IS THERE ANY BENEFIT FOR ENHANCED STORMWATER TREATMENT FROM NON-FORECOURT DISCHARGES?

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ABSTRACT

In 1998, the Oil Industry Environment Working Group (OIEWG) finalised a set of "Environmental Guidelines for Water Discharges from Petroleum Industry Sites in New Zealand" (the Guidelines). These guidelines have been used as a means of compliance with permitted activity rules in some regional plans, but this is less common with newer plans. The OIEWG has initiated a review of the guidelines and determined a number of areas requiring further evaluation. Research has been conducted in these areas to assist with a revision of the Guidelines. Non-forecourt discharges are the focus of this paper.

Since January 2016, Pattle Delamore Partners (PDP) on behalf of Z Energy Limited (Z) have been monitoring the quality of stormwater discharges derived from active service station non-forecourt areas. Non-forecourt areas are defined as the service stations impermeable surface areas where refueling is not carried out, or where the stormwater discharge is not treated via an oil-water separator (or similar) device (i.e. where there is a low risk of any spill). Typically, these non-forecourt areas would be treated using catch pits only. However, recently in Christchurch (and some other centres), Z have also been required to include Stormfilters (in addition to catch pits) to treat non-forecourt stormwater discharges.

To understand what stormwater treatment performance is being achieved by the catch pits and Stormfilters, water quality monitoring has been conducted using irrigation systems. The purpose of using the irrigation systems is to allow stormwater quality assessments to be conducted using flow rates which are equivalent to the peak flow rates that the Stormfilters can treat. Furthermore, first flush or peak contaminant concentrations are also able to be obtained using irrigation systems, which is typically difficult to achieve when monitoring true rainfall events.

This paper outlines: the monitoring methodology; a summary of the water quality results obtained; and answers if there are benefits for requiring enhanced stormwater treatment for service station non-forecourt stormwater discharges?

KEYWORDS

Service Station, Non-forecourt areas, Stormfilter Performance, Catchpit Performance, MfE Guidelines

PRESENTER PROFILE

Hayden is an Environmental Services Leader with Pattle Delamore Partners Ltd. With approximately 14 years of experience, he has knowledge in the following fields; stormwater quantity and quality management, flood assessment and management, integrated catchment management planning, water sensitive design, and environmental monitoring.

Martin Robertson is the Environmental Manager at Z Energy and has 26 years' experience in environmental consulting.

1.0 THE MFE GUIDELINES

In 1998 the Oil Industry Environment Working Group (OIEWG) finalised a set of "Environmental Guidelines for Water Discharges from Petroleum Industry Sites in New Zealand" (the Guidelines). These guidelines have been used as a means of compliance with permitted activity rules in some regional plans but this is less common with newer plans.

The OIEWG has undertaking a review of the guidelines and have identified a number of areas warranting further evaluation in light of changing expectations around water quality.

A number of significant studies have subsequently been completed to support the guideline revision.

- URS (2008) focused on water and sediment sampling and confirmed a high level of treatment by typical modern (Guideline compliant) stormwater systems.
- PDP (2012) used simulated rainfall events to look more closely at first flush discharges.
- Easton *et al.* (2015) looked at the impact of Diesel Exhaust Fluid (ZDEC) on forecourt run-off and developed a simple box model to assess the sensitivity of receiving environments to ammoniacal nitrogen.
- Robertson and Lukey (2017) looked at the BTEX concentrations in dewatering petroleum contaminated sites.

This work represents a significant effort to evaluate the performance of current approaches in the industry.

One final area for assessment was identified due to a focus by some Councils on stormwater quality treatment of non-forecourt run-off. That is the subject of this paper.

2.0 SCOPE

Pattle Delamore Partners Limited (PDP) was contracted by Z Energy Limited (Z) to assess the water quality treatment performance provided by stormwater treatment devices located at Z Moorhouse, Christchurch. Specifically, Z are interested to understand the treatment performance of stormwater catch pits/ACO drains and Stormwater 360 Stormfilters that are located within two non-forecourt drainage areas at the Z Moorhouse service station.

The requirement to install these devices arises out of the provisions of the Canterbury Land and Water Regional Plan (Rule 5.95) that enable a stormwater discharge into a reticulated stormwater system to be a permitted activity provided the written permission is obtained from the stormwater system owner. In issuing their permission, as system owner, the Christchurch City Council sought that certain treatment devices be installed in order to ensure it can continue to meet its own network discharge consent conditions. If the devices were not installed, the stormwater discharge from Z Moorhouse would have been regarded as a non-complying activity, resulting in Z having to obtain a stormwater discharge consent from the Canterbury Regional Council.

In regards to the minimum stormwater quality standards for all new stormwater discharge consents, these are prescribed by environmental protection triggers set within the Canterbury Regional Council's Land and Water Regional Plan, Schedule 5. These environmental triggers are considered to be similar to ANZECC (2000) 90% environmental protection triggers.

The objectives of the project were to understand:

- The design, operation, performance and achievable water quality discharge from catch pits and Stormfilters located at Z service station non-forecourt drainage areas; and,
- The overall environmental benefit that can be achieved within a receiving environment as a result of the implementation of the various stormwater treatment devices located within a service station non-forecourt drainage catchment.

3.0 DRAINAGE CATCHMENTS

3.1 Z MOORHOUSE

The stormwater drainage layout for the Z Moorhouse site is presented in Appendix A.

The site can be divided into two non-forecourt drainage areas:

- A northern drainage area: collects stormwater from the non-forecourt areas to the north of the shop. Stormwater enters into the drainage network via ACO drains. The catchment area for the northern drainage area (that discharges to the Stormfilters) has been determined to be 840 m^2.
- A southern drainage area: Collects stormwater from non-forecourt areas located east and south of the shop. Stormwater enters into the drainage network via catch pits and ACO drains. The southern drainage area also receives roof runoff from the shop and the car wash, however, these discharges enter into the stormwater network down gradient of the Stormfilters (i.e. these roofed areas are not treated by the Stormfilters). The catchment area for the southern drainage area (that discharges to the Stormfilters) has been determined to be 690 m^2.

