1

Critical Source Area Controls for Stormwater Treatment

2

3

Observed Wet Pond Performance (when constructed and operated according to best guidance)

- Suspended solids: 70 to 95%
- COD: 60 to 70%
- BOD_5: 35 to 70%
- Total Kjeldahl nitrogen: 25 to 60%
- Total phosphorus: 35 to 85%
- Bacteria: 50 to 95%
- Copper: 60 to 95%
- Lead: 60 to 95%
- Zinc: 60 to 95%

4

Wet Detention Pond Advantages

- Very good control of particulate pollutants
- Opportunity to utilize biological processes
  - Protozoa as bacteria predators
  - Aquatic plants enable higher levels of nutrient removal
- Outfall ponds capture and treat all storm sewer discharges
  - Wet weather stormwater runoff
  - Dry weather baseflows
  - Snowmelt
  - Industrial spills
  - Illegal discharges

5

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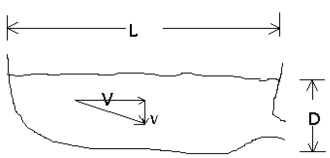
Particulate Settling



$$\frac{V}{v} = \frac{L}{D} \rightarrow v = \frac{Q_{out}}{A}$$

Pages 23-25 of detention pond design.pdf

- Ideal Settling – Particle path is vector sum of particle velocity through pond and settling (upflow) velocity

- L – Pond Length
- D – Outlet Depth
- V – Water Velocity through Pond
- v – Settling Velocity
- Q_{out} – Outflow from Pond
- A – Pond Surface Area

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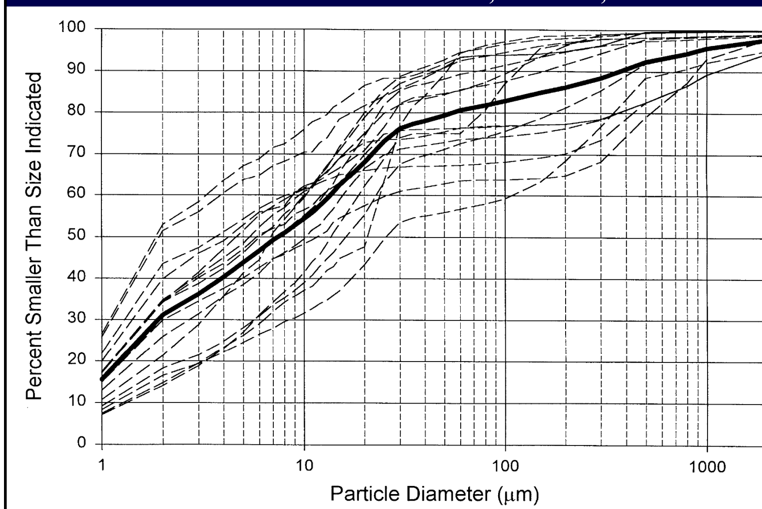
Measured Particle Sizes, Including Bed Load Component, at Monroe St. Detention Pond, Madison, WI



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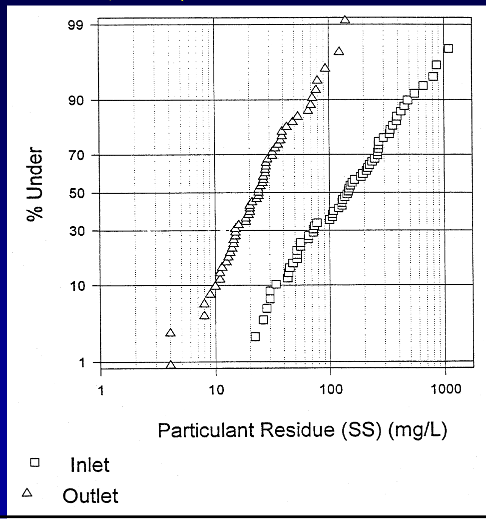
Suspended Solids Control at Monroe St. Detention Pond, Madison, WI (USGS and WI DNR data)



