites displayed opposite trends in TSS concentration over time, with Bromley increasing rapidly and Northwood decreasing slowly. Again, this is likely reflective of the Bromley samples being taken during the peak of the storm and the latter Northwood samples being taken during the tail end of the storm. Bromley recorded much higher values than Northwood, with an exceptionally high value of 190 mg/L recorded during the third time period.

3.8 *Turbidity*

Turbidity levels showed similar trends to TSS, as these two parameters are related. Bromley recorded much higher levels than Northwood, with a particularly high value of 180 NTU during the third period. The three time periods at Northwood recorded similar concentrations to each other. All three time periods at Bromley and the first two events at Northwood were above the guideline level of 5.6 NTU (Figure 10).

3.9 *BOD_5*

BOD_5 was not measured at Bromley, due as explained in the methods. The Northwood site recorded levels higher than the receiving water quality guideline of 2 mg/L in the first two time periods (Figure 11). Concentrations decreased through time.

3.10 *Total Ammonia*

All samples for all sites were substantially below the receiving water quality guideline of 1.61 mg/L (Figure 12). Both sites displayed a trend of decreasing concentrations over time, but levels were much higher at Bromley than Northwood. Concentrations at Northwood also dropped off more quickly than at Bromley. This suggests the peak of ammonia occurred towards the beginning of the storm event, with either this contaminant mobilising easier, or the source being closer to the outfall (as compared to metals that increased in concentration over time).

3.11 *Nitrate*

Nitrate levels in all samples were well below the grading and surveillance guideline levels for receiving waters of 3.8 and 5.6 mg/L, respectively (Figure 13). Concentrations increased over time at the Bromley site and generally increased over time at the Northwood site, with the exception of the final sample. Levels were generally similar between sites. Again, these results are likely reflective of the differing sampling of the first flush at these sites.

3.12 *NNN*

All samples recorded NNN levels below the receiving water quality guideline of 0.444 mg/L (Figure 14). Levels were similar to nitrate, as these two parameters are related, with concentrations increasing over time at the Bromley site and generally increasing at the Northwood site, with the exception of the final sample. Levels were generally similar between sites.

3.13 *DIN*

DIN concentrations for all time periods and sites were considerably below the receiving water quality guideline of 1.5 mg/L (Figure 15). Levels within sites showed a similar pattern to nitrate and NNN, although on a more subtle scale. Bromley generally recorded higher levels than Northwood.

3.14 *DRP*

DRP levels were substantially higher than the receiving water quality guideline of 0.016 mg/L for all samples (Figure 16). Levels at the Bromley site decreased slightly over time, which suggests the peak of phosphorous (similar to ammonia) occurred towards the beginning of the storm event, with either this contaminant mobilising easier, or the source being closer to the outfall. Levels peaked at Northwood during the second time period, indicative of the first sample being at the beginning of the storm and the latter sample being towards the end. Northwood generally recorded higher levels than Bromley.

3.15 *E. coli*

Both outfalls recorded *E. coli* levels above the guideline of 550 CFU/100ml for all time periods; the concentration of *E.coli* in the second Northwood time period was considerably higher than all other samples (16,000 CFU/100ml; Figure 17). Concentrations increased slightly over time at Bromley and peaked at Northwood during the second time period, again these trends are likely due to the differing sampling of the first flush.

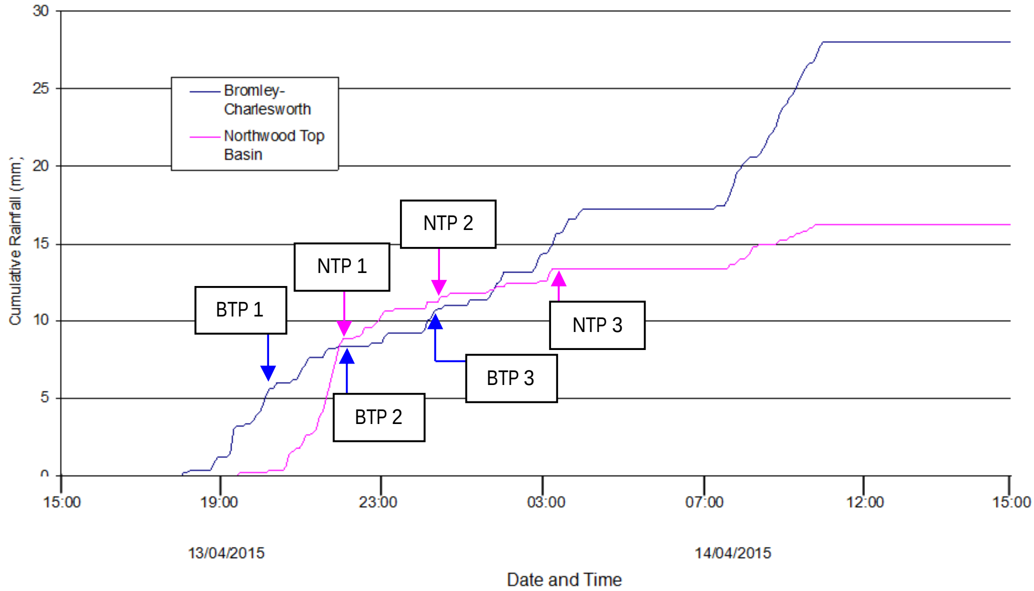

Figure 3. Rainfall during the wet weather event at the two stormwater outfall sites, with approximate times of sampling arrowed. BTP = Bromley Time Period; NTP = Northwood Time Period.

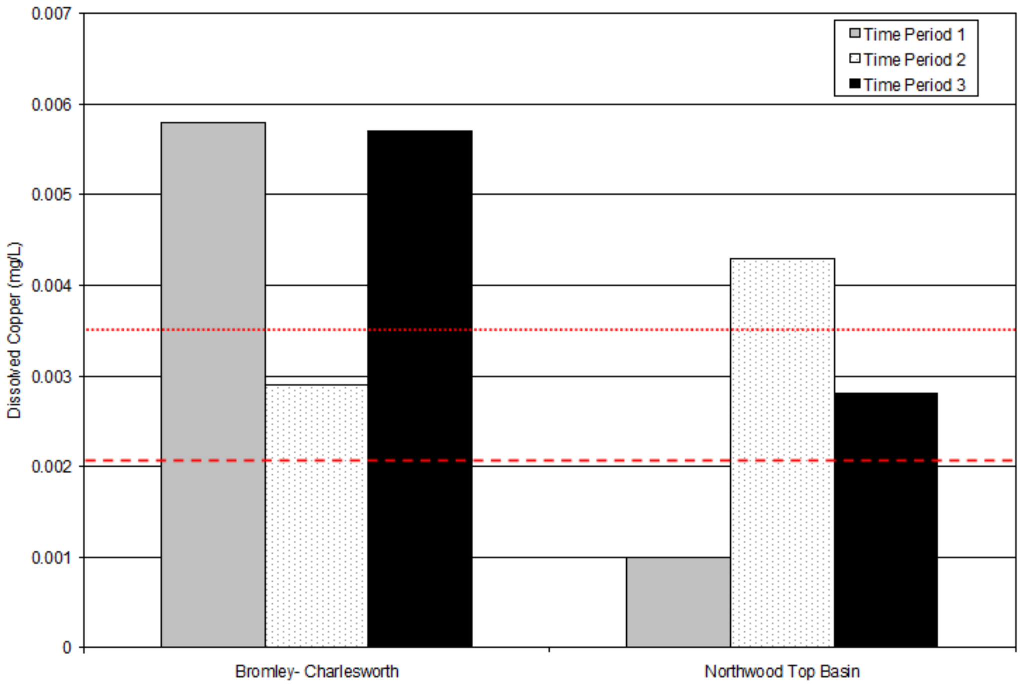

Figure 4. Dissolved copper levels in water samples from stormwater outfalls, during three time periods of a wet weather event (collected using autosamplers). The dashed (Styx [Northwood]: 0.00212 mg/L) and dotted (Avon [Bromley]: 0.00356 mg/L) lines represent the proposed Canterbury Land and Water Regional Plan trigger value for receiving waters (Environment Canterbury, 2012), which have been modified to account for water hardness, as per the ANZECC (2000) guidelines methodology. Values below the Laboratory Limit of Detection of 0.002 mg/L were converted to half this limit (0.001 mg/L) for statistical presentation.

