Centre for Organic
Research & Education

CORE WATER DIVISION

Performance & Validation Standards

for Organic Bio-filtration Media.

CORE Standard
CS-1510-18

April 2018

NOTICE

This document is a Centre for Organic Research & Education Incorporated, Standard. It has been developed to provide performance and validation standards for use with Organic Biofiltration Media. It is not suitable for any other purpose and must not be used for any other purpose or in any other context.

REVISION REGISTER

Ed/Rev Number	Doc ID	Description of Revision	Authorised By	Date
Ed 1/Version 1	810361-1	First issue	EL	19.12.2017
Ed 1/ Version 2	810361-2	Updated in accordance with peer review	EL	28.02.2018
Ed 1/ Version 3	810361-3	Editorial review	EL	20.03.2018
Ed 1/ Version 4	810361-4	Standard Chairman's final review draft	EL	21.05.2018
Ed1/Version 4-2	810361-4-2	Published version	EL	10.10. 2018

Acknowledgements

The Standards project is supported by EPA NSW as part of the Waste Less, Recycle More initiative and is funded from the waste levy.

Special thanks are given to the following people and organisation for their input and support in the development of this standard.

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Prof Peter Coombes	Urban Water Cycle Solutions
Dr Alan Heyvaert,	Desert Research Institute (Nevada)
Formal Collaborator	Stormwater Australia

Tim Gowing	Penrith City Council
Vicki Shelton	Geelong City Council
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Charmaine Cheung	CORE Volunteer
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SECTION 1: SCOPE OF THE STANDARDS

1 PREFACE

Organic bio-filtration media contains at least 25% organic matter and is made from at least 25% (v/v) recycled materials to support sustainable procurement practices. Organic bio-filtration media effectively supports plant growth and physically, chemically and biologically reacts with pollutant to reduce contamination of our natural waterways.

Organic bio-filtration media can meet performance requirements including treatment of conservative and non-conservative pollutants, manage infiltration rates and support sustainable plant establishment and growth. Used all over the world in non-vegetated and vegetated systems, organic filter media is proving to be an efficient and effective measure for stormwater management and reuse [1].

This performance standard defines general media characteristics, establishes pollutant removal performance benchmarks, provides benchmarks for vegetation integrity and sets standards, frequencies and guidelines for maintenance and monitoring of organic biofiltration media. Validation methods containing test methods under different circumstances are also included. This standard is designed to provide design and assessment guidelines for specifiers and practitioners including engineers, urban planners, landscape architects, educators and local government.

The benchmark standards in this document are to be advanced through appropriate testing in laboratory studies and suitable installations as part of an ongoing continuous improvement process for this standard. It is accepted that any refinement may change some of the parameters contained in this version. In the interests of having a suitable standard in the market as soon as possible it is considered that continuous improvement is preferable to delayed perfection.

2 SCOPE

This Standard sets out performance requirements and methods of validating performance for organic biofiltration media, used in systems to manage storm water run-off in vegetated and non-vegetated systems. Standards of performance and validation of organic bio filtration media systems are provided. The standard covers the following areas that relate to the performance in a biofiltration media system.

1. General Requirements
2. Pollutant Removal
3. Hydraulic Conductivity
4. Vegetation Integrity
5. Maintenance
6. Monitoring
7. Validation of Performance
8. Guidelines for Implementation
9. Environmental Compliance

Organic filter media can be used to remove pollutants from water with high levels of pollutants such as trade waste water and acid mine drainage. This is considered beyond the scope of this edition of the standard but may be addressed in future versions as part of the continuous improvement program.

3 OBJECTIVES

This Standard has the following objectives:

1. Provide independently developed performance and validation standards for organic bio-filtration media that enable well informed comparisons and product selection decisions to be made relative to performance requirements for the intended purpose(s).
2. Specify descriptors that define effective organic bio-filtration media system performance.
3. Specify methods and protocols for validating performance claims.
4. Provide performance standards for organic bio-filtration media that ensure they are fit for purpose and perform as expected when in use.
5. Encourage sustainable procurement principles and the increased use of recycled materials in organic bio filtration media systems.

NOTE: Performance conditions may be defined within regulatory requirements for environmental sustainability, catchment management and other design criteria.

4 DEFINITIONS

Organic Bio-filtration Media: Contains >25% Organic Matter[i].

Organic Matter: Fit for purpose organic matter used in organic filter media must comprise of more than 85% stable organic materials to prevent unacceptable leaching. Some labile carbon content up to 15% can be used to assist plant establishment without sustaining harm to the environment through leaching. The CORE BIOMASS accreditation [2] system is one method of ensuring the correct types of organic matter are used in a filter media to ensure stability and acceptable leaching behaviour. The stable organic fraction can be calculated by applying a multiplier to the total carbon of the material determined by loss on ignition of the material.

[i] Refer to organic matter content of organic soil listed by "The Australian Soil Classification"

SECTION 2: PERFORMANCE STANDARDS

5 GENERAL PROPERTY REQUIREMENTS

The following general media properties are essential for the proper performance of organic filter media. These characteristics are elemental to successful plant establishment and growth and also meet landscape and engineering requirements. The media shall have an appropriate hydraulic conductivity to provide sufficient residence time to achieve performance requirements including pollutant removal, retention time and should be free of physical and chemical contaminants, declared noxious plants and local weeds (as listed in local guidelines/Acts), and not be hydrophobic [3].

5.1 Organic bio-filtration media general media properties

Table 5.1 lists fundamental properties to ensure organic bio-filtration media is fit for purpose. The validation methods of these performance requirements are described in Clause 10.1.

Table 5.1 General physical and chemical properties

Property	Units	Specification
Hydraulic Conductivity	mm/hr	<300 (Laboratory test)
		<1200 (Field saturation K_{sat})
pH	units	6.5-8.0
EC	dS/m	<1.2
Bioassay	mm	60
Wettability	mm/m	<5
Dispersion	Category	Emerson Class No 8
Effective Cation Exchange Capacity	Cmol/Kg	>10
Exchangeable Na	% of ECEC	<10
Exchangeable Ca	% of ECEC	40 - 80
Ca:Mg	ratio	≥ 2:1
K:Mg	ratio	≤ 1.5:1
Total Phosphorus	mg/kg	<100
Total Nitrogen (TN)	mg/kg	<1800
Organic Carbon	% w/w	2 - 5
Initial growth enhancer	µS/cm	Effluent EC < 450 after 350mm rainfall
Ponding	Hours	Fully drains within 2 hours
Moisture content (air dried)	%	>10%<50%
Inherent Retention Capacity	%	>25%

5.2 Sustainable procurement requirements

This organic bio-filtration media standard requires the use of recycled materials (>25%) in manufacturing of media formulations. Therefore, apart from the physical and chemical properties, organic bio-filtration media requirements include compliance with sustainable procurement procedures which are described in Clause.11 and Appendix A.

6 POLLUTANT RETENTION

Organic bio-filtration media shall be able to remove or retain targeted pollutants through the bio-filtration process. Organic filter media can be designed to last the life of the asset. Table 6.1 lists performance standards for key pollutants often found in stormwater runoff. The “Australian and New Zealand Guidelines for Fresh and Marine Water Quality” (ANZECC Guidelines) are given as a minimum threshold as water quality concentrations are considered acceptable. Water quality concentrations below these thresholds are unlikely to require treatment. Above the ANZECC Guideline thresholds water quality improvement is likely required.

Upper limits of pollutant concentrations in Table 6.1 consist of the maximum identified from published water quality data available in the Australian literature. Water quality above these limits would likely require additional responses such as treatment train approaches at the lot scale and/or improved land use management at the catchment scale. Removal standards are established from published reports and results of independent laboratory studies [4].