Both the southern and northern drainage catchments each have two Stormfilters cartridges (i.e. the whole site has a total of four Stormfilters cartridges) to treat the non-forecourt stormwater discharge.

The media within the Stormfilters is comprised of zeolite, perlite, and granulated carbon mix, which is specially formulated to treat stormwater contaminants that would be expected to be sourced from service stations e.g. sediments, heavy metals, and hydrocarbons.

3.2 AVON RIVER CATCHMENT

The Z Moorhouse service station is located within the Avon River catchment.

The stormwater reticulation catchment is approximately 53 ha with the major landuse being Business zoned (based on zoning depicted from the Canterbury Regional Council's GIS). The Z Moorhouse station is towards the 'headwater's' of the stormwater reticulation network, with approximately 2 ha of reticulated stormwater catchment upstream of the site.

At the point where the stormwater reticulation network discharges to the Avon River, there is an upstream Avon River catchment of approximately 3,950 ha. This catchment comprises of rural, residential, and business land use.

4.0 METHODOLOGY

The following presents the methodology PDP used to evaluate the performance of stormwater treatment devices located at the Z Moorhouse site. Prior to field work commencing, the monitoring methodology was discussed with Christchurch City Council and Canterbury Regional Council officers to obtain feedback. In addition, Council staff were also invited to witness the synthetic rainfall events.

4.1 SYNTHETIC RAINFALL

All monitoring events used in this project were synthetically generated using sprinkler arrays. Sprinklers used in this project were selectively chosen to ensure that droplets were produced, rather than a mist. This was to ensure the characteristics of natural rainfall were achieved.
Each sample drainage area assessed had sprinklers arranged so an even distribution of rainfall was applied. Field notes were made describing the extent of the synthetic rainfall achieved during each assessment.

4.2 FLOW RATE AND RAINFALL INTENSITY CALCULATIONS

PDP has developed a manifold that allows the individual flow rates through each sprinkler to be independently altered. This enables accurate rainfall characteristics for an assessed location to be obtained.

PDP chose to simulate the rainfall conditions so that the data obtained from the site could be compared to similar studies conducted elsewhere.

Based on similar Stormfilter performance assessment studies that have been conducted by Contech for vehicle related activities (shopping centre car parks) peak flow rates of 7.5 gpm per cartridge (or 0.47 L/s per cartridge) were applied (Contech 2006a, and Contech, 2006b, and Contech 2008). For two Stormfilters, PDP therefore consider that a flow rate of 1 L/s is appropriate to assess performance.
Based upon an average irrigation area of 120 m2 (as used for previous irrigation studies), an irrigation flow rate of 1 L/s would be equivalent to a 30 mm/hour rainfall intensity. In the Christchurch region this rainfall intensity is equivalent to a 10 minute 5 year ARI rainfall intensity (based on HIRDS, accessed November 2016).

4.3 APPLYING THE DETERMINED FLOW RATE

To ensure that the determined flow rates are correctly applied to the respective drainage areas, flow rates were calibrated in the field by carrying out volumetric gauging assessments.

For the volumetric gauging assessment, the following procedures were carried out:

- Water discharged from sprinklers was placed within a 20 L container;

- The time to fill the 20 L container was measured;
- The flow rate was then either adjusted or further sprinklers were included/removed (if required), with the above steps repeated to achieve the desired flow rate.

Photograph 1 presented below illustrates the application of the synthetic rainfall across the Z non-forecourt catchment.

Figure 1: Synthetic rainfall being applied across a non-forecourt catchment.

4.4 WATER QUALITY MONITORING OF NON-FORECOURT AREAS

When selecting the non-forecourt areas to be monitored within the northern and southern drainage catchments, the following were considered:

- Whether the stormwater runoff would contain sufficient contaminant load to meet laboratory levels of detection when analysed, i.e. the drainage area had to be of sufficient size to allow a required minimum contaminant concentration to be mobilised.
- In contrast however, the area cannot be too large as it would change:
    - The intensity of rainfall applied across the drainage area, i.e. a Stormfilter is designed by specific flow rate and therefore the design rate at which rainfall is to be applied to a drainage area should not alter. If therefore, the drainage area was too large, a lower rainfall intensity would have to be applied, which may limit the mobilisation of contaminants.

- The operation of the service station. The project requires shutting down an area of the service station; if the drainage area is too large, this excluded area would affect the operation of the site.

It is recognised that by not applying simulated rainfall across the entire non-forecourt area that drains to the catch pits and Stormfilter, there may be differences to the true potential contaminant load that may enter the device. This however, can be compensated for by choice of the selected irrigation areas. These were chosen based upon the perceived movement paths of vehicles, i.e. PDP has made the assumption that the greatest contaminant loads that will be discharged to the catch pits and Stormfilters will be from areas where vehicle movements are greatest. This also included areas where vehicle turning takes place, as we consider this is where greatest tyre wear (and consequently heavy metal loads) will occur.

Using the above methodology to determine appropriate non-forecourt sampling areas, we consider that the catchments selected (and consequently data obtained) will be generally representative for all Z non-forecourt drainage catchments.

4.5 SITE MAINTENANCE PRE SAMPLING

All stormwater catch pits/ACO drains, Stormfilter chambers and Stormfilters were maintained on 18 January 2016. Maintenance included:

- Cleaning and removal of accumulated sediment and debris from catch pits/ACO drains and Stormfilter chambers.
- Replacement of Stormfilter cartridges.

The purpose of this site maintenance regime was to ensure there was no sediment or debris within the onsite stormwater network at the commencement of the project.

4.6 WATER QUALITY SAMPLE COLLECTION

Key water quality sampling methods used in this project were:

- Water quality sampling was only conducted if at least three days dry antecedent weather conditions had occurred.
- For each monitoring event, PDP collected ten stormwater samples in total for each Stormfilter assessed. A single sample of irrigation water was also collected (i.e. nineteen samples (19) in total were collected in a monitoring round). A suite of samples therefore included:
    - One 'first flush' stormwater sample collected from the initial stormwater discharge into the stormwater reticulation network i.e. as the stormwater enters into the catch pit or ACO drain.
    - One 'mid flow' stormwater sample at the catch pit/ACO drain, collected approximately 30 minutes after the first flush sample was obtained.
    - One 'base concentration' stormwater sample at the catch pit/ ACO drain, collected approximately 60 minutes after the first flush sample was obtained.
    - One 'first flush' stormwater sample collected from the initial stormwater discharge enters into the Stormfilter chamber.

