SQIDEP Independent Evaluators' Joint Report

StormFilter

December 2023

Background

The initial evaluation of the Ocean Protect StormFilter device was undertaken separately by two members of the Independent Evaluation Panel: Dr Ricky Kwan and Andrew Allan. Once individual reports were finalised, the independent evaluators worked together to develop a Joint Report. The Joint Report identified a number of points that required additional advice from the SQIDEP Technical Review Panel and/or Governance Panel. The additional advice was required because SQIDEP either did not specify the requirements in sufficient detail to answer the Evaluator's questions or the wording was able to be interpreted in different ways. To ensure consistency for all applications, the Governance Panel was required to make a ruling on the following items:

(1) the 'equivalence' of data obtained in icy conditions in the US to Australian conditions, particularly when salt treatment is used for de-icing on roads; and

(2) the actual number of events submitted, as determined by the inter-event time period.

After the significant time involved in assessing this device, the Applicant requested that a 'Conflict Resolution process' be triggered. The SQIDEP Conflict Resolution process requires that a third independent Evaluator be appointed to reassess the application and make a ruling on any contentious issues. . Subsequently, a third Independent Evaluator was appointed, being Baden Myers. Baden's role was to review all previous assessment material, any additional supplementary information provided, rule on any contentious issues and provide a summary report of his findings.

The third-party evaluation verified the claims for the Stormfilter device, subject to a number of conditions. This report combines the third-party evaluation and also includes the original joint evaluation report, as follows:

Part A: Third Party Report - Baden Myers

Part B: Initial Joint Verification Report - Dr Ricky Kwan and Andrew Allan

PART A: Third Party Report - Baden Myers

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4 December 2023

Re: Stormwater Australia Stormwater Quality Improvement Device Evaluation Protocol – Application for the Ocean Protect StormFilter

Dear Jega,

Thank you for the opportunity to review and comment on documentation relating to the Stormwater Australia Stormwater Quality Improvement Device Evaluation Protocol (SQIDEP) application from Ocean Protect (OP) relating to their StormFilter product. Based on your request for this review to myself by email on 1 September 2023, the review was to focus on the following items:

1. *Review the recent letters issued by the Governance Panel regarding key issues raised in the two Evaluation reports (being international data, inter-event timing and similarity of old vs new devices).*
2. *Based on those letters, assess the available data and build on the existing reports to determine the following:*
    a. *with the ruling on the inter-event time, international data and agreed comparability of old vs new devices, do both devices meet the minimum compliant dataset requirements?*
    b. *as per above list, adding the additional data into the data analysis, are the two devices SQIDEP compliant or not? If not, what is required for them to be compliant?*
    c. *any other comments?*

I understand that the 'recent letter' referred to above refers to a letter from the Stormwater Australia SQIDEP Governance Panel to OP dated 28 July 2023. It details a response for the assessment of the OP OceanGuard and OP StormFilter. Note that the review here refers explicitly to the OP StormFilter and the OP OceanGuard was addressed separately in a letter to you on 21 November 2023. The 28 July 2023 letter from Stormwater Australia to OP addresses four points of concern that have so far prevented verification of the performance claim of the OP StormFilter. In addition, there were several concerns raised by independent evaluators in a draft version of a joint report relating to the OP StormFilter. These issues and a summary of how they may be resolved are presented in Table 1. Note that this table also includes reference to Attachments 1 to 9 of this letter which discuss each matter in greater detail. There is one final attachment (Attachment 10) which shows a list of all referred documents and publications used in this review process. It is also noted that unless otherwise noted (such as in the consideration of gross pollutant interception) this review focussed only on data submitted as part of the claim for the site at Lolo Pass Road, Zigzag, Oregon, United States.

Table 1: Summary of responses to concerns relating to the OP StormFilter; further information on each concern is provided in the listed attachments

Attach -ment	Concern	Source	Summary finding
1	Six-hour limit between qualifying storm events	Letter*	SQIDEP recommends that all events in a performance claim have an antecedent period of less than six hours. Four of the 21 events in the performance claim had an antecedent period of less than six hours. Stormwater Australia have confirmed that this is a recommendation only, and the four events do not show undue influence on the performance. As such, the four events are accepted.
2	Use of ER/CRE Ratio to Disqualify Events	Letter*	Relevant only to the OP OceanGuard evaluation. No impediment to OP StormFilter verification.
3	Use of combined data for OceanGuard and Enviropod (Mark 1) assessment	Letter*	Relevant only to the OP OceanGuard evaluation.
4	Use of Overseas Data	Letter*	SQIDEP does not preclude the use of overseas data for a Body of Evidence Claim. There is sufficient evidence that snow and deicing do not affect the case study site. One event that may have been impacted by de-icing is retained as it has a conservative (negative) impact on the average efficiency ratio supporting the performance claim.
5	Collection of unmatching numbers of aliquots at the inlet and outlet	Draft report**	The draft report raises a concern for sample events in the performance claim where the number of aliquots in the influent and effluent composite samples differed by more than 15%. SQIDEP provides no advice regarding this, and an analysis of the data indicates that there is little evidence that events with greater or fewer aliquots in the effluent compared to the influent had an impact on the performance claim.
6	Uncertainty over sample locations.	Draft report**	The sample locations have been illustrated in a submission by OP.
7	No available data on gross pollutant interception	Draft report**	There was no data provided for gross pollutants in the field study. The claim of gross pollutant removal is conceded here based on photographic evidence of retention and examination of the design of the treatment system but is contingent on the presence of a hood on the overflow weir of the pit containing StormFilter devices.
8	Analytical methods used for samples from the case study site	Draft report**	Test methods used by TestAmerica are from reputable sources and compliant with local authorities such as the NSW Environment Protection Authority.
9	Box and whisker plots were not provided	Draft report**	OP provided box plots and these were reviewed and considered compliant.

* Letter from Stormwater Australia to OP dated 28 July 2023

** OP StormFilter Independent Evaluators Joint Report (Allan and Kwan, 2023)

Based on the overview of key issues provided in Table 1, it is recommended that the OP StormFilter submission data be considered to comply with SQIDEP requirements. A summary of the recommended performance claim is shown in Table 2.

Table 2: Summary of the performance claim for the OP StormFilter

Pollutant	**OP Performance claim (% removal)**	**Verified performance claim (% removal)**
Total Suspended Solids	88.6	88.6
Total Phosphorous	77.1	77.1
Total Nitrogen	61.9	61.9
Gross Pollutants*	100	100

* The gross pollutant performance claim is based on photographic evidence and evaluation of the design.

During this review of the available information, there were some conditions apparent that should be accompany any verification of the OP StormFilter. These may be summarised as follows:

1. The performance claim data submitted for the OP StormFilter setup on Lolo Pass Road, Zig Zag, Oregon, Unites States was designed with Phosphosorb™ media. Any certificate of compliance that may be issued for the OP StormFilter should make it clear that the certification is specific to the use of Phosphosorb™ media. The compliance certificate should make it clear that compliance is specific to StormFilter systems configured to include Phosphosorb™. The marketing of the device with other media such as the ZPG™ and Perlite media listed in the OP StormFilter Technical Design Guide (or any other natural or proprietary media) are not considered compliant at this time and should be assessed in a separate SQIDEP claim.
2. As noted by the OP StormFilter Independent Evaluators Joint Report (Allan and Kwan, 2023), the results, like all stormwater treatment devices, are dependent on the maintenance of the device being consistent with manufacturer guidelines. Also, similar to the point above, the configuration of StomFilters should be situated in a chamber similar to the for the trial on Lolo Pass Road, Zig zag, Oregon, United States. Deviations from this design, such as not using an inflow chamber setup as per the conceptual image of the system setup (see Figure 1, Appendix 6) are not considered compliant as changes to flow conditions may affect performance.

Yours sincerely

Baden Myers, PhD BE DipEngPrac

Attachment 1 - Six-hour limit between Qualifying Storm Events

This matter is relevant to the OP StormFilter application. According to the 28 July 2023 letter from Stormwater Australia to OP:

The SQIDEP 1.3 Protocol (4.5 Qualifying Storm Events) does not set a minimum period between storm events and stipulates that there is no minimum storm event duration. As a result, if two events are adequately sampled to describe the pollutograph (see Section 4.5) and both result in pollutant concentrations consistent with SQIDEP 1.3 Table 1, no time limits between the events should be used to disqualify an event.

This is consistent with an extensive review by (Duncan, 2006) that found:

- *Accumulating pollutant loads on catchment surfaces were not exhausted in any one rainfall event.*
- *Build-up periods and wash-off concentrations and loads are poorly correlated.*
- *Rainfall intensity was the crucial factor in liberating pollutants from catchment surfaces and determining pollutant wash-off concentrations and loads.*

I agree with the statement of the letter. In Table 3, page 32, SQIDEP states a recommended interevent time of 6 hours but it is not explicitly required. There is a relevant sub note in the table that states:

'Interevent time or antecedent dry period (ADP) will be dependent on sampling practicalities and catchment pollutant generation. Shorter ADP events may be considered where influent concentrations are above detection limits. Including minimum qualifying concentrations and aliquot collection will impose a limitation on events that can be included in analysis, but if samples are collected, their analysis and/or omission should be disclosed for completeness of data presentation'

According to the latest version of the OP StormFilter Independent Evaluators Joint Report Table 3, page 19 (Allan and Kwan, 2023) the interceding period was "non-compliant for some events" but there was no further detail on why this was the case. It is also noted that in the supporting documentation for the monitoring (Contech Engineered Solutions, Undated) it is conceded that: "The minimum inter-event (antecedent) period was greater than or equal to 6 hours for all events sampled with the exception of LPR052412, LPR060412, LPR062513, and LPR013014." This is correct, and the interevent period of all events in this current OP StormFilter claim are presented in Table 3 in comparison with their performance. It is noted that:

- the average CRE of the four events for TSS, TP and TN is 92%, 78% and 55%, which is similar to the average CRE and ER values;
- the inflow TSS concentration for events LPR052412 and LPR060412 is higher than most other events, but less than the acceptable peak concentration as per Table 1 of SQIDEP.

Given that there is no stipulation that the events should be rejected on the basis of their antecedent period in SQIDEP and that the events do not appear to represent outliers in the dataset, it is recommended that the events be accepted.

Table 3: Summary of rainfall duration, depth and antecedent dry period for events submitted in the performance claim

Technology ID & Storm Event Date	Duration of rainfall (hours)	Rainfall (mm)	Antecedent dry period (hours)	TSS in (mg/L)	TSS out (mg/L)	CRE TSS (%)	TP in (mg/L)	TP out (mg/L)	CRE TP (%)	TN in (mg/L)	TN out (mg/L)	TN (%)
LPR021012	16	16.0	21	182	63	65	0.141	0.104	26	1.062	0.280	74
LPR021412	18	8.6	21	539	32	94	0.220	0.062	72	1.204	0.531	56
LPR021712	46	34.0	18	387	48	88	0.310	0.067	78	1.576	0.638	60
LPR022012	43	59.9	14	246	5	98	0.163	0.026	84	0.696	0.265	62
LPR022412	11	20.3	31	512	43	92	0.424	0.070	83	1.105	0.265	76
LPR031012	32	14.7	89	360	27	93	0.140	0.049	65	1.715	0.265	85
LPR031212[A]	6	11.2	28	150	18	88	0.150	0.037	75	0.760	0.400	47
LPR032912[B]	47	119.1	26	370	47	87	0.280	0.081	71	1.230	0.265	78
LPR052412	5	12.2	4	510	43	92	0.170	0.070	59	1.850	0.400	78
LPR060412	13	19.6	5	580	32	94	0.210	0.043	80	1.057	0.327	69
LPR060712	12	18.5	36	570	120	79	0.170	0.140	18	0.579	0.555	4
LPR110612	9	11.9	117	40	10	75	0.068	0.025	63	0.569	0.555	2
LPR111112	17	39.6	47	100	14	86	0.076	0.025	67	0.584	0.650	-11
LPR113012	16	17.5	7	230	17	93	0.170	0.025	85	1.215	0.515	58
LPR051713	9	6.6	13	94	6	94	0.282	0.029	90	1.372	0.250	82
LPR052113	6	17.8	9	389	24	94	0.558	0.050	91	0.531	0.248	53
LPR062513	4	18.0	2	308	21	93	0.583	0.045	92	0.619	0.253	59
LPR013014	21	13.0	5	170	17	90	0.317	0.053	83	0.240	0.212	12
LPR030314	9	19.3	6	280	95	66	0.417	0.133	68	0.530	0.230	57
LPR030814[A]	18	48.0	27	173	26	85	0.261	0.051	80	0.432	0.080	81
LPR042314	22	17.5	6	159	18	89	0.234	0.037	84	0.410	0.190	54
Average				302	35	87.3	0.254	0.058	72.2	0.921	0.351	54.1

					ER	*88.6*		*ER*	*77.1*		*ER*	*61.9*

Attachment 2 - Use of ER/CRE Ratio to Disqualify Events

This matter was relevant only to the OP OceanGuard and is addressed separately for that device. The use of the ER/CRE ratio has not been adopted by the Independent Evaluation Panel to recommend excluding events for the OP StormFilter. However, using the same methodology used for the review of the application for the OP OceanGuard, it was considered useful to review the performance claim data for potential outliers.