Organic filter media can be formulated to specifically target either conservative or non-conservative pollutants in which case discrete removal standards can be applied.

Additionally, outflow pollutant concentrations should be monitored over time to ensure continuing treatment is occurring (see monitoring plan Clause 10.1). All media has a life span and corrective action must be implemented prior to pollutant break-through i.e. pollutant removal has ceased. Allowing pollutant break-through can lead to environmental damage, unnecessary maintenance and subsequent costs. This can be prevented by adequate monitoring (see Clause.9 “Monitoring and Maintenance”).

Pollutant concentration analysis methods are described in Clause.11.1 “Pollutants analysis methods”.

Table 6.1 Pollutant retention performance benchmarks for organic bio-filtration media.

Pollutant Category	Pollutant	Unit	Water Quality[ii]		
			Concentration[iii]		Removal
			Minimum	Maximum	(%)
Solids	Total suspended solids	mg/L	15 [5]	50	>85 [5]
	Dissolved oxygen	mg/L	6.5 [6]	Not standardised	>80 [6]
	Biological oxygen demand (BOD)	mg/L	5 [6]	20	>60 [6]
Hydro - carbons	Oil and grease	mg/L	50 [6]	100	> 90 [5]
	Total petroleum hydrocarbon (TPH)	mg/L	10 [6]	No maximum	> 80 [5]
	Total polycyclic aromatic hydrocarbon (PAH)	mg/L	0.15 [6]	No maximum	> 80 [5]
Metals Conservative Pollutants	Copper (Total/ dissolved Cu)	µg/L	5 [6]	50	>90
	Lead (Total/ dissolved Pb)	µg/L	5 [6]	100	>90
	Zinc (Total/ dissolved Zn)	µg/L	5 [6]	2000	>90

[ii] If the pollutant outflow concentration is lower than the minimum target concentration value, the need for pollutant removal is considered unlikely. If the pollutant outflow concentration is higher than the maximum target concentration value, then additional treatment measures may be required e.g. treatment trains.

[iii] ANZECC guideline provides the trigger limits above which pollutant treatment is required. This standard also identifies the upper limits for pollutant concentrations suitable for stand-alone bio filtration methods beyond which additional treatment measures may be required.

Pollutant Category	Pollutant	Unit	Water Quality[ii]		
			Concentration[iii]		Removal
			Minimum	Maximum	(%)
	Iron (Total/ dissolved Fe)	µg/L	10 [6]	1000	>90
	Aluminium (Total/ dissolved Al)	µg/L	20 [6]	100	>90
Nutrients Non conservative pollutants	Total P	mg/L	0.01 [6]	2	> 45
	Nitrate/nitrite	mg/L	10 [6]	50	> 60
	Ammonium	mg/L	0.05 [6]	1	> 60
	TN	mg/L	1 [6]	10	> 45
Micro-organisms	E.coli	MPN/ 100mL	< 1000 [6]	10000	>90
	Total coliform		< 1000 [6]	10000	>90

7 HYDRAULIC CONDUCTIVITY

This section describes the hydraulic conductivity specification of organic bio-filtration media. Hydraulic conductivity is a critical characteristic for filtration media to achieve suitable permeability of the filtration system during rain events. Organic bio-filtration media shall generally meet the specific standards for hydraulic conductivity (K_{sat}) to ensure adequate retention time to achieve pollutant removal standards. Higher conductivity than the standard given is likely to reduce treatment efficiency.

However, where influent flow rates are in excess of the conductivity standard, higher conductivity can be used without reducing inherent water retention capacity.

7.1 Hydraulic conductivity standards

Organic bio-filtration media shall meet the criterion listed in the Table 7.1 below:

Table 7.1 Hydraulic conductivity specification for organic bio-filtration media

Property		Units	Standard	Monitoring Frequency
K_{sat}	compacted	*mm/hr*	<300	Every 5 years
	field		>100 <1200	Every 5 years
Inherent Water retention		%	25% - 50%	Alternative year
Dispersion		%	Emerson Class No 8	Every 5 years
Ponding		*hours*	Stagnant water fully drained from surface within 6 hours from rainfall secession	Alternative year

8 VEGETATION INTEGRITY FOR VEGETATED BIO-FILTRATION SYSTEMS

Where the General Property Standards (Clause.5.1) are met, Organic bio-filtration media supports robust plant establishment and growth. High inherent water holding capacity and natural microbial activity creates a favourable growing environment and provides resilience in times of climatic stress. Table 8.1 establishes performance standards to ensure that vegetated stormwater management assets perform efficiently.

Table 8.1 Vegetation integrity and assessment

Property	Units	Criterion	Standard
Establishment	Plant/m^2	Plant density	0.5-6 plants/m^2 depending on plant species[iv] [7] (For example: native grasses: 4 - 6/m^2; groundcovers: 2/m^2; low shrubs: 1/m^2; trees: 0.5/m^2)
	%	Establishment period - 6 months	At least 95% of survival rate shall be achieved at the end of establishment period.
	% or m^2	Vegetation coverage	denude area < 5% of total area or < 3 m^2 (whichever is smaller) at all times.
Nutrient utilisation	*µS/*cm	Plant establishment/ media ripening period	EC < 300 µS/cm after 450mm rainfall
Attrition/ mortality	%	Survival rate	> 95%
Plant life span	Years	--	5-25 years with >90% natural survival rate [8]
Inherent Moisture Retention capacity	Days	--	Moisture content of sample > 30% after a dry period. (Validation method in Section 3.10.2.1)
Resilience	--	Extreme weather resilience	Survival rate >95%: Heat spell: less than 3 days at 40°C maximum. Nuisance flooding: less than 3 days before abatement.
Root measurement	kgs/grams	Root shoot ratio	Root:shoot ratio is between 1:5 to 1:6 [9]. (Detailed method in Section 3.10.2.3).

9 MONITORING and MAINTENANCE

Monitoring and maintenance are required for maintaining a well performing bio-filtration system. This bio-filtration standard will also set monitoring and maintenance plans for vegetated bio-filtration system with organic filtration media.

9.1 Monitoring tasks and frequency standards

A bio-filtration system shall be monitored for its media, assets and vegetation presentation (only applicable for vegetated system) to ensure the system is fully functional. Table 9.1 lists bio-filtration monitoring tasks and frequencies.

Table 9.1 Monitoring tasks and frequencies

Object	Tasks	Frequency
Media	Solids pollutants removal	Half-yearly
	Hydrocarbons removal	Yearly
	Metals removal	Yearly

[iv] Plant density at planting stage is related to the grown vegetation cover per plant, the indicative plant density is nominated in the Table 8.1. The denude area shall be also considered for a healthy vegetated system after establishment period (Table 8.1. and 9.2).

Object	Tasks	Frequency
	Nutrients removal	Half-yearly
	Microorganism removal	Yearly
Assets	Life span prediction	Before the start of project
	Periodical assessment	At least one inspection every 5 years.
	Damage or failure	On reporting
Vegetation	Establishment	Monthly
	Attrition	At least twice during 6 – 9 months from planting
	Aesthetics	At least once every 3 years.
	Species effects	At least once every 3 years.
	Resilience	At least once every 5 years. Or once a year during long dry spell.
	Extreme weather events	On event.

