Canadian Procedure for Field Testing of Stormwater Filtration Manufactured Treatment Devices

A Publicly Available Specification

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This Publicly Available Specification (PAS) was prepared by the Toronto and Region Conservation Authority (TRCA) with support from the Standards Council of Canada. As a Vocabulary this PAS takes the form of guidance and recommendations on policies, practices and approaches. The user should be aware that the process used to develop this document does not include the full consensus process normally associated with standards. It is the responsibility of the user of this document to judge the suitability of the document for the user's purpose. A PAS can be considered for further development as a Canadian Standard.

The *Procedure* presented in this document is largely based on the State of Washington, Department of Ecology's *Technical Manual for Evaluating Emerging Stormwater Treatment Technologies - Technology Assessment Protocol – Ecology* revised in September 2018.

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Developing a Publicly Available Specification

In collaboration with the SCC, the TRCA leveraged Canada's standardization system to bring together experts and organizations to define key terms and develop a PAS on how to apply these definitions.

This PAS builds on preliminary research and a series of public consultations with key experts, as well as those representing provincial agencies, municipalities, small and medium enterprises, large businesses, non-profit organizations, post-secondary institutions and others. Their comments on initial base documents, as well as written feedback and consultation transcripts, were analyzed. Suggestions were reviewed by the Steering Group and representatives from the SCC.

This PAS provides definitions and procedures for performance testing, reporting and verification of stormwater filtration manufactured treatment devices.

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Preface

In Canada and other jurisdictions, different regulatory agencies and permitting authorities have different requirements and performance criteria for approval and acceptance of various stormwater treatment devices for specific applications and operating conditions. To support their decisions, these agencies and authorities can benefit from scientifically defensible, verifiable performance data applicable to a range of possible end use requirements and operating conditions.

In support of this goal, the "*Procedure for Field Testing of Stormwater Filtration Manufactured Treatment Devices*" has been prepared by the Toronto and Region Conservation Authority based on testing requirements stipulated in the State of Washington Department of Ecology's *Technical Guidance Manual for Evaluating Emerging Stormwater Treatment Technologies - Technology Assessment Protocol – Ecology* (WSDE, 2018), which is also a field testing procedure. The *Technology Assessment Protocol* is used as the basis for the Canadian Stormwater Filtration Manufactured Treatment Device (MTD) Field Testing Procedure for three main reasons;

(i) the protocol provides a robust and scientifically defensible field evaluation methodology for proprietary and non-proprietary stormwater treatment technologies that is well regarded by stormwater practitioners, having been. It was developed and continuously updated through an extensive third-party expert peer review process;

(ii) the protocol specifies field testing that subjects devices to conditions not easily replicated in a laboratory environment, and that are essential to understanding the real world water quality and quantity performance of MTDs. Testing in field settings is of particular importance for Filtration MTDs because stormwater sediments consist of a mixture of cohesive silts, clay, sand, and may include organic matter, emulsified oils, fine debris, bacteria and other pollutants that build up on filter surfaces and/or penetrate into the filter structure(s) resulting in clogging dynamics that may vary significantly across different filtration system designs; and,

(iii) the protocol includes performance testing of stormwater pollutants other than suspended solids, which are best evaluated in field settings where the complex physical, chemical, and biological interactions that influence MTD removal processes are present.

The *Procedure* is to be used by various parties as the basis for stormwater filtration technology performance field testing and subsequent verification following the requirements of the International Organization for Standardization ISO 14034:2016 Environmental Technology Verification (ETV) standard, published in November 2016. The intent of the *Procedure* is to provide a common protocol for testing and verifying the performance of proprietary and non-proprietary stormwater filtration MTDs under field conditions in an independent and transparent manner. Independent verification of the performance data using the *Procedure* as the basis for testing will assist Canadian regulatory agencies, permitting authorities and other affected stakeholders in evaluating treatment technology options.

Although the proposed performance testing procedure is not intended to be a compulsory standard, it does represent an effective approach for conducting testing in order to produce verifiable performance data on Filtration MTDs under defined operating conditions. When applied in accordance with the requirements of the ISO 14034 ETV standard, the *Procedure* reduces uncertainties and improves the likelihood of market acceptance of the independently generated performance data, contributing to more informed technology decisions.

It is understood that the ultimate decision to approve, select and implement a particular technology is the responsibility of the technology buyer, guided by the requirements of the respective permitting authorities within the affected jurisdiction(s).

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1.0 Scope

This Canadian Publicly Available Specification (PAS) was developed under the Canadian Stormwater Environmental Technology Verification (SETV) project, which was established to develop publicly available specifications for testing and verification of stormwater manufactured treatment devices. It responds to a recognized market need, representing a consensus among stakeholders and experts for a standardization approach that serves an important public policy interest in an evolving technology and services market.

This PAS specifies the technology performance testing procedures required for Filtration Manufactured Treatment Devices (MTDs) seeking verification following the International Organization for Standardization ISO 14034:2016 ETV standard. Filtration MTDs (also referred to in this *Procedure* as MTDs) are structures consisting of one or more chambers with filtration media, membranes and/or filtration cartridges that remove solids and debris/trash from runoff. Some units may also have oil separation functions.

The *Procedure* is to be used as a basis for determining the capacity of Filtration MTDs to improve the quality of stormwater runoff under field conditions. Application of this *Procedure* will inform MTD sizing methods applied by regulators and the regulated community to predict the effectiveness of these devices in meeting regulatory goals and other stormwater management requirements. A separate PAS provides guidance on the use and application of verified testing data of stormwater treatment technologies for regulatory review.

The specific objectives of the *Procedure* are to:

- quantify the water quality performance of MTDs (removal efficiencies and effluent concentrations) for a range of parameters under field conditions;
- determine the recommended inspection and maintenance interval and document required maintenance methods and MTD specific metrics used to trigger maintenance activities;
- measure and document MTD specific operational parameters such as maximum filtration flux rates or infiltration rates, minimum and maximum driving head, detention time, and the maximum treatment system flow rate prior to the onset of bypass;
- describe a methodology for scaling the performance results obtained from this testing *Procedure* to larger or smaller untested devices in the same device classification

2.0 Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

- ISO 14034:2016, Environmental management — Environmental technology verification (ETV)
- ISO/IEC 17020, Conformity assessment - Requirements for the operation of various types of bodies performing inspection.
- ISO/IEC 17025, General requirements for the competence of testing and calibration laboratories

3.0 Terms and Definitions

Analyte: A physical or chemical parameter that is measured in a chemical analysis.

Automated sampler: A portable unit that can be programmed to collect discrete sequential samples, time-composite samples, or flow-composite samples.