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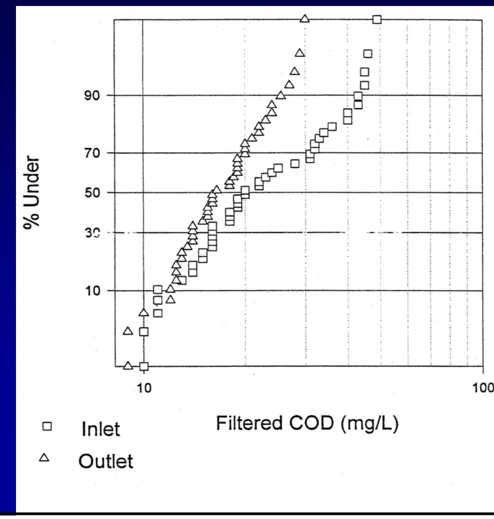
COD Control at Monroe St. Detention Pond, Madison, WI (USGS and WI DNR data)



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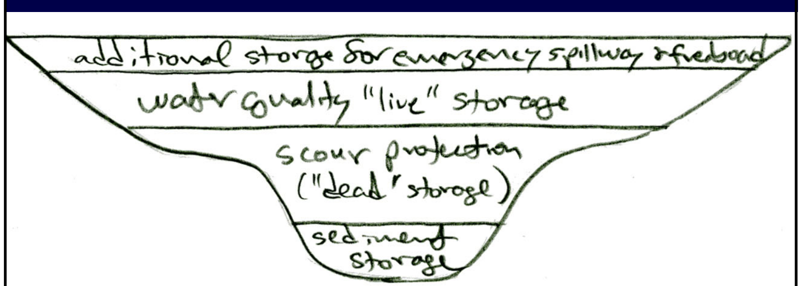

Pond surface areas should be about 3% of the paved area plus about 0.5% of the pervious area.

11

Hydrodynamic Devices

Retro-fitted Catchbasin with Sump Tested at Ocean County, NJ

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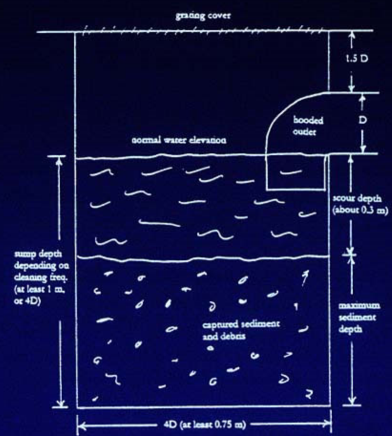
Dimensions of Optimally-Designed Catchbasin



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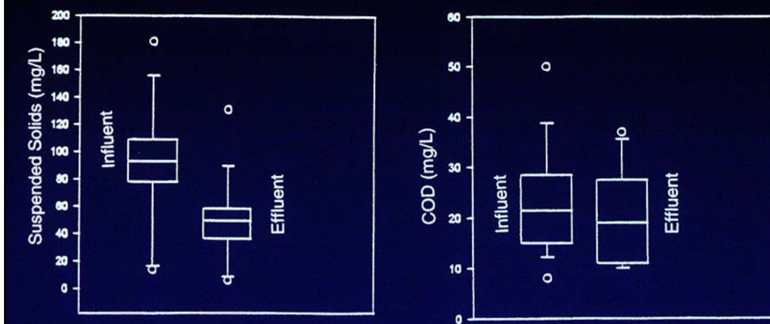
Box Plots - Catchbasin with Sump



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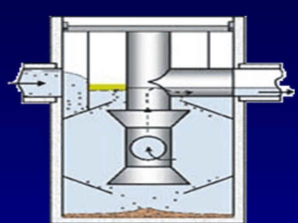
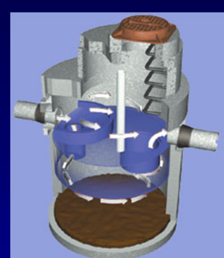
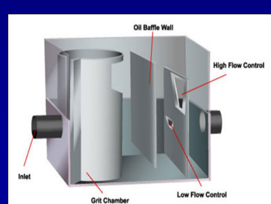
Examples of Proprietary Stormwater Controls Using Settling for Treatment



