Technical Abstract
Downstream Defender®

Performance Verification of Fine Sediment Removal with US Silica OK-110

The Downstream Defender® is an advanced Hydrodynamic Vortex Separator intended for removing the bulk of the pollutant load from urban stormwater runoff. Flow modifying internal components (Fig.1) differentiate the Downstream Defender® from conventional gravity-based and other vortex separators. These internals are designed to facilitate high-rate separation of pollutants and minimize turbulence. The design also ensures that bypassing is prevented and the entire flow is treated. Compared to devices that have poorly designed internal components and/or an internal bypass that discharges a portion of flow with no treatment, the Downstream Defender® captures and retains more of the annual pollutant load.

Capable of providing high pollutant removals for a wide range of flow rates with minimal headlosses, the Downstream Defender® is an economical solution for constrained sites. Its proven efficiency ensures the longevity and simplifies the maintenance of subsurface storage, infiltration and filtration practices.

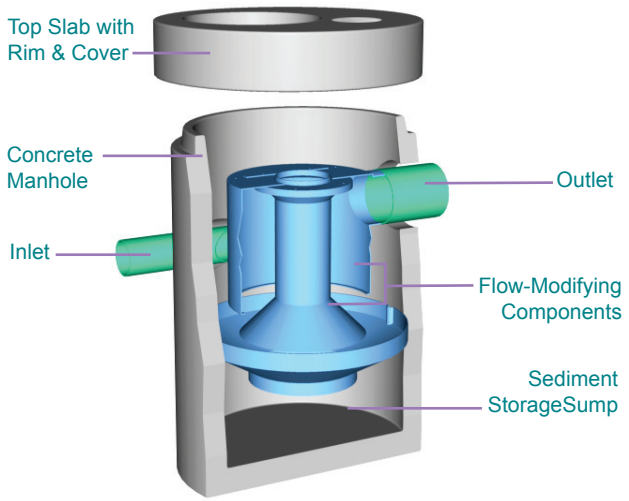

Fig.1 The unique internal components of the Downsream Defender® enhance pollutant removal performance and prevent washout.

Fine Sediment Removal

To quantify the pollutant removal efficacy, a full-scale 4-ft diameter Downstream Defender® was tested under controlled laboratory conditions. Test procedures were based on protocols used for regulatory approval throughout North America.

Commercially available U.S. Silica brand OK-110 (Fig.2) was used to determine the Downstream Defender® treatment loading rate that achieves an 80%-removal efficiency goal. OK-110 has a fine gradation primarily in the 75-150 micron range with a mean of 106-micron. Because about 20% of the particles are between 50-75 micron, use of OK-110 sediment provides a conservative estimate of annual load reductions.

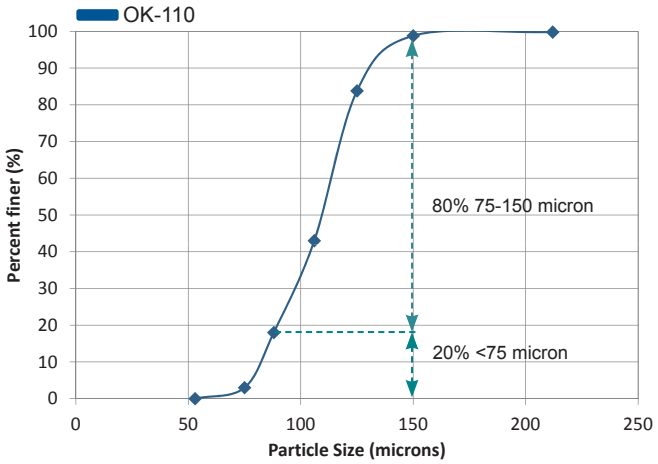

Fig.2 Particle size distribution of the U.S. Silica OK-110 test sediment.

For performance testing, clean water from a 23,000 gal. reservoir was pumped to the Downstream Defender® at flow rates varying from about 0.4 to 2.2 cfs (Fig.3). A concentrated slurry of test sediment was pumped into the inlet pipe at an injection rate that delivered influent concentrations ranging from 200-300 mg/L.