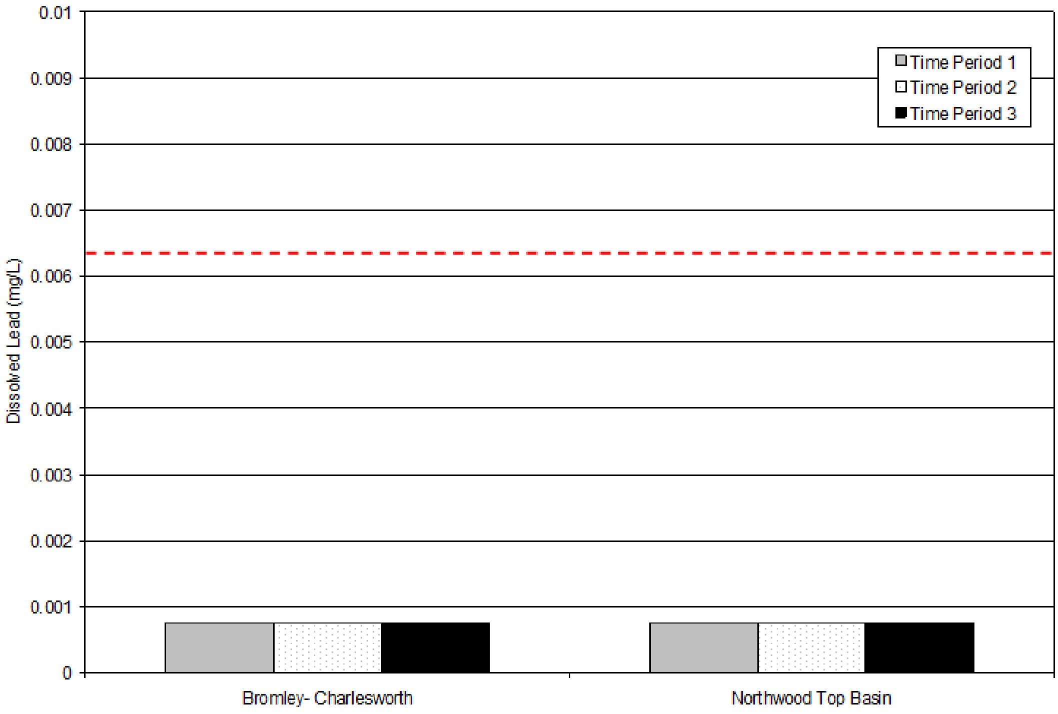

Figure 5. Dissolved lead levels in water samples from stormwater outfalls, during three time periods of a wet weather event (collected using autosamplers). The dashed line (Styx [Northwood]: 0.00634 mg/L) represents the proposed Canterbury Land and Water Regional Plan trigger value for receiving waters (Environment Canterbury, 2012), which has been modified to account for water hardness, as per the ANZECC (2000) guidelines methodology. The line for the Avon River (Bromley) is not visible as it is of the scale (0.01554 mg/L). Values below the Laboratory Limit of Detection of 0.0015 mg/L were converted to half this limit (0.00075 mg/L) for statistical presentation.

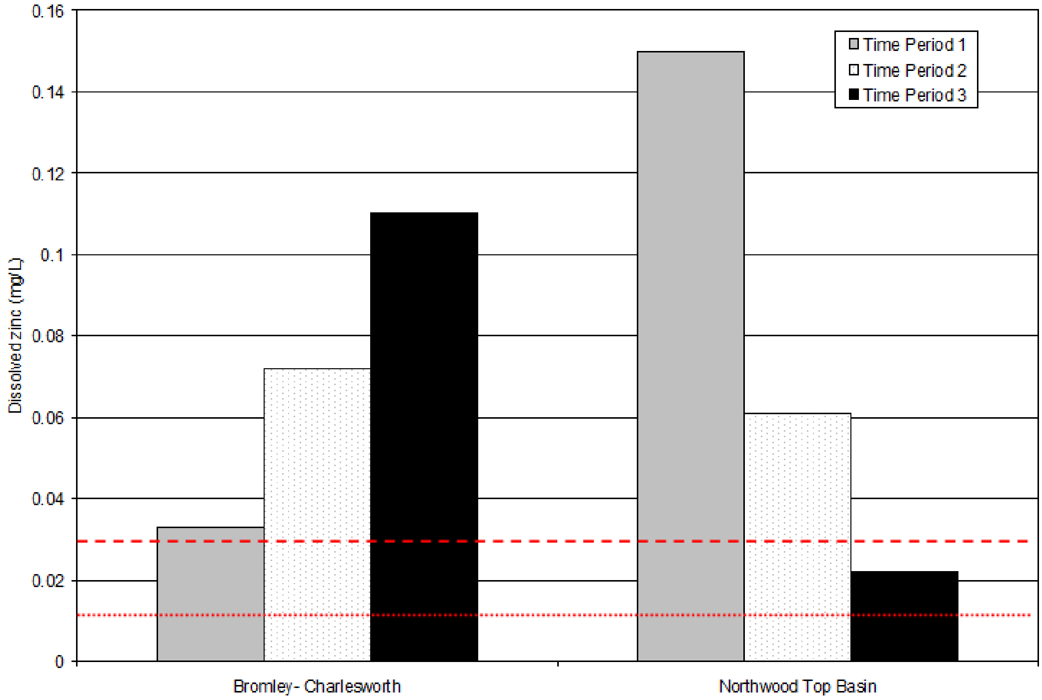

Figure 6. Dissolved zinc levels in water samples from stormwater outfalls, during three time periods of a wet weather event (collected using autosamplers). The dashed (Styx [Northwood]: 0.01214 mg/L) and dotted (Avon [Bromley]: 0.02970 mg/L) lines represent the proposed Canterbury Land and Water Regional Plan trigger value for receiving waters (Environment Canterbury, 2012), which have been modified to account for water hardness, as per the ANZECC (2000) guidelines methodology. No values were below the Laboratory Limit of Detection of 0.0010 mg/L.