The analysis is based on SQIDEP Section 5.4.3 which discusses the determination of 'Average and median concentration removal efficiency' as reported by the original claim from OP for the StormFilter. On p.25 SQIDEP states that a quality check can be undertaken to evaluate if extreme events affect the performance claim. It suggests that where 'variation < 10% between the median and average CRE indicate that the overall statistic is not influenced by an extreme event/s'.

SQUIDEP also states that this difference refers to the 'difference between the arithmetic average CRE and the median CRE' – it is not a percentage difference between the two values, but an arithmetic difference. The results of this analysis based on all claimed events are presented in Table 4. An arithmetic difference and a percentage difference are presented.

Table 4: Arithmetic difference and percentage difference between the average CRE and median CRE

	TSS	TP	TN
Median CRE, %	90.0	78.3	59.2
Average CRE, %	87.3	72.2	54.1
Difference (Arithmetic, %)	-2.7	-6.1	-5.1
Difference (%)	3.0	7.7	8.6

The results for TSS, TP and TN show a small difference which is less than 10% and therefore of little concern based on the SQIDEP requirement.

Attachment 3 - Use of combined data for OceanGuard and Enviropod (Mark 1) assessment

This matter is relevant only to the OP OceanGuard and is addressed separately for that device. The use of combined data from two design variants for one device is not a relevant consideration for the OP StormFilter.

Attachment 4 - Use of Overseas Data

This matter is relevant to the OP StormFilter application. According to the 28 July 2023 letter from Stormwater Australia to OP:

As per the earlier statement made by the Technical Review Panel and Governance Panel, the GP agrees that the use of overseas data is generally appropriate for existing devices available in Australia.

Overseas data can be accepted if the catchment conditions are equivalent to Australian conditions, acknowledging that there are locations in Australia where cold or icy conditions occur. However, it will not be accepted from regional climates where there is a period of seasonal snow cover, particularly where de-icing salts are used. This is partially related to the chemical conditions created where de-icing salts are used but also related to differences in geology in Australia. Australia has ancient soils that are much finer than soils in the US and many other locations (CSIRO 1983). This may result in different responses when salts are applied.

Based on the response from Stormwater Australia to OP, the use of overseas data is considered appropriate and in accordance with SQIDEP. This is also evidence in SQIDEP where it is noted that a body of evidence claim 'must demonstrate climate and rainfall is transferable' (SQIDEP, Page 10, Figure 1). A key inhibitor for accepting the data according to the letter and SQIDEP is that data should not be used from areas where there is a period of ice and snow cover or where de-icing salts are used. On this basis, the study site is considered compliant.

The original report detailing data collection and results used for the performance claim (Contech Engineered Solutions, Undated) indicated that 'Sanding, graveling, and de-icing occur on the site as necessary during winter to control ice accumulation and assist with tire traction'. This may affect the applicability of some events in the claim. There is however a subsequent letter in the claim from Gretchen Tellessen of Contech Engineered Solutions, United States, who conducted the field monitoring. The letter indicates that the site would not have had any de-icing salts applied directly as the local authority only applies salt to the nearby highway. The letter does note that de-icing salt (in the form of magnesium chloride) may have been tracked onto the catchment via vehicles exiting the adjacent Highway 26. However, de-icing on the highway only occurs for extreme events and in cases where there are several nights where temperature is below zero. It is noted that sampling was suspended during the coldest periods, reducing the risk of snow conditions affecting monitoring results. The letter also noted that while it was not known if de-icing salts were ever applied, the most likely time for application was on or around the event reported for 12 March 2012 (Sample LPR032912B), which corresponded with a time where there were consecutive nights with temperature below zero. If this event was removed from the dataset, the average and median CRE values increase slightly in the 21 sample dataset supporting the claim and I suggest that this event in the dataset should remain as a conservative influence in the claimed performance.

Attachment 5 – Collection of unmatching numbers of aliquots at the inlet and outlet

The latest draft of the OP StormFilter Independent Evaluators Joint Report (Allan and Kwan, 2023) indicated that there were a number of events where the number of aliquots at the inflow and outflow differed. There are 21 events in the performance claim and 12 events had a 15% difference in the number of inflow and outflow aliquots. It was noted that these events should be treated with caution. On further review, it was found that of the 21 events used for the performance claim, most have more inlet than outlet samples (which may be attributed to the influence of unmonitored bypass flows in some events) but there are seven events where more effluent aliquots are collected than influent samples.

It has subsequently been conceded that there was ongoing alteration to the rate of volume based sample collection during the study in an attempt to match predicted rain conditions. It was also noted that there was in some cases different sample collection rates identified for the influent and effluent samples collected and that this caused differences in the number of aliquots collected at the inflow and outflow sample point.

SQIDEP requirements are not clear on how deviations in the number of aliquots should be treated. It does note that there should be 15 sample events submitted with a claim, and that this should include 'Sufficient events to achieve 90% confidence interval, as determined by defensible statistical method (e.g. ANOVA, t-test) that examines influent and effluent pairs' (SQIDEP, p.32, Table 3). This wording is used in several instances (p.15, p.24, p.34) but is clearly referring to paired composite samples at the inlet and outlet of devices. As such, there is no strict guidance on what implications there are when individual inlet and outlet sample aliquots differ. As such, the question arises whether the different number of aliquots at the inlet and outlet may have influenced the results – were the inflow and outflow samples equally representative of the storm hydrograph?

A review of the data shows that this difference has not affected the stormwater event coverage. All of the events where the number of sample aliquots differed by more than 15%, for example, had a hydrograph coverage of more than 80%. The analysis in Table 5 show that there is little difference in the performance claim when the events are included – the efficiency ratio, which forms the basis of the OP StormFilter claim, is relatively similar for TSS and TP, with some difference evident for TN. This difference is not considered as a reasonable basis to change the claim however, because any difference attributable to the number of aliquots should be reflected in TSS, TP and TN. For this reason, the differences in the number of aliquots are not considered to impact on this performance claim, but it should be noted that SQIDEP itself could be improved by providing clear advice in this regard.

Table 5: Storm events in the OP StormFilter performance claim and the impact of including samples where aliquots differed

Storm Event ID (Location & Date)	Rainfall Depth (mm)	Number of aliquots (Influent)	Number of aliquots (Effluent)	Hydrograph Coverage, Influent (%)	Hydrograph Coverage, Effluent (%)	Difference (inlet - outlet)	Difference in aliquots (%)	CRE TSS (%)	CRE TP (%)	CRE TN (%)
LPR021012	16.0	10	7	99%	91%	3	30%	65%	26%	74%
LPR021412	8.6	7	7	93%	92%	0	0%	94%	72%	56%
LPR021712	34.0	40	32	93%	97%	8	20%	88%	78%	60%
LPR022012	59.9	48	45	69%	83%	3	6%	98%	84%	62%
LPR022412	20.3	23	17	97%	92%	6	26%	92%	83%	76%
LPR031012	14.7	20	8	98%	97%	12	60%	93%	65%	85%
LPR031212A	11.2	14	12	86%	89%	2	14%	88%	75%	47%
LPR032912B	119.1	48	45	67%	77%	3	6%	87%	71%	78%
LPR052412	12.2	13	15	81%	80%	-2	-15%	92%	59%	78%
LPR060412	19.6	24	25	85%	93%	-1	-4%	94%	80%	69%
LPR060712	18.5	24	25	92%	87%	-1	-4%	79%	18%	4%
LPR110612	11.9	13	16	92%	95%	-3	-23%	75%	63%	2%
LPR111112	39.6	32	31	63%	59%	1	3%	86%	67%	-11%
LPR113012	17.5	27	15	87%	98%	12	44%	93%	85%	58%
LPR051713	6.6	16	13	97%	96%	3	19%	94%	90%	82%
LPR052113	17.8	35	28	98%	95%	7	20%	94%	91%	53%
LPR062513	18.0	26	24	80%	76%	2	8%	93%	92%	59%
LPR013014	13.0	36	41	99%	98%	-5	-14%	90%	83%	12%

LPR030314	19.3	34	43	98%	100%	-9	-26%	66%	68%	57%
LPR030814A	48.0	47	48	82%	74%	-1	-2%	85%	80%	81%
LPR042314	17.5	50	50	70%	47%	0	0%	89%	84%	54%
				ER, %, all events				88.6%	77.1%	61.9%
				ER, %, where aliquot numbers differed > 15%				87.4%	76.7%	67.1%
				ER, %, where aliquots numbers < 15%				89.7%	77.6%	52.8%

Attachment 6 - Uncertainty over sample locations

A noncompliance was recorded in the latest draft of the OP StormFilter Independent Evaluators Joint Report (Allan and Kwan, 2023) because of uncertainty over the location of sampling equipment in the United States field study reported by Contech Engineering Solutions (Contech Engineered Solutions, Undated). OP provided additional data to clarify this issue in a spreadsheet titled '2022-10-25 StormFilter SQIDEP compliance summary for reviewers.xlsx'. Worksheet 'QAPP Figure 7' is claimed to address this, and it does effectively show that

- influent samples were extracted at a point immediately after influent flow measurement and prior to the OP StormFilter cartridges, and
- effluent samples were extracted immediately after treatment by filter cartridges, and prior to mixing with bypass flows. Effluent flow measurement included both treated flow and bypass, and based on inflow and outflow measurements, one should be able to get a reasonable measure of the treatment flow rate.

This has been addressed.

Attachment 7 - No available data on gross pollutant interception

There were no gross pollutant results presented to back up the performance claim of 100% interception. While this lack of data presents a clear case to deny the claim, it may be reasonable to accept the 100% interception claim with suitable caveats. This includes considering the potential pathways for gross pollutants to proceed through a StormFilter device, and the potential for the device to be installed in isolation of any upstream pre-treatment measures.

In this review, no pre-treatment measures are noted to be a pre-requisite, and therefore none are assumed. OP have advised that the device may be installed with or without pre-treatment, and any pre-treatment (such as the OP OceanGuard) is assessed separately.

OP have also advised that the only pathway for gross pollutants to pass through an OP StormFilter is via the overflow weir of the chamber which contains StormFilter units. It is agreed that this is the case, based on the typical StormFilter setup provided by Dalrymple and Wicks (2021) reproduced below in Figure 1. It is considered unlikely that gross pollutants will proceed through an OP StormFilter chamber set up as below. The only pathways are:

- through the OP StormFilter units, which is considered impossible due to the pore size of filter media in the units, or;
- through the overflow riser, which is a relatively minor risk. The hood over the overflow riser outlet means that gross pollutants (particles generally defined to be greater than 5 mm) would need to be 'floatable' to reach the overflow riser, or conditions turbulent enough to lift them. In these cases, gross pollutants may flow out of the chamber in overflow events, but are impended by the presence of the hood over the overflow riser. Gross pollutants in the chamber would need to rise up underneath the hood over the overflow riser as water levels increase in the chamber to flow out of the chamber.

