UP-FLO® FILTER

HYDRAULIC CHARACTERIZATION

EAGLEBY FILTER SAND
LANGWARRIN FILTER SAND

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1.0 INTRODUCTION

Upflow filters are filtration devices that utilize an upward flow path through filtration and absorption media to separate suspended particulate matter and other pollutants out of a liquid. They have been shown to be more efficient than traditional down flow or radial flow filters offering a smaller footprint than down-flow filters because they have a higher flow-through capacity per unit of surface area. Flow in an upward direction counters gravitational forces to fluidize the media allowing the entire depth of the media bed to be utilized.

The Up-Flo® Filter has been designed as a modular filtration system. Each Filter Module has a treatment capacity of up to 1.6 l/s (25 gpm), depending on the filtration media type. Each Filter Module has a surface area of 0.1 m^2 and up to 6 modules can fit into a 1.2 m (4 ft) catch basin (either round or square), for a combined surface area of 0.6 m^2 and treatment flow rate of up to 9.5 l/s (150 gpm). Its unique siphon-activated bypass is capable of discharging up to 116 l/s (4.1 cfs) for a standard 1.2 m diameter manhole.

The principles governing the flow rate through an upflow filter are:

- Height of driving head

- Filtration bed properties
  - Surface area of filtration bed
  - Bed depth

- Media-specific properties
  - Expansion velocity
  - Particle size distribution
  - Density

For an upflow filter with a given media composition, bed depth and driving head, the flow rate through the filter will be proportional to the surface area and head acting on the filtration bed. The flow rate through each Up-Flo® Filter Module depends on the depth of water acting on top of the filter media. Generally, filtration rate increases proportionally to driving head. The standard Up-Flo® Filter is designed with a bypass weir set at 508 mm (20 inches) above the top of the media or 750 mm (29.5 inches) from invert to the bypass weir.

2.0 OBJECTIVES

One of the key attributes of the Up-Flo® Filter is that its filtration media may be customized to target site-specific pollutants. However, different media will have different flow-through capacities. Because the Up-Flo® Filter is most often sized to meet a treatment flow rate, a hydraulic characterization for each media in the Up-Flo® Filter portfolio is required. This testing program evaluated the filtration rate of Eagleby Filter Sand and Langwarrin Filter Sand provided by Rocla Pty Ltd of Australia.

3.0 THE UP-FLO® FILTER TEST FACILITY DESCRIPTION

3.1 LABORATORY SET UP

The Hydro International test facility contains a 23,000-gallon clean water storage reservoir equipped with a Flygt submersible pump to distribute feed water. The 75 mm Flygt pump delivers water to the Up-Flo® Filter through a 75 mm PVC pipe network that freely discharges into the open top of the test tank.

3.2 UP-FLO® FILTER CONFIGURATION

The 1.2 m diameter concrete test tank stands 2.1 m high and houses from one (1) to six (6) Up-Flo® Filter Modules. The test tank has a 300 mm outlet pipe that discharges into a large underflow basin on the floor of the lab. A 50 mm Flygt pump sends water from the underflow basin back into the feed reservoir.

A Catch Basin configuration Up-Flo® Filter equipped with one (1) Filter Module is used for testing. The Filter Module is filled with two (2) Media Bags and latched shut. A schematic of the laboratory set-up can be seen in Appendix A.

3.3 INFLUENT FLOW RATE

The flow rate to the Up-Flo® Filter can be adjusted from 0 - 30 l/s (0 - 450 gpm) using a pinch valve fixed to the delivery pipework.

The chosen influent flow rate will vary with the number of Filter Modules included in the Up-Flo® Filter test tank. The testing takes place under steady-state conditions, where the influent flow rate equals the filtration flow rate. The maximum filtration rate of each Filter Module is dependent on the driving head on the media. For this test, the maximum driving head on the media was 800 mm.

3.4 EFFLUENT MONITORING ARRANGEMENT

The hydraulic monitoring program determines the flow characteristic of the Up-Flo® Filter on a per Filter Module basis. The flow rate of a single module is dependent on the media type. A calibrated V-notch weir is used to determine the flow rate.

A compartmentalized underflow tank is situated next to the test tank. The Up-Flo® Filter outlet pipe discharges directly into one of three 170 gallon (23-cubic foot) compartments. A 4 gallon bin is also kept on hand to use when filtration flows are low to calculate flows based on the time to fill method.