Downstream Defender



Stormceptor



Vortechs

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TSS Load Reduction Results based on WI DNR and USGS Monitoring

- *TSS Loads, Kg.*

Type of Load	Influent	Effluent	% TSS Reduction
Vortechs (18 events, no bypass)	63	51	19%
Stormceptor (15 events, bypass)	939	895	5%

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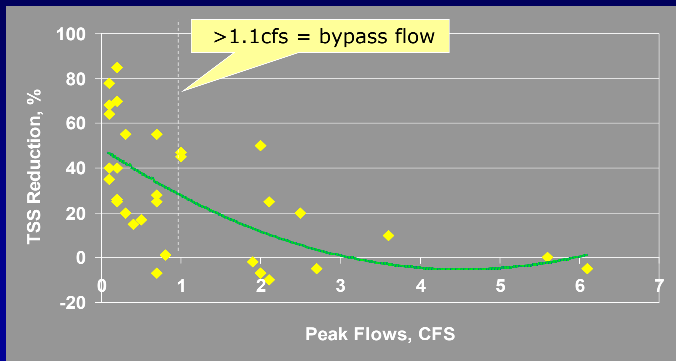
TSS Reduction as a Function of Peak Discharge for the Stormceptor

(includes both treated & bypass water)



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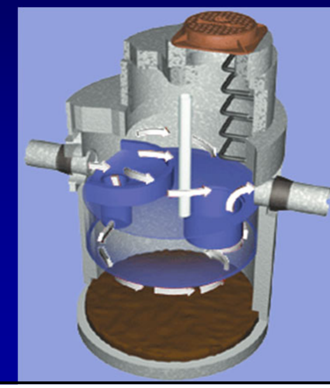
How Big Do We Have to Make Stormceptor to Achieve TSS Performance Standards at Maintenance Yard?

Stormceptor



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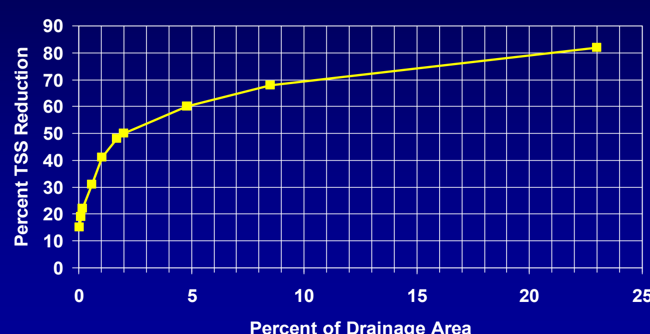
TSS Reductions for Stormceptor using DETPOND (Madison Rain81 and NURP PSD)



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Number of 10' Diameter Stormceptors to Achieve TSS Reduction on a 4.3 acre Site

Percent TSS Reduction	Number of Stormceptors for 4.3 acre Site
10%	1
20%	3
40%	20

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The Multi-Chambered Treatment Train (MCTT)

- The MCTT was developed to control toxicants in stormwater from critical source areas.
- Pilot-scale monitoring indicated median reductions of >90% for toxicity, lead, zinc, and most organic toxicants. Suspended solids were reduced by 83% and COD was reduced by 60%.
- Full-scale installations substantiated, or showed improved reductions.

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- The MCTT most suitable for use at critical source areas, such as vehicle service facilities, industrial storage and equipment yards, convenience store parking areas, vehicle maintenance areas, and salvage yards.
- The MCTT is an underground device and is typically sized between 0.5 to 1.5 percent of the paved drainage area.