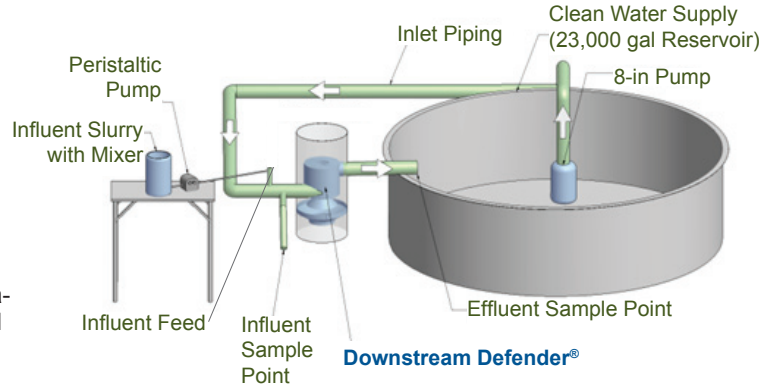

Fig.3 Set-up of the Portland, Maine hydraulic testing facility.

Downstream Defender®

Performance Test Procedures

Five influent and effluent grab samples were taken at 4 different flow rates for a total of 20 samples (Fig.4). All influent and effluent samples were analyzed for Total Suspended Solids (TSS) by APHA SM2540D.

Fig.4 Grab samples were collected from the influent (not pictured) and effluent (above) over a range of hydraulic loading rates.

Performance Results

The resulting test data demonstrates 80% removal of fine sediment for all flows up to 1.56 cfs and 65% efficiency at the highest flow rate tested at 2.2 cfs. As the Downstream Defender® does not incorporate an internal bypass, it will continue to capture sediment at all states of flow up to and including its rated peak treatment flow rate (PTFR). By way of contrast, internally bypassing units will begin to discharge untreated flows as soon as flows exceed their rated treatment flows. For example, tests for the 4-ft Downstream Defender® clearly show continual positive removal efficiencies for flows in excess of its rated treatment flow of 1.56 cfs and positive removals even at its peak rated flow of 3 cfs (Fig.5).

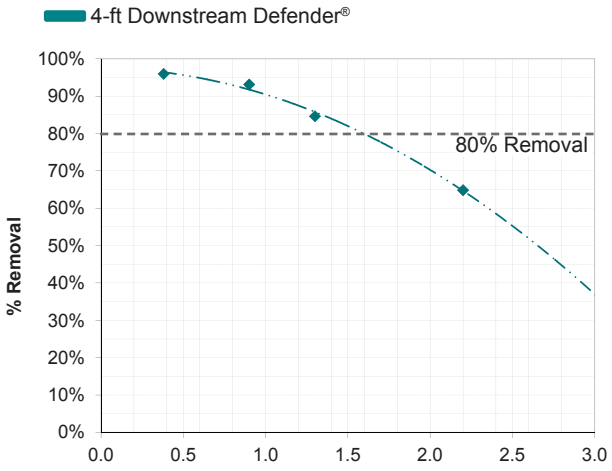

Fig.5 OK-110 silica sand removal efficiency results of the 4-ft Downstream Defender®.

These results confirm the efficacy of the Downstream Defender® for pollutant capture over a wide range of tested flow rates and highlight the benefits of its specially designed internal components that stabilize the flows and prevent bypassing of untreated flow.

Downstream Defender® Sizing

Test results were used to determine the treatment flow rates for larger Downstream Defender® models (see table below). For design purposes, the selected model's Treatment Flow Rate must be greater or equal to the site's Water Quality Flow Rate (WQf).

Model Unit Diameter	Maximum Pipe Diameter	Treatment Flow Rates for 80% TSS Removal	Peak Treatment Flow Rates
(ft)	(in)	(cfs)	(cfs)
4	12	1.56	3.0
6	18	4.25	8.0
8	24	8.82	15.0
10	30	15.42	25.0
12	36	24.32	38.0

The PTFR and maximum pipe size must be considered to determine whether the application of a given Downstream Defender® model is appropriate for the site. An offline configuration or arrangement may be used to overcome constraints presented by the Downstream Defender®'s maximum allowable pipe diameter or PTFR. Contact Hydro International for technical support and design assistance.

Fig.6 Model sizes range from 4-ft to 12-ft in diameter.

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