9.2 Maintenance tasks and frequency standards

Table 9.2 Maintenance tasks and frequency

Object	Tasks	Frequency
Media	Replacement	Non-vegetated system: Every 10 years; or >50% of the pollutants' outflow concentrations are higher than limits (Table 6.1), whichever comes first.
		Vegetated system: > 15 years; or > 50% of the pollutants' outflow concentrations are higher than limits (Table 6.1); or plants are not healthy due to possible low nutrient level, whichever comes first.
	End of life span	Every 20 years.
Assets	Routine maintenance[v]	Every 5 years.
	Failure replacement	On reporting.
	End of lifespan replacement[vi]	Varied for each asset, usually approximately every 20 year.
Vegetation	Replant and replace	Survival rate < 85%; or denude area > 5% of total area; or > 3 m^2, whichever comes first.
	Watering	If no precipitation or <5 mm for 6 months, water once a month.
	Trimming and harvesting	Half yearly trimming. Yearly harvesting or whenever fruiting.

[v] The routine maintenance can be carried out at the same time of periodically assessment.
[vi] The end of life span of asset is usually much longer than media, but replacement of asset requires some earthwork. It is recommended that end of life span replace of asset should be carried out with media replacement.

SECTION 3: PERFORMANCE VALIDATION

10 VALIDATION METHODS

To confirm the performance of organic bio-filtration media, appropriate validation methods are required. Some of the validation methods have been listed in Table 10.1 – 10.5. This section describes additional methods required for performance validation of organic bio-filtration media.

10.1 General property validation

Organic bio-filtration media performance requirements were listed in Tables 5.1 and 6.1; the following validation methods apply to the general properties:

a) Compacted K_{sat} shall be laboratory analysed by constant head method for a remoulded specimen. The test method can be found in the AS1289.6.7.1-0-2000 - “Soil strength and consolidation tests - Determination of the permeability of a soil”.
b) Field K_{sat} shall be analysed by the method provided in AS 1547.
c) pH of media shall follow the 1:5 in water or HCl method provided in “Soil Chemical Methods – Australasia” by George E Rayment and David J Lyons.
d) EC, bioassay, wettability, phosphorus, available nitrogen (N as Nitrate), and organic carbon shall be analysed by the method provided by AS4454.
e) Dispersion shall be analysed by Emerson aggregated test (available at https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0008/127277/Slaking-and-dispersion.pdf)
f) Exchangeable Na, exchangeable Ca, Ca:Mg ratio and total nitrogen (TN) shall be analysed by methods provided in “Soil Chemical Methods – Australasia” by George E Rayment and David J Lyons.
g) Moisture content (air dried) shall be determined by drying a suitably sized aliquot to constant mass at 104^{O}C (See below “Analysis method e)”.
h) Inherent retention capacity (See below “10.4.2 Inherent Water Retention Capacity”)

10.2 Hydraulic conductivity validation

Hydraulic conductivity standards (Table 8.1) shall be validated as follows:

Sampling method

a) Bio-filtration media shall be collected from application site(s) and laboratory analysis conducted for compacted K_{sat}, nutrient leaching, moisture retention and dispersion at the frequency nominated in Table 9.1.
b) Field K_{sat} shall be measured at the bio-filtration media application site on the frequency nominated in Table 8.1.

Analysis method

c) Compacted K_{sat} shall be analysed using AS1289.6.7.1-0-2000.
d) Field K_{sat} shall be analysed by the method provided in AS 1547.
e) Nutrient leaching and moisture retention shall be analysed using AS4454 methods.
f) Dispersion shall be analysed by Emerson aggregated test (available at https://www.dpi.nsw.gov.au/_data/assets/pdf_file/0008/127277/Slaking-and-dispersion.pdf)
g) Ponding shall be accessed by visual assessment following an >8 mm/hr rainfall event every alternative year.

10.3 Pollutant removal validation

10.3.1 Sample collection methods

In order to validate pollutant removal performance of organic bio-filtration media, the inflow and outflow of a bio-filtration device are required to be sampled.

Field site testing

First flush and Runoff Storm samples are to be taken in a field site validation activity. A dry period of at least 48 hours is required before sampling the inflow water. Water sample should be stored in dark glass sampling bottles under 4 °C until analysis

Laboratory studies - Column experiments

Pollutant removal can also be validated in a laboratory using column leaching studies.

Column experiments can be designed to determine leaching rates and/or pollutant retention properties. Pollutant retention properties rely on the column (filled with media) to be “flushed” using freshwater. This removes any excess salts and the first-flush water (equalling at least 1 pore volume) can be discarded if leaching is not the priority issue. After flushing, the contaminated sample water can be introduced to the column under constant head conditions.

1. Characterise contaminated water to be tested based on pollutants to be removed.
2. Place some glass fibre material or similar at the bottom of the column to restrict the media in the column.
3. Place ½ kilogram of organic filter media into the column(s) in 100 gram increments to create some natural compaction.
4. Measure the volume of material in the column by marking the height of the material up the column.
5. Secure the column in a clamp stand.
6. Place tap water into a beaker, stir and measure resistance and electrical conductivity and record.
7. Place one (1) litre of the contaminated source water into a one (1) litre capacity flask. The flask should have a long neck that can fit into the inside of the column.
8. Turn over flask and place into column and clamp in a position that creates a constant head (i.e. neck opening of flask placed into column with water level near to the top of the column).
9. Extract samples into clean 100ml containers for water quality pollutant analysis testing.
10. Measure height to identify if any slumping.

10.3.2 Pollutants analysis methods

Table 10.1 Summary of the pollutants analysis methods

Pollutant	Test method	Source
Total suspended solids	Standard methods 2540D	Standard Methods for the Examination of Water and Wastewater” by Arnold E. Greenberg
COD/BOC	Standard methods 5220D	
Oil and grease	US EPA 1664	https://www.epa.gov/sites/production/files/ 2015-08/documents/method_1664a_1999.pdf
TPH	US EPA 8015C	https://www.epa.gov/sites/production/files/2015-07/documents/epa-8015c.pdf
PAH	US EPA 8270D	https://www.epa.gov/ sites/production/files/2015-07/documents/epa-8270d.pdf

Pollutant	Test method	Source
All metals	US EPA 200.8	https://www.epa.gov/sites/production/files /2015-08/documents/ method_200-8_rev_5-4_1994.pdf
Total P	US EPA 365.2	https://www.epa.gov/sites/ production/ files/2015-08/documents/method_365-3_1978.pdf
Nitrate/nitrite	US EPA 300	https://www.epa.gov/sites/production/files /2015-08/documents/method_300-0_rev_2-1 _1993.pdf
Ammonium	Standard methods 4500	Standard Methods for the Examination of Water and Wastewater" by Arnold E. Greenberg
TKN	US EPA 351.3	https://www.epa.gov/sites/production/ files/2015-06/documents/epa-350.1.pdf
TN	Standard methods 5310	Standard Methods for the Examination of Water and Wastewater" by Arnold E. Greenberg
E.coli / Total coliform	Standard methods 9221E	Standard Methods for the Examination of Water and Wastewater" by Arnold E. Greenberg
Enterocci	Standard methods 9230B	Standard Methods for the Examination of Water and Wastewater" by Arnold E. Greenberg

10.4 Vegetation integrity validation

10.4.1 Water holding capacity

Water holding capacity can be defined as the amount of water that a given media can hold for vegetation use. Field capacity is the point where the soil water holding capacity has reached its maximum for the entire media content of a field site.

10.4.2 Inherent Water Retention Capacity

Inherent Water Retention Capacity establishes the capacity of a media to retain water and measures how long a media can retain suitable moisture content for vegetation growth after a dry period. Usually, a minimum moisture content of 25%-50% is required for vegetation establishment and growth. Therefore, this method assesses the media moisture content after a few days of natural drying.

Material:

a) Containers: 32-cm deep pots with 200 mm diameter
b) Tested media samples.

