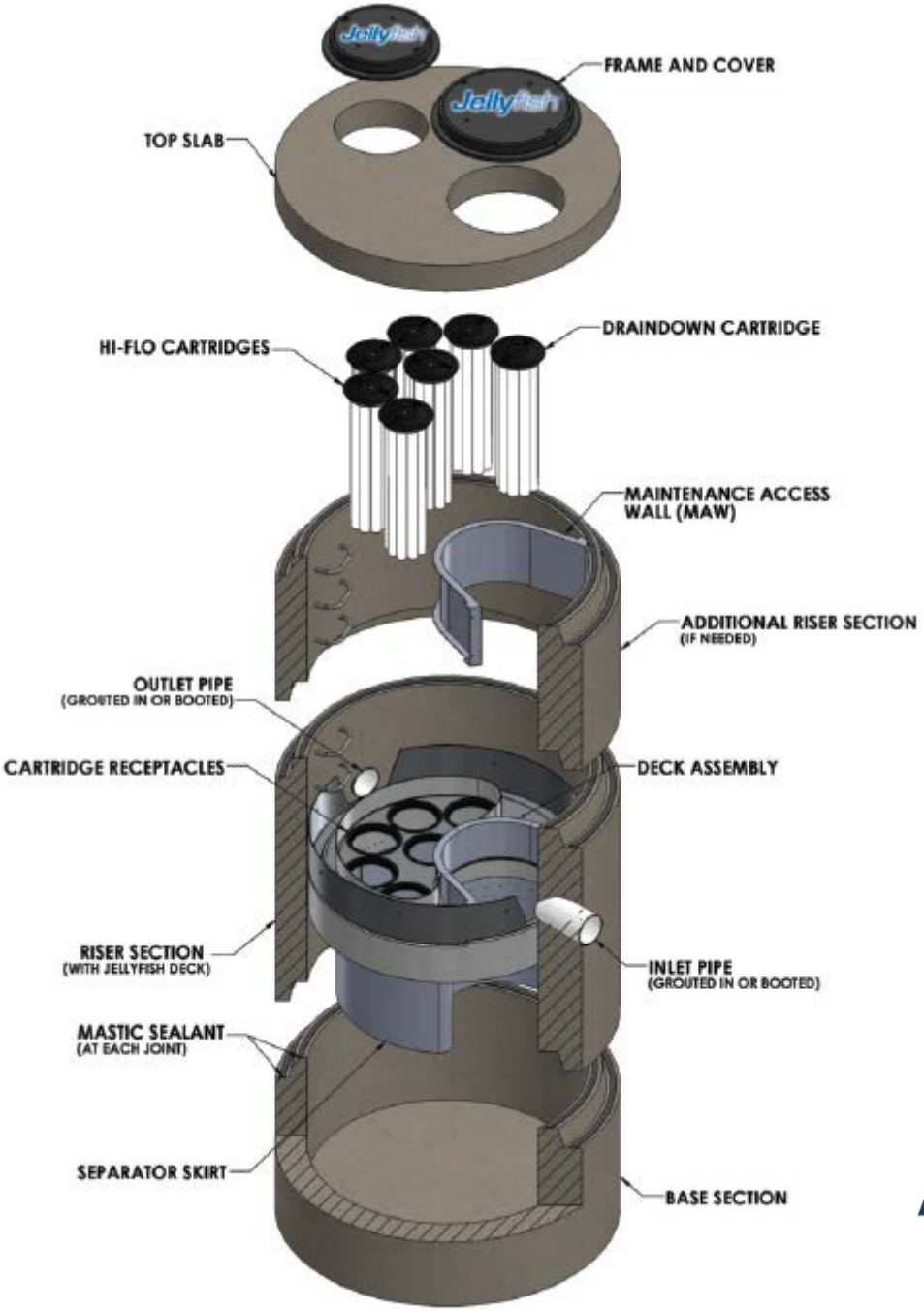
Stormwater360 Jellyfish® Filter Interim Proprietary Device Evaluation: Final June 2016



Auckland Council
Te Kaunihera o Tāmaki Makaurau

Reviewed for Auckland Council by
Name: Nick Vigar Position: Principal – Green Infrastructure Planning, Healthy Waters Date:
Approved for Auckland Council publication by
Name: Andrew Chin Position: Strategy and Resilience Manager, Healthy Waters Date:

Recommended citation:

Wells J, Clarke C, 2016, Stormwater360 Jellyfish® Filter: Interim Proprietary Device Evaluation, Prepared by Morphum Environmental Ltd for Auckland Council.

Executive Summary

Auckland Council Stormwater Unit (SU) 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 will be provided for a maximum period of 3 years and a review on the installation and performance of any devices installed is likely to be undertaken as part of any extension request. Auckland Council may amend, extend or revoke approval. Certifications 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 Stormwater Management Jellyfish® Filter (Jellyfish Filter) supplied by Stormwater 360. The Jellyfish Filter has a NJDEP Full Certification. Due to the small volume of certified field study data, additional data from an Australian interim field study was included in this evaluation to support confidence in the performance of the device and allow for performance comparison.

The evaluations are split into two parts, this report (part 1) summarises a review of the information provided to Morphum by Stormwater360 Ltd regarding the Jellyfish® Filter (Jellyfish Filter) system 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 Jellyfish Filter against the Proposed Auckland Unitary Plan (PAUP).

As a result of this review, we conclude that the Jellyfish Filter can be granted interim approval from the date of issue for use on private sites for offline configurations at 300-457mm of driving head with a standard 150mm backwash pool weir height. 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.

Table of Contents

List of Figures

List of Tables

1.0 Introduction

Auckland Council Stormwater Unit (SU) 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 will be provided for a maximum period of 3 years and a review on the installation and performance of any devices installed is likely to be undertaken as part of any extension request. Auckland Council may amend, extend or revoke approval.

This approval, if granted, does not extend to use on public sites, roads nor 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.

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.

The SU 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:

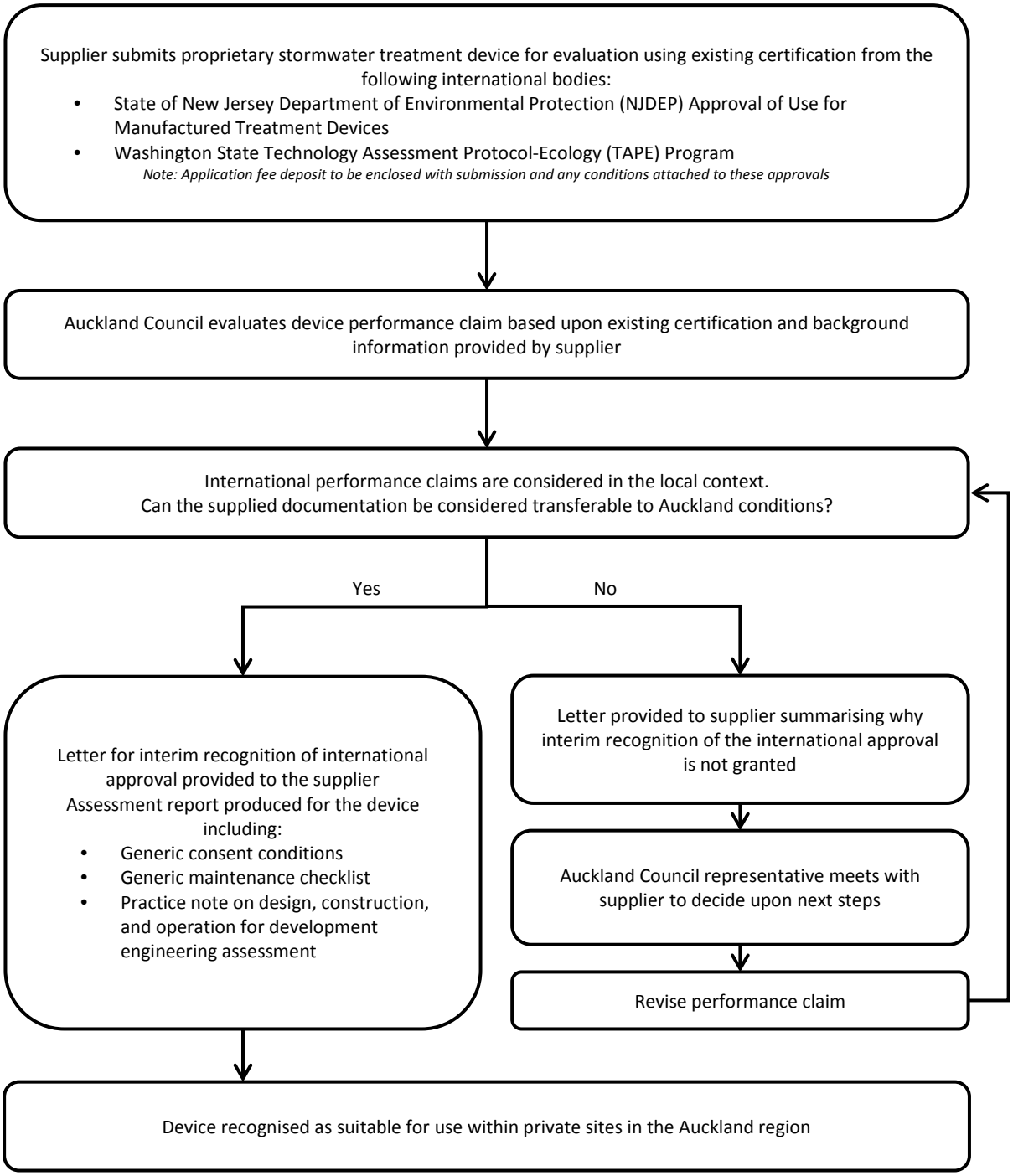
- State of New Jersey Department of Environmental Protection (NJDEP) Approval of Use for Manufactured Treatment Devices, and
- Washington State Technology Assessment Protocol-Ecology (TAPE) Program: General Use Level Designation (GULD) Approval.

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 1:1 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 Stormwater Management Jellyfish® Filter (Jellyfish Filter) supplied by Stormwater 360. 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.



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

Figure 1:1: Interim recognition of international approval flowchart

2.0 Device Description & Current Certifications

2.1 Description

The Jellyfish® Filter is described within manufacturer specifications as *an engineered Stormwater quality treatment technology featuring pre-treatment and membrane filtration in a compact stand-alone treatment system that removes a high level and wide variety of Stormwater pollutants.* Stormwater pollutants are removed *at high treatment flow rates with minimal head loss and low maintenance costs.* The lightweight Jellyfish cartridges filter the influent stormwater by providing *an extraordinarily large amount of membrane surface area, resulting in superior flow capacity and pollutant removal capacity.*

Stormwater typically enters the system into the height adjustable maintenance access wall zone via the inlet pipe, and is channelled through a large-diameter opening in the cartridge deck into the lower (treatment) chamber. The large opening and change in flow direction attenuate the inflow velocity. Water entering the chamber spreads slowly in a lateral and downward direction throughout the pre-treatment channel, further reducing the average flow velocity and enhancing separation of pollutants into the high-volume sump. Floatables rise to the surface with some being trapped beneath the cartridge deck and the majority accumulating in the maintenance access wall zone. A separator skirt creates a filtration zone around the cartridge tentacles and protects them by trapping oil and floatables outside.

The pre-treated water then flows beneath the large opening in the bottom of the separator skirt and upwards into the filtration zone, further reducing the average flow velocity and enhancing pollutant separation (generally trapping < 50 microns). As water flows upwards in the filtration zone, the membrane of each filtration tentacle filters out fine suspended particles and particulate-bound pollutants like nutrients, toxic metals, hydrocarbons, and bacteria. As the filtered water passes through the membranes, it enters a perforated centre tube and flows upward and out of the top opening of each filtration tentacle. Flow exiting from each tentacle combines under the cartridge lid and exists through the hi-flow cartridge lid orifice. The combined treated water from the hi-flo cartridges is contained by a height adjustable backwash pool weir, providing driving head.

When the storm event subsides, the driving head in the backwash pool decreases, reverses the flow direction back into the treatment chamber, and water is displaced through the draindown cartridge(s) located outside the backwash pool. As water exits through the

draindown cartridge(s), it is channelled along the cartridge deck to the effluent pipe. For inflow events with a driving head that exceeds the maximum backwash pool weir height, the water is treated through the hi-flo cartridges, overtops the weir and spills onto the cartridge deck flowing towards the effluent pipe.

The system comprises a self-cleaning mechanism. From the reversed flow back into the treatment pool, the system automatically passively cleans the membrane surfaces of the hi-flow cartridges, removing accumulated sediment from the membrane surfaces and significantly extending their service life and maintenance interval. The self-cleaning mechanism occurs at the end of each runoff event and can also occur multiples times during a single storm event as the rainfall/runoff intensities and driving head varies. Cartridges can also be manually backwashed while installed or be removed and externally rinsed. The multiple options for hi-flo cartridge cleaning minimise cartridge replacement costs and life-cycle treatment costs while ensuring long-term treatment performance.

Draindown cartridge(s) are not passively backwashed. A flow control orifice in the draindown cartridge lid controls the design flow rate to one-half the design flow rate of a hi-flo cartridge of similar length, and thereby reduces the likelihood of occlusion prior to scheduled maintenance.

The Jellyfish system can be designed in various configurations, summarised below:

- The Jellyfish cartridges are designed as either a hi-flo or draindown cartridge and are available in various lengths and flow ratings.
- Inflow can be above the cartridge deck (invert elevation of inlet pipe typically 150 mm above the invert elevation of the outlet pipe) or below the cartridge deck (invert elevation of inlet pipe typically 600 mm below the invert elevation of the outlet pipe). But for either the invert elevation of the outlet pipe is identical to the cartridge deck elevation
- Wide range of angles available between the inlet and outlet pipe, with the inlet pipe being able to be anywhere about the circumference of the structure. Offline configurations typically have an inlet to outlet separation angle of 90 to 120 degrees (table for min separation angle for standard manhole configurations with an above deck inlet pipe available in Technical manual Table 3)
- System can have multiple inlet pipes within certain restrictions
- System can be built at all depths of cover generally associated with conventional stormwater conveyance systems

- Systems can be designed with an external or internal bypass. NJ certification requires the system to be constructed as an offline system, and thus only data from offline system configurations are discussed and analysed
- The system is available in two standard inlet chamber configurations, curb inlet and grated inlet, which can replace conventional storm inlets in retrofit applications. Both configurations use the shorter 686 mm cartridge length and require minimal cover.