4.0 TESTING PROCEDURE

4.1 MEDIA

Two (2) bags of the filter sand were filled to the required volume and placed into the Up-Flo® Filter Module. The particle size distributions of Eagleby Filter Sand, Langwarrin Filter Sand and Hydro Filter Sand are shown in Figure 1. The gradations range from 300 microns to over 1180 microns. Only a small portion of each media, if any, falls above 1180 microns. D_{50} values for Eagleby Filter Sand and Langwarrin Filter Sand are 820 and 790 microns respectively and both are greater than the 765 microns for the Hydro Filter Sand. Eagleby Filter Sand and Hydro Filter Sand have a small portion of fines less than 600 microns not seen in Langwarrin Filter Sand. Information on the Hydro Filter Sand is added for comparative purposes. The Hydro Filter Sand is one of the media types supplied by Hydro International in the US for removing fine particulates from stormwater runoff.

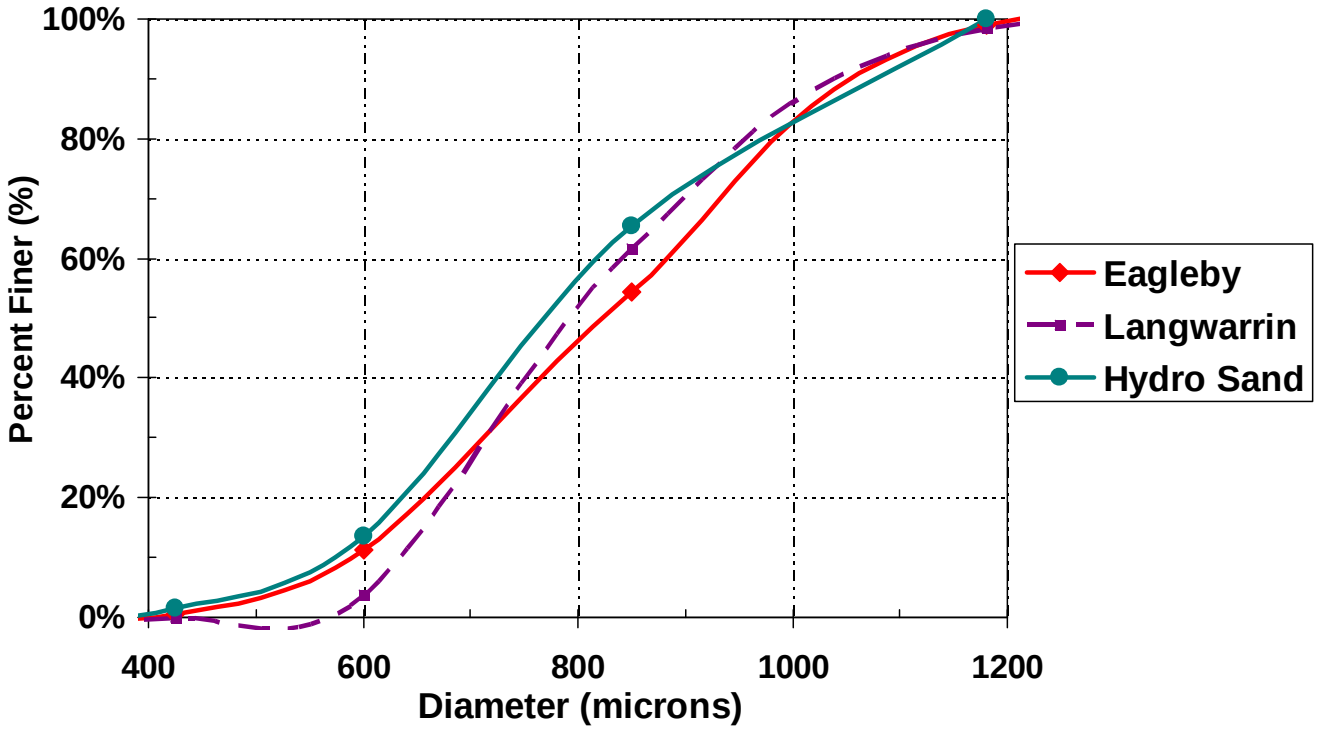


Figure 1 – Particle size distribution of filter sand used as media

4.2 INFLUENT FLOW RATE CALIBRATION

A 75 mm, non-variable Flygt pump delivers flows at a constant rate of 30 l/s (450 gpm). A pinch valve is used to adjust the flow to the desired influent flow rate. The flow rate is calculated using a V-notch weir.