Backwater: Water upstream from an obstruction which is deeper than it would normally be without the obstruction.

Blank: A synthetic sample, free of the analyte(s) of interest. For example, in water analysis, pure water is used for the blank. In chemical analysis, a blank is used to estimate the analytical response to all factors other than the analyte in the sample. In general, blanks are used to assess possible contamination or inadvertent introduction of analyte during various stages of the sampling and analytical process.

Bypass: An MTD design feature or upstream diversion structure that allows flow rates or flow volumes higher than a predetermined flow rate to be routed past the stormwater treatment technology without receiving treatment.

Calibration: The process of configuring a measurement instrument to provide a result for a parameter that falls within an acceptable range of the 'true' value.

Commercially available: A MTD that is engineered, sold and deployed in the field for use as a stormwater control measure.

Composite sample: Used to determine "average" loadings or concentrations of pollutants, such samples are collected at specified intervals, and pooled into one large sample. They can be developed based on time, flow volume, or flow rate.

Detention time: The theoretical time required to displace the contents of a stormwater treatment facility at a given rate of discharge (volume divided by rate of discharge).

Directly connected impervious cover: A surface where stormwater conveys directly to a surface water, drain or treatment system inlet.

Effective filtration treatment area: The surface area of the filtration media or membrane perpendicular to the flow path. For vertical media filters where flow enters from the top, it is the surface area of the filter.

Equipment Rinsate blank: Samples of de-ionized water used to rinse sampling equipment used to determine the effectiveness of cleaning or de-contamination of the equipment.

Event Mean Concentration: Pollutant concentration of a composite of multiple samples (aliquots) collected during the course of a storm. The Event Mean Concentration (EMC) is proportioned according to flow and depicts pollutant levels from site over an entire runoff event.

Field duplicate: Separate sample collected simultaneously at the identical source location and analyzed separately. Field duplicates are used to assess total sample variability (i.e., field plus analytical variability).

Filtration: Use of media such as sand, perlite, zeolite, and carbon, or membranes to remove total suspended solids (TSS) and associated pollutants from runoff through mechanical processes and adsorption. Some media such as activated carbon or zeolite can enhance the removal of hydrocarbons and soluble metals. Filter systems can be configured as basins, trenches, cartridges or membranes.

Filtration Manufactured Treatment Devices: Filtration MTDs are structures with one or more chambers with filtration media, membranes and/or filtration cartridges that remove solids and debris/trash from runoff. Some units may have oil separation functions and pre-treatment chambers for coarse sediment and debris. The filter components are designed to remove the coarse and fine sediment fraction of suspended solids and associated pollutants in stormwater runoff and may also target removal of dissolved pollutants such as phosphorus or metals through biological and/or chemical processes.

Grab sample: A sample collected during a very short time period at a single location.

Head Loss: The difference in static water pressure upstream and downstream of a structure. Head loss is influenced by material roughness, flow velocity, system eddies, direction of flow and flow path length.

Indirectly connected impervious cover: An impervious drainage surface that does not have a direct drainage connection to an impervious drainage system. Stormwater runoff from such areas is forced to pass over a pervious surface before entering any impervious drainage system.

International Organization for Standardization (ISO) Environmental Technology Verification (ETV) Standard: ISO 14034:2016 specifies principles, procedures and requirements for environmental technology verification (ETV) and was developed and published by the International Organization for Standardization (ISO). The ISO ETV standard specifies that technology operating conditions shall be clearly stated, and the performance parameters shall be measurable using quality-assured test procedures and analytical techniques. The objective of ETV is to provide credible, reliable, and independent verification of the performance of environmental technologies. An environmental technology is a technology that either results in an environmental added value or measures parameters that indicate an environmental impact.

Laboratory duplicate: Laboratory samples are split into two aliquots and separate sample preparation and analysis are conducted on each aliquot to detect potential errors in the sample preparation and analysis process.

Lag time: The detention time for a stormwater treatment technology that occurs between the inlet and outlet.

Maintenance Sediment Storage Depth and Volume: The maintenance sediment storage depth and volume of a MTD represents the amount of sediment that can accumulate in the MTD prior to maintenance, as recommended by the manufacturer or approval agency.

Matrix spike duplicate: Two spiked samples are analyzed by the same method to determine precision and bias of an analytical method.

Matrix spike recovery: A known amount of an analyte is added to a sample. The 'spiked' sample is analyzed to determine how much was recovered.

Method blanks: A sample representative of the matrix is analyzed by the same method as field samples to assess potential contamination arising from lab preparation and analysis procedures.

Method detection limit: The smallest concentration at which the true physical and chemical characteristics of a target analyte or parameter can be measured and statistically distinguished from zero at a specified confidence level (usually 99%).

Oil-grit Separators: Treatment devices consisting of one or more chambers with internal components that remove high specific gravity particulates by sedimentation and low specific gravity liquids and debris by floatation. These devices are also referred to as hydrodynamic separators.

Particle size distribution: The particle-size distribution (PSD) of a material, or particles dispersed in fluid, is a list of values that defines the relative amount, typically by mass, of particles present according to size.

Quality Assurance: The planned and systematic activities implemented within a quality system that can be demonstrated to provide confidence that a product or service will fulfill requirements for quality. ISO 14034:2016 ETV refers to a test plan with quality-assured test procedures and analytical techniques. The quality assurance components of the field test plan are the procedures and methods used to collect and analyze monitoring data to ensure results are scientifically defensible and meet the objectives outlined in the verification plan. The State of Washington Department of Ecology's *Technology Assessment Protocol – Ecology* (TAPE) uses the term "Quality Assurance Project Plan" (QAPP).

Removal efficiency: The percentage of contaminants retained by the MTD relative to those entering through the inlet(s).

Suspended Solids Concentration (SSC): The concentration of suspended sediments in a water column as defined by analytical testing in accordance with ASTM D3977.

System treatment flow rate: The treatment flow rate represents the maximum flow rate that was conveyed through the treatment chamber during field testing without bypassing. The system bypass rate is greater than the system treatment flow rate. When the system treatment flow rate is expressed per unit sedimentation area, it is referred to as the system treatment surface loading rate.

Test Body: The Test Body is an organization providing the means for test implementation, including performing and reporting on the testing of an environmental technology for the purposes of verification as specified in ISO 14034.

Test Plan: Prepared by the third-party Test Body and submitted to the Verification Body for review by the Verification Expert prior to the initiation of monitoring or technology performance testing. The term "Technology Specific Test Plan" (TSTP) is also used.

Test Procedure: Detailed instructions on the testing required to meet test requirements.