- One 'mid flow' stormwater sample from the discharge entering into the Stormfilter chamber. This is collected approximately 30 minutes after the first flush effluent sample was obtained.
- One 'base concentration' stormwater sample from the discharge entering into the Stormfilter chamber. This is collected approximately 60 minutes after the first flush effluent sample was obtained.
- One 'first flush' stormwater sample collected from the initial stormwater discharge as it exits (effluent) the Stormfilter.
- One 'mid flow' stormwater sample from the discharge exiting the Stormfilter. This is collected approximately 30 minutes after the first flush effluent sample was obtained.
- One 'base concentration' stormwater sample from the discharge exiting the Stormfilter. This is collected approximately 60 minutes after the first flush effluent sample was obtained.
- One sample of the water used to create the synthetic storm. This sample is used to test presence of contaminants before passing across the test areas.

4.7 CONTAMINANTS OF CONCERN

URS (2008) and PDP (2013) have assessed stormwater quality discharges from service stations, including non-forecourt areas. Using the data obtained from these reports, we were able to identify what were the key contaminants of concern that could be encountered on a service station. The identified key contaminants of concern were then chosen as the parameters we would monitor for in this study.

All water quality samples collected were laboratory analysed for the following contaminants, which are considered to be typical of the metal and petroleum compounds found on vehicular pathways:

- Total Petroleum Hydrocarbons (TPH);
- Benzene, toluene, ethyl benzene, xylene (BTEX);
- Polycyclic Aromatic Hydrocarbons (PAH);
- Total heavy metals, consisting of:
  - Arsenic;
  - Cadmium;
  - Chromium;
  - Copper;
  - Lead;
  - Nickel; and
  - Zinc.
- Dissolved heavy metals (consisting of the same metal suite as total heavy metals);
- Total Suspended Solids;
- pH; and
- Electrical conductivity.

In addition to the above contaminants, field measurements were collected using a handheld water quality sensor (Professional Plus YSI Multiparameter Handheld with Quatro Probe) for the following parameter suite:

- Dissolved oxygen (% Saturation);
- Temperature (°C);
- Oxygen reduction potential (mV); and

- Turbidity (NTU).

5.0 RESULTS

The following section presents the relevant results obtained during this project.

5.1 WATER QUALITY SAMPLE COLLECTION TIMING

Water quality monitoring was undertaken on the following days (note that sampling was conducted during off peak hours, typically between 10 pm to 3 am):

- 31 March - 1 April 2016;
- 16 June - 17 June 2016; and,
- 23 November - 24 November 2016.

Table 1 below presents the date on which water quality samples were obtained, and the respective period of dry antecedent weather conditions prior to sampling.

Table 1: Antecedent Weather Conditions prior to sampling

Date Sampled[1]	Days of Dry Antecedent Weather[2]
31/3/2016 - 1/4/2016	5
16/6/2016-17/6/2016	3
23/11/2016 - 24/11/2016	6

Notes:

1. *Sampling occurred during the night during the sites off peak hours. Monitoring therefore is carried out over two dates.*
2. *Rainfall data obtained from automatic rainfall station located at Christchurch Botanical Gardens.*

5.2 WATER QUALITY RESULTS

Of the contaminants monitored only those listed below were elevated such that an exceedance of the ANZECC (2000) 90% environmental protection triggers would occur in the receiving environment.

- Total Suspended Solids.
- Total Copper.
- Total Zinc.
- Dissolved Copper.
- Dissolved Zinc.

All other contaminants monitored were either below laboratory levels of detection or were considered to be well below environmental protection triggers (ANZECC, 2000 and Canterbury Regional Council, 2015).

Figures 2 to 6 present water quality results for the contaminants with elevated concentrations.