4.3 FILTRATION FLOW RATE MONITORING

The filtration rate is determined by monitoring the effluent flow rate of an Up-Flo® Filter consisting of one (1) Filter Module.

4.3.1 EFFLUENT MONITORING

The following procedure is used:

1. Place two (2) filled media bags in the Filter Module and latch the Filter Module shut.
2. Testing was conducted with a siphon activated filtered Draindown.
3. Start the 75 mm submersible pump and allow it to pump water into the Up-Flo® Filter test tank until there is enough driving head to start pushing water up through the filter.
4. Continue to pump flows into the tank until equilibrium is reached.
5. Allow the water in the underflow collection tank to reach an equilibrium height over the weir.
6. Measure the height over the weir and determine flow from calibration table.
7. Be sure the water head in the test tank remains unchanged which indicates equilibrium has indeed been achieved.

8. Adjust the pinch valve to change the water level 50-125 mm and allow flows to stabilize. Repeat Steps 4-7.

9. Repeat Step 8 for a few more data points to ensure a full head-discharge curve is developed.
10. Stop influent pump. Drain the test unit and prepare to repeat hydraulic characterization.

5.0 RESULTS

The flow rate through Eagleby Filter Sand was determined to be 1.4 l/s at an operating head of 500 mm. The flow rate through Langwarrin Filter Sand was 1.0 l/s at an operating head of 500 mm. The hydraulic characterization curves shown

in Figure 2 confirm that the hydraulic throughput for the Eagleby Filter Sand is higher than the Langwarrin Filter Sand. The equations in Figure 2 can be used to determine the discharge flow rates for a given driving head through the media.