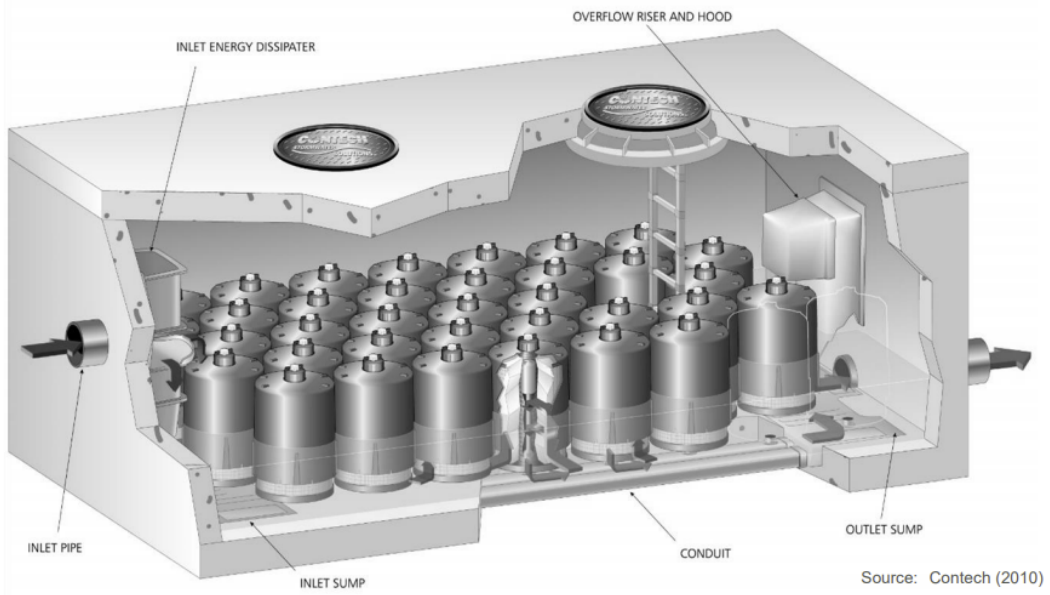

Figure 1: Conceptual diagram of the OP StormFilter units in a chamber

As evidence that gross pollutants are intercepted, OP provided photographs of OP StormFilters being maintained in Australia. Gross pollutants such as leaves and litter are visible in the sediment in the supplied photos, an example of them reproduced in Figure 2.

(a)

(b)

(c)

Figure 2: Examples of gross pollutant interception within OP StormFilter chambers in Australia including leaf litter in image (a) and other gross pollutants including litter in images (b) and (c)

Based on the design of the OP StormFilter chamber, and the photographic evidence submitted, the claim of 100% gross pollutant interception is considered acceptable in this case, but it is strongly

dependent on the presence of a hood on the overflow. In the absence of this hood, it is considered reasonable to assume that some portion of gross pollutants that are floatable or otherwise mixed into the water column through turbulence in high flow events may exit the chamber.

Appendix 8 – Analytical methods used for samples from the case study site

A 'subsequent check' was noted to be required in the latest draft of the OP StormFilter Independent Evaluators Joint Report (Allan and Kwan, 2023) because of uncertainty over the analytical methods used by the laboratory measuring the concentrations of TSS, TP and TN in samples from the Lolo Pass Road, Zigzag case study site. It was noted that 'Analytical methods should be assessed for equivalence with local standards'. A review of the available data indicated that all water quality analysis for the case study site was conducted by TestAmerica (TestAmerica Job ID: PVB0393). Table 6 shows the test methods employed by the analytical laboratory and comments on applicability to Australian conditions.

Table 6: Methods employed by TestAmerica for water quality analysis and commentary on relevance to equivalent testing in Australia

Water quality indicator	**Method used by Test America**	**Comment**
Total suspended solids	SM 2540D	Test method is sourced from *Standard Methods for the Examination of Water and Wastewater*[1]*;* method is considered acceptable by NSW EPA[2]
Total phosphorous	SM 4500-P F	Test method is sourced from *Standard Methods for the Examination of Water and Wastewater*[1]; method is considered acceptable by NSW EPA[2]
Total Kjeldahl Nitrogen	EPA 351.2 *Determination of Total Kjeldahl Nitrogen by Semi-Automated Colorimetry*	Test method is sourced from USEPA; method is considered acceptable by NSW EPA[2]
Nitrate/Nitrite-Nitrogen	EPA 353.2 *Determination of Nitrate-Nitrite by Automated Colorimetry*	Test method is sourced from USEPA; method is considered acceptable by NSW EPA[2]
[1] Currently available in 24th edition (American Public Health Association et al., 2017) [2] See NSW Environment Protection Authority (2022)		

Based on this review, the methods used for water quality analysis that are relevant ot eh claim for the OP StormFilter are reasonable and compliant.

Appendix 9 – Box and whisker plots were not provided

The latest draft of the OP StormFilter Independent Evaluators Joint Report (Allan and Kwan, 2023) indicated that box and whisker plots were not provided as required by SQIDEP (e.g. Section 5.2 p.23). OP were approached for these and they were provided. The plots for the three claimed pollutants are shown in Figure 3 to 5 below.

Interpretation of the results is difficult because SQIDEP does not provide guidance on how strictly to interpret the data. But the following is noted:

- The results for TSS show two outliers, specifically two effluent TSS results, that are higher than 1.5 times the interquartile range.
- The results for TP show two outliers on the influent data and one outlier in the effluent data. In both cases, the samples are higher than 1.5 times the interquartile range.
- The results for TN shows compliance in the data, as there are no outliers.

In the absence of clear guidance on whether outlier data points are acceptable, the data is considered compliant on the basis that:

- all influent sample concentration outliers are within the influent specifications of SQIDEP (Table 1), and;
- all effluent sample concentrations that are outliers for are greater than 1.5 times the interquartile range, not below, and their inclusion in the dataset will therefore reduce, not increase the claimed performance.

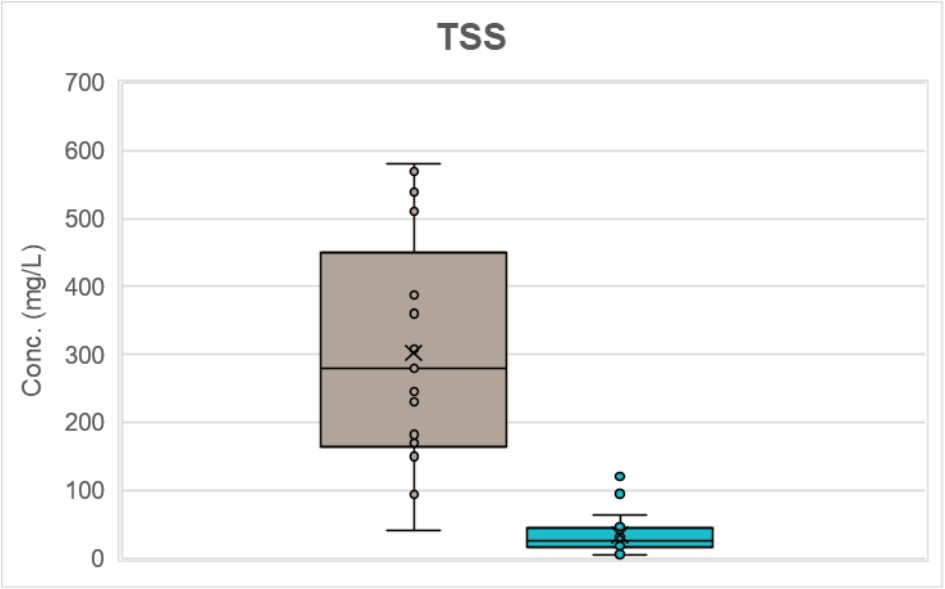

Figure 3: Box and whisker plot for TSS, based on the 21 field samples that form the OP StormFilter claim from Lolo Pass Road, Zigzag, Oregon, United States

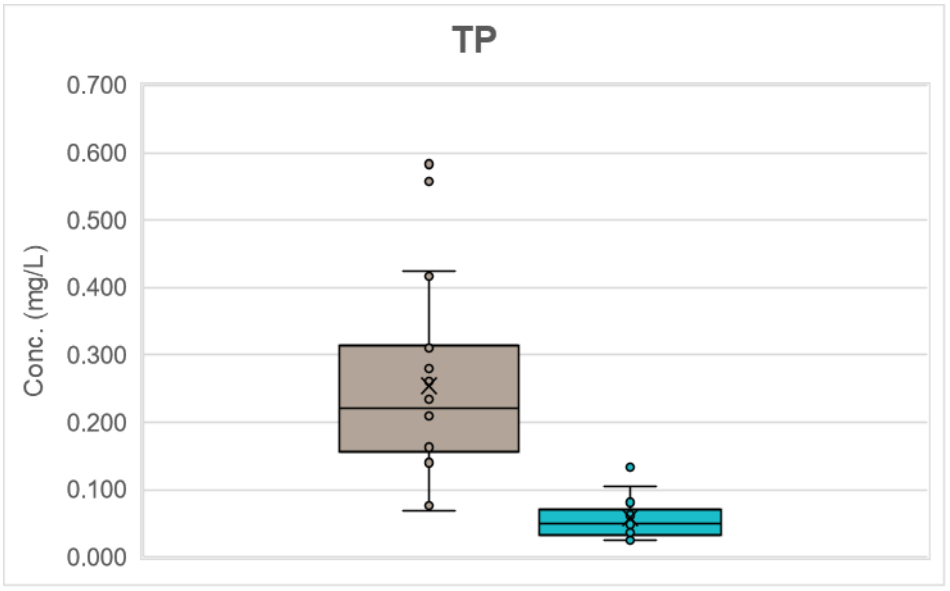

Figure 4: Box and whisker plot for TP, based on the 21 field samples that form the OP StormFilter claim from Lolo Pass Road, Zigzag, Oregon, United States

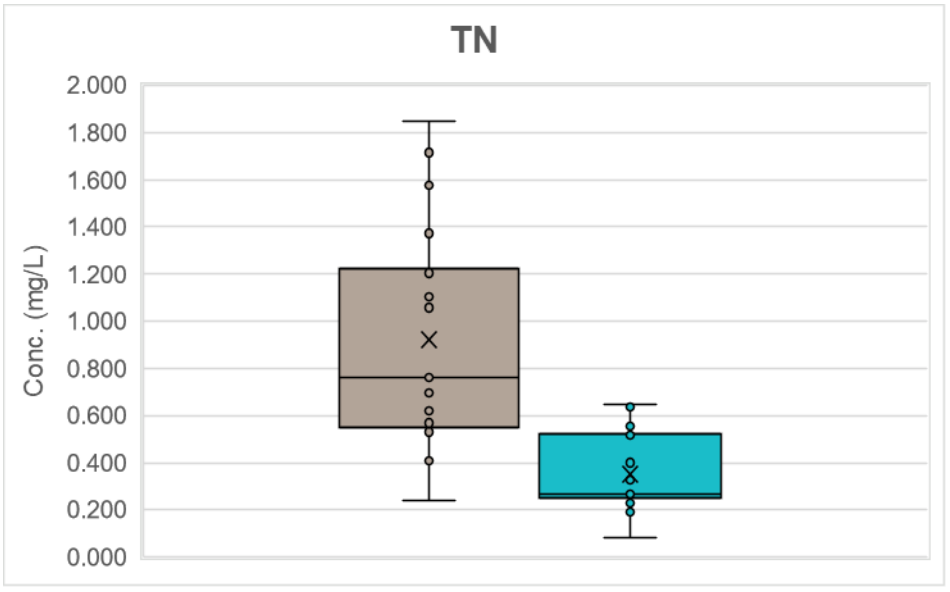

Figure 5: Box and whisker plot for TN, based on the 21 field samples that form the OP StormFilter claim from Lolo Pass Road, Zigzag, Oregon, United States

Attachment 10 - References used in this letter

Allan, A., Kwan, R., 2023. Stormwater independent evaluators joint report 485-04 SQIDEP StormFilter (Draft report). Afflux Consulting for Stormwater Australia.