Only relevant data was included for analysis and was derived from field testing performed at the University of Florida campus and at the Ipswich commercial facility. The device configurations used within the field testing are summarised in Table 2-2.

The technology physical description treatment mechanism 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 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 were 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, subjected 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.

The Jellyfish Filter currently holds the following certification:

- State of New Jersey Department of Environmental Protection (NJDEP)Certification
    - Superseded Laboratory Test Certification for 80% TSS removal (Expired: 1/09/2013)
    - Field Test (Full) Certification for 80% TSS removal (Expires: 1/12/2016) subject to conditions summarised in Table 2-1
- Washington State Department of Ecology ('Ecology') Certification
    - CULD for basic TSS removal (Expires 30/6/2017)
    - PULD for phosphorous removal and oil treatment (Expires 30/6/2017)
- The Jellyfish Filter further holds approvals from other state and federal verification programs not considered within this report.

While the Jellyfish Filter holds NJDEP Laboratory (Interim) certification and Washington CULD and PULD certifications, only the NJDEP Field Certification (Full) and Washington GULD are considered for the Auckland Council Interim Approval Assessment. The reason being, that interim and provisional certifications allow a device to carry out field testing meeting requisite assessment protocols. Since Auckland does not currently have an active field testing protocol, these certifications are not suitable for use in Auckland.

At the time of the report, the Jellyfish Filter did not have GULD certification, and therefore performance data from only one field study, within the above stated certification criteria, was available for performance assessment. To support confidence in the performance of the device and allow for performance comparison, additional data from another field study outside New Jersey and Washington State was included in analysis.

The additional field study was performed by the Queensland University of Technology (QUT) in Ipswich, Australia. The study reported initial findings only and has not been independently assessed. However, results were deemed comparable for performance assessment, since the interim field study confirmed that:

- the monitored rainfall events were representative for typical Brisbane rainfall events and comparable with the events monitored in the Florida, New Jersey field study;
- the monitored TSS inflow water quality data was representative to the expected Brisbane water quality characteristics, and comparable to TSS concentrations in Florida, New Jersey;
- the Ipswich study used a similar Jellyfish Filter configuration, summarised in Table 2-2.

NJDEP Field Certification (Full) is summarised in Table 2-1 and can be found in full in Appendix B.

Table 2-1 Summary of New Jersey Department of Environmental Protection Certification for the Jellyfish Filter

Criteria	**NJDEP Field Test**
Expiration date	1 Dec 2016
Treatment performance	80% TSS removal
Design storm is the Water Quality Design storm	31.75mm/2hrs
Maximum peak inflow of the WQ storm per inch of cartridge length[1]	Hi-flo: 1.48 GPM (0.09 lps) Draindown: 0.74 GPM (0.05 lps)
Maximum impervious inflow drainage area per inch of cartridge length	Hi-flo: 0.012 acres (48.6 m^2) Draindown: 0.006 acres (24.3 m^2) This is superseded in Auckland by the Initial Maintenance frequency estimate undertaken by Stormwater360 (Section 0).

Criteria	NJDEP Field Test
Additional Conditions	- Tentacles are a minimum of 600 mm (2ft) above the bottom of the vault - The minimum sedimentation area of the vault is 0.37m^2 per cartridge - Certified as an offline system only - System cannot be used in series with a settling chamber or a media filter for enhanced TSS removal under N.J.A.C. 7.8 – 5.5 - Minimum maintenance requirements are listed in Table 6-1 and Appendix C
1 The maximum inflow rate is based on a standard (457mm) driving head. The effect of driving head on design flow rates is discussed in Section 4.1.3	

2.3 Testing & Performance

Field studies provide the basis of current final Jellyfish Filter certifications from Washington and New Jersey. Since the Jellyfish Filter has not, at the time of this report, received GULD certification from Washington, only data from field testing from the New Jersey field study has been used for assessment. However, due to the limited available performance data (only one study within the certification criteria), additional performance data from an interim field study in Ipswich, Australia was included in performance evaluation.

Table 2-2 summarises Jellyfish Filter performance from the New Jersey independently certified field study and the Ipswich Interim field study. Results from the former study were undertaken to confirm the manufacturer's performance claim, whilst the latter was undertaken to verify the unit performance under South East Queensland (SEQ) climatic conditions. Results from both field studies provide the basis for comparison for Jellyfish Filter use in an Auckland context (Section 3.0).

Table 2-2 International field test studies demonstrating Jellyfish Filter performance

	New Jersey[1]	**Ipswich, Australia**
Location	University of Florida campus	Commercial facility at 292 Brisbane Street, Ipswich
Site land use	Asphalt paved car park incl. raised vegetated islands, approx. 75 % imperviousness	Roof, driveway and parking lost, 100 % imperviousness
Monitoring period	13 month between the 28/5/2010-27/06/2011	5 month between 28/06/2014-6/11/2014
# Events[4]	25 events with 381 mm of cumulative rainfall depth and a medium rainfall intensity of 51 mm/hr.	7 events with 69.2 mm of cumulative rainfall depth and a medium rainfall intensity of 19 mm/hr.
Jellyfish Filter model	US standard JF1219-2-1 including 2x Hi-Flo and 1x Draindown cartridges of standard length	JF1000-2-1 including 2x Hi-Flo and 1x Draindown cartridges of standard length
Filtration flux rate	Hi-flo: 0.14 lps/m^2 Draindown: 0.07 lps/m^2	Hi-flo: 0.14 lps/m^2 Draindown: 0.07 lps/m^2
Maximum Design Flow rate	200 GPM (12.6lps)	200 GPM (12.6lps)
System sedimentation area	0.37 m^2 per cartridge	0.25 m^2 per cartridge[5]
Compliance	TARP[2] Protocol for Stormwater Best Management Practice, and VTAP[3] field test protocols	Not independently verified, Rainfall events qualified based on 2 criteria: minimum of 3 antecedent dry days, minimum of 2.6mm rainfall
Outcome	NDEP certification	
Treatment results	99% SSC removal efficiency 89% TSS removal efficiency 90% of Total Copper removal efficiency 70% of Total Zinc removal efficiency 59% of Total Phosphorous removal efficiency 51% of Total Nitrogen removal efficiency	89% TSS removal efficiency 68% Total Copper removal efficiency 86% Total Zinc removal efficiency 65% Total Phosphorous removal efficiency 55% Total Nitrogen removal efficiency

	New Jersey[1]	**Ipswich, Australia**
Additional comments	- The test unit: • used second generation filtration cartridges • was installed above ground but on the hillside just below the catchment area • was configured with a below deck inlet pipe and deflector plate • used a circular maintenance access pipe. This design was later replaced with a horseshow-shaped maintenance access wall • contained a pressure relief pipe that could potentially function as an internal bypass, but was rendered non-functional due to the installation of an external bypass • storms generating flows that exceeded the maximum driving head were bypassed to a downstream drop box where effluent samples were taken - No maintenance was required or conducted during the test range - Samples of the whole influent and effluent flows were collected manually, providing a more accurate representation of the actual pollutant load transported in the runoff	- The test unit: • was configured with an above deck inlet pipe • used a horseshow-shaped maintenance access wall • was installed as an offline system with high-flow bypass - Maintenance requirements were not reported within the Interim field monitoring report - Sampling was conducted upstream and downstream of the device. The upstream station was fitted with a flow measuring device and automatic sampling station. The downstream station had an automatic sampling collection system.
1. Results from this independently certified study conform to the respective study protocols, providing robust data that has been verified by an independent organisation. 2. Technology Acceptance and Reciprocity Partnership 3. Virginia Technology Assessment Protocol 4. Only events qualifying for evaluation, additional events may have been recorded during each study. Criteria for qualifying events varied between the studies, with criteria for the NJ study meeting TARP and VTAP guidelines and the latter being based on ensuring representative rainfall and pollutant contributions from the site. 5 The per cartridge sedimentation area for the Ipswich Jellyfish Filter configuration is below the required 0.37m^2 NJDEP minimum. Expected implications are discussed in Section 4.2 and Section 4.4.		

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 international field study (Table 2-2) to the Auckland context. The PSD of stormwater runoff (influent) in the field study was compared to example PSDs for the Auckland region in order to assess the likely performance of the Jellyfish Filter in an Auckland context (Figure 3:1).

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 3:1 demonstrates the variation of Auckland stormwater PSD dependant on catchment location in relation to the event based influent particle distribution measured at the University of Florida campus (UF) and Ipswich Queensland University of Technology (QUT) site. Table 3-1 compares the d_{10}, d_{50}, and d_{90} values for the field studies and Auckland data, showing the measurements of the three Auckland data sets to be largely within the range of the event based measurements from the field studies.

Whilst the New Jersey study largely had a coarser than Auckland influent PSD, the Ipswich study largely had a finer than Auckland influent PSD. Despite this, both study devices met the ALWP requirement (see Section 3.2) and achieved similar TSS removal rates (discussed in Section 3.2). This indicates the device's capability to remove particles across a large range of particle size distribution and suggesting performance in an Auckland context will be comparable.

The New Jersey and Ipswich field study test results are considered applicable in an Auckland context based on particle size distribution.

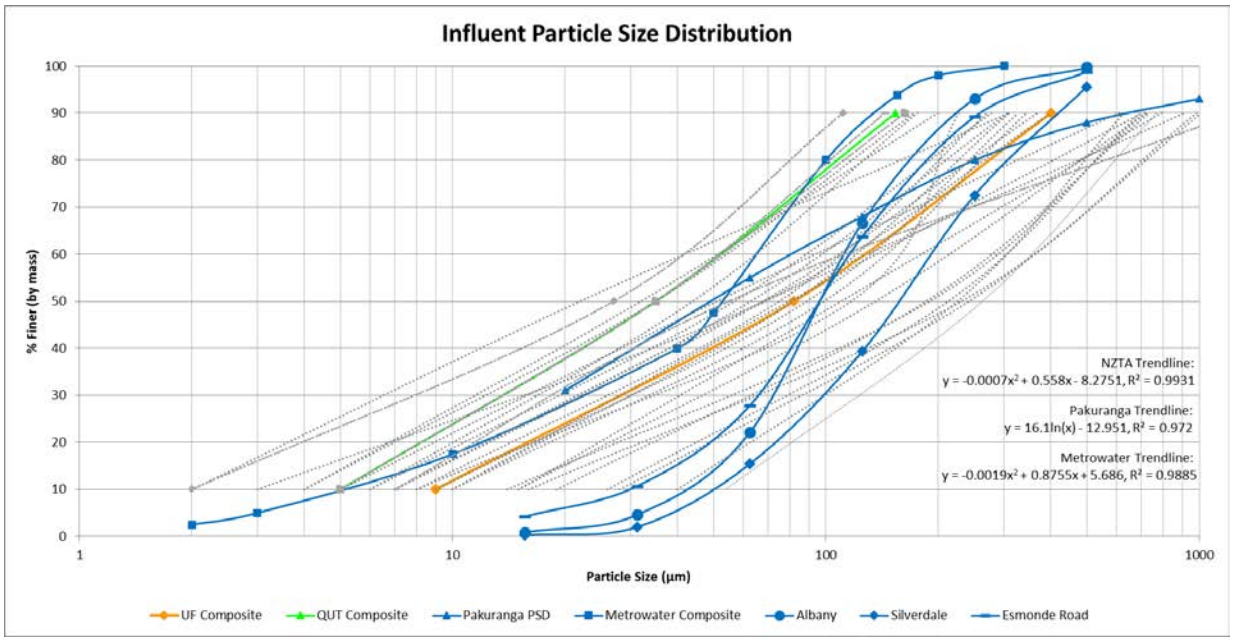


Figure 3:1 Particle size distribution of suspended solids in stormwater runoff

Table 3-1 Comparison of % finer by mass

% Finer by mass	**Median Influent PSD (µm)**		
	d_{10}	d_{50}	d_{90}
UF Field Test[1]	9 (2-54)[2]	82 (22-263)[2]	401 (173-1016)[2]
QUT Field Test[1]	5 (2-7)[2]	35 (27-55)[2]	154 (111-1260)[2]
Pakuranga PSD[3]	4	50	599
Metrowater Composite[3]	5	58	137
NZTA Composite[3]	34	124	263
1 Median influent PSD. 2 Range of influent particles sizes monitored over 25 and 4 storm events for the NJ and Ipswich study respectively. 3 The d_{10}, d_{50}, and d_{90} values for the Auckland data were calculated from the best fit line for each data set shown on Figure 3:1.			

3.2 Performance relative to ALWP

Stormwater treatment devices in Auckland are currently required by Air, Land and Water Plan (AWLP) to achieve 75 percent of TSS removal on a long term average basis (ARC, 2003). TSS removal performance was assessed from the independently certified field study utilised for the New Jersey approval and from the Ipswich interim field monitoring study (Table 2-2). Results from both studies are summarised in

Table 3-2. The observed inflow concentrations ranged between 16.3 mg/L to 261 mg/L for the New Jersey study and between 19 mg/L to 180 mg/L for the Ipswich study. The minimum

and maximum removal performance for all 32 qualifying storm events were 71% and 99% respectively. The medium TSS removal performance for both studies was 89% and only four of the 32 qualifying storm events were below but close to 75 % TSS removal, deemed to meet the AWLP requirement. TSS removal performance is expected to be similar for the Auckland context, given:

- the Auckland PSD is within range of the field study PSDs,
- the expected pollutant loads in Auckland are similar to those observed for the Ipswich study, and
- the lower Auckland rainfall intensity compared with both field studies.