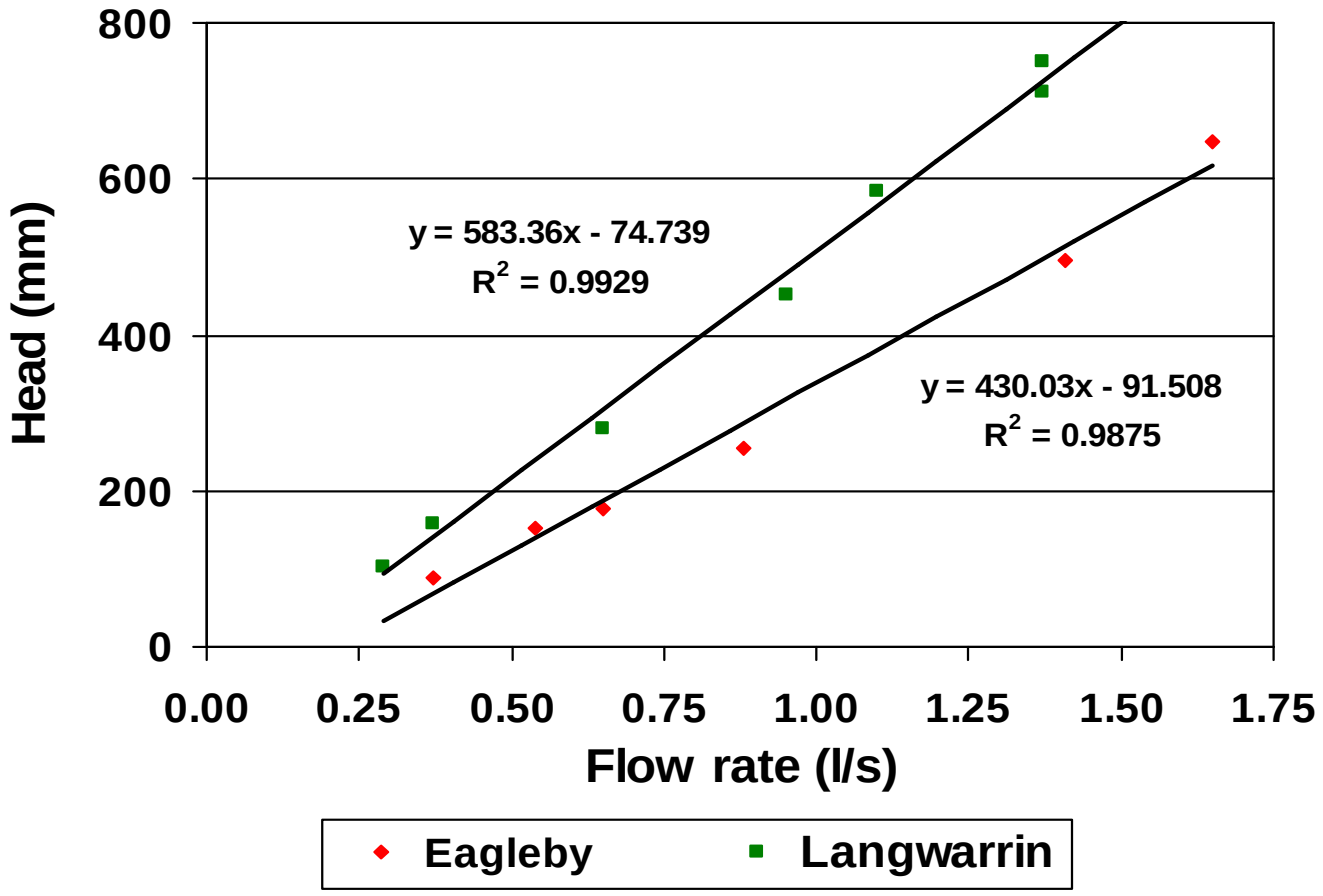


Figure 2 – Head discharge characteristics for filter sands sourced from Rocla Pty Ltd

6.0 BYPASS CAPACITY

The Up-Flo® Filter is equipped with a siphonic bypass designed to discharge flows in excess of the treatment flow. When influent flows exceed the filtration capacity, the water level in the Up-Flo® Filter chamber rises above the height of the internal bypass weir in the outlet chute. If water levels continue to rise, the outlet chute will fill and displace any air, at which time the siphon is activated.

Full-scale hydraulic characterization of the siphonic bypass has been completed. The testing involved the installation of the Up-Flo® Filter's bypass module into a 1.2 m diameter chamber with enough height to discharge up to 4 cfs. The water elevations are minimized as a result of the siphonic actions. Once water begins to flow over the weir, the siphon is activated when there is 800 mm of driving head from the invert of the outlet pipe. This allows a large flow range to be discharged.

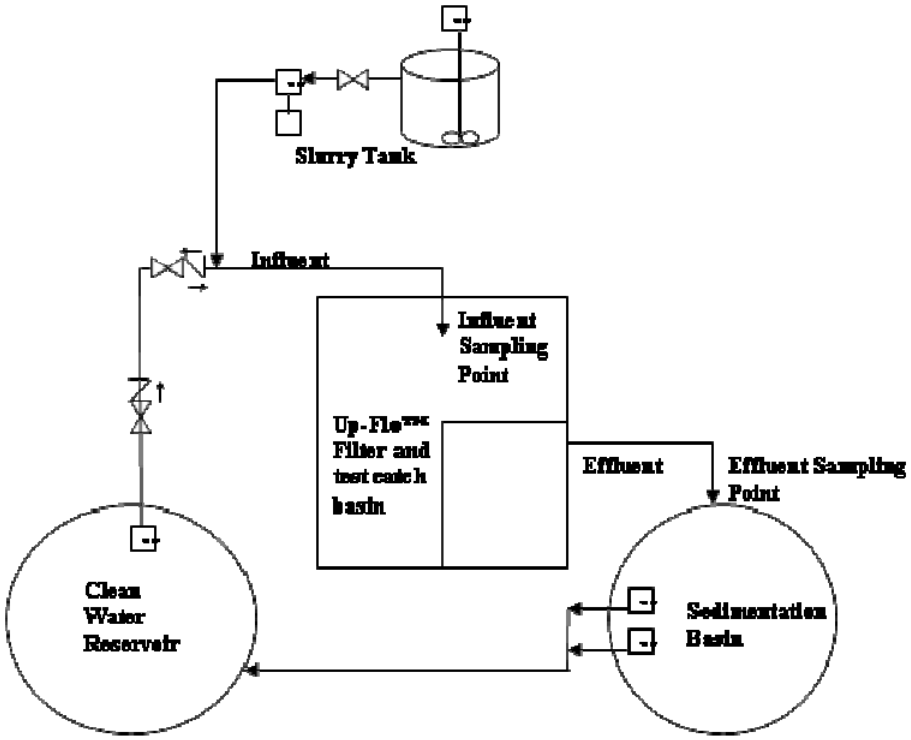
Due to the suction forces generated by the siphonic action, up to 96 l/s can be discharged with a water elevation that does not exceed 860 mm from invert. For flows that exceed 96 l/s, the following expression can be used to determine the water elevation above the invert.