Test procedure:

1) Fill up at least 80% of the pots with the tested media samples. Each sample should have triplicate pots for the test.
2) Water the pots thoroughly with 5 L of water or until no more water can be taken by the media.
3) The pots need to be placed in a well-ventilated area or growth chamber. The air temperature in the growing area is to be set to a day/night temperature regime of 25/15 °C under a 16-hours photoperiod. Alternatively, the natural light/temperature regime is to be applied consistent with the local conditions.
4) No watering will be applied to the pots, and avoid rain fall to the pots until the end of test.

5) Collect media samples (approximately 20 g) from each pot according to the regime in Table 10.2, and measure the moisture content (%) of each sample and record the data. Note: media samples should be taken from approximately 15 cm depth rather than surface.

Table 10.2 Moisture retaining capacity monitor plan

Day	Sample 1 Moisture content (%)			Sample 2 Moisture content (%)		
	Pot 1	Pot 2	Pot 3	Pot 1	Pot 2	Pot 3
1						
7						
10						
14						
16						
18						
20						
21						
Once a day until all pot's moisture content is below 10%						
22						
23						
…						

Average moisture content from triplicate pots will be reported for each media sample. When the average moisture content is lower than 10%, the test can end. Record the number of days at the end of the test.

The number of days indicate how well the media can retain a suitable moisture content level for vegetation growth. The media with longer duration is superior to the ones with shorter duration.

NOTE: This method is used to compare the moisture retention capacity for different media, and 10% of moisture content is designed to be the end point of the test as it is the average wilting point for most plants. Please note that different plants will have varied wilting points and moisture decreasing trend would be different when vegetation is introduced to the system. This method will only provide an indication on the capacity of a media for retaining moisture.

10.4.3 Resilience

This method is adapted from a 2016 research paper by Gagné-Bourque et al. [10]. It should be noted that this test method is only guidance for drought resistance test for different bio-filtration media with certain vegetation. The test procedure may change when specific plants are chosen for the test.

Material:

a) Containers:
b) If plants seeds are used in the test, the seed need to be planted individually in microcell trays (1.5cm X 1.5 cm X 3 cm).
c) If plants are directly used, or plants have established from seedling (3 – 4 weeks post seeding), the plants need to be transferred to 32-cm deep pots. The number of plant pots depends on the surface area of the pot and the plant types.
d) Tested media:
e) Tested media should be clearly labelled and stored in cool, ventilated area until use.

Test procedure:

Once plants are planted in the 32-cm deep pots with the tested media, testing is to be carried out using the following procedures:

1) Plant pots need to be placed in a well-ventilated area or growth chamber. The air temperature in the growing area is set to a day/night temperature regime of 25/15 °C under a 16-hours photoperiod. Alternatively, the natural light/temperature regime can be applied subjecting to the local condition.
2) Plants need to be treated under well-watered conditions for 2 weeks from establishment in the pots before commencing the testing.
3) If the growing area is large and the natural light/temperature regime is applied, the pots need to be rotated every week to make sure all pots are exposed to the same light conditions.
4) If different media mixtures are tested at one batch, each media should have at least 30 pots of plants, and all pots of plant should be well watered for 2 weeks.
5) After 2 weeks' establishment, commence the test following the watering regime of Table 10.3.

Table 10.3 Drought resilience batch test water regime

Media		Control Group (10 pots)	Water-stressed (10 pots)	Drought (10 pots)
	Water volume	Water to field capacity	Water to field capacity	None
	Frequency	2 times per week	1 time every 2 weeks	N/A
Media 1				
Media 2				
Media X				

6) Photos are to be taken every week for each pot. Colour and plant height need to be recorded every week (as in Table 10.4).
7) The test ends when more than 70% drought group plants are withered and yellow.
8) Any plants remaining alive at the end of the test are to be assessed by the following steps.

Assessment and analysis:

1) During the test, each pot of plant's colour and height are to be recorded in Table 10.4 each week for assessment.
2) At the end of test, collect all biomass from each pot. Measure the plant's height and biomass weight above ground. Additional root shoot ratio shall be measured according to the method described in Section 3.10.4.4.

Table 10.4 Weekly plant condition monitoring table

Week No. xx			Colour (1 to 10)[vii]	Height (cm)
Media 1	Control group	Pot No. 1		
		…		
		Pot No. 10		
	Water-stressed	Pot No. 1		
		…		
		Pot No. 10		
	Drought	Pot No. 1		
		…		
		Pot No. 10		

[vii] The variance (colour) can be scaled from 1 to 10 where 1 is withered and yellow and 10 is green and healthy.

Week No. xx			Colour (1 to 10)[vii]	Height (cm)
Media 2	Control group	Pot No. 1		
		…		
	Water-stressed	Pot No. 1		
		…		
	Drought	Pot No. 1		
		…		

10.4.4 Root shoot ratio

The root shoot ratio is one measure to assess the overall health of plants. Control group of plants will provide a "normal" root shoot ratio for each of plant types and an increase or decrease of the normal ratio will indicate the overall health of plant. For example, an increase in root shoot ratio could be an indication of a healthier plant, if the increase came from greater root size rather than from a decrease in shoot weight.

The root shoot ratio measurement method is adapted from a research paper by Wood and Roper [11]:

1) Remove the plants from media and wash off any loose media.
2) Blot the plants removing any free surface moisture.
3) Dry the plants in an oven set to low heat (37 °C) overnight.
4) Let the plants cool in a dry environment, and weigh them.
5) Separate the root from the top (cut at soil line).
6) Separately weigh and record the root and top for each plant.
7) Root/shoot ratio = dry weight for roots/dry weight for top of plant.
8) Average root/shoot ratios from each group should be reported in a box chart.

SECTION 4: GUIDELINES

11 Guideline for Sustainable Procurement

Sustainable procurement is recommended by the “Sustainable Procurement Guide” published by Department of Sustainability, Environment, Water, Population and Communities, aiming to reduce the adverse environmental, social and economic impacts of purchased products and services throughout their life, and can include considerations such as waste disposal and the cost of operation and maintenance over the life of the goods.

The performance standard of organic bio-filtration media shall reflect all three aspects of media including performance, quality and cost-effectiveness. This section will state a guideline of sustainability assessment of bio-filtration media in terms of the production, transportation and recyclability. Table 11.1 lists the assessment criteria for bio-filtration media sustainability.

Table 11.1 Sustainability assessment criteria for bio-filtration media

Criteria	Specification	Test method
Production		
Use of recycled materials	≥25% recycled material	At least 25% (v/v) of the product was made from recycled materials.
Transportation		
Local/community transportation	≤100 km	≥50% (v/v) of media components can be found within 100 km of the project site.
Reuse/Recycle		
Recyclability	>50%	More than 80% of the spent product can be reused.

The above sustainability assessment criteria shall be used as an assessment guide for selecting a bio-filtration media that complies with sustainable procurement guidelines. When the performance, quality and cost effectiveness of media is equivalent, preference shall be given to the media with higher content of recycled material, shortest transportation distance and recyclability. A manufacture batch certificate or test report from media supplier shall be provided at procurement for consumers to confirm the product’s recycled content.

Sustainable procurement guidelines also contain other aspects such as life cycle cost, continual improvement, circular economy, environmental impacts and social impacts. Supplementary information is provided in the Appendix A.