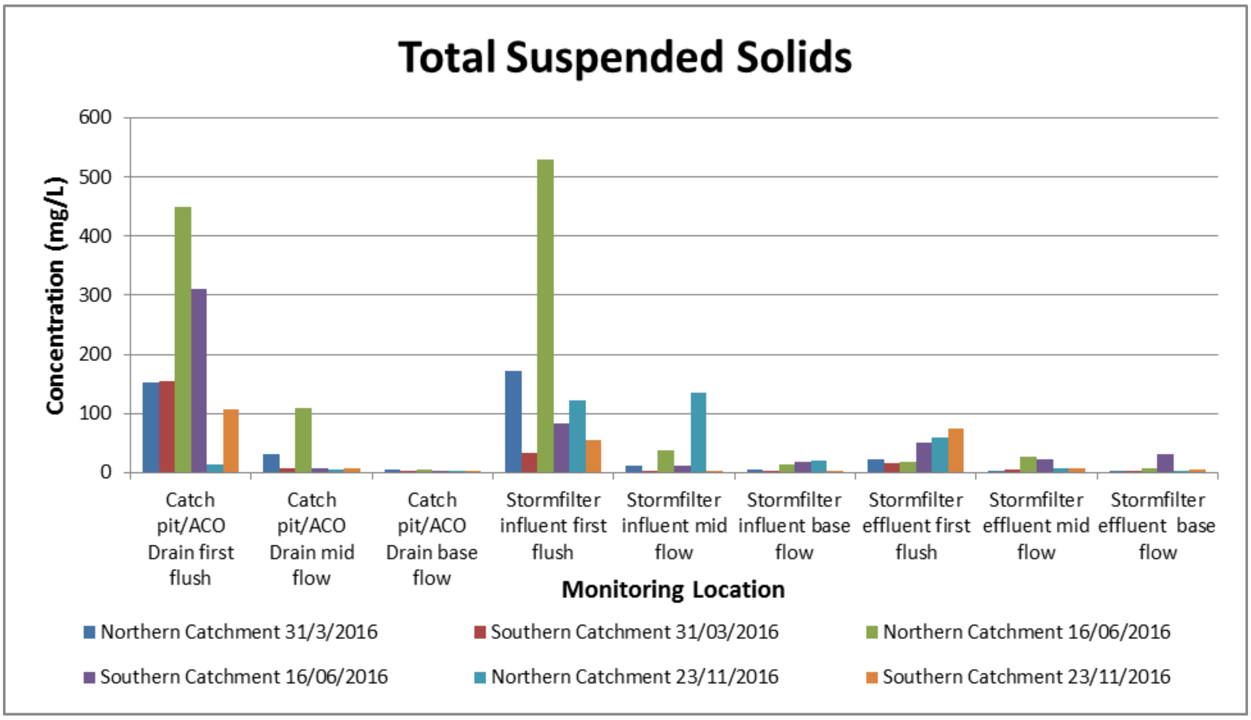

Figure 2: Total Suspended Solids

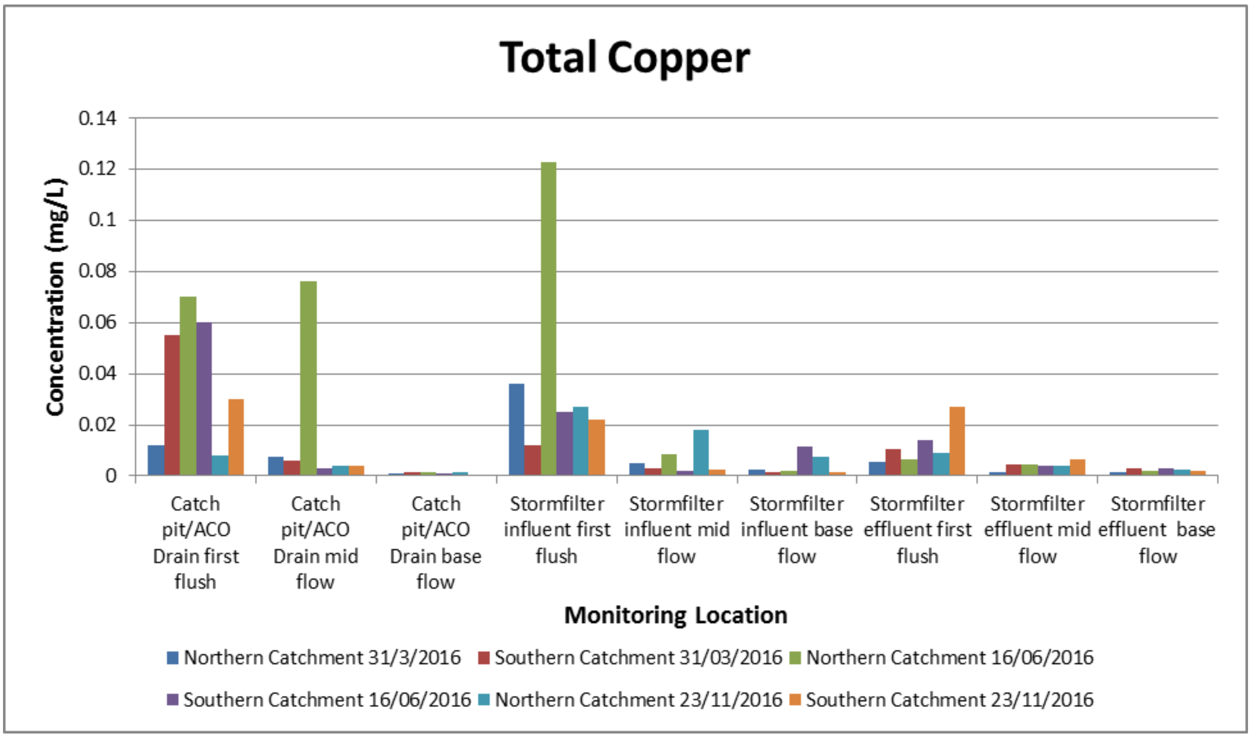

Figure 3: Total Copper

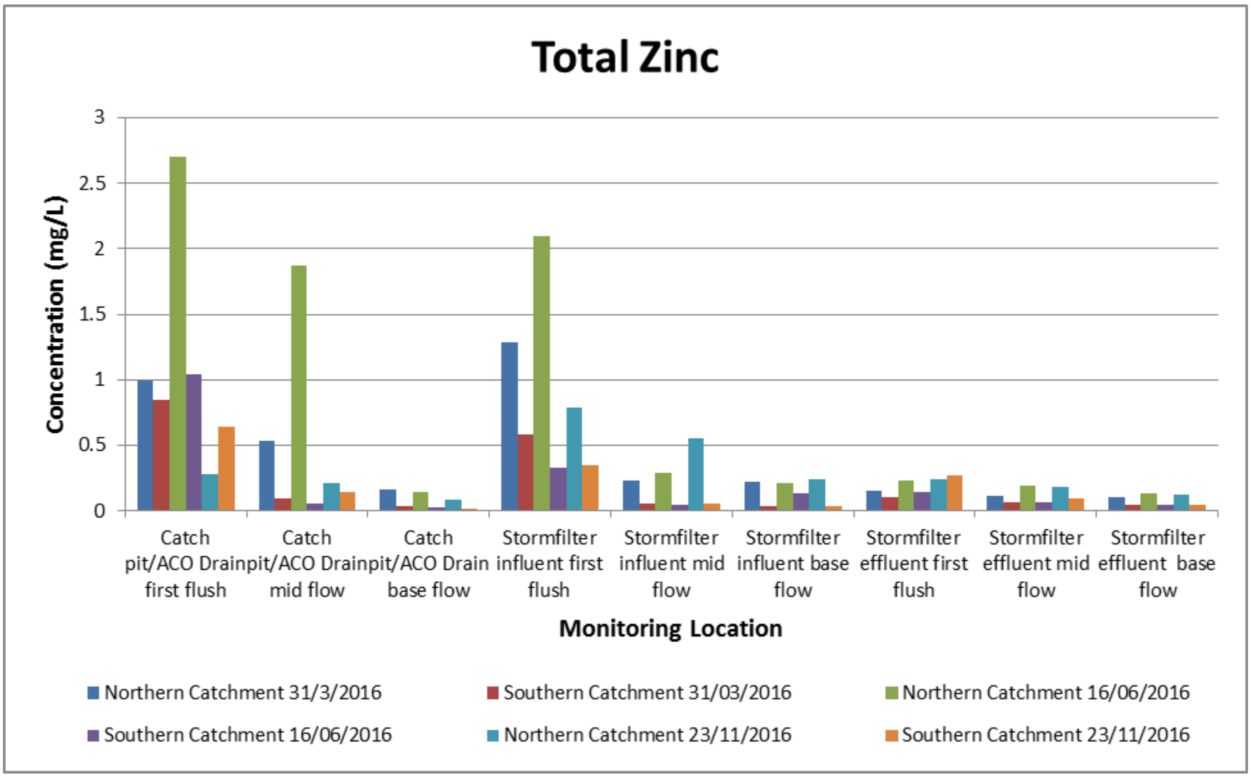

Figure 4: Total Zinc

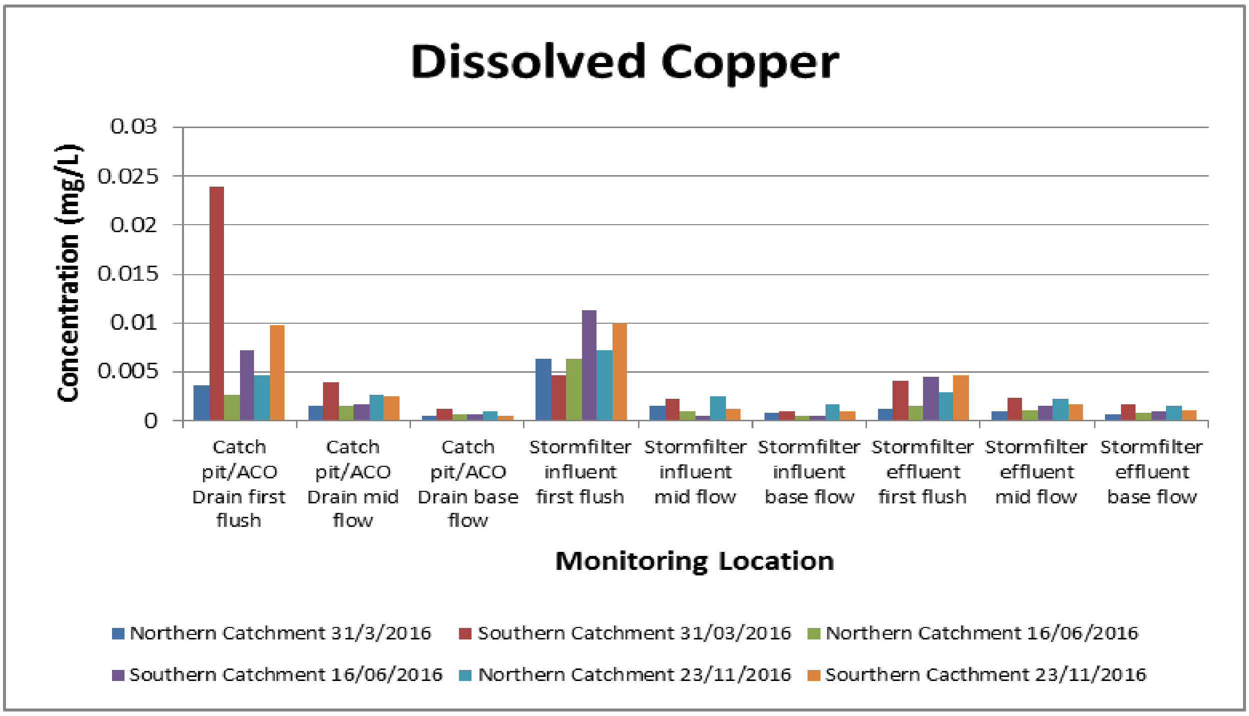

Figure 5: Dissolved Copper

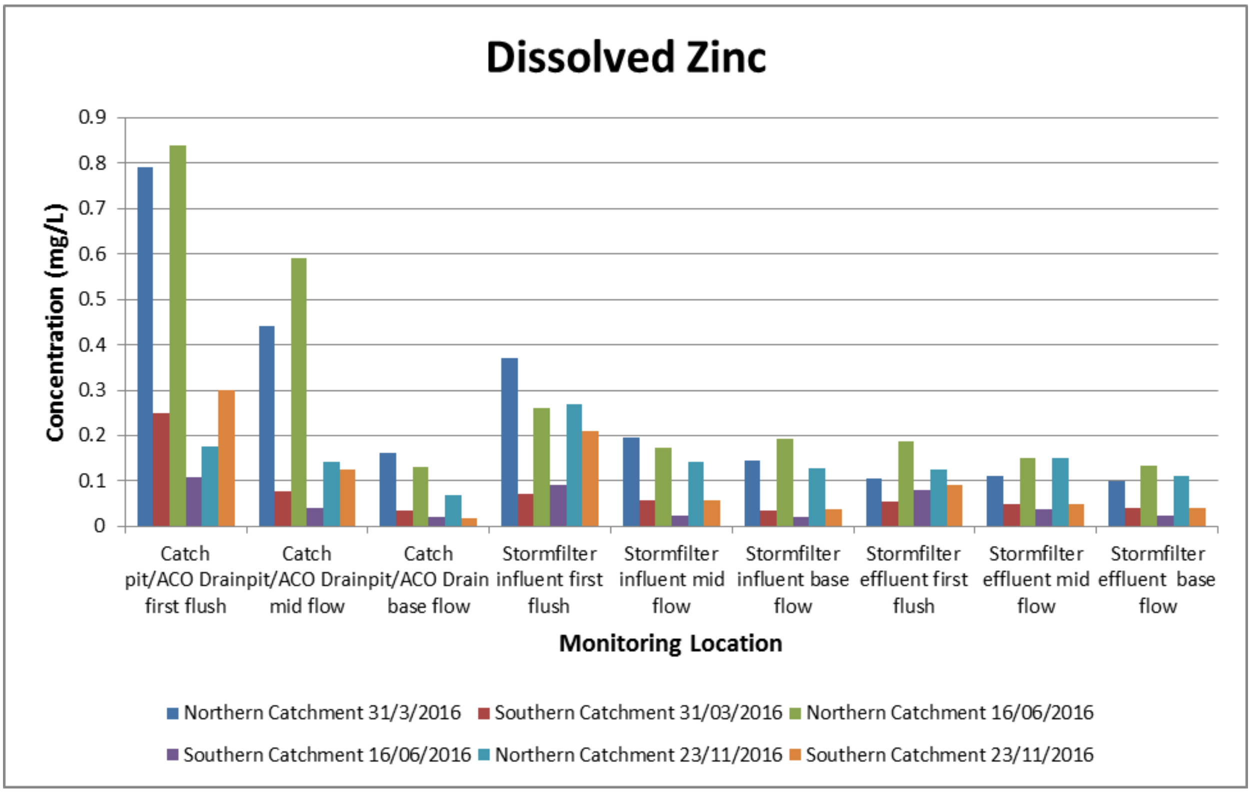

Figure 6: Dissolved Zinc

Table 2 presented below provides a summary of the data obtained for the elevated contaminant suite. Table 3 provides the relevant treatment performances that were obtained by the various stormwater treatment devices monitored onsite.

Table 2: Average contaminant concentration measured during all monitoring events conducted

.Contaminant	Northern Catchment			Southern Catchment		
	ACO Influent	ACO Effluent	Stormfilter Effluent	Catchpit Influent	Catchpit Effluent	Stormfilter Effluent
Total Suspended Solids	86	116	17	67	24	24
Total Copper	0.020	0.025	0.004	0.018	0.009	0.009
Total Zinc	0.781	0.651	0.163	0.322	0.182	0.106
Dissolved Copper	0.002	0.003	0.001	0.006	0.004	0.003
Dissolved Zinc	0.378	0.202	0.131	0.108	0.113	0.052

Note:

1. *All units are mg/L.*

Table 3: Average Stormwater Treatment Removal Rates obtained from the Onsite Stormwater Devices.

Contaminant	Northern Catchment			Southern Catchment		
	ACO Treatment Performance	Stormfilter Treatment Performance	Overall Site Treatment	Catchpit Treatment Performance	Stormfilter Treatment Performance	Overall Site Treatment
Total Suspended Solids	-35%	85%	80%	64%	0%	64%
Total Copper	-25%	84%	80%	50%	0%	50%
Total Zinc	17%	75%	79%	43%	42%	67%
Dissolved Copper	-50%	67%	50%	33%	25%	50%
Dissolved Zinc	-35%	85%	80%	-5%	54%	64%

Note

1. *Average stormwater treatment removal rates are based on three monitoring events.*