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The MCTT is comprised of three main sections:

- an inlet having a conventional catchbasin with litter traps,
- a main settling chamber having lamella plate separators and oil sorbent pillows (and sometimes aeration/dissolved air floatation), and
- a final chamber having a mixed sorbent media (usually peat moss and sand).

Long-term continuous simulations are used to size the unit for specific toxicant reduction goals based on local rain conditions

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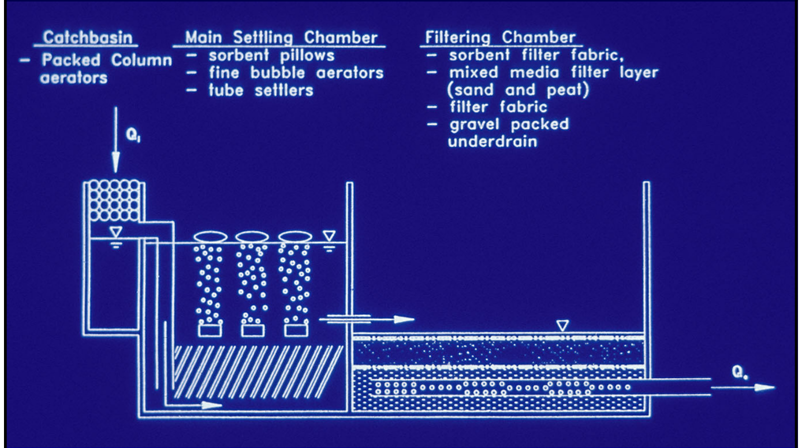
MCTT Cross-Section



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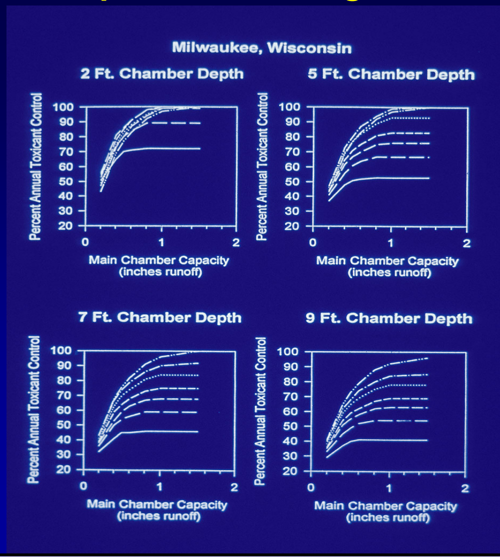
Example MCTT Sizing Curves



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Example MCTT Main Settling Chamber Sizes

- (all 48 hours holding times, except as noted)

City	Annual Rain Depth (in)	Runoff Capacity (in) for 70% Toxicant Control	Runoff Capacity (in) for 90% Toxicant Control
Phoenix, AZ	7	0.25 (24 hours)	0.35
Los Angeles, CA	15	0.30	0.45
Madison, WI	31	0.32	0.52
Buffalo, NY	38	0.35	0.50
Seattle, WA	39	0.25	0.40
Portland, ME	44	0.42	0.72
Birmingham, AL	55	0.37	0.53
New Orleans, LA	60	0.80	0.92

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Milwaukee, WI, Ruby Garage Public Works Maintenance Yard

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Minocqua, WI, MCTT Test Area

- Minocqua MCTT test site is a 1 ha (2.5 acre) newly paved parking lot for a state park and commercial area.
- Located in a grassed area and was a retro-fit installation.
- Installed capital cost was about $95,000 and included the installation of 3.0 m X 4.6 m (10 ft X 15 ft) box culverts used for the main settling chamber (13 m, or 42 ft long) and the filtering chamber (7.3 m, or 24 ft long).
- Costs are about equal to the costs of installation of porous pavement (about $40,000 per acre of pavement).