Total Suspended Solids (TSS): The concentration of suspended solids in a water column as defined by analytical testing in accordance with SM2504B/D. The TSS method is differentiated from the SSC method (see above) in that the former collects a sub-sample using a pipette from the whole sample container after stirring whereas the SSC method uses the whole sample.

Treatment System Bypass Rate: The rate at which flow begins to bypass the treatment chamber. The rate is often expressed as flow per surface sedimentation area.

Verification Body: The Verification Body (VB) is a third-party organization that administers the testing and verification process and acts as the point of contact for all questions relating to the verification. The VB and Verification Expert must meet the conformity requirements of ISO 17020 or equivalent.

Verification Expert: The Verification Expert (VE) is the third-party, impartial technical reviewer sub-contracted by the ISO 14034 VB to supply assessment and validation expertise and services. The VE may not both generate the required data and then assess/validate that same data for any one performance claim, as this would present a conflict of interest with respect to that verification. The VB and VE must meet the conformity requirements of ISO 17020 or equivalent.

Verification Plan: Prepared by the Verification Body to guide the verification process, specifying accountabilities and related quality requirements in accordance with the ISO 14034 ETV standard.

Verifier: The verifier is the organization that performs environmental technology verification (as defined in ISO 14034:2016). The term can apply to a Verification Body, a Verification Expert, or a combination of the two.

4.0 Performance Test Body and Verification Requirements

4.1 Test Body

The testing shall be conducted by an independent third-party Test Body that meets the requirements of ISO 17025 or equivalent. The Test Body shall be familiar with the field testing and analytical methods specified in this *Procedure* and have the infrastructure and expertise needed to perform the full range of testing in a manner that generates reliable, representative and repeatable results. In addition, technology performance Test Body staff shall have a thorough understanding of the design and operation of Filtration MTDs, acquired through research, field work hydraulics and stormwater sampling, including expertise in the statistical analysis of the data being collected. The Test Body prepares the Technology Specific Test Plan and Test Report.

4.2 Verification Body and Expert

The VB is a third-party organization that administers the verification process and acts as the point of contact for all questions relating to the verification. The VB contracts an independent, impartial VE that is responsible for reviewing the reporting and analysis prepared by the Technology Performance Test Body and delivering a verification report and verification statement. The VB and VE must meet the conformity requirements of ISO 17020 or equivalent.

The ISO 14034 ETV standard guides the verification process, specifying accountabilities and related quality requirements in the form of a verification plan. The publicly available verification statement for the class of technologies referred to as MTDs shall conform to the minimum content requirements listed in Appendix A.

5.0 Performance Testing Requirements

The performance testing requirements described in this document are based on the State of Washington Department of Ecology's TAPE, which is a field testing protocol that was developed through an extensive peer review process targeted at a wide range of short detention time (<1 hour) proprietary and non-proprietary stormwater treatment technologies (WSDE, 2018). Existing 'General Use Level Designation' certification of Filtration MTDs through the Washington TAPE process may satisfy ETV testing requirements in Canada provided that the design of the tested unit has not changed, TAPE requirements were followed, and hydraulic laboratory testing is used only to augment, rather than replace field testing requirements. Additional testing and data analysis may be required to support the ISO 14034 verification. Other performance test results not certified through the TAPE process may also be accepted but, again, additional data analysis and/or partial or full retesting may be required if, upon review by the VB and VE, the testing and reporting methodology differs significantly from that prescribed in this document.

This field testing *Procedure* may also be used without prior certifications as the basis for a new testing program that meets ISO 14034 ETV requirements. For new field monitoring programs or new testing supported by previous certifications, a Test Plan shall be prepared by the third-party Test Body and submitted to the VB for review by the VE prior to the initiation of monitoring or testing.

5.1 Technology Design and Treatment System Sizing

The tested MTD shall be a full scale, commercially available device with the same configuration and components as would be typical for an actual installation. Details on the design and function of the device, inspection and maintenance procedures, expected life span of device components, and site installation requirements shall be included in the Test Report. For media filters, the compaction techniques and final installed bulk density of the material shall be specified. Recommended treatment system sizing methodologies shall be provided along with details on how the system was sized for the test site, including hydrologic modeling results, site plans, hydraulic routing details and parameter inputs if applicable. Pre-treatment should be avoided to ensure runoff directed into the MTD meets the influent quality ranges specified in this *Procedure*. In general, MTDs should be sized to treat at least 90% of the total runoff volume without bypass based on historical precipitation records relevant to the monitoring site (see TRCA, 2023).

5.2 Monitoring Site

Monitoring sites and stormwater pollutant loading shall be representative of a typical site where the MTD would be installed. The area draining to MTDs would normally consist of areas without steep slopes (>20%) that have greater than 80% paved impervious pavement (roads and walkways). Areas with less impervious cover will be considered by the VE depending on the typical drainage area imperviousness for the MTD being tested. Details of the drainage area shall be provided, including aerial photos, time of construction, summer/winter pavement maintenance practices, land cover types and percentages, pollutant sources (e.g., roads, landscaped areas, roofs), and any unique characteristics which may affect stormwater pollutant loading or overall system performance. Sites with residual construction sediment and sand applied for winter maintenance shall be avoided. Photo documentation of site conditions during the course of monitoring shall also be provided.

Preferred sites are ones with simple inlet and outlet configurations that are amenable to equipment installation, allow for accurate measurement of flows and water quality, and provide easy access for regular equipment downloads. Prior to commencing the monitoring program, 5 to 10 water quality grab samples shall be collected during rain events of varying intensities to ensure the influent pollutant concentrations fall within the acceptable influent ranges (as per the guidance provided in section 5.3.3) and the site has water quality loading profile that is representative of a typical site where the MTD would be installed. It should be confirmed that the monitoring location not be subject to backwater or surcharge effects for (at least) event flows up to 125% of the MTD treatment system bypass rate.

5.3 Monitoring Program

The monitoring program shall include continuous on-site precipitation and inlet/outlet flow monitoring over the duration of the performance test, collection of water quality samples during eligible events (see section 5.3.3 below) and accumulated sediment sampling. Additional measurements and tests may be added to the Test Plan to provide a fulsome evaluation of the specific technology being evaluated. The Test Report shall include detailed descriptions of methods for data collection and quality control measures undertaken.

5.3.1 Precipitation monitoring

The precipitation monitoring shall be conducted with automated gauges on-site within or within 75 m of the contributing drainage area. Rain gauges are to be installed in an open area away from potential obstructions that would impact measurement accuracy. Rainfall equipment shall be regularly inspected and maintained during routine data downloads and calibrated at least 4 times over the duration of the test period to safeguard data quality. Rainfall measurements shall be recorded at intervals no greater than 15 minutes, and preferably at maximum 5 minute intervals, in increments of 0.25 mm or less. Gaps in rain gauge data may be filled with nearby third-party rain gauges identified as part of the monitoring plan, but a regression relationship between the on-site and third-party rain gauge shall be established and used to adjust data as may be appropriate.

