Attachment 1

Manufactured Treatment Device (MTD) Registration

1. **Manufactured Treatment Device Name:** First Defense®
2. **Company Name:** Hydro International
   Mailing Address: **94 Hutchins Drive**
   City: **Portland**
   State: **Maine** Zip: **04102**

3. **Contact Name (**to whom questions should be addressed): **Lisa Lemont, CPSWQ**
   Mailing Address: **94 Hutchins Drive**
   City: **Portland**
   State: Maine Zip: **04102**
   Phone number: **207 756 6200**
   Fax number: **207 756 6212**
   E-mail address: **llemont@hydro-int.com**
   Web address: **www.hydro-int.com**

4. **Technology**
   Specific size/capacity of MTD assessed (include units):

Table 1 – First Defense® Model Sizes

First Defense Model Number	Diameter	TSS Treatment Flow Rates	Peak Recommended Internal Bypass Flow Rate
	(ft)	(cfs)	(cfs)
FD-4	4	0.7	6.0
FD-4HC	4		15.0
FD-6	6	2.2	18.0
FD-6DB	6		25.0

Range of drainage areas served by MTD (acres):
The First Defense treatment performance is dependent upon flow rate. Therefore, when sized appropriately there is no upper limit on the drainage area served by the First Defense as long as the water quality runoff rate from the drainage area is within the 80% TSS Flow Rate shown in the table above.

Include sizing chart or describe sizing criteria:
The First Defense® is a vortex separator that operates on the combined principles of Stokes Law for particle settling and Centrifugal Force. Sizing criteria is dependent upon:

1) Flow rate (flow rate determines residence time within the device, and residence time determines the time particles have to settle out)
2) Particle settling velocity (which, in stormwater, is most influenced by particle size and particle density).

The First Defense sizing was shown above in Table 1.

Intended application: on-line or offline:
The First Defense is designed for online use. It accommodates large pipe sizes and incorporates an internal bypass that conveys high peak flows above the main treatment chamber. The First Defense has been independently verified to prevent washout of previously captured pollutants at flow rates exceeding 200% of its treatment flow rate.

Media used (if applicable): N/A

5. **Warranty Information** (describe, or provide web address)**:**

Hydro International warrants all of its products to be free from defects in materials and workmanship; and will replace, repair, or reimburse at its discretion any part or parts which, after Hydro's examination, Hydro shall have determined to have failed under normal use and service by the original user within two years following initial installation. Such repair or replacement shall be free of charge for all items except for (i) those items that are consumable and normally replaced during maintenance, (ii) labor costs incurred by Hydro to obtain access to the part or unit for repair or replacement, (iii) any costs to repair or replace any surface treatment / cover after repair or replacement or (iv) other charges that Hydro may incur incident to such repair or replacement. Repair or replacement of such consumable items shall be subject to assessment of a pro-rated charge based upon Hydro International's estimate of the percentage of normal service life realized by the item. Hydro International's obligation under this Warranty is conditioned upon (a) its receiving prompt notice of claimed defects which shall in no event be later than thirty (30) days following expiration of the above warranty period and (b) owner of the product properly operating, inspecting, maintaining and caring for the product and is limited to repair or replacement as aforesaid. Purchaser agrees that the foregoing warranty is Purchaser's sole remedy under any legal theory whether pleaded in contract, tort, or otherwise.

6. **Treatment Type**

X Hydrodynamic Structure
☐ Filtering Structure
☐ Manufactured Bioretention System
Provide Infiltration Rate (in/hr):
☐ Other (describe):

7. **Water Quality Treatment Mechanisms** (check all that apply)

X Sedimentation/settling
☐ Infiltration
☐ Filtration with media
☐ Adsorption/cation exchange
☐ Chelating/precipitation
☐ Chemical treatment
☐ Biological uptake

☐ Other (describe):

8. Performance Testing and Certification (check all that apply):

Performance Claim (include removal efficiencies for treated pollutants, flow criteria, drainage area):

- The First Defense® will remove at least 20% Total Phosphorus when sized to capture 80% of Total Suspended Solids with a particle size of 106 micron (i.e., OK-110 silica sand gradation) from stormwater runoff at the following treatment flow rates:

Table 2 – First Defense® Treatment Flow Rates

First Defense Model Size	FD-4	FD-4HC	FD-6	FD-6DB
80% TSS Flow Rate (d50=106 micron)	0.7 cfs	0.7 cfs	2.2 cfs	2.2 cfs
Peak Recommended Online Flow Rate	6.0 cfs	15.0 cfs	18.0 cfs	25.0 cfs

Specific size/Capacity of MTD assessed:
A 4-ft First Defense model has been tested numerous times. Two of these independent reports are enclosed with this submission:

1) 4-ft First Defense® laboratory testing for approval to be used as a 60% TSS Stormwater Treatment Device by Maine Department of Environmental Protection. The target 80% treatment flow rate was 0.7 cfs.
2) A 4-ft First Defense® model was also independently verified for washout performance using a protocol based primarily off the NJDEP Protocol for Manufactured Hydrodynamic Sedimentation Devices for Total Suspended Solids Based on Laboratory Analysis, Dated August 5, 2009. The target performance was zero washout at flow rates up to 200% of the maximum treatment flow rate.