Based upon the water quality results obtained, there is a noticeable contaminant load difference between the Northern and Southern drainage catchments. The Northern drainage catchment typically had higher contaminant concentrations than the Southern catchment. Whilst no vehicle count data has been obtained, we consider that this result is likely due to the higher vehicle movements (and consequently higher contaminant load) present within the Northern drainage catchment. Surprisingly however, copper concentrations are similar in both catchments. This result is likely due to the greater braking requirements (therefore providing a greater copper load) in the southern catchment i.e. we consider that the southern catchment would require greater braking due to the turning requirements and also speed bumps within the drainage catchment.

Whilst listed in the treatment table, the ACO drain is not a treatment device (it is a stormwater diversion device). As would be expected, sediment appears to accumulate in the ACO drain between events (via wind-blown material) and is mobilised to the treatment device in rain events (hence the negative treatment value in the table). It is evident from maintenance records that in some instances there is a net accumulation of sediment in ACO drains. Windblown particles from adjacent landscaped planter beds are common in the suspended sediment load at some Z sites (PDP, 2013).

The treatment performance from a catch pit was however, surprisingly high in comparison to previous catch pit performance studies (ARC, 2010), (20% TSS, 11% Total Zinc, 15% Total Copper). PDP (2013) has assessed the sediment grainsize derived from forecourt and non-forecourt areas. From this study it was found that the dominant grainsize from non-forecourt areas was typically coarse sands. Having a dominant coarse grainsize may improve a catch pit's treatment performance when compared to previous studies which are likely to have a more normal distribution of sediment grainsizes (i.e. fine and coarse grain sizes). As expected, catch pits provided a poor treatment performance for dissolved metals.