If monitoring extends into the winter period, a suitable gauge shall be installed that can measure rain, snow, sleet or hail. Weigh gauges measure the amount of precipitation by using vibrating wire load sensors. Antifreeze is used so that any solid precipitation is melted in the collection container. A thin layer of oil can be added to prevent evaporation. Weigh gauges often have attachments surrounding the gauge that limit errors associated with wind. Radar or optical precipitation sensors measure the speed and size of all forms of precipitation. The gauges calculate precipitation quantity and type by correlating drop size and speed. In some cases, a heater may be required for the winter months. While rain gauges are typically considered three season gauges there are heater elements that can be wrapped around the gauge. This heater allows for the frozen precipitation to be melted and measured by the gauge as a liquid throughout the winter season. Temperature and wind speed measurements can help with interpretation of event data.

5.3.2 Flow monitoring

Treatment performance testing shall distinguish between flows passing through the treatment chamber of the MTD and flows that bypass the treatment chamber. The field monitoring program shall target flow rates that are a minimum of 20% greater than the treatment system bypass rate. The monitoring program shall continue until at least two flow rates exceed the treatment system bypass rate for the tested MTD for a period greater than 5 minutes. At least one of the two required bypass flows must occur within the second half of the maintenance interval for the MTD.

Flows into and out of the system shall be monitored continuously at no more than 15-minute recording intervals (5 minutes preferred). Bypass and effluent flows shall be monitored separately, where feasible. Flow equipment shall be regularly maintained and calibrated according to standard methods or equipment manufacturer instructions at set intervals over the duration of the test to ensure accuracy. Flow equipment shall be installed at locations that meet the calibrated flow measurement device requirements for accurate flow measurements and that are easily accessible for maintenance. Inspections shall be conducted after each event and equipment maintained as appropriate. Comparing hydrologic model estimates of flow volumes and rates (based on measured event precipitation and contributing area land use characteristics) to measured inlet flow volumes/rates for precipitation events over the monitoring period, can help identify potential measurement errors in precipitation, flow or both. For MTDs that do not reduce flow volumes, differences in inlet and outlet flow volumes during events indicates problems with flow measurements at the inlet, outlet or both.

Head loss from the inlet to outlet of the MTD shall be measured at the beginning of the test and prior to sediment maintenance. The specific method for head loss measurements may vary based on the unit configuration and shall be submitted to the VE for approval as part of the Test Plan. Head loss measurements may also be used to document minimum and maximum driving head requirements for the MTD. If the testing for which verification is sought was conducted prior to the release of this *Procedure*, and field measurements of head loss were not conducted, laboratory measurements of head loss with simulated clogging of filter(s) may be accepted. In this instance, the filter(s) shall be occluded to a level corresponding to that occurring at the lowest field measured system treatment flow rate prior to the initiation of bypass. The laboratory testing with partially occluded filter(s) may also be used to supplement field data where high flow measurements during field testing were judged by the VE to be insufficient. These tests may also be done in the field through hydrant tests, where feasible.

5.3.3 Water quality sampling

A minimum of 15 inlet/outlet flow proportioned water quality sample pairs shall be collected during monitored storm events (one flow proportioned inlet/outlet pair of composite samples for each event) that meet the guidelines for TAPE eligible events reproduced in Table 5.1. Additional samples may be required to establish statistically significant performance results over a range of rainfall intensities and sizes. Events sampled for water quality shall represent a range of rainfall volumes and intensities, including at least two events with flows that exceed the treatment system bypass rate for the tested MTD. All sample pairs collected during eligible events shall be included in the performance analysis.

Samples shall be collected over at least one and a half maintenance cycles to verify recommended maintenance intervals and changes in water quality performance and bypass rates over time. A maintenance cycle is completed when the manufacturers recommendations for maintenance triggers have been reached, as detailed in the maintenance manual for the tested MTD. The lowest flow rate during which bypass occurs over the monitoring period shall be established as the treatment system bypass rate for the unit.

Table 5.1: Guidelines for Storm Events (adapted from WSDE, 2018).

Parameter	Definition	Guideline
Minimum storm depth	Defines the minimum depth of rainfall over the duration of the rain event	3.8 mm
Storm start (antecedent dry-period)	Defines the start of the event based on minimum time interval with little or no rain	6 hours minimum with less than 1.0 mm of rain
Storm end (post storm dry period)	Defines end of the event based on minimum time interval with little or no rain	6 hours minimum with less than 1.0 mm of rain
Minimum storm duration	Defines the shortest acceptable rainfall duration for an event	30 minutes
Average storm intensity	Total rainfall amount divided by total rainfall duration	Range of rainfall intensities[1] with at least two events having short duration rainfall intensities that generate flows greater than the system bypass rate

[1] A range of rainfall intensities shall be monitored to assess performance on an average annual basis and at flow rates exceeding the design hydraulic loading rate.

Water quality samples for each event and sampling location shall be comprised of a minimum 10 equal volume aliquots or discrete samples that are combined to form a flow proportional composite sample for the sampling event and location. For storms lasting less than 24 hours, a minimum 75% of the storm event hydrograph (by volume) shall be sampled. For storms longer than 24 hours, sampling shall cover at least 75% of the first 24 hours of the storm event hydrograph. The maximum sampling duration from the collection of the first to last aliquot is 36 hours. Bypass flows that redirect flows around the treatment chamber need not be sampled as it is assumed that the quality would be similar to that of the influent. Samples shall be collected at well mixed locations that do not interfere with or bias flow sampling measurements.

The minimum water quality parameters to be included in the monitoring program are presented in Table 5.2. Other water quality parameters may be added at the discretion of the manufacturer, but influent concentration ranges for eligible events may need to be set for the added parameters following discussions with the VB and VE.

The parameters are analyzed in all inlet and outlet flow proportional composite samples collected over the monitoring period, except for total petroleum hydrocarbons (TPH) and pH. TPH is collected as discrete grab samples at representative flow rates, and pH is measured with a handheld meter or collected in samples but measured for pH within 2 hours of sample collection. The grab samples may be collected at different flow rates within a single event but should be distributed evenly over the monitoring period.

Several of the listed parameters may also be used as screening parameters for each other (*e.g.*, hardness and pH for metals) to help interpret results for individual water quality parameters, assess whether the water quality data are representative, and flag potential needs for adjustments to the treatment system to reduce undesired changes in certain parameters (*e.g.*, pH, TPH).