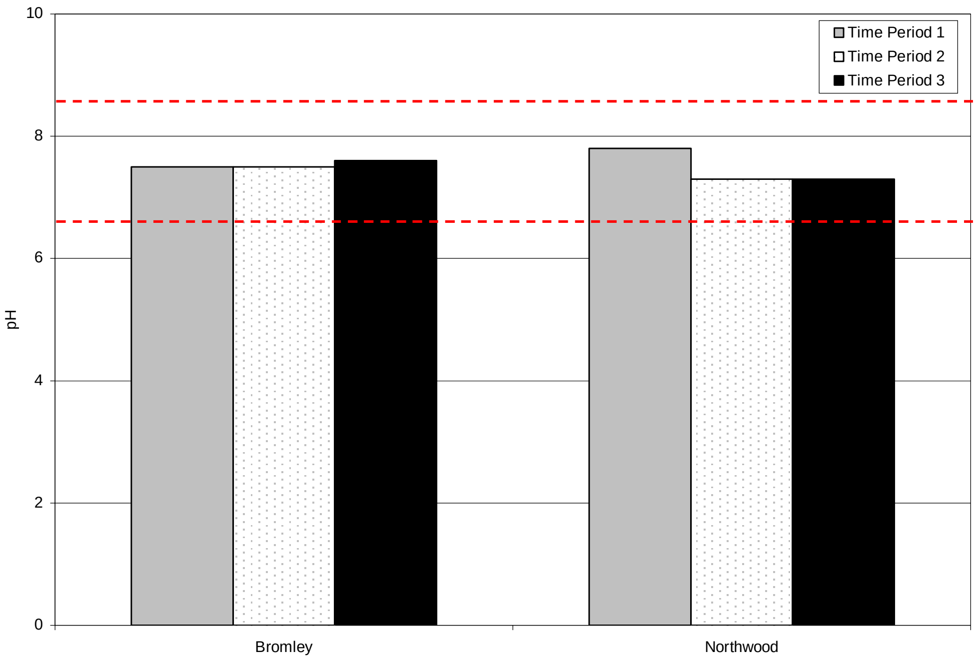

Figure 7. pH levels in water samples from stormwater outfalls, during three time periods of a wet weather event (collected using autosamplers). The dashed lines represent the proposed Canterbury Land and Water Regional Plan receiving waters lower (6.5) and upper (8.5) limits (Environment Canterbury, 2012).

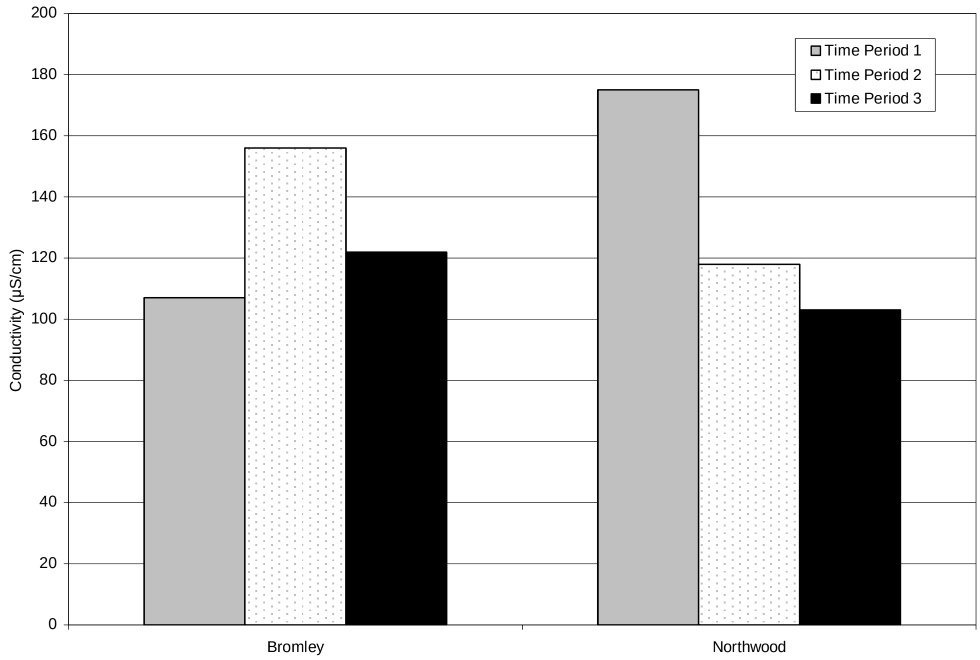

Figure 8. Conductivity levels in water samples from stormwater outfalls, during three time periods of a wet weather event (collected using autosamplers). There are no relevant guideline levels for this parameter.

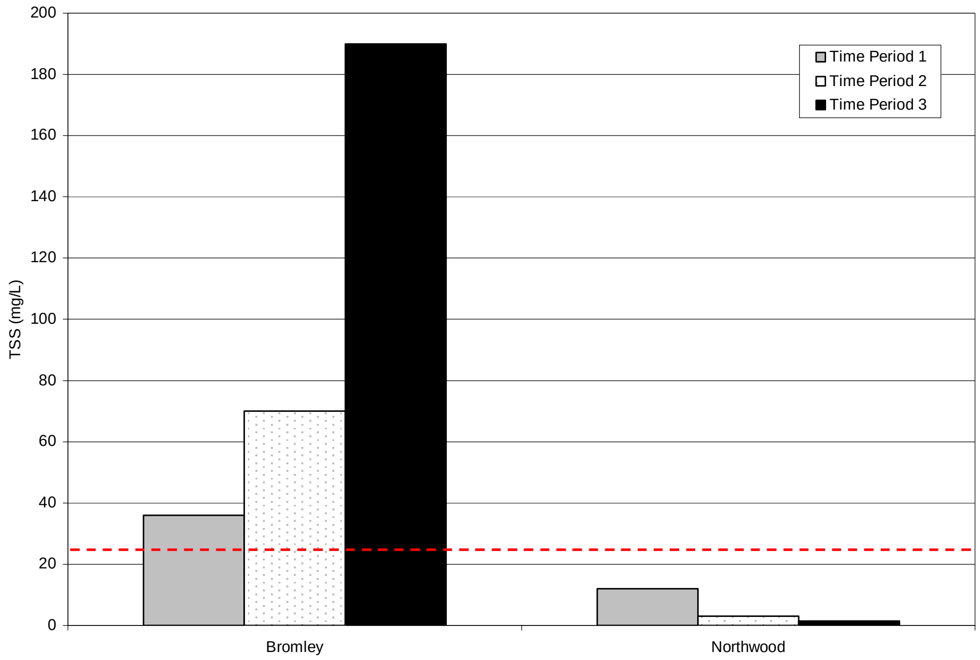

Figure 9. Total Suspended Solid (TSS) levels in water samples from stormwater outfalls, during three time periods of a wet weather event (collected using autosamplers). The dashed line represents the Ryan (1991) guideline value for receiving waters of 25 mg/L. Values below the Laboratory Limit of Detection of 3 mg/L were converted to half this limit (1.5 mg/L) for statistical presentation.

