Stormwater360 Filterra® system Interim Proprietary Device Evaluation: Final November 2016

Auckland Council
Te Kaunihera o Tāmaki Makaurau

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Recommended citation:

Wells J, Ferguson R, Emson J, Clarke C, 2015, Stormwater360 Filterra® system: Interim Proprietary Device Evaluation, Prepared by Morphum Environmental Ltd for Auckland Council.

Executive Summary

Auckland Council Healthy Waters Department (HW) has engaged Morphum Environmental Ltd. (MEL), in conjunction with AECOM, to undertake evaluations for proprietary devices for use on *private* infrastructure. The process provides interim recognition of international certifications for proprietary stormwater devices for use on private sites. Interim recognition is provided until further notice. Auckland Council may amend or revoke approval at any time, with reasonable notice.

Certifications for interim approval are considered from:

- State of New Jersey Department of Environmental Protection (NJDEP) Approval of Use for Manufactured Treatment Devices, and
- Washington State Technology Assessment Protocol-Ecology (TAPE) Program: General Use Level Designation (GULD) Approval.

This report provides evaluation for the Filterra® Filter (Filterra system) supplied by Stormwater 360. The Filterra® has Washington GULD certification for the Filterra Boxed system for basic treatment at a design infiltration rate of 2.5 m/h. This report only considers Basic Treatment, i.e. device performance with regard to removal of Total Suspended Solids (TSS).

The evaluations are split into two parts. This report (Part 1) summarises a review of the information provided to MEL by Stormwater360 regarding the Filterra® System and evaluates the performance against the Air, Land and Water Plan (ALWP); i.e. 75% TSS removal. Part 2, to be completed at a later date, evaluates the performance of the Filterra system against the Proposed Auckland Unitary Plan (PAUP).

Washington GULD certified offline standard and shallow Filterra® configurations were amended and provided by Stormwater360 based on standard vault, manhole and box culvert configurations for Auckland use. These local offline configurations have been compared against the Washington GULD certification and confirmed as acceptable in meeting the ALWP requirements for 75% sediment removal, as per the detail contained in Section 4.0. The GULD approved online Filterra® and Filterra® Bioscape™ are considered functionally equivalent, and therefore are also regarded as acceptable in meeting the ALWP requirements for 75% sediment removal.

As a result of this review, we conclude that the following Filterra® configurations can provide basic treatment as defined by Washington GULD certification:

- standard offline Filterra® designed with an infiltration rate of 2.5 m/hr,

- standard online Filterra® on the basis that
    - the surface area is sized like a standard offline Filterra,
    - their functioning and performance is not affected by the internal bypass, and
    - the internal bypass needs to meet the requirements of the Building Act and Auckland Council Code of Practice/Stormwater
- shallow Filterra® designed on the basis of a flux rate of 1.8 m/hr by controlling the outflow for equivalent contact time and a surface area upsizing factor of 1.4 for equivalent media volume to the standard Filterra® for a shallower media depth.
- Filterra® Bioscape™ with its surface area sized like a standard offline Filterra and a hydraulic gradient of 1.41 m/m.

Therefore the listed Filterra® configurations can be granted interim approval from the date of issue for use on private sites. This approval does not extend to use on public sites for devices to be vested to Auckland Council. To extend for use on public sites vested to Auckland Council, the device will need to be certified under Auckland Council's new products approval process. Other public organisations (e.g. AT and NZTA) may have their own separate product approval processes.

It should be noted that because of the high hydraulic conductivity of the filter media, the Filterra® has a smaller footprint than bioretention designed according to TP10 /GD01. As such, volume reduction and flow attenuation will be less than conventional bioretention. Ecosystem goods and services, such as provision of habitat, may also be less than is provided by larger footprint biofilters. The high infiltration rate is achieved through the use of a specifically engineered filter media and replaceable mulch. The media and mulch has different physical and chemical properties to a conventional raingarden. It is essential that the manufacturer's recommendations on operation are carried out to ensure the long term successful operation of the device.

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1.0 Introduction

Auckland Council Healthy Waters (HW) has engaged Morphum Environmental Ltd. (MEL), in conjunction with AECOM, to undertake evaluations for several proprietary devices for use on *private* infrastructure. These evaluations (if successful) will provide interim recognition of international certifications for proprietary stormwater devices for use on private sites within Auckland. Interim recognition is provided until further notice. Auckland Council may amend or revoke approval at any time, with reasonable notice.

This approval, if granted, does not extend to use on public sites and roads; nor for devices to be vested to Auckland Council. To extend for use on public sites vested to Auckland Council, the device will also need to be certified under Auckland Council's new products approval process. Other public organisations (e.g. AT and NZTA) may have their own separate product approval process.

The evaluation includes:

- Reviewing existing approvals for the proposed proprietary devices.
- Relating overseas approvals to local context.
- Developing practice notes to cover the requirements for local installations.
- Developing pro-forma consent conditions appropriate for inclusion in resource consents, approving the use of the proprietary devices.

Auckland Council previously released the Proprietary Device Evaluation Protocol (PDEP) for Stormwater Quality Treatment Devices (Guideline Document 03) in December 2012. The document provides guidance to evaluate permanent proprietary stormwater quality management devices providing for a *Body of Evidence* or *Local Pilot Trial* route to certification of performance claims from a device manufacturer.

As of May 28th 2014, all Proprietary Device Evaluation Protocol (PDEP) applications were put on hold. A replacement process has been implemented to provide interim recognition of international certifications for proprietary stormwater devices for use on private sites. Certification from the following two bodies is to be considered:

- State of New Jersey Department of Environmental Protection (NJDEP) Approval of Use for Manufactured Treatment Devices, and
- Washington State Technology Assessment Protocol-Ecology (TAPE) Program: General Use Level Designation (GULD) Approval.

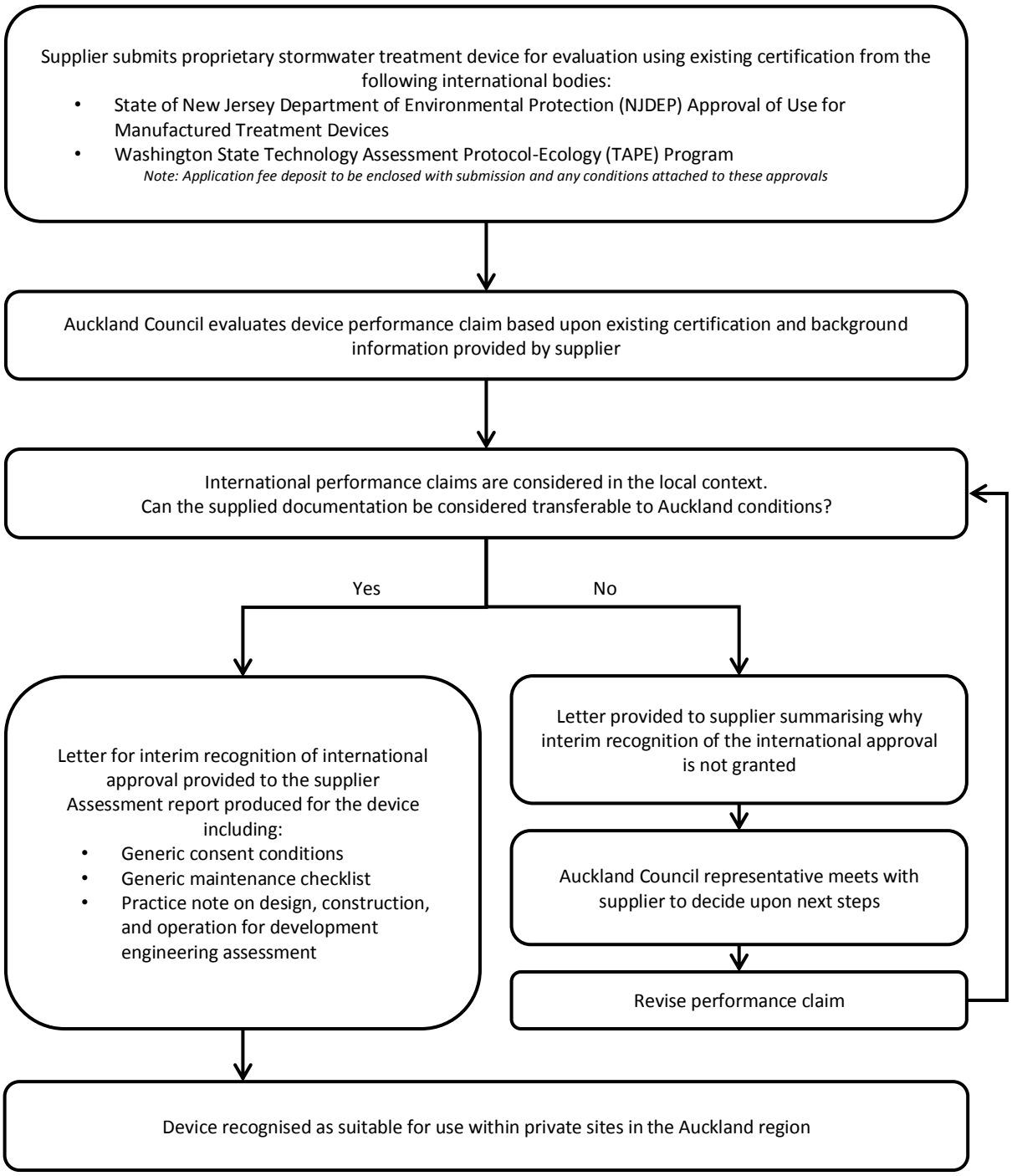
Discussions within the water industry and with Water NZ have identified that in the longer term a national stormwater product approval system should be developed for NZ, as has been done in other countries. It is hoped that a national system would supersede this interim recognition process in the future.

Some proprietary devices have had overseas certifications with approved laboratory or field test data. However, this data may not be suitable for local Auckland conditions and application. Figure 1 illustrates the methodology used for the interim assessment of the overseas data. It is important to note that this interim process is only for use of the proprietary device on private sites.

This report provides evaluation for the Filterra® system (Filterra®) supplied by Stormwater360. This includes:

- Comparison of the device performance against the stormwater management requirements in the Auckland region.
- Understanding and description of the operation and maintenance requirements for the device.
- Practice notes and consent conditions for local installations should the device be deemed suitable for use within private sites in the Auckland region.

It should be noted that because of the high hydraulic conductivity of the filter media, the Filterra® has a smaller footprint than bioretention designed according to TP10 /GD01. As such, volume reduction and flow attenuation will be less than conventional bioretention. Ecosystem goods and services, such as provision of habitat, may also be less than is provided by larger footprint biofilters. The high infiltration rate is achieved through the use of a specifically engineered filter media and replaceable mulch. The media and mulch has different physical and chemical properties to a conventional raingarden. It is essential that the manufacturer's recommendations on operation are carried out to ensure the long term successful operation of the device



Note: To permit vesting of the device to Auckland Council, the supplier will require approval under the New Products Approval Process

Figure 1 Interim recognition of international approval flowchart

2.0 Device Description & Current Certifications

2.1 Description

The boxed Filterra® is an offline, engineered biofilter device for the treatment of contaminated stormwater runoff from paved surfaces. The system is optimised for high flow rate treatment. This allows a small footprint to be used, making the device suitable for highly constrained sites. The Filterra® is typically housed within a precast concrete kerb inlet structure with a tree frame and grate cast into the top slab. Stormwater 360 also provides open top systems.

Stormwater enters the Filterra® through a kerb inlet opening and flows through a filter media mixture topped with mulch within a pre-fabricated concrete container. The filter media captures pollutants which are then decomposed, volatilised and incorporated into the biomass of the system's micro and macro flora and fauna. Captured runoff flows through the media to an underdrain system at the bottom of the container from which the treated water is discharged, either to the reticulated stormwater system or to a retention system for subsequent re-use. Higher flows bypass the system via a downstream inlet structure or outfall. Variations to the standard offline Filterra® provide flexibility in installation for different site conditions. Approved alternative configurations include:

- Filterra® Shallow – Provides flexibility where depth and elevation constraints preclude use of the standard configuration. This offline version can be designed up to 150 mm shallower than standard configurations. The shallow Filterra® is designed on the basis of a flux rate of 1.8 m/hr by controlling the outflow for equivalent contact time and a surface area upsizing factor of 1.4 for equivalent media volume to the standard Filterra® for a shallower media depth.

- Filterra® Internal Bypass-Pipe (FTIB-P) – an online configuration, where flows may be piped from area drains, grated inlets, trench drains, and/or roof drains. Stormwater enters through an internal slotted pipe that drops through to a series of splash plates that disperse the flows over the top surface of the Filterra® mulch layer. Higher flows are able to bypass the slotted pipe and pass out of the structure.

- Filterra® Internal Bypass-Curb (FTIB-C) – For online use in a sump condition to receive flows from both directions along a gutter line. The kerb inlet, bio filtration treatment chamber and internal high-flow bypass are contained within a single structure. An

internal flume tray weir directs flows through the kerb inlet to the treatment chamber. Flows greater than the design flow rise above the weir and discharge through a standpipe orifice.

- Filterra® Bioscape™ (formerly named Filterra® Boxless) – Allows some infiltration to native soils, but within the Auckland region, no retention (volume credit) is approved. It can be designed without an underdrain; in such cases a detention reservoir is required to prevent treatment media becoming saturated.

The two listed online configurations have GULD approval and are accepted as part of this interim approval on the basis that

- the surface area is sized like a standard offline Filterra,
- their functioning and performance is not affected by the internal bypass, and
- the internal bypass needs to meet the requirements of the Building Act and Auckland Council Code of Practice/Stormwater.

Likewise, the Filterra® Bioscape™ has GULD approval and is accepted as part of this interim approval on the basis that its surface area is sized like a standard offline Filterra with a hydraulic gradient of 1.41 m/m.

Analysis within this report was derived from field testing performed in Western Washington in two locations; Bellingham and Port of Tacoma. The device configurations used within the field testing are summarised in Table 2-2.

The technology's physical description treatment mechanisms can be found in Appendix A.

2.2 Current Certifications

Two specific International Certifications are to be considered herein: State of New Jersey Department of Environmental Protection (NJDEP) Certification for Manufactured Treatment Devices and Washington State Department of Ecology Certification.

NJDEP requires that manufactured treatment devices obtain verification through the New Jersey Corporation for Advanced Technology (NJCAT) prior to Certification being awarded. Verification based on laboratory data will lead to Interim Certification with verification incorporating field testing meeting or exceeding 2006 New Jersey Tier II Stormwater Test Requirements leading to Final Certification. Verified and certified stormwater technologies may be acceptable under the Technology Acceptance Reciprocity Partnership (TARP) Protocol

(Tier II) for Stormwater Best Management Practice Demonstrations endorsed by California, Massachusetts, Maryland, New Jersey, Pennsylvania, and Virginia.

Washington State Department of Ecology (Ecology) recognises different use level designations based on the quality and quantity of the performance data supplied. The designations are:

- Pilot Use Level Designation (PULD) – limited use of the proposed device to enable field testing. This designation level may be given based solely on laboratory performance data. PULD applies for a specified time period only.
- Conditional Use Level Designation (CULD) – for emerging technologies with a considerable amount of performance data but the data was not collected per the Technology Assessment Protocol – Ecology (TAPE) protocol set by the Ecology. This designation level may be given based on field data collected by a protocol that is reasonably consistent but does not necessarily meet the full TAPE protocol. CULD applies for a specified time period only.
- General Use Level Designation (GULD) – confers general acceptance for the treatment device. GULD technologies may be used anywhere in Washington, subject to Ecology conditions. Ecology plans to include GULD technologies in future stormwater manual updates. A Technical Evaluation Report (TER) is required as part of the application. Devices with GULD certification, are also approved for Pre-treatment.

Washington State Department of Ecology further distinguishes stormwater treatment technology certification by treatment type; including Pre-treatment, Basic treatment, Enhanced treatment, Phosphorous treatment, Oil treatment and Construction treatment.