Table 5.2: Required Water Quality Parameters

Water Quality Parameter	**Required Parameters**[1]
Conventional Parameters and Total Petroleum Hydrocarbons (TPH)	Total Suspended Solids (TSS) or Suspended Solids Concentration (SSC)[2] Particle Size Distribution (PSD) Hardness pH[3] Total Petroleum Hydrocarbons[4]
Nutrients	Total Phosphorus (TP), orthophosphate (OP), Nitrate (NO_3-N), Nitrite (NO_2-N), Total Kjeldhal Nitrogen (TKN)[5]
Metals	Total Copper (Cu) and Zinc (Zn)

[1] These parameters are analyzed in all inlet-outlet composite sample pairs.
[2] SSC is preferred, but TSS shall be permitted if analytical capacity in the testing area is not available, or results are based on an earlier evaluation through TAPE or equivalent field testing programs.
[3] pH is to be measured *in situ* with a pH meter, or in samples within 2 hours of sample collection.
[4] TPH shall be collected as a grab sample at representative flow rates during at least 5 events More than one grab sample can be collected per rain event, but the inlet outlet sample pairs shall be collected at intervals greater than one hour.
[5] Total Nitrogen shall be calculated as $NO_2 + NO_3$ + TKN.

Water quality samples may be collected with automated samplers or as discrete grab samples during events according to the influent concentration ranges and sample collection requirements referenced above. Methods shall follow *Standard Operating Procedure for Automatic Sampling for Stormwater Monitoring v1.1* (Ecology, 2009a) and/or *Standard Operating Procedure for Collecting Grab Samples from Stormwater Discharges, v1.1* (Ecology, 2009b), including recommended quality assurance and control measures. Grab sampling is often used for certain water quality variables such as TPH but may also be used for other variables as an alternative to discrete automated sampling. In the latter instance, the grabs would normally be collected at equal intervals over the minimum storm duration of 30 minutes (or longer) and later combined into composite samples based on flow data to form a representative flow proportioned composite sample for the event. Other paired discrete sampling methods for constant flow rates or combination methods may also be considered valid by the VE based on TAPE guidelines (WSDE, 2018), but samples must be collected in a field setting. Sample handling and preservation methods shall follow *Standard Methods for the Examination of Water and Wastewater* (APHA, AWWA and WEF, 2022).

5.3.4 Water quality sample analysis

Water quality sample and hydrologic data shall include a description of measurement quality objectives and acceptance criteria for the data. Field sample collection and laboratory quality control parameters for water quality variables are to include percent recovery ranges for laboratory/field duplicates and matrix spikes (where applicable), as well as methods used to minimize bias during sample collection, storage and transport (see Appendix B)

All analytical laboratories performing sample analysis shall meet the requirements of ISO 17025, or equivalent. Tables shall be submitted showing the parameter, sample matrix (water), analytical method, reporting limits, time of collection, preservation, submission and analysis, and other relevant laboratory notes. The water quality parameters, target minimum reporting method detection limits and eligible analytical methods to be included in the evaluation are presented in Table 5.3. If a different analytical method is proposed, the key differences and potential effect on results are to be discussed with the VE prior to initiating the monitoring program.

Table 5.3: Analytical Methods and Reporting Method Detection Limit Targets for Water Samples.

Category	Parameter	Method (aqueous)	Description	RMDL Target[4]
Conventional Parameters and Petroleum Hydrocarbons	TSS SSC	SM 2540B or D[1], ASTM D3977-97 (2019)[1]	Gravimetry	1.0 mg/L
	PSD	ISO 13320:2020	Laser diffraction	N/A
	pH	EPA 150.2[2], or APHA 4500-H	Continuous monitoring (electrometric) by pH meter; pH by meter: Potentiometry	0.2 units
	Hardness as $CaCO_3$	EPA Method 200.7, SM 2340B (calculated from Ca/Mg), SM 2340C (titration), or SM 3120B	Titration; calculated from Ca/Mg (through ICP/AES)	1.0 mg/L
	TPH[3]	NWTPH-Dx: Ecology 1997 (Publication No. 97-602) or EPA SW-846 method 8015B or D, TPH: ASTM D7678, or EPA 3511/CCME Tier 1	Gas chromatography; GC-FID (flame ionization detector)	0.50 mg/L
Nutrients	Total phosphorus	EPA Method 365.3 or 365.4, SM 4500-P E or SM 4500-P F or SM 4500-P B	Spectroscopy (Colorimetry; Photometry); Automated Spectrophotometer	0.01 mg/L
	Orthophosphate	EPA Method 365.3 or 365.1, SM 4500-P E or SM 4500-P F or SM 4500-P B	Spectroscopy (Colorimetry; Photometry), Automated Spectrophotometer	0.01 mg/L
	Nitrate and Nitrite (as N)	EPA Method 353.2 or SM 4500 –NO3I, or EPA 300.1	Automated Spectrophotometer; Spectroscopy (Colorimetry; Photometry); Ion Chromatography	0.01 mg/L
	TKN (as N)	EPA Method 351.2 or SM 4500 Norg-D, or FIAlab 100	Colorimeter; block digestion; fluorescence	0.5 mg/L
Metals	Total Copper	EPA Method 200.8 (ICP-MS), SM 3125 (ICP-MS), or EPA 200.2/6020B	ICP-OES; ICP-MS	0.5 µg/L
	Total Zinc	EPA Method 200.8 (ICP-MS) or SM 3125 (ICP-MS), or EPA 200.2/6020B	ICP-OES; ICP-MS	5 µg/L

[1] The ASTM D3977-97 method for SSC is preferred and should be followed in monitoring programs initiated after the development of this protocol, unless parallel certification is being sought through TAPE. In the latter instance, it is recommended that the SM 2504B/D method be modified to include analysis of the whole sample as sub-sampling has been shown to result in lower accuracy.
[2] pH measurements in water samples may be accepted to fill gaps in pH meter data if necessary.
[3] The wider allowable range of methods for TPH is justified by the fact that it is for screening purposes only.
[4] Reporting Method Detection Limit: The lowest amount of an analyte in a sample that can be quantitatively determined with stated, acceptable precision and accuracy under stated analytical conditions.