Has the MTD been "approved" by an established granting agency, e.g. New Jersey Department of Environmental Protection (NJDEP) , Washington State Department of Ecology, etc.
☐ **No**
X **Yes**;

For each approval, indicate (1) the granting agency, (2) use level if awarded (3) the protocol version under which performance testing occurred (if applicable), and (4) the date of award, and attach award letter.
The First Defense has been reviewed and approved by more than 20 state, city and county regulators across the US. The list below contains examples of First Defense® approvals:

1) Granting Agency – Maine Department of Environmental Protection
    a. Use Level Awarded – The First Defense was granted use as a 60% TSS removal device because it demonstrated greater than 80% TSS/SSC removal at the target flow rate of 0.7 cfs when tested according to the Maine DEP protocol for TSS/SSC removal.

2) Granting Agency – City of Indianapolis, Indiana
    a. Use Level Awarded – 80% TSS Removal
    b. Protocol Under Which Performance Testing Occurred – The City of Indianapolis accepted the independent laboratory testing as per the Maine Department of Environmental Protection protocol, which used OK-110 grade silica sand as the test pollutant
    c. Date of the Award – the First Defense was first approved by the City of Indianapolis in March 2014.

Was an established testing protocol followed?

X **No**

a. To be rated by the MASTEP Program, First Defense® testing for washout was independently witnessed and verified. No single existing protocol would generate the data needed for so the protocol developed and followed was a blended composite of three washout test protocols:
    1. NJDEP's Protocol for Manufactured Hydrodynamic Sedimentation Devices for Total Suspended Solids Based on Laboratory Analysis, Dated August 5, 2009
    2. CONTECH's VortSentry® HS Performance Testing with OK-110, prepared by Heather Treteault (used to obtain MASTEP rating of "2")
    3. City of Knoxville, TN Post-Construction Water Quality Control for Proprietary Flow-Through Best Management Practices (BMPs) testing requirements

(1) Provide name of testing protocol followed, (2) list any protocol deviations:

X **Yes**

    a. The First Defense® was tested according to the Maine Department of Environmental Protection's standard protocol for "OK-110 Sand SSC (TSS) Removal Confirmation". During the testing, there were no deviations from the protocol.

Provide the information below and provide a performance report (attach report):

For lab tests:

i. Summarize the specific settings for each test run (flow rates, run times, loading rates) and performance for each run:

ME DEP Testing: For the Maine DEP test, the goal was to verify that the First Defense® would achieve at least 80% removal of OK-110 grade sand at a flow rate of 0.7 cfs. Six paired influent and effluent samples were taken. The first influent sample was taken three residence times after the slurry/flow feed into the First Defense was started. The first effluent sample was taken 1 residence time after the first influent sample. The remaining influent and effluent samples were taken in pairs at one minute intervals.

Table 3 – First Defense® Performance Results for ME DEP Testing with OK-110 Sand

Test Run	Flow Rate (cfs)	Influent TSS (mg/L)	Effluent TSS (mg/L)	Removal Efficiency (%)
1	0.61	299.8	13.7	95.4
2	0.73	268.6	16.8	93.7
3	0.67	189.1	12.6	93.3
4	0.66	279.1	15.8	94.3
5	0.58	291.1	17.3	94.1
6	0.63	267.2	15.8	94.1
Mean	0.65	265.5	15.3	94.2

Washout Testing: Two flow rates were tested to verify washout performance – 0.88 cfs, which represents 125% of the 4-ft First Defense maximum treatment flow rate, and 1.4 cfs, which represents 200% of the maximum treatment flow rate. The sump of the First Defense was pre-loaded to 50% capacity with sediment. The protocol did not call for effluent samples to be taken. Instead, the depth of sediment in the sump was measured in 13 locations across the sump area after each test run. If sump depth measurements were within 90% of their original depth, it was deemed that no washout occurred.

Table 4 – First Defense® Washout Performance Results

Test Run	Length of Test Run (min)	% of Sump Pre-loaded with Sediment	Flow Rate (cfs)	% MTFR	Washout Indicated by Sediment Depth Measurements?
1	15	50%	0.88 cfs	125%	No
2	15	50%	1.4 cfs	200%	No

ii. If a synthetic sediment product was used, include information about the particle size distribution of the test material:

Both the ME DEP TSS/SSC Removal Testing and the Washout testing used OK-110 grade silica sand from U.S. Silica as the test sediment. The gradation of OK-110 is shown in Table 5.

