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RE: GREEN BUILDING COUNCIL OF AUSTRALIA TOTAL PETROLEUM HYDROCARBON TARGET

This correspondence describes our review of the Green Building Council of Australia (GBCA, 2021) stormwater management target for hydrocarbon removal. Key findings from this review are:

- The GBCA (2021) stormwater management target for hydrocarbon removal of 98% removal is inappropriate since it is likely impossible to demonstrate compliance with the aforementioned target, given that a 98% reduction of typical hydrocarbon concentrations in urban stormwater is below the limit of detection for hydrocarbon concentrations
- 'Real world' stormwater treatment performance monitoring studies have included the analysis of the removal of hydrocarbons (and/ or 'oil and grease') for 'conventional' biofiltration systems, Filterra® biofiltration systems and StormFilter® technologies, which have demonstrated high reductions of these pollutants
- Discharged hydrocarbon concentrations in stormwater from development sites (excluding 'high risk'[1] sites) that comply with the GBCA (2021) target for total suspended solids (and total nitrogen and total phosphorus) via an appropriate stormwater treatment strategy (including, for example, conventional biofiltration systems, Filterra® biofiltration systems, StormFilter® and/ or Jellyfish®) are highly unlikely to cause any significant risk to downstream waterway health, consistent with the desired outcome of 'waterway protection' within GBCA (2021).

[1] Blacktown City Council (2020) states 'high risk' include Higher risk developments include (i) service stations; (ii fuel depots; (iii) car and truck washing facilities; (iv) high turn-over uncovered car parks which have over 50 car spaces and (iv) mechanical workshops and car sales yards that have outside parking for more than 20 vehicles.

Our recommendations are:

- GBCA should remove the aforementioned target for hydrocarbon removal of 98% removal
- Compliance with GBCA (2021) targets for total suspended solids (and total nitrogen and total phosphorus) should be demonstrated via the use of an industry-accredited method (e.g. eWater's MUSIC software) in accordance with associated industry guidelines (e.g. Water by Design (2010) and/ or Blacktown City Council (2020)).
- Supporting information must be provided (with no distribution restrictions) for any claimed removal of total suspended solids and nutrients for any manufactured stormwater control measures, including the methodology and results of rigorous 'real world' performance monitoring.

I trust this is suitable for your current purposes. Please contact me if you have any questions, or if you would like to discuss anything further.

Yours faithfully

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Principal Environmental Engineer

Introduction

Green Building Council of Australia

The Green Building Council of Australia (GBCA) aims to assist in developing a sustainable property industry in Australia and drive the adoption of sustainable practices. An initiative of the GBCA is *Green Star Buildings*, which is a rating tool developed to rate the design and construction of any building. *Green Star Buildings* features eight categories representing the issues that will define the next decade of the built environment, and one of these issues is 'Nature'. One of the credits available to buildings in the 'Nature' category is 'waterway protection' – with the outcome that "Local waterways are protected, and the impacts of flooding and drought are reduced" (GBCA, 2021).

To achieve credit associated with 'waterway protection', the project must comply with both of the following criteria:

- Stormwater Volume
- Pollution Reduction Targets

One of the pollution reduction targets is:

> if a site has more than 200m² of uncovered areas where vehicles are likely to transit and/or park, then hydrocarbon treatment devices must be installed, specified to remove at least 98% of hydrocarbons, sized to treat a 1-in-3 month ARI (4EY) flow. Electric vehicle only parking areas do not count towards the total.

Hydrocarbon removal processes in stormwater control measures

Removal of oil, grease and hydrocarbons is promoted by several mechanisms within stormwater control measures (SCMs), namely:

- Sediment removal (e.g. sedimentation, filtration)
- Adsorption/ absorption
- Biodegradation.

Various studies (e.g. cited in Walker et al (1994)) show that the majority of heavy metal and contaminants (e.g. hydrocarbons) found in stormwater runoff are associated with fine particles (under 500 microns). Colwill et al (1994) also states that 70% of oils and 85% of polycyclic aromatic hydrocarbons are associated with solids in the stormwater and that, over a period of dry weather conditions, the highest oil content was found in the sediment range of 200 to 400 microns. E2DesignLab (2015) also demonstrated that the majority of sediment in urban stormwater runoff are fine particles. Therefore, treatment processes within SCMs that remove sediment will significantly contribute to the removal of hydrocarbons.