During analysis, event water quality composite samples shall be divided into three sample sets based on the influent concentration ranges shown in Table 5.4, as follows: (i) samples with influent event mean concentrations (EMCs) below the lower concentration limit; (ii) samples with influent EMCs within the influent concentration range, and (iii) samples with influent EMCs above the influent concentration range. Effluent EMCs shall be reported separately for each category. Samples with influent EMCs below the lower range shall be reported but not used in evaluating performance. Samples of TP, TN, OP and metals with influent EMCs below the lower limit may be included as long as a well reasoned rationale for a change in the specified lower limit is provided and the new lower limit is applied across the entire data set. Removal efficiencies shall be calculated only for the samples with influent concentration ranges equal to or greater than the lower limit, except for TSS, for which removal efficiencies shall be calculated only on samples with influent TSS concentrations between 100 and 200 mg/L. Events with samples having influent TSS concentrations between 20 and 100 mg/L would be assessed based on effluent concentrations.

All samples with influent concentrations above the upper limit of the range (including TSS) shall be either discarded or artificially set at the upper range value for the purpose of calculating removal efficiencies. Including samples with influent EMCs greater than the upper range is optional but if the option is chosen, the approach shall be applied to all samples collected over the monitoring period that exceeded the upper range value. All samples with average pH influent EMC values outside of the stated range are discarded, regardless of the individual parameter concentration ranges.

Table 5.4: Influent Concentration Ranges

Parameter	**Influent Concentration Range (mg/L)**[1]
TSS or SSC	20 to 200
Total Phosphorus (TP)	0.1 to 0.5
Orthophosphate (OP)	0.04 to 0.3
Total Nitrogen (TN)[2]	0.06 to 4.0
Total Copper	0.005 to 0.02
Total Zinc	0.020 to 0.3
pH	4 to 9 (no units)[3]
Hardness	none
Total Petroleum Hydrocarbons (motor oil fraction)	none

[1] Samples greater than the specified range may be used to calculate removal efficiencies by artificially setting the sample EMC at the upper range. Including samples with influent EMCs greater than the upper range is optional but if the option is chosen, all samples collected over the monitoring period that exceeded the upper range value shall be included. Similarly, Samples of TP, TN, OP and metals with influent EMCs below the lower limit may be included as long as a well-reasoned rationale for a change in the specified lower limit is provided and the new lower limit is applied across the entire data set.

[2] Total nitrogen is calculated as the sum of nitrate (NO_3-N) + nitrite (NO_2-N) + Total Kjeldhal Nitrogen (TKN)

[3] Samples with pH values outside of the stated range shall be discarded.

It is recognized that this *Procedure* identifies some influent concentration ranges and required parameters that differ from those identified in the TAPE protocol. The differences between the two protocols would not prevent manufacturers from seeking verification through the ISO 14034 ETV process in Canada but may require some water quality and/or quantity data to be re-analyzed to meet the requirements of this *Procedure*. New monitoring programs conducted after the release of this *Procedure* shall follow the requirements stipulated in this *Procedure*.

5.3.5 Sediment measurement and sampling

Sediment depths are measured prior to cleaning and at the end of the monitoring period to assess the sediment accumulation rate and inform the development of an operation and maintenance plan. The sediment depth measurement method may be tailored to the MTD tested but shall be undertaken at a sufficient number of locations to characterize the average and standard deviation of depths across the sediment settling area. Sediment chemistry analysis is optional but may be included to assess disposal options. The parameters to be analyzed in sediment samples will vary based on local regulations. Analytical methods shall be based on standard methods by a lab accredited to ISO 17025 or equivalent.

5.4 Statistical Analysis of Data

Data shall be analyzed to assess whether differences in pollutant concentrations (and/or loads) at the inlet and outlet are statistically significant at a 95% level of confidence. The analysis shall evaluate the following two hypotheses:

(i) null hypothesis (H_o): effluent pollutant concentrations are equal to or greater than influent concentrations

(ii) Alternative hypothesis (H_a): Effluent concentrations are less than influent concentrations

The TAPE protocol recommends that these hypotheses be evaluated using the non-parametric 1-tailed Wilcoxon signed-rank test (Helsel and Hirsch, 2002). Other methods may be used but the rationale for the use of alternative methods shall be reviewed and approved by the VE.

Removal efficiencies for measured water quality parameters are calculated using one of the two methods below. If the effluent concentration is below the reporting method detection limit, the detection limit shall be used in the removal efficiency calculation:

$$R = \frac{100(A-B)}{A}$$

where:

R = Removal Efficiency (%)

A = Flow proportioned influent concentration (mg/L)

B = Flow proportioned effluent concentration (mg/L)

If the influent volume is reduced through infiltration or evaporation (*e.g*: bioretention), the removal efficiency calculation for individual events shall be based on loads:

$$R_L = \frac{100(A_L - B_L)}{A_L}$$

where:

R_L = Removal Efficiency (%)

A_L = storm influent concentration (mg/L) x storm influent volume (L)

B_L = storm effluent concentration (mg/L) x storm effluent volume (L)

If the latter method is used, both concentration and load-based removal efficiencies shall be reported. The second method shall only be used if the unit is designed to reduce water volumes, and not due to unintended leaks in the structure in which the treatment system is housed. All efforts shall be made prior to initiating the monitoring program to ensure a leak proof structure.

The 95% confidence intervals for influent and effluent concentration data and removal efficiencies shall be analyzed using Bootstrapping (Efron and Tibshirani, 1993). The accuracy of this method is not reliant on the distribution of data and can be calculated on means, geometric means or medians, whichever best represents the central tendency of the data analyzed. The upper one-sided 95th percentile confidence limit of the effluent concentrations shall be used to evaluate effluent concentration-based performance goals for each water quality parameter. Conversely, the lower one-sided 95th percentile confidence limit of the system removal efficiencies shall be used to evaluate removal efficiency performance goals for the same parameters.

To determine the influence of flow rate on treatment performance for sampled events, a regression analysis for monitored water quality parameters shall be performed with the 90th percentile influent flow rate over the sample collection interval as the independent variable and pollutant removal efficiency as the dependent variable. The regression analysis shall be repeated with flow proportioned effluent concentrations as the dependent variable. The p-values shall be evaluated to determine whether the trend is not statistically different from zero at a 95% confidence level. The Test Body shall consult the TAPE Protocol (WSDE, 2018) for a summary of the regression analysis methodology and Helsel and Hirsch (2002) for a more detailed description. Where correlations are observed, the Test Body shall perform additional analysis to determine the probable cause (e.g. influent SSC concentration, influent PSD, driving head), accepting the limitations imposed by the available of relevant data.

The Test Report shall include an error analysis that identifies and quantifies/estimates key sources of error and explains variances from the test plan. Methods used to analyze censored data (i.e values below the method detection limit) shall follow standard methods and be detailed in the Test Report. Details shall also be provided on MTD maintenance requirements (based on testing), changes in performance (if any) during the maintenance period and at flow rates exceeding the MTD bypass rate, along with explanations of observed relationships.

