Verification Statement

Hydroworks HydroFilter HF2i
Registration number: (V-2024-02-01)
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Technology type	Stormwater Filtration Device		
Application	Technology to treat stormwater and facilitate its infiltration into the ground.		
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Verified Performance Claims for the HydroFilter HF2i

The Hydroworks HydroFilter HF2i was tested by Alden Research Laboratory, Holden, Massachusetts, USA in 2020. The performance test results were verified by the Sir Sandford Fleming College of Applied Arts and Technology's Centre for Advancement of Water and Wastewater Technologies (CAWT) following the requirements of ISO 14034:2016 and the VerifiGlobal Performance Verification Protocol. The following performance claims were verified:

Sediment Removal: The Hydroworks HydroFilter HF2i (two-cartridge 'dry' filter system) removed at least 84.6% of cumulative TSS, based on a 95% confidence level, with a particle size distribution of 1-1000 µm and an inlet test sediment concentration of 200 mg/L at a flow rate of 1.58 L/s (0.79 L/s per cartridge) based on 20 runs performed under controlled conditions during laboratory testing.

Maximum Treatment Flow Rate (MTFR): The Hydroworks HydroFilter two cartridge filter system has an MTFR of 25 gpm (0.06 cfs; 94.6 lpm) and an effective filtration treatment area (EFTA) of 12.57 ft^2 (1.17 m^2) (loading rate = 2.0 gpm/ft^2, 81.5 lpm/m^2).

Hydraulic Losses: The maximum driving head, which was recorded at the end of run 20, was 1.96 ft (60 cm), which correlates to 0.08 ft (2.4 cm) below bypass.

Technology Application

HydroFilter is a stormwater management device designed to both treat stormwater and facilitate its infiltration into the ground. The infiltration portion of HydroFilter is a removable component, which allows the HydroFilter to serve as either solely a filter or a filter with recharge capability for maintenance of the hydrologic cycle (i.e., groundwater/aquifer recharging and flood risk mitigation). This verification is specific to total suspended solids (TSS) removal.

Technology Description

Under normal or low flows, water enters the HydroFilter through a grate or horizontal inlet pipe. Incoming water builds up around the filters and creates a pressure head to drive water radially into the filter cartridges from the outside through to the centre of the cartridge. There is a 6" (150 mm) diameter opening in the centre that is contiguous through the centre of each cartridge. Water reaching the centre of each cartridge falls by gravity into the base plug and is transported out of the structure by a standard storm drain and/or recharge pipes into the surrounding soil.

A solid high deflection cone 24" (61 cm) diameter by approximately 12" (30.5 cm) height with a check valve is located on top of the top filter cartridge to prevent incoming water from entering the 6" (15.2 cm) diameter opening, while still allowing air to escape from the centre of the cartridges as water enters the filters. High flows are bypassed through a high pipe in the HydroFilter.

A schematic of the Hydroworks HydroFilter is shown in Figure 1.