Basic treatment:

- Goal of 80% TSS removal for an influent concentration range of 100 mg/L to 200 mg/L
- Effluent TSS goal of 20 mg/L for influent concentrations less than 100 mg/L
- Higher/enhanced treatment required for influent concentrations greater than 200 mg/L

Enhanced treatment

- Goal of achieving a higher level treatment than basic treatment
- Removal of dissolved metals

The Filterra® currently holds the following certification:

- State of New Jersey Department of Environmental Protection (NJDEP) Certification

- Laboratory Test Certification for 80% TSS removal for the Filterra® Boxed system (Approved on: 27/05/2014, no expiration date stated)

- Washington State Department of Ecology Certification
  - GULD for basic (TSS) treatment for the Filterra® Boxed and Bioscape system at 1.80 m/hr hydraulic conductivity for western Washington Sizing and 2.54 m/hr infiltration rate for eastern Washington sizing (no expiration date, but Ecology may amend or revoke it)
  - GULD for enhanced treatment for the Filterra® Boxed and Bioscape system at 0.63 m/hr hydraulic conductivity for Western Washington Sizing and 0.89 m/hr infiltration rate for Eastern Washington sizing (no expiration date, but Ecology may amend or revoke it)
  - GULD for phosphorous treatment for the Filterra® Boxed and Bioscape system at 1.8 m/hr hydraulic conductivity for Western Washington Sizing and 2.54 m/hr infiltration rate for Eastern Washington sizing (no expiration date, but Ecology may amend or revoke it)
  - GULD for oil treatment for the Filterra® Boxed and Bioscape system at 0.90 m/hr hydraulic conductivity for Western Washington Sizing and 1.27 m/hr infiltration rate for Eastern Washington sizing (no expiration date, but Ecology may amend or revoke it)
  - CULD for basic treatment for the Filterra® Boxed system at 1.80 m/hr hydraulic conductivity for western Washington Sizing and 2.54 m/hr infiltration rate for eastern Washington sizing (Expires on 30/06/2018)
  - CULD for enhanced treatment for the Filterra® Boxed system at 1.80 m/hr hydraulic conductivity for western Washington Sizing and 2.54 m/hr infiltration rate for eastern Washington sizing (Expires on 30/06/2018)

  Note that the GULD hydraulic conductivity was calculated based on the GULD specified infiltration rate for Eastern Washington sizing with a hydraulic gradient of 1.41 m/m. This hydraulic gradient applies to all approved Filterra® configurations.

- The Filterra® further holds approvals from other state and federal verification programs.

The Filterra® holds the most up to date NJDEP certification. In 2015 NJCAT moved to a solely laboratory based protocol. Filterra® also holds Washington CULD and GULD certifications;

however only the Field Certifications are considered for the Interim Approval Assessment; the reason being, that interim and provisional certifications allow a device to carry out field testing in order to meet requisite assessment protocols. However, Auckland does not currently have an active testing protocol.

As NJDEP do not now require field testing, only performance data from Washington GULD certifications was used in the device assessments, summarised in Table 2-1.

Due to GULD certification including four different treatment levels (defined by Washington Department of Ecology) and differing sizing criteria for eastern and western Washington, further distinguishing was required for the Auckland assessment, as outlined below.

Part 1 of the Interim Recognition Process requires assessment against the Air, Land and Water Plan (ALWP), under which a stormwater treatment device is required to achieve 75 percent TSS removal. Therefore analysis focused on performance results from studies assessing GULD basic treatment.

Washington GULD certification is summarised in Table 2-1 and can be found in full in Appendix B.

Table 2-1 Summary of Washington State Department of Ecology Certification for the Filterra®

Criteria	Standard Filterra®	Shallow Filterra®
Expiration date	None, but may be amended or revoked	
Filterra® media	Total media depth comprises: - 76 mm mulch layer - 533 mm engineered soil media - 152 mm gravel	The system can be designed up to 150 mm shallower than the standard Filterra®. Note the ponding depth for a shallow Filterra® is reduced to 0.17m, to achieve the recommended surface area upsizing factor (1.4) and hence same hydraulic gradient as for the standard Filterra®.
Treatment performance	Basic TSS removal	
Hydraulic conductivity	1.80 m/hr	1.3[1] m/hr
Infiltration rate	2.5 m/h	1.8[1] m/hr The shallow Filterra® is designed on the basis of a flux rate of 1.8 m/hr by controlling the outflow for equivalent contact time and a surface area upsizing factor of 1.4 for equivalent media volume to the standard Filterra® for a shallower media depth.

Criteria	Standard Filterra®	Shallow Filterra®
Maximum water quality design flow rate[5]	- For treatment installed upstream of de/retention, the water quality design flow rate is the 15-min flow using the appropriate methods for western and eastern Washington. - For treatment installed downstream of detention, the water quality design flow rate) is, for the entire state, the full 2-yr release rate of the detention facility.	
Minimum size filter surface-area	- Western: determined using the sand filter module in the latest version of the WWHM or other Ecology approved continuous runoff model. - Eastern: determined by dividing the water quality flow rate (above) by the Infiltration rate[7].	- Based on sizing for a standard Filterra® system and applying an upsizing factor of 1.4 in order to provide equivalent contact time at a shallower depth.
Additional Conditions	- The Filterra® unit is not appropriate for use as an oil-water separator, or oil spill-control purposes - Filterra® units should be designed, assembled, installed, operated, and maintained in accordance with applicable Filterra® manuals, document, and the Ecology Decision. - Each site plan must undergo Filterra® review before Ecology can approve the unit for site installation, to ensure appropriate site grading and slope for use of the Filterra® unit - Filterra® media must conform to the specifications submitted to an approved by Ecology. - Maintenance includes removing trash, degraded mulch, and accumulated debris from the filter surface and replacing the mulch layer. Inspections are used to determine site-specific maintenances schedules and requirements. Maintenance procedures should be followed using the latest version of the Filterra® Operation and Maintenance Manual - Maintenance interval is dependent on the catchment pollutant loading, and therefore a "one size fits all" maintenance cycle is not endorsed by Ecology. Filterra® designs their systems with a target maintenance interval of 6 months. - Discharges should not cause or contribute to WQ standards violations in receiving waters	
1 The shallow Filterra® is designed on the basis of a flux rate of 1.8 m/hr by controlling the outflow for equivalent contact time and a surface area upsizing factor of 1.4 for equivalent media volume to the standard Filterra® for a shallower media depth.		

2.3 Testing & Performance

Field studies provide the basis of current Filterra® certifications from Washington State. Table 2-2 summarises Filterra® performance from US GULD approved field studies conducted at two Washington sites, Bellingham and the Port of Tacoma. The studies were undertaken to confirm the manufacturer's performance claim for pollutant removal. Claimed removal rates, which may vary according to particle size, pollutant loading and site conditions, are 85% for TSS, 70% for phosphorus, 43% for nitrogen, 58% for total copper, 46% for dissolved copper, 66% for total zinc, 58% for dissolved zinc, and 93% for oil and grease.

The above two field studies had varying treatment criteria; basic and enhanced treatment for the Bellingham and Tacoma study respectively. As the basis for analysis within this report focuses on basic treatment (see Section 2.2), the Bellingham study formed the basis for evaluating the Filterra® for use in an Auckland context (Section 3.0). However performance results from the Tacoma study were nevertheless included in Table 2-2, to demonstrate GULD approved Filterra® performance at a reduced infiltration rate (0.9 m/hr).

A third field study undertaken in at Falls Church, Virginia, was provided by Stormwater 360. However, this study was excluded from analysis due to the following reasons:

- Filterra® systems do not have full NJDEP certification
- The study did not form part of GULD certification
- The study used an above GULD certified infiltration rate
- The study assessed less than 50% of the monitored storm events

Table 2-2 International field test studies demonstrating Filterra system performance

	Western Washington	
Location	Bellingham, Washington	Port of Tacoma (POT), Tacoma, Washington
Site land use	Sealed road (Hayward Drive) (0.16 ha of which 100% impervious)	POT 1 carpark (0.10 ha of which 100% impervious) POT 2 carpark and rooftops (0.06 ha of which 100% impervious)
Monitoring period	Continuous flow and rainfall data collected from 1/1/2013 to 23/07/2013 (7 months)	Continuous flow and rainfall data collected from May 2008 to May 2009 (12 months)

	Western Washington	
Events	- 18 of the 22 TAPE WQ qualifying events met the TSS basic treatment criteria with influent TSS concentrations ranging between 25-138 mg/L - Average rainfall intensity ranged from 0.36 mm/hr to 2.06 mm/hr - 4 events resulted in bypass - Sampled infiltration rates ranged from 0.42 m/hr to 3.81 m/hr with a mean of 1.80 m/h.	- 27/89 storm events meeting TAPE criteria for storm and/or water quality data - 22 events sampled for POT1 and 13 events sampled for POT2 - Minimum storm duration requirement (1 hour) met for all storms - Bypass occurred during 9 events for POT 1 and 1 event for POT 2 - Minimum rainfall depth (3.8 mm) was met for 23 of 27 storm events - Average rainfall intensity ranged from 0.1 mm/hr to 2.5 mm/hr
Filterra® unit	6.5 ft x 4 ft (1.98 m x 1.22 m)	6 ft x 4 ft (1.83 m x 1.22 m) (POT1) 4 ft x 4 ft (1.22 m x 1.22 m) (POT2)
Design hydraulic conductivity	1.80 m/h (GULD basic treatment)	0.90 m/h (GULD enhanced treatment)
Compliance	Washington Department of Ecology TAPE	
Outcome	Washington GULD Certification	Washington GULD Certification

	Western Washington	
Treatment results	- 98.9% of the total runoff volume treated during the testing period, exceeding the goal for 91% volume treatment - 90.1% mean TSS removal for TSS influent concentrations < 100mg/L: 5.2 mg/L UCL95 mean effluent concentration (below 20 mg/L threshold) - 85.2% mean TSS removal for TSS influent concentrations > 100 mg/L (3 events) - Consistent TSS removal above 80% at the design flow rates of 2.54 m/hr, and also observed at an infiltration rate of 3.8 m/hr -	- 98.96% and 99.89% of the annual influent runoff volume passed through POT 1 and POT 2, respectively, exceeding the goal for 91% volume treatment - > 80% TSS removal for influent concentration >20 mg/L at an average instantaneous hydraulic loading rate up to 1.35 m/hr - For all 22 storm events sampled at POT 1, effluent TSS concentrations ranged from 1.7 to 7.8 mg/L; below the 20 mg/L GULD criteria - Statistical analysis showed Filterra® had equivalent or better dissolved metal removal than a grass swale.

3.0 Application in an Auckland Context

3.1 Comparison of PSDs

Comparison of particle size distribution (PSD) provides an indicative assessment for the transferability of device performance results from the Bellingham and Port of Tacoma field studies to the Auckland context. The PSD of stormwater runoff (influent) in the field studies was compared to example PSDs for the Auckland region in order to assess the likely performance of the Filterra® in an Auckland context (Figure 2).

Three Auckland PSDs are provided:

- A "Pakuranga" PSD as presented in TP10 (ARC 2003);
- A mean PSD for eight central Auckland catchments based upon NIWA monitoring commissioned by Metrowater and Auckland City for the period 2002-2003 (Semadeni-Davies 2013); and
- A set of three PSDs from the three northern Auckland catchments (Albany, Silverdale and Esmonde Road), based upon a study undertaken for NZTA and Auckland Council (Semadeni-Davies 2013).

Figure 2 demonstrates the variation of Auckland stormwater PSD dependent on catchment location in relation to the event-based influent particle distribution measured at the Bellingham site and the two Port of Tacoma sites. The measurements of the three Auckland data sets are shown to be largely comparable to the measurements from the field studies. The composite NZTA result is generally coarser than the other two Auckland sites but shows the same general grading pattern. The Pakuranga sample was not measured at the very fine end of the scale but also shows a similar grading profile.

The Port of Tacoma PSD exhibits a higher proportion of fine sand than the Auckland samples, the Metrowater measurements in particular, but is generally finer than the NZTA measurements. Effective removal in the field studies of particles of similar size to those exhibited in the Auckland samples, and the device's ability to remove particles across a wide range of particle sizes, suggests that the Filterra® device could be expected to perform at least as well in an Auckland context.

The Bellingham study indicates a higher proportion of finer material than other samples and shows a similar distribution of particle sizes to the Port of Tacoma and Pakuranga studies at the coarser end of the spectrum. Removal rates based on the finer sediments of the Bellingham study should translate to comparable or enhanced removal rates in Auckland.

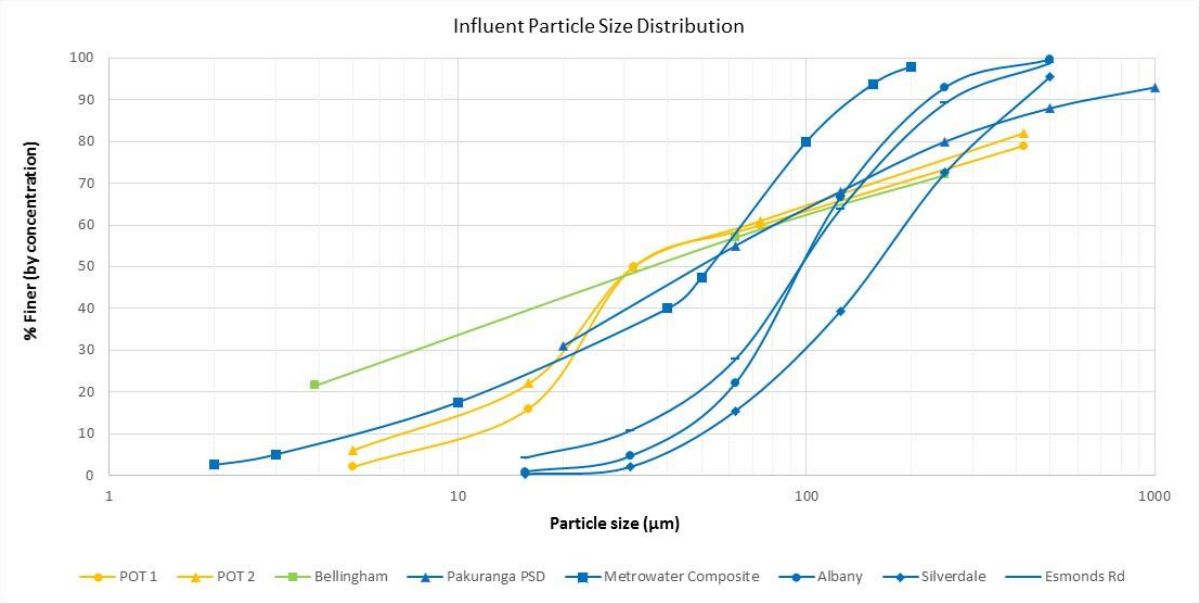


Figure 2 Particle size distribution of suspended solids in stormwater runoff in US and Auckland studies

Note: Bellingham median PSD values read from graph in Herrera (2014).

3.2 Performance relative to ALWP

Stormwater treatment devices in Auckland are currently required by Air, Land and Water Plan (ALWP) to achieve 75% TSS removal on a long term average basis (ARC, 2003). The TSS removal performance of Filterra® was assessed from the independently certified field studies used for the Washington GULD approvals (Table 2-2) for comparison to the ALWP requirement. The TSS removal performance from each studies listed in Table 3-1, were deemed to meet the ALWP requirement.

Table 3-1 Comparison of TSS percent load reduction and median effluent levels against AWLP requirement

Location	Bellingham	Port of Tacoma
Device	4 ft x 6.5 ft box	4 ft x 6 ft box (POT1) 4 ft x 4 ft box (POT2)
TSS	Mean 85.2%	Median 86%

The observed influent concentrations ranged from 7.5 mg/L to 138 mg/L for the Bellingham study, with the majority being below 100 mg/L. Minimum and maximum TSS removal rates for all qualifying storms were 66% and 95%, respectively, with a mean removal rate of 85.2% for influent concentration >100 mg/L (based on 3/22 sampled storm events), and 90.1 % mean

TSS removal for influent concentrations between 20-100 mg/L (based on 15/22 sampled storm events).

For the Port of Tacoma (POT1) study, influent TSS concentrations ranged between 11 mg/L and 40 mg/L. Minimum and maximum removal rates were 79% and 90%, respectively, with a median removal rate of 86% (only two of the 23 qualifying storm events had removal rates less than 75% TSS removal).

Performance analysis focused predominantly on results from the Bellingham study, due to the study using the GULD hydraulic conductivity of 1.8 m/hr for a standard Filterra®. TSS removal performance (as indicated in Table 3-1 for the Bellingham study) is expected to be similar for the Auckland context, given:

- the Auckland PSD samples are generally comparable to the US field study PSDs, and
- the expected pollutant loads in Auckland are similar to those observed for the Bellingham study

The US field studies also monitored the removal performance of other water quality parameters (e.g. metals, TP, TN, etc.); however since these are currently not a required assessment criteria in Auckland, other than TSS treatment results have not been included into analysis.

The Filterra® is available in various configurations (described in Section 2.1). Analysis focused on performance results from an offline standard Filterra®. Performance results from alternative approved Filterra® configurations were not available; however they are regarded as functionally equivalent to the standard configuration with amendments discussed in Section 4.1.2 and Section 4.1.3.

4.0 Filterra® Device Sizing

4.1 Flow based sizing

In the Auckland context, stormwater devices sized using flow based methods must provide a peak flow rate calculated via the rational method, and based on a rainfall intensity of 10 mm/h for the catchment they serve (Auckland Council, 2013). This definition is based on analysis of rainfall records over the Auckland region, and is equivalent a volume based sized device following the TP10 (ARC, 2003) water quality volume design process.

Stormwater quality devices with little or no storage volume, such as the Filterra®, are best sized to treat a defined Water Quality Flow (WQF) for the site which in Auckland's case is based on a 10 mm/hr constant rainfall intensity. The Rational Method can be used to calculate the runoff flows to the device (Auckland Council, 2013).

$$Q_d = CiA_C \qquad Equation\ 1$$

Where

Q_d is the water quality flow in m^3/h requiring treatment,

C is the runoff coefficient derived as outlined below,

A_c is the catchment area in m^2, and

i is the design rainfall intensity of 10 mm/hr.