Both studies also monitored removal performance of other water quality parameters, but as there is currently no performance standard for these within Auckland, results were not assessed within Part 1 of the Interim Recognition Report.

The Jellyfish Filter is available in various configurations (described in Section 2.1). Analysis of performance variations was limited, due to only 2 field studies being available for interim recognition. Both studies monitored a Jellyfish Filter with 2 hi-flo and 1 draindown cartridge of standard length, albeit with varying inlet configuration (above and below deck) and varying manhole size (1218 mm and 1000 mm). Due to the interim field study having only 5 months of performance data, the effect of the reduced sump volume (discussed in Section 4.1) is unclear at this stage. However, it is expected that the device will require increased maintenance under the same loading or performance results may reduce between maintenance intervals. It will be of value to assess the effect on performance and maintenance where the minimum sedimentation area criteria was not achieved at a later point; however design of Jellyfish Filter configurations in Auckland should follow design as discussed in Section 4.0.

Table 3-2 Comparison of percent load reduction and median effluent levels against AWLP requirement

Location	**New Jersey**	**Ipswich**
Device	US standard JF1219-2-1, standard length	JF1000-2-1, standard length
TSS[1]	88 %	89 %
1. Load reduction efficiency weighted by EMC		

4.0 Device Sizing – Jellyfish Filter

The Jellyfish Filter is sized based on the specified design treatment flow rate, anticipated sediment mass load that will enter the system, and the required pollutant storage capacities.

The design treatment flow rate, sediment mass loading capacity and cartridge weight vary with the cartridge length.

4.1 Flow based sizing

In the Auckland context, stormwater devices sized using flow based methods must provide a peak flow rate calculated 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 Jellyfish Filter, 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).

$$Q_d = CiA_C \qquad \text{Equation E 1}$$

Where

Q_d is the water quality flow in m³/h requiring treatment,

C is the runoff coefficient derived as outlined below,

A_c is the catchment area in m², and

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

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

4.1.1 Jellyfish filter sizing

The system size and number of cartridges required varies with the driving head (discussed in Section 4.1.3) and the length of cartridges. The design flow rate is based on the design flux rate discussed in Section 4.1.2.

For flow based sizing, the sum of the product of the maximum treatment flow rate (design flow rate) for each cartridge type and the selected number of respective cartridges types is determined to achieve the target water quality treatment rate.

$$Q_{HF} x\, N_{HF} + Q_{DD} x\, N_{DD} \geq WQF \qquad \text{Equation E 2}$$

where

Q_{HF} is the design flow rate for the hi-flo cartridge at a given cartridge length and driving head, see Table 4-3 and Table 4-5 (lps)

N_{HF} is the number of hi-flo cartridges

Q_{DD} is the design flow rate for the draindown cartridge at a given cartridge length and driving head, (see Table 4-3and Table 4-5 (lps)

N_{DD} is the number of draindown cartridges

WQF is the target water quality treatment rate for the site (lps), see Equation E 3

The design flow rate for each cartridge type is calculated as the maximum peak inflow per cartridge type (Table 4-2) for each inch of cartridge length at a given driving head. Design flow rates for typical cartridge lengths are summarised in Table 4-3 and Table 4-5 .

Table 4-2 maximum peak inflow per inch cartridge type

Driving head (mm)	Hi –flo	Draindown
457	1.48 GPM (0.094 lps)	0.74 GPM (0.047 lps)
305	0.89 (0.056lps)	0.52 (0.033 lps)

To suit Auckland typical manhole sizes, Stormwater360 proposed Jellyfish Filter units varying in diameter from those listed the USA and Australia. Table 4-4 lists typical Jellyfish Filter configurations available in Auckland and their respective maximum treatment flow rates (MTFRs) based on a standard length cartridge. Table 4-4 can be used as a quick reference for checking the selected system configuration achieves the target water quality treatment flow rate. Other manhole configurations or sizes were not included in the review. Any other configurations would need to meet the sizing criteria outlined in this report. The MTFRs for the same Jellyfish Filter configurations with differing cartridge lengths and/or driving head can be determined using Equation E 4.

Although online Jellyfish configurations exist, they were not included in the review, due to the device, at the time of the report, being certified as an offline system only. Typical New Jersey unit configurations are listed in Appendix B, whilst the Jellyfish Filter configuration currently tested in Australia is detailed in Table 2-2.

Custom designs are available for when the water quality treatment flow rate exceeds the total design flow rate of the largest standard Jellyfish Filter model. Here multiple Jellyfish Filters can be hydraulically connected in parallel or larger than currently listed standard Auckland Jellyfish Filter configurations (Table 4-4) be selected, which meet the sizing criteria outlined within this report.

Table 4-3 Standard Jellyfish cartridge hydraulic loading rates

Cartridge length mm (in)	**Per cartridge Design Treatment Flow Rate[1,2] (Lps)**	
	Hi –flo	**Draindown**
381 (15)	1.4	0.7
686 (27)	2.5	1.3
1016 (40)	3.8	1.9
1372 (54)	5.0	2.5
1 The design flow rates (also called Maximum Treatment Flow Rate, MTFR) are based on 457mm of driving head, rounded to 1 SF. Refer to Table 4-5 to calculate system flow rates for different driving heads. 2 The total design treatment flow rate for a system configuration is established as sum of the respective design flow rates for each cartridge type multiplied by its number of cartridges.		

Table 4-4 Design flow capacities for standard Auckland Jellyfish Filter offline configurations

Manhole dia[1] (mm)	Model No.	Hi-flo cartridges (No)	Draindown cartridges (No)	System MTFR[2] (GPM/Lps)
1050	JF1050-1-1	1	1	120 / 7.5
1200	JF1200-2-1	2	1	200 / 12.5
1800	JF1800-3-1	3	1	280 / 17.5
	JF1800-4-1	4	1	360 / 22.5
	JF1800-5-1	5	1	440 / 27.5
	JF1800-6-1	6	1	520 / 32.5
2300[3]	JF2300-6-2	6	2	560 / 35
	JF2300-7-2	7	2	640 / 40
	JF2300-8-2	8	2	720 / 45
	JF2300-9-2	9	2	800 / 50
	JF2300-10-2	10	2	800 / 50
3000[4]	JF3000-10-2	10	2	880 / 55
	JF3000-11-3	11	3	1000 / 62.5
	JF3000-12-3	12	3	1080 / 67.5
	JF3000-13-3	13	3	1160 / 72.5
	JF3000-14-3	14	3	1240 / 77.5
	JF3000-15-3	15	3	1320 / 82.5
	JF3000-16-3	16	3	1400 / 87.5
	JF3000-19-4	19	4	1400 / 87.5
3600[4]	JF3600-17-4	17	4	1520 / 95
	JF3600-18-4	18	4	1600 / 100
	JF3600-19-4	19	4	1680 / 105
	JF3600-20-4	20	4	1760 / 110
	JF3600-21-4	21	4	1840 / 115
	JF3600-22-4	22	4	1920 / 120
	JF3600-23-4	23	4	2000 / 125
	JF3600-24-4	24	4	2080 / 130
	JF3600-27-5	27	5	2080 / 130
Vault[5]		varies	varies	Varies

Manhole dia[1] (mm)	Model No.	Hi-flo cartridges (No)	Draindown cartridges (No)	System MTFR[2] (GPM/Lps)

1 Smaller and larger systems may be custom designed.
2 MTFRs are based on standard cartridge length, 1372 mm and a standard driving head (457mm). The design engineers has to determine the system MTFR using Table 4-5 and Equation E 5 for varying cartridge length and driving head configurations.
3. The MTFR for the 2300mm diameter unit occurs with the JF2300-9-2 model. This leaves one unoccupied hi-flo cartridge receptacle. Designers may add one more hi-flo cartridge (JF2300-10-2) for increased sediment capacity; however its MTFR should not exceed that of the JF2300-9-2 unit.
4. The MTFR for the 3000mm and 3600mm diameter unit occur with the JF3000-16-3 and JF3600-24-4 models respectively. This leaves 4 unoccupied hi-flo cartridge receptacles for each manhole configuration. Designers may add up to three hi-flo and one draindown cartridges to increase system sediment capacity; however their MTFRs should not be greater than that of the JF3000-16-3 and JF3600-24-4 model respectively.

5. The Jellyfish Filter vault configuration is custom designed. Its MTFR occurs when the sedimentation surface area is reduced to 0.370 m^2 per cartridge. The design engineer has the option to add additional cartridges to increase the mass load capacity of the system.

4.1.2 Design membrane filtration flux rate

The design membrane filtration flux rate, also known as specific flow rate or hydraulic loading, is the design flow rate through the surface area of the filter. The flux rate influences contaminant removal and occlusion of the filter surface. Contact time and thus contaminant removal increases with a lower flux rate. The rate of occlusion decreases for lower flux rates, as the velocity of water passing through the filter is lower.

The maximum design treatment flow rate (MTFR) is controlled by an orifice in the cartridge lid and is based on the design flux rate. The maximum cartridge flux rate is 0.14 lps/m^2 for the hi-flow cartridge and 0.07 lps/m^2 for the draindown cartridge, and need to be checked for devices with cartridge and driving head configurations different to those listed in Table 4-5.

4.1.3 Driving head requirement

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.

For systems with an external bypass with an upstream diversion structure or the bypass diversion included in a vault system, the design driving head associated with the design flow

rate is established from the elevation difference between the top of the upstream diversion structure weir and the invert of the Jellyfish Filter outlet pipe.

Inflow events with a driving head ranging from less than 25 mm up to the maximum design driving head causes continuous forward flow and filtration treatment through the draindown cartridge(s). For inflow events where the driving head exceeds the height of the backwash pool weir height (typically 150 mm), continuous forward flow and filtration treatment is through the hi-flo cartridges.

A minimum driving head is selected to achieve the design flow rate, while accounting for gradual increase in system head loss at the design flow rate due to long-term accumulation of sediment on the filtration membranes. A clean cartridge has a flow capacity far in excess of the design flow rate at the design driving head. This ensures that the design flow capacity is maintained in between maintenance service operations

The typical minimum design driving head is 457mm, and varies with specific site requirements. New Jersey certifies systems with a driving head ranging between 300-600mm. However design flux rates at driving head configurations greater than 457mm using a standard backwash pool weir height and cartridge orifice dimensions, would exceed the maximum stated in Section 4.1.2, and thus are not approved.

Design flow rates for varying driving head applications are summarised in Table 4-5. These were established based on the hydraulic testing conducted on standard hi-flo and draindown Jellyfish Filter cartridges at the University of Florida, demonstrating the cartridge flow capacities at varying driving heads. Results demonstrate how the hi-flo and draindown cartridge flux rates decrease with decreasing driving head and stay below the design flux rates discussed in Section 4.1.2, thereby maintaining design performance.

Table 4-5 Relationship between the net driving head and flow rate for a standard cartridge

Head[1] (mm)	Backwash pool height (mm)	Cartridge length	HF design flow rate[2]		DD design flow rate[2]		Filtration surface area (m2)	Flux rate (lps)[2]	
			gpm	lps	gpm	lps		HF	DD
457	150	1372	80	5.0	40	2.5	35.4	0.14	0.07
		1016	59	3.8	30	1.9	26.2	0.14	0.07
		686	40	2.5	20	1.3	17.7	0.14	0.07
		381	22	1.4	11	0.7	9.8	0.14	0.07
305	150	1372	48	3.0	28	1.8	35.4	0.09	0.05
		1016	36	2.3	21	1.3	26.2	0.09	0.05
		686	24	1.5	14	0.9	17.7	0.09	0.05
		381	13	0.8	8	0.5	9.8	0.09	0.05

1 New Jersey approved driving heads. 2 Design flux rates are equal or below the respective maximum cartridge flux rates stated in Section 4.1.2. New Jersey certifies systems up to a 600 mm driving head, however design flux rates at the standard backwash pool height exceeds the maximum per cartridge flux rate, and thus were not included.

The Jellyfish Filter system capacity for varying driving head and backwash pool weir height applications are calculated as described in Section 4.1

For systems that experience submerged or backwater conditions due to dry weather, base flow or tidal effects, driving head calculations must account for water elevation during the backwater conditions and must remain within approved design limits. The Jellyfish Filter will continue to operate during forward flow despite backwater conditions, but the maintenance access wall height may need to be increased to ensure floatable capture and the backwash weir height may need to be increased to ensure function of the automatic passive backwash feature.

4.2 Initial Maintenance Frequency Estimate

Stormwater360 has proposed an initial maintenance frequency to provide an initial inspection frequency and give some guidance for mass load design.

4.2.1 Part 1: Initial Maintenance Frequency Estimate

The method proposed by Stormwater 360 gives an estimate for the maintenance frequency of selected filter cartridges, and takes into account the catchment pollutant load and cartridge capacity. This estimate will need to be verified and updated through field testing and maintenance records that will be provided to Council through the consent conditions."

Stormwater 360's Initial Maintenance Frequency Estimate is based on more than 12 years' experience in estimating the sediment load in Auckland with the design of the StormFilter proprietary device and historically has provided a conservative estimate of maintenance frequency when compared to field monitoring results. Field monitoring is required to confirm the proposed alternative method and its assumptions.

Step 1: Determine expected annual mass load

Determine the annual mass load expected off the site (M_{total}) using the estimated contaminate loads for differing land uses from Table 4-6 and multiplying by the catchment area:

Table 4-6 Estimated Loading rates (T.P.10)

Land use	TSS (kg/ha/yr)
Road	281 - 723
Commercial	242 - 1369
Residential (low)	60 - 340
Residential (high)	97 - 547
Terraced	133 - 755
Bush	26 - 146
Grass	80 - 588
Roof	50-110
Pasture	103 - 583

Step 2: Determine the pretreatment removal efficiency and mass load reduction
Determine the pretreatment removal efficiency ($E_{pre)}$ provided by external pretreatment structure. Pretreatment removal credit can be used up to a maximum of 50 percent. Pretreatment performance must be verified.