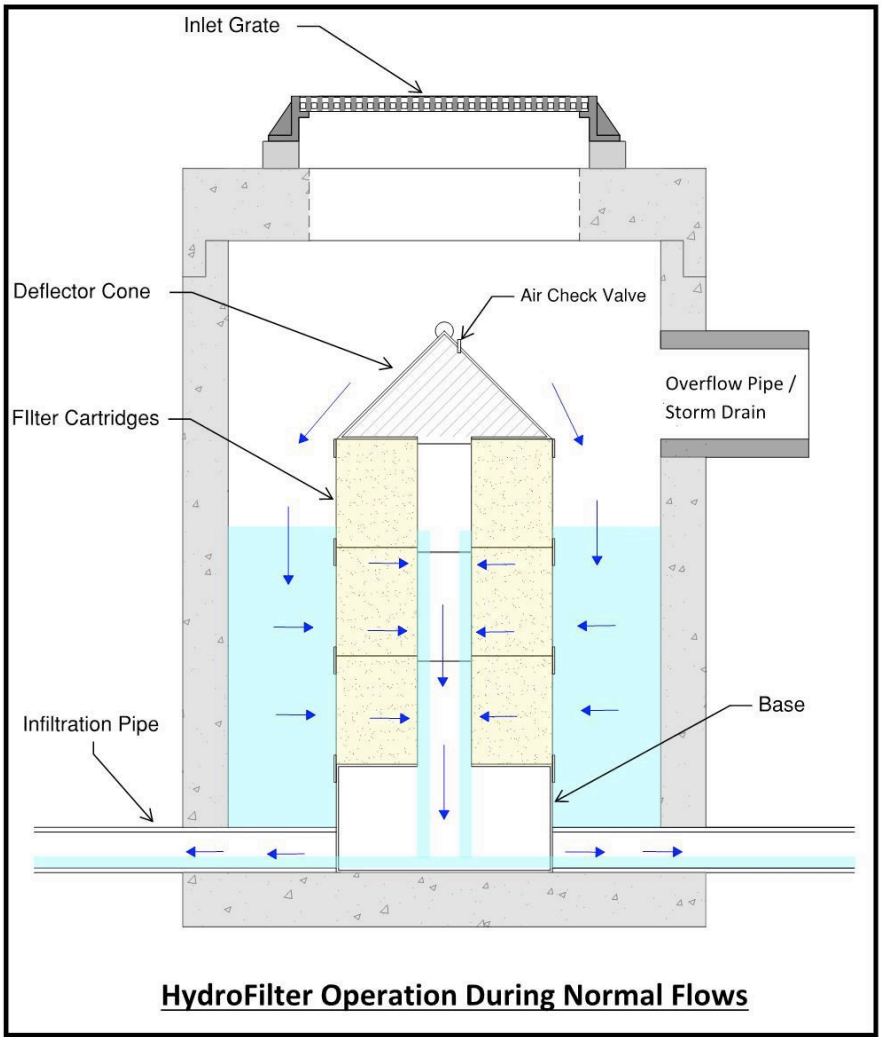

Figure 1: Schematic of the Hydroworks HydroFilter

Description of Test Procedure

Performance testing of the Hydroworks HydroFilter HF2i by Alden Laboratories was based on a "dry" filter, where the discharge point is below the cartridges such that it operates without the benefit of pre-treatment in a permanent pool. This differs from the "wet" configuration, which uses a weir wall to create a pre-treatment pool around the cartridges and allows for discharge above the cartridges by the head differential created by the weir wall.

The tested treatment filter (HF2i) was comprised of two (2) 24" (61 cm)-diameter x 12" (30.5 cm) high stacked interlocking filter cartridges installed inside a 3-ft diameter tank. Each cartridge contained a proprietary filter media. The inner and outer flow surfaces of the cartridges were perforated. The filter assembly was installed on a 24" (61 cm) diameter by 12" (30.5 cm) high base pedestal, which was sealed to the tank floor.

Water was transported into the tank by means of an 8" (20.3 cm) diameter inlet pipe, which discharged onto a sloped inlet containing a 24" (61 cm) storm grate. The flow was deflected around the annular space between the filter and tank, by the cone on top of the filters, and was transported radially through the cartridges.

A 6" (15.2 cm) centre opening transported the treated flow down into the base pedestal and into a 6" (15.2 cm) outlet pipe located at the bottom of the tank. The pipe was sealed to the pedestal and tank wall. A 6" (15.2 cm) bypass pipe was installed with the invert elevation at 3.04 ft (0.93 m). The pipe was connected to a tee in the outlet pipe upstream of the sampling point.

The annular area around the base pedestal (3.93 ft^2, 0.36m^2) was designed as a settling area for larger particles. A series of anti-scour pads were installed at the height of the pedestal to protect the captured sediment from scour.

Verification Results

A Verification Plan for the Hydroworks HydroFilter HF2i was prepared to guide the verification process based on the requirements of ISO 14034:2016 and the VerifiGlobal Performance Verification Protocol.