Auckland Council specifies use of C=1 for paved or otherwise impervious surfaces (ARC, 2003). Table 4-1 provides a range of values for pervious surfaces. For sites with mixed surface types, an area weighted composite C value should be used.

Table 4-1 Range of typical runoff coefficient values for natural surface types (Source: DBH, 2011)

Natural Surface Types	Rational Coefficient, C
- Heavy clay soils	0.30–0.40
- Medium soakage soil types	0.20–0.30
- High soakage gravel, sandy, and volcanic soil types	0.10–0.20
- Parks, playgrounds, reserves, lawns	0.25–0.30

For flow based sizing, the peak water quality design flow rate is used to identify the minimum filter surface area required to achieve the target water quality treatment rate.

Stormwater360 currently is undertaken work with respect to inlet configuration for the manhole system in the Auckland context. Until further clarification, the inlet can be configured as proposed by Stormwater360:

- As per Humes metro pit, or
- In conjunction with a filter strip for sheet flow from the road surface to the system

It is noted that the designer is responsible for ensuring the hydraulic design of the connected units does not affect the performance/treatment efficiency of the units, nor that of the upstream stormwater system. The manufacturer is responsible to inform the designer of this responsibility.

4.1.1 Design of a standard Filterra®

A standard Filterra® is designed to be offline and may be installed upstream of a detention/retention device. A standard Filterra® uses the following parameters for sizing:

- Filter media depth of 0.56 m,
- Effective ponding depth: 0.23 m, the effective ponding depth is equivalent to the 150 mm clear zone between the top of the mulch and the bottom of the slab plus 75 mm of mulch

Correct Filterra® box sizing is necessary to achieve expected pollutant removal rates for a given catchment area. The required Filterra® surface area is calculated using Equation 2 and assumes standard Filterra® layer dimensions. It equates to a conservative surface area and needs to be verified for local conditions.

$$A_F = \frac{Q_d}{F} \qquad \textit{Equation 2}$$

Where

A_F is the required Filterra® surface area for a standard system (m^2),

Q_d is the water quality flow rate (m^3/h) derived using Equation 1, and

F is the infiltration rate (m/h) as represented by Equation 3 below

$$F = k \times i \qquad \textit{Equation 3}$$

where

F is the infiltration rate (m/hr), GULD approved design infiltration rate is 2.5 m/hr for basic treatment of a standard Filterra®.

k is the approved hydraulic conductivity (m/hr). GULD approved hydraulic conductivity is 1.8 m/hr for basic treatment of a standard Filterra®

i is the hydraulic gradient (m/m). The GULD hydraulic gradient is 1.41m/m for basic treatment provided by a standard Filterra®.

Equations 1 and 2 are used to establish a relationship between the required Filterra® surface area for a given catchment area and the associated WQF. To suit Auckland conditions, Stormwater 360 provided typical Auckland Filterra® configurations, which differ to those used for GULD certification. Table 4-2 identifies the Auckland standard Filterra® configurations with their respective surface area, allowable design flow rates and associated catchment areas. A standard Filterra® surface area equates to 0.37% of the catchment area, using standard Filterra® unit layer dimensions.

Any deviation from the specified media characteristics would require a review of the design flow rates.

Table 4-2 Design flow capacities for standard Auckland Filterra® configurations

Model	Vault/ Manhole	Diameter [m]	Length [m]	Width [m]	Filter Area [m²]	Design flow rate[1] [L/s]	Catchment Area[2] [m²]
FT1212	V	-	1.200	1.200	1.440	1.016	385.011
FT1218	V	-	1.800	1.200	2.160	1.524	577.516
FT1224	V	-	2.400	1.200	2.880	2.032	770.021
FT1236	V	-	3.600	1.200	4.320	3.048	1155.032
FT1812	V	-	1.800	1.200	2.160	1.524	577.516
FT1818	V	-	1.800	1.800	3.240	2.286	866.274
FT1824	V	-	2.400	1.800	4.320	3.048	1155.032
FT1830	V	-	3.000	1.800	5.400	3.810	1443.789
FT1836	V	-	3.600	1.800	6.480	4.572	1732.547
FT2140	V	-	4.000	2.100	8.400	5.927	2245.895
FT2412	V	-	2.400	1.200	2.880	2.032	770.021
FT2418	V	-	2.400	1.800	4.320	3.048	1155.032
FT3018	V	-	3.000	1.800	5.400	3.810	1443.789
FT3612	V	-	3.600	1.200	4.320	3.048	1155.032
FT3618	V	-	3.600	1.800	6.480	4.572	1732.547
FT4021	V	-	4.000	2.100	8.400	5.927	2245.895
FTBC1010	BC	-	1.000	1.000	1.000	0.706	267.368
FTBC1510	BC	-	1.500	1.000	1.500	1.058	401.053
FTBC1515	BC	-	1.500	1.500	2.250	1.588	601.579
FTBC2010	BC	-	2.000	1.000	2.000	1.411	534.737
FTBC2015	BC	-	2.000	1.500	3.000	2.117	802.105
FTBC2020	BC	-	2.000	2.000	4.000	2.822	1069.474
FTBC2510	BC	-	2.500	1.000	2.500	1.764	668.421
FTBC2515	BC	-	2.500	1.500	3.750	2.646	1002.632
FTBC2520	BC	-	2.500	2.000	5.000	3.528	1336.842
FTBC2525	BC	-	2.500	2.500	6.250	4.410	1671.053

Model	Vault/ Manhole	Diameter [m]	Length [m]	Width [m]	Filter Area [m²]	Design flow rate[1] [L/s]	Catchment Area[2] [m²]
FTBC3010	BC	-	3.000	1.000	3.000	2.117	802.105
FTBC3015	BC	-	3.000	1.500	4.500	3.175	1203.158
FTBC3020	BC	-	3.000	2.000	6.000	4.233	1604.211
FTBC3025	BC	-	3.000	2.500	7.500	5.292	2005.263
FTBC3030	BC	-	3.000	3.000	9.000	6.350	2406.316
FTBC3515	BC	-	3.500	1.500	5.250	3.704	1403.684
FTBC3520	BC	-	3.500	2.000	7.000	4.939	1871.579
FTBC3525	BC	-	3.500	2.500	8.750	6.174	2339.474
FTBC3530	BC	-	3.500	3.000	10.500	7.408	2807.368
FTBC3535	BC	-	3.500	3.500	12.250	8.643	3275.263
FTBC4015	BC	-	4.000	1.500	6.000	4.233	1604.211
FTBC4020	BC	-	4.000	2.000	8.000	5.644	2138.947
FTBC4025	BC	-	4.000	2.500	10.000	7.056	2673.684
FTBC4030	BC	-	4.000	3.000	12.000	8.467	3208.421
FTBC4035	BC	-	4.000	3.500	14.000	9.878	3743.158
FTBC4040	BC	-	4.000	4.000	16.000	11.289	4277.895
FTBC4520	BC	-	4.500	2.000	9.000	6.350	2406.316
FTBC5015	BC	-	5.000	1.500	7.500	5.292	2005.263
FTBC5020	BC	-	5.000	2.000	10.000	7.056	2673.684
FTBC5025	BC	-	5.000	2.500	12.500	8.819	3342.105
FTBC5520	BC	-	5.500	2.000	11.000	7.761	2941.053
FTBC5530	BC	-	5.500	3.000	16.500	11.642	4411.579
FTBC6020	BC	-	6.000	2.000	12.000	8.467	3208.421
FTBC6025	BC	-	6.000	2.500	15.000	10.583	4010.526
FTBC6030	BC	-	6.000	3.000	18.000	12.700	4812.632
FTMH10	MH	1.050	-	-	0.866	0.611	231.515
FTMH12	MH	1.200	-	-	1.131	0.798	302.387
FTMH15	MH	1.500	-	-	1.767	1.247	472.479
FTMH18	MH	1.800	-	-	2.545	1.795	680.370
FTMH21	MH	2.050	-	-	3.301	2.329	882.486
FTMH23	MH	2.300	-	-	4.155	2.931	1110.851
FTMH30	MH	3.050	-	-	7.306	5.155	1953.438

1. The design flow rate is established using Equation 2 with the GULD approved design infiltration rate of 2.5 m/hr. 2. The maximum allowable catchment area (assumed 100% impervious) is determined using Equation 1, with a rational C of 0.95 and Auckland's rainfall intensity of 10 mm/hr.

4.1.2 Design of a shallow Filterra®

The standard Filterra® can be designed as an offline shallow Filterra® with a reduced media. To achieve equivalent pollutant removal based on equivalent contact time, design of a shallower system requires increasing the calculated standard Filterra® surface area by a factor

of 1.4 and reducing the ponding depth to 0.17 m. The upsizing factor of 1.4 was calculated based on providing the same contact time (0.3 hrs) as for a standard Filterra®.

Performance data for a shallow Filterra® was, at the time of the report, not available. Therefore, it is unknown if, given the high media infiltration rate, flow entering a Shallow Filterra® will actually spread over its entire surface area to increase contact time and provide equivalent treatment.

Discussions on equivalent treatment using an increased surface area with a high infiltration rate, led to an additional guidance proposed by Stormwater 360. In order to ensure the whole media bed is utilised for equivalent contact time, a flow control should be installed on shallow units. The flow control is sized as a free discharging orifice limiting the flux rate to 1.8 m/hr. This reduced design flux rate is established by relating Equation 3 for the standard and shallow Filterra® with the upsizing factor of 1.4 and a reduced ponding depth of 0.17 m.

Table 4-3 identifies the Auckland shallow Filterra® configurations with their respective surface area, allowable design flow rates and associated catchment areas. Shallow Filterra® systems equate to 0.52 percent of the catchment area, using shallow Filterra® unit layer dimensions of 0.41m media depth and 0.17 m ponding depth.

Any deviation from the specified media characteristics would require a review of the design flow rates.

Table 4-3 Design flow capacities for shallow Auckland Filterra® configurations

Model	Vault/ Manhole	Diameter [m]	Length [m]	Width [m]	Filter Area [m²]	Design flow rate[1] [L/s]	Catchment Area[2] [m²]
FT1212	V	-	1.200	1.200	1.440	0.726	275.090
FT1218	V	-	1.800	1.200	2.160	1.089	412.635
FT1224	V	-	2.400	1.200	2.880	1.452	550.180
FT1236	V	-	3.600	1.200	4.320	2.178	825.269
FT1812	V	-	1.800	1.200	2.160	1.089	412.635
FT1818	V	-	1.800	1.800	3.240	1.633	618.952
FT1824	V	-	2.400	1.800	4.320	2.178	825.269
FT1830	V	-	3.000	1.800	5.400	2.722	1031.587
FT1836	V	-	3.600	1.800	6.480	3.267	1237.904
FT2140	V	-	4.000	2.100	8.400	4.235	1604.691
FT2412	V	-	2.400	1.200	2.880	1.452	550.180
FT2418	V	-	2.400	1.800	4.320	2.178	825.269
FT3018	V	-	3.000	1.800	5.400	2.722	1031.587
FT3612	V	-	3.600	1.200	4.320	2.178	825.269
FT3618	V	-	3.600	1.800	6.480	3.267	1237.904

Model	Vault/ Manhole	Diameter [m]	Length [m]	Width [m]	Filter Area [m²]	Design flow rate[1] [L/s]	Catchment Area[2] [m²]
FT4021	V	-	4.000	2.100	8.400	4.235	1604.691
FTBC1010	BC	-	1.000	1.000	1.000	0.504	191.035
FTBC1510	BC	-	1.500	1.000	1.500	0.756	286.552
FTBC1515	BC	-	1.500	1.500	2.250	1.134	429.828
FTBC2010	BC	-	2.000	1.000	2.000	1.008	382.069
FTBC2015	BC	-	2.000	1.500	3.000	1.512	573.104
FTBC2020	BC	-	2.000	2.000	4.000	2.016	764.138
FTBC2510	BC	-	2.500	1.000	2.500	1.260	477.587
FTBC2515	BC	-	2.500	1.500	3.750	1.890	716.380
FTBC2520	BC	-	2.500	2.000	5.000	2.521	955.173
FTBC2525	BC	-	2.500	2.500	6.250	3.151	1193.966
FTBC3010	BC	-	3.000	1.000	3.000	1.512	573.104
FTBC3015	BC	-	3.000	1.500	4.500	2.269	859.656
FTBC3020	BC	-	3.000	2.000	6.000	3.025	1146.208
FTBC3025	BC	-	3.000	2.500	7.500	3.781	1432.760
FTBC3030	BC	-	3.000	3.000	9.000	4.537	1719.311
FTBC3515	BC	-	3.500	1.500	5.250	2.647	1002.932
FTBC3520	BC	-	3.500	2.000	7.000	3.529	1337.242
FTBC3525	BC	-	3.500	2.500	8.750	4.411	1671.553
FTBC3530	BC	-	3.500	3.000	10.500	5.293	2005.863
FTBC3535	BC	-	3.500	3.500	12.250	6.175	2340.174
FTBC4015	BC	-	4.000	1.500	6.000	3.025	1146.208
FTBC4020	BC	-	4.000	2.000	8.000	4.033	1528.277
FTBC4025	BC	-	4.000	2.500	10.000	5.041	1910.346
FTBC4030	BC	-	4.000	3.000	12.000	6.049	2292.415
FTBC4035	BC	-	4.000	3.500	14.000	7.058	2674.484
FTBC4040	BC	-	4.000	4.000	16.000	8.066	3056.554
FTBC4520	BC	-	4.500	2.000	9.000	4.537	1719.311
FTBC5015	BC	-	5.000	1.500	7.500	3.781	1432.760
FTBC5020	BC	-	5.000	2.000	10.000	5.041	1910.346
FTBC5025	BC	-	5.000	2.500	12.500	6.301	2387.933
FTBC5520	BC	-	5.500	2.000	11.000	5.545	2101.381
FTBC5530	BC	-	5.500	3.000	16.500	8.318	3152.071
FTBC6020	BC	-	6.000	2.000	12.000	6.049	2292.415
FTBC6025	BC	-	6.000	2.500	15.000	7.562	2865.519
FTBC6030	BC	-	6.000	3.000	18.000	9.074	3438.623
FTMH10	MH	1.050	-	-	0.866	0.437	165.417
FTMH12	MH	1.200	-	-	1.131	0.570	216.055
FTMH15	MH	1.500	-	-	1.767	0.891	337.586
FTMH18	MH	1.800	-	-	2.545	1.283	486.124
FTMH21	MH	2.050	-	-	3.301	1.664	630.536
FTMH23	MH	2.300	-	-	4.155	2.094	793.702

Model	Vault/ Manhole	Diameter [m]	Length [m]	Width [m]	Filter Area [m²]	Design flow rate[1] [L/s]	Catchment Area[2] [m²]
FTMH30	MH	3.050	-	-	7.306	3.683	1395.731
1. The design flow rate is established based on Equation 2 using the Stormwater 360 proposed design flux rate of 1.8 m/hr established using an equivalent contact time and hydraulic gradient to the standard Filterra® in a shallower media. 2. The maximum allowable catchment area (assumed 100% impervious) is determined using Equation 1, the established design flow rate, a rational C of 0.95 and Auckland's rainfall intensity of 10 mm/hr.							

4.1.3 Design of an online Filterra®

Online Filterra® configurations include:

- Filterra® Internal Bypass-Pipe (FTIB-P) – an online configuration, where flows may be piped from area drains, grated inlets, trench drains, and/or roof drains. Stormwater enters through an internal slotted pipe that drops through to a series of splash plates that disperse the flows over the top surface of the Filterra® mulch layer. Higher flows are able to bypass the slotted pipe and pass out of the structure.
- Filterra® Internal Bypass-Curb (FTIB-C) – For online use in a sump condition to receive flows from both directions along a gutter line. The kerb inlet, bio filtration treatment chamber and internal high-flow bypass are contained within a single structure. An internal flume tray weir directs flows through the kerb inlet to the treatment chamber. Flows greater than the design flow rise above the weir and discharge through a standpipe orifice.

Online Filterra® configurations (FTIB-P and FTIB-C) have GULD approval and are accepted as part of this interim approval on the basis that:

- the surface area is sized like a standard offline Filterra,
- their functioning and performance is not affected by the internal bypass, and
- the internal bypass needs to meet the requirements of the Building Act and Auckland Council Code of Practice/Stormwater.

4.1.4 Design of Filterra® Bioscape™

The Filterra® Bioscape™ (formerly named Filterra® Boxless) is a GULD approved Filterra® configuration. It allows some infiltration to native soils; however within the Auckland region no retention (volume credit) is approved. SMAF requirements must be met using other approved retention devices. In such a case, for online configurations, the bypass and undertrain should connect to downstream detention, which must meet SMAF requirements.

The Filterra® Bioscape™ can be designed without an underdrain; in such cases a detention reservoir is required to prevent treatment media becoming saturated. Water shall not saturate the treatment media at any time.

The Filterra® Bioscape™ surface area is sized like a standard offline Filterra.