12 Guidelines for Vegetation Presentation

Vegetated bio-filtration systems require specific assessment for the vegetation. This section of the guidelines lists additional assessment criteria on the vegetation presentation supplementary to Table 10.1. Vegetation integrity and assessment guidelines should include the following factors:

a) Vegetation establishment integrity.
b) Vegetation shall be planted in spring or autumn for temperate climates. Tropical and sub-tropical climates can have a wider planting window.
c) Some watering or irrigation may be required for non-ideal season planting [7].
d) Vegetation areas are to be kept free of disease. Less than 5% of vegetation should experience disease, dieback, pest infection or stunted growth in an organic bio-filtration system [7].

e) Use aesthetics effect for surroundings:
   - Shade, fragrance or colour can be provided.
   - Compliment the surrounding landscape context, or designer's goals and bring visual appreciation.
   - Green, flowering or foliage plants provide different colour or tones of the same colour [12].
   - Use ecological planting guides to ensure viability of species.
   - Promote multi layered landscape effects, such as trees, shrubs, groundcover and grass.

f) Nutrient efficiency
   - At least 50% plant species should be nitrogen/ phosphorus removers (Appendix B1). Avoid nitrogen/ phosphorus fixing species [7].
   - Preference should be given to plants with high:
     I. root length
     II. root mass
     III. root shoot ratio
     IV. proportion of fine roots
     V. rapid growth, and,
     VI. drought tolerant.
   - Yearly inspection for outflow nitrogen removal analysis.

g) Phyto pollutant take up

Phyto pollutant removal can be monitored by the method provided by "Ground Water Issue: Phytoremediation of Contaminated Soil and Ground Water at Hazardous Waste Sites" by Bruce E Pivetz [13]. Typical monitored compounds and phyto-mechanism shows in table below:

Table 12.1 Typical monitored compounds and phyto-mechanism

Typical compounds		Phyto-mechanism
Petroleum constituents	Fluoranthene	Rhizodegradation, phytoextraction, phytovolatilization [14]
	PAH	
	Pyrene	
	TPH	
	Benzene	
Halogenated compounds and surfactants[15]	Trichloroethylene (TCE)	Rhizodegradation, phytoextraction, phytodegradation, phytovolatilization [14]
	Perchloroethylene (PCE)	
	Vinyl chloride (VC)	
	Dichloroethane (DCA)	
Pesticides[15]	Atrazine	Rhizodegradation, phytoextraction, phytodegradation [14]
	Alachlor	
	Dieldrin	
Salts	Salinity	Phytoextraction, rhizofiltration
Heavy metals	Lead (Pb)	Phytoextraction, phytosequestration [14]
	Arsenic (As)	
	Cadmium (Cd)	
	Zinc (Zn)	
	Copper (Cu)	

h) Species effect
   - Choose native species that can rapidly colonise
   - Increase biodiversity and habitat area in urban areas.
   - Create faunal habitat and activate fauna movement, attract bird and insect
   - Reduce mosquito and midges risk.
   - Plant flowers and seeds that favour the key local fauna.

13 Guidelines for Monitoring and Maintenance Activities

13.1 Monitoring activities

Figure 13.1 is a schematic monitoring plan for bio-filtration system, listing monitoring items for a performed bio-filtration system. Please note that the vegetation monitoring item is only applicable for vegetated systems.

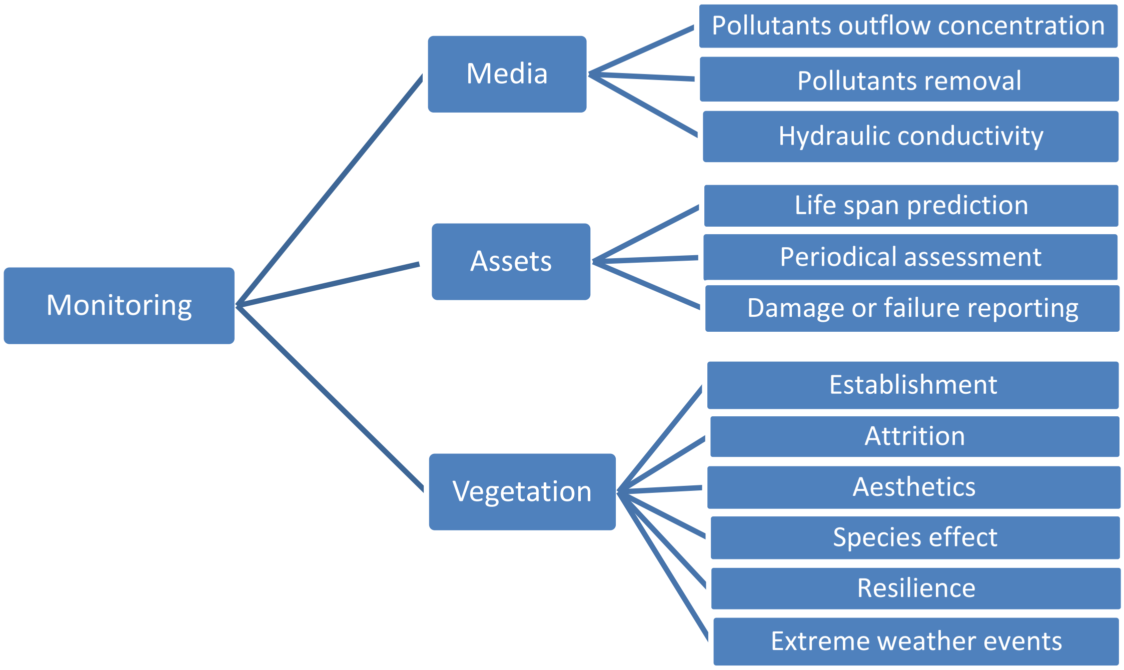

Figure 13.1 Schematic monitoring plan for bio-filtration system

a) Media

Pollutant removal rates or the pollutant outflow concentration are critical to maintaining standards for media performance over time. If the pollutants concentrations in the outflow remains higher than the level nominated in the Table 6.1, or removal rates declined to breakthrough point, then the media is not functional and will require maintenance or replacement.

Sample collection of inflow and outflow of the filtration system can be taken manually (grab sample) or automatically. In order to act effectively, the sampling activities of different facilities should be arranged according to their location, working load and man power availability etc.

On the other hand, hydraulic conductivity of the media is to be monitored according to the criterion and method listed in Table 7.1.

b) Assets

Bio-filtration systems need asset monitoring to keep them functioning well. The following Table 13.1 includes monitoring tasks and methods that may be used for asset management.

Table 13.1 Bio-filtration system assets monitoring tasks

Tasks	Methods
Life span prediction	1. Obtain asset information from suppliers, engineers, and facility managers to determine the life span of each asset. 2. Obtain baseline and operational data from proposed site, including the original flow rate, pollutant loadings and inflow water characteristics. Consider the effect of the inflow's nature and predict the asset's life span under specific circumstance. If possible, use Modelling tools to predict media life span by inputting collected actual data.
Periodical assessment	1. Produce a periodical assessment time frame for each asset of the facility. 2. Prepare monitoring check list for each asset. 3. Propose at least one inspection every 5 years for each asset. If the predicted life span is shorter than 10 years, propose at least one inspection at the half-life point. 4. Assess the condition of the asset, predict the remaining life and compare it to the predicted life span. Adjust the predicted life span on the assessment results. 5. Inspect for any potential damaged or defunct part of the device. 6. Check for signs of previous device failure during a storm event. For example, if there are excess sediment/debris residues staying on the surface, if there are surface runoff tracks on the media surface, or if there is the evidence of ponding exiting on site. 7. Generate a detailed assessment report for each inspection activity for future reference and maintenance activity guide.
Damage or failure	1. Damage or failure can be reported by customers, facility manager, nearby residents, or building managers. 2. The signs of the device failure/damage include, but are not limited to, flooding or ponding after rain event, sediment movement during storm, outflow water quality decrease and vegetation attrition (for vegetated systems.) 3. Once the failure/damage is reported, arrange inspection for the device immediately with the check list used for regular assessment. 4. Replace any damaged parts. 5. Keep a record of the details of the damage/failure, replaced parts for future assessment.