Biofiltration systems and Ocean Protect's StormFilter® also augment hydrocarbon removal by adsorption/ absorption to the media during storm events and subsequent breakdown over time. The hydrophobic nature of oil and its affinity for an inert or carbon-based surface also promotes adsorption/ absorption. Zeolite media (often used in StormFilter®), in particular, has a high affinity for oil since the oil's hydrocarbon chains interact with the media through the process of adsorption. The perlite media (typically used in StormFilter®) is slightly different in that oil is physically separated from the water through surface attachment or by capillary action within the perlite's micropores.

For biofiltration systems, removal can benefit from increased soil organic matter content (but this will compromise nutrient removal) and drying. Back-to-back storm events do not benefit removal as there is limited opportunity for decomposition and some adsorbed contaminants can be flushed (Payne et al, 2015).

Review of GBCA (2021) hydrocarbon removal target

The GBRCA (2021) stormwater management target for hydrocarbons is unlikely to be appropriate for several reasons, including:

- It is unlikely to be possible to demonstrate compliance with the aforementioned target (with sufficient evidence)
- Typical hydrocarbon concentrations in urban stormwater (excluding 'high risk' sites) are highly unlikely to cause any significant impact to waterway health
- This target is higher than the target required by Blacktown City Council for low risk developments, noting Blacktown City Council (2020) outlines five (5) deemed-to-comply solutions for hydrocarbon removal in low risk developments
- No 'real world' performance monitoring of SCMs treating 'typical' hydrocarbon concentrations in urban stormwater have demonstrated compliance with the GBCA (2021) target.

These aspects are described in the following sub-sections.

Demonstrating compliance

It is unlikely to be possible to demonstrate compliance with the aforementioned target (with sufficient evidence) for two key reasons:

- Available research shows that stormwater runoff concentrations of hydrocarbons are typically low for the vast majority of land use types (except for petrol stations and similar).
    - Data from the *International Stormwater BMP Database* (2020), for example, shows that the mean total petroleum hydrocarbon concentration (from 294 samples) was 2.7mg/L (with a median of 1.8mg/L, and maximum of 37.5mg/L) with over a third of all samples below the limit of detection (which was typically 0.5mg/L). It should be noted that this data includes a mix of land use types, including highways and/or freeways, commercial, industrial and residential.
- It is impossible to demonstrate an effluent concentration "at least 98% lower" than typical stormwater concentrations given effluent concentrations necessary to demonstrate compliance are significantly below the limit of detection for laboratories.
    - To "remove at least 98% of hydrocarbons" from stormwater flows for sites with a hydrocarbon concentration equal to the aforementioned average value of 2.7 mg/L would require an average effluent concentration of below 0.05mg/L. This effluent concentration would be impossible to demonstrate given that typical laboratory detection limits (between 0.1 and 0.5mg/L) are higher than this concentration.

It is subsequently unlikely that compliance with this target (if it could be achieved) could be appropriately demonstrated or achieved (with sufficient evidence).

Impact to waterway health

Typical hydrocarbon concentrations in untreated urban stormwater (excluding 'high risk' sites) are unlikely to cause any significant impact to waterway health. Auckland Council (2016), for example, states:

> There appears to be no downstream environmental data (water or sediment quality or ecotoxicological responses) that identifies TPH (Total Petroleum Hydrocarbons) as a pollutant of concern in Auckland requiring specific upstream controls in relation to specific land uses or general activities (e.g. carparking). Consequently, there is insufficient information and data to conclude treatment of urban stormwater (from residential and commercial landuse) to specifically remove TPH is required.

As noted above, treatment processes within SCMs that remove sediment will also significantly contribute to the removal of hydrocarbons. As also described above, GBCA (2021) requires 85% removal of total suspended solids loads. Therefore, discharged hydrocarbon concentrations from sites that comply with the GBCA (2021) targets for total suspended solids (and total phosphorus and nitrogen) are highly unlikely to cause any significant impact to waterway health, consistent with the desired outcome of 'waterway protection' within GBCA (2021) (regardless of demonstrated compliance with the 98% hydrocarbon removal target).