The distance from the point of entry of water to the most distant point on the surface of the Filterra® Bioscape™ treatment media, shall be less or equal to 3.7m.

4.1.5 Plant selection

For the design of a Filterra®, manufacturer specified plants should be chosen.

The high hydraulic conductivity of filter media may limit the plant pallet for use in the Filterra®. Stormwater360 has undertaken trials regarding suitable NZ plants. It is recommended that all installations require a plant selection approved by the manufacturer.

5.0 Device Installation

Filterra® installed prior to site stabilisation, must have adequate and complete site/inlet protection. A Filterra® can be activated for full operation once the site is fully stabilised and any accumulated sediment has been removed from the Filterra® structure and upstream diversion structure.

Installation should follow Stormwater 360's vault, manhole or box culvert installation guidelines. The contractor is responsible for the correct installation of Filterra® units as shown in approved plans. A comprehensive installation manual is available from Stormwater 360. Each unit must be constructed at the locations and elevations according to the sizes identified on approved drawings, with any modification to these needing to be directed and approved by the Engineer.

Important notes regarding the installation of the Filterra® structure are described in the following sections.

5.1 Pretreatment

Pretreatment is not typically used for Filterra®, as they are designed to function without pre-treatment.

5.2 Soil and groundwater characteristics

The Filterra® is a self-contained, water-tight system so it requires no specific soil characteristics in order to function optimally. Its fully-enclosed construction also means the system has no depth-to-groundwater limitations.

The system is delivered to the site filled with filter media so has no flotation potential, regardless of local groundwater conditions.

The Filterra® unit must be placed on a compacted sub-grade with a minimum 150 mm gravel base matching the final grade of the curb line in the area of the unit. Unit placement must be such that the unit and top slap match the grade of the curb in the area of the unit.

Manufacturer's guidance is required for installations on grades greater than 5 percent.

5.3 Hydraulic requirements

Filterra® is a surface treatment that requires no head to achieve the treatment flow rate. The elevation difference between the influent entry and the invert is 0.94 m. The system allows 0.23 m of freeboard for head accumulation; provided by the distance between the bottom of the top slab and the surface of the Filterra® filter media.

Positive drainage of each effluent treatment pipe is required to prevent free standing water from accumulating in the system or underdrain; e.g. due to improper connection of the effluent pipe to a bypass structure or another outfall.

5.4 Inlet

Offline standard and shallow Filterra® unit installation should ensure cross linear surface inflow rather than installation in a head-on configuration. Contractors must provide curb and gutter and appropriate transition to the Filterra® unit for proper stormwater flow into the system through the throat opening.

5.5 Device footprint

A variety of precast standard footprint sizes exist for use depending on site constraints, rainfall characteristics, and the maximum contributing drainage area. The appropriate footprint is to be designed as outlined in Section 4.1. A standard Filterra® footprint is typically sized to be 0.37 percent of its respective catchment area.

5.6 Shallow Installations

The Filterra® system can be designed and installed in an offline shallow configuration in situations where limited depth availability prevents installation of the standard depth system. The reduced depth, up to 150 mm less than the standard system, requires a corresponding increase in filter media surface area to ensure equivalent contact time to that of the standard depth system. The surface area of a shallow system is increased by a factor of 1.4, translating to 0.52 % of their catchment area.

In order to ensure the whole media bed is utilised for equivalent contact time, a flow control should be installed for shallow units. The flow control is sized as a free discharging orifice limiting the design flux rate to 1.8 m/hr. This reduced flux rate is established by relating Equation 3 for the standard and shallow Filterra® with the factor of increase of 1.4 and a reduced ponding depth of 0.17m.

5.7 Structural loading

A standard and shallow Filterra® is housed in a concrete container that is designed to withstand a non-live water load. The floor and walls are made from 100-150 mm thick reinforced concrete and the top slab is made from 200 mm thick concrete. The tree grate within the top slab is designed to withstand pedestrian loading. A bioscape Filterra® will require consideration of structural loading if present.

5.8 Overflow, diversion, or bypass

The standard and shallow Filterra® units operate in an offline configuration. When their hydraulic capacity is exceeded, flow bypasses the system and enters a standard catch pit or other detention or infiltration device down-gradient. This serves to bypass flow in excess of the design flow such that it does not enter the Filterra® system's treatment chamber.

It is important to align and seal outlet connections to meet the configuration shown in the approved drawings with modifications necessary to meet site conditions and local regulations.

For the two online configurations, FTIB-P and FTIB-C, flows greater than the design flow bypass the systems internally. In the FTIB-P online configuration, excess flows bypass the slotted pipe and are conveyed out of the system. In the FTIB-C online configuration, excess flows bypass the system by rising above the internal flume tray weir and discharging through a standpipe orifice.

5.9 Sump condition

The standard Filterra® must not be placed in a sump condition. The standard and shallow Filterra® cannot be used as a standalone unit inlet; it needs effective bypass during higher intensity rainfall events. The proposed location can be tested by imagining a complete blockage of the Filterra® throat. If this would result in ponding or pooling of drainage, the placement is inappropriate. If stormwater continues to flow past the blocked Filterra® throat to the bypass inlet without ponding, the placement is appropriate.

The online FTIB-C variant can be placed in a sump condition.

5.10 Planting selection and installation

Vegetation selected to grow in the Filterra® filter media should be appropriate for local conditions to prevent die back without requirement for excessive watering given the filter media's high infiltration rate.

Manufacturer specified plants and their respective irrigation requirements should be chosen for NZ Filterra® systems. Ongoing research by Stormwater360 Ltd (Cheah et al 2016) demonstrated that plants grew well if watered twice a week in the first 6 weeks. The volume of water used for watering was calculated to be equal to that passing through a 1.8m x 1.8m treatment unit with a 1011 m^2 impervious catchment during a 2.5 mm rainfall event.

Inspection of vegetation is required every 6 months. This requirement may be amended in the future if further proof of plant survival is supplied

Supplementary irrigation may be required to preserve plant life in accordance with the Filterra® maintenance specifications.

To maximise benefit to the surrounding environment, plant selection should also consider the integration of the system with other design disciplines; urban design, transport, etc.

5.11 Construction discharge and commissioning

Installation of a Filterra® requires excavation and is often installed as part of a wider construction process requiring soil disturbance. The contractor is responsible to provide adequate and complete site/inlet protection for Filterra® systems installed prior to final site stabilisation. The protective boards or tree grates should not be removed from the top slab during installation.

Once the unit is set, the wooden internal bracing and protective silt fabric cover must be left intact. Seal the top lid onto the box section before backfilling, using a non-shrink grout, butyl rubber or similar waterproof seal, and place boards on top of the lid. The protective throat boards should not be removed.

Backfill carefully, bringing the appropriate fill material up in 150mm lifts on all sides. Set precast sections in a manner resulting in a watertight joint.

A Filterra® can be activated for full operation once the site is fully stabilised (full landscaping, grass cover, final paving and street sweeping completed) and any accumulated sediment has been removed from the Filterra® structure and upstream diversion structure. Full operation is defined as the unit installed, curb and gutter and transitions in place and activation by the Supplier when mulch and plant are added and temporary throat protection removed.

If the Filterra® is placed online (activated) before the site is stabilised, the ingress of mobilised sediment may clog the filter media. If construction sediment is allowed to enter the system, more frequent maintenance of the system will likely be required.

6.0 Inspection & Maintenance

Regular inspection and maintenance is required to promote long-term flows and ensure that the Filterra® continues to operate at design efficiency. Maintenance is simple, inexpensive and safe, and does not require confined space access or specialised equipment. The major limit to Filterra® system's longevity is sediment build-up on the surface of the filter media which may reduce the infiltration rate, plant health, and compromise system performance. A Filterra® recycles and accumulates pollutants within the biomass, but is also subjected to other materials entering the throat; e.g. trash, silt and leaves etc. which will be contained within the void below the top grate and above the mulch layer. Too much silt may inhibit the Filterra® system's flow rate, which is the reason for site stabilization before activation. Regular replacement of the mulch stops accumulation of such sediment.

The maintenance plan commences when the system is activated for full operation. Full operation is defined as the unit installed, kerb and gutter and transitions in place and activation (by Supplier) when mulch and plant are added and temporary throat protection removed.

Activation cannot be carried out until the site is fully stabilised (full landscaping, grass cover, final paving and street sweeping completed).

- Inspection refers to regular checking of the system to ensure that it is operating as designed and to determine the site specific maintenance schedules and requirements.
- Maintenance is focused on pollutant removal from the filter surface and replacing the mulch layer. Removal of accumulated sediment and replacement of mulch reduces the potential for migration of pollutants into the media bed and removes dissolved constituents that have adsorbed to accumulated sediment and mulch.
- As the Filterra® contains many living organisms, regular maintenance will extend the device's functional life span. Infiltration rates have been shown to increase over time as the physical and biological components of the system mature. Plant root growth creates macropores in the filter media to counteract clogging mechanisms. Increased plant growth also increases the surface area available for phytoremediation, and root expansion increases the surface area available for increased pollutant adsorption.
- Vegetation and mulch at the surface help promote localised settling and inhibit resuspension of settled pollutants. The mulch has been shown to play an important role in capturing relatively small particles without limiting the hydraulic capacity of the system.

Owners/operators must inspect Filterra® systems for a minimum of twelve months from the start of post-construction operation to determine site-specific maintenance schedules and requirements. Owners/operators must conduct inspections at least every six months.

Inspections must be conducted by qualified personnel, follow manufacturer's guidelines, and use methods capable of determining either a decrease in treated effluent flow rate and/or a decrease in pollutant removal ability.

Comprehensive manufacturer maintenance guidance for the Filterra® can be found in the Stormwater360 "Filterra® Bio retention Systems Operation & Maintenance (OM) Manual v01".

The minimum inspection and maintenance procedures, approved in the Washington GULD certifications for the standard and shallow Filterra® units, are summarised in Table 6-1. These also include guidance provided within the Stormwater360 Filterra® OM manual v.01. Refer to Appendix B for GULD specified inspection and maintenance conditions of use.

The maintenance interval depends on the degree of pollutant loading within a particular catchment. It may be necessary to adjust the inspection and maintenance schedule depending on the actual operating conditions encountered by the system. Sites with higher than expected sediment loads may require more frequent inspection and maintenance. Industrial areas with heavy petroleum loading may also require a higher frequency of maintenance so that the flow rate of the mulch layer that protects the filtration media is maintained.

Table 6-1 Standard and shallow Filterra® inspection and maintenance details

Item	Detail
Inspection	• Inspect at least twice a year and after every major storm of greater than 25 mm rainfall depth. • Inspection should note the presence of standing water, damage to the box structure, and damage to the tree grate, assess plant health and any blockage of the bypass. • Inspect vegetation at least every 6 month once established, or more frequently where specified by Supplier • The supplier should be promptly notified of any damage to the plant(s). Landscapers and maintenance contractors should be aware to leave all maintenance to the Supplier (i.e. no pruning or fertilising).

Item	Detail

Maintenance	• Target maintenance interval of six months but dependent on site specific pollutant load. Additional maintenance may be necessary depending on sediment and trash loading.
	• The amount of maintenance visits further depends on the amount of annual rainfall. Findings showed that regions with:
	  o <75 mm of annual rainfall typically require one annual visit,
	  o 75-130mm of annual rainfall typically require two annual visits
	• Seasonal maintenance. Spring maintenance is targeted to clean up following winter loads, while fall visits help the system by removing excessive leaf litter.
	• In industrial areas with heavy petroleum loading, frequency of maintenance may need to increase to maintain the flow rate of the mulch layer that protects the filtration media
	• Remove accumulated sediment, rubbish, debris and degraded mulch from the filter surface
	• Remove erosion control stones prior to maintenance and appropriately replace them afterwards
	• Following mulch and debris removal, recharge Filterra® media (not top soil or other) if the distance between bottom of top slab and surface of filter media is greater than 0.30 m for a standard Filterra® and 0.25m for a shallow Filterra®. Recharge until this distance measures 0.3m for a standard Filterra® and 0.25m for a shallow Filterra®; i.e.0.23m/0.17m ponding (standard/shallow) topped with 75mm of mulch.
	• Replace mulch layer at a thickness of 75 mm at least every 6 months. Spread evenly across the entire unit to inhibit silt accumulation on the filter media surface.
	• Evaluate plant health, and prune the plant to promote appropriate growth or replace the plant if necessary
	• Clean area around unit and remove all refuse to be disposed of appropriately
	• Irrigate the system during dry periods to ensure survival of living elements

Access for cleaning	• Maintenance access to the device is by opening the tree grate • Only typical landscaping tools are required, including a rake, shovel and pruning tools • Appropriate Personal Protective Equipment (PPE) should be used in accordance with local or company procedures.

The maximum treatment life of the Filterra® is conservatively estimated to be 20 years, based on the expected life span of the plant, but the system is expected to function indefinitely as long as routine maintenance is performed. The concrete components of certain Filterra® systems are expected to last in excess of 50 years.

7.0 Summary & Conclusions

This report summarises a review of the information provided to MEL by the agent for the Filterra® Filter system in New Zealand, Stormwater360 Ltd.

The evaluations are split into two parts, this report (Part 1) summarises a review of the information provided to MEL by Stormwater360 Ltd regarding the Filterra® System (Filterra®) and evaluates the performance against the Air, Land and Water Plan (ALWP). Part 2, to be completed at a later date, evaluates the performance of the Filterra® against the Proposed Auckland Unitary Plan (PAUP).

Washington GULD certified offline standard and shallow configurations were amended and provided by Stormwater 360 based on standard vault, manhole and box culvert configurations for Auckland use on private sites. An Auckland Design Guidance document for the Filterra® Rapid Bio filtration System was also provided Stormwater 360. These local configurations have been compared against the Washington GULD certification and confirmed as acceptable in meeting the ALWP requirements for 75% sediment removal, as per the detail contained in Section 4.0. The GULD approved online Filterra® and Filterra® Bioscape™ are considered functionally equivalent, and therefore are also regarded as acceptable in meeting the ALWP requirements for 75% sediment removal.

As a result of this review, we conclude that the following Filterra® configurations can provide basic treatment as defined by Washington GULD certification:

- standard offline Filterra® designed with an infiltration rate of 2.5 m/hr,
- standard online Filterra® on the basis that
    - the surface area is sized like a standard offline Filterra,
    - their functioning and performance is not affected by the internal bypass, and
    - the internal bypass needs to meet the requirements of the Building Act and Auckland Council Code of Practice/Stormwater.
- shallow Filterra® designed on the basis of a flux rate of 1.8 m/hr by controlling the outflow for equivalent contact time and a surface area upsizing factor of 1.4 for equivalent media volume to the standard Filterra® for a shallower media depth.
- Filterra® Bioscape™ with its surface area sized like a standard offline Filterra and a hydraulic gradient of 1.41 m/m.

Therefore the listed Filterra® configurations can be granted interim approval from the date of issue for use on private sites. This approval does not extend to use on public sites for devices to be vested to Auckland Council. To extend for use on public sites vested to Auckland Council, the device will need to be certified under Auckland Council's new products approval process. Other public organisations (e.g. AT and NZTA) may have their own separate product approval process.

Interim recognition is provided until further notice. Auckland Council may amend or revoke approval at any time, with reasonable notice.

It should be noted that because of the high hydraulic conductivity of the filter media, the Filterra® has a smaller footprint than bioretention designed according to TP10 /GD01. As such, volume reduction and flow attenuation will be less than conventional bioretention. Ecosystem goods and services, such as provision of habitat, may also be less than is provided by larger footprint biofilters. The high infiltration rate is achieved through the use of a specifically engineered filter media and replaceable mulch. The media and mulch has different physical and chemical properties to a conventional raingarden. It is essential that the manufacturer's recommendations on operation are carried out to ensure the long term successful operation of the device

Appendix C provides a Practice Note regarding installation of the Filterra® and

Appendix D provides the conditions for PDE approval.

8.0 References

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Auckland Council (2013). Auckland Unitary Plan stormwater management provisions: Technical basis of contaminant and volume management requirements. Prepared by Auckland Council. Auckland Council technical report, TR2013/035.

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Stormwater360 (unpublished) Operation & Maintenance (OM) Manual v01

Stormwater360 (unpublished) Auckland Design Guidance Document Stormwater360 Filterra Rapid Biofiltration System

Washington State Department of Ecology. (2015). General Use Level Designation for Basic (TSS), Enhanced, Phosphorus & Oil Treatment. Conditional Use Level Designation for Basic and Enhanced at 100 in/h.