6.0 Scaling

The performance results determined for the tested full scale, commercially available filtration MTD may be applied to other model sizes of that filtration MTD provided that appropriate scaling principles are applied. Scaling the tested filtration MTD to determine other model sizes and performance without completing additional testing is acceptable provided that:

- The depth, composition, bulk density and gradation of media remain constant. *The nominal pore size of membrane based filters remain constant.*
- The ratio of the system treatment flow rate to effective filtration treatment area (filter surface area) is the same or less than the tested filtration MTD; and
- The ratio of effective sedimentation treatment area to effective filtration treatment area is the same or greater than the tested filtration MTD; and
- The ratio of wet volume to effective filtration treatment area is the same or greater than the tested filtration MTD.

Manufacturers shall submit available or proposed model sizes and names as part of the ISO 14034 verification to confirm how performance results from the tested model can be applied to other unit sizes based on the scaling rules above.

7.0 Reporting

A Test Plan shall be submitted prior to initiating the monitoring program with details on the technology design, proposed site, monitoring methods, statistical methods proposed for data analysis, presentation of results, and quality control measures taken to safeguard data quality (e.g., field quality control samples, equipment maintenance and calibration procedures/schedules, sample collection and preservation methods, record keeping details, etc). Detailed guidance on the quality assurance components of the Test Plan are provided by the Washington State Department of Ecology (Lombard and Kirchmer, 2016). The Test Plan shall provide details on how the criteria documented in this *Procedure* will be met, with reference to more detailed methodological descriptions provided in the Washington TAPE protocol (WSDE, 2018) if needed. Detailed descriptions of the technology, sub-components (*e.g.,* filters, media composition, media bulk density) and design parameters (e.g., bypass flow rate, head loss) shall be provided in the Test Plan along with the performance claims to be evaluated through testing. Test Plans for monitoring programs implemented prior to application for ISO 14034 verification shall be submitted for review.

The Test Report is used by the VE to confirm that testing meets the requirements stipulated in the Technology Specific Test Plan. The Test Report is to be prepared by the third-party Test Body. The Test Report shall include detailed technology and site descriptions, site sizing methodology, model outputs for site sizing, test plan design, monitoring results, lab studies (if relevant) and statistical analysis methods, along with explanations and interpretation of variances between this *Procedure* and the submitted Test Plan. Further details on the content of the Test Report (referred to as the Technical Evaluation Report) are provided by TAPE (WSDE, 2018). Lists of relevant reporting parameters are provided in Appendix C. Data spreadsheets and modelling files (if appropriate) generated during the performance test shall be made available to the VE for review and assessment.

Additional information on operation and maintenance procedures, installation guidelines, applicable codes and standards, warranties and other relevant information shall be provided to the VE as part of the ISO 14034 ETV process.

8.0 References

APHA, AWWA, and WEF. 2022. *Standard Methods for the Examination of Water and Wastewater*, 24th Edition. American Public Health Association, American Water Works Association, and Water Environment Federation, Washington, D.C.

Efron, B. and R.J. Tibshirani. 1993. *An Introduction to the Bootstrap: Monographs on Statistics and Applied Probability*. Chapman & Hall, New York.

Helsel, D.R. and R.M. Hirsch. 2002. *Statistical Methods in Water Resources*. Elsevier Publications, Amsterdam.

Lombard, S and Kirchmer, C, 2004 (revised 2016). *Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies*. Washington Department of Ecology. Washington, US.

Toronto and Region Conservation Authority (TRCA), 2023. *Guidance on the Use and Application of Results from Verified Laboratory and Field Testing for Stormwater Manufactured Treatment Devices.* TRCA, Toronto, Ontario.

Washington State Department of Ecology (WSDE). 2009a. *Standard Operating Procedure for Automatic Sampling for Stormwater Monitoring, Version 1.0*. No. ECY 002. Washington State Department of Ecology, Olympia, Washington. September 16, 2009.

Washington State Department of Ecology (WSDE). 2009b. *Standard Operating Procedure for Collecting Grab Samples from Stormwater Discharges, Version 1.0*. No. ECY 001. Olympia, Washington. September 16, 2009.

Washington State Department of Ecology (WSDE). 2018. *Guidance for Evaluating Emerging Stormwater Treatment Technologies-Technology Assessment Protocol—Ecology (TAPE)*, Olympia, Washington.

APPENDIX A: Minimum content requirements for ISO 14034 Verification Statements

Table A1: The following content shall be provided in the publicly available Verification Statement to ensure that the document provides a sufficient basis for decision making and is consistent for all ISO 14034 verified Filtration MTDs. Additional descriptive notes, photos, figures and tables may be provided as required.

Sections / subsections	**Brief Content Description**	**Tables and/or Figures**
General Information	Names of vendor, verified MTD model, VE and VB. Organization addresses. Brief information on the ISO 14034 standard. Contact information for the Vendor and VB.	none
Manufactured Treatment Device Description and Application	Description of the MTD, including overview of device function, operation, design hydraulic parameters (e.g., design head loss, maximum hydraulic capacity), number of chambers, chamber dimensions, maintenance sediment storage depth/volume, baffle configurations, high flow bypass specifications (if applicable), filter details, inlet and outlet sizes, invert elevations, and other components. A specific statement shall be included describing the bypass and clarifying whether or not the bypass component allows high flows to fully bypass all filters and areas where sediment was observed to settle.	Schematic showing MTD dimensions and pipe/baffle locations/sizes, filter sizes and locations, etc.
Test Procedure	References the Field Procedure(s) used as the basis of testing.	none
Performance Claim	Performance claims for each of the water quality parameters for which the vendor is seeking verification and the conditions under which the claim is valid. The claim shall clearly indicate whether the claim is valid for all flows (including bypass) or treated flows only.	none
Performance Conditions	The conditions under which the claim is valid may include, but are not necessarily limited to: (i) maximum filtration flux rate (maximum flow rate per unit filter surface area) or design infiltration rate, (ii) system treatment flow rate prior to bypass , (iii) mass sediment loading capacity, (iv) driving head (minimum head requirement) and (v) filter sizing details (e.g., media depth, media bulk density, filter cartridge clearance from sump floor).	optional
Test Site	Details on the test site, including location, drainage area size and contributing land covers	Graphic showing site layout with monitoring locations