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Duncan, H.P., 2006. Urban stormwater pollutant characteristics, in: Australian Runoff Quality. Engineers Australia, Crows Nest, NSW, Australia.

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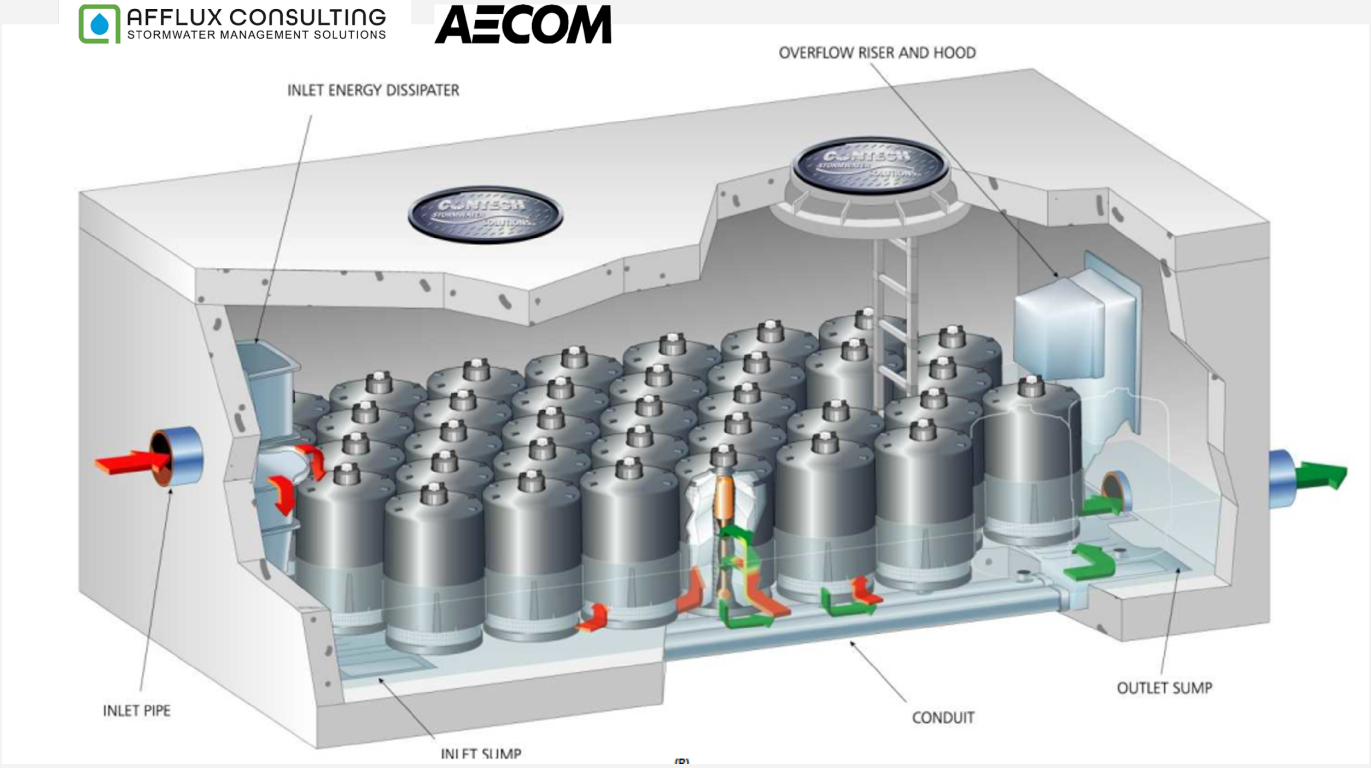
Part B: Joint Verification Report

Dr Ricky Kwan and Andrew Allan

Date	14 June 2023
Version	v02
Author(s)	AA/ RK
Client	Stormwater Australia



Document History

Revision:

Distribution:

Climate Change Statement

A wide range of sources, including but not limited to the IPCC, CSIRO and BoM, unanimously agree that the global climate is changing. Unless otherwise stated, the information provided in this report does not take into consideration the varying nature of climate change and its consequences on our current engineering practices. The results presented may be significantly underestimated; flood characteristics shown (e.g. flood depths, extents and hazards) are may be different once climate change is taken into account.

Disclaimer

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Contents

Tables

Figures

1. Introduction

This document reports on the independent evaluation of an application by Ocean Protect to have Stormwater Australia approve the StormFilter treatment technology under the requirements included in Stormwater Quality Improvement Device Evaluation Protocol (SQIDEP) v1.3 (hereafter referred to as SQIDEP) published in 2019 by Stormwater Australia. SQIDEP v1.3 is available on Stormwater Australia's website at the time of reporting.

This is a joint report prepared by Independent Evaluators, Andrew Allan (Afflux) and Ricky Kwan (AECOM). As part of our internal Quality Assurance process the report has been reviewed by Chris Beardshaw of Afflux Consulting.

The Independent Evaluators were appointed by Stormwater Australia on a fee for service basis to provide an independent evaluation of an StormFilter device which is described as a media filled cartridge system capable of capturing pollutants entering into stormwater drains and which can be installed within new and existing stormwater pits or vaults.

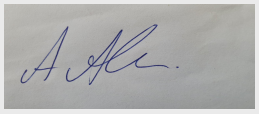
The application was accepted by Stormwater Australia and provided (along with supporting information) to evaluators for their review.

Evaluators Declaration of Independence

It is declared that both evaluators, Andrew Allan and Ricky Kwan, are completely independent and neither Independent Evaluator has any conflict of interest with respect to this engagement.

We jointly declare that:

We are not, nor have we ever been employed or commissioned by the Applicant, Ocean Protect. We have not been involved in the design or development or monitoring of the StormFilter device and have undertaken this assessment without prejudice and in good faith.

Name- Andrew Allan	Name- Ricky Kwan
Signature 	Signature 

Background

The application submitted by Ocean Protect relied on overseas testing results at a site in Oregon, USA as well as various peer reviews conducted through a range of approval agencies and under different jurisdictional protocols across America.

The initial phase of assessment under the SQIDEP pathways determined that supporting datasets should be local (Australian) based, however this was disputed by the applicant.

After further discussions the evaluation panel for this product was asked to consider if, and under what circumstances international data could be considered. Upon further review of data the evaluators felt that there was a prima facie basis to consider the laboratory information, and the integrity of the various supporting processes that have been mentioned under the various pathways within the USA.

It is on this basis that the assessment will proceed and influence any recommendations. Aside from the specific laboratory data and its statistical relevance the evaluators would expect that the processes should be able to demonstrate the following:

- Independence of testing
- Completeness of results disclosure
- Integrity of Quality Assurance processes and
- General agreement and adherence to the requirements of SQIDEP (i.e. consistent with the required QAPP, qualifying events etc)

The evaluators are also mindful that:

- It is not the role of evaluators to authorise significant departures from SQIDEP for individual products
- There is an important principle to maintain that local data should continue to be generated to support the acceptance of claims for devices within the Australian market.

We expect that there will be useful and relevant information that can be gleaned from international studies. However, Stormwater Australia would need to engage on a separate process to fully understand the relevance of these, and potentially develop pathways for '*equivalent*' information generated in other settings.

We note that while we have proceeded in making suggestions and recommendations as part of this evaluation, despite the use of international rather than Australian data; ultimately it will be the decision of Stormwater Australia to accept and adopt these after following its own process of diligence and risk assessments.

The device is broadly described as a filter media cartridge installed within a chamber connected to a stormwater diversion. Water entering the chamber flows through filter elements prior to reaching the outlet.

The underlying PhosphoSorb technology has been developed by Contech Engineered Solutions, a United States company who provide a range of stormwater treatment technologies, and tested at a filed site in Oregon, USA.

Alignment with QAPP

At the outset a submission under SQIDEP has to adhere to Quality Assurance procedures. This would be the norm for any products undergoing local testing and the QAPP is a formal process to agree upfront what information is to be collected, how this will be done and under what circumstances will there be sufficient weight of evidence to support a claim.

While the use of a QAPP has been described in various associated documents, these have not been entirely provided for review. As it is of assistance to these reviews to have a Quality Assurance framework in place to guide the process, we will examine aspects of the testing program from available evidence and align it with SQIDEP requirements in Section 2.

Independence of Monitoring Scientist(s)

Ideally the Independence of Monitoring Scientists will need to be verified to provide confidence in the process.

We have been provided with a report prepared under the Contech name, for a product developed by the same entity. It would be preferred if this were not the case, but we also acknowledge that there have been other processes that can assist in verifying independence and include:

- Separate analytical facilities were used

- There have been peer reviews under jurisdictional requirements

In cases where local testing has been undertaken it is normal to look for evidence of independence between commissioning and testing agencies, and where this is not contractually clear request statutory declarations as an alternate method to understand the relationship between parties.

It is not clear if the above can be done retrospectively, and as such we will make recommendations on this for the future.

2. Assessment

Stormwater Australia published the Stormwater Quality Improvement Device Evaluation Process (SQIDEP) in January 2019. The SQIDEP process seeks to "provide a uniform set of criteria to which stormwater treatment measures can be field-tested and reported. These criteria should guide and inform field monitoring programs seeking to demonstrate pollutant removals for stormwater treatment measures included in pollutant export modelling software. Future revisions of the protocol are anticipated to also include laboratory testing." (Stormwater Australia, 2019).

Review Documents

The following documents form the basis of this independent evaluation:

- **The Int'l Corporate Center Stormwater Treatment System Field Evaluation (17 September 2010)**

This was a comparative study looking at two different filter media. From dates indicated this is suggestive of an earlier phase in the product development cycle.

Information on sample setup is provided and appears to be reasonable in relation to the objectives of the study. The report was prepared by Contech, and it indicated that employed staff were engaged in all aspects of sample setup, collection and system maintenance; however laboratory analysis was carried out by a third party (Test America).

The report states that only selected samples were sent to laboratory for analysis; there are no criteria presented for the selection process. A total of 19 samples were analysed, with only limited results for nutrient species, however the dataset for metals is more substantive.

There are no details on Quality Assurance procedures provided.

- **Mitchell Community College Stormwater Treatment System Field Evaluation (18 December 2012)**

This study was conducted in partnership with a North Carolina Department of Environment and Natural Resources (NCDENR) Division of Water Quality (DWQ) with independent oversight from staff at North Carolina State University. There is no specific document to substantiate how these parties interacted; however the presence of a Governmental body and academic institute does provide some level of assurance of independence.

Descriptions of the site, sample collection setup and methodology are provided and appear to be reasonable. Over a 20-month period 13 samples were collected and assessed for performance in reduction of Solids and Phosphorus related species. Not all samples were submitted for analysis, however results provided indicate a high removal ratio for both Suspended Solids and Total Phosphorus.

No statistical analysis for significance has been undertaken.

No hydrological inputs or summaries have been provided to compare inflows.

- **The Stormwater Management StormFilter® PhosphoSorb® at a Specific Flow Rate of 1.67 gpm/ft2 GULD Technical Evaluation Report for Basic & Phosphorus Treatment (Urban Green) (9 October 2015)**

This report was prepared to support a TAPE application for technology verification in Washington State.

It provides a greater level of clarity on the technology background and sampling setup than included in other documents that were provided as evidence for SQIDEP evaluation.

Some supporting information has been excluded from this reporting (including QAPP) for a variety of reasons (such as protection of proprietary information).

Not all storm events included in the initial data provision have been accepted for final performance assessment. Of 25 samples submitted only 17 have been selected as suitable for review and analysis. Unfortunately, there is not always a direct relationship between the performance claims explicitly requested through the current evaluation and the Urban Green analysis.

Field data reports are provided and are marked up in different coloured writing. In particular, some field records are marked with 'event D'Qed.' The alignment of these records with the final (limited) dataset is beyond the scope of this assessment but appears to substantiate an approach that not all samples can be trusted on face value alone.