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Appendix A Filterra® system Detail

Filterra® system Physical Description

Treatment Mechanisms

Treatment mechanisms for the Filterra® Bioretention system configurations include:

- Sedimentation/settling
- Infiltrations into native soils for Filterra® Bioscape configuration and other Filterra® Boxed systems including weep holes and/or slots to promote infiltration into native soils
- Filtration by Filterra® proprietary bioretention media
- Adsorption/cation exchange by hydrophilic and hydrophobic adsorbents
- Chelation/precipitation
- Biological uptake including nutrient assimilation, biodegradation, bioremediation, phytoremediation
- Absorption by high percentage of organic material in the filter media which is replenished by mulch and rhizosphere degradation
- Evapotranspiration
- Bacterial Inactivation Processes
- Soil Processes and microbial mediated transformations, including volatilisation of petroleum products

For further information regarding the Filterra® treatment processes, please read the Filterra® Bioretention Systems: Technical Basis for High Flow Rate Treatment and Evaluation of Stormwater Quality Performance White Paper available at:

http://www.filterra.com/images/uploads/2010-09-20_Filterra_High_Flow_Rate_Treatment_Whitepaper.pdf

Appendix B Certifications

New Jersey

State of New Jersey

CHRIS CHRISTIE
Governor

KIM GUADAGNO
Lt. Governor

DEPARTMENT OF ENVIRONMENTAL PROTECTION
Bureau of Nonpoint Pollution Control
Division of Water Quality
Mail Code 401-02B
Post Office Box 420
Trenton, New Jersey 08625-0420
609-633-7021 Fax: 609-777-0432
http://www.state.nj.us/dep/dwq/bnpc_home.htm

BOB MARTIN
Commissioner

May 27, 2014

Chris French
Filterra® Bioretention Systems,
A Division of Americast, Inc.
11352 Virginia Precast Road
Ashland, Virginia 23005

Re: MTD Lab Certification for the
Filterra Bioretention System
by Americast, Inc.

TSS Removal Rate: 80%

Dear Mr. French:

The Stormwater Management rules under N.J.A.C. 7:8-5.5(b) and 5.7(c) allow the use of manufactured treatment devices (MTDs) for compliance with the design and performance standards at N.J.A.C. 7:8-5 if the pollutant removal rates have been verified by the New Jersey Corporation for Advanced Technology (NJCAT) and have been certified by the New Jersey Department of Environmental Protection (NJDEP). Filterra® Bioretention Systems has requested a Laboratory Certification for the Filterra Bioretention System.

This project falls under the "Procedure for Obtaining Verification of a Stormwater Manufactured Treatment Device from New Jersey Corporation for Advanced Technology" dated January 25, 2013. The applicable protocol is the "New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Filtration Manufactured Treatment Device" dated January 25, 2013.

NJCAT verification documents submitted to the NJDEP indicate that the requirements of the aforementioned protocol have been met or exceeded. The NJCAT letter also included a recommended certification TSS removal rate and the required maintenance plan. The NJCAT Verification Report with the Verification Appendix for this device is published online at http://www.njcat.org/verification-process/technology-verification-database.html.

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The NJDEP certifies the use of the Filterra Bioretention System by Filterra Bioretention Systems, A Division of Americast, Inc. at a TSS removal rate of 80%, when designed, operated and maintained in accordance with the information provided in the Verification Appendix.

Be advised a detailed maintenance plan is mandatory for any project with a Stormwater BMP subject to the Stormwater Management Rules, N.J.A.C. 7:8. The plan must include all of the items identified in Stormwater Management Rules, N.J.A.C. 7:8-5.8. Such items include, but are not limited to, the list of inspection and maintenance equipment and tools, specific corrective and preventative maintenance tasks, indication of problems in the system, and training of maintenance personnel. Additional information can be found in Chapter 8: Maintenance of the New Jersey Stormwater Best Management Manual.

If you have any questions regarding the above information, please contact Ms. Lisa Schaefer of my office at (609) 633-7021.

Sincerely,

James J. Murphy, Chief
Bureau of Nonpoint Pollution Control

C: Chron File
Richard Magee, NJCAT
Madhu Guru, DLUR
Elizabeth Dragon, BNPC
Lisa Schaefer, BNPC

Washington

June 2015

GENERAL USE LEVEL DESIGNATION FOR BASIC (TSS), ENHANCED, PHOSPHORUS & OIL TREATMENT
CONDITIONAL USE LEVEL DESIGNATION FOR BASIC AND ENHANCED AT 100 IN/HR

For

Americast Filterra®

Ecology's Decision:

Based on Americast's submissions, including the application dated May 15, 2015, Final Technical Evaluation Reports, dated March 27, 2014, December 2009 and additional information provided to Ecology dated October 9, 2009, Ecology hereby issues the following use level designations:

1. A General Use Level Designation for Basic, Enhanced, Phosphorus, and Oil Treatment at the following water quality design hydraulic loading rates:

Treatment	Hydraulic Conductivity* (in/hr) for use in Western Washington Sizing	Infiltration Rate (in/hr) for use in eastern Washington Sizing
Basic	70.92	100
Phosphorus	70.92	100
Oil	35.46	50
Enhanced	24.82	35

*calculated based on listed infiltration rate and a hydraulic gradient of 1.41 inch/inch.

2. A Conditional Use Level Designation for Basic and Enhanced Treatment at the following water quality design hydraulic loading rates:

Treatment	Hydraulic conductivity* (in/hr) for use in Western Washington Sizing	Infiltration Rate (in/hr) for use in Eastern Washington Sizing
Basic	70.92	100
Enhanced	70.92	100

3. The Filterra® unit is not appropriate for oil spill-control purposes.
4. Ecology approves the Filterra® units for treatment at the hydraulic loading rates listed above, to achieve the maximum water quality design flow rate. Calculate the water quality design flow rates using the following procedures:

1

- Western Washington: for treatment installed upstream of detention or retention, the water quality design flow rate is the peak 15-minute flow rate as calculated using the sand filter module in the latest version of the Western Washington Hydrology Model or other Ecology-approved continuous runoff model. The model must indicate the unit is capable of processing 91 percent of the influent runoff file.
- Eastern Washington: For treatment installed upstream of detention or retention, the water quality design flow rate is the peak 15-minute flow rate as calculated using one of the three flow rate based methods described in Chapter 2.2.5 of the Stormwater Management Manual for Eastern Washington (SWMMEW) or local manual.
- Entire State: For treatment installed downstream of detention, the water quality design flow rate is the full 2-year release rate of the detention facility.

5. This General Use Level Designation has no expiration date but Ecology may revoke or amend the designation, and is subject to the conditions specified below.
6. The Basic and Enhanced CULD expires on June 30, 2018 unless extended by Ecology.

Ecology's Conditions of Use:

Filterra® units shall comply with these conditions shall comply with the following conditions:

1. Design, assemble, install, operate, and maintain the Filterra® units in accordance with applicable Americast Filterra® manuals, document, and the Ecology Decision.
2. Each site plan must undergo Americast Filterra® review before Ecology can approve the unit for site installation. This will ensure that site grading and slope are appropriate for use of a Filterra® unit.
3. Filterra® media shall conform to the specifications submitted to and approved by Ecology.
4. Maintenance includes removing trash, degraded mulch, and accumulated debris from the filter surface and replacing the mulch layer. Use inspections to determine the site-specific maintenance schedules and requirements. Follow maintenance procedures given in the most recent version of the Filterra® Operation and Maintenance Manual.
5. Maintenance: The required maintenance interval for stormwater treatment devices is often dependent upon the degree of pollutant loading from a particular drainage basin. Therefore, Ecology does not endorse or recommend a "one size fits all" maintenance cycle for a particular model/size of manufactured filter treatment device.
   - Filterra designs their systems for a target maintenance interval of 6 months. Maintenance includes removing accumulated sediment and trash from the surface area of the media, removing the mulch above the media, replacing the mulch, providing plant health evaluation, and pruning the plant if deemed necessary.
   - Conduct maintenance following manufacturer's guidelines.
6. Filterra® units come in standard sizes.

7. The minimum size filter surface-area for use in western Washington is determined by using the sand filter module in the latest version of WWHM or other Ecology approved continuous runoff model for western Washington. Model inputs include
    a) Filter media depth: 1.8 feet
    b) Effective Ponding Depth: 0.75 feet (This is equivalent to the 6-inch clear zone between the top of the mulch and the bottom of the slab plus 3-inches of mulch.)
    c) Side slopes: Vertical
    d) Riser height: 0.70 feet
    e) Filter Hydraulic Conductivity: Use the Hydraulic Conductivity as listed in the table above (use the lowest applicable hydraulic conductivity depending on the level of treatment required) under Ecology's Decision, above.

8. The minimum size filter surface-area for use in eastern Washington is determined by using the design water quality flow rate (as determined in item 3, above) and the Infiltration Rate from the table above (use the lowest applicable Infiltration Rate depending on the level of treatment required). Calculate the required area by dividing the water quality design flow rate (cu-ft/sec) by the Infiltration Rate (converted to ft/sec) to obtain required surface area (sq ft) of the Filterra unit.
9. Discharges from the Filterra® units shall not cause or contribute to water quality standards violations in receiving waters.
10. Contech commits to submitting a QAPP for Ecology approval by October 1, 2015 that meets the TAPE requirements for attaining a GULD for Basic and Enhanced Treatment
11. Contech shall complete all required testing and submit a TER on TSS and dissolved metals removal for Ecology's review by December 31, 2017
12. Contech may request Ecology to grant deadline or expiration date extensions, upon showing cause for such extensions.

Approved Alternate Configurations

Filterra® Internal Bypass - Pipe (FTIB-P)

1. The Filterra® Internal Bypass – Pipe allows for piped-in flow from area drains, grated inlets, trench drains, and/or roof drains. Design capture flows and peak flows enter the structure through an internal slotted pipe. Filterra® inverted the slotted pipe to allow design flows to drop through to a series of splash plates that then disperse the design flows over the top surface of the Filterra® planter area. Higher flows continue to bypass the slotted pipe and convey out the structure.
2. To select a FTIB-P unit, the designer must determine the size of the standard unit using the sizing guidance described above.

Filterra® Internal Bypass – Curb (FTIB-C)

1. The Filterra® Internal Bypass –Curb model (FTIB-C) incorporates a curb inlet, biofiltration treatment chamber, and internal high flow bypass in one single structure. Filterra® designed the FTIB-C model for use in a "Sag" or "Sump" condition and will accept flows from both directions along a gutter line. An internal flume tray weir component directs treatment flows entering the unit through the curb inlet to the biofiltration treatment chamber. Flows in excess of the water quality treatment flow rise above the flume tray weir and discharge through a standpipe orifice; providing bypass of untreated peak flows. Americast manufactures the FTIB-C model in a variety of sizes and configurations and you may use the unit on a continuous grade when a single structure providing both treatment and high flow bypass is preferred. The FTIB-C model can also incorporate a separate junction box chamber to allow larger diameter discharge pipe connections to the structure.
2. To select a FTIB-C unit, the designer must determine the size of the standard unit using the sizing guidance described above.

Filterra® Shallow

1. The Filterra® Shallow provides additional flexibility for design engineers and designers in situations where there is limited depth and various elevation constraints to applying a standard Filterra® configuration. Engineers can design this system up to six inches shallower than any of the previous Filterra unit configurations noted above.
2. Ecology requires that the Filterra® Shallow provide a contact time equivalent to that of the standard unit. This means that with a smaller depth of media, the surface area must increase.
3. To select a Filterra® Shallow System unit, the designer must first identify the size of the standard unit using the modeling guidance described above.
4. Once you establish the size of the standard Filterra® unit using the sizing technique described above, use information from the following table to select the appropriate size Filterra® Shallow System unit.

Shallow Unit Basic, Enhanced, and Oil Treatment Sizing

Standard Depth	Equivalent Shallow Depth
4x4	4x6 or 6x4
4x6 or 6x4	6x6
4x8 or 8x4	6x8 or 8x6
6x6	6x10 or 10x6
6x8 or 8x6	6x12 or 12x6
6x10 or 10x6	13x7

Notes:

1. Shallow Depth Boxes are less than the standard depth of 3.5 feet but no less than 3.0 feet deep (TC to INV).

4

Applicant:	Filterra® Bioretention Systems, division of Contech Engineered Solutions, LLC.
Applicant's Address:	11815 NE Glenn Widing Drive Portland, OR 97220

Application Documents:

- State of Washington Department of Ecology Application for Conditional Use Designation, Americast (September 2006)
- Quality Assurance Project Plan Filterra® Bioretention Filtration System Performance Monitoring, Americast (April 2008)
- Quality Assurance Project Plan Addendum Filterra® Bioretention Filtration System Performance Monitoring, Americast (June 2008)
- Draft Technical Evaluation Report Filterra® Bioretention Filtration System Performance Monitoring, Americast (August 2009)
- Final Technical Evaluation Report Filterra® Bioretention Filtration System Performance Monitoring, Americast (December 2009)
- Technical Evaluation Report Appendices Filterra® Bioretention Filtration System Performance Monitoring, Americast, August 2009
- Memorandum to Department of Ecology Dated October 9, 2009 from Americast, Inc. and Herrera Environmental Consultants
- Quality Assurance Project Plan Filterra® Bioretention System Phosphorus treatment and Supplemental Basic and Enhanced Treatment Performance Monitoring, Americast (November 2011)
- Filterra® letter August 24, 2012 regarding sizing for the Filterra® Shallow System.
- University of Virginia Engineering Department Memo by Joanna Crowe Curran, Ph. D dated March 16, 2013 concerning capacity analysis of Filterra® internal weir inlet tray.
- Terraphase Engineering letter to Jodi Mills, P.E. dated April 2, 2013 regarding Terraflume Hydraulic Test, Filterra® Bioretention System and attachments.
- Technical Evaluation Report, Filterra® System Phosphorus Treatment and Supplemental Basic Treatment Performance Monitoring. March 27th, 2014.
- State of Washington Department of Ecology Application for Conditional Use Level Designation, Contech Engineered Solutions (May 2015)
- Quality Assurance Project Plan Filterra® Bioretention System, Contech Engineered Solutions (May 2015)

Applicant's Use Level Request:

General Level Use Designation for Basic (100 in/hr), Enhanced (35 in/hr), Phosphorus (100 in/hr), and Oil Treatment (50 in/hr).

Conditional Use Level Designation for Basic and Enhanced at 100 in/hr

Applicant's Performance Claims:

Field-testing and laboratory testing show that the Filterra® unit is promising as a stormwater treatment best management practice and can meet Ecology's performance goals for basic, enhanced, phosphorus, and oil treatment.

Findings of Fact:

Field Testing 2013

1. Filterra® completed field-testing of a 6.5 ft x 4 ft. unit at one site in Bellingham, Washington. Continuous flow and rainfall data collected from January 1, 2013 through July 23, 2013 indicated that 59 storm events occurred. The monitoring obtained water quality data from 22 storm events. Not all the sampled storms produced information that met TAPE criteria for storm and/or water quality data.
2. The system treated 98.9 percent of the total 8-month runoff volume during the testing period. Consequently, the system achieved the goal of treating 91 percent of the volume from the site. Stormwater runoff bypassed during four of the 59 storm events.
3. Of the 22 sampled events, 18 qualified for TSS analysis (influent TSS concentrations ranged from 25 to 138 mg/L). The data were segregated into sample pairs with influent concentration greater than and less than 100 mg/L. The UCL95 mean effluent concentration for the data with influent less than 100 mg/L was 5.2 mg/L, below the 20-mg/L threshold. Although the TAPE guidelines do not require an evaluation of TSS removal efficiency for influent concentrations below 100 mg/L, the mean TSS removal for these samples was 90.1 percent. Average removal of influent TSS concentrations greater than 100 mg/L (three events) was 85 percent. In addition, the system consistently exhibited TSS removal greater than 80 percent at flow rates at a 100 inches per hour [in/hr] infiltration rate and was observed at 150 in/hr.
4. Ten of the 22 sampled events qualified for TP analysis. Americast augmented the dataset using two sample pairs from previous monitoring at the site. Influent TP concentrations ranged from 0.11 to 0.52 mg/L. The mean TP removal for these twelve events was 72.6 percent. The LCL95 mean percent removal was 66.0, well above the TAPE requirement of 50 percent. Treatment above 50 percent was evident at 100 in/hr infiltration rate and as high as 150 in/hr. Consequently, the Filterra® test system met the TAPE Phosphorus Treatment goal at 100 in/hr. Influent ortho-P concentrations ranged from 0.005 to 0.012 mg/L; effluent ortho-P concentrations ranged from 0.005 to 0.013 mg/L. The reporting limit/resolution for the ortho-P test method is 0.01 mg/L, therefore the influent and effluent ortho-P concentrations were both at or near non-detect concentrations.

Field Testing 2008-2009

1. Filterra® completed field-testing at two sites at the Port of Tacoma. Continuous flow and rainfall data collected during the 2008-2009 monitoring period indicated that 89 storm events occurred. The monitoring obtained water quality data from 27 storm events. Not

all the sampled storms produced information that met TAPE criteria for storm and/or water quality data.