Comparison to Blacktown City Council (2020) requirements

Blacktown City Council is arguably the leading local government in Australia in relation to stormwater quality management and Water Sensitive Urban Design and associated waterway protection. Blacktown City Council requires that 'low risk' developments achieve 90% removal of hydrocarbons (relative to the untreated development), which is obviously lower than the GBCA (2021) 98% removal target.

Blacktown City Council (2020) also outlines five (5) deemed-to-comply solutions for hydrocarbon removal in low risk developments, including:

- Gross pollutant trap (GPT) with hydrocarbon trap
- Oil baffle (excluding Jellyfish)
- Oil baffle for Jellyfish
- Bioretention with shallow or no OSD
- Fully covered car parks and driveways.

Whilst these deemed-to-comply solutions will result in a reduction in hydrocarbon loads discharged downstream, to the best of our knowledge, it is worth noting that there is no supporting information from 'real world' stormwater performance monitoring studies that any of these deemed-to-comply solutions would achieve 90% reduction in hydrocarbon loads. Payne et al (2015) provides a "general indication" that bioretention systems are expected to achieve greater than 99% reduction in hydrocarbon concentrations, but no references are cited to support this "general indication". Payne et al (2015) does, however, later reference a study by Zhang et al (2014) in relation to the removal of organic toxicants/micro-pollutants, which is described in the following sub-section.

SCM performance monitoring studies

Table 1 provides a summary of SCM performance monitoring studies that have included the analysis of hydrocarbons (or 'oil and grease').

Table 1 Summary of SCM performance monitoring studies for hydrocarbon, oil and grease removal

Reference	Treatment system type	Treatment system summary	Methodology summary	Hydrocarbon performance summary
Flanagan et al (2018)	Vegetated filter strip	Paris, France; installed September 2012; highly trafficked highway catchment; 1.8m width; 48m length; 86m^2 area (17% of impermeable catchment); sandy loam filter.	19 real events; flow and water quality monitored; February 2016 to July 2017	• Median influent TPH concentration 1.12mg/L • Median effluent TPH concentration 0.27mg/L • TPH concentration reduction 71%.
	Biofiltration swale	Paris, France; installed March 2016; highly trafficked highway catchment; 0.5m width; 32m length; 16m^2 area (4.5% of impermeable catchment; sandy loam filter.		• Mean influent TPH concentration 1.12mg/L • mean effluent TPH concentration 0.27mg/L • mean TPH concentration reduction 64%.
Contech (2016)	Filterra® biofiltration system	Columbia, Maryland, USA; 3.3m^2 area (unknown catchment area); installed June 2005, 0.53m deep Filterra® filter media; unidentified shrub/ tree	92 real events; water quality monitored; 2008-2016	• Mean influent 'oil and grease' concentration 30.1mg/L • mean effluent 'oil and grease' concentration 4.3mg/L • mean 'oil and grease' concentration reduction 48%.
Zhang et al (2014)	Conventional biofiltration system	Two systems: System 1 with loamy sand (and no submerged zone); System 2 with sandy loam and submerged zone; both vegetated.	Three (3) synthetic 'challenge' tests of synthetic stormwater with high (95% percentile) micropollutant concentrations for both systems	• Mean influent TPH concentration 4.3mg/L • mean effluent TPH concentration <0.1mg/L • mean TPH concentration reduction 98.9%.
Herrera Environ-mental Consultants (2009)	Filterra® biofiltration systems	System 1: Port of Tacoma, Washington, USA; installed June 2005; 2.2m^2 area (0.22% of catchment); 0.53m deep Filterra® filter media	26 real events; water quality monitored; May 2008 to May 2009	• Mean influent TPH concentration 35mg/L • mean effluent TPH concentration 1.7mg/L • mean TPH concentration reduction 91%.
		System 2: Port of Tacoma, Washington, USA; installed June 2005; 1.5m2 area (0.23% of catchment); 0.53m deep Filterra® filter media		• Mean influent TPH concentration 0.47mg/L • mean effluent TPH concentration 0.15mg/L • mean TPH concentration reduction 49%.
Diblasi et al (2008)	Conventional biofiltration system	College Park, Maryland, USA; installed 2004, 181m^2 area (6% of catchment); 0.5 to 0.8m filter depth	Five (5) real events; flow and water quality monitored; April 2006 to October 2007	• Mean influent polyaromatic hydrocarbon (PAH) concentration 2.08mg/L • mean effluent TPH concentration 0.22mg/L • mean TPH concentration reduction 90%.
Stormwater Management Inc (2000)	StormFilter®	Nine (9) StormFilter® cartridges with surface modified zeolite and perlite filtration media; San Francisco, USA; 2428m^2 car park catchment.	3 real events; water quality monitored; January/ February 1999	• Mean influent 'oil and grease' concentration 11.3mg/L • mean effluent 'oil and grease' concentration 5mg/L (2 out of 3 samples below detection limit) • mean 'oil and grease' concentration reduction 51%.
Stormwater Management Inc (2000)	StormFilter®	StormFilter® with surface modified zeolite and perlite filtration media; Department of California maintenance facility; roadway/bridge catchment.	3 real events; water quality monitored; March/ April 1999	• Mean influent TPH concentration 7.2mg/L • mean effluent TPH concentration 1.83mg/L • mean TPH concentration reduction 76%.