When the pretreatment removal efficiency is known, calculate the mass removed by the pretreatment system ($M_{pre)}$ and deduct it from the annual mass load to determine the mass load passed on to the filters (M_{pass1})

$M_{pre}= (E_{pre})*(M_{total})$, and
$M_{pass1}= (M_{total}) - M_{pre}$

Step 3: Determine mass removal target

Estimate the filter efficiency (E_{filter}), required to meet the overall system efficiency target, and the mass to be removed by the cartridge filters (M_{filter}).

$$M_{filter} = (E_{filter})*(M_{pass1})$$

Step 4: Determine load capacity of filters
Calculate the total load capacity of the proposed Jellyfish filter (LC_{Filter}) by adding the load capacity for the number of Hi flo (HF) and drain down (DD) cartridges in the device. Table 4-7 lists this load capacity of different cartridge sizes. Stormwater360 recommends that an 80% safety factor be applied to synthetic sediment mass load testing.

$$LC_{Filter} = 0.8 \times ((\#HF\ Carts\ X\ LCHF) + (\#DD\ Carts \times LCDD))$$

Table 4-7 Loading capacity of Jellyfish Filter cartridges

Cart length (mm)	Filter cartridges loading capacity (kg)	
	HF	DD
380	15.9	7.7
684	28.6	14.1
1014	42.2	20.9
1368	56.7	28.6

Step 5: Determine the maintenance frequency of the Jellyfish filter cartridges

Determine the estimated maintenance frequency using the mass captured by the filter annually (M filter) to determine the estimated maintenance frequency as follows:

Estimated maintenance frequency = LC (Filter)/ M_{filter}

Where the estimated maintenance frequency is less than 12 month, additional Jellyfish Filter cartridges may be used to increase sediment capacity. Alternatively additional inspections and maintenance activities may be required.

4.2.2 Part 2: Check on per cartridge sedimentation area

Once the required unit size and number of cartridges has been established following sizing as outlined in Section 4.1 and Section 0, the per cartridge sedimentation area for the selected unit must be checked. NJDEP requires a minimum per cartridge sedimentation area of 0.37m^2. It is calculated by dividing the minimum sedimentation capacity for each unit diameter (Table 4-8) with half the minimum sump depth of 600 mm and the total number of cartridges. The minimum provided sump depth assumes half of the provided sump to be filled with sediment.

The minimum per cartridge sedimentation area sets the system MTFR, as discussed in Table 4-4. This results in larger units having unoccupied cartridge receptacles in the cartridge deck. Design engineers may use additional cartridges for increased sediment mass load capacity; however the system MTFR, used to check against the target water quality treatment rate, must not be exceeded.

Table 4-8 Design sediment capacity for typical Auckland Jellyfish Filter manhole configurations

Model Diameter (m)	Max #. Of cartridges available[2]	Sediment capacity[1] (L)	Sedimentation area per cartridge (m^2)
1050[2]	2	255	0.42
1200	3	340	0.35[3]
1800	7	765	0.35[3]
2300	11	1246	0.38
3000	19	2152	0.37[3]
3600	28	3087	0.36[3]
Vault	Varies	Varies	Varies[4]

1. Sediment capacity is based on a 600 mm (2ft) sump depth and assumes 305mm of sediment depth in the sump. Systems may be designed with increased sediment capacity. 2 This is the maximum allowable number of cartridges that achieves the minimum NJDEP per cartridge sedimentation area. The 2300mm, 3000mm, and 3600mm diameter manhole configurations have unoccupied cartridge receptacles within the cartridge deck, that may be used for increased mass load capacity. Where more cartridges are used, designers must check the respective MTFRs (Table 4-4) are not exceeded. 3 Although the calculated per cartridge sedimentation area is below the NJDEP minimum, the values are within 7 percent of the requirement, and were regarded suitable for the Auckland region. 4. The sedimentation area in a vault configuration sets the MTFR of the unit as it is reduced to 0.370 m^2 per cartridge. More cartridges may be used for increased mass load, but the system MTFR should not be exceeded.

Design requires establishing the balance between site constraints, unit dimensions and filter cartridge selection required to treat the target WQF and site sediment loading. For example, a smaller unit with longer length cartridges may results in a greater system MTFR and total load capacity compared with a larger unit with shorter length cartridges. In addition, increasing the driving head for a system with the same unit diameter and cartridge number and length, results in an increased MTFR but the same sediment load capacity.

Design should select an appropriate combination of the approved driving head, unit diameter (limiting the number of cartridges) and cartridge length, which results in a Jellyfish Filter system that achieves and closely matches the target WQF and site sediment loading to avoid under/oversizing and keeping within design limits such as the maximum per cartridge drainage area and minimum per cartridge sedimentation area.

4.3 Sizing for retention or detention

A Jellyfish Filter provides minimal volume storage, but can be installed downstream of a detention facility. In such cases the Jellyfish Filter receives a relatively low flow rate (orifice-controlled release flow rate) from the detention facility compared to flow rates that would be treated if the Jellyfish Filter received the site runoff directly. In such cases, design of the Jellyfish Filter and the required number of filter cartridges is typically based on the projected annual sediment mass load (see Section 4.2) transported to the device. The maximum flux must also be maintained to below those specified in Section 4.1.2.

The Jellyfish Filter does not provide retention by the system alone, but may be installed upstream of a retention device. Levels and potential backwater effects must be checked and accounted for in driving head calculations. Driving head and design flow calculations must remain within the approved limits listed above.

4.4 Comparison with overseas studies

The design approach of stormwater treatment devices in New Jersey and Ipswich vary. While New Jersey uses a design storm for device sizing, Ipswich uses a continuous simulation model (MUSIC).

The Jellyfish Filter has been certified using a design storm (16mm/hr) sizing approach, however the field test results used for certification based the Jellyfish Filter size on historical rainfall data monitored at the field test site, rather than the New Jersey design storm. The historical data showed 2 out of 15 monitored storm events generated peak runoff flow rates that exceeded 200 GPM. Subsequently a Jellyfish Filter model with a maximum treatment flow rate (MTFR) of 200 GPM was selected (standard JF4-2-1 with 457 mm of driving head) to monitor performance over 25 storm events. The historical and during field testing observed rainfall measurements were at least 3 times that of the New Jersey design rainfall intensity. Nevertheless, had the design storm been used for sizing, the device size would have still been the same for the field test site, due to it being the smallest available model size. However the device, from a pure design perspective that is based on the 16mm/hr design storm, was oversized for the site. For the interim recognition approval, the theoretical “oversizing” is considered not relevant, since historical and observed rainfall intensities were similar and the device demonstrated its ability to efficiently remove TSS above the ALWP requirement, despite the site’s observed high (median of 51mm/hr) and greater than Auckland rainfall intensity. However, it does highlight the importance of matching design rainfall intensity with a representable average design year to ensure adequate device design that appropriately manages the WQF of a site. Field test

performance results may have been worse, had the New Jersey field study device been sized based on the New Jersey design storm and had a smaller device been available for selection.

The Ipswich Jellyfish Filter size was based on the Australian continuous simulation model, MUSIC, which uses local rainfall data. This was further cross-checked using another continuous simulation model, PCSWMM, with nearby local rainfall data that ensures capturing and treating 90 % of site runoff on an annual average basis. In this case, 90 % of the cumulative runoff volume gave a target WQF of 159GPM (10L/s) and equated to a rainfall intensity of 21mm/hr for the test site. This rainfall intensity was similar to the median observed rainfall intensity of 19mm/hr, indicating adequate sizing. The Ipswich study also selected a Jellyfish Filter with 2 Hi-flo and 1 Draindown cartridge (with a MTFR of 200GPM), but installed the unit within a slightly smaller manhole (1000mm) that is similar to the smallest Jellyfish Filter configuration proposed for Auckland (1050mm).

Both Ipswich and New Jersey studies sized their Jellyfish Filter using local rainfall data. Median rainfall intensities observed during testing, were approximately two and five times that of the Auckland design rainfall intensity respectively, indicating the device's ability to remove TSS under high rainfall intensity conditions. Likewise, despite the differences in rainfall intensities, site characteristics, and influent PSDs, both field studies achieved similar median TSS removal rates for the qualifying storm events, and exceeded the ALWP requirement for TSS removal. However it should be noted that the Ipswich study did not provide the minimum sedimentation area per cartridge of 0.37m^2, a NJDEP certification requirement. The effect of this is unknown, since maintenance information for the study was not included within the interim report and only 5 months of performance data was analysed. It is anticipated that the unit would require an earlier than the typical annual cleanout, as sediment (under the same loading) is anticipated to build up faster given the reduced sedimentation area within the smaller unit diameter. If cleanout is done annually, the reported TSS removal performance is anticipated to worsen between maintenance intervals. It will be of value to assess the effect on performance and maintenance where the minimum sedimentation area criteria was not achieved at a later point; however design of Jellyfish Filter configurations in Auckland should follow design as discussed in Section 4.0.

Given the above, the flow based and sediment mass based sizing approach described in Section 4.1 and Section 4.2 is regarded as appropriate for use in the Auckland context.

5.0 Device Installation

Jellyfish Filtration cartridges can be installed after the upstream catchment and site is stabilised and any accumulated sediment has been removed from the Jellyfish Filter structure and upstream diversion structure. Installation should follow Stormwater360 manhole installation guidelines.

Important notes regarding the installation of the Jellyfish Filter structure are described in the following sections.

5.1 Head loss

The differential in upstream and downstream water level provides the minimal driving head required to overcome minor cumulative friction loss through the system and commence flow through the system. Driving head design requirements are discussed in Section 4.1.3 and backwater effects on driving head calculations must be evaluated.

5.2 Footprint

The required device footprint varies depending on the selected Jellyfish Filter unit size (Table 4-4) selected to meet design targets for the site, discussed in Section 4.0. Design requires establishing the balance between site constraints, unit dimensions and filter cartridge selection required to treat the target WQF and site sediment loading. For example, a smaller unit with longer length cartridges may results in a greater system MTFR and total load capacity compared with a larger unit with shorter length cartridges. In addition, increasing the driving head for a system with the same unit diameter and cartridge number and length, results in an increased MTFR but the same sediment load capacity. The cartridge length selection is limited by the per cartridge maximum inflow drainage area.

5.3 Structural loading

The manhole or rectangular structure constructed of either precast concrete or fibreglass and available in various configurations, serves as a vessel for long-lasting structural support of the system.

Installation of manholes should conform to local specifications and all elevation should be verified to ensure continuous forward flow and filtration treatment through the Jellyfish Filter cartridges.

More information can be found in the manufacturer Owner's Manual and Technical Manual.

5.4 Overflow, diversion, or bypass

Designs for both offline and online configurations exist. New Jersey certification, and thus Auckland Council, requires systems to be constructed offline. Consequently online configurations with optional internal bypass pressure relief pipe(s) fitted into cartridge receptacle(s), are not discussed at the time of this report.

Standard offline configurations have an external bypass using an upstream diversion structure, with the elevation difference between the top of the diversion weir and the invert elevation of the system's outlet pipe setting the design driving head. Flow in excess of the design flow rate overtops the diversion weir and bypasses the system.

System performance is pro-longed between maintenance services when designed in an offline configuration.

5.5 Shallow or Low Cover Installations

The Jellyfish Filter system can be designed for shallow applications using a hatch cover to provide adequate access to all the cartridges within the unit. Generally the minimum cover depth is governed by the height of the maintenance access wall. However if there is no hatch cover, the minimum cover for maintenance access needs to be 1520mm measured from the invert elevation of the outlet pipe to the underside of the hatch or converter slab.

5.6 Sump Drain

Standard Jellyfish Filters typically maintain a pool of water in the lower chamber between storms. Maintenance is triggered when the backwash pool has more than 76mm of water after 12 hours of dry weather have elapsed since the most recent rainfall/runoff event.

Where the sump is required to be drained between storms, a sump drain can be installed to slowly drain the lower chamber pool to the subgrade in infiltration applications or to an approved alternative point of discharge other than the stormwater network.

5.7 Pre-treatment

The Jellyfish Filter has an in-build pre-treatment channel, which, regardless of above or below deck inlet configuration, acts to slow the flow velocity and removes coarse sediment (generally > 50 microns), particulate bound pollutants attached to coarse sediment (nutrients, toxic metals, hydrocarbons), free oil and floatables trash and debris.

5.8 Construction discharge and commissioning

Installation of a Jellyfish Filter system requires excavation and is often installed as part of a wider construction process requiring soil disturbance. If the Jellyfish Filter is placed online before the site is stabilised, construction sediment may reduce the capacity of the cartridges for the design goal of removing post-construction sediment. If construction sediment is allowed to enter the system, more frequent maintenance of the system is likely required.

It is necessary to verify elevations using precise survey techniques. All Jellyfish Filter elevations are based on the outlet pipe invert elevation (assuming the outlet pipe is centred in the hole provided) and the Jellyfish Filter was designed and fabricated around the outlet elevation, unless otherwise stated.

The level and elevation of the manhole base section should be verified. The manhole structure should conform to the New Zealand standard.

6.0 Inspection & Maintenance

Periodic inspection and maintenance is required to ensure that the Jellyfish Filter system continues to operate at design efficiency:

- Inspection refers to regular checking of the system interior to ensure that it is operating as designed and to determine whether maintenance is required.
- Maintenance is focused on pollutant removal and filter cartridge service as the Jellyfish Filter has no moving parts

System performance can be compromised if:

- Sediment in the manholes accumulates beyond 300 mm in depth – potentially reducing filter cartridge life and sediment removal efficiency. Sediment capacities (see
- Table 4-8) are based on a 600 mm minimum sump depth and assumes half of the sump to be filled with sediment.
- Filter cartridges become saturated with sediment – may not provide filtration treatment at the designed water quality flow rate and unfiltered water may bypass filter cartridges
- Oil capacity is exceeded during an oil spill(s) – subsequent spills may not be captured and potential fouling of the filter cartridges
- Debris clogs the system inlet – reduced removal efficiency for sediment, hydrocarbons, and gross pollutants
- Backwater conditions may occur from a downstream blockage – reducing removal efficiency of sediment, hydrocarbons, and gross pollutants

The minimum Inspection and maintenance procedures, approved in the NJDEP final certification, are summarised in Table 6-1. Table 6-1 provides initial inspection and maintenance guidelines, it may be necessary to adjust the inspection/maintenance schedule depending on the actual operating conditions encountered by the system, i.e. sites with higher than expected sediment loads may require more frequent inspection and maintenance. Refer to Appendix C for the Stormwater360 Ltd. Jellyfish Filter Inspection and Maintenance Procedures.