2. During the testing at the Port of Tacoma, 98.96 to 99.89 percent of the annual influent runoff volume passed through the POT1 and POT2 test systems respectively. Stormwater runoff bypassed the POT1 test system during nine storm events and bypassed the POT2 test system during one storm event. Bypass volumes ranged from 0.13% to 15.3% of the influent storm volume. Both test systems achieved the 91 percent water quality treatment-goal over the 1-year monitoring period.
3. Consultants observed infiltration rates as high as 133 in/hr during the various storms. Filterra® did not provide any paired data that identified percent removal of TSS, metals, oil, or phosphorus at an instantaneous observed flow rate.
4. The maximum storm average hydraulic loading rate associated with water quality data is <40 in/hr, with the majority of flow rates < 25 in/hr. The average instantaneous hydraulic loading rate ranged from 8.6 to 53 inches per hour.
5. The field data showed a removal rate greater than 80% for TSS with an influent concentration greater than 20 mg/l at an average instantaneous hydraulic loading rate up to 53 in/hr (average influent concentration of 28.8 mg/l, average effluent concentration of 4.3 mg/l).
6. The field data showed a removal rate generally greater than 54% for dissolved zinc at an average instantaneous hydraulic loading rate up to 60 in/hr and an average influent concentration of 0.266 mg/l (average effluent concentration of 0.115 mg/l).
7. The field data showed a removal rate generally greater than 40% for dissolved copper at an average instantaneous hydraulic loading rate up to 35 in/hr and an average influent concentration of 0.0070 mg/l (average effluent concentration of 0.0036 mg/l).
8. The field data showed an average removal rate of 93% for total petroleum hydrocarbon (TPH) at an average instantaneous hydraulic loading rate up to 53 in/hr and an average influent concentration of 52 mg/l (average effluent concentration of 2.3 mg/l). The data also shows achievement of less than 15 mg/l TPH for grab samples. Filterra® provided limited visible sheen data due to access limitations at the outlet monitoring location.
9. The field data showed low percentage removals of total phosphorus at all storm flows at an average influent concentration of 0.189 mg/l (average effluent concentration of 0.171 mg/l). We may relate the relatively poor treatment performance of the Filterra® system at this location to influent characteristics for total phosphorus that are unique to the Port of Tacoma site. It appears that the Filterra® system will not meet the 50 percent removal performance goal when you expect the majority of phosphorus in the runoff to be in the dissolved form.

Laboratory Testing

1. Filterra® performed laboratory testing on a scaled down version of the Filterra® unit. The lab data showed an average removal from 83-91% for TSS with influents ranging from 21 to 320 mg/L, 82-84% for total copper with influents ranging from 0.94 to 2.3 mg/L, and 50-61% for orthophosphate with influents ranging from 2.46 to 14.37 mg/L.
2. Filterra® conducted permeability tests on the soil media.

3. Lab scale testing using Sil-Co-Sil 106 showed percent removals ranging from 70.1% to 95.5% with a median percent removal of 90.7%, for influent concentrations ranging from 8.3 to 260 mg/L. Filterra® ran these laboratory tests at an infiltration rate of 50 in/hr.
4. Supplemental lab testing conducted in September 2009 using Sil-Co-Sil 106 showed an average percent removal of 90.6%. These laboratory tests were run at infiltration rates ranging from 25 to 150 in/hr for influent concentrations ranging from 41.6 to 252.5 mg/l. Regression analysis results indicate that the Filterra® system's TSS removal performance is independent of influent concentration in the concentration rage evaluated at hydraulic loading rates of up to 150 in/hr.

Contact Information:

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Ecology web link: http://www.ecy.wa.gov/programs/wq/stormwater/newtech/index.html

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Water Quality Program
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Date	Revision
December 2009	GULD for Basic, Enhanced, and Oil granted, CULD for Phosphorus
September 2011	Extended CULD for Phosphorus Treatment
September 2012	Revised design storm discussion, added Shallow System.
January 2013	Revised format to match Ecology standards, changed Filterra contact information
February 2013	Added FTIB-P system
March 2013	Added FTIB-C system
April 2013	Modified requirements for identifying appropriate size of unit
June 2013	Modified description of FTIB-C alternate configuration
March 2014	GULD awarded for Phosphorus Treatment. GULD updated for a higher flow-rate for Basic Treatment.
June 2014	Revised sizing calculation methods
March 2015	Revised Contact Information
June 2015	CULD for Basic and Enhanced at 100 in/hr infiltration rate

December 2015

GENERAL USE LEVEL DESIGNATION FOR BASIC (TSS), ENHANCED, PHOSPHORUS & OIL TREATMENT

For

Americast Filterra® Bioscape™

Ecology's Decision:

Based on Americast's submissions, including the Final Technical Evaluation Reports, dated March 27, 2014, December 2009 and additional information provided to Ecology, Ecology hereby issues the following use level designations:

1. A General Use Level Designation for Basic, Enhanced, Phosphorus, and Oil Treatment at the following water quality design hydraulic loading rates:

Treatment	Hydraulic Conductivity* (in/hr) for use in Western Washington Sizing	Infiltration Rate (in/hr) for use in eastern Washington Sizing
Basic	70.92	100
Phosphorus	70.92	100
Oil	35.46	50
Enhanced	24.82	35

*calculated based on listed infiltration rate and a hydraulic gradient of 1.41 inch/inch.

2. The Filterra® Bioscape™ unit is not appropriate for oil spill-control purposes.
3. Ecology approves the Filterra® Bioscape™ units for treatment at the hydraulic loading rates listed above, to achieve the maximum water quality design flow rate. Calculate the water quality design flow rates using the following procedures:

- Western Washington: for treatment installed upstream of detention or retention, the water quality design flow rate is the peak 15-minute flow rate as calculated using the latest version of the Western Washington Hydrology Model or other Ecology-approved continuous runoff model. The model must indicate the unit (represented in the model by a sand filter element routed to a gravel trench bed) is capable of processing 91 percent of the influent runoff file.
- Eastern Washington: For treatment installed upstream of detention or retention, the water quality design flow rate is the peak 15-minute flow rate as calculated using one of the three flow rate based methods described in Chapter 2.2.5 of the Stormwater Management Manual for Eastern Washington (SWMMEW) or local manual.

1

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   - Eastern Washington: For treatment installed upstream of detention or retention, the water quality design flow rate is the peak 15-minute flow rate as calculated using one of the three flow rate based methods described in Chapter 2.2.5 of the Stormwater Management Manual for Eastern Washington (SWMMEW) or local manual.

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- Entire State: For treatment installed downstream of detention, the water quality design flow rate is the full 2-year release rate of the detention facility.

4. This General Use Level Designation has no expiration date but Ecology may revoke or amend the designation, and is subject to the conditions specified below.

Ecology's Conditions of Use:

Filterra® units shall comply with the following conditions:

1. Design, assemble, install, operate, and maintain the Filterra® Bioscape™ units in accordance with applicable Americast Filterra® manuals, document, and the Ecology Decision.

2. Each site plan must undergo Americast Filterra® review before Ecology can approve the unit for site installation. This will ensure that site grading and slope are appropriate for use of a Filterra® Bioscape™ unit.

3. Filterra® Bioscape™ media shall conform to the specifications submitted to and approved by Ecology. The media shall not differ from the media used in the standard Filterra unit and as approved by Ecology.

4. Maintenance includes removing trash, degraded mulch, and accumulated debris from the filter surface and replacing the mulch layer. Use inspections to determine the site-specific maintenance schedules and requirements. Follow maintenance procedures given in the most recent version of the Filterra® Bioscape™ Operation and Maintenance Manual.

5. Maintenance: The required maintenance interval for stormwater treatment devices is often dependent upon the degree of pollutant loading from a particular drainage basin. Therefore, Ecology does not endorse or recommend a "one size fits all" maintenance cycle for a particular model/size of manufactured filter treatment device.
    - Filterra designs their systems for a target maintenance interval of 6 months. Maintenance includes removing accumulated sediment and trash from the surface area of the media, removing the mulch above the media, replacing the mulch, providing plant health evaluation, and pruning the plant if deemed necessary.
    - Conduct maintenance following manufacturer's guidelines.

6. The minimum size filter surface-area for use in western Washington is determined by using the sand filter element connected to a gravel trench bed element in the latest version of WWHM or other Ecology approved continuous runoff model.

Sand Filter element model inputs include

a. Filter media depth: 1.8 feet
b. Effective Ponding Depth: 0.75 feet (This is equivalent to the 6-inch clear zone between the top of the mulch and the bottom of the slab plus 3-inches of mulch.)
c. Side slopes: Vertical
d. Riser height: 0.70 feet
e. Filter Hydraulic Conductivity: Use the Hydraulic Conductivity as listed in the table above (use the lowest applicable hydraulic conductivity depending on the level of treatment required) under Ecology's Decision, above.

Gravel Trench Bed element model inputs include:

a. Outlet 2 (discharge through the bottom of the sand filter element) should be connected to the gravel trench bed
b. Outlet 1 (surface discharge from the sand filter element) represents the overflow (bypass through the Terraflume weir tray in the flow splitter) and should not be connected to the gravel trench bed
c. Trench length and width: same as the Filterra® Bioscape™ unit (modeled in the sand filter element)
d. Effective total depth: 1.167 feet (includes 1 foot of freeboard)
e. Bottom slope: 0.001 ft/ft (must be a non-zero input)
f. Riser height: 0.167 feet (depth of aggregate layer below underdrain pipe)
g. Layer 1 thickness: 0.167 feet
h. Layer 1 porosity: 0.3
i. Infiltration: yes, if native soil infiltration is possible. Use short-term native soil infiltration rate with a safety factor of 4.

7. The minimum size filter surface-area for use in eastern Washington is determined by using the design water quality flow rate (as determined in item 3, above) and the Infiltration Rate from the above table (use the lowest applicable Infiltration Rate depending on the level of treatment required). Calculate the required area by dividing the water quality design flow rate (cu ft/sec) by the Infiltration Rate (converted to ft/sec) to obtain required surface area (sq ft) of the Filterra unit.
8. The distance from the point of entry of water to the most distant point on the surface of the Filterra® Bioscape™ treatment media shall not exceed 12-feet. The Filterra® Bioscape™ requires water to flow across the entire surface area to obtain optimal performance.
9. Users can design the Filterra® Bioscape™ units without an underdrain. Users shall design the system with a temporary water storage area beneath the treatment media to provide a detention reservoir. Water shall not saturate the treatment media at any time.
10. Discharges from the Filterra® units shall not cause or contribute to water quality standards violations in receiving waters.

Applicant: Filterra® Bioretention Systems, division of Americast, Inc.

Applicant's Address: 11352 Virginia Precast Road
Ashland, VA, 23005

Application Documents:

- State of Washington Department of Ecology Application for Conditional Use Designation, Americast (September 2006)
- Quality Assurance Project Plan Filterra® Bioretention Filtration System Performance Monitoring, Americast (April 2008)
- Quality Assurance Project Plan Addendum Filterra® Bioretention Filtration System Performance Monitoring, Americast (June 2008)

- Draft Technical Evaluation Report Filterra® Bioretention Filtration System Performance Monitoring, Americast (August 2009)
- Final Technical Evaluation Report Filterra® Bioretention Filtration System Performance Monitoring, Americast (December 2009)
- Technical Evaluation Report Appendices Filterra® Bioretention Filtration System Performance Monitoring, Americast (August 2009)
- Memorandum to Department of Ecology Dated October 9, 2009 from Americast, Inc. and Herrera Environmental Consultants
- Quality Assurance Project Plan Filterra® Bioretention System Phosphorus treatment and Supplemental Basic and Enhanced Treatment Performance Monitoring, Americast (November 2011)
- Filterra® letter August 24, 2012 regarding sizing for the Filterra® Shallow System.
- University of Virginia Engineering Department Memo by Joanna Crowe Curran, Ph. D dated March 16, 2013 concerning capacity analysis of Filterra® internal weir inlet tray.
- Filterra® Bioscape™ Bioretention System Model Configuration Approval Request, January 2014
- Terraphase Engineering letter to Jodi Mills, P.E. dated April 2, 2013 regarding Terraflume Hydraulic Test, Filterra® Bioretention System and attachments.
- Technical Evaluation Report, Filterra® System Phosphorus Treatment and Supplemental Basic Treatment Performance Monitoring. March 27th, 2014.

Applicant's Use Level Request:

General Level Use Designation for Basic, Enhanced, Phosphorus, and Oil Treatment.

Applicant's Performance Claims:

Field-testing and laboratory testing show that the Filterra® unit is promising as a stormwater treatment best management practice and can meet Ecology's performance goals for basic, enhanced, phosphorus, and oil treatment.

Findings of Fact:

Field Testing 2013

1. Filterra® completed field-testing of a 6.5 ft x 4 ft. unit at one site in Bellingham, Washington. Continuous flow and rainfall data collected from January 1, 2013 through July 23, 2013 indicated that 59 storm events occurred. The monitoring obtained water quality data from 22 storm events. Not all the sampled storms produced information that met TAPE criteria for storm and/or water quality data.
2. The system treated 98.9 percent of the total 8-month runoff volume during the testing period. Consequently, the system achieved the goal of treating 91 percent of the volume from the site. Stormwater runoff bypassed during four of the 59 storm events.

3. Of the 22 sampled events, 18 qualified for TSS analysis (influent TSS concentrations ranged from 25 to 138 mg/L). The data were segregated into sample pairs with influent concentration greater than and less than 100 mg/L. The UCL95 mean effluent concentration for the data with influent less than 100 mg/L was 5.2 mg/L, below the 20-mg/L threshold. Although the TAPE guidelines do not require an evaluation of TSS removal efficiency for influent concentrations below 100 mg/L, the mean TSS removal for these samples was 90.1 percent. Average removal of influent TSS concentrations greater than 100 mg/L (three events) was 85 percent. In addition, the system consistently exhibited TSS removal greater than 80 percent at flow rates at a 100 inches per hour [in/hr] infiltration rate and was observed at 150 in/hr.
4. Ten of the 22 sampled events qualified for TP analysis. Americast augmented the dataset using two sample pairs from previous monitoring at the site. Influent TP concentrations ranged from 0.11 to 0.52 mg/L. The mean TP removal for these twelve events was 72.6 percent. The LCL95 mean percent removal was 66.0, well above the TAPE requirement of 50 percent. Treatment above 50 percent was evident at 100 in/hr infiltration rate and as high as 150 in/hr. Consequently, the Filterra® test system met the TAPE Phosphorus Treatment goal at 100 in/hr. Influent ortho-P concentrations ranged from 0.005 to 0.012 mg/L; effluent ortho-P concentrations ranged from 0.005 to 0.013 mg/L. The reporting limit/resolution for the ortho-P test method is 0.01 mg/L, therefore the influent and effluent ortho-P concentrations were both at or near non-detect concentrations.

Field Testing 2008-2009

1. Filterra® completed field-testing at two sites at the Port of Tacoma. Continuous flow and rainfall data collected during the 2008-2009 monitoring period indicated that 89 storm events occurred. The monitoring obtained water quality data from 27 storm events. Not all the sampled storms produced information that met TAPE criteria for storm and/or water quality data.
2. During the testing at the Port of Tacoma, 98.96 to 99.89 percent of the annual influent runoff volume passed through the POT1 and POT2 test systems respectively. Stormwater runoff bypassed the POT1 test system during nine storm events and bypassed the POT2 test system during one storm event. Bypass volumes ranged from 0.13% to 15.3% of the influent storm volume. Both test systems achieved the 91 percent water quality treatment-goal over the 1-year monitoring period.
3. Consultants observed infiltration rates as high as 133 in/hr during the various storms. Filterra® did not provide any paired data that identified percent removal of TSS, metals, oil, or phosphorus at an instantaneous observed flow rate.
4. The maximum storm average hydraulic loading rate associated with water quality data is <40 in/hr, with the majority of flow rates < 25 in/hr. The average instantaneous hydraulic loading rate ranged from 8.6 to 53 inches per hour.
5. The field data showed a removal rate greater than 80% for TSS with an influent concentration greater than 20 mg/l at an average instantaneous hydraulic loading rate up to 53 in/hr (average influent concentration of 28.8 mg/l, average effluent concentration of 4.3 mg/l).

6. The field data showed a removal rate generally greater than 54% for dissolved zinc at an average instantaneous hydraulic loading rate up to 60 in/hr and an average influent concentration of 0.266 mg/l (average effluent concentration of 0.115 mg/l).
7. The field data showed a removal rate generally greater than 40% for dissolved copper at an average instantaneous hydraulic loading rate up to 35 in/hr and an average influent concentration of 0.0070 mg/l (average effluent concentration of 0.0036 mg/l).
8. The field data showed an average removal rate of 93% for total petroleum hydrocarbon (TPH) at an average instantaneous hydraulic loading rate up to 53 in/hr and an average influent concentration of 52 mg/l (average effluent concentration of 2.3 mg/l). The data also shows achievement of less than 15 mg/l TPH for grab samples. Filterra® provided limited visible sheen data due to access limitations at the outlet monitoring location.
9. The field data showed low percentage removals of total phosphorus at all storm flows at an average influent concentration of 0.189 mg/l (average effluent concentration of 0.171 mg/l). We may relate the relatively poor treatment performance of the Filterra® system at this location to influent characteristics for total phosphorus that are unique to the Port of Tacoma site. It appears that the Filterra® system will not meet the 50 percent removal performance goal when you expect the majority of phosphorus in the runoff to be in the dissolved form.