Table 5 – OK-110 Silica Sand Particle Size Gradation

OK-110 Particle Size Distribution	
Micron	% Finer
212	99.8%
150	98.8%
125	83.8%
105	43.0%
88	18.0%
75	3.0%
53	0.0%

If less than full-scale setup was tested, describe the ratio of that tested to the full-scale MTD:

A full scale commercially available 4-ft First Defense model was used for all testing.

For field tests:

i. Provide the address, average annual rainfall and characterized rainfall pattern, and the average annual number of storms for the field-test location:

N/A

ii. Provide the total contributing drainage area for the test site, percent of impervious area in the drainage area, and percentages of land uses within the drainage area (acres):

N/A

iii. Describe pretreatment, bypass conditions, or other special circumstances at the test site:

N/A

iv. Provide the number of storms monitored and describe the monitored storm events (amount of precipitation, duration, etc.):

N/A

v. Describe whether or not monitoring examined seasonal variation in MTD performance:

N/A

vi. If particle size distribution was determined for monitored runoff and/or sediment collected by the MTD, provide this information:

N/A

9. MTD History:

How long has this specific model/design been on the market?

The First Defense (FD-4, FD-6 and FD-6DB) models have been on the market in the US since 2005. The First Defense-4HC has been on the market in the US since March 2014.

List no more than three locations where the assessed model size(s) has/have been installed in Virginia. If applicable, provide permitting authority. If known, provide latitude & longitude:

1) Carroll County High School, Hillsville, VA. Permitter Unknown. Lat/Long. Unknown.
2) Episcopal High School, Alexandria, VA. Permitter Unknown. Lat/Long. Unknown.
3) Hoadly Road Car Wash, Manassas, VA. Permitter Unknown. Lat/Long. Unknown.

List no more than three locations where the assessed model size(s) has/have been installed outside of Virginia. If applicable, provide permitting authority. If known, provide latitude & longitude:

1) University of North Carolina Student & Academic Services Building, Chapel Hill, NC. Permitter was City of Chapel Hill. Lat/Long. Unknown.
2) Adventure World – Six Flags America, Mitchellville, MD. Permitter Unknown. Lat/Long Unknown.
3) Ganesvoort Elementary School, Rome, NY. Permitter Unknown. Lat/Long. Unknown.

10. Maintenance:

What is the generic inspection and maintenance plan/procedure? (attach necessary documents):

The generic inspection procedures include:

- Lifting the manhole lid(s) to inspect for visual damage and gauge floatable trash accumulation rate
- Measuring pollutant accumulation rate in the sediment storage sump using a Sludge-Judge® or similar sludge measuring device

The generic maintenance procedures include:

- Either vactoring out floatable trash or skimming out floatable trash with a skimming net and pole
- Vactoring sediment from the sump
- Disposing of removed pollutants as required per local ordinance

Refer to the enclosed First Defense Operation & Maintenance Manual for additional details and step-by-step instructions.

Is there a maintenance track record/history that can be documented?

X No, no track record.

☐ Yes, track record exists; (provide maintenance track record, location, and sizing of three to five MTDs installed in Virginia [preferred] or elsewhere):

NOTE: Unlike Hydro International's Up-Flo Filter stormwater treatment device, the First Defense requires no spare or replacement parts to be purchased from Hydro International for maintenance. Hydro International currently does not offer maintenance contracts. Therefore, maintenance on First Defense devices in Virginia is contracted by the owner to a local partner without involvement from Hydro International. For that reason, Hydro International does not have a track record of First Defense maintenance in Virginia.

Recognizing that maintenance is an integral function of the MTD, provide the following: amount of runoff treated, the water quality of the runoff, and what is the expected maintenance frequency for this MTD in Virginia, per year?

For a typical commercial site with average stormwater runoff TSS concentrations ranging from 80 to 160 mg/L, Hydro International will recommend that First Defense units are maintained once per year in Virginia.

Total life expectancy of MTD when properly operated in Virginia and, if relevant, life expectancy of media:
When installed and operated properly, the life expectancy of the First Defense is in line with a 75-year design life due to suitability of precast concrete, rotationally molded PEX and stainless steel hardware fittings for a stormwater drainage environment.