In summary the Urban Green report suggests that the full dataset should be interpreted with caution, and that all data cannot be taken at face value.

The Urban Green report reads as a reasonable attempt at a comprehensive third-party review and appears at odds with the unqualified information supplied in reports with Contech branding.

- **Test America Analytical Reports (20 February 2012)**

Certificates of Analysis have been provided for the testing program and include results, Chain of Custody and Sample receipt reports indicating condition and holding time compliance. A sample review of these has been undertaken (around 1/3) and identified a few instances where samples weren't delivered in time for requested tests (e.g. Ortho Phosphate) and one where the sample was received at an elevated temperature.

- **Memorandum Water Quality Data Quality Assurance Review (18 May 2015)**

This was an in-house prepared document that examined the various quality assurance parameters associated with the laboratory analytical program. While it concludes that the results were acceptable it did identify qualifiers on some results (namely Ortho-Phosphate and nitrogen species) which were accepted as estimated quantities due to holding time or reporting limit exceedances. While these were related to speciation of results the impact on 'total' results is unknown and should indicate caution in accepting these results.

- **MUSIC File**

A MUSIC file has been provided in the form of a sqz file and contains three configurations of StormFilter setup.

Each configuration includes an initial chamber connected with a treatment element of differing flow configurations (i.e. bypass) relating to the treatment effect.

- **Performance Evaluation Study**

A report prepared by Contech Engineered Solutions "The Stormwater Management StormFilter® with PhosphoSorb® Media Performance Evaluation, Study: Lolo Pass Road, Zigzag, Oregon". See notes below.

Ocean Protect StormFilter (application summary)

The Ocean Protect StormFilter was submitted for evaluation against the SQIDEP protocol on 31 January 2022.

For the most part the claim is based on performance data collected at an overseas test site as detailed in a report prepared by Contech Engineered Solutions "The Stormwater Management StormFilter® with PhosphoSorb® Media Performance Evaluation, Study: Lolo Pass Road, Zigzag, Oregon". From information in the report, field testing was conducted over the period from February 2012 to April 2014. Contech staff were responsible for commissioning, operation and maintenance, and collected and prepared samples in response to rain events. Analytical testing was conducted at Test America laboratories. The report details the catchment tested and the sample collection methods.

The field testing was undertaken without a Quality Assurance Project Plan having been reviewed by Stormwater Australia evaluators.

Ocean Protect has provided a package of material to assist in claim verification.

According to the submission the StormFilter is seeking pollutant reduction claims for TSS, TP, TN and Gross Pollutants and will be assessed in this report.

Figure 1. *StormFilter test location (Contech)*

Figure 2. *StormFilter- catchment area (Contech)*

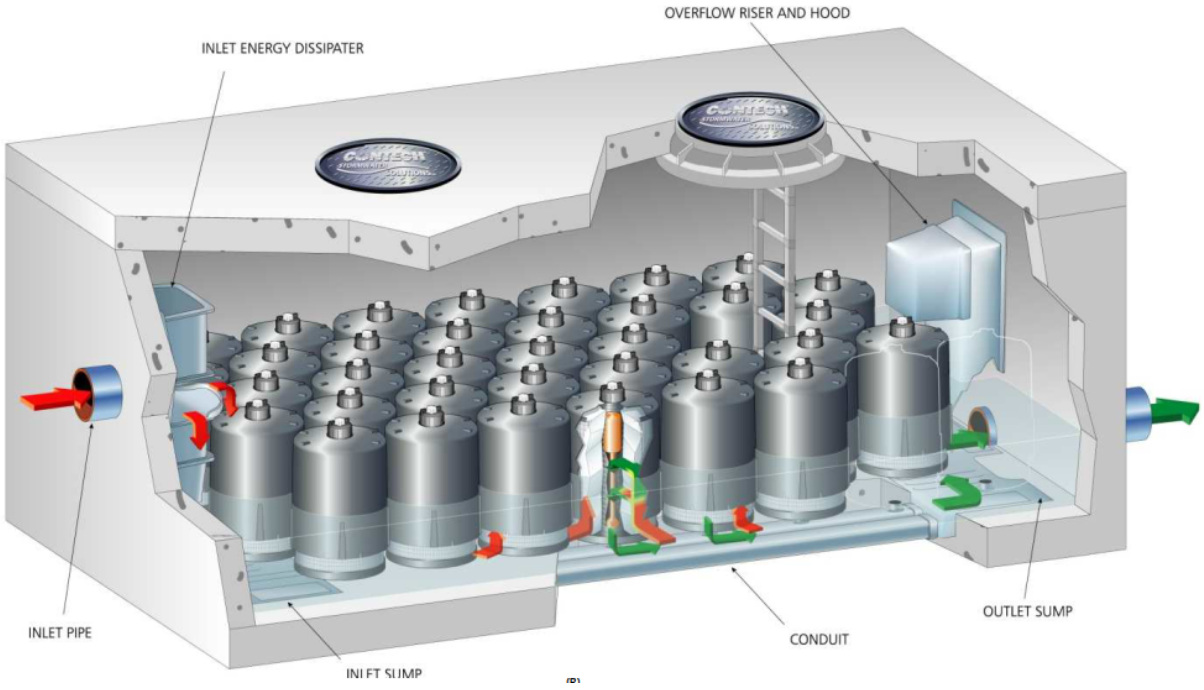
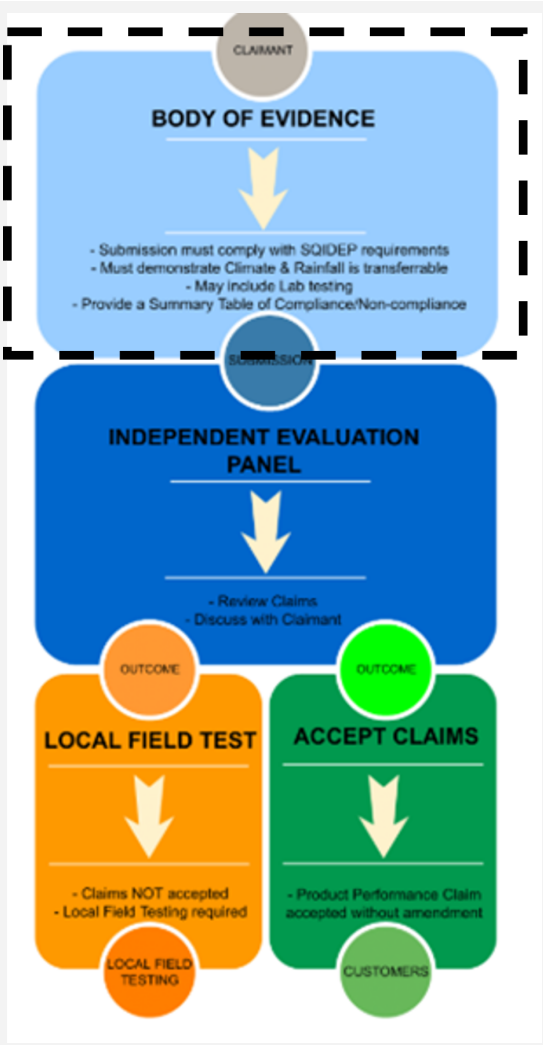


Figure 3. *StormFilter sample setup*

Under the SQIDEP protocol there are separate pathways to demonstrate whether a device is able to achieve pollutant reduction under field conditions. This claim is being assessed under the Body of Evidence pathway which includes an assessment of field testing/ monitoring across a range of storm events, and independent evaluation of claims as indicated in Figure 4. The Body of Evidence pathway allows consideration of

international data which is able to demonstrate compliance with SQIDEP criteria and Australian climatic and rainfall conditions.



Source:

Figure 4. *SQIDEP Pathway- Body of Evidence*

Performance Claim

The performance claim is stated in the application and is shown below in Table 1.

For the purposes of assessment, the data provided from the Lolo Pass will be reviewed to see if it satisfies the requirements of SQIDEP.

It should be noted that these claims are contingent on the device being sized (designed) and installed correctly, and with appropriate maintenance undertaken.

Table 1. *Ocean Protect StormFilter pollution reduction claim*

Pollutant	Removal claim (BoE application)
Total Suspended Solids (TSS)	88.6%
Total Phosphorous (TP)	77.1%

Total Nitrogen (TN)	61.9%
Gross Pollutants	100%

It is noted that gross pollutants were not tested, however the claim is made for a substantial reduction in this pollutant category. Based on the physical nature of the device and its mode of operation (i.e. water passing through a filter media is treated) it is expected that gross pollutants will be removed from the treated effluent stream and prima facie this could be considered a legitimate claim. It should be noted that gross pollutants are likely to be washed downstream when the device is operating in bypass mode unless they are removed prior.

Based on a strict interpretation of the protocol the reviewers have formed the view that Gross Pollutant removal should not be claimed based on the evidence presented.

It remains a separate consideration if the product is marketed for gross pollutant removal but to retain integrity of the SQIDEP process, any promotional material should avoid implying that compliance has been achieved.

Site Background and Assumptions

The test catchment is a road that may operate under different climatic and operational conditions that would typically be encountered in much of Australia. In particular, road treatments associated with icy conditions may be prevalent in winter months.

The site is located at an altitude of 1400 feet (~420 metres) and climatically has an annual runoff of around 1400mm and close to freezing temperatures over a 4 month period as shown in Figure 5.

	January	February	March	April	May	June	July	August	September	October	November	December
Avg. Temperature °C (°F)	-0.5 °C (31) °F	-0.2 °C (31.7) °F	1.4 °C (34.5) °F	3.8 °C (38.8) °F	8.1 °C (46.6) °F	11.5 °C (52.7) °F	15.9 °C (60.7) °F	16.4 °C (61.5) °F	12.8 °C (55.1) °F	7.4 °C (45.4) °F	2.2 °C (36) °F	-0.9 °C (30.4) °F
Min. Temperature °C (°F)	-2.9 °C (26.8) °F	-2.8 °C (26.9) °F	-1.8 °C (28.8) °F	-0.1 °C (31.9) °F	3.6 °C (38.5) °F	6.6 °C (43.9) °F	9.7 °C (49.5) °F	10.3 °C (50.5) °F	7.8 °C (46) °F	3.9 °C (39.1) °F	-0.4 °C (31.3) °F	-3.2 °C (26.3) °F
Max. Temperature °C (°F)	3.1 °C (37.6) °F	3.9 °C (38.9) °F	6 °C (42.8) °F	9.1 °C (48.3) °F	13.9 °C (57.1) °F	17.6 °C (63.7) °F	23.1 °C (73.5) °F	23.8 °C (74.8) °F	19.7 °C (67.4) °F	12.8 °C (55.1) °F	6.2 °C (43.2) °F	2.4 °C (36.3) °F
Precipitation / Rainfall mm (in)	259 (10)	204 (8)	210 (8)	176 (6)	123 (4)	87 (3)	25 (0)	28 (1)	63 (2)	160 (6)	252 (9)	288 (11)
Humidity(%)	84%	85%	84%	78%	74%	72%	61%	58%	63%	78%	85%	85%
Rainy days (d)	14	12	14	14	11	9	4	3	5	11	13	14
avg. Sun hours (hours)	4.1	4.7	5.3	6.3	7.3	8.1	10.6	10.1	8.2	5.9	4.3	3.8

Source: *https://en.climate-data.org/north-america/united-states-of-america/oregon/zig-zag-986982/*

Figure 5. *Zig Zag, Oregon- Climate*

The site is described as a bridge with associated co-ordinates. Based on this information we have located the site for a better contextual understanding of surrounding land use. It appears that the site is on a side road in a low density population area; the road itself (E Lolo Pass Road) heads in a north easterly direction into what appears to be a 'wilderness' area.

As reviewers the implications of this contextual understanding are:

- Consider the representativeness of the site to other application areas
- Consider the implications of potential road management activities in winter months on representative samples

3. SQIDEP Compliance

Quality Assurance Project Plan

A Quality Assurance Project Plan was not provided as part of the initial submission. In the summary of information provided it was indicated that one had been prepared but was being withheld to protect IP. Without having access to this upfront it becomes difficult to assess the integrity of process.