The CAWT verified the performance test data and other information pertaining to the Hydroworks HydroFilter HF2i based on performance testing conducted at Alden Labs, which followed the requirements outlined in the "*New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Filtration Manufactured Treatment Device, January 25, 2013".* The intent of this protocol is to ensure that filtration manufactured treatment devices (MTDs) are tested under controlled conditions in a consistent, verifiable manner.

The HydroFilter HF2i technology performance claims verified by the CAWT are as follows:

Sediment Removal	The Hydroworks HydroFilter HF2i (two-cartridge 'dry' filter system) removed at least 84.6% of cumulative TSS, based on a 95% confidence level, with a particle size distribution of 1-1000 µm and an inlet test sediment concentration of 200 mg/L at a flow rate of 1.58 L/s (0.79 L/s per cartridge) based on 20 runs performed under controlled conditions during laboratory testing.
Maximum Treatment Flow Rate (MTFR)	The Hydroworks HydroFilter two cartridge filter system has an MTFR of 25 gpm (0.06 cfs, 94.6 lpm) and an effective filtration treatment area (EFTA) of 12.57 ft^2 (1.17 m^2) (loading rate = 2.0 gpm/ft^2, 81.5 lpm/m^2).
Hydraulic Losses	The maximum driving head, which was recorded at the end of run 20, was 1.96 ft (60 cm), which correlates to 0.08 ft (2.4 cm) below bypass.

Removal efficiency is based on the ability of the filtration MTD to reduce the influent TSS concentration. TSS removal efficiency was established by the Effluent Sampling Test Method. As indicated in Table 1, the test sediment consisted of ground silica (1 – 1000 micron) with a specific gravity of 2.65, uniformly mixed to meet the particle size distribution (PSD) specified in

the *"New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Filtration Manufactured Treatment Device, January 25, 2013".* The protocol requires that the three-sample average of the test sediment PSD meet the specified PSD. The allowable tolerance of 2% variation from the specified PSD curve was met at each discrete particle size tested and the d50 was finer than 75 µm.

Table 1 – Test Sediment Particle Size Distribution

Particle Size (Microns)	Target Minimum % Less Than*
1,000	100
500	95
250	90
150	75
100	60
75	50
50	45
20	35
8	20
5	10
2	5

**A measured value may be lower than a target minimum % less than value by up to two percentage points (e.g., at least 3% of the particles must be less than 2 microns in size [target is 5%]), provided the measured d50 value does not exceed 75 microns.*

Laboratory testing of filters for TSS removal requires the use of a consistent PSD, which permits direct comparisons of filter products and a benchmark for filter design. The prescribed NJDEP PSD for filter testing (commonly referred to as the NJDEP PSD), is used by NJDEP for laboratory testing of both separators and filters.[1]

Figure 2 provides a comparison of average test sediment PSD to the PSD specified by NJDEP, indicating that the test sediment used for the removal test met the above-mentioned requirements. The median particle size (D_{50}) was 60 µm. In addition, samples from test sediment batches used for each run met the specified PSD within the required tolerance thresholds.

The capacity of the device to remove sediment was quantified at the 100% MTFR of 25 gpm (94.6 lpm) for 2 filter cartridges based on the Effluent Sampling Test Method. This method involved calculating the TSS concentration of the injected sediment, based on the mass injected and the volume of flow during the test period, and sampling the effluent leaving HydroFilter for each test run and calculating the average cumulative TSS removal efficiency.

The target influent total sediment concentration was 200 mg/L (+/-20 mg/L) for all tests. The allowed Coefficient of Variance (COV) for the measured samples was 0.10. The temperature of the supply water was below 26.7°C (80°F).

Five (5) time-stamped effluent samples and three (3) background samples of the supply water were collected from the end of the outlet pipe during each run. At the conclusion of each run, two (2) volume-based, evenly-spaced effluent samples were collected from the pipe during drawdown.

Table 2 provides the percent removal of cumulative TSS by the Hydroworks HydroFilter HF2i.