For media or amendments functioning based on cation exchange or adsorption, how long will the media last before breakthrough (indicator capacity is nearly reached) occurs?
N/A

For media or amendments functioning based on cation exchange or adsorption, how has the longevity of the media or amendments been quantified prior to breakthrough (attach necessary performance data or documents)?
N/A

Is the maintenance procedure and/or are materials/components proprietary?
☐ Yes, proprietary
X No, not proprietary

Maintenance complexity (check all that apply):
☐ Confined space training required for maintenance
X Liquid pumping and transportation
Specify method:
Vactor truck removal of accumulated oil and standing water in sump; transportation to disposal location
X Solids removal and disposal
Specify method:
Vactor truck removal of sediment in sump; removal of floatable trash by either vactor truck or by hand with skimming pole.
Other noteworthy maintenance parameter (describe):

11. Comments

Include any additional explanations or comments:
As was discussed in Hydro International's submission to VDEQ for our Downstream Defender® vortex separator, a study by leading stormwater researchers (Morquecho, et al., 2005) showed a strong association between the removal of very fine Total Suspended Solids (TSS) with the removal of a broad range of secondary constituents. These findings were confirmed and expanded in a 2005-2006 study conducted by the University of Alabama, in which Total Phosphorus was shown to be most highly associated with solids <75 micron (3580 mg TP per kg of solids) and 75 to 150 microns (1620 mg TP per kg of solids) (Pitt & Khambhammettu, 2006).

The studies by Morquecho et al. (2005) and Pitt & Khambhammettu (2006) concluded that a reduction of particulate matter will lead to a reduction of Total Phosphorus.

The particle size bands studied by Pitt & Khambhammettu (Table 6) correlate closely with the cut points of OK-110 grade silica sand (shown previously in Table 5), a test material with which the First Defense® performance has been well characterized.

Table 6 – Reported associations of TP with various solids particle size bands (Pitt & Khambhammettu, 2006)

Particle Size Range (micron)	Concentration of TP (mg/kg)
< 75	3580
75 – 150	1620
150 – 250	511
250 – 425	315
425 – 850	496
850 - 2000	854
2000 – 4750	1400
> 4750	1700

The 4-ft First Defense® was shown to remove 80% of OK-110 grade material at a flow rate of 0.7 cfs. OK-110 has 98.8% of material between 212 and 53 microns, with only 3% of material below 75 microns. Conservatively assuming that it was the coarsest fraction of OK-110 that was removed by the First Defense, it can be assumed that the First Defense removed 100% of OK-110 material down to 90 microns. Table 7 shows an estimation of associated TP that the First Defense would remove by virtue of removing 100% of OK-110 grade material down to 90 microns can be calculated given 1 kg of OK-110 material and 100% removal at 1.56 cfs down to 90 microns.

Table 7 – Calculation of TP removal by the First Defense® given 80% OK-110 Removal

Particle Size Range (micron)	Mass TSS In (kg)	Mass TSS Captured (kg)	Mass of TP In (mg)	Mass of TP Captured (kg)
> 212	0	0	0	0
150 – 212	0.012	0.012	= 0.012 kg * 511mg/kg = 6.312	6.312 mg
90 – 150	0.788	0.788	= 0.788 kg * 1620 mg/kg = 1277 mg	1277 mg
75 – 90	0.17	0	= 0.17 kg * 1620 mg/kg = 275.4 mg	0 mg
< 75	0.03	0	= 0.03 kg * 3580 mg/kg = 107.4 mg	0 mg
		Total	1666 mg	1283 mg
		TP Removal Efficiency		77%

Because a multitude of research has shown that large fraction of fine material (<75 micron) is present in stormwater runoff, Hydro International is not claiming that the First Defense® will remove 77% of TP from all stormwater runoff. However, we believe that the device's demonstrated sediment removal performance, coupled with industry literature showing the association of TP with various particle size ranges, supports the use of the First Defense for 20% TP removal in Virginia.

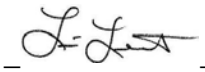
References:

1. Morquecho, R., R. Pitt, S. Clark. Pollutant Associations with Particulates in Stormwater. World Water & Environmental Resources Contress, ASCE/EWRI. Anchorage, Alaska. May 15 – 19, 2005. January 2005.
2. Pitt, R., & Khambhammettu, U. (2006). Field Verification Report for the Up-Flo™ Filter. Small Business Innovative Research, Phase 2 (SBIR2) Report. U.S. Environmental Protection Agency.

12. Certification

Signed by the company president or responsible officer of the organization:

"I certify that all information submitted is to the best of my knowledge and belief true, accurate, and complete."

Signature: _  _____

Name: _Lisa Lemont, CPSWQ_____

Title: __Business Development Manager_____

Date: __August 27,2014_____

NOTE: All information submitted to the department will be made publically accessible to all interested parties. This MTD registration form will be posted on the Virginia Stormwater BMP Clearinghouse website.