13.2 Maintenance activities

Figure 13.2 is a schematic maintenance plan for bio-filtration system, listing items required and how to maintain. Please note that the vegetation monitoring item is only applicable for vegetated systems.

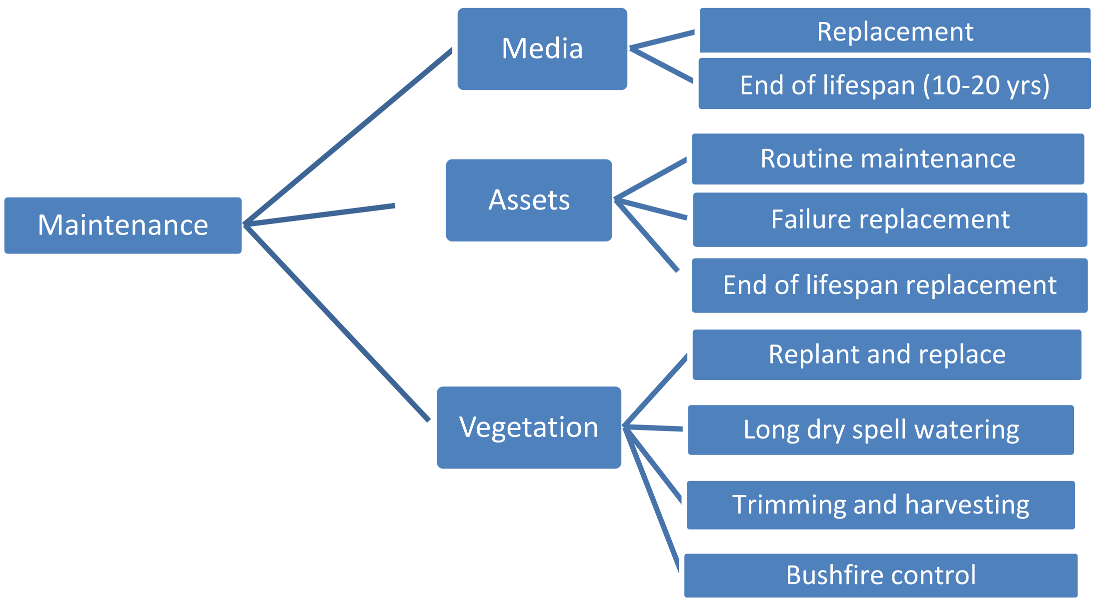

Figure 13.2 Schematic maintenance plans for bio-filtration systems

Table 13.2 Maintenance activity procedures

Task	Procedure
Replacement of media	1. Before replacement, review media monitoring data, if possible, use real data in modelling software to generate modified media formulation. If modelling is not available, use the existing formulation. 2. Extract expired filter media from site. 3. Replace with new media. 4. For vegetated system, dig out the herbaceous plant, leave the bushes or tree on site. 5. Replace the media layer. 6. Replant the plants according to the existing design plan, or switch to another planting design.
Routine asset maintenance[viii]	Follow the maintenance procedure for each asset (obtain the procedure from the asset supplier) and record details of the maintenance job.
Failure asset replacement	1. Obtain the damage and failure report and decide which assets need to be replaced. 2. Contact the asset supplier or subcontractors to arrange installation.
End of lifespan asset replacement[ix]	Contact asset supplier or subcontractors to arrange installation.
Vegetation replant and replace	1. If more than 15% of the plants expire, replace the dead plant with new ones. 2. If less than 5 plants/m^2 survive on site, replant should commence to ensure at least 95% of the area is covered by live plants. 3. For herbaceous plant, complete replanting every 20 years [16]
Vegetation watering	Organic filter media should not require additional watering. However, if long dry spells occur during vegetation establishment, water as needed.
Trimming and harvesting	Contact landscaping team for trimming and harvesting.
Mowing and edging[x]	Contact landscaping team for mowing.
Noxious weed control[xi]	Follow the Noxious Weed Act 1993.
Rubbish removal	Contact the local council for rubbish removal.
Bushfire control[xii]	Consult regional bushfire control office for detailed procedure and requirements.

14 Documentation Guidelines

14.1 Labelling and Information

Organic bio-filtration media shall be accompanied by documentation (e.g. an information sheet, online product information page, SDS, etc.) stating the following:

1) Intended use of the product:
2) Health and/or Hazard warning:
3) Limitations on product use:

[viii] The routine maintenance can be carried out at the same time of periodically assessment.
[ix] The end of life span of asset is usually much longer than media, but replacement of asset requires some earthwork. It is recommended that end of life span replace of asset should be carried out with media replacement.
[x] Refer to the RMS "Landscape design and maintenance guidelines to improve the quality, safety and cost effectiveness of road corridor planting and seeding"
[xi] Refer to the RMS "Landscape design and maintenance guidelines to improve the quality, safety and cost effectiveness of road corridor planting and seeding"
[xii] Bushfire control can be taken along with the periodical trimming activity.

4) Disposal when contaminated or at the end of its useful life:
5) Other.

14.2 Provenance

The supplier shall keep adequate records of the source of raw materials used in the manufacture of the product and records of appropriate production and quality control activities undertaken in the manufacture, storage and distribution of the product.

SECTION 4: ENVIRONMENTAL COMPLIANCE

15 Compliance with Environmental Standards, Health and Hazardous Information

15.1 Compliance with environment protection, health regulations and guidelines

All products shall fully comply with the chemical, physical, organic and pathogen contaminant provisions specified for products suitable for unrestricted use as expressed in the currently applicable federal and state or territory guidelines and regulations for land application of products derived from organic wastes, compostable organic materials or biosolids, or with the provisions of this Standard, whichever is the more restrictive.

Where there are no such currently applicable federal and state or territory provisions for composts, soil conditioners and mulches, products shall comply with the list of chemical contaminant upper limit values (Table 15.1) and the labelling provisions of Clause 14.1 “Labelling and Information”.

NOTE: Non-conformance with this Standard does not indicate that the product may not otherwise be suitable for a range of specified applications that comply with other state or territory government regulations, guidelines, or specified end user requirements. Consequently, it is not appropriate for regulators to specify compliance with this Standard as a mandatory requirement for facility operations, licensing or application to land of production outputs.

15.2 Plant propagules (weeds)

AS4419 - Soils for landscaping and garden use, specifies that all soils/media should be free from any living parts (seeds, bulbs, corms, vegetative propagules and the like) of plants that are generally considered to be weeds.

NOTE: Method which may be used to assess the presence of propagules can be found in AS4419.

15.3 Chemical contaminants

To comply with the OHS requirements for application of the organic bio-filtration media, chemical contaminant concentrations shall not exceed the limits nominated by “1997 Environmental Guidelines on the Use and Disposal of Biosolids Products”. Table 15.1 provides the guideline limits for chemical contaminants.