[1] Note: The NJDEP PSD is the same as the PSD specified for testing oil/grit separators under the *"Procedure for Laboratory Testing of Oil/Grit Separators"* (TRCA, 2014), which some jurisdictions in Canada call the Canadian ETV PSD.

Figure 2 – Average particle size distribution (PSD) of the 1-1000 micron test sediment used for the sediment removal test compared to the specified PSD (NJDEP specifications)

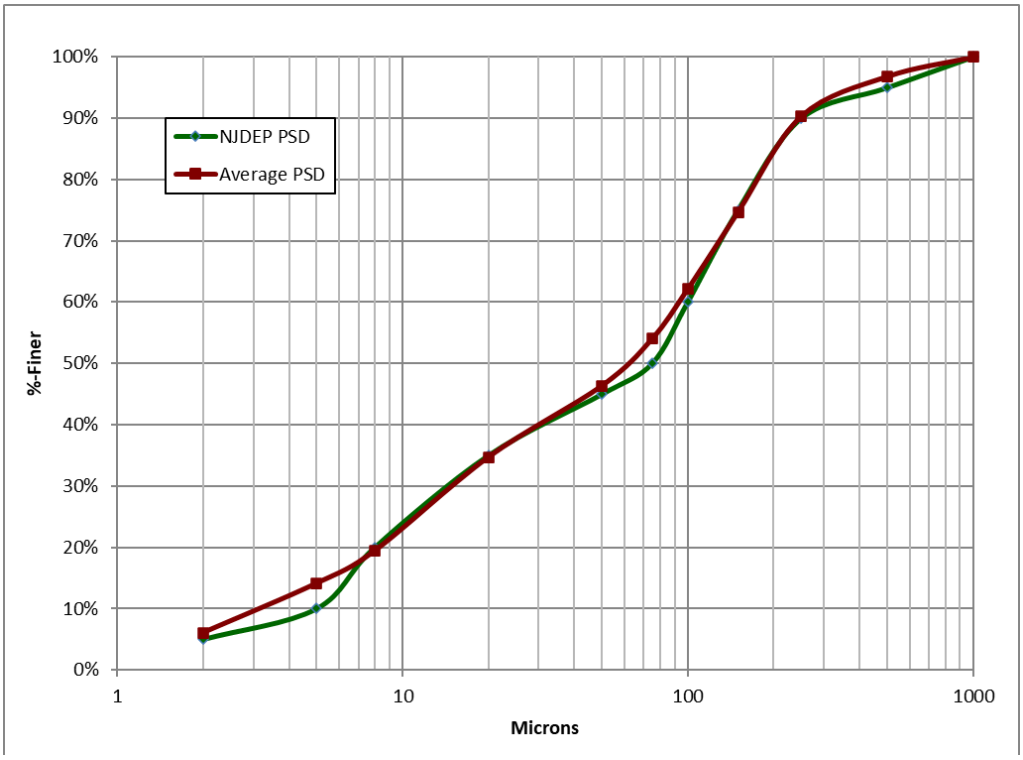

Table 2 – Removal efficiency summary (Source: Alden Report No.: 1182HF2i-R1)