The treatment performance obtained by the Stormfilters varied at each drainage catchment. The results obtained at the Northern drainage catchment are very consistent to other Stormfilter evaluation reports (Contech, 2006a, Contech, 2006b). The results however, for the Southern drainage catchment were significantly less. The authors consider that the significant difference in Stormfilter performance is likely due to the (well performing) catch pits in the Southern drainage catchment. Influent loads to the Southern catchment Stormfilters could be considered as cleaner (compared to the concentrations in the Northern catchment) and/or dominated by a finer grainsize fraction (i.e. the catch pit has removed the coarse grain size fraction therefore a dominant finer grain size (which is more difficult to treat) is discharged to the Southern Stormfilters).

This result is supported by conclusions found by Moores et al (2012), where they demonstrated that the treatment performance rate achieved by a stormwater treatment device can be very low when the influent sediment concentrations are low.

The Stormfilter has the effect of collaring the outlet of the sump in which it is located and results for the "Stormfilter effluent" will no doubt include a contribution from settlement in the chamber. However this is unlikely to affect the dissolved heavy metal phase performance. Results of the end of project maintenance sediment removal were not available for the written paper but may be available for the presentation. They may shed some light on the relative contribution of catchpit and stormfilter.

6.0 BENEFITS OF ADDITIONAL NON-FORECOURT TREATMENT

To assess the actual benefits that the Stormfilters are providing to the public network and ultimately the Avon River, PDP modelled the potential contaminant concentrations as they migrate through the stormwater reticulation network to the receiving environment. For comparative purposes, we also modelled the contaminant concentrations should catch pits be the only stormwater treatment devices present at Z Moorhouse.