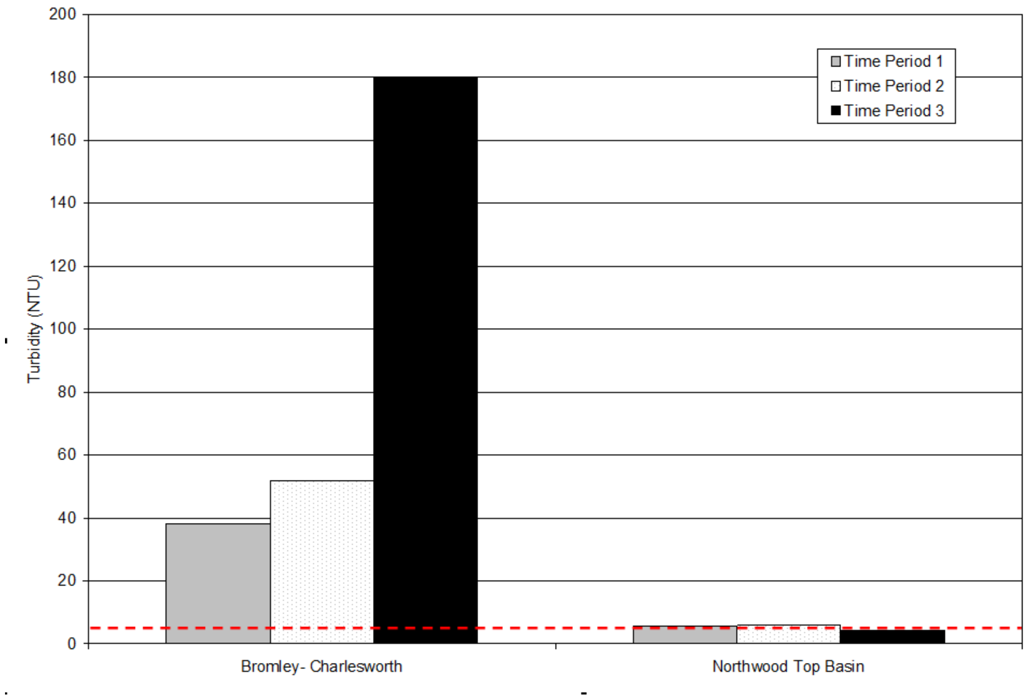

Figure 10. Turbidity levels in water samples from stormwater outfalls, during three time periods of a wet weather event (collected using autosamplers). The dashed line represents the ANZECC (2000) receiving water guideline value of 5.6 Nephelometric Turbidity Units (NTU).

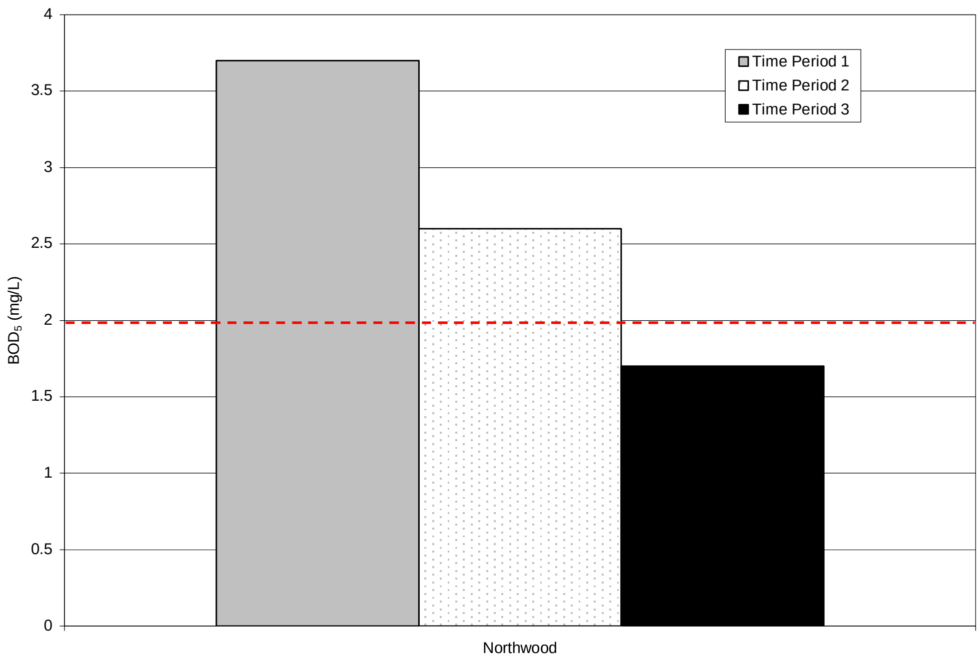

Figure 11. Biochemical Oxygen Demand (BOD_5) levels in water samples from stormwater outfalls, during three time periods of a wet weather event (collected using autosamplers). The dashed line represents the Ministry for the Environment guideline value for receiving waters (2 mg/L; Ministry for the Environment, 1992). The Laboratory Limit of Detection was 1.0 mg/L, analysed as half this value (0.5 mg/L) to allow statistics to be undertaken.

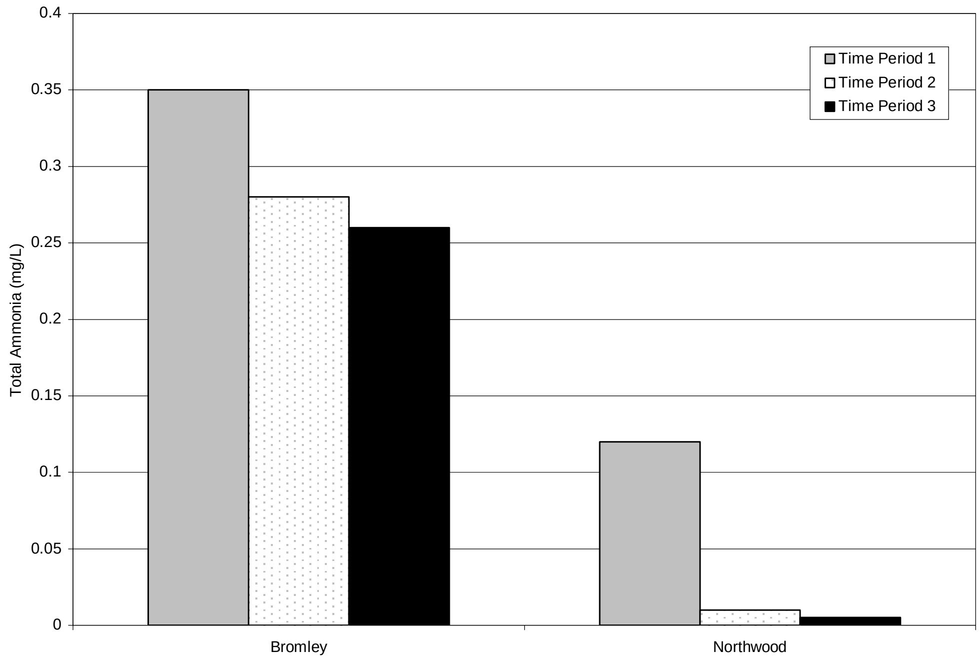

Figure 12. Total ammonia levels in water samples from stormwater outfalls, during three time periods of a wet weather event (collected using autosamplers). The proposed Canterbury Land and Water Regional Plan receiving waters trigger value (1.61 mg/L; Environment Canterbury, 2012), calculated based on median pH levels (7.5) of the stormwater for the annual monitoring period, are not shown on the graph, as the y-axis scale does not extend this far.

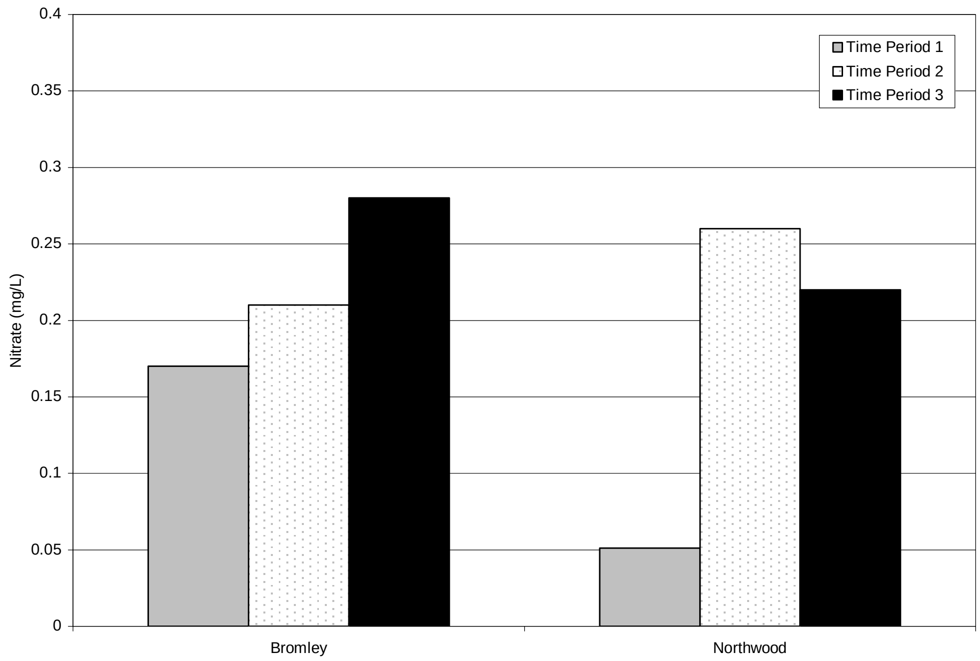

Figure 13. Nitrate levels in water samples from stormwater outfalls, during three time periods of a wet weather event (collected using autosamplers). The Hickey (2013) grading and surveillance guideline levels for receiving waters (3.8 mg/L and 5.6 mg/L, respectively) are not shown on the graph, as the y-axis scale does not extend this far.