Table 15.1 Chemical contaminants limits for organic bio-filtration media application

Contaminant	Maximum Contaminant Concentration (mg/kg dry weight of media)
Arsenic (As)	20
Cadmium (Cd)	1
Chromium (Cr, total)	100
Copper (Cu)	100
Lead (Pb)	150
Mercury (Hg)	1
Nickel (Ni)	60
Selenium (Se)	5
Zinc (Zn)	200
DDT/DDD/DDE	0.50

Contaminant	Maximum Contaminant Concentration (mg/kg dry weight of media)
Aldrin	0.02
Dieldrin	0.02
Chlordane	0.02
Heptachlor and heptachlor epoxide	0.02
Hexachlorobenzene	0.02
Lindane	0.02
Benzene hexachloride	0.02
PCBs	0.30

SECTION 5: REFERENCE AND APPENDIX

16 Reference

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17 Appendix A: Sustainable procurement[xiii]

A1 Scope

Sustainable procurement is defined as “a process whereby organisations meet their needs for goods, services, works and utilities in a way that achieves value for money on a whole of life basis in terms of generating benefits not only for the organisation, but also to society and the economy, whilst minimising damage to the environment.” All procurement can be sustainable and should be considered by all staff involved in any purchasing. Sustainable procurement aims to reduce the adverse environmental, social and economic impacts of purchased products and services throughout their life [17]. Whether tendering for a major project, making a standard purchase from a preferred contract supplier, or a simple one-off purchase, sustainable procurement practices should be routinely integrated.

Sustainable procurement takes into consideration the responsibility for the economic, environmental, social and governance impacts of any purchase – products or services. These four factors can be referred to as the Quadruple Bottom Line (QBL):

- Cost and economic impact of the purchase.
- Environmental impact of the growth, manufacture and transport of the product or service
- Social and ethical implications, and
- Application of good governance.

Consistent with many sustainable procurement publications including “Sustainable Procurement Guide for Local Government in NSW (2017)”, organic bio-filtration media should be assessed under the framework for sustainable procurement. Several principles should be considered, including life cycle costs, continual improvement and circular economy.

A2 Life cycle costs

Life cycle costing is a practical method to put a dollar value on all aspects of the QBL. It quantifies the full financial benefits by providing complete sustainability details addressing all phases of the life of the product or service, aiming for the “best value across the asset life cycle (ALC).” Organic bio-filtration media’s (*inter alia*) life cycle cost can be assessed by the following framework

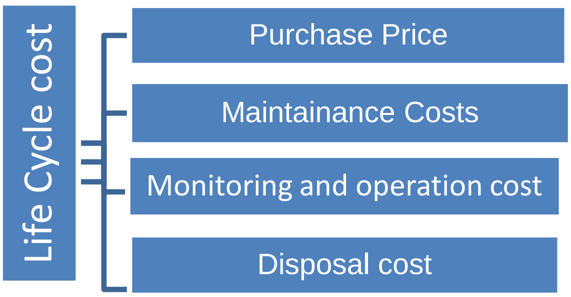

Figure A1 Life Cycle Cost Framework

[xiii] Adapted from “Sustainable Procurement Guide for Local Government in NSW (2017)”

Life cycle cost assessment requires consideration of factors including:

- Initial purchase prices.
- Lifespan of the bio-filtration media or filtration system.
- Economic cost over the lifespan (15-20 years) including any replacement cost of vegetation and media.

The Table A1 provides a tool for assessment of the cost item for a bio-filtration system during a proposed 20-year ALC.

Table A2 Cost Analysis Table (for a 20-year LOA period)

	Unit	Quantity	Frequency	Item Description	Total Price
Purchase Price	AUD/ton	xx tons	every 15-20 years	The cost for purchasing products during 20 years.	AUD
Maintenance Cost[xiv]					
(Installation)	AUD/h	xx h p.a.	every year	Annual installation cost for system maintenance	AUD
(Material)	AUD/ton	xx ton	every year	Annual cost for purchasing materials required for maintenance	AUD
(Annual cost)	AUD p.a		every year	Annual installation cost + annual material coast	AUD
Monitoring and operation Cost					
(Labour)	AUD/h	xx h p.a.	every year	Annual labour cost on monitoring/ operation.	AUD
(Other cost)	AUD/y	--	every year	Annual cost for analysis etc.	AUD
Replacement					
(Media)	AUD/ton	xx ton/ replace	every 15-20 years	The material cost for replacing media up to once during 20 years	AUD
(Vegetation)	AUD/m^2	--	comply with vegetation lifespan	The purchase cost for plants during 20 years	AUD
(Installation)	AUD/h	xx h/ replace	every 15-20 years	The labour /equipment cost for replacing media or/and plants during 20 years	AUD
Disposal Cost					
(Disposal)	AUD/ton	xx ton	every 15-20 years	Total cost for dispose old media during 20 years.	AUD

A3 Continuous improvement

Continuous improvement must consider the performance of the products or service against the sustainability criteria and document lessons learned to be used to guide future procurement.

Assessment of the sustainability of the purchased products can be carried out on a frequency of every 5 years. Sustainability criteria may include labels, certifications and recognition programs which readily provide clear, verifiable and specific requirements for suppliers.

If the purchased item was selected on some available sustainability criteria, it should be given a preference for next purchase. Otherwise, alternative items with sustainability certification should be purchased.

A4 Circular economy

The circular economy is another key concept in sustainable procurement which looks beyond the 'take, make and dispose' and instead aims to create a closed loop. Rather than sending a product

[xiv] The items required for maintenance, monitoring and operation can be found in "Maintenance and Monitoring" section.

to landfill at the end of its life, it is reused, reprocessed or recycled into other products. The circular economy contributes to resource efficiency and low-carbon economy, reducing costs and supply chain risks.

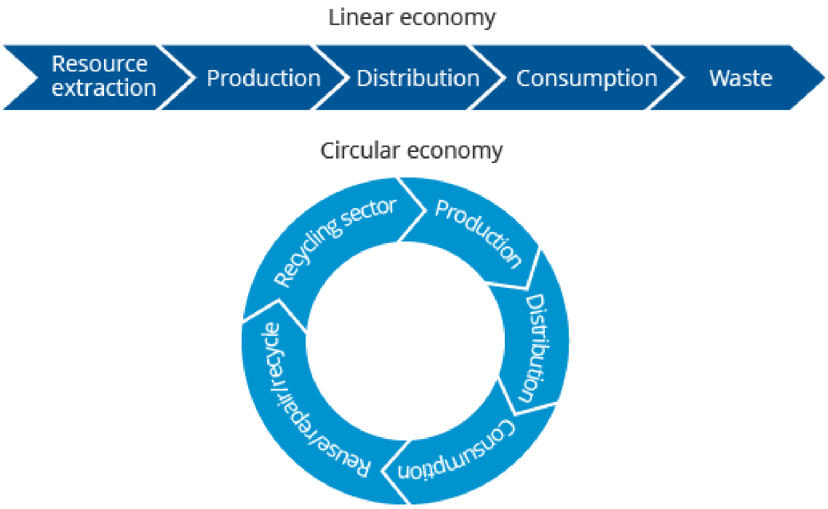

Figure A4 Circular Economy V.S. Linear Economy

Where products are of similar quality, cost effectiveness and performance, products that comply with the above circular economy criteria should be given preference during procurement. When buying organic bio-filtration media, information can be requested from the supplier on recycling options, product take-back services, lease agreements or improved design to minimize wastage (packaging and obsolete parts). This can ensure the resources used in the product are not lost to landfill but instead are reincorporated into the circular economy.

A5 Environmental impacts

Environmental impacts can be assessed by the criterion nominated in Table A5:

Table A5 Environmental impacts criteria assessment

Criteria	Specification	Test method	Yes/No
Waste generation/ disposal	<20%	less than 20% (v/v) of the product could not be reused/recycled and must be disposed after use.	
Application of fertilizers	<2 times every 10 years	Vegetated biofiltration system will not require the application of fertilizer for more than 2 times every 10 years	
Greenhouse gases (GHG)	Non/negative GHG emission during production	Compared to landfilling organic waste, which leads to massive GHG emission, organic biofiltration media products reduce methane emission from landfill and sequester carbon when applied to land.	
	Negative GHG emission during application	Organic biofiltration media support robust vegetated system which reduce GHG emission.	
Biodiversity	--	Details see Table 9.1.	