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Minocqua, WI, MCTT Installation

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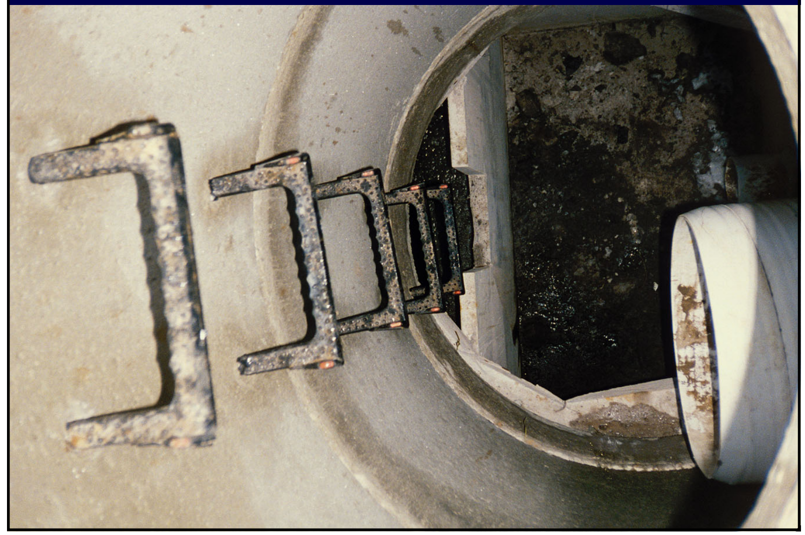
Minocqua, WI, MCTT Inlet Chamber



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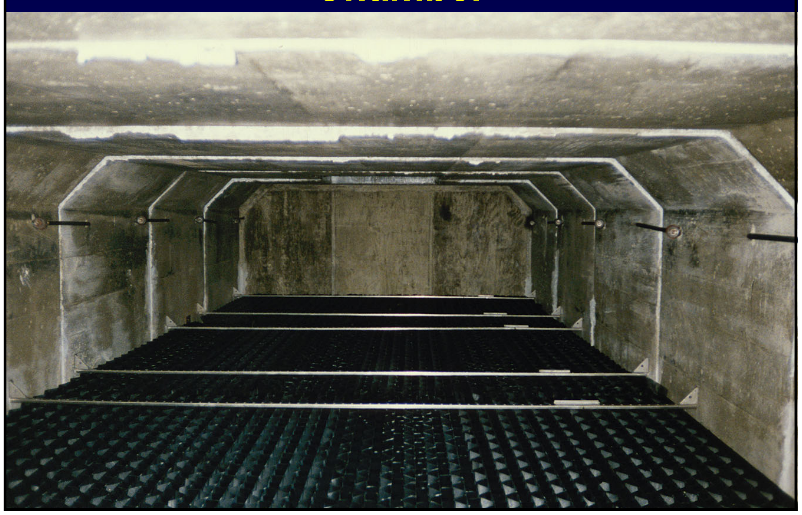
Minocqua, WI, MCTT Sedimentation Chamber



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Minocqua, WI, MCTT Filter Chamber

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Maintenance of MCTT Units

- Major maintenance items for MCTTs include removal of sediment from the sedimentation basin when the accumulation exceeds 150 mm (6 in.) and removing and replacing the filter media about every 3 years.
- After two wet seasons, the total accumulated sediment depth at the Caltrans installations was less than 25 mm (1 in.), indicating that sediment removal may not be needed for about 10 years.

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MCTT Maintenance (cont.)

- The sorbent pillows were replaced annually, or sooner if darkened by oily stains.
- Weekly general inspections were conducted during the wet season for such things as trash removal from the inlet and outlet structures.
- Monthly inspections were also conducted to identify and correct damage to inlet and outlet structures, and to remove graffiti.
- Because the Caltrans MCTT test units were above ground and not initially covered, the permanent pools were available for mosquito breeding. The Via Verde site was finally completely covered with netting to prevent mosquito access.