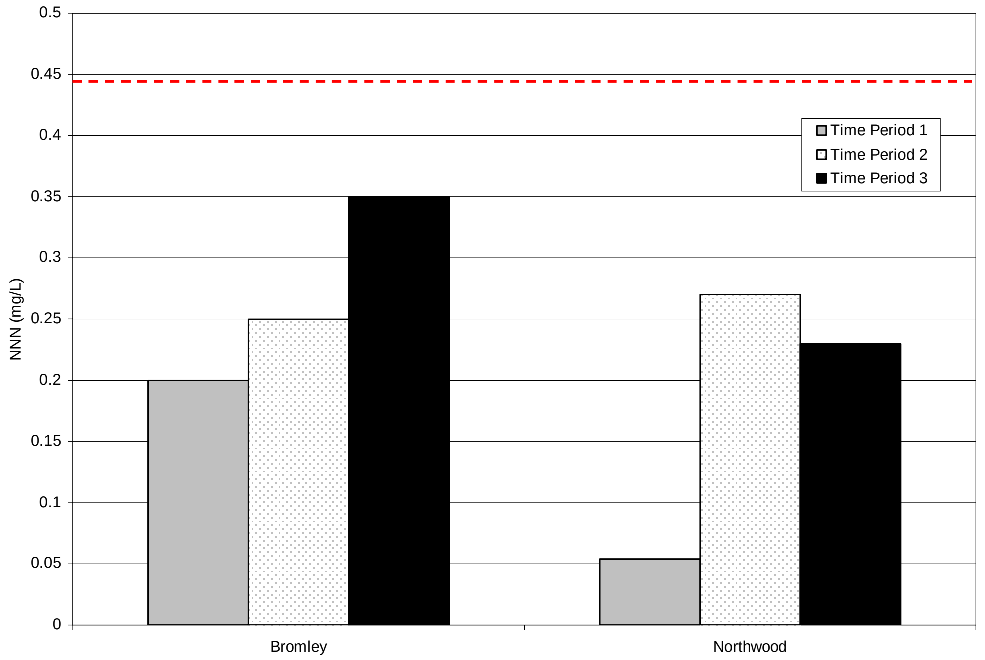

Figure 14. Nitrate Nitrite Nitrogen (NNN) levels in water samples from stormwater outfalls, during three time periods of a wet weather event (collected using autosamplers). The dashed line represents the ANZECC receiving water guideline (0.444 mg/L; ANZECC, 2000).

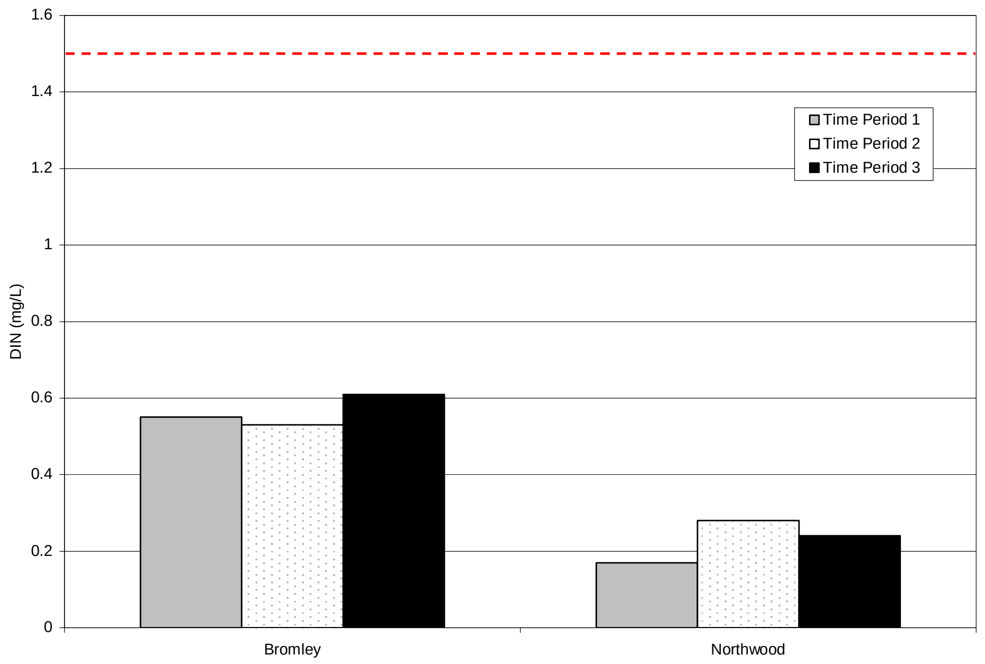

Figure 15. Dissolved Inorganic Nitrogen (DIN) levels in water samples from stormwater outfalls, during three time periods of a wet weather event (collected using autosamplers). The dashed line represents the proposed Canterbury Land and Water Regional Plan receiving water trigger value of 1.5 mg/L (Environment Canterbury, 2012).

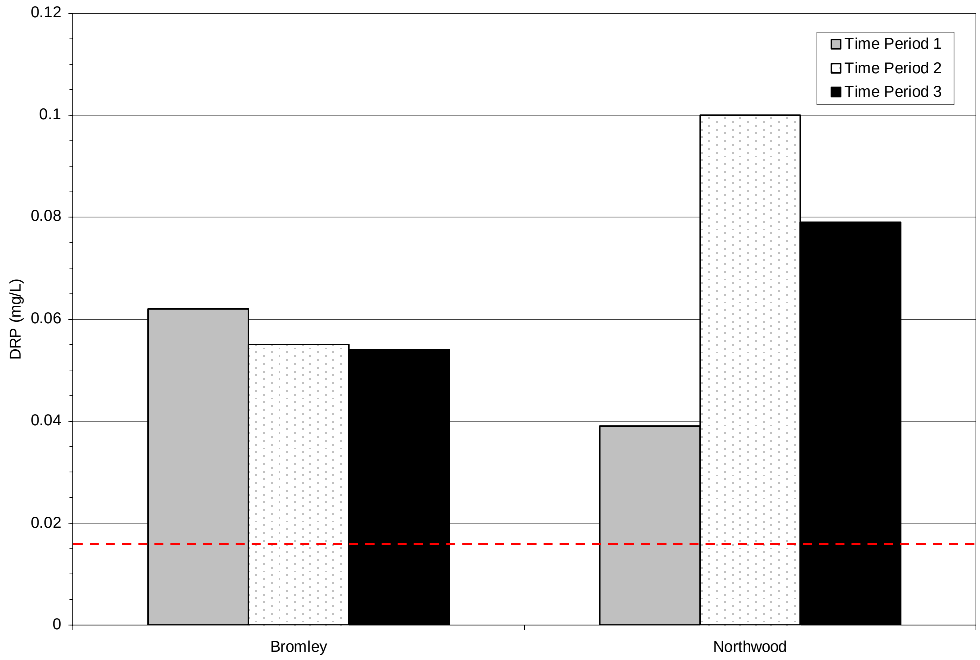

Figure 16. Dissolved Reactive Phosphorous (DRP) levels in water samples from stormwater outfalls, during three time periods of a wet weather event (collected using autosamplers). The dashed line represents the proposed Canterbury Land and Water Regional Plan receiving water trigger value of 0.016 mg/L (Environment Canterbury, 2012). No concentrations were below the Laboratory Limit of Detection of 0.003 mg/L.