The intent of the QAPP is two-fold. It provides guidance on the design and implementation of a field evaluation program, and if agreed upfront prior to field work commencing, provides a template for collection and assessment of data.

In the absence of this document, and to progress the application we have undertaken a review against the requirements of QAPP as it has been applied in other assessments and is summarised below. We have also attempted to interpret other documentation provided to assist in gaining a holistic assessment of the technology and any (aggregated) nature of testing undertaken previously.

Outside of this, we do not consider it realistic to retrospectively pursue a 'QAPP' pathway. The time elapsed since the study was undertaken, the jurisdictional complexities and omission of key documents upfront places additional burden on the independent reviewers and potentially compromises an impartial role in the assessment process.

Performance Claim Requirement	Commentary	Evaluator Response
Data Quality Objectives	Data quality objectives are not explicitly mentioned in the QAPP but are effectively covered in the Testing Protocol described under Section 4.1 which details sample collection and analytical methodologies.	This is probably sufficient in so far as the main analytical species have been identified and processes developed around these.
Organisational roles and responsibilities	Describe the organisational role, and relationship between the applicant, data collection and analysis. Where there may be doubt as to the independence between parties any further information to attest to this (i.e. statutory declaration) would be useful as evidence	The information provided suggests that there was no separation between site operation and sample collection. The use of an independent analytical facility is considered 'Business as Usual.' Statutory Declaration has been provided by Ocean Protect as part of the information provided but does not meet the assurance standards that are expected.
Description of test site	Describes the test site, and its influence on generating pollutants that will be claimed. In part this characterisation will be used in the assessment to determine what sites would be suitable for commercial application.	The test site was described in general detail. Further review indicated above raises questions as to how applicable the site may be, and to how data may need to be assessed, particularly in relation to ice and snow conditions.
Measuring rainfall	Data on how rainfall is to be recorded. Any additional data sets that may be useful for independently verifying the rainfall data (e.g. BoM stations or nearby gauges)	Rainfall recording is well explained. Storm reports are provided for each event in Appendices.
Storm events sampled	Describe how storm events will be sampled such as manual sampling, automated sampling and any trigger for taking samples (e.g. flow response, rainfall depth), and whether the samples will be composited etc. Also, any decision framework for determining which samples are selected for analysis and device 'reset' process.	Sampling procedures are explained in high level detail, including references to published guidelines (e.g. Washington Department of Ecology TAPE, 2011) and specific technical details (i.e. sampling equipment models). It is assumed from the description that only samples meeting 'qualifying criteria' were selected for analysis,

Flow monitoring	How will flow monitoring be undertaken, any calibration etc. This should apply both to the inlet and outlet, especially if there are losses through the device or alternate outlet streams. If bypass is expected, the relationship between flow monitoring and treated effluent should also be established.	Flow monitoring was undertaken using a combination of Flumes and Bubblers, however no details on set up have been provided.
Sampling location	Description of sampling location and information to verify they are able to collect 'reference' samples of influent and treated effluent, and ensure a correlation between these two flows.	The Urban Green report provides information on the location of sampling points. From results it appears that the aliquots between influent and effluent are not always the same and may be suggestive of either storage in device or loss of mass through the system.
Sampling equipment	Sampling equipment used, with reference to appropriate maintenance etc throughout the testing period. If the sampling equipment has supporting manufacturing information this would be useful, along with compliance with recommended operational procedures.	Sampling equipment is described. It is understood that Contech personnel were responsible for maintenance, although no specific detail is provided. Maintenance dates are provided in the Appendix A, and events identified, however it is unclear what activities were undertaken at this time.
Sampling methodology	How are samples to be collected, any limits on data to be collected relative to storm duration. Any information on composite samples and how these are weighted during a storm.	Sample methodology is described and allows for flow weighted samples in response to climatic triggers.
Sampling Quality Assurance and Quality Control	Information on standards governing sample collection, preparation/ preservation, handling and transport relevant to the analytical methods used.	Sample preparation and preservation procedures have been described and indicated as being complied with in the report. For greatest confidence primary evidence of procedures being followed should be provided (e.g. CoC)

Laboratory analysis	Analytical information on tests etc. If a contracted laboratory is used this does not need to be overly detailed, just to provide an assurance that the tests are appropriate for expected concentration etc and are being undertaken using defensible methods.	Laboratory analysis was conducted by Test America. It is assumed that this is a reputable laboratory and operates under similar Quality Assurance framework as is typically for Australian NATA registered facilities. Analytical methods are assumed to be equivalent to local requirements but would require specialist chemistry knowledge to confirm. For greatest confidence laboratory results should be presented as original certified copies, although collated or interpreted results can be used to assist with assessment.
Laboratory Quality Assurance and Quality Control	Most laboratories undertake their own QA processes and are likely to be suitable as long as a linkage between samples arriving in a fit and proper condition for analysis, holding times are appropriate and if any issue is identified at the laboratory that corrective measures are implemented.	This would need to be examined based on the published standards of the test facility and any relevant accreditation (i.e. NATA equivalent)
Data management	Data management is an area that should provide assurance that data collected is stored appropriately, labelled and dated for appropriate identification and that there is a process for aligning different datasets (e,g. sample collection to rainfall records) to assist in analysis.	This is not specifically covered in the report, although it is noted that some detail in sample collection and delivery is noted. For completeness it would be useful to have certified laboratory data indicating sample receipt, condition etc at arrival at the laboratory.
Reporting	The process for reporting to provide clarity that the elements contained in the QAPP are able to be identified throughout the report. Ideally the QAPP provides a suitable structure to assemble data and report against the headings required in the SQIDEP.	This is not explicitly covered in the report. It is noted that Ocean Protect has assembled the analytical data into a series of spreadsheets which has been useful to conduct further review of data.

SQIDEP Assessment

The SQIDEP provides a structured framework in which to present evidence and information. Compliance with all elements of SQIDEP Table 3- Minimum data and qualifying event requirements for assessment (SA, 2019) can be used as a basis for determining if the BOE test has been met. Following receipt of supplementary information Table 2 provides a status against each of the Performance criteria.

Note that while the initial USC testing included events that subsequently did not meet qualifying event criteria the data collected is none the less useful as it adds to the robustness of the entire dataset. As such, and where appropriate this has been referenced.

Table 2. *SQIDEP Assessment*

Performance Criteria	Performance requirement	Monitoring action or result	Outcome
Min number of events	15 or enough to achieve 90% confidence interval	A total of 23 storm events were sampled	Compliant
Min rainfall depth	Sufficient to collect minimum sample volume for lab testing.	0.1 inch (2.5mm) for event	Compliant
Inter event period	Minimum 6 hours dry	4 of the events have less than 6 hours inter event time	Non-compliant for some events
Device Size	Single pit	A single 18 inch cartridge treating up to 0.77 litres/ second	To be noted in sizing recommendations for any verified claims
Runoff Characteristics	Target pollutant profile of influent and effluent	Influent and effluent concentrations reported as 'matched pairs.' Some questions are raised about differing numbers of aliquots collected at influent and effluent.	Treat with caution any sample pairs where there is a 15% or greater discrepancy in aliquots collected. (12 in total)
Runoff volume or peak flow	At least 2 events should exceed the 75% of the TFR and 1 event greater than the TFR. The TFR for the device is 12.5 gpm i.e. 0.77 litres/ second	12 events exceed 75% TFR 9 events exceed TFR One result is 2x TFR	Can accept data as compliant
Automated sampling	Composite samples on a flow or time weighted basis	Flow weighted sample. See comments under Runoff Characteristics	See above
Minimum number of aliquots	80% of field test collections should have at least 8 per event.	Compliant. Only 1 event has less than 8 influent aliquots. 2 events have less than 8 effluent aliquots	Compliant
Hydrograph coverage	At least 50% of qualifying storms should include the first 70% storm coverage	Examination of storm hydrograph reports and sample collection confirms this is OK	Compliant

Hydrograph coverage	Multiple peaks should be accounted for (at least 1 occurrence).	Examination of storm hydrograph reports and sample collection confirms this is OK	Compliant
Grab sampling	Not applicable		
Sampling locations	No detail specified	Samples collected in a trailer mounted unit developed for the purpose, but no details provided. This same unit is evident in other tests for the same product.	Non-compliant
Chemical and physical analytes	As identified in QAPP	No QAPP provided. Assumed to be as detailed in the claim	Results presented for TSS, TP and TN. No results presented for gross pollutants.
Min and Max concentrations within range	Refer to Table 1 SQIDEP repeated below *Table 1 — Typical Untreated Stormwater Contaminant Concentrations* Adopted minimum / Recommended Mean Influent Concentration & (Standard Deviation)[1] / Adopted maximum average for all qualifying storms: (Mean + 1SD)[2] / Maximum any indivi event: Me 2SD TSS Limit of detection 151 (+220) 371 591 TP Limit of detection 0.34 (+0.37) 0.71 1.1 TN Limit of detection 1.82 (+1.27) 3.09 4.4	Examination of influent results indicates all within acceptable limits.	Provisionally compliant, Results should be interpreted with caveats based on location and activities (i.e. how representative)
Analytical methods	NATA accredited sample handling and analytical methods	Analytical methods provided and should be assessed for equivalence with local standards	Subsequent check
Flow measurement location	Inlet, outlet and bypass as applicable	Assumed, but no detail provided	Further information should be supplied
Precipitation measurement	A pluviometer is required	Yes	Compliant
Rainfall recording interval	5 minutes or less	Yes	Compliant
Rainfall recording increments	No greater than 0.25mm	0.01 inch resolution (0.25mm) tipping bucket	Compliant
Pluviometer calibration	To be calibrated twice during the monitoring period.	No details on calibration	Not known
Performance indicators	The target pollutants and testing rationale must be described in the QAPP and Detailed Performance Report.		Performance claims relate to TSS, TP, TN and Gross Pollutants. However, no data provided on gross pollutants as noted earlier.
Performance indicators	ER and CRE. If CRE average and median > 10% difference inspect dataset. As a minimum, CRE and ER shall be provided.		ER and CRE calculated. Provided

Performance variability	Box and Whisker plots of inlet and outlet EMCs		Not provided
Statistical significance testing	Log-transformed inlet and outlet paired samples at 90% confidence level.		Provided

Comparison of Inflow Concentrations

In this section we consider whether the influent concentrations are within a 'normal range' and present the range of influent concentrations in this study along with published results and other SQIDEP assessments completed[1].

Influent concentrations are impacted by a range of factors including antecedent conditions and catchment activity. Antecedent conditions allow accumulation of pollutants between events and it is possible to examine reported influent concentrations to identify indicative trends.

The inflow concentrations from this study were compared to previous studies of road catchments for cross-reference. In particular, the pollutant concentrations of TSS, TP and TN were extracted from Duncan (1999) which examined 42 (road) sites across Australia:

The most noticeable point between the studies is the pollutant concentration range. Drapper and Lucke (2015) cited that the inflow concentrations observed in that study were significantly different to results of Duncan (1999). This highlights the difficulty of quantifying pollutant runoff parameters, and consequently, modelling inflows.

For this study, mean TSS influent concentrations (at 314mg//L) are about 20% higher than MUSIC EMC values for sealed roads, mean TN concentrations (at 0.95 mg/L) and TP (at 0.24 mg/L) are about 50% of default MUSIC values for a sealed road.

While the overall results fall within the typically expected range we note that the results are slightly higher than other published Australian SQIDEP results (at least for TSS). As part of the review process we need to consider whether these differences are a result of natural variability or an actual difference in the way the site is operated from a management or climatic perspective.