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Pilot-Scale MCTT Pollutant Control by Chamber for Selected Toxicants

	Main Settling Chamber	Peat/Sand Chamber	Overall Device
Microtox™	18	70	96
Lead	89	38	100
Zinc	39	62	91
Pyrene	100	-	100
Bis (2- ethylhexyl) phthalate	99	-	99

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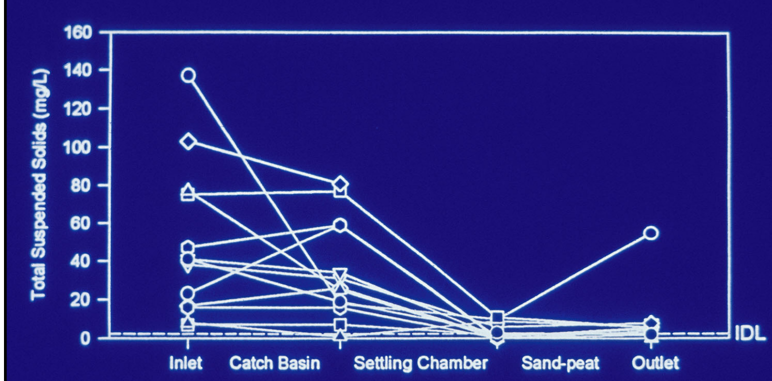
Pilot-Scale Test Results



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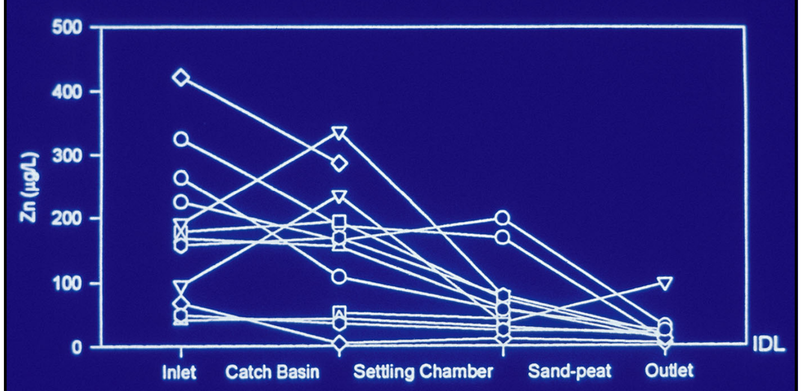
Pilot-Scale Test Results



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Wisconsin Full-Scale MCTT Test Results

(median % reductions and median effluent quality)	Milwaukee (15 events)	Minocqua (7 events)
Suspended Solids	98 (<5 mg/L)	85 (10 mg/L)
Phosphorus	88 (0.02 mg/L)	>80 (<0.1 mg/L)
Copper	90 (3 µg/L)	65 (15 µg/L)
Lead	96 (1.8 µg/L)	nd (<3 µg/L)
Zinc	91 (<20 µg/L)	90 (15 µg/L)
Benzo (b) fluoranthene	>95 (<0.1 µg/L)	>75 <0.1 µg/L)
Phenanthrene	99 (<0.05 µg/L)	>65 (<0.2 µg/L)
Pyrene	98 (<0.05 µg/L)	>75 (<0.2 µg/L)

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Caltrans Full-Scale MCTT Test Results

	Mean % reductions and mean effluent quality
Suspended solids	80 (6 mg/L)
TKN	35 (0.82 mg/L)
Total Phosphorus	39 (0.11 mg/L)
Copper	38 (5 µg/L)
Lead	50 (3 µg/L)
Zinc	85 (13 µg/L)
Total petroleum hydrocarbons	85 (210 µg/L)
Fecal coliforms	82 (171 MPN/100 mL)

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Upflow Filtration

- Multiple treatment processes can be incorporated into stormwater treatment units sized for various applications.
  - Gross solids and floatables control (screening)
  - Capture of fine solids (settling or filtration)
  - Control of targeted dissolved pollutants (sorption/ion exchange)

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Upflow filter insert for catchbasins