A6 Social impact

Social impacts can be assessed by the criterion nominated in Table A6:

Table A6 Social impacts criteria assessment

Criteria	Specification	Yes/No
Local employment	Localized manufacture (<100 km)	
Community recycling	Support the community material recycling (glass sand, recycled organics)	
Innovation degree	Application of innovated technology or materials	
Cost for the community	Reduce community product and waste management costs by using recycled materials rather than virgin materials.	

A7 Principles for sustainable procurement

Consistent with the principles of NSW Procurement Policy Framework (2015) government agencies, the international standard for sustainable procurement (ISO20400:2017) states that organisations should consider the following principles:

- **Accountability**: be accountable for its impacts on society the economy and the environment including the impacts of the organisation's supply chain.
- **Transparency**: be transparent about its procurement processes and how its decisions and activities impact on the environment, society and the economy.
- **Ethical behaviour**: behave ethically and promote ethical behaviour throughout its supply chains.
- **Full and fair opportunity**: avoid bias, and prejudice in all procurement decision making.
- **Respect for stakeholder interests**: respect, consider and respond to the interests of stakeholders impacted by its procurement activities.
- **Respect for human rights**: the rule of law and international norms of behaviour: be aware of any violations throughout its supply chains and actively encourage its suppliers to do the same.
- **Innovative solutions**: seek solutions to address sustainability objectives and encourage innovative procurement practices to promote more sustainable outcomes throughout the entire supply chain.
- **Focus on needs**: review demand, buy only what is needed and seek more sustainable alternatives first.
- **Integration**: ensure that sustainability is integrated into all existing procurement practices to maximise sustainable outcomes.
- **Life cycle costing**: consider the cost incurred, the value for money achieved and the costs and benefits to society, the environment and economy, resulting from its procurement activities.
- **Continuous improvement**: work towards continually improving sustainability practices and outcomes and encouraging all supply chains to do the same.

18 Appendix B: Suggested plants list for vegetated bio-filtration system

B1 Suggested plants for pollutants removal and infiltration capacity for vegetated bio-filtration system

Organic bio-filtration media can support most plants. Consequently, there are few limitations on the types of plants that can be used. However the Adoption Guidelines for Stormwater Bio-filtration Systems [7] listed suggested plants for a vegetated bio-filtration system, as in Table B1:

Table B1 Suggested plants list for vegetated biofiltration system

Objective	Effective	Medium or Mixed performance	Poorer performers
Nitrogen removal	*Baumea juncea* *Baumea rubiginosa* *Carex appressa* *Carex tereticaulis* *Ficinia nodosa* *Goodenia ovata* *Juncus amabilis* *Juncus flavidus* *Juncus pallidus* *Juncus subsecundus* *Melaleuca ericifolia* *Melaleuca incana* *Melaleuca lateritia*	**Medium** *Poa labillardieri* *Poa sieberiana* *Sporobolus virginicus* **Effective in wet/ poorer in dry** *Allocasurina littoralis* *Cyperus gymnocaulos* *Juncus kraussii* *Leptospermum continentale* **Effective in dry/poorer in wet** *Poa poiformis*	*Acacia suaveolens* *Astartea scoparia* *Banksia marginata* *Dianella revoluta* *Dianella tasmanica* *Gahnia trifida* *Gahnia sieberiana* *Hakea laurina* *Leucophyta brownii* *Lomandra longifolia* *Microlaena stipoides* *Rytidosperma* caespitosum
Pathogen removal	*Carex appressa* *Leptospermum continentale* *Melaleuca incana* *Palmetto® buffalo*		*Dianella tasmanica* *Poa labillardieri* *Sporobolus virginicus*
Infiltration capacity	*Melaleuca incana* *Melaleuca ericifolia*		
Iron removal	*Carex appressa*		

B2 Suggested plants list for different zones of a vegetated bio-filtration media

A vegetated bio-filtration system has different zones for treatment as shown in Figure B1

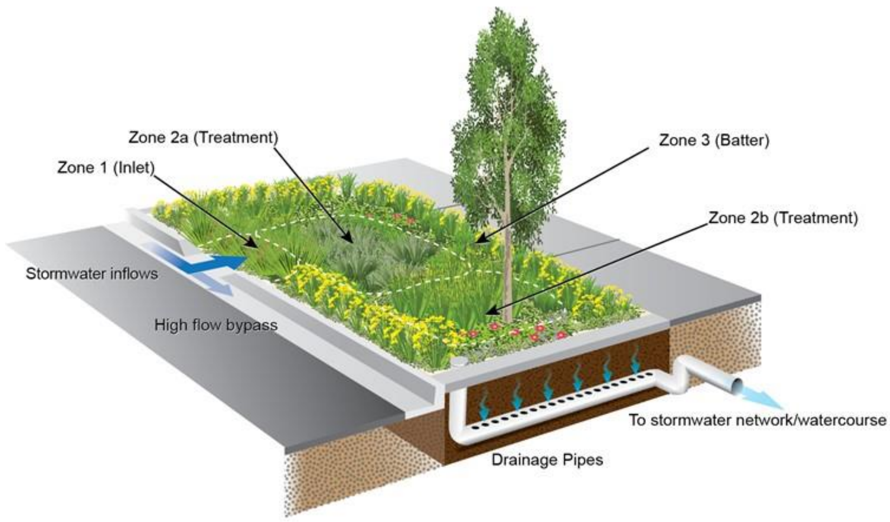

Figure B1 Schematic diagram of a vegetated bio-filtration system with zones

South Australia EPA published “A guide to raingarden plant species selection and placement” [18], which listed plants for different zones of a vegetated bio-filtration system (Table B1).

Table B2 Plants list for vegetated bio-filtration system

Species	Common name	Height (mm)	Plant area				Description
			Zone				
			1 (Inlet)	2a (Treatment)	2b	3 (Batter)	
Carex tereticaulis	Rush Sedge	600-1200	√	√			Spiky
Goodenia ovata	Hop Goodenia	1000-2500			√	√	Spreading shrub, formative pruning recommended to achieve compact form
Ficinia nodosa	Knobby Club-rush	500-1500	√	√	√	√	Full sun to 70% shade, ideal for full coastal exposure. Inland it can handle cold and light frost to –5ºC.
Juncus amabilis	Hollow Rush	600-1200	√	√			Suitable for moist soils with seasonal flooding & will tolerate drying out in Summer. Full sun - semi-shade.
Juncus flavidus	Juncus	350-1500	√	√	√		Moist to wet soils of depressions and drains, tolerating drier conditions in summer. Full sun, semi shade
Juncus palidus	Pale Rush	500-2000	√	√			Quite drought tolerant
Juncus subsecundus	Finger Rush	300-1000	√	√	√		Attractive foliage, tolerates some dryness
Baumea juncea	Bare Twig-rush	*200-1200*	√	√			Wet dependent species

Centre for Organic Research & Education Incorporated (CORE)

Charitable purpose

CORE is a charity registered by the Australian Charity and Not-for-profit commission with the following charitable purpose.

"The Collaboration, Advocacy, Research, and Education activities of CORE continue to serve to educate people about the organic cycle and organic systems. Particular focus is placed on the role of organic recycling, food production and bio-products in providing high quality, healthier and safer organic products, systems and soils, creating the foundation for a more liveable and sustainable environment".