Table 3. *Typical pollutant concentrations for road catchments*

	Duncan (1999) study	Drapper and Lucke (2015) study	Previous SQIDEP Assessments completed	Current study –StormFilter
TSS (mg/L)	60 – 700 (n=42)	1.45 – 5800 (n=325)	15 – 357 (n=25)	40-780 (n=23)
TP (mg/L)	0.1 – 0.8 (n=25)	0.08 – 26 (n=325)	0.04 – 0.49 (n=25)	0.07– 0.58 (n=23)
TN (mg/L)	1 – 9 (n=17)	0.38 - 8.5 (n=325)	0.3-4.0 (n=20)	0.24-2.12 (n=23)

[1] This is from previous assessments that have been completed by Andrew Allan in a review capacity, and subsequently published on the Stormwater Australia website as verified.

Reported Concentrations Analysis (Antecedent)

While the performance of the device is based on changes between influent and effluent concentrations as reported and elsewhere the influent concentrations are examined (see above) for representativeness of the recommended installation type, it is considered worthwhile to examine the influent concentrations with respect to antecedent conditions to gain an understanding of how the catchment is behaving.

Pollutant concentrations in runoff are influenced by a range of conditions that include the type, intensity and timing of catchment activity, and can be influenced by specific events that add to loadings, and detailed analysis is beyond a simple correlation with antecedent dry weather (ADW) conditions.

In general, it is expected that

- prolonged ADW will lead to increased pollutant concentrations; and
- some pollutants (e.g. Total Suspended Solids) will exhibit a more definitive correlation with ADW.

Influent concentrations are listed in Table 4 for three ranges of ADW. Given the possibility of road works in colder months these have also been identified.

Upon analysis it appears that the shorter ADW conditions have trended toward higher than average TSS loading, while the results for TP and TN respectively decrease and increase.

Table 4. *Comparison of Concentrations and Antecedent Conditions*

	Sample Designation	Antecedent Dry Period (days)	TSS (mg/l)	TP (mg/l)	TN (mg/l)
SHORT ADWP (<1 week)	LPR060712	2	570	0.17	0.579
	LPR021712*	3	387	0.31	1.576
	LPR022012*	3	246	0.163	0.696
	LPR060412	3	580	0.21	1.057
	LPR021412*	4	539	0.22	1.204
	LPR022412*	4	512	0.424	1.105
	LPR052113	4	389	0.558	0.531
	LPR111112*	5	100	0.076	0.584
	LPR030814A*	5	173	0.261	0.432
	LPR113012*	7	230	0.17	1.215
		AVERAGE	372.6	0.2562	0.8979
MEDIUM ADWP (1 week– 1 month)	LPR032912B*	8	370	0.28	1.23
	LPR060112	8	780	0.2	2.115
	LPR031212A*	11	150	0.15	0.76
	LPR112312*	12	110	0.082	*0.515*
	LPR031012*	15	360	0.14	1.715
			354	0.1704	1.267
LONG ADWP (>1 month)	LPR030314*	32	280	0.417	0.53
	LPR062513	35	308	0.583	0.619
	LPR042314	46	159	0.234	0.41
	LPR052412*	56	510	0.17	1.85
	LPR110612*	153	40	0.068	0.569
	LPR051713	168	94	0.282	1.372
	LPR013014	219	170	0.317	0.24
	LPR021012*	-	182	0.141	1.062
			217.875	0.2765	0.8315

*denotes samples taken in months coinciding with icy conditions

Sensitivity Assessment

Based on the analysis above sensitivity assessment can be undertaken to improve confidence in results (i.e. are they robust enough to withstand specific events being removed).

The main issue identified is the effect of potentially high loadings that could arise from road management in the winter months. In addition, a number of samples did not meet the requirement for inter event time, and one 'outlier' for TSS was identified.

The minimum number of samples to meet SQIDEP compliance is 15. As such sensitivity tests will reduce the sample pool down from 23 to 15 as follows.

- Remove outlier
- Remove non compliance AQWP
- Retain 'warmer weather' samples
- Randomly remove remaining 'winter' samples to achieve the 15 events

The selected samples and subsequent statistical analysis is presented in Appendix 2, and summarised in Table 5.

Table 5. *Sensitivity Assessment summary*

Sensitivity test undertaken	Description	Change	Implication
Removal of high TSS, short duration ADWP and random events selected from colder periods	The total sample pool was reduced to 15 to address potential issues identified with testing location	Pollutant removal efficiencies remain in similar order of magnitude and statistical evidence of treatment effect remains valid	Consider modifying claim to be conservative in verified parameters

The design of the SQIDEP included a recognition that different performance metrics may result in slight changes in overall assessment, but that it was important that across all performance metrics there is an observable trend to have confidence in the interpretation of results.

Considering the three main performance metrics (ER, Mean CRE and Average CRE) there is an observable trend with metrics calculated for TSS and TP within 5% of each other, and within 10% for TN. A similar trend is observable on the modified data used in sensitivity testing.

Rainfall Review

For other assessments a review radar records has been undertaken as a spot check to assist with verifying storm events.

Given the time elapsed and the overseas location it is beyond the scope of this review to undertake this type of assessment.

It is noted however that pluviographs are provided for each rainfall event along with influent and effluent flows and appear consistent.

Cherry Picking of Storm Events

Cherry Picking implies that a full set of data has been provided and only favourable results have been included for analysis.

Based on a strict adherence to the SQIDEP criteria and specific data presented in tables and primary reports a prima facie assessment would suggest that this was not the case, and an ideal set of data has been presented to substantiate the claim.

Upon deeper review it would appear that some of the results are qualified based on laboratory data and other independent reviews further limit the potential dataset which raises questions as to the overall veracity of the data.

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Pollutant removal and statistical analysis

The statistical analysis and methodology for determining significance was reviewed. It was found that the steps taken follow standard procedures for evaluating stormwater data.

Typically stormwater concentration data is not normally distributed, as denoted from a Shapiro-Wilk normality test. Log_{10} transformation does result in normality of the data. Paired Student T-test can be used on the transformed dataset to test significance between data sets.

Afflux Consulting undertook its own Paired Student T-test and these results are provided in Appendix A.

It should be noted that the statistical analysis has been based on a prima facie acceptance of data provided by OceanProtect and a reduced set of samples through Sensitivity testing.

While the statistical results included present a high degree of certainty that there is a treatment effect this needs to be moderated as follows:

- An assessment of the catchment representativeness; and
- Qualified acceptance of storm events and results based on other independent assessments.

We have not undertaken further assessment in light of the latter consideration, and it is possible that the sample set could be reduced when these are included and will be addressed in recommendations.

4. Evaluation of Enduring Performance

The Independent Reviewers have endeavoured to consider the long term enduring performance of the StormFilter Device and is consistent with other assessments undertaken for devices that have a filtration component that is expected to change in treatment performance based on loads experienced in deployment.

While the information supplied indicates that maintenance has been undertaken during field evaluations, no specific information has been provided to allow these elements to be fully appreciated in context.

We have instead referred to a Maintenance document downloaded from the OceanProtect website (https://oceanprotect.com.au/wp-content/uploads/2019/03/StormFilter-Operations-Maintenance-Manual.pdf).

The specific operation of the treatment components is not described in explicit detail and it is summarised in a Contech document as follows

> contained a total of eight 18 inch tall, media filled filter cartridges operating at a maximum surface area specific flow rate of 1 gpm/ft^2 (7.5 gpm/cartridge). Each of the filter cartridges was filled with an innovative coated reactive perlite media (PhosphoSorb). The PhosphoSorb media employs both physical straining and adsorption as primary and secondary pollutant removal mechanisms respectively thus allowing the media to sequester both particulate and dissolved pollutants.

The maintenance manual describes a typical process of regular inspection(6 monthly) and minor servicing (12 months) in which evaluation cartridge performance is undertaken and cleaning if required. Major servicing through replacement of cartridges is undertaken as required and is indicated to be between 1 and 3 years.

It is expected that the treatment capacity of the media will deteriorate over time and the approach to maintenance appears reasonable, although would benefit with additional information on potential replacement intervals under typical application scenarios. This information is likely to be of benefit to potential purchasers who should be concerned with operational costs and longevity.

OceanProtect are able to provide a maintenance option as part of their supply arrangements. While the assessment of maintenance falls outside the purview of this review it is noteworthy that this is provided, as this is often an area that is overlooked.

The description of maintenance activities provide guidance if third party maintenance was undertaken, however additional information would be useful to assist in determining when cartridge replacement was required.

Maintenance is often overlooked and/ or underfunded, however the provision of technical guidance should transfer the risk of underperforming systems from the manufacturer to the operator (i.e. the device can't be blamed for underperformance if it is not maintained).

As it is not possible nor required of the Evaluators to determine the life of the device or the media it is recommended that OceanProtect continues to monitor and assimilate data o confirm the long-term performance and range of media life-expectancy for the StormFilter under both light and heavy pollutant loading rates.

5. Discussion

Our independent evaluation finds that:

- The field study appears to be a scientifically sound study based on the information presented
- There is no pre-testing Quality Assurance procedures provided. While it is possible that the results could be replicated elsewhere without access to this information it is difficult to say with this with certainty
- While the test results were sound there are concerns raised about the 'equivalence' of overseas methods which should be addressed by Stormwater Australia. In particular, this should include:

  Agreed processes for transferring international data and establishing independence of testing and/ or oversight

  In this case we were not able to conclude with absolute certainty that the data was truly scientifically developed. There were reviews undertaken post testing and for earlier studies that provide some level of comfort but may fall short of expectations placed upon other organisation undertaking testing regimes within Australia.

  Guidance on the types of supporting information that should be provided to assist in evaluation. In some cases this should be contemporaneous primary source data rather than summary information and interpretations.

  It could be expected that this may raise concerns, particularly around Intellectual Property or how data will be handled. However, in the absence of this information being provided in an open and transparent manner the assessment process is open to challenge. It would be beneficial if Stormwater Australia could assist with establishing partnership arrangements with similar bodies internationally to facilitate this type of technology exchange.

  Agreed format for data

  It has been a real challenge to review a multitude of documents that have been prepared at different times and for different purposes. Some of the date appears as summary information that is more appropriate for marketing, while some of it relates to historical testing and product development phases.

  Agreement on equivalence of overseas oversight processes

  In addition, it became apparent through the review process that a significant body of work had been done to review studies into StormFilter's performance by what appears to be Government auspice agencies. (i.e. through the TAPE program)

  We are aware that there are a number of processes that operate in overseas jurisdictions, either in perpetuity or for specific timeframes. It is beyond the scope of the review process for evaluators to be thoroughly familiar with the requirements of overseas programs and their strengths and limitations. The process used in this review was to look independently at the data provided, to form an initial view and re-evaluate after assessing supporting information. It seems that the TAPE process has many similar attributes and it may be possible to improve process efficiency if this is understood and properly documented in a manner to assist with information exchange.
- The device was maintained on what appears to be a quarterly basis; however there was no specific information on methodology or pollutants removed (i.e. in what form) or if replacement or rejuvenation of components was required. It is considered that the claim should be accompanied with guidance on maintenance and intervals. These may be subject to loading rates (i.e. for a particular catchment maintain every X period), or if appropriate on an assessed performance of any filter and residual life.

The Urban Green report included additional information on maintenance related activities which weren't apparent on the review of initially directed material. This information if raised in prominence would be a useful inclusion in the overall assessment.

- It would appear from the information that the site fell into the higher load category. While this is expected to make reductions easier to achieve, it also means that maintenance requirements may be higher than on less loaded site.
- The SQIDEP protocol does not assess the effective life of the media and is unable to verify any claim by the supplier in this regard.
- OceanProtect should provide guidance on how and when the viability of media should be measured as part of its operational guidelines.
- The final claimed Pollution Reduction Performance was developed after consideration of sensitivity of testing results to slight changes in protocol parameters, and various other documents provided.
- The final claim has been revised down from the initial submission in response to inconsistencies with the data as presented and how this could impact the overall assessment. The samples presented could be interpreted as an optimistic set of performances after reviewing secondary documents. Based on the assessment we have determined that a 50% reduction in some rated claims could be adopted to provide a forward pathway, whiles still requiring additional local data to improve the dataset.
- The 50% value is based on the ratio of samples collected under icy conditions and those required to ensure a compliant dataset of 15 for statistical purposes (e.g. as describe under sensitivity testing section).
- Subject to Stormwater Australia's acceptance of recommendations we feel this would form a reasonable basis to move the process forward while still respecting the integrity of the SQIDEP process.
- Any provisional acceptance should be time limited to allow data to be reframed and presented in line with the overall assessment contained within this review. This could include additional interpretation of results, or supplementary sampling either in the laboratory or field.
- More broadly the SQIDEP process allows for derated claims to be offered to the claimant (i.e. as an outcome of an Independent Evaluation Panel process).