Laboratory Testing

1. Filterra® performed laboratory testing on a scaled down version of the Filterra® unit. The lab data showed an average removal from 83-91% for TSS with influents ranging from 21 to 320 mg/L, 82-84% for total copper with influents ranging from 0.94 to 2.3 mg/L, and 50-61% for orthophosphate with influents ranging from 2.46 to 14.37 mg/L.
2. Filterra® conducted permeability tests on the soil media.
3. Lab scale testing using Sil-Co-Sil 106 showed percent removals ranging from 70.1% to 95.5% with a median percent removal of 90.7%, for influent concentrations ranging from 8.3 to 260 mg/L. Filterra® ran these laboratory tests at an infiltration rate of 50 in/hr.
4. Supplemental lab testing conducted in September 2009 using Sil-Co-Sil 106 showed an average percent removal of 90.6%. These laboratory tests were run at infiltration rates ranging from 25 to 150 in/hr for influent concentrations ranging from 41.6 to 252.5 mg/l. Regression analysis results indicate that the Filterra® system's TSS removal performance is independent of influent concentration in the concentration rage evaluated at hydraulic loading rates of up to 150 in/hr.

Contact Information:

Applicant: Sean Darcy
Contech Engineered Solutions, LLC.
11815 Glenn Widing Dr
Portland, OR 97220
(503) 258-3105
darcys@conteches.com

Applicant's Website: http://www.conteches.com

Ecology web link: http://www.ecy.wa.gov/programs/wq/stormwater/newtech/index.html

Ecology: Douglas C. Howie, P.E.
Department of Ecology
Water Quality Program
(360) 407-6444
douglas.howie@ecy.wa.gov

Date	Revision
July 2014	GULD for Basic, Enhanced, Phosphorus and Oil granted
March 2015	Revised Contact Information
December 2015	Revised device name from Filterra® Boxless™ to Filterra®Bioscape™

Appendix C Filterra® System Practice Note

Background

Auckland Council Stormwater Unit (SU) has evaluated the Filterra® system against current certification from the Washington State Technology Assessment Protocol Ecology (TAPE) program. The Filterra® has Washington GULD certification for the Filterra® Boxed and Bioscape systems, see Appendix B.

The Filterra® is available in various offline and online configurations and has GULD certification for multiple levels of treatment. This report focuses on performance and design of the standard Filterra® (including its GULD approved alternative configurations) and the Filterra® Bioscape™ designed for the basic treatment level only.

The following were excluded from analysis due to the reasons listed.

- Enhanced TSS, Phosphorous, and Oil treatment levels: Under the ALWP, a stormwater treatment device is required to achieve 75 percent TSS removal. Since GULD enhanced treatment is above what is required by the ALWP, analysis focus will be on performance results from studies assessing basic treatment.

Washington GULD certified offline standard and shallow configurations were amended and provided by Stormwater360 based on standard vault, manhole and box culvert configurations for Auckland use. These local offline configurations have been compared against the Washington GULD certification and confirmed as acceptable in meeting the ALWP requirements for 75% sediment removal. The GULD approved online Filterra® and Filterra® Bioscape™ are considered functionally equivalent, and therefore are also regarded as acceptable in meeting the ALWP requirements for 75% sediment removal.

The following Filterra® configurations can provide basic treatment as defined by Washington GULD certification:

- standard offline Filterra® designed with an infiltration rate of 2.5 m/hr,
- standard online Filterra® on the basis that
    - the surface area is sized like a standard offline Filterra,
    - their functioning and performance is not affected by the internal bypass, and
    - the internal bypass needs to meet the requirements of the Building Act and Auckland Council Code of Practice/Stormwater

- shallow Filterra® designed on the basis of a flux rate of 1.8 m/hr by controlling the outflow for equivalent contact time and a surface area upsizing factor of 1.4 for equivalent media volume to the standard Filterra® for a shallower media depth.
- Filterra® Bioscape™ with its surface area sized like a standard offline Filterra and a hydraulic gradient of 1.41 m/m.

Therefore the listed Filterra® configurations are granted interim approval from the date of issue for use on private sites. This approval does not extend to use on public sites for devices to be vested to Auckland Council. To extend for use on public sites vested to Auckland Council, the device will need to be certified under Auckland Council's new products approval process. Other public organisations (e.g. AT and NZTA) may have their own separate product approval process.

Interim recognition is provided until further notice. Auckland Council may amend or revoke approval at any time, with reasonable notice.

It should be noted that because of the high hydraulic conductivity of the filter media, the Filterra® has a smaller footprint than bioretention designed according to TP10 /GD01. As such, volume reduction and flow attenuation will be less than conventional bioretention. Ecosystem goods and services, such as provision of habitat, may also be less than is provided by larger footprint biofilters. The high infiltration rate is achieved through the use of a specifically engineered filter media and replaceable mulch. The media and mulch has different physical and chemical properties to a conventional raingarden. It is essential that the manufacturer's recommendations on operation are carried out to ensure the long term successful operation of the device

Description

The boxed Filterra® is an offline, engineered biofilter device for the treatment of contaminated stormwater runoff from paved surfaces. The system is optimised for high flow rate treatment. This allows a small footprint to be used, making the device suitable for highly constrained sites. The Filterra® is typically housed within a precast concrete kerb inlet structure with a tree frame and grate cast into the top slab. Stormwater 360 also provides open top systems. Pollutants are captured and immobilised within the filter media and subject to various treatment processes to improve the quality of stormwater discharged from the system.

Sizing

Flow based sizing

In the Auckland context, stormwater devices sized using flow based methods must provide a peak flow rate calculated via the rational method, and based on a rainfall intensity of 10 mm/h for the catchment they serve (Auckland Council, 2013). This definition is based on analysis of rainfall records over the Auckland region, and is equivalent a volume based sized device following the TP10 (ARC, 2003) water quality volume design process.

Stormwater quality devices with little or no storage volume, such as the Filterra®, are best sized to treat a defined Water Quality Flow (WQF) for the site which in Auckland's case is based on a 10 mm/h constant rainfall intensity. The Rational Method can be used to calculate the runoff flows to the device (Auckland Council, 2013).

$$Q_d = CiA_C \qquad Equation\ 1$$

Where

Q_d is the water quality flow in m^3/h requiring treatment,

C is the runoff coefficient derived as outlined below,

A_c is the catchment area in m^2, and

i is the design rainfall intensity of 10 mm/hr.

Auckland Council specifies use of C=1 for paved or otherwise impervious surfaces (ARC, 2003). Table 4-1 provides a range of values for pervious surfaces. For sites with mixed surface types, an area weighted composite C value should be used.

Table 8-1 Range of typical runoff coefficient values for natural surface types (Source: DBH, 2011)

Natural Surface Types	Rational Coefficient, C
- Heavy clay soils	0.30–0.40
- Medium soakage soil types	0.20–0.30
- High soakage gravel, sandy, and volcanic soil types	0.10–0.20
- Parks, playgrounds, reserves, lawns	0.25–0.30

For flow based sizing, the peak water quality design flow rate is used to identify the minimum filter surface area required to achieve the target water quality treatment rate.

Stormwater360 currently is undertaking work with respect to inlet configuration for the manhole system in the Auckland context. Until further clarification, the inlet can be configured

- As per Humes metro pit, or
- In conjunction with a filter strip for sheet flow from the road surface to the system

It is noted that the designer is responsible for ensuring the hydraulic design of the connected units does not affect the performance/treatment efficiency of the units, nor that of the upstream stormwater system. The manufacturer is responsible to inform the designer of this responsibility.

Washington GULD certified standard and shallow configurations were amended and provided by Stormwater360 based on standard vault, manhole and box culvert configurations for Auckland use. These local configurations have been compared against the Washington GULD certification and confirmed as acceptable in meeting the ALWP requirements for 75% sediment removal. The design of Auckland standard and shallow Filterra® is summarised below.

Standard Filterra® sizing

A standard Filterra® is designed to be offline and may be installed upstream of a detention/retention device. A standard Filterra® uses the following parameters for sizing:

- Filter media depth of 0.56 m,
- Effective ponding depth: 0.23 m, equivalent to the 150 mm clear zone between the top of the mulch and the bottom of the slab plus 75 mm of mulch

The required Filterra® surface area is calculated using Equation 2 and assumes standard Filterra® layer dimensions. It equates to a conservative surface area and needs to be verified for local conditions.

$$A_F = \frac{Q_d}{F} \quad \textit{Equation 2}$$

Where

- A_F is the required Filterra® surface area for a standard system (m^2),
- Q_d is the water quality flow rate (m^3/h) derived using Equation 1, and
- F is the infiltration rate (m/hr) as represented by Equation 3 below

$$F = k \times i \quad \textit{Equation 3}$$

where

- F is the infiltration rate (m/hr), GULD approved design infiltration rate is 2.5 m/hr for basic treatment of a standard Filterra®
- k is the approved hydraulic conductivity (m/hr). GULD approved hydraulic conductivity is 1.8 m/hr for basic treatment of a standard Filterra®
- i is the hydraulic gradient (m/m). The GULD hydraulic gradient is 1.41m/m for basic treatment.

Equations 1 and 2 are used to establish a relationship between the required Filterra® surface area for a given catchment area and the associated WQF. To suit Auckland conditions, Stormwater360 provided typical Auckland standard Filterra® configurations provided in Table D 1.

Standard Filterra® systems equate to 0.37% of the catchment area, using standard Filterra® unit layer dimensions.

Any deviation from the specified media characteristics would require a review of the design flow rates.

Table D 1 Design flow capacities for standard Auckland Filterra® configurations

Model	Vault/ Manhole	Diameter [m]	Length [m]	Width [m]	Filter Area [m²]	Design flow rate[1] [L/s]	Catchment Area[2] [m²]
FT1212	V	-	1.200	1.200	1.440	1.016	385.011
FT1218	V	-	1.800	1.200	2.160	1.524	577.516
FT1224	V	-	2.400	1.200	2.880	2.032	770.021
FT1236	V	-	3.600	1.200	4.320	3.048	1155.032
FT1812	V	-	1.800	1.200	2.160	1.524	577.516
FT1818	V	-	1.800	1.800	3.240	2.286	866.274
FT1824	V	-	2.400	1.800	4.320	3.048	1155.032
FT1830	V	-	3.000	1.800	5.400	3.810	1443.789
FT1836	V	-	3.600	1.800	6.480	4.572	1732.547
FT2140	V	-	4.000	2.100	8.400	5.927	2245.895
FT2412	V	-	2.400	1.200	2.880	2.032	770.021
FT2418	V	-	2.400	1.800	4.320	3.048	1155.032
FT3018	V	-	3.000	1.800	5.400	3.810	1443.789
FT3612	V	-	3.600	1.200	4.320	3.048	1155.032
FT3618	V	-	3.600	1.800	6.480	4.572	1732.547
FT4021	V	-	4.000	2.100	8.400	5.927	2245.895
FTBC1010	BC	-	1.000	1.000	1.000	0.706	267.368
FTBC1510	BC	-	1.500	1.000	1.500	1.058	401.053
FTBC1515	BC	-	1.500	1.500	2.250	1.588	601.579

Model	Vault/ Manhole	Diameter [m]	Length [m]	Width [m]	Filter Area [m²]	Design flow rate[1] [L/s]	Catchment Area[2] [m²]
FTBC2010	BC	-	2.000	1.000	2.000	1.411	534.737
FTBC2015	BC	-	2.000	1.500	3.000	2.117	802.105
FTBC2020	BC	-	2.000	2.000	4.000	2.822	1069.474
FTBC2510	BC	-	2.500	1.000	2.500	1.764	668.421
FTBC2515	BC	-	2.500	1.500	3.750	2.646	1002.632
FTBC2520	BC	-	2.500	2.000	5.000	3.528	1336.842
FTBC2525	BC	-	2.500	2.500	6.250	4.410	1671.053
FTBC3010	BC	-	3.000	1.000	3.000	2.117	802.105
FTBC3015	BC	-	3.000	1.500	4.500	3.175	1203.158
FTBC3020	BC	-	3.000	2.000	6.000	4.233	1604.211
FTBC3025	BC	-	3.000	2.500	7.500	5.292	2005.263
FTBC3030	BC	-	3.000	3.000	9.000	6.350	2406.316
FTBC3515	BC	-	3.500	1.500	5.250	3.704	1403.684
FTBC3520	BC	-	3.500	2.000	7.000	4.939	1871.579
FTBC3525	BC	-	3.500	2.500	8.750	6.174	2339.474
FTBC3530	BC	-	3.500	3.000	10.500	7.408	2807.368
FTBC3535	BC	-	3.500	3.500	12.250	8.643	3275.263
FTBC4015	BC	-	4.000	1.500	6.000	4.233	1604.211
FTBC4020	BC	-	4.000	2.000	8.000	5.644	2138.947
FTBC4025	BC	-	4.000	2.500	10.000	7.056	2673.684
FTBC4030	BC	-	4.000	3.000	12.000	8.467	3208.421
FTBC4035	BC	-	4.000	3.500	14.000	9.878	3743.158
FTBC4040	BC	-	4.000	4.000	16.000	11.289	4277.895
FTBC4520	BC	-	4.500	2.000	9.000	6.350	2406.316
FTBC5015	BC	-	5.000	1.500	7.500	5.292	2005.263
FTBC5020	BC	-	5.000	2.000	10.000	7.056	2673.684
FTBC5025	BC	-	5.000	2.500	12.500	8.819	3342.105
FTBC5520	BC	-	5.500	2.000	11.000	7.761	2941.053
FTBC5530	BC	-	5.500	3.000	16.500	11.642	4411.579
FTBC6020	BC	-	6.000	2.000	12.000	8.467	3208.421
FTBC6025	BC	-	6.000	2.500	15.000	10.583	4010.526
FTBC6030	BC	-	6.000	3.000	18.000	12.700	4812.632
FTMH10	MH	1.050	-	-	0.866	0.611	231.515
FTMH12	MH	1.200	-	-	1.131	0.798	302.387
FTMH15	MH	1.500	-	-	1.767	1.247	472.479
FTMH18	MH	1.800	-	-	2.545	1.795	680.370
FTMH21	MH	2.050	-	-	3.301	2.329	882.486
FTMH23	MH	2.300	-	-	4.155	2.931	1110.851
FTMH30	MH	3.050	-	-	7.306	5.155	1953.438

Model	Vault/ Manhole	Diameter [m]	Length [m]	Width [m]	Filter Area [m²]	Design flow rate[1] [L/s]	Catchment Area[2] [m²]
1. The design flow rate is established using Equation 2 with the GULD approved design infiltration rate of 2.5 m/hr. 2. The maximum allowable catchment area (assumed 100% impervious) is determined using Equation 1, with a rational C of 0.95 and Auckland's rainfall intensity of 10 mm/hr.							

Shallow Filterra® sizing

The standard Filterra® can be designed as an offline shallow Filterra® with a reduced media. To achieve equivalent pollutant removal based on equivalent contact time, design of a shallower system requires increasing the calculated standard Filterra® surface area by a factor of 1.4 and reducing the ponding depth to 0.17 m. The upsizing factor of 1.4 was calculated based on providing the same contact time (0.3 hrs) as for a standard Filterra®.

Performance data for a shallow Filterra® was, at the time of the report, not available. In order to ensure the whole media bed is utilised for equivalent contact time, a flow control should be installed on shallow Filterra® units. The flow control is sized as a free discharging orifice limiting the flux rate to 1.8 m/hr. This reduced design flux rate is established by relating Equation 3 for the standard and shallow Filterra® with the upsizing factor (1.4) and shallower ponding depth (0.17m).

Typical Auckland shallow Filterra® configurations provided in Table D 2.

Shallow Filterra® systems equate to 0.52% of the catchment area, using shallow Filterra® unit layer dimensions of 0.41m media depth and 0.17m ponding depth.

Any deviation from the specified media characteristics would require a review of the design flow rates.