$$h = 1.6(Q)^2 + 4.6(Q)$$

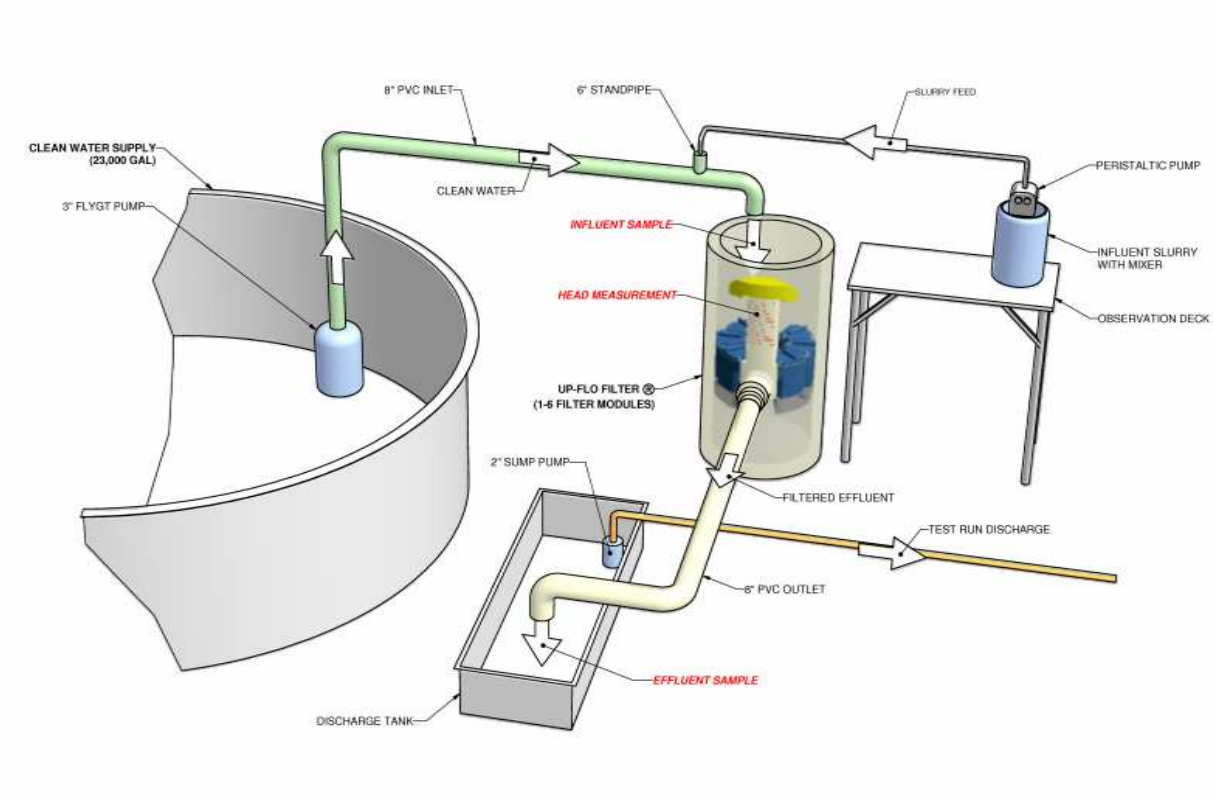
where; Q = flow in cfs
h* = water elevation in inches (measured from the invert of the outlet pipe)

The minimum height of a standard 1.2 m diameter Up-Flo® Filter measured from the invert of the outlet pipe is 1.15 m, which is equivalent to 116 l/s (4.1 cfs). If the storm drain profile allows for more than 1.15 m, additional risers can be supplied to enable a higher water elevation and thus flow through the system.

APPENDIX A - TEST UNIT AND FACILITY DETAILS



Up-Flo® Filter System as tested in the Laboratory



Laboratory Setup

Overhead view showing inlet and outlet piping

Two Filter Modules

Used media bags

Eagleby Filter Sand

Langwarrin Filter Sand