Table 6. *OceanProtect StormFilter performance claim*

Pollutant	Removal claim (BoE application)	Outcome
Total Suspended Solids (TSS)	88.6%	Provisionally Accept at 44%
Total Phosphorous (TP)	77.1%	Provisionally accept at 37.5%
Total Nitrogen (TN)	61.9%	Provisionally accept at 25%
Gross Pollutants	100%	Not verified

We also recommend that the acceptance of the claims above be made on a 'Provisional' basis or for an interim period. While there is reasonable agreement between the testing results and the performance there are other issues that sit outside the analytical program that would improve transparency. We note that this request is unique in that it is heavily reliant in international data that has been supplied across multiple documents, and with parts removed.

Having a provisional or interim approach to accepting claims would provide greater assurance to the industry if the interim time was used by Stormwater Australia to establish processes to allow 'equivalent' reviews to establish the necessary independence and data assurance.

5.1. MUSIC Node

MUSIC (Model for Urban Stormwater Improvement Conceptualisation) is an industry standard software program that is widely used in Australia for the sizing and conceptual design of stormwater treatment trains.

As such it is appropriate that some guidance is provided to enable the inclusion of OceanProtect StormFilter in a stormwater quality node.

While a suggested node has been provided it would be premature to offer validation.

From the assessment the following recommendations are made.

- The node should be constructed to respond to the modified validation criteria until such time greater confidence is determined.
- Modular performance should be recognised when assessing treatable inflow and bypass.
- Modular performance should be explicit in how the node is to be applied and should include bypass flows and guidance on how hydraulics (such as inlets) should be included in modelling approaches.
- Based on the collection of aliquots through the testing it is possible that storage effects are involved. If these are significant (based on inflow and throughput) the modelling approach should be explicit in how these are properly accounted for.
- From our understanding of the modularity of the device it is possible that multiple units could be employed within a pit configuration. Guidance should include description on how these multi cell installations should operate and relate to any bypass or inflow limitation.

5.2. Limitations of Acceptance

The limitations of the acceptance of these testing results include:

- The results are for a road based catchment. The results lie within acceptable inflow limits for this type of catchment and based on the analysis are found to be acceptable. This does not necessarily relate to other catchment types, though it is noted that hard stand catchments will behave similarly. Cleaner, roof catchments may not achieve the same pollutant reduction targets.
- The results are for a hydraulic loading rate up to 0.5l/s per module. Should the hydraulic load rate exceed this, the results would be expected to decline in line with excessive loading on the device.
- The results are reliant on the maintenance of the device being consistent with the manufacturers guidelines and those that are contained in the report. Most importantly the cleaning of the gross pollutant traps and filter cartridge at regular intervals.
- The life expectancy of the device and the media is unknown. It is suggested that an estimated lifespan of both media and the whole device be written into any technical guidelines as the filter material will deteriorate over time.
- Performance is contingent upon the installation being similar to that shown in this trial. Alternative installations may result in different outcomes.

Recommendation for Associated Technical Guidelines

- The results of this analysis can be seen to be reliant on a number of factors, including a set of technical installation and maintenance guidelines. As such it is strongly recommended that the SQIDEP results be tied to a product guideline to ensure future consistency.

6. Conclusions

OceanProtect have submitted for assessment a body of evidence (BOE) to demonstrate that performance claims for the StormFilter proprietary device have been tested.

The outcome of our review indicates that a lower performance claim would be appropriate, which may be revised, pending the provision of additional data and compliance with SQIDEP criteria.

7. References

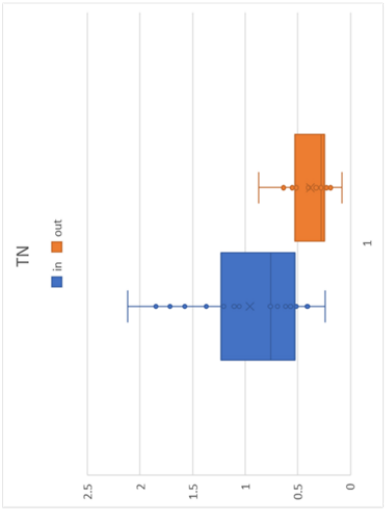
Stormwater Australia, Stormwater Quality Improvement Device Evaluation Protocol v 1.3, Stormwater Australia, 2018

Appendices

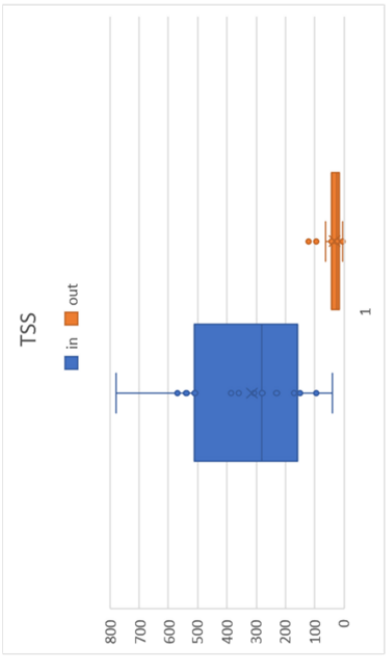
Appendix A -

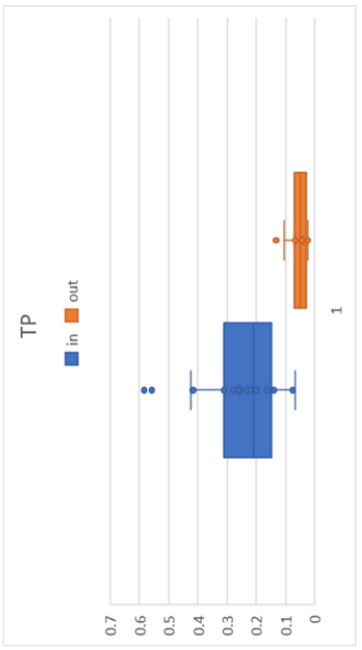
Statistical analysis and confirmation

SQIDEP Evaluation- StormFilter.
Statistical Summary. Data Supplied (n=23)



Descriptive Statistics	TSS		TP		TN	
	in	*out*	*in*	*out*	*in*	*out*
Mean	314.7391	32.47826	0.244609	0.055739	0.955043	0.380913
Standard Error	40.51566	5.910689	0.029186	0.006816	0.107202	0.039658
Median	280	24	0.21	0.049	0.76	0.28
Mode	#N/A	32	0.17	0.025	#N/A	0.265
Standard Deviation	194.3063	28.34667	0.13997	0.032688	0.514125	0.190191
Sample Variance	37754.93	803.5336	0.019592	0.001068	0.264324	0.036173
Kurtosis	-0.26646	3.69102	0.848706	1.63507	-0.39088	0.347545
Skewness	0.651732	1.866841	1.117288	1.436558	0.715972	0.847497
Range	740	115	0.515	0.115	1.875	0.792
Maximum	780	120	0.583	0.14	2.115	0.872
Minimum	40	5	0.068	0.025	0.24	0.08
Sum	7239	747	5.626	1.282	21.966	8.761
Count	23	23	23	23	23	23
Geometric Mean	253.0311	23.4972	0.209837	0.048449	0.826725	0.33647
Harmonic Mean	189.7089	16.66676	0.17841	0.042896	0.709518	0.290552
AAD	160.8355	20.14367	0.107002	0.024442	0.434393	0.158423
MAD	160.8355	20.14367	0.107002	0.024442	0.434393	0.158423
IQR	285	26.5	0.1395	0.0365	0.6725	0.2715





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SQIDEP Evaluation- StormFilter.
Statistical Significance. Data Supplied (n=23)

T-TEST (2 DATASETS, UNEQUAL VARIANCE) ALL DATA

TSS

		Significance Level	0.1
t-Test: Two-Sample Assuming Unequal Variances			2.59699E-07
	Variable 1	*Variable 2*	
Mean	314.7391304	32.47826087	
Variance	37754.92885	803.5335968	
Observations	23	23	
Hypothesized Mean Difference	0		
df	23		
t Stat	6.893737452		
P(T<=t) one-tail	2.49459E-07		
t Critical one-tail	1.31946024		
P(T<=t) two-tail	4.98917E-07		
t Critical two-tail	1.713871528		is t stat < Critical
			One Tailed YES
			Two Tailed YES
			Equal Variance check YES

TP

		Significance Level	0.1
t-Test: Two-Sample Assuming Unequal Variances			1.11841E-06
	Variable 1	*Variable 2*	
Mean	0.244608696	0.05573913	
Variance	0.019591522	0.001068474	
Observations	23	23	
Hypothesized Mean Difference	0		
df	24		
t Stat	6.301744362		
P(T<=t) one-tail	8.15095E-07		
t Critical one-tail	1.317835934		
P(T<=t) two-tail	1.63019E-06		
t Critical two-tail	1.71088208		is t stat < Critical
			One Tailed YES
			Two Tailed YES
			Equal Variance check YES

TN

		Significance Level	0.1
t-Test: Two-Sample Assuming Unequal Variances			0.002789881
	Variable 1	*Variable 2*	
Mean	0.955043478	0.380913043	
Variance	0.264324043	0.036172538	
Observations	23	23	
Hypothesized Mean Difference	0		
df	28		
t Stat	5.022902175		
P(T<=t) one-tail	1.3025E-05		
t Critical one-tail	1.312526782		
P(T<=t) two-tail	2.605E-05		
t Critical two-tail	1.701130934		is t stat < Critical
			One Tailed YES
			Two Tailed YES
			Equal Variance check YES

SQIDEP Evaluation- StormFilter.
Statistical Significance. Sub Data set (n=15)

T-TEST (2 DATASETS, UNEQUAL VARIANCE) ALL DATA

TSS

		Significance Level	0.1
t-Test: Two-Sample Assuming Unequal Variances			
	Variable 1	*Variable 2*	
Mean	314.7391304	32.47826087	
Variance	37754.92885	803.5335968	
Observations	23	23	
Hypothesized Mean Difference	0		
df	23		
t Stat	6.893737452		
P(T<=t) one-tail	2.49459E-07		significance
t Critical one-tail	1.31946024		0.1
P(T<=t) two-tail	4.98917E-07		
t Critical two-tail	1.713871528		is t stat < Critical
			One Tailed YES
			Two Tailed YES
			Equal Variance check YES

TP

		Significance Level	0.1
t-Test: Two-Sample Assuming Unequal Variances			
	Variable 1	*Variable 2*	
Mean	0.244608696	0.05573913	
Variance	0.019591522	0.001068474	
Observations	23	23	
Hypothesized Mean Difference	0		
df	24		
t Stat	6.301744362		
P(T<=t) one-tail	8.15095E-07		
t Critical one-tail	1.317835934		
P(T<=t) two-tail	1.63019E-06		
t Critical two-tail	1.71088208		is t stat < Critical
			One Tailed YES
			Two Tailed YES
			Equal Variance check YES

TN

		Significance Level	0.1
t-Test: Two-Sample Assuming Unequal Variances			
	Variable 1	*Variable 2*	
Mean	0.955043478	0.380913043	
Variance	0.264324043	0.036172538	
Observations	23	23	
Hypothesized Mean Difference	0		
df	28		
t Stat	5.022902175		
P(T<=t) one-tail	1.3025E-05		
t Critical one-tail	1.312526782		
P(T<=t) two-tail	2.605E-05		
t Critical two-tail	1.701130934		is t stat < Critical
			One Tailed YES
			Two Tailed YES
			Equal Variance check YES

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