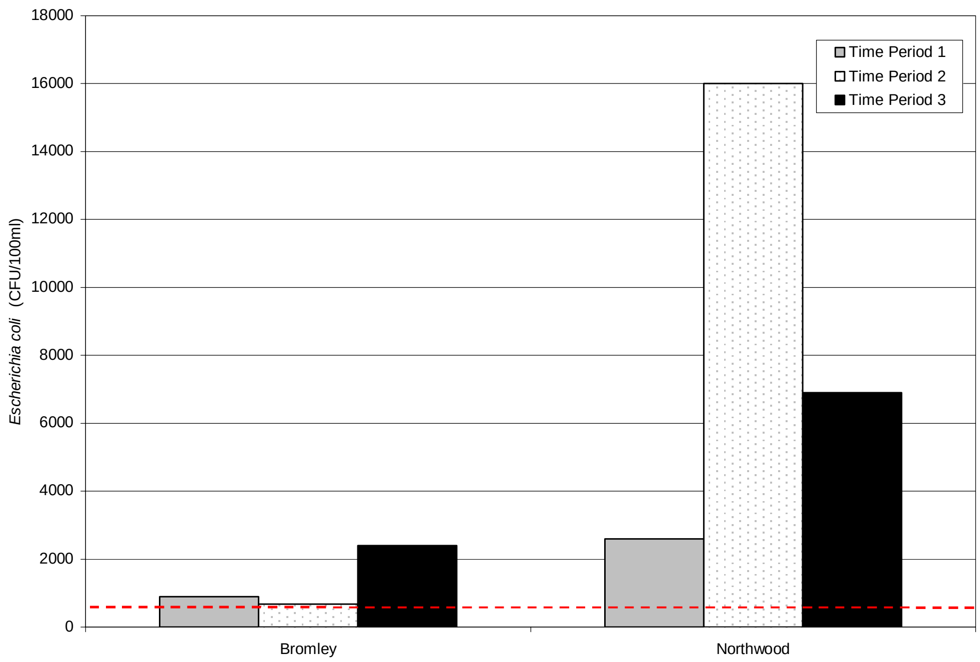

Figure 17. *Escherichia coli* levels in water samples from stormwater outfalls, during three time periods of a wet weather event (collected using autosamplers). The dashed line represents the proposed Canterbury Land and Water Regional Plan receiving water trigger value of 550 CFU/100ml for 95% of samples (Environment Canterbury, 2012).

4 Discussion

The three Bromley stormwater outfall samples were likely taken during the first flush, based on the rainfall recorded at the nearest rainfall gauge. In contrast, the first two Northwood stormwater outfall samples were likely taken during the peak of the storm and the final one during the tail end. This is reflected in the trends shown for the majority of contaminants, in that levels were similar or increased over time for the Bromley samples, whereas concentrations peaked during the second time period for Northwood. However, it is difficult to extrapolate reliable trends from only two sites, over only one sampling event.

The Bromley stormwater outfall recorded higher levels of copper, ammonia, TSS and turbidity), while the Northwood outfall recorded much higher levels of *E.coli* and generally DRP. The other contaminants were fairly comparable between sites. The outfall at Bromley drains an industrial and residential area which may explain the higher levels of copper (e.g. from industrial activities), and TSS and turbidity (e.g. from unsealed industrial sections). There are also many waterfowl in the area, largely due to its close proximity to the city's wastewater treatment ponds and the surrounding grassland, which could explain the higher ammonia levels. In contrast, the Northwood catchment is predominantly residential, with surrounding rural land-use, potentially explaining the higher levels of *E.coli* (e.g. from pets, birds and livestock) and DRP (e.g. from fertilisers) than Bromley.

Parameters in the stormwater outfall samples that were well above the receiving water quality guidelines, and therefore may cause adverse effects if dilution in the receiving water is not sufficient enough, were copper, zinc, TSS (at Bromley), turbidity, BOD_5 (at Northwood), DRP and *E. coli*. These constituents may cause adverse effects on biota (copper, zinc, TSS, turbidity and BOD_5), cause proliferation of algae and plants (DRP), and result in human health risks for contact recreation (*E. coli*). The remainder of the parameters did not exceed the receiving water quality guidelines, so are not likely to have adverse effects on these waterways, particularly after further dilution in the receiving environment.

Annual monitoring within the rivers shows that nitrate, NNN and DIN often exceed guideline levels (Margetts and Marshall, 2015). There is evidence that this is due to input from contaminated groundwater in springs, rather than stormwater (Munro, 2015). The results of this stormwater outfall monitoring supports this view, as low levels of these constituents were recorded in the stormwater that were below guideline levels.

Sampling has previously been undertaken at the Bromley outfall on two occasions during the 2012 - 2013 and 2013 - 2014 monitoring years (Margetts, 2014; Whyte, 2013). The Northwood outfall has been sampled once prior during last year's monitoring (Margetts, 2014). Rainfall depth before sampling (and therefore time since the first flush of contaminants) varied between monitoring years, and therefore differences in concentrations across time periods and years cannot accurately be assessed. However, visual comparisons of this data (i.e. statistical comparisons were not carried out) suggests the following trends:

1. Copper and zinc levels at Bromley and Northwood are generally close to or above guideline levels during all monitoring years
2. Both outfalls have generally recorded pH, lead and ammonia concentrations within guideline levels

3. Bromley generally records higher levels of metals, ammonia, TSS and turbidity than Northwood
4. The trend of higher levels of *E. coli* and DRP at Northwood this year compared to Bromley did not occur last monitoring year

5 Conclusions

The results of this wet weather monitoring suggests that stormwater contributes a relatively high concentration of some contaminants (namely copper, zinc, TSS, turbidity, BOD_5, DRP and *E. coli)*. These constituents may cause adverse effects on biota (copper, zinc, TSS, turbidity and BOD_5), cause proliferation of algae and plants (DRP), and result in human health risks for contact recreation (*E. coli*), if they are not sufficiently diluted within the receiving environment. This wet weather monitoring also highlights potential differences in results depending on when events are sampled. Water quality throughout these catchments should improve over time with the instigation of the Christchurch City Council's stormwater management plans (e.g. the Avon Stormwater Management Plan), and ECan and CCC catchment pollution projects (e.g. for the Bromley area).

6 References

ANZECC (Australian and New Zealand Environment and Conservation Council, ANZECC, and Agriculture and Resource Management Council of Australia and New Zealand, ARMCANZ), 2000. Australian and New Zealand guidelines for fresh and marine water quality. Volume 1: The guidelines. ANZECC & ARMCANZ, Artarmon, New South Wales.

Collier, K.J, Ball, O.J., Graesser, A. K., Main, M.R. & Winterbourn, M.J. 1990. Do organic and anthropogenic acidity have similar effects on aquatic fauna? *Oikos 59:* 33-38.