Manufacturer maintenance guidance for Jellyfish Filters can also be found in the Imbrium Jellyfish Filter Owner's Manual.

A NJDEP requirement is that a maintenance plan must include all of the items identified in Stormwater Management Rules N.J.A.C 7:8-5.8, including:

- List of inspection and maintenance equipment and tools
- Specific corrective and preventative maintenance tasks
- Indication of problems in the system
- Training of maintenance personnel

Table 6-1 Jellyfish Filter inspection and maintenance details

Item	Detail
Inspection	• Post-construction – prior to putting the system into service • Twice during the first year of operation • Inspection frequency based on maintenance plan developed in the first year • Immediately after an oil, fuel or other chemical spill[1] • System inspection includes the checking of sediment and oil depth in sump, floatable pollutant accumulation, backwash pool depth after at least 12hours of dry weather since the last rainfall/runoff event, and checking of the internal components for obvious damage.
Maintenance	• Unit clean-out once sediment depth reaches half the provided sump depth (typically 305mm) with generally a minimum of once per annum cleaning frequency. Sediments and accumulated floatable litter are removed using a vacuum hose through the maintenance access wall or, for larger systems, using a combination of a garden hose (to break up sediment on the bottom) and vacuum hose. • If oil is present (tested by using an oil dipstick or sampling tool in the maintenance access wall), the oil layer should be pumped off using a small pump or tubing or vacuum hose for small oil amounts • Unit clean out immediately after an oil, fuel or chemical spill • Decanting of water from the lower chamber using a vacuum hose • Filter cartridge cleaning, re-commissioning or replacement every 12 month or when the automatic backwash feature no longer functions due to cartridge saturation with sediment; whichever occurs first. The ceasing of the backwash function and saturation of the filter cartridges is indicated if the backwash pool contains more than 76mm of water after 12 or more hours of dry weather have elapsed since the most recent rainfall/runoff event. • If required, refill lower chamber with water after vacuuming of sediment, floatables and water
Access for cleaning	• Access is via the standard surface manhole access cover or a custom door for inspection and vacuum removal of water and pollutants. A maintenance worker can climb down the ladder built into the structure's sidewall to access the cartridge deck for manual cleaning or cartridge replacement, but should be careful not to step directly onto the backwash pool weir.

Item	Detail
Disposal of materials	• Disposal of recovered pollutants and spent filter cartridges varies depending on local guidelines, but in most areas pollutants are, once dewatered, disposed of in a sanitary landfill. The sediment is not anticipated to be classified as hazardous waste. Decanted water is disposed of to the sanitary sewer, if permitted by the local regulatory authority, or into a separate containment tank. • Petroleum-based pollutants should be disposed of by a licensed waste management company.
Health & safety for device entry	• Confined space entry training and certification is required, since some of the maintenance procedures require manned entry • Lightweight cartridges allow manual lifting to a worker on the cartridge deck. • Cartridges are recommended to be removed and replaced one at a time, leaving no more than one opened receptacle/hole exposed for safety.
1 Note that sheen at the outlet does not mean the unit is not working. A rainbow or sheen can be visible at oil concentrations of less than 10 mg/L.	

The maximum treatment life of the Jellyfish Filter systems appears to yet be unknown. Whilst statements about the design and inspection and maintenance procedures extending the life-cycle of the system are made, the provided information does not advise on an actual maximum treatment life. However, a requirement of the WSDoE CULD and PULD certification is, amongst others, that the company is to conduct load testing on the filter to determine the maximum treatment life of the system. It is assumed that more information will become available once Imbrium Systems has submitted QUAPP for Ecology review by 30/06/2015, which meets the TAPE requirements for attaining a GULD certification for basic TSS, phosphorous, and oil treatment.

7.0 Summary & Conclusions

This report summarises a review of the information provided to Morphum by the agent for the Jellyfish® 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 Morphum by Stormwater360 Ltd regarding the Jellyfish® Filter (Jellyfish Filter) system 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 Jellyfish Filter against the Proposed Auckland Unitary Plan (PAUP).

NJDEP certified configurations were amended and provided by Stormwater 360 based on standard manhole configurations for Auckland use. An Addendum to the Jellyfish Filter Technical Manual for Design in Auckland was also provided. These local configurations have been compared against the NJDEP certification and confirmed as acceptable in meeting the ALWP requirements for 75% sediment removal, as per the detail contained in Section 4.0.

As a result of this review, we conclude that the Jellyfish Filter can be granted interim approval from the date of issue for use on private sites for offline configurations at 300-457mm of driving head with a standard 150mm backwash pool weir height. This approval does not extend to use on public sites, roads nor 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 will be provided for a maximum period of 3 years and a review on the installation and performance of any devices installed is likely to be undertaken as part of any extension request. Auckland Council may amend, extend or revoke approval.

Appendix D provides a Practice Note regarding installation of the Jellyfish Filter system and Appendix E provides the conditions for PDE approval.

8.0 References

ARC. (2003). TP10 Stormwater Management Devices: Design Guidelines Manual. 2 ed. Auckland, New Zealand.

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.

Frankel, E. (2012). Final Certification Jellyfish® Filter by Imbrium Systems. State of New Jersey Department of Environmental Protection Bureau of Nonpoint Pollution Control Division of Water Quality.

Goonetilleke, A., & Egodawatta, P. (2014). Evaluation of Treatment Performance of the Jellyfish® Filter Installation at Ipswich, Interim Report on the Field Monitoring Program. Ipswich, Queensland: HUMES AUSTRALIA.

imbrium. (n.d.). Innovative Stormwater Treatment: Jellyfish® Filter, JFBRO-V2_0512. www.imbriumsystems.com.

imbrium. (n.d.). Jellyfish® Filter Owner's Manual, JF OWN MAN_v3_0413. www.imbriumsystems.com.

imbrium. (n.d.). Jellyfish® Filter Technical Manual, JFTM_V3-0512- US. www.imbriumsystems.com.

Imbrium Systems Corporation. (2010). Quality Assurance Project Plan, Stormwater Performance Monitoring of a Jellyfish™ JF4 (Physical Modeling of a Jellyfish JF4 Subject to Rainfall-Runoff Events; Revision #8. Prepared By: University of Florida, Department of Environmental Engineering Sciences, 218 Black Hall, University of Florida, Gainesville, Florida 32611.

Imbrium Systems Corporation. (2012). NJCAT Technology Verification Jellyfish® Filter. http://www.njcat.org/verification-process/technology-verification-database.html .

State of New Jersey Department of Environmental Protection. (February 2004). New Jersey Stormwater Best Management Practices Manual • Chapter 3: Regional and Municipal Stormwater Management Plans. www.njstormwater.org.

State of New Jersey Department of Environmental Protection. (February 2004). New Jersey Stormwater Best Management Practices Manual • Chapter 5: Computing Stormwater Runoff Rates and Volumes. www.njstormwater.org.

Stormwater360. (2015). Addendum to JellyfishTM Filter Technical Manual Design in Auckland New Zealand. Auckland: unpublished.

University of Florida. (2011). TARP Field Test Performance Monitoring of a Jellyfish® Filter JF4-2-1, Final Version. Performance Monitoring Report for JF4-2-1 Prepared By: University of Florida, Engineering School of Sustainable Infrastructure and Environment (ESSIE), University of Florida, Gainesville, FL 32611 USA.

Washington State Department of Ecology. (2015). Conditional Use Level Designation for Basic Treatment and Pilot Use Level Designation for Phosphorus and Oil Treatment for Imbrium Systems Jellyfish® Filter. www.ecy.wa.gov.

Appendix A Jellyfish Filter Detail

Jellyfish Filter Physical Description

The Jellyfish Filter® is described within manufacturer specifications as *an engineered Stormwater quality treatment technology featuring pre-treatment and membrane filtration in a compact stand-alone treatment system that removes a high level and wide variety of Stormwater pollutants.* Stormwater pollutants are removed *at high treatment flow rates with minimal head loss and low maintenance costs.* The lightweight Jellyfish cartridges filter the influent stormwater by providing *an extraordinarily large amount of membrane surface area, resulting in superior flow capacity and pollutant removal capacity.*

The systems comprises various structural and functional components including: a cylindrical (manhole) or rectangular structure; a rigid-high-strength fibreglass cartridge deck; a maintenance access wall; cartridge receptacles; Jellyfish membrane filtration cartridges; cartridge lids with flow control orifice or blank for unoccupied cartridge receptacles; a separator skirt; a backwash pool weir; an optional bypass pressure relief pipe(s); a deflector plate; standard covers, rectangular hatches, or inlet grates for maintenance access; and built-in steps or ladder(s) for maintenance personnel.

Treatment Mechanisms

Pretreatment:

- Traps oil, trash and debris outside the filtration zone
- Coarse particles settle to the sump (generally > 50 microns)
- Separator skirt protects the cartridge from floatables contamination

Filtration:

- Membrane filtration tentacles capture fine particles as small as 2 microns demonstrated from Laboratory and Field testing
- Removes a high percentage of particulate bound pollutants including nutrients, metals, hydrocarbons and bacteria
- High surface area membranes ensure long-lasting treatment

Self-cleaning:

- During filtration, vibrational pulses dislodge sediment from the membrane surfaces
- After every storm peak, filtered water backwashes membrane filtration tentacles
- Sediment is continuously removed from the tentacles by gravity

Appendix B NJDEP Final Certification

State of New Jersey

DEPARTMENT OF ENVIRONMENTAL PROTECTION
Bureau of Nonpoint Pollution Control
Division of Water Quality
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

CHRIS CHRISTIE
Governor

KIM GUADAGNO
Lt. Governor

BOB MARTIN
Commissioner

May 14, 2012

Joel Garbon
Product Manager
7564 Standish Place
Suite 112
Rockville, MD 20855

Re: Final Certification
Jellyfish® Filter by Imbrium Systems

Expiration Date: December 1, 2016
TSS Removal Rate: 80%

Dear Mr. Garbon:

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). Imbrium Systems. has requested a Final Certification for the Jellyfish® Filter.

This project falls under the "Transition for Manufactured Treatment Devices July 15, 2011". The Jellyfish Filter by Imbrium Systems qualified for Category C. Manufactured Treatment Devices Seeking Final Certifications - In Process which are MTDs that have commenced field testing on or before August 1, 2011.

NJDEP received the required information from signed statement sby the NJCAT Technical Director and the manufacturer listing the indicating that the requirements of the 2009 NJDEP Field Testing Protocols have been met or exceeded. NJDEP also received a signed statement from the third party testing entity, University of Florida, indicating that the testing requirements have been met or exceeded. The NJCAT letter also includes a recommended certification TSS removal rate and the required maintenance plan.

The NJDEP certifies the use of the Jellyfish Filter by Imbrium Systems at TSS removal rate of 80%, subject to the following conditions:

1. The Jellyfish Filter is designed according to the NJ Water Quality Design Storm in N.J.A.C. 7:8-5.5.
2. The peak inflow of the water quality design storm is limited to the following:

For each hi-flow cartridge, the maximum inflow is 1.48 gpm and a maximum inflow drainage area is 0.012 impervious acres, for each inch of cartridge length.

For each draindown cartridge, the maximum inflow 0.74 gpm and the maximum inflow drainage area is 0.006 impervious acres for each inch of cartridge length.

Example: For a 54-inch hi-flo cartridge length, the maximum inflow is 80 gpm and the maximum inflow drainage area is 0.65 impervious acres.

Maximum treatment flow rates for typical Jellyfish Filter models are provided in Table 1.

Maximum treatment flow rates and maximum inflow drainage areas for various cartridge lengths are provided in Table 2.

3. The bottom of the Jellyfish tentacles is a minimum of 2 feet above the bottom of the vault. The sedimentation area in the vault shall be a minimum of 4 ft^2 per cartridge.
4. The Jellyfish Filter is certified as an off-line system only.
5. The Jellyfish Filter cannot be used in series with a settling chamber (such as a hydrodynamic separator) or a media filter (such as a sand filter), to achieve an enhanced removal rate for total suspended solids (TSS) removal under N.J.A.C. 7:8-5.5.
6. The maintenance plan for sites using this device shall incorporate, at a minimum, the maintenance requirements for the Jellyfish Filter shown in Appendix A below.

In addition to the attached, any project with a Stormwater BMP subject to the Stormwater Management Rules, N.J.A.C. 7:8, must include a detailed maintenance plan. The detailed maintenance 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.

NJDEP anticipates proposing further adjustments to this process through the readoption of the Stormwater Management Rules. Additional information regarding the implementation of the Stormwater Management Rules, N.J.A.C. 7:8, are available at www.njstormwater.org. If you have any questions regarding the above information, please contact Ms. Sandra Blick of my office at (609) 633-7021.