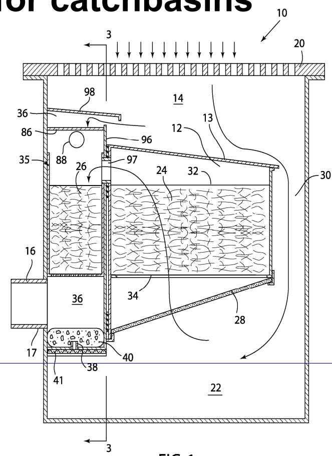


FIG. 1

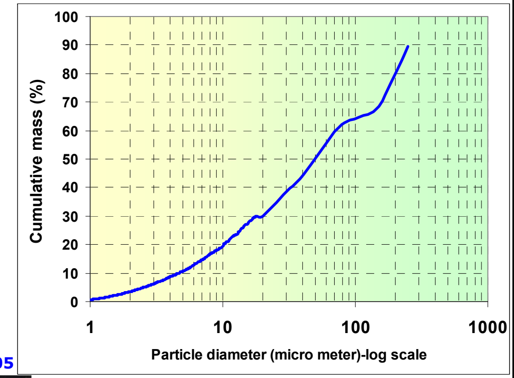
Upflow Filter™ patented

Main features of the MCTT can be used in smaller units.

The Upflow Filter™ uses sedimentation (22), gross solids and floatables screening (28), moderate to fine solids capture (34 and 24), and sorption/ion exchange of targeted pollutants (24 and 26).

Composition of test sediments used to measure repeatability of cone splitter

Test mixture for Dekaport/USGS cone splitter	Amount (g)
Sil Co Sil #105	0.0752
Sil Co Sil #250	0.2408
Sieved Sand (90um-250um)	0.1225
Sieved Sand (300um-425um)	0.0532
Total	0.4917

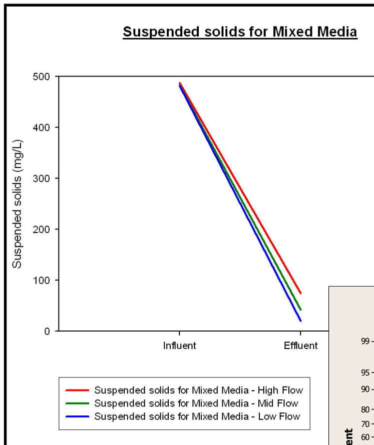


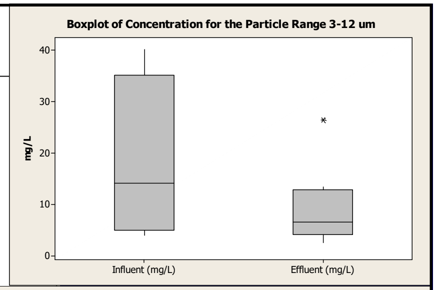
Test solution contained more large particles than normally seen to stress the test.

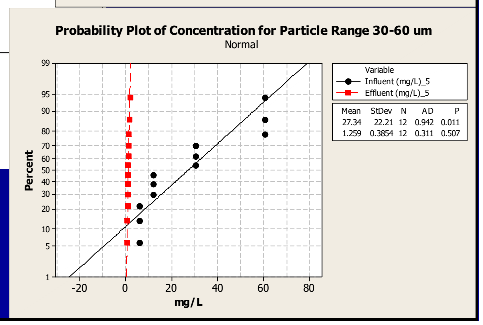
Suspended Solids Removal Tests

Media (each bag)	Flow (gpm)	Influent SS Conc. (mg/L)	Average Effluent SS Conc. (mg/L)	% SS reduc.
Zeo+ Zeo	High (21)	480	75	84
Zeo+ Zeo	Mid (10)	482	36	92
Zeo+ Zeo	Low (6.3)	461	16	97
Mix + Mix	High (27)	487	75	85
Mix + Mix	Mid (15)	483	42	91
Mix + Mix	Low (5.8)	482	20	96