Crowe, A. & Hay, J. 2004. Effects of fine sediment on river biota. Report Number 951, prepared for Motueka Integrated Catchment Management Programme. Cawthron Institute, Nelson.

Environment Canterbury, 2009. Review of proposed NRRP water quality objectives and standards for rivers and lakes in the Canterbury region. Report No. R09/16. Environment Canterbury, Christchurch.

Environment Canterbury, 2012. Proposed Canterbury Land and Water Regional Plan - Volume 1. Environment Canterbury, Christchurch.

Harding, J.S., 2005. Impacts of metals and mining on stream communities, in *Metal Contaminants in New Zealand*, T.A. Moore, A. Black, J.A. Centeno, J.S. Harding & D.A. Trumm (Editors), p. 343-357. Resolutionz press, Christchurch.

Hickey, C.W., 2013. Updating nitrate toxicity effects on freshwater aquatic species. Report prepared for Ministry of Business, Innovation and Employment, Report Number HAM2013-009. NIWA, Hamilton.

Margetts, B. I. 2014. IGSC wet weather monitoring report for the period May 2013 – April 2014. Christchurch City Council, Christchurch. TRIM 14/810224.

Margetts, B. (née Whyte) & Marshall, W. (2015). Surface Water Quality Monitoring Report for Christchurch City Waterways: January – December 2014. Christchurch City Council, Christchurch. TRIM 15/458527.

Ministry for the Environment, 1992. Water Quality Guidelines No. 1: Guidelines for the control of undesirable biological growths in water. Ministry for the Environment, Wellington.

Munro, B. (2015). CCC instream spring water quality project - Waimairi and Wairarapa Stream. Report prepared by Pattle Delamore Partners Limited for Christchurch City Council, Christchurch.

Ryan, P.A., 1991. Environmental effects of sediment on New Zealand streams: a review. *New Zealand Journal of Marine and Freshwater Research 25:* 207-221.

Wahl, C.M., Neils, A. & Hooper, D. 2013. Impacts of land use at the catchment scale constrain the habitat benefits of stream riparian buffers. *Freshwater Biology 58(11):* 2310-2324.

Whyte, B. I. 2013. IGSC wet weather monitoring annual results summary: May 2013 – April 2013. Christchurch City Council, Christchurch.

7 Appendix A: Metal Hardness Modified Trigger Values

1. Introduction

The Australian and New Zealand guidelines for fresh and marine water quality (ANZECC, 2000) provides a set of default guideline trigger values for metals, with which to compare measured contaminant concentrations. These trigger values represent concentrations below which there is considered to be a low risk of adverse biological effects (ANZECC, 2000). The guidelines also provide a process for modifying the given trigger values for local environmental conditions. If measured concentrations of toxicants are below default trigger values, then there is a low risk of adverse effects. However, if measured concentrations exceed these guidelines, then it is possible to consider site specific factors that may modify the trigger values, to gain a better understanding of whether a real risk exists. If measured concentrations also exceed modified trigger values, then the next step would be to directly assess biological effects.

Christchurch City Council has measured concentrations of metals (total cadmium, total copper, total lead, total zinc) in water samples from 33 river monitoring sites across the city since 2008. Measured concentrations vary widely across the monitoring sites, and there are several sites where values often exceed guideline trigger values. In fresh waters, the hardness, pH and alkalinity of the water can alter the toxicity of metals and hence the risk of adverse biological effects (ANZECC, 2000). The default guideline trigger values for metals assume that water is soft (with a hardness value of between 0 and 59 mg/L as CaCO3), but as water hardness increases, the toxicity of some metals decreases and therefore the trigger value may increase, without increasing the risk of adverse biological effects.

To make an informed assessment of the real risks associated with exceeding the default trigger values, additional monitoring for water hardness has been included at sites within each catchment for the purpose of calculating appropriate hardness modified trigger values (HMTV) for Christchurch rivers using the water hardness dependent algorithms provided in the ANZECC (2000) guidelines.

2. Sites and sampling regime

Water samples are collected monthly at sites across the five main catchments within Christchurch City (Avon, Heathcote, Styx, Halswell, Otukaikino). These samples are analysed at the Christchurch City Council laboratory for a range of physical and chemical characteristics, including temperature, nutrients, microbiological indicators and metals. Since December 2010, samples from the eight sites listed in Table 1 have also been analysed for water hardness measured in mg/L as $CaCO_3$. Routine water quality monitoring was disrupted on several occasions during 2011, by the significant earthquakes experienced in the city. Despite this, each of the sites had between 9 and 12 water hardness measures recorded by March 2012 and the results were relatively consistent over time for each site.

Table 1. Sampling sites for water hardness investigation (December 2010 to March 2012)

Site Description	Easting	Northing	Number of water hardness samples
Otukaikino at Groynes Inlet	2477878	5750484	11
Styx River at Gardiners Road	2476786	5748821	12
Styx River at Marshland Road bridge	2482356	5749417	12
Avon River at Mona Vale	2478279	5742653	9
Avon River at Gayhurst Road	2483549	5742827	9
Heathcote River at Templetons Road	2475913	5738516	12
Heathcote at Opawa Road/Clarendon Terrace	2483072	5739226	12
Halswell River at Akaroa Highway	2474427	5733346	9

3. Results

3.1. Water Hardness by catchment

Sites on the Styx and Otukaikino rivers had median hardness values within the 'soft' water category, the Avon and Halswell river sites were within the 'moderate' hardness category and the Heathcote sites had 'moderate' to 'hard' water (Figure 1). For the Heathcote River, the Templetons Road site had a number of low hardness outlier values, but median water hardness was higher at the upstream site (Templetons Road) than the downstream site (Opawa Road).