Sincerely,

Ed Frankel, P.P., Section Chief
Bureau of Nonpoint Pollution Control

C: Chron File
Richard Magee, NJCAT
Mark Pedersen, DLUR
Elizabeth Dragon, BNPC

Table 1
Maximum Treatment Flow Rates for
Standard (54" Cartridge Length) Jellyfish® Filter Models

Manhole Diameter (ft)	Model No.	Hi-Flo Cartridges (54" Length)	Draindown Cartridges (54" Length)	Maximum Treatment Flow Rate (gpm / cfs)
Catch Basin		varies	varies	varies
4	JF4-2-1	2	1	200 / 0.45
6	JF6-3-1	3	1	280 / 0.62
	JF6-4-1	4	1	360 / 0.80
	JF6-5-1	5	1	440 / 0.98
	JF6-6-1	6	1	520 / 1.16
8	JF8-6-2	6	2	560 / 1.25
	JF8-7-2	7	2	640 / 1.43
	JF8-8-2	8	2	720 / 1.60
	JF8-9-2	9	2	800 / 1.78
	JF8-10-2	10	2	880 / 1.96
10 [1]	JF10-11-3	11	3	1000 / 2.23
	JF10-12-3	12	3	1080 / 2.41
	JF10-13-3	13	3	1160 / 2.58
	JF10-14-3	14	3	1240 / 2.76
	JF10-15-3	15	3	1320 / 2.94
	JF10-16-3	16	3	1400 / 3.12
12 [2]	JF12-17-4	17	4	1520 / 3.39
	JF12-18-4	18	4	1600 / 3.57
	JF12-19-4	19	4	1680 / 3.74
	JF12-20-4	20	4	1760 / 3.92
	JF12-21-4	21	4	1840 / 4.10
	JF12-22-4	22	4	1920 / 4.28
	JF12-23-4	23	4	2000 / 4.46
	JF12-24-4	24	4	2080 / 4.63
Vault		varies	varies	varies

[1] The MTFR for a 10-ft diameter unit occurs with Model JF10-16-3. Since this leaves 4 unoccupied cartridge receptacles in the 10-ft diameter deck, the design engineer has the option to add up to 4 additional cartridges to increase the sediment capacity of the system, however may not increase the MTFR above that of the JF10-16-3.

[2] The MTFR for a 12-ft diameter unit occurs with Model JF12-24-4. Since this leaves 4 unoccupied cartridge receptacles in the 12-ft diameter deck, the design engineer has the option to add up to 4 additional cartridges to increase the sediment capacity of the system, however may not increase the MTFR above that of the JF12-24-4.

Table 2
Maximum Treatment Flow Rate and
Maximum Inflow Drainage Area
for Various Jellyfish® Cartridge Lengths

Cartridge Length (inches)	Maximum Treatment Flow Rate (gpm)	Maximum Inflow Drainage Area (impervious acres)
15	Hi-Flo 22 Draindown 11	Hi-Flo 0.18 Draindown 0.09
27	Hi-Flo 40 Draindown 20	Hi-Flo 0.32 Draindown 0.16
40	Hi-Flo 60 Draindown 30	Hi-Flo 0.48 Draindown 0.24
54	Hi-Flo 80 Draindown 40	Hi-Flo 0.65 Draindown 0.32

Appendix C Maintenance Requirements

NJDEP minimum Maintenance Requirements

Appendix A

Imbrium Systems Jellyfish® Filter
Inspection and Maintenance Information

Jellyfish® Filter Inspection and Maintenance
Regular inspection and maintenance are proven, cost-effective ways to maximize water resource protection for all stormwater pollution control practices, and are required to insure proper functioning of the Jellyfish Filter. Inspection of the Jellyfish Filter is easily performed from the surface, while proper maintenance requires a combination of procedures conducted from the surface and with worker entry into the structure. The Jellyfish Filter's patented technology has no moving parts, keeping the process simple.

Please refer to the following information and guidelines before conducting inspection and maintenance activities.

When is inspection needed?

- Post-construction inspection is required prior to putting the Jellyfish Filter into service.
- A minimum of two inspections are required during the first year of operation to accurately assess the sediment and floatable pollutant accumulation, and to ensure that the automatic backwash feature is functioning properly.
- Inspection frequency in subsequent years is based on the maintenance plan developed in the first year.
- Inspections must also be performed immediately after an oil, fuel or other chemical spill.

When is maintenance service needed?

- For optimum performance, the unit must be cleaned out once the sediment depth reaches 12 inches of accumulation. Generally, the minimum cleaning frequency is once annually, although the frequency can be based on historical inspection results.
- Filter cartridges must be cleaned and re-commissioned, or replaced, every 12 months or when the automatic backwash feature no longer functions, whichever occurs first. The automatic backwash function will be disabled if the filter cartridges become saturated with sediment. This saturated condition is indicated if the backwash pool contains more than 3 inches depth of water after 12 or more hours of dry weather have elapsed since the most recent rainfall/runoff event.
- The unit must be cleaned out immediately after an oil, fuel or chemical spill.

1

What conditions can compromise the Jellyfish Filter's performance?

- If sediment accumulates beyond 12 inches in depth, filter cartridge life and sediment removal efficiency may be reduced.
- If filter cartridges become saturated with sediment, the system may not provide filtration treatment at the designed water quality flow rate, and unfiltered water may bypass the filter cartridges.
- If an oil spill(s) exceeds the oil capacity of the system, subsequent spills may not be captured and may cause fouling of the filter cartridges.
- If debris clogs the inlet of the system, removal efficiency of sediment, hydrocarbons, and gross pollutants may be reduced.
- If a downstream blockage occurs, a backwater condition may occur in the system and removal efficiency of sediment, hydrocarbons, and gross pollutants may be reduced.

What training is required?

The Jellyfish Filter is inspected and maintained by professional vacuum cleaning service providers with experience in the maintenance of underground tanks, sewers and catch basins. Since some of the maintenance procedures require manned entry into the Jellyfish structure, only professional maintenance service providers trained in confined space entry procedures should enter the vessel. Service provider companies typically have personnel who are trained and certified in confined space entry procedures according to local, state, and federal standards.

For typical inspection and maintenance activities, no specific supplemental training is required for the Jellyfish Filter. Information provided in this document or the Jellyfish Filter Owner's Manual contains sufficient guidance to maintain the system properly.

What equipment is typically required for inspection?

- Manhole access cover lifting tool
- Oil dipstick or sampling tool
- Sediment probe
- Flashlight
- Camera
- Data log
- Safety cones and caution tape
- Hard hat, safety shoes, safety glasses, and chemical-resistant gloves

How is the Jellyfish Filter inspected?

- The Jellyfish filter system can be inspected from the surface through the standard surface manhole access cover or custom doors.
- Sediment and oil depth inspections are performed with a sediment probe and oil dipstick. Sediment and oil depth are measured through the maintenance access wall.
- Visual inspection for floatable pollutant accumulation such as litter and hydrocarbons is also performed by shining a flashlight into the maintenance access wall.
- Visual inspection of the backwash pool (6-inch high kidney-shaped or oval-shaped

weir) should also be performed to check for standing water in the pool. If at least 12 hours of dry weather have elapsed since the most recent rainfall/runoff event and the backwash pool contains more than 3 inches of water, this condition indicates that the filter cartridges are saturated with sediment and should be cleaned or replaced.
- Inspections also involve a visual inspection of the internal components of the system for obvious damage.

What equipment is typically required for maintenance?

- Vacuum truck equipped with water hose and jet nozzle
- Small pump and tubing for oil removal, if necessary
- Manhole access cover lifting tool
- Oil dipstick or sampling tool
- Sediment probe
- Flashlight
- Camera
- Data log
- Safety cones and caution tape
- Hard hats, safety shoes, safety glasses, chemical-resistant gloves, and hearing protection for service providers
- Gas analyzer, respiratory gear, and safety harness for specially trained personnel if confined space entry is required
- Replacement cartridges are required if manual cleaning and re-commissioning of existing cartridges is not possible or adequate to restore proper system function.
- Jellyfish Cartridge Backflush Pipe

How is the Jellyfish Filter maintained?

- The Jellyfish Filter can be maintained through the standard surface manhole access cover. All access covers should be removed to provide additional light and ventilation. If custom doors were installed instead of frames and covers, open all doors.
- If the filter cartridges are to be manually backflushed (see procedure below), perform the manual backflush service prior to vacuum removal of sediment, floatable, and water (i.e. perform the manual backflush with the lower chamber full of water).
- Insert the oil dipstick or sampling tool into the maintenance access wall. If oil is present, pump off the oil layer into separate containment using a small pump and tubing. Some maintenance service providers may elect to use the vacuum hose if the oil amount is small.
- Maintenance cleaning of accumulated floatable litter and sediment is performed with a vacuum hose inserted through the maintenance access wall.
- Using the vacuum hose, decant the water from the lower chamber to the sanitary sewer, if permitted by the local regulating authority, or into a separate containment tank.
- Remove the sediment from the bottom of the unit using the vacuum hose.
- For larger Jellyfish Filters, (8-ft, 10-ft, 12-ft diameter), complete sediment removal

may be facilitated by inserting a garden hose sprayer through a hole in the cartridge deck where a blank cartridge lid (no orifice in the cartridge lid) or filter cartridge has been removed. Use the garden hose sprayer to break up sediment on the bottom of vessel that is farthest from the maintenance access wall, being careful not to cut or otherwise damage the filter tentacle membranes with excessive water pressure. (Note: Use of a garden hose sprayer is recommended. Do not use a high pressure jet sprayer or power washer, as excessive water pressure may damage the filter tentacle membranes.) Rinse the loosened sediment toward the maintenance access wall for easy vacuum removal.

- To access the cartridge deck for manual cleaning or replacement of filter cartridges, descend the ladder that is built into structure's sidewall, observing all precautions for safe and proper confined space entry. Note that the cartridge deck may be slippery. Care should be taken to avoid stepping directly onto the backwash pool weir, as damage may result.
- A manual backflush of the cartridges is recommended to remove a high percentage of accumulated sediment from the filtration tentacles, restore flow capacity, and extend the service life of the cartridges. A Jellyfish Cartridge Backflush Pipe (12-inch diameter x 40-inch length aluminum pipe with flapper valve) may be purchased from Imbrium Systems that allows each cartridge to be selectively backwashed using water that is supplied from either (a) the previously decanted water stored in a vactor truck compartment; (b) clean water from a separate water truck delivered to the site; or (c) water from a nearby fire hydrant or other clean water source. NOTE: Manual backflushing of the cartridges is best performed with the lower chamber full of water (i.e. prior to vacuuming out the sediment, floatables, and water). This ensures that a uniform backflush pressure is applied across all of the filter media surface area.
- **Manual backflush procedure**: Twist the threaded cartridge lid on the cartridge receptacle counter-clockwise to remove the lid and expose the cartridge head. (**NOTE: Do not step directly onto an exposed cartridge head when a cartridge lid is removed, as excessive downward force may damage the cartridge receptacle and result in injury if the cartridge head is forced through the receptacle and into the lower chamber.**) Place the Jellyfish Cartridge Backflush Pipe over the cartridge receptacle such that the gasket on the bottom of the Backflush Pipe is seated on the rim of the cartridge receptacle. Fill the Backflush Pipe with water (approximately 16 gallons). Pull the cord to open the flapper valve and backflush the water through the cartridge. Refill the Pipe and backflush a second time. The full Pipe contents should drain down to the top of the open flapper valve (30 inches from the top of the Pipe) within approximately 15 seconds to remove a high percentage of accumulated sediment and restore the flow capacity of the cartridge. Remove the Pipe and re-install the lid hand-tight. For the most thorough backflushing, backflush the Draindown Cartridge(s) first, followed by the Hi-Flo Cartridges, then finish with a final single backflush on the Draindown Cartridge(s). (NOTE: The Hi-Flo Cartridges are those cartridges within the kidney-shaped 6-inch high backwash pool weir. The Draindown Cartridges are those cartridges outside the backwash pool weir. See the diagram below for reference.) When backflushing a cartridge, it is important to keep the lids in place on all other cartridges both as a safety precaution and so that water displaced from the lower chamber during backflushing is properly filtered when discharged to the top of the cartridge deck.

- **Optional manual rinsing procedure:** If manual backwashing using the Jellyfish Cartridge Backflush Pipe is ineffective in restoring adequate cartridge flow capacity, cartridges may be removed, manually rinsed, and re-commissioned. With the threaded cartridge lid removed, slowly and carefully remove the cartridge from the receptacle using the lifting loops in the cartridge head. (NOTE: Should a snag occur, do not force the cartridge upward as this may result in damage to the tentacles. Instead, gently rotate the cartridge with a slight sideways motion to clear the snag and remove the cartridge.) Remove the cartridge from the vessel, as rinsing is best performed outside the vessel. Immediately replace the lid on the exposed receptacle/hole as a safety precaution. Using a garden hose sprayer, direct the water spray at an angle across the tentacle membrane surface, starting at the top of the tentacle and working downward. For most effective rinsing, remove each tentacle from the cartridge head plate by unscrewing the attachment nut, and perform a 360 degree rinse of each tentacle. Re-attach the rinsed tentacles to the head plate and re-commission the cleaned cartridge. If manual rinsing cannot be performed, or if inspection upon rinsing indicates damage to the tentacles, provisions must be made to replace the spent or damaged tentacles with new tentacles. Contact Imbrium Systems to order replacement tentacles.
- New cartridges are lightweight (less than 20 pounds), and can be easily lowered down to a worker on the cartridge deck. Care should be taken not to bend or otherwise damage the tentacles during the handling and installation procedures.
- For maximum safety, it is recommended that each cartridge be removed and replaced one at a time, such that there is never more than one cartridge receptacle/hole exposed.
- After vacuuming out sediment, floatables, and water, re-fill the lower chamber with water where required by the local jurisdiction.

What is required for proper disposal?

- Disposal requirements for recovered pollutants and spent filter cartridges may vary depending on local guidelines. In most areas the sediment and spent filter cartridges, once dewatered, can be disposed of in a sanitary landfill. It is not anticipated that the sediment would be classified as hazardous waste.

What about oil spills?

- Petroleum-based pollutants captured by the Jellyfish Filter (oil/chemical/fuel spills) should be removed and disposed of by a licensed waste management company.
- Although the Jellyfish Filter captures virtually all free oil, a sheen at the outlet **does not** mean the unit isn't working. A rainbow or sheen can be visible at oil concentrations of less than 10 mg/L (ppm).