Zeo: Manganese-coated zeolite
Mix: 45% Mn-Z, 45% bone char, 10% peat moss







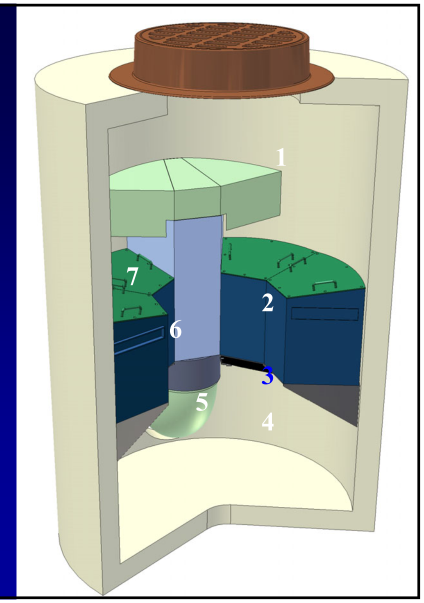
Very high levels of control, even for very small particles.

UpFlow Filter™

Components:

1. Access Port
2. Filter Module Cap
3. Filter Module
4. Module Support
5. Coarse Screen
6. Outlet Module
7. Floatables Baffle/Bypass

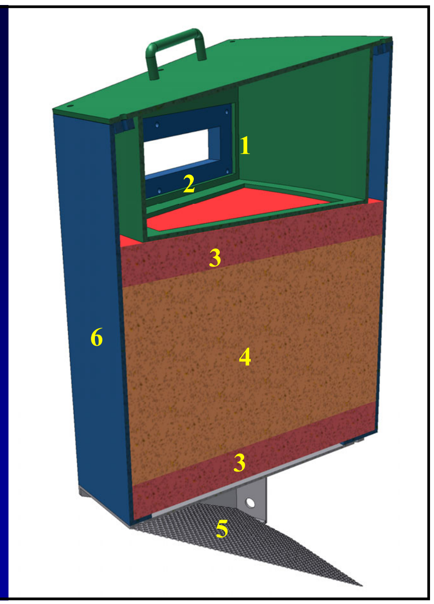
Hydro International



Upflow Filter Components

1. Module Cap/Media Restraint and Upper Flow Collection Chamber
2. Conveyance Slot
3. Flow-distributing Media
4. Filter Media
5. Coarse Screen
6. Filter Module

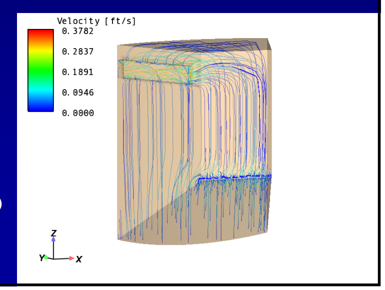
Hydro International



Hydraulic Characterization

High flow tests

Assembling Upflow Filter modules for lab tests



Initial CFD Model Results

Hydro International

Conclusions (continued)

Constituent and units	Reported irreducible concentrations (conventional high-level stormwater treatment)	Effluent concentrations with treatment train using sedimentation along with sorption/ion exchange
Particulate solids (mg/L)	10 to 45	<5 to 10
Phosphorus (mg/L)	0.2 to 0.3	0.02 to 0.1
TKN (mg/L)	0.9 to 1.3	0.8
Cadmium (μg/L)	3	0.1
Copper (μg/L)	15	3 to 15
Lead (μg/L)	12	3 to 15
Zinc (μg/L)	37	<20

Appropriate Combinations of Controls

- No single control is adequate for all problems
- Only infiltration reduces water flows, along with soluble and particulate pollutants. Only applicable in conditions having minimal groundwater contamination potential.
- Wet detention ponds reduce particulate pollutants and may help control dry weather flows. They do not consistently reduce concentrations of soluble pollutants, nor do they generally solve regional drainage and flooding problems.
- A combination of biofiltration and sedimentation practices is usually needed, at both critical source areas and at critical outfalls.