	(e.g., asphalt, roof, landscaped areas), native soil texture (if relevant), traffic conditions, and other information that may have an influence on the test results.	
Performance Results	Brief description of the method used to arrive at results along with actual hydrologic and water quality results for each water quality parameter and each event, along with summary statistics for the test period. Performance is also reported as a function of flow rate. Statistical results are used as the basis for performance claims. A specific statement shall be added that clarifies whether the bypass component allows high flows to fully bypass the filters and all areas where sediment was found to settle during testing.	Tables show performance results for all sampled rain events along with rainfall depths, intensities, peak flow rates, lag times (if appropriate), EMCs for tested parameters (including screening parameters like pH and hardness) and statistical analysis results. Graphics include water quality boxplots, inlet/outlet cumulative PSD, representative inlet and outlet hydrographs and performance graphed as a function of flow rate.
Scaling	A list of models other than the tested model that the performance claims can be applied to based on manufacturer submissions showing conformity of model sizes to the scaling rules. The specific scaling parameters shall be referenced: (i) depth, composition and gradation of media (where relevant); (ii) ratio of system treatment flow rate to effective filtration treatment area; (iii) ratio of effective sedimentation treatment area to effective filtration treatment area; (iv) ratio of wet volume to effective filtration treatment area.	none
Operational Parameters	In addition to test data and conditions relevant to the performance claim, the following operational data shall also be provided: measured energy losses (head loss), measured bypass flow rate (the lowest rate at which bypass occurred over the duration of the performance test), relationship between head loss and filter clogging, and recommended maintenance frequency based on test results.	optional
Variances from the field procedure used for testing and sources of potential error	Describes any variations from the field testing procedure(s) utilized to generate the results with comments on significance of the variances in relation to the Performance Claims. This section shall also highlight potential sources of error which may affect confidence in the overall results	optional

APPENDIX B: Quality control measures for water quality sampling and analysis

Table B1: Examples of quality control measures for water quality monitoring and analysis

Quality Control Measure	Description	Typical measurement quality objective ranges
Laboratory Duplicate	Laboratory samples are split into two aliquots and separate sample preparation and analysis is conducted on each aliquot	≤10% for SSC and ≤20% for most other parameters;
Matrix Spike Recovery	A known amount of an analyte is added to a sample. The 'spiked' sample is analyzed to determine how much was recovered	75-125% for phosphorus, nitrogen, metals and hardness
Matrix Spike Duplicate	Two spiked samples are analyzed by the same method to determine precision and bias of an analytical method	≤20% for phosphorus, nitrogen, metals and hardness
Field Duplicate	Separate sample collected simultaneously at the identical source location and analyzed separately. Field duplicates are used to assess total sample variability (i.e., field plus analytical variability).	≤20% for most parameters
Equipment Rinsate Blanks	Samples of de-ionized water used to rinse sampling equipment used to determine the effectiveness of cleaning or de-contamination of the equipment.	No more than 5% of blanks shall exceed the method detection limit
Method blanks	A sample representative of the matrix is analyzed by the same method as field samples to assess potential contamination arising from lab preparation and analysis procedures.	No more than 5% of blanks shall exceed the method detection limit

APPENDIX C: Data summary information

Table C1: Required information to be included in the report and data summaries.

Site Data	Monitoring site name
	Site location
	Site GPS co-ordinates, aerial photos, ground level photos
	Drainage area size
	Percent land cover in drainage area by type (paved, roof, lawn, garden, etc)
	Distinguish between direct and indirectly connected impervious cover
	Estimated runoff coefficient for the site for different event sizes
	Modelled flow rate and duration to MTD for the 10, 15 and 25 mm storms, 2,5,10, 25 and 100 year return periods
	Unique features of the site that may be relevant to the performance test
Technology and Filter Information	Model name and number
	MTD dimensions
	Bypass rate
	Date MTD was put into service
	Indicate if facility was off-line or in-line with an internal bypass
	Other useful design information, such as depth/volume of media, number of cartridges, flow path length, hydraulic function, media composition, target pollutants, etc.
	Filter dimensions (e.g., surface areas, length, width, depth) and intended function
	Media grain size, porosity, bulk density and composition (if appropriate)
	Media infiltration rate (if appropriate)
	Membrane pore size and flux rate (design and measured over time)
Monitoring Program Details	GPS co-ordinates of rain gauge
	Schematics and photos of the location and set-up of monitoring equipment (with GPS co-ordinates as needed)
	Monitoring equipment types and accuracy levels
	Monitoring equipment calibration reports
Storm event information	Date, start and end time of storms sampled and reported
	Precipitation depth (mm)
	Antecedent dry period (hours)
	Precipitation duration (hours)
	Maximum and mean precipitation intensity per event (mm/h)
	Number of storms monitored for flow
	Precipitation gauge calibration times and procedures
	Comparison of data to storm event guidelines
	Influent peak flow rate for each event (L/s)

Hydrologic information	Effluent peak flow rate for each event (L/s)
	Average influent flow rate (L/s)
	Average effluent flow rate (L/s)
	Bypass peak flow rate for each event (L/s)
	Lowest flow rate that initiated bypass (L/s)
	Bypass flow volume for each event (L or m^3)
	Bypass flow duration for each event (hours)
	Percentage of total volume bypassed for each event
	Total influent runoff volume per event (m^3)
	Total effluent runoff volume per event (m^3)
	Lag time between influent and effluent peaks (min)
	Head loss curves and driving head requirements (m)
	Stage discharge curves
	Event hydrographs showing flow, precipitation, influent/effluent flow, and sample aliquot collection times
	Flow equipment in-field calibration times and procedures
	Data quality flags
Water quality information	Number of storms monitored for water quality
	Type of sample taken for each parameter and sampling event (grab, composite)
	Start and end time of sampling of influent and effluent (hours)
	Number of influent aliquots for each event
	Number of effluent aliquots for each event
	Percent of total storm volume sampled at the inlet and outlet
	Parameters monitored
	Influent EMCs (flow proportioned) with and without bypass – concentrations and loads if appropriate
	Effluent EMCs (flow proportioned) with and without bypass - concentrations and loads if appropriate
	Removal efficiency for each parameter (%) with and without bypass – concentrations and loads if appropriate
	Relationship between water quality performance and flow rate, using the method described in the *Procedure*.
	Laboratory detection limits and other flags
	Quality Assurance/control procedures for each event and parameter
	Water quality equipment calibration times and procedures
	Data quality flags
Sediment Quantity and Quality Information	Location and time of sediment sampling
	Sediment accumulation depths (cm or m)
	Rate of sediment accumulation (cm/month)

	Recommended maintenance intervals based on sediment accumulation measurements
	Sediment quality for regulatory parameters of interest
Maintenance Information	Date/time and duration of maintenance conducted
	Details of maintenance performed including equipment required, components damaged (if any), quantities of sediment removed, condition of filter(s) etc.
	Level of restoration prior to re-initiating monitoring
	Details and photos of filter condition (e.g. clogging level, depth of sediment penetration, etc).