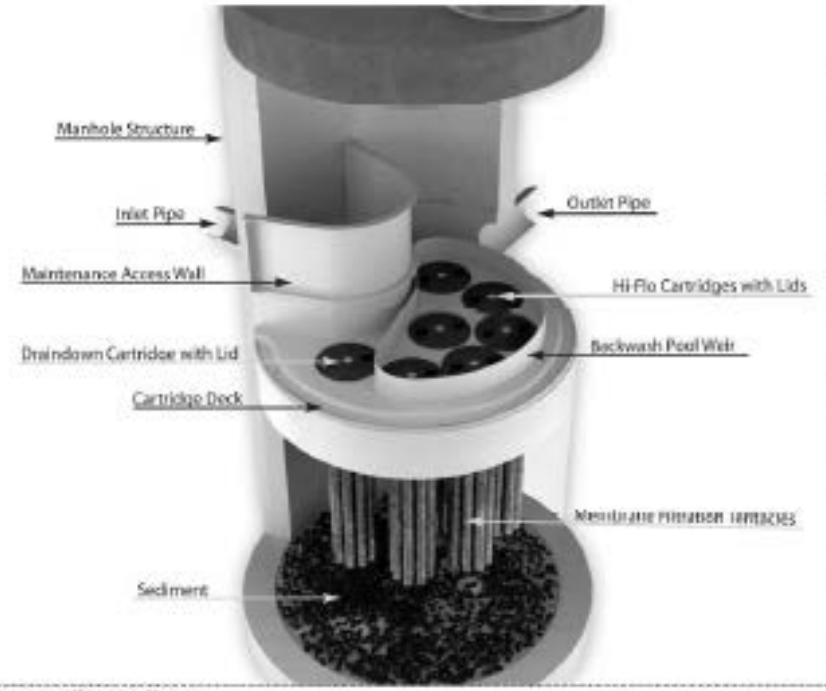
What factors affect the costs involved with inspection/maintenance?

- Inspection and maintenance costs are based on unit size, cartridge count, sediment/oil/hazardous material loads, transportation distances, tipping fees, disposal requirements and other local regulations. Maintenance costs are anticipated to be substantially lower in instances where dirty cartridges are manually cleaned and re-commissioned rather than replaced with new cartridges.

Below is a cut-away schematic of the Jellyfish Filter with key components identified (6-ft diameter manhole configuration is depicted).

FIGURE 1

Jellyfish Filter and Components



Note: Separator Skirt Not Shown

The Jellyfish Filter has no moving parts to wear out and therefore maintenance activities are generally focused on pollutant removal and filter cartridge service.

Below is a schematic of a Jellyfish Filter membrane filtration cartridge. The extraordinarily high surface area of the membrane filtration tentacles provides superior flow and sediment capacity as well as low head loss. Tentacles can be easily removed from the head plate and replaced.

FIGURE 2

Jellyfish Membrane Filtration Cartridge

7

The depth of sediment and oil can be measured from the surface by using a sediment probe or dipstick tube equipped with a ball check valve and inserted through the Jellyfish Filter's maintenance access wall. The large opening in the maintenance access wall provides convenient access for inspection and vacuum removal of water and pollutants.

A maintenance worker stationed on the surface uses a vacuum hose to evacuate water, sediment, and debris from the system.

The benefits of regular inspection and maintenance are many – from ensuring maximum operation efficiency, to keeping maintenance costs low, to the continued protection of natural waterways – and provide the key to the Jellyfish Filter's long and effective service life.

Ordering Replacement Parts

Jellyfish filter cartridges, replacement tentacles, cartridge lids, Jellyfish Cartridge Backflush Pipes (for manual backflushing), and other system components can be ordered by contacting:

Imbrium Systems Corporation
1-888-279-8826
www.imbriumsystems.com

(revised 3-28-12)

8

Appendix D Jellyfish® Filter Practice Note

Background

Auckland Council Stormwater Unit (SU) has evaluated the Jellyfish® Filter against current certification from the following two bodies:

- 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.

The Jellyfish Filter has been granted interim approval from the date of issue for use on private sites for offline configurations at 300-457mm of driving head with a standard 150mm backwash pool weir height. This approval does not extend to use on public sites, roads nor 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 will be provided for a maximum period of 3 years and a review on the installation and performance of any devices installed is likely to be undertaken as part of any extension request. Auckland Council may amend, extend or revoke approval.

Description

The Jellyfish® Filter is described within manufacturer specifications as *an engineered Stormwater quality treatment technology featuring pre-treatment and membrane filtration in a compact stand-alone treatment system that removes a high level and wide variety of Stormwater pollutants.* Stormwater pollutants are removed *at high treatment flow rates with minimal head loss and low maintenance costs.* The lightweight Jellyfish cartridges filter the influent stormwater by providing *an extraordinarily large amount of membrane surface area, resulting in superior flow capacity and pollutant removal capacity.*

The system comprises a self-cleaning mechanism, which automatically passively cleans the membrane surfaces of the hi-flow cartridges, removing accumulated sediment from the membrane surfaces and significantly extending their service life and maintenance interval. The draindown cartridge reduces occlusion from sediments by controlling the design flow through a flow control orifice in the cartridge lid.

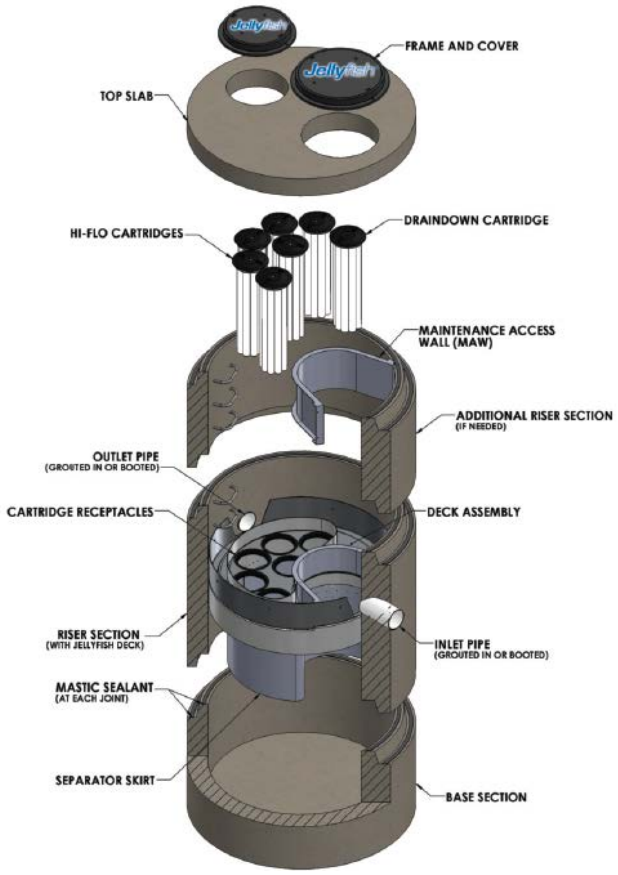


Figure E 1 Example of a typical Jellyfish Filter

Sizing

Flow based sizing

In the Auckland context, stormwater devices sized using flow based methods must provide a peak flow rate calculated 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 Jellyfish Filter, 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).

$$Q_d = CiA_C \qquad \text{Equation E1}$$

where

Q_d is the water quality flow in m³/h requiring treatment,

C is the runoff coefficient derived as outlined below,

A_c is the catchment area in m², and

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

Auckland Council specifies use of C=1 for paved or otherwise impervious surfaces (ARC, 2003). Table E 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 E 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

The Jellyfish Filter is sized to treat the WQF for the site. For flow based sizing, the sum of the product of the design flow rate for each cartridge type (Table E2) and the selected number of respective cartridges is determined to achieve the target water quality treatment rate. A minimum driving head is selected to suit the site, and is associated with a design flow rate for each cartridge type and length.

$$Q_{HF} x\, N_{HF} + Q_{DD} x\, N_{DD} \geq WQF \qquad \text{Equation E2}$$

where

Q_{HF} is the design flow rate for the hi-flo cartridge at a given cartridge length and driving head, see Table E2 (lps)

N_{HF} is the number of hi-flo cartridges

Q_{DD} is the design flow rate for the draindown cartridge at a given cartridge length and driving head, Table E2 (lps)

N_{DD} is the number of draindown cartridges

WQF is the target water quality treatment rate for the site (lps)

Table E2 summarises the design treatment rates for Auckland available Jellyfish Filter cartridges at the two approved driving heads, which equate to equal to or below the maximum cartridge flux rate of 0.14 lps/m^2 for the hi-flow cartridge and 0.07 lps/m^2 for the draindown cartridge.

Auckland Jellyfish Filter units are based on typical Auckland manhole sizes. Each unit has an associated number of available cartridge receptacles, setting the maximum treatment flow rates (MTFR) for the particular unit. Table E3 lists typical Jellyfish Filter manhole configurations with their associated number of available cartridge receptacles and calculated system MTFR based on standard length cartridges with a typical driving head of 457mm. Other manhole configurations or sizes were not included in the review. Any other configurations would need to meet the sizing criteria outlined in this report. The MTFRs for the same Jellyfish Filter configurations with differing cartridge lengths and/or driving head can be determined using Equation E2.

For systems that experience submerged or backwater conditions due to dry weather, base flow or tidal effects, driving head calculations must account for water elevation during the backwater conditions and must remain within approved design limits. The Jellyfish Filter will continue to operate during forward flow despite backwater conditions, but the maintenance access wall height may need to be increased to ensure floatable capture and the backwash weir height may need to be increased to ensure function of the automatic passive backwash feature.

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.

Table E2 Jellyfish Cartridge hydraulic loading rates

Head[1] (mm)	**Backwash pool height (mm)**	**Cartridge length**	**HF design flow rate[2]**		**DD design flow rate[2]**		**Filtration surface area (m2)**	**Flux rate (lps)[2]**	
			gpm	lps	gpm	lps		HF	DD
457	150	1372	80	5.0	40	2.5	35.4	0.14	0.07
		1016	59	3.8	30	1.9	26.2	0.14	0.07
		686	40	2.5	20	1.3	17.7	0.14	0.07
		381	22	1.4	11	0.7	9.8	0.14	0.07
305	150	1372	48	3.0	28	1.8	35.4	0.09	0.05
		1016	36	2.3	21	1.3	26.2	0.09	0.05
		686	24	1.5	14	0.9	17.7	0.09	0.05
		381	13	0.8	8	0.5	9.8	0.09	0.05
1 New Jersey approved driving heads. 2 Design flux rates are equal or below the respective maximum cartridge flux rates stated in Section 4.1.2.									

Table E3 Design flow capacities for standard Auckland Jellyfish Filter offline configurations

Manhole dia[1] (mm)	Model No.	Hi-flo cartridges (No)	Draindown cartridges (No)	System MTFR[2] (GPM/Lps)
1050	JF1050-1-1	1	1	120 / 7.5
1200	JF1200-2-1	2	1	200 / 12.5
1800	JF1800-3-1	3	1	280 / 17.5
	JF1800-4-1	4	1	360 / 22.5
	JF1800-5-1	5	1	440 / 27.5
	JF1800-6-1	6	1	520 / 32.5
2300[3]	JF2300-6-2	6	2	560 / 35
	JF2300-7-2	7	2	640 / 40
	JF2300-8-2	8	2	720 / 45
	JF2300-9-2	9	2	800 / 50
	JF2300-10-2	10	2	800 / 50
3000[4]	JF3000-10-2	10	2	880 / 55
	JF3000-11-3	11	3	1000 / 62.5
	JF3000-12-3	12	3	1080 / 67.5
	JF3000-13-3	13	3	1160 / 72.5
	JF3000-14-3	14	3	1240 / 77.5
	JF3000-15-3	15	3	1320 / 82.5
	JF3000-16-3	16	3	1400 / 87.5
	JF3000-19-4	19	4	1400 / 87.5
3600[4]	JF3600-17-4	17	4	1520 / 95
	JF3600-18-4	18	4	1600 / 100
	JF3600-19-4	19	4	1680 / 105
	JF3600-20-4	20	4	1760 / 110
	JF3600-21-4	21	4	1840 / 115
	JF3600-22-4	22	4	1920 / 120
	JF3600-23-4	23	4	2000 / 125
	JF3600-24-4	24	4	2080 / 130
	JF3600-27-5	27	5	2080 / 130
Vault[5]		varies	varies	Varies

Manhole dia[1] (mm)	Model No.	Hi-flo cartridges (No)	Draindown cartridges (No)	System MTFR[2] (GPM/Lps)

1 Smaller and larger systems may be custom designed.
2 MTFRs are based on standard cartridge length, 1372 mm and a standard driving head (457mm). The design engineers has to determine the system MTFR using Table E2 and Equation E2 for varying cartridge length and driving head configurations.
3. The MTFR for the 2300mm diameter unit occurs with the JF2300-9-2 model. This leaves one unoccupied hi-flo cartridge receptacle. Designers may add one more hi-flo cartridge (JF2300-10-2) for increased sediment capacity; however its MTFR should not exceed that of the JF2300-9-2 unit.
4. The MTFR for the 3000mm and 3600mm diameter unit occur with the JF3000-16-3 and JF3600-24-4 models respectively. This leaves 4 unoccupied hi-flo cartridge receptacles for each manhole configuration. Designers may add up to three hi-flo and one draindown cartridges to increase system sediment capacity; however their MTFRs should not be greater than that of the JF3000-16-3 and JF3600-24-4 model respectively.

5. The Jellyfish Filter vault configuration is custom designed. Its MTFR occurs when the sedimentation surface area is reduced to 0.370 m^2 per cartridge. The design engineer has the option to add additional cartridges to increase the mass load capacity of the system.

Initial Maintenance Frequency Estimate

Sizing Jellyfish Filters in Auckland is a two part step by step process described below, which establishes the required number of filter cartridges for the site sediment loading, the recommended maintenance frequency, and checks the maximum per cartridge sedimentation area of the chosen Jellyfish Filter unit. This method gives an estimate only, and field monitoring is required to confirm this proposed method and its assumptions.

Sediment mass load sizing may increase the required device size, but should not result in a size reduction from the unit size established in flow based sizing.

Part 1

This sizing method gives an estimate for the maintenance frequency of selected filter cartridges, and takes into account the catchment pollutant load and cartridge capacity. This estimate will need to be verified and updated through field testing and maintenance records that will be provided to Council through the consent conditions."