Table 1 shows that SCM performance monitoring studies have included the analysis of hydrocarbons (or 'oil and grease') for biofiltration ('conventional' and Filterra® biofiltration) systems and the StormFilter® technology. The results in Table 1 also shows that high reductions of these pollutants were observed for these studies.

The Zhang et al (2014) study is, however, the only known study that demonstrated hydrocarbon concentration reductions greater than 98%. It should be noted, however, that the Zhang et al (2014) study was for six (6) different 'challenge' tests of synthetic stormwater with high (95% percentile) micropollutant concentrations, with an average influent total petroleum hydrocarbon (TPH) concentration of 4.3mg/L (60% higher than the average reported in the International Stormwater Database (2021), and an average effluent below the limit of detection (0.1mg/L) – resulting in an average reduction of 98.9% (assuming half of the detectable limit was taken as the concentration for determination, as is the practice in literature (Dombeck et al (1998), cited in Zhang et al (2014).

The high TPH concentration reductions observed in the Zhang et al (2014) study would be in part due to the elevated influent concentrations (relative to typical urban stormwater) used in this study. As described by Neumann et al (2010) and International Stormwater Database (2007), for example, it is easier for SCM's to achieve higher pollutant concentration reduction rates when runoff has higher pollutant concentrations. Nevertheless, the biofiltration systems in this study still achieved TPH effluent concentrations below the limit of detection. Similarly, the first Filterra® biofiltration system within the Herrera Environmental Consultants study (2009) showed an average hydrocarbon concentration reduction of 91%, noting the high average influent TPH concentration (of 35mg/L).

Conclusion

This correspondence describes our review of the Green Building Council of Australia (GBCA, 2021) stormwater management target for hydrocarbon removal. Key findings from this review are:

- The GBCA (2021) stormwater management target for hydrocarbon removal of 98% removal is inappropriate, particularly given that it is likely impossible to demonstrate compliance with the aforementioned target as a 98% reduction of typical hydrocarbon concentrations in urban stormwater is below the limit of detection for hydrocarbon concentrations.
- Performance monitoring studies have included the analysis of hydrocarbons (and/ or 'oil and grease') for biofiltration systems and StormFilter® technologies, which have demonstrated high reductions of these pollutants.
- High rates of hydrocarbon removal are anticipated when compliance with the GBCA (2021) target for total suspended solids (and total phosphorus and nitrogen), and discharged hydrocarbon concentrations from development sites that satisfy this target (excluding 'high risk' sites) are highly unlikely to cause any significant risk to downstream waterway health, consistent with the desired outcome of 'waterway protection' within GBCA (2021).

A stormwater management strategy for sites (excluding 'high risk' sites) that complies with the GBCA (2021) targets for total suspended solids (and total phosphorus and total nitrogen) is likely to ensure that hydrocarbon discharges pose no significant risk to downstream waterway health, consistent with the desired outcome of 'waterway protection' within GBCA (2021).

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