To identify if non-forecourt stormwater discharges from Z Moorhouse could potentially lead to an adverse environmental effect, the modelling results (in water quality concentrations) were compared to the Schedule 5 environmental protection triggers presented in the Canterbury Regional Council Land and Water Plan. The trigger values were obtained based on the spring fed urban stream recommended Level of Protection of 90% (Canterbury Regional Council, 2015). The Schedule 5 environmental protection figures used are chronic toxicity guidelines primarily derived from ANZECC (2000) environmental protection triggers. As such, all data used from modelling are based on the average measured 30 minute effluent concentration data from the site.

Total and dissolved zinc and copper along with total suspended solids have been modelled through the stormwater network and into the receiving environment of the Avon River. All other contaminants have not been modelled as they are not expected to be present in elevated concentrations in the non-forecourt influent or effluent.

6.1 ASSESSMENT METHODOLOGY

For the Z Moorhouse site, the following assessment was carried out to determine the expected contaminant concentrations within the public stormwater reticulation network and the Avon River. To be conservative, PDP based the effluent service station data on the maximum measured catch pit and Stormfilter effluent concentration obtained at the mid flow condition (30 minutes after first flush).

To undertake the above assessment, a simplified mass balance model that determines the mixing and dilution of the contaminant concentrations was developed. The equation used to develop the mass balance model was:

$$Contaminant\ Concentration = \frac{C_1 \times V_1 + C_2 \times V_2}{V_1 + V_2} \quad \text{Eqn. 1}$$

Where C1 = Contaminant concentration measured at the trapped sump effluent.

V1 = Flow rate discharged from the non-forecourt catchment.

C2 = Concentration from ‘upstream’ water.

V2 = Flow rate from ‘upstream’ water.

To estimate typical natural background contaminant concentrations from surrounding impervious urban development, data prescribed in Williamson (1993) was applied. The event mean concentrations of contaminants in typical urban runoff were used.

Background contaminant concentrations in the Avon River were obtained from the ECan long term water quality monitoring station located at Manchester Road.

For the purposes of this assessment, a 6 mm/hour peak intensity rainfall rate was applied to the flow calculations. This rainfall intensity is equivalent to the peak rainfall intensity during the water quality storm event (NZWERF, 2004).

For the up gradient/down gradient piped drainage catchment area, and where relevant, the upstream surface water catchment discharge flows were calculated using the rational method. The runoff coefficients used in the rational method equations were derived from Chow (1988):

- Concreted surfaces 0.95;
- Gravelled surfaces 0.75;
- Industrial surfaces 0.7-0.75;
- Asphalted surfaces 0.9; and
- Grassed surfaces 0.5.

The resulting discharge contaminant concentration within the receiving environment is dependent upon the following factors:

1. The contaminant concentration discharged from the Stormfilter (the last treatment device before the site discharges enter the public stormwater reticulation network).
2. The stormwater discharges that occur within the piped network flowing from the Z Moorhouse site and the surrounding landuses to the Avon River.
3. The flow that occurs into the receiving environment (i.e. the Avon River)

The key model parameters adopted are provided in Table 4:

Table 4: Drainage Catchment Areas used in Mass Balance Modelling

Stormwater Network Catchment Area from surrounding landuses upgradient of Z Moorhouse (Hectare)	**Stormwater Network Catchment Area from surrounding landuses downgradient of Z Moorhouse (Hectare)**	**Avon River catchment area at point of discharge (Hectare)**
2[1]	53[1]	3,950[2]
Notes: *1. Determined from the Canterbury Regional Council's GIS viewer.* *2. Determined from Golder Associates Ltd (2014).*		

The discharge into Avon River is modelled to mix with 1.2 m^3/s of flow (value taken from the ECan long term hydrological monitoring records based at Avon River @ Manchester Road). This is considered by PDP to be a conservative estimate of the river flow during the water quality event (i.e a lower flow has been used so that less dilution is available).

6.2 RESULTS

Table 5 shows the modelled concentrations of contaminants at various stages in the discharge network, 30 minutes into the water quality rainfall event.

Table 5: Assessment of Additional Stormwater Treatment Benefit at Various Stages within the Pipe Network and Receiving Environment

Contaminant	Treatment Device	Concentration exiting the Stormfilter	Concentration once mixed with the upgradient Stormwater Drainage Catchment [3]	Concentration when discharged from the Stormwater reticulation Network [3]	Concentration when mixed within the Avon River [5, 6]	Avon River Concentration upstream of the Stormwater Discharge Pont [7]	Trigger Value [4]
Total Zinc	Catchpit	0.290	0.169	0.161	0.0729	0.018	0.015
	Stormfilter	0.190	0.162	0.160	0.0728		
Total Copper	Catchpit	0.0085	0.0108	0.0110	0.005	0.001	0.0018
	Stormfilter	0.0045	0.0106	0.0110	0.005		
Dissolved Zinc	Catchpit	0.196	0.052	0.043	0.023	0.0105	0.015
	Stormfilter	0.151	0.049	0.042	0.023		
Dissolved Copper	Catchpit	0.0026	0.0032	0.0032	0.0019	0.001	0.0018
	Stormfilter	0.0023	0.0032	0.0032	0.0019		
Total Suspended Solids	Catchpit	37	37.9	38	16.2	2.5	20 % change shall not be exceeded [8]
	Stormfilter	26	37.2	38	16.1		

Notes:

1. *All units presented as mg/L, unless otherwise stated.*
2. *Assessments are based on mid flow (30 mins) contaminant concentrations obtained during this project.*
3. *Contaminant concentrations in stormwater drainage catchment based on average event mean concentrations taken from Williamson (1993).*
4. *Derived from the ECan Land and Water Plan, Schedule 5. We note that the stormwater discharge into the Avon River meets Water Quality Class Spring-fed Plains-Urban classification.*
5. *Based upon a conservative 1.2 m^3/s flow.*
6. *Applies water quality data obtained from the ECan long term monitoring site: Avon River @ Manchester Road.*
7. *Data obtained from the ECan long term monitoring site: Avon River @ Manchester Road (Bartram and Bolton Ritchie, 2013).*
8. *Trigger is for visual clarity. For purposes of providing an acceptable discharge concentration we have applied the visual clarity trigger as guidance.*

In the absence of a discharge from the service station site the model indicates that the urban run-off will not meet the receiving water standard after mixing. Adding the service station discharge (both with and without stormwater filtration) does not have any significant impact on that outcome.