Step 1: Determine expected annual mass load

Determine the annual mass load expected off the site (M_{total}) using the estimated contaminate loads for differing land uses from Table E 4 and multiplying by the catchment area:

Table E 4 Estimated Loading rates (T.P.10)

Land use	TSS (kg/ha/yr)
Road	281 - 723
Commercial	242 - 1369
Residential (low)	60 - 340
Residential (high)	97 - 547
Terraced	133 - 755
Bush	26 - 146
Grass	80 - 588
Roof	50-110
Pasture	103 - 583

Step 2: Determine the pretreatment removal efficiency and mass load reduction
Determine the pretreatment removal efficiency ($E_{pre)}$ provided by external pretreatment structure. Pretreatment removal credit can be used up to a maximum of 50 percent. Pretreatment performance must be verified.

When the pretreatment removal efficiency is known, calculate the mass removed by the pretreatment system ($M_{pre)}$ and deduct it from the annual mass load to determine the mass load passed on to the filters (M_{pass1})

$M_{pre}= (E_{pre})*(M_{total})$, and
$M_{pass1}= (M_{total}) - M_{pre}$

Step 3: Determine mass removal target

Estimate the filter efficiency (E_{filter}), required to meet the overall system efficiency target, and the mass to be removed by the cartridge filters (M_{filter}).

$$M_{filter} = (E_{filter})*(M_{pass1})$$

Step 4: Determine load capacity of filters
Calculate the total load capacity of the proposed Jellyfish filter (LC_{Filter}) by adding the load capacity for the number of Hi flo (HF) and drain down (DD) cartridges in the device. Table E 5 lists this load capacity of different cartridge sizes. Stormwater360 recommends that an 80% safety factor be applied to synthetic sediment mass load testing.

$$LC_{Filter} = 0.8 \times ((\#HF\ Carts\ X\ LCHF) + (\#DD\ Carts \times LCDD))$$

Table E 5 Loading capacity of Jellyfish Filter cartridges

Cart length (mm)	Filter cartridges loading capacity (kg)	
	HF	DD
380	15.9	7.7
684	28.6	14.1
1014	42.2	20.9
1368	56.7	28.6

Step 5: Determine the maintenance frequency of the Jellyfish filter cartridges

Determine the estimated maintenance frequency using the mass captured by the filter annually (M filter) to determine the estimated maintenance frequency as follows:

Estimated maintenance frequency = LC (Filter)/ M_{filter}

Where the estimated maintenance frequency is less than 12 month, additional Jellyfish Filter cartridges may be needed to increase sediment capacity. Alternatively additional inspections and maintenance activities may be required.

Part 2

Once the required unit size and number of cartridges has been established following flow based sizing and Part 1 of sediment load based sizing, the per cartridge sedimentation area for the selected unit must be checked to prevent a reduction in TSS removal performance.

At a minimum, the per cartridge sedimentation area should be 0.37 m^2, and is calculated by dividing the minimum sedimentation capacity for each unit diameter (Table E6) with the minimum provided sump depth and the total number of cartridges. The minimum sump depth is 600 mm of sump below the bottom of the cartridges, and calculations assume half of the provided sump (typically 300 mm) to be filled with sediment. The sedimentation area per cartridge available for the different manhole configurations is shown in Table E6.

Design requires establishing the balance between site constraints, unit dimensions and filter cartridge selection required to treat the target WQF and site sediment loading. For example, a smaller unit with longer length cartridges may results in a greater system MTFR and total load capacity compared with a larger unit with shorter length cartridges. In addition, increasing the driving head for a system with the same unit diameter and cartridge number and length, results in an increased MTFR but the same sediment load capacity.

It is recommended to select an appropriate combination of driving head, unit diameter (limiting the number of cartridges) and cartridge length, which results in a Jellyfish Filter system that achieves and closely matches the target WQF and site sediment loading to avoid under/oversizing and keeping within design limits such as the maximum per cartridge drainage area, minimum per cartridge sedimentation area, and maximum unit MTFR.

Table E6 Design sediment capacity for typical Jellyfish Filter manhole configurations

Model Diameter (m)	**Max #. Of cartridges available[2]**	**Sediment capacity[1] (L)**	**Sedimentation area per cartridge (m^2)**
1050[2]	2	255	0.42
1200	3	340	0.35[3]
1800	7	765	0.35[3]
2300	11	1246	0.38
3000	19	2152	0.37[3]
3600	28	3087	0.36[3]
Vault	Varies	Varies	Varies[4]

1. Sediment capacity is based on a 600 mm (2ft) sump depth and assumes 305mm of sediment depth in the sump. Systems may be designed with increased sediment capacity. 2 This is the maximum allowable number of cartridges that achieves the minimum NJDEP per cartridge sedimentation area. The 2300mm, 3000mm, and 3600mm diameter manhole configurations have unoccupied cartridge receptacles within the cartridge deck, that may be used for increased mass load capacity. Where more cartridges are used, designers must check the respective MTFRs (Table E3) are not exceeded. 3 Although the calculated per cartridge sedimentation area is below the NJDEP minimum, the values are within 7 percent of the requirement, and were regarded suitable for the Auckland region. 4. The sedimentation area in a vault configuration sets the MTFR of the unit as it is reduced to 0.370 m^2 per cartridge. More cartridges may be used for increased mass load, but the system MTFR should not be exceeded.

A Jellyfish Filter provides minimal volume storage, but can be installed downstream of a detention facility. In such cases the Jellyfish Filter receives a relatively low flow rate (orifice-controlled release flow rate) from the detention facility compared to flow rates that would be treated if the Jellyfish Filter received the site runoff directly. In such cases, design of the Jellyfish Filter and the required number of filter cartridges is typically based on the projected

annual sediment mass load (see sediment mass load sizing) transported to the device. The maximum flux must also be maintained to below those specified in flow based sizing.

The Jellyfish Filter does not provide retention by the system alone, but may be installed upstream of a retention device. Levels and potential backwater conditions must be checked and accounted for in driving head calculations. Driving head and design flow calculations must remain within the approved limits listed above.

Construction and Installation

The following aspects must be considered during Jellyfish® Filter design and installation:

- Head loss
    - Provide minimum design driving head (within approved limits) to achieve the design flow rate and continuous forward flow and filtration treatment through the Jellyfish Filter cartridges.
    - Assess for submerged or backwater conditions, and increase maintenance access wall height for floatable capture and backwash weir height for the functioning of the automatic passive backwash feature were necessary
- Device footprint
    - Sufficient to ensure the combination of driving head, number and length of cartridges achieves and closely matches the target WQF and site sediment loading and keeps within design limits such as the maximum cartridge design flux, maximum unit MTFR, and minimum per cartridge sedimentation area (Table E2, Table E3, and Table E6)
- Structural loading
    - The manhole or rectangular structure constructed of either precast concrete or fibreglass serves as a vessel for long-lasting structural support of the system
    - Installation of manholes should conform to local specifications and all elevation should be verified to ensure continuous forward flow and filtration treatment through the Jellyfish Filter cartridges
- Bypass
    - The Jellyfish® Filter must be installed as an offline system; flows above the Auckland Council Water Quality Design Storm must be bypassed.

- Shallow or Low Cover Installations
    - The minimum cover is governed by the height of the maintenance access wall. However if there is no hatch cover, the minimum cover for maintenance access needs to be 1520mm measured from the invert elevation of the outlet pipe to the underside of the hatch or converter slab.
    - Shallow systems designs are achievable and include a hatch cover for access to all cartridges
- Sump Drain
    - Systems typically maintain a pool of water within the lower chamber
    - Maintenance is triggered once the backwash pool has more than 76mm of water following 12hrs of dry weather since the most recent rainfall/runoff event
    - The pool of water can be drained between storms using a sump drain
- Pre-treatment
    - The Jellyfish Filter has an in-build pre-treatment channel, slowing the flow velocity and removing coarse sediment, particulate bound pollutants attached to coarse sediment, free oil and floatables trash and debris.
- Construction discharge and commissioning
    - Ensure the site is stabilised prior to placing the Jellyfish Filter system online, or allow for additional maintenance
    - Verify all elevations. All Jellyfish Filter elevations are based on the outlet pipe invert elevation, assuming the outlet pipe is centred in the hole provided.
    - Verify the level and elevation of the manhole base section. The manhole structure should conform to the New Zealand standard.

Inspection and Maintenance Requirements

Periodic inspection and maintenance is required to ensure that the Jellyfish Filter system continues to operate at design efficiency:

- Inspection refers to regular checking of the system interior to ensure that it is operating as designed and to determine whether maintenance is required.
- Maintenance is focused on pollutant removal and filter cartridge service as the Jellyfish Filter has no moving parts

An initial maintenance plan for sites using the Jellyfish® Filter must be submitted to Council for approval prior to the device becoming operational. The initial maintenance plan shall incorporate, at a minimum, the maintenance requirements for the Jellyfish® Filter in accordance with the manufacturer's Jellyfish® Filter Owner's Manual. 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 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 Jellyfish® Filter system.

- Typically Jellyfish Filter maintenance includes the cleaning, recommissioning or replacing of filter cartridges (every 12 month or if cartridge saturation is indicated); vacuum removal of sediment, floatables, and water; pump off of oil layer. An estimate of the required maintenance frequency is established in Jellyfish Filter sizing for sediment mass loading and should be verified through field monitoring.
- Owners/operators must inspect Jellyfish® Filter systems for a minimum of one maintenance cycle (as established in Part 1 of Sediment mass load based sizing) from the start of post-construction operation to determine site-specific maintenance schedules and requirements. Owners/operators must conduct inspections quarterly.
- Conduct inspections 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.

- When inspections are conducted, the following serves as maintenance triggers:
    - Sediment depth reaches half the provided sump depth (typically 300mm)
    - The backwash pool contains more than 76mm of water after 12 or more hours of dry weather have elapsed since the most recent rainfall/runoff event, indicating cartridge saturation
    - Presence of oil
    - Debris clogs the system inlet
    - Backwater conditions occur from a downstream blockage

After the first maintenance cycle of operation (as established in Part 1 of Sediment mass load based sizing), owners/operators must conduct inspections based on the findings during the first cycle of inspections. The owner/operator may revise the initial maintenance plan after the first maintenance cycle of operation, based on the findings during the first maintenance cycle of inspections. The final, potentially revised, maintenance plan outlining long term routine inspection and maintenance requirements shall be submitted to Auckland Council for approval, with appropriate evidence from inspections during the first maintenance cycle of operation supporting the proposed long term routine inspection and maintenance frequencies.

References

ARC. (2003). TP10 Stormwater Management Devices: Design Guidelines Manual. 2 ed. Auckland, New Zealand.

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.

Frankel, E. (2012). Final Certification Jellyfish® Filter by Imbrium Systems. State of New Jersey Department of Environmental Protection Bureau of Nonpoint Pollution Control Division of Water Quality.

Goonetilleke, A., & Egodawatta, P. (2014). Evaluation of Treatment Performance of the Jellyfish® Filter Installation at Ipswich, Interim Report on the Field Monitoring Program. Ipswich, Queensland: HUMES AUSTRALIA.

imbrium. (n.d.). Innovative Stormwater Treatment: Jellyfish® Filter, JFBRO-V2_0512. www.imbriumsystems.com.

imbrium. (n.d.). Jellyfish® Filter Owner's Manual, JF OWN MAN_v3_0413. www.imbriumsystems.com.

imbrium. (n.d.). Jellyfish® Filter Technical Manual, JFTM_V3-0512- US. www.imbriumsystems.com.

Imbrium Systems Corporation. (2010). Quality Assurance Project Plan, Stormwater Performance Monitoring of a Jellyfish™ JF4 (Physical Modeling of a Jellyfish JF4 Subject to Rainfall-Runoff Events; Revision #8. Prepared By: University of Florida, Department of Environmental Engineering Sciences, 218 Black Hall, University of Florida, Gainesville, Florida 32611.

Imbrium Systems Corporation. (2012). NJCAT Technology Verification Jellyfish® Filter. http://www.njcat.org/verification-process/technology-verification-database.html .

State of New Jersey Department of Environmental Protection. (February 2004). New Jersey Stormwater Best Management Practices Manual • Chapter 3: Regional and Municipal Stormwater Management Plans. www.njstormwater.org.

State of New Jersey Department of Environmental Protection. (February 2004). New Jersey Stormwater Best Management Practices Manual • Chapter 5: Computing Stormwater Runoff Rates and Volumes. www.njstormwater.org.

Stormwater360. (2015). Addendum to JellyfishTM Filter Technical Manual Design in Auckland New Zealand. Auckland: unpublished.

University of Florida. (2011). TARP Field Test Performance Monitoring of a Jellyfish® Filter JF4-2-1, Final Version. Performance Monitoring Report for JF4-2-1 Prepared By: University of Florida, Engineering School of Sustainable Infrastructure and Environment (ESSIE), University of Florida, Gainesville, FL 32611 USA.

Washington State Department of Ecology. (2015). Conditional Use Level Designation for Basic Treatment and Pilot Use Level Designation for Phosphorus and Oil Treatment for Imbrium Systems Jellyfish® Filter. www.ecy.wa.gov.

Appendix E Conditions of Proprietary Device Evaluation approval

Auckland Council approves the use of the Stormwater360 Ltd. Jellyfish® Filter for 75% TSS removal under the ALWP on private sites using a standard Jellyfish Filter model provided that the project design is consistent with the following conditions:

1. Design and installation must be in accordance with the Auckland Council Jellyfish® Filter Practice Note. If conditions affecting operation or design parameters vary from those included in the consent application, or the requirements of the Jellyfish® Filter 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 Jellyfish® Filter following the requirements outlined in the Auckland Council Jellyfish® Filter Practice Note and allowing for maintenance provisions and processes in accordance with the manufacturer's Jellyfish® Filter Owner's Manual. Where specifications in the Auckland Council Jellyfish® Filter Practice Note vary to those in the manufacturer's Jellyfish® Filter Owner's 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.
    c. Copy of current maintenance contract if renewed in the last 12 months