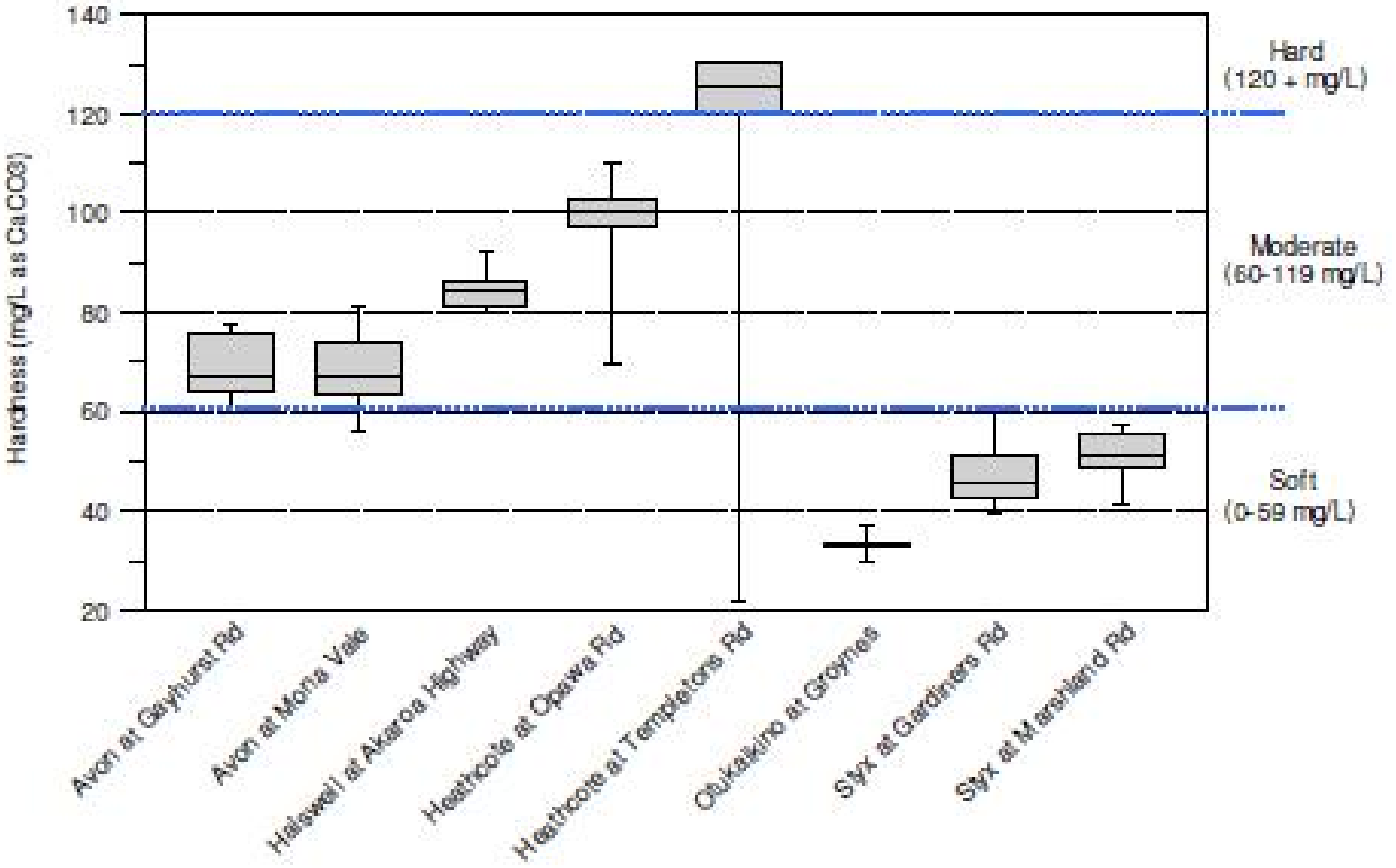

Figure 1 Box plots displaying median (and upper, lower quartiles, max and min) water hardness values for monitoring sites on the Avon, Heathcote, Halswell, Styx and Otukaikino rivers between December 2010 and March 2012.

3.2. *Hardness Modified Trigger Values (HMTV)*

Hardness modified trigger values (HMTV) are greater than default trigger values in each of the rivers in Christchurch (Table 1). This is because the default values assume that water is in the 'soft' category and this provides trigger values to conservatively protect aquatic ecosystems values in the absence of further information to refine these values.

Table 2 Default and HMTV for metals in the Avon, Heathcote, Halswell, Styx and Otukaikino rivers, based on 99, 95 and 90% levels of species protection as described by ANZECC (2000).

		Default trigger values (µg/L) (ANZECC, 2000)			Hardness modified trigger values (µg/L)		
Level of species protection		**99%**	**95%**	**90%**	**99%**	**95%**	**90%**
Avon	Cadmium	0.06	0.20	0.40	0.12	0.41	0.82
	Copper	1.00	1.40	1.80	1.98	2.77	3.56
	Lead	1.00	3.40	5.60	2.77	9.43	15.54
	Zinc	2.40	8.00	15.00	4.75	15.84	29.70
Heathcote	Cadmium	0.06	0.20	0.40	0.19	0.64	1.27
	Copper	1.00	1.40	1.80	3.02	4.22	5.43
	Lead	1.00	3.40	5.60	5.21	17.71	29.16
	Zinc	2.40	8.00	15.00	7.24	24.14	45.26
Halswell	Cadmium	0.06	0.20	0.40	0.15	0.50	1.00
	Copper	1.00	1.40	1.80	2.40	3.36	4.32
	Lead	1.00	3.40	5.60	3.70	12.57	20.71
	Zinc	2.40	8.00	15.00	5.76	19.19	35.99
Styx	Cadmium	0.06	0.20	0.40	0.09	0.31	0.62
	Copper	1.00	1.40	1.80	1.52	2.12	2.73
	Lead	1.00	3.40	5.60	1.86	6.34	10.44
	Zinc	2.40	8.00	15.00	3.64	12.14	22.76
Otukaikino	Cadmium	0.06	0.20	0.40	0.07	0.22	0.44
	Copper	1.00	1.40	1.80	1.08	1.52	1.95
	Lead	1.00	3.40	5.60	1.13	3.84	6.32
	Zinc	2.40	8.00	15.00	2.60	8.68	16.27

4. References

ANZECC (Australian and New Zealand Environment and Conservation Council), 2000. Australian and New Zealand guidelines for fresh and marine water quality.

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8 Appendix B: Raw Data

Parameter	Bromley			Northwood Top Basin		
	Time Period 1	**Time Period 2**	**Time Period 3**	**Time Period 1**	**Time Period 2**	**Time Period 3**
Date	13/04/2015	14/04/2015	14/04/2015	13/04/2015	14/04/2015	14/04/2015
24-hour rainfall (mm)*	5.6	8.4	10.2	8.8	11.8	13.4
48-hour rainfall (mm)*	5.6	8.4	10.2	8.8	11.8	13.4
Time	20:19	22:19	0:19	22:13	00:53	03:33
Copper acid extractable	0.014	0.018	0.048	0.0024	0.0036	0.0034
Copper soluble	0.0058	0.0043	0.0057	<0.002	0.0029	0.0028
Lead acid extractable	0.014	0.027	0.076	0.0021	<0.0015	<0.0015
Lead soluble	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015
Zinc acid extractable	0.12	0.3	0.73	0.28	0.07	0.016
Zinc soluble	0.033	0.072	0.11	0.15	0.061	0.022
pH	7.5	7.5	7.6	7.8	7.3	7.3
Conductivity	107	156	122	175	118	103
Total Suspended Solids (TSS)	36	70	190	12	3	<3
Turbidity	38	52	180	5.7	5.8	4.2
BOD5 - carbonaceous	Not measured	Not measured	Not measured	3.7	2.6	1.7
Ammonia Nitrogen	0.35	0.28	0.26	0.12	0.01	<0.01
Nitrate Nitrogen	0.17	0.21	0.28	0.051	0.26	0.22
Nitrate+Nitrite Nitrogen (NNN)	0.2	0.25	0.35	0.054	0.27	0.23
Dissolved Inorganic Nitrogen (DIN)	0.55	0.53	0.61	0.17	0.28	0.24
Dissolved Reactive Phosphorous (DRP)	0.062	0.055	0.054	0.039	0.1	0.079
Escherichia coli	890	680	2400	2600	16000	6900
Arsenic acid extractable	0.0015	0.0024	0.0059	<0.0015	<0.0015	<0.0015
Arsenic soluble	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015
Dissolved Oxygen	11.4	11.7	11.7	8.6	10.2	10.1
Dissolved Oxygen Saturation	110	110	110	81	97	96
Nitrite Nitrogen	0.027	0.037	0.064	<0.0050	<0.0050	<0.0050
Phosphorus Total	0.18	0.22	0.44	0.24	0.2	0.12
Temperature @ time of analysis	12.8	12.4	12.1	13.5	13.4	13.4
Total Nitrogen	1.1	1.2	1.9	1.1	0.89	0.65
Total Petroleum Hydrocarbons	Not measured	Not measured	Not measured	<0.3	<0.3	<0.3
TPH (S) Band C15-C36	Not measured	Not measured	Not measured	0.23	<0.25	<0.25
TPH (S) Band C10-C14	Not measured	Not measured	Not measured	<0.23	<0.25	<0.25
TPH (S) Band C7-C9	Not measured	Not measured	Not measured	<0.23	<0.25	<0.25

* rainfall recorded at Botanic Gardens for the Northwood site and Tunnel Road for the Bromley site