Run #	Average Influent Concentration	Average Adjusted Effluent Concentration	Average Adjusted Drawdown Concentration	Influent Volume	Effluent Volume	Drawdown Volume	Removal Efficiency	Cumulative Average
	mg/L	mg/L	mg/L	L	L	L		
1	203	27.6	19.3	3353	3253	100	**86.5%**	**86.5%**
2	202	28.8	16.6	3350	3238	113	**86.0%**	**86.2%**
3	202	31.4	23.1	3352	3226	126	**84.6%**	**85.7%**
4	200	46.4	21.7	3364	3229	135	**77.3%**	**83.6%**
5	203	35.1	22.0	3360	3216	144	**83.0%**	**83.5%**
6	200	24.2	13.9	3361	3211	150	**88.1%**	**84.2%**
7	202	22.9	16.5	3356	3199	157	**88.8%**	**84.9%**
8	202	30.7	22.6	3357	3193	164	**85.0%**	**84.9%**
9	203	33.0	17.6	3547	3375	171	**84.1%**	**84.8%**
10	200	24.7	15.6	3548	3369	178	**87.9%**	**85.1%**
11	203	24.7	15.8	3538	3356	182	**88.0%**	**85.4%**
12	201	26.8	21.0	3561	3374	187	**86.8%**	**85.5%**
13	202	35.7	17.9	3543	3351	192	**82.8%**	**85.3%**
14	203	31.0	18.2	3545	3348	196	**85.1%**	**85.3%**
15	201	26.2	19.7	3547	3348	199	**87.1%**	**85.4%**
16	202	37.4	19.1	3554	3349	205	**82.0%**	**85.2%**
17	202	27.6	13.8	3557	3351	206	**86.7%**	**85.3%**
18	201	27.5	22.4	3553	3342	211	**86.5%**	**85.3%**
19	202	32.6	18.0	3545	3333	212	**84.3%**	**85.3%**
20	202	27.4	23.7	3548	3333	215	**86.5%**	**85.3%**

Scour testing was done after the sediment removal tests based on the sediment collected in the sump. Subsequent tests with and without the scour pads indicated acceptable scour (average TSS <2mg/l) in both cases, suggesting that the anti-scour pads have minimal impact on preventing sediment scour. HydroFilter can be used online based on current regulatory standards as long as the maximum conveyance rate of the drainage system does not exceed the maximum conveyance rate used for scour testing *("New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Filtration Manufactured Treatment Device", NJDEP, 2023*).

Quality Assurance

A number of Quality Assurance (QA)/Quality Control (QC) measures are documented in the *"New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Filtration Manufactured Treatment Device, January 25, 2013"* to ensure results are accurate and precise, and that tests conducted by multiple vendors of the same category of technology are employing the same test method. The QA/QC measures include the use of certified laboratories, established test methods, calibration of equipment, tolerance limits for results variation, data checks during testing, and stringent documentation requirements.

The verifier, the CAWT, has confirmed that quality assurance requirements were addressed throughout the HydroFilter performance testing process and in the generation of performance test results. This includes reviewing all data sheets and data downloads, as well as overall management of the test system, quality control and data integrity. QA/QC parameters reviewed and validated by the verifier are summarized in Table 3, including the acceptance criteria for particle size distribution, solids concentration in test water, water temperature, flow measurement equipment, flow rate variation, head measurement equipment, sediment feed, sediment moisture content, and sample analysis.

Table 3 - Validation of QA/QC Procedures

QC Parameter	Acceptance Criteria
Particle Size Distribution	Analyzed by a certified laboratory (GeoTesting Express) in accordance with ASTM D422-63(2007)e1. The particle size utilized for testing was the NJDEP particle size distribution (Table 1). The allowable tolerance of 2% variation from the specified PSD curve was met at each discrete particle size tested and the d50 was finer than 75 µm.
Solids concentration in test water	Total suspended solids (TSS) concentration of test water (background TSS) of less than 20 mg/L. TSS analyzed in accordance with ASTM: D3977-97 (re-approval 2019).
Water temperature	Temperature of water less than 26.7ºC (80ºF)
Flow measurement equipment	Equipment calibration reports submitted to confirm that reported flow rate match actual flow rate. Flow rates from calibrated flow instruments recorded at no longer than 60 second intervals over the duration of the test.
Head measurement equipment	The water level recorded at a minimum of five-minute intervals. The minimum tolerance of the standpipe was within +/- 0.125 inches (0.32 cm).

Sediment feed	TSS concentration target = 200 mg/L with a tolerance limit of ±20 mg/L. The allowed Coefficient of Variance (COV) for the measured samples was 0.10.
Sediment moisture content	Determined by ASTM D4959-07 *"Standard Test Method for Determination of Water (Moisture) Content of Soil by Direct Heating".*
Sample analysis	Conducted by qualified laboratories using standard methods and meeting the requirements of ISO.

9. Verification Summary

In summary, the HydroFilter HF2i is a viable technology that, when sized appropriately, can be used to filter sediment from stormwater runoff.