Table D 2 Design flow capacities for shallow Auckland Filterra® configurations

Model	Vault/ Manhole	Diameter [m]	Length [m]	Width [m]	Filter Area [m²]	Design flow rate[1] [L/s]	Catchment Area[2] [m²]
FT1212	V	-	1.200	1.200	1.440	0.726	275.090
FT1218	V	-	1.800	1.200	2.160	1.089	412.635
FT1224	V	-	2.400	1.200	2.880	1.452	550.180
FT1236	V	-	3.600	1.200	4.320	2.178	825.269
FT1812	V	-	1.800	1.200	2.160	1.089	412.635

Model	Vault/ Manhole	Diameter [m]	Length [m]	Width [m]	Filter Area [m²]	Design flow rate[1] [L/s]	Catchment Area[2] [m²]
FT1818	V	-	1.800	1.800	3.240	1.633	618.952
FT1824	V	-	2.400	1.800	4.320	2.178	825.269
FT1830	V	-	3.000	1.800	5.400	2.722	1031.587
FT1836	V	-	3.600	1.800	6.480	3.267	1237.904
FT2140	V	-	4.000	2.100	8.400	4.235	1604.691
FT2412	V	-	2.400	1.200	2.880	1.452	550.180
FT2418	V	-	2.400	1.800	4.320	2.178	825.269
FT3018	V	-	3.000	1.800	5.400	2.722	1031.587
FT3612	V	-	3.600	1.200	4.320	2.178	825.269
FT3618	V	-	3.600	1.800	6.480	3.267	1237.904
FT4021	V	-	4.000	2.100	8.400	4.235	1604.691
FTBC1010	BC	-	1.000	1.000	1.000	0.504	191.035
FTBC1510	BC	-	1.500	1.000	1.500	0.756	286.552
FTBC1515	BC	-	1.500	1.500	2.250	1.134	429.828
FTBC2010	BC	-	2.000	1.000	2.000	1.008	382.069
FTBC2015	BC	-	2.000	1.500	3.000	1.512	573.104
FTBC2020	BC	-	2.000	2.000	4.000	2.016	764.138
FTBC2510	BC	-	2.500	1.000	2.500	1.260	477.587
FTBC2515	BC	-	2.500	1.500	3.750	1.890	716.380
FTBC2520	BC	-	2.500	2.000	5.000	2.521	955.173
FTBC2525	BC	-	2.500	2.500	6.250	3.151	1193.966
FTBC3010	BC	-	3.000	1.000	3.000	1.512	573.104
FTBC3015	BC	-	3.000	1.500	4.500	2.269	859.656
FTBC3020	BC	-	3.000	2.000	6.000	3.025	1146.208
FTBC3025	BC	-	3.000	2.500	7.500	3.781	1432.760
FTBC3030	BC	-	3.000	3.000	9.000	4.537	1719.311
FTBC3515	BC	-	3.500	1.500	5.250	2.647	1002.932
FTBC3520	BC	-	3.500	2.000	7.000	3.529	1337.242
FTBC3525	BC	-	3.500	2.500	8.750	4.411	1671.553
FTBC3530	BC	-	3.500	3.000	10.500	5.293	2005.863
FTBC3535	BC	-	3.500	3.500	12.250	6.175	2340.174
FTBC4015	BC	-	4.000	1.500	6.000	3.025	1146.208
FTBC4020	BC	-	4.000	2.000	8.000	4.033	1528.277
FTBC4025	BC	-	4.000	2.500	10.000	5.041	1910.346
FTBC4030	BC	-	4.000	3.000	12.000	6.049	2292.415
FTBC4035	BC	-	4.000	3.500	14.000	7.058	2674.484
FTBC4040	BC	-	4.000	4.000	16.000	8.066	3056.554
FTBC4520	BC	-	4.500	2.000	9.000	4.537	1719.311
FTBC5015	BC	-	5.000	1.500	7.500	3.781	1432.760
FTBC5020	BC	-	5.000	2.000	10.000	5.041	1910.346

Model	Vault/ Manhole	Diameter [m]	Length [m]	Width [m]	Filter Area [m²]	Design flow rate[1] [L/s]	Catchment Area[2] [m²]
FTBC5025	BC	-	5.000	2.500	12.500	6.301	2387.933
FTBC5520	BC	-	5.500	2.000	11.000	5.545	2101.381
FTBC5530	BC	-	5.500	3.000	16.500	8.318	3152.071
FTBC6020	BC	-	6.000	2.000	12.000	6.049	2292.415
FTBC6025	BC	-	6.000	2.500	15.000	7.562	2865.519
FTBC6030	BC	-	6.000	3.000	18.000	9.074	3438.623
FTMH10	MH	1.050	-	-	0.866	0.437	165.417
FTMH12	MH	1.200	-	-	1.131	0.570	216.055
FTMH15	MH	1.500	-	-	1.767	0.891	337.586
FTMH18	MH	1.800	-	-	2.545	1.283	486.124
FTMH21	MH	2.050	-	-	3.301	1.664	630.536
FTMH23	MH	2.300	-	-	4.155	2.094	793.702
FTMH30	MH	3.050	-	-	7.306	3.683	1395.731

1. The Design flow rate is established based on Equation 2 with a design infiltration rate of 1.8 m/hr established using the upsizing factor of 1.4. 2. The maximum allowable catchment area (assumed 100% impervious) is determined using Equation 1, the established design flow rate, a rational C of 0.95 and Auckland's rainfall intensity of 10 mm/hr.

Online Filterra® sizing

Online Filterra® configurations include:

- Filterra® Internal Bypass-Pipe (FTIB-P) – an online configuration, where flows may be piped from area drains, grated inlets, trench drains, and/or roof drains. Stormwater enters through an internal slotted pipe that drops through to a series of splash plates that disperse the flows over the top surface of the Filterra® mulch layer. Higher flows are able to bypass the slotted pipe and pass out of the structure.
- Filterra® Internal Bypass-Curb (FTIB-C) – For online use in a sump condition to receive flows from both directions along a gutter line. The kerb inlet, bio filtration treatment chamber and internal high-flow bypass are contained within a single structure. An internal flume tray weir directs flows through the kerb inlet to the treatment chamber. Flows greater than the design flow rise above the weir and discharge through a standpipe orifice.

Online Filterra® configurations (FTIB-P and FTIB-C) have GULD approval and are accepted as part of this interim approval on the basis that:

- the surface area is sized like a standard offline Filterra,

- their functioning and performance is not affected by the internal bypass, and
- the internal bypass needs to meet the requirements of the Building Act and Auckland Council Code of Practice/Stormwater.

Filterra® Bioscape™ sizing

The Filterra® Bioscape™ (formerly named Filterra® Boxless) is a GULD approved Filterra® configuration. It allows some infiltration to native soils; however within the Auckland region no retention (volume credit) is approved. SMAF requirements must be met using other approved retention devices. In such a case, for online configurations, the bypass and undertrain should connect to downstream detention, which must meet SMAF requirements.

The Filterra® Bioscape™ can be designed without an underdrain; in such cases a detention reservoir is required to prevent treatment media becoming saturated. Water shall not saturate the treatment media at any time.

The Filterra® Bioscape™ surface area is sized like a standard offline Filterra.

The distance from the point of entry of water to the most distant point on the surface of the Filterra® Bioscape™ treatment media, shall be less or equal to 3.7m.

Plant selection

For the design of a Filterra®, manufacturer specified plants should be chosen.

The high hydraulic conductivity of filter media may limit the plant pallet for use in the Filterra®. Stormwater360 has undertaken trials regarding suitable NZ plants. It is recommended that all installations require a plant selection approved by the manufacturer.

Construction and Installation

Filterra® systems installed prior to site stabilisation, must have adequate and complete site/inlet protection. A Filterra® can be activated for full operation once the site is fully stabilised and any accumulated sediment has been removed from the Filterra® structure and upstream diversion structure.

Installation should follow Stormwater360 vault, manhole or box culvert installation guidelines. The contractor is responsible for the correct installation of Filterra® units as shown in approved plans. A comprehensive installation manual is available from Stormwater 360.

Each unit must be constructed at the locations and elevations according to the sizes identified on approved drawings, with any modification to these needing to be directed and approved by the Engineer.

The following aspects must be considered during Filterra® system design and installation.

Pretreatment

- Pretreatment is typically not required

Soil and groundwater characteristics

- Must be placed on a compacted sub-grade with a minimum 150 mm gravel base matching the final grade of the curb line in the area of the unit.
- Unit placement must be such that the unit and top slap match the grade of the curb in the area of the unit.
- Manufacturer guidance is required for installations on grades greater than 5 percent
- No depth-to-groundwater limitations due to fully enclosed unit construction
- System is delivered to the site filled with filter media so has no flotation potential, regardless of local groundwater conditions

Hydraulic requirements

- No head requirements to achieve the treatment flow rate as Filterra® is a surface treatment system
- 0.94m elevation difference between the influent entry and the invert for a standard Filterra®
- 0.23m freeboard for head accumulation for a standard Filterra®, provided by the distance between the bottom of the top slab and the surface of the Filterra® media
- Positive drainage to each effluent treatment pipe to prevent free standing water from accumulating in the system or underdrain

Inlet

- Ensure cross linear surface inflow for offline standard and shallow configurations
- Contractors to provide curb and gutter and appropriate transition to Filterra® unit for proper stormwater flow into the system through the throat opening

Device footprint

- Device footprint varies to suit site constraints, rainfall characteristics, and drainage catchment
- Footprint is designed as per sizing guideline, but is typically 0.37 percent of the for the drainage catchment area for a standard Filterra® and 0.52% of the drainage catchment for a shallow Filterra®

Shallow installations

- A shallow Filterra® is up to 150 mm shallower than the standard Filterra® media depth of 560 mm.
- Shallow Filterra® footprint is increased by an upsizing factor of 1.4 for equivalent media volume at a reduced media depth
- Install flow control for shallow Filterra® to ensure the whole media bed is utilised for equivalent contact time to that provided by a standard Filterra®. Size flow control as free discharging orifice, limiting the shallow Filterra® design flux rate to 1.8 m/hr

Structural loading

- Filterra® is designed to withstand a non-live water load
- Boxed Filterra® unit floors and walls are made from 100-150 mm thick reinforced concrete
- Top slab is made from 200 mm thick concrete
- Filterra® tree grate is designed to withstand pedestrian loading

Bypass

- Typically the standard and shallow Filterra® configurations are installed as offline systems, with flows in excess of the WQF bypassing the system externally to a downstream catch pit or other detention or infiltration device
- Align and seal outlet connections to meet the approved drawings with modifications necessary to meet site conditions and local regulations.
- For online configurations (FTIB-P and FTIB-C) flows greater than the design flow bypass the systems internally. In the FTIB-P online configuration, excess flows bypass the slotted pipe and are conveyed out of the system. In the FTIB-C online configuration, excess flows bypass the system by rising above the internal flume tray weir and discharging through a standpipe orifice

Sump condition

- Ensure standard and shallow Filterra® units are not placed in a sump condition
- Ensure effective bypass during higher intensity rainfall events. The standard and shallow Filterra® unit can be imagined with a blocked inflow throat. If this would result in ponding or pooling of drainage, placement is inappropriate.

Planting selection and installation

- Consult with and install manufacture specified plants suitable for a Filterra® and the local conditions and surrounding environment, to prevent die back, avoid excessive watering, and contribute to other design disciplines for a better integration
- Consult with manufacturer for watering requirements of Filterra® plants following installation, in the first 6 weeks, and once plants have established

Construction discharge and commissioning

- The contractor is responsible to provide adequate and complete site/inlet protection for Filterra® systems installed prior to final site stabilisation.
- The protective boards or tree grates should not be removed from the top slab during installation.
- When unit is set, leave the internal wooden forms and protective silt fabric cover intact. Seal the top lid onto the box section before backfilling, using a non-shrink grout, butyl rubber or similar waterproof seal, and place boards on top of the lid.
- The protective throat boards should not be removed.
- Backfill carefully, bringing the appropriate fill material up in 150mm lifts on all sides. Set precast sections I a manner resulting in a watertight joint.
- Supplier to activate system only once site is stabilised (full landscaping, grass cover, final paving, and street sweeping completed) and any accumulated sediment has been removed from the Filterra® structure and upstream diversion structure. This helps to avoid ingress of mobilised sediment, which may clog the filter media and result in additional maintenance requirements.

Inspection and Maintenance Requirements

Regular inspection and maintenance is required to ensure that the Filterra® continues to operate at design efficiency.

An initial maintenance plan for sites using the Filterra® system must be submitted to Council for approval prior to the device being activated for full operation. The maintenance plan commences when the system is activated for full operation. Full operation is defined as the unit installed, kerb and gutter and transitions in place and activation (by supplier) when mulch and plant are added and temporary throat protection removed. Activation cannot be carried out until the site is fully stabilised (full landscaping, grass cover, final paving and street sweeping completed).

The initial maintenance plan shall incorporate, at a minimum, the maintenance requirements for the Filterra® system in accordance with the manufacturer's instructions. The site specific detailed maintenance plan should also include, but is not limited to, the following items:

- List of inspection and maintenance equipment and tools;
- Specific corrective and preventative maintenance tasks;

- Indication of problems in the system; and
- Training of maintenance personnel.

The required inspection and maintenance interval is dependent upon the degree of pollutant loading from a particular catchment. Therefore, Auckland Council does not endorse or recommend a "one size fits all" maintenance cycle for the Filterra®. It may be necessary to adjust the inspection and maintenance schedule depending on the actual operating conditions encountered by the system. Sites with higher than expected sediment loads may require more frequent inspection and maintenance. Industrial areas with heavy petroleum loading may also require a higher frequency of maintenance so that the flow rate of the mulch layer that protects the filtration media is maintained.

Owners/operators must inspect Filterra® systems for a minimum of twelve months from the start of post-construction operation to determine site-specific maintenance schedules and requirements. Owners/operators must conduct inspections at least every six months.

Inspections must be conducted by qualified personnel, follow manufacturer's guidelines, and use methods capable of determining either a decrease in treated effluent flow rate and/or a decrease in pollutant removal ability.

Comprehensive manufacturer maintenance guidance for the Filterra® can be found in the Stormwater360 "Filterra® Bio retention Systems Operation & Maintenance (OM) Manual v01".

Filterra® typical inspection and maintenance frequencies and activities are listed in Table D 3.

Table D 3 Standard and shallow Filterra® inspection and maintenance details

Item	Detail
Inspection	• Inspect system at least twice a year and after every major storm of greater than 25 mm rainfall depth • Inspection should note the presence of standing water, damage to the box structure, and damage to the tree grate, assess plant health and any blockage of the bypass. • Inspect vegetation at least every 6 months once established, or more frequently were specified by Supplier • The supplier should be promptly notified of any damage to the plant(s). Landscapers and maintenance contractors should be aware to leave all maintenance to the Supplier (i.e. no pruning or fertilizing).

Item	Detail

Maintenance	• Target maintenance interval of six months but dependent on site specific pollutant load. Additional maintenance may be necessary depending on sediment and trash loading.
	• The amount of maintenance visits further depends on the amount of annual rainfall. Findings showed that regions with:
	  o <75 mm of annual rainfall typically require one annual visit,
	  o 75-130mm of annual rainfall typically require two annual visits
	• Seasonal maintenance. Spring maintenance is targeted to clean up following winter loads, while fall visits help the system by removing excessive leaf litter.
	• In industrial areas with heavy petroleum loading, frequency of maintenance may need to increase to maintain the flow rate of the mulch layer that protects the filtration media
	• Remove accumulated sediment, rubbish, debris and degraded mulch from the filter surface
	• Remove erosion control stones prior to maintenance and appropriately replace them afterwards
	• Following mulch and debris removal, recharge Filterra® media (not top soil or other) if the distance between bottom of top slab and surface of filter media is greater than 0.30 m for a standard Filterra® and 0.25m for a shallow Filterra®. Recharge until this distance measures 0.3m for a standard Filterra® and 0.25m for a shallow Filterra®; i.e.0.23m/0.17m ponding (standard/shallow) topped with 75mm of mulch.
	• Replace mulch layer at a thickness of 75 mm at least every 6 months. Spread evenly across the entire unit to inhibit silt accumulation on the filter media surface.
	• Evaluate plant health, and prune the plant to promote appropriate growth or replace the plant if necessary
	• Clean area around unit and remove all refuse to be disposed of appropriately
	• Irrigate the system during dry periods to ensure survival of living elements

Access for cleaning	• Maintenance access to the device is by opening the tree grate • Only typical landscaping tools are required, including a rake, shovel and pruning tools • Appropriate Personal Protective Equipment (PPE) should be used in accordance with local or company procedures.

Appendix D Conditions of Proprietary Device Evaluation approval

Auckland Council approves the use of the Stormwater360 Ltd. Filterra® Filter for 75% TSS removal under the ALWP on private sites for a standard Filterra® Filter model and its GULD approved alternative configurations, provided that the project design is consistent with the following conditions:

1. Design and installation must be in accordance with the Auckland Council Filterra® System Practice Note. If conditions affecting operation or design parameters vary from those included in the consent application, or the requirements of the Filterra® System Practice Note are no longer met, an application for variation of consent must be applied for by the consent holder.
2. Owners/operators must submit a signed maintenance contract for the first three maintenance years.
3. Owner/operators must submit an initial maintenance plan for sites using the Filterra® System following the requirements outlined in the Auckland Council Filterra® System Practice Note and allowing for maintenance provisions and processes in accordance with the manufacturer's Filterra® System Operation and Maintenance Manual. Where specifications in the Auckland Council Filterra® System Practice Note vary to those in the manufacturer's Filterra® System Operation and Maintenance Manual, the Practice Note guidance takes priority. This initial maintenance plan must be approved by Auckland Council prior to the device becoming operational.
4. During the first year of operation, owners/operators must conduct inspections at a supplier specified initial maintenance frequency to determine the optimum inspection and maintenance schedule based on specific site characteristics. The owner/operator shall submit a final maintenance plan outlining long term routine inspection and maintenance requirements to Auckland Council for approval, with appropriate evidence from inspections during the first year of operation supporting the proposed long term routine inspection and maintenance frequencies.
5. The owner/operator must retain the following records and provide to Auckland Council at the end of each year of operation, for the life of the device.
    a. Signed records of inspections

b. Signed records of performed maintenance activities including photographs before, during and after maintenance and any other comments of relevance to the device.

Copy of current maintenance contract if renewed in the last 12 months