Based upon the data obtained and used in the model, all modelled heavy metal concentrations (total and dissolved) once discharged into Avon River are expected to exceed the Schedule 5 Environmental Protection triggers regardless if the discharge was treated by catch pits alone or catch pits and Stormfilters collectively. Similarly, the concentrations of TSS discharged from the catchment would also cause an exceedance to the Schedule 5 Environmental Protection triggers under both onsite stormwater treatment scenarios.

From the modelling results obtained, it is therefore apparent that providing additional treatment to stormwater runoff from Z Moorhouse will not lead to contaminant concentrations within the receiving environment achieving concentrations lower than Schedule 5 Environmental Protection triggers. This result is likely to be due to small runoff rates and relatively low contaminant concentrations in the Z Moorhouse stormwater compared to the concentrations that are generated from the surrounding urban catchment.

The Z Moorhouse site represents less than 1% of the catchment area above the discharge to the Avon. Major contributors of zinc and copper in the urban environment are vehicles (tyre and brake pad wear) and unpainted and weathering galvanised rooves. Rather than targeting individual industries it is clear that catchment wide solutions and addressing the source of contaminants (in this case vehicles) is a more appropriate response.

The results obtained indicate there is little benefit achieved from using Stormfilters at service station sites in general. Accordingly, the use of Stormfilters will not be recommended in the upcoming guideline revision. There will however be a list of scenarios where such treatment should be considered. For example, stormwater discharges that discharge to sensitive ecosystems and sites draining into small catchment areas. This site specific assessment approach is similar to the current approach adopted by Z for the assessment of environmental effects associated from Diesel Exhaust Fluid use (Easton et al, 2015).

Whilst intended to address off forecourt product spills this projects results demonstrate that use of trapped sumps appears have an additional stormwater treatment benefit. Consequently, the updated guideline is likely to recommend the use of trapped sumps (subject to safety considerations with respect to explosion risk).

7.0 WHERE TO FOR THE MFE GUIDELINES?

The OIEWG will be looking for feedback on the existing guidelines and interested parties for consultation. Please email martin.robertson@z.co.nz if you have any feedback or suggestions.

8.0 CONCLUSIONS

PDP have over the past year been monitoring the performance of stormwater treatment devices located within non-forecourt areas of the Z Moorhouse service station, Christchurch. Stormwater devices monitored were ACO drains, catch pits and Stormfilters.

Stormfilters were required to be installed by Z to gain permission from the Christchurch City Council to discharge the site’s stormwater into the public reticulation network as a permitted activity. The installation of Stormfilters also allowed the Christchurch City Council to remain compliant with their stormwater network discharge consent. By installing the Stormfilters, the Z Moorhouse’s stormwater discharges were considered by the Christchurch City Council to provide adequate water quality treatment such that the environmental protection triggers prescribed within the Canterbury Regional Council Land and Water Regional Plan, Schedule 5 are not exceeded within the receiving environment (the Avon River).

Based upon water quality results obtained, only Total Suspended Solids, Total Zinc, Total Copper, Dissolved Zinc and Dissolved Copper were considered elevated within the receiving environment. All other contaminants of concern were either below laboratory levels of detection or were considered to be well below environmental protection triggers (ANZECC, 2000 and Canterbury Regional Council, 2015).

The treatment performance provided by the onsite devices varied. As expected the ACO drains provided a poor treatment performance. This result is due to there being no storage within an ACO drain. The catch pits monitored at Z Moorhouse performed very well and exceeded performance efficiencies reported in previous catch pit performance studies. This result is likely due to the coarse sediment grain size typically found on non-forecourts.

The Stormfilters located at site were also considered to provide good stormwater treatment. Our monitoring results were very similar to other assessments undertaken by Contech (Contech, 2006a, Contech, 2006b) for one catchment. A poorer treatment performance was obtained in the other catchment however, this result could be attributed to the good treatment performance provided by the catch pits upgradient of the Stormfilter which caused a 'cleaner' influent quality to the Stormfilter.

To determine if the sites discharges were meeting Canterbury Regional Council Land and Water Regional Plan, Schedule 5 criteria, and what benefits the Stormfilters were providing to the catchment water quality, PDP modelled the potential contaminant concentrations as they migrate through the stormwater reticulation network to the receiving environment. Based upon the results obtained, additional treatment (i.e. Stormfilters) will not lead to contaminant concentrations within the receiving environment achieving concentrations lower than Schedule 5 Environmental Protection triggers. This result is likely to be due to small runoff rates and relatively low contaminant concentrations in the Z Moorhouse stormwater compared to those that are generated from the surrounding large urban catchment.

The authors do acknowledge however, that should a service station be located within a smaller catchment, or alternatively the stormwater discharged to a watercourse that has less flow the outcome could be different. The requirement for Stormfilters to manage non-forecourt discharges should therefore be considered on a case-by-case basis, not as a blanket requirement for every service station.

Z is committed to enhancing the environmental performance of the industry through its own actions and through participation in the OIEWG. As a result of the review project, Z has introduced trapped sumps to non-forecourt areas. These trapped sumps ensure that small volume losses such as drips from vehicles trafficking these areas will be captured on-site. The increased sump size will enhance capture of sediment.

When Z set out on this review, one possible outcome was that the case for additional treatment of non-forecourt areas would be so compelling that it would become part of the revised guidelines. Based upon the results obtained from the Z Moorhouse project, this however has not been the case. The costs and challenges associated treatment of non-forecourt areas appear to far outweigh the environmental benefits. We note that this conclusion applies only to service stations of the type studied. Further research (on a case by case approach) to understand the potential benefits that stormwater proprietary devices may provide for stormwater discharges from larger car parks and roads in sensitive areas may reach different conclusions than this project has obtained.

Z has introduced recycling on forecourts and stage 2 vapour recovery on all new builds and retanks at considerable expense. In terms of 'bang for buck', Z consider that these environmental initiatives are a better investment to enhance environmental outcomes rather than the regulatory requirement to invest in proprietary stormwater devices for all non-forecourt areas that may not provide any environmental benefit within the receiving environment.

9.0 REFERENCES

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Appendix A - Site Drainage Plan