Verification of performance claims for the Hydroworks HydroFilter was conducted by the CAWT based on independent third-party performance test results provided by Alden Research Laboratory, as well as additional information provided by Hydroworks on the operation of the technology. The verification follows the requirements outlined in the HydroFilter Verification Plan, which is based on the ISO 14034 ETV standard. The verified performance claims are provided in Table 4.

Table 4 - Verified Performance Claims for the HydroFilter HF2i

Parameter	Verified Claim	Accuracy
Sediment Removal	During the sediment removal efficiency test, the HydroFilter HF2i (two-cartridge 'dry' filter system) removed at least 84.6% of cumulative TSS, based on a 95% confidence level, with a particle size distribution of 1-1000 µm and an inlet test sediment concentration of 200 mg/L at a flow rate of 1.58 L/s (0.79 L/s per cartridge) based on 20 runs performed under controlled conditions during laboratory testing.	Sediment removal characteristics were quantified at the maximum treatment flow rate (MTFR) of 25 gallons per minute (gpm) (94.6 liters per minute (lpm)), with a particle size distribution (PSD) gradation of 1-1000 micron fractions. The target influent total sediment concentration was 200 mg/L (+/-20 mg/L) for all tests. The allowed Coefficient of Variance (COV) for the measured samples was 0.10. The temperature of the supply water was below 26.7 °C (80 °F). Five (5) time-stamped effluent samples and three (3) background samples of the supply water were collected from the end of the outlet pipe during each run. At the conclusion of each run, two (2) volume-based evenly-spaced effluent samples were collected from the pipe during drawdown. Collected samples were analyzed for Total Suspended Solids (TSS) concentration. The average cumulative TSS removal efficiencies were calculated using the injected influent sediment concentrations. Performance testing of the Hydroworks HydroFilter HF2i by Alden Laboratories was based on a "dry" filter, where the discharge point is below the cartridges such that it operates without the benefit of pre-treatment in a permanent pool. This differs from the "wet" configuration, which uses a weir wall to create a pre-treatment pool around the cartridges and allows for discharge above the cartridges by the head differential created by the weir wall.

Maximum Treatment Flow Rate (MTFR)	The HydroFilter two cartridge filter system has an MTFR of 25 gpm (0.06 cfs, 94.6 lpm) and an effective filtration treatment area (EFTA) of 12.57 ft^2 (1.17 m^2) (loading rate = 2.0 gpm/ft^2, 81.5 lpm/m^2).	Flow rates from calibrated flow instruments were recorded at no longer than 60 second intervals over the duration of the test. Instrument calibration reports were submitted with the final technical report. The accuracy of the flow measurement is ±1%.
Hydraulic Losses	The maximum driving head, which was recorded at the end of run 20, was 1.96 ft (60 cm), which correlates to 0.08 ft (2.4 cm) below bypass.	Accuracy of the readings was 0.3 mm.

What is ISO 14034?

The purpose of environmental technology verification is to provide a credible and impartial account of the performance of environmental technologies. Environmental technology verification is based on a number of principles to ensure that verifications are performed and reported accurately, clearly, unambiguously and objectively. The International Organization for Standardization (ISO) standard for environmental technology verification (ETV) is ISO 14034, which was published in November 2016.

Benefits of ETV

ETV contributes to protection and conservation of the environment by promoting and facilitating market uptake of innovative environmental technologies, especially those that perform better than relevant alternatives. ETV is particularly applicable to those environmental technologies whose innovative features or performance cannot be fully assessed using existing standards. Through the provision of objective evidence, ETV provides an independent and impartial confirmation of the performance of an environmental technology based on reliable test data. ETV aims to strengthen the credibility of new, innovative technologies by supporting informed decision-making among interested parties.

For more information on the HydroFilter technology, contact:	For more information on VerifiGlobal, contact:
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Signed for Hydroworks: Graham Bryant Owner	Signed for VerifiGlobal: Thomas Bruun Managing Director John Neate Managing Director

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