Treatment BMP Technology Report

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Final Report

California Department of Transportation

Division of Environmental Analysis

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EXECUTIVE SUMMARY

The Treatment BMP Technology Report consolidates and standardizes information on storm water quality technologies that are part of the California Department of Transportation's (Department's) BMP identification, and evaluation process described in Section 3.3.2 of the Storm Water Management Plan (SWMP). Technologies include the latest innovations in permanent storm water treatment and control, as well as existing technologies currently in use by municipal or other states' Department of Transportation (DOT) storm water management programs. 127 fact sheets are included in this report.

To introduce products to the Department, manufacturers and suppliers must contact the New Product Coordinator at (916) 227-7185. Fact sheets are prepared for each identified technology and added to the report. Appendix A explains the format and content of the fact sheets found in Appendices B, C, and D.

Fact sheets in Appendix B summarize information for technologies that are untested and unapproved by the Department. Appendix B has been substantially expanded in this year's report, so that each BMP product has a fact sheet rather than grouping similar BMPs as in previous reports.

Favorable evaluations of promising BMP technologies can lead to pilot studies to gather cost and performance data. Fact sheets in Appendix C summarize information for existing and completed full-scale pilot studies of unapproved technologies. Current studies are described in the Storm Water Monitoring and BMP Development Status Report (CTSW-RT-04-069.04.05).

If piloted technologies are successful, they may be approved and listed in the Department's SWMP to be used according to the BMP implementation procedures. Fact sheets in Appendix D summarize information for approved BMPs.

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Appendices

1.0 INTRODUCTION

The Treatment BMP Technology Report consolidates and standardizes information on technologies that are part of the Department's BMP identification, evaluation and approval process described in Section 3.3.2 of the SWMP (1 Caltrans 2003). The BMP fact sheets in Appendices B and C summarize available design, construction, performance, and cost information for BMPs considered for further testing or approval. For comparison, Appendix D fact sheets report on treatment BMPs approved by the Department.

> ***Department-Approved Treatment BMPs***
>
> **Austin Sand Filters**
> **Biofiltration** (strips and swales)
> **Delaware Sand Filter**
> **Detention Basins**
> **Dry Weather Flow Diversions**
> **GSRD** (Inclined Screen and Linear Radial)
> **Infiltration** (Basins and Trenches)
> **Multi-Chambered Treatment Trains**
> **Traction Sand Traps**
> **Wet Basin**

To introduce products to the Department, manufacturers and suppliers must contact the New Product Coordinator at (916) 227-7185. Fact sheets are prepared for identified technologies and added to this report. The Department reviews the fact sheets to determine if a BMP warrants further research, which may include full scale pilot testing.

The Department's ongoing review of technologies consists of evaluating the latest innovations in storm water treatment and control, including technologies used by municipal or Department of Transportation (DOT) storm water management programs.

2.0 IDENTIFYING NEW TECHNOLOGY

The Department, with input from universities, consultants, regulators, third parties, and manufacturers, continually reviews BMP information reported in literature. Manufacturers' exhibits at professional conferences also provide an opportunity to identify new technologies. After identification, a fact sheet of the BMP is included in this report.

2.1 Fact Sheets

BMP fact sheets are developed using a standard format to facilitate comparison among BMPs. Each fact sheet addresses a standard series of topics. This summary information is used to evaluate the potential applicability of BMPs to the Department. Topics covered include: design parameters, operations, maintenance, treatment effectiveness, costs, advantages and constraints. These topics are discussed in Appendix A. Completed BMP fact sheets are presented in Appendices B, C, and D. Section 4 provides an index of all the BMPs to aid in locating the fact sheet of a specific BMP.

Fact sheets in Appendix B summarize information for technologies unapproved and untested by the Department. Appendix B has been substantially expanded in this year's report. In most cases, there is a specific fact sheet for each BMP product rather than grouping similar BMPs into a single fact sheet.

Favorable evaluations of promising BMP technologies can lead to pilot studies to gather cost and performance data. Fact sheets in Appendix C summarize information for existing and completed full-scale pilot studies of unapproved technologies. Publications on Caltrans Pilot studies are summarized in Section 2.2.

Successfully piloted technologies may be approved and listed in the Department's SWMP to be used according to the BMP implementation procedures also contained in the SWMP. Fact sheets in Appendix D summarize information for approved BMPs. The Caltrans Storm Water Project Planning and Design Guide should be consulted for more details on approved BMPs (2 Caltrans 2002).

2.2 Pilot Study Publications

Table 2-1 presents, in alphabetical order, summary information and related publications for the Department's completed and existing BMP pilots. Publications cited in this report (not including the fact sheets) are found in Section 3 in order of occurrence in this report. The Storm Water Monitoring and BMP Development Status Report (CTSW-RT-04-069.04.05) describes current pilot studies in more detail. Current pilots are those in any phase of pilot testing, from project scoping to final report publication.

2.3 Low Impact Development (LID)

LID, as it pertains to stormwater management is a design approach that uses a mixture of BMPs to reduce the load of pollutants to surface waters from developed areas. The primary strategy is to capture or slow water so that evaporation and infiltration losses reduce the quantity of stormwater. Many BMPs can be used in, LID such as bioretention, infiltration basins, infiltration trenches, porous surfaces, swales and strips. The following are several sources for LID designs using these BMPs:

- www.owp.org
- www.thcahill.com
- www.lowimpactdevelopment.org

TABLE 2-1. STORM WATER BMP PILOTS

Study	Dist	RWQCB	Location	Status as of Summer 2004	Final Report Reference No.	Professional Paper Ref. No.
Alternative media filters	3	Lahontan	Meyers Maintenance Station	Fourth year monitoring season (03/04) draft report is available.	3	
Austin Filter with Alt Media (2)	3	Lahontan	Hwy 50 near Tahoe	Construction complete. Monitoring began in 03/04.	Anticipated 2008.	
Austin Sand Filters (8)	7	Los Angeles	Paxton Park and Ride	Construction complete, no water quality monitoring.	n/a	5, 6, 7, 8, 9
			Eastern Regional Maintenance Station	Study complete.	4	
			Foothill Maint Station			
			Termination Park/Ride			
	11	San Diego	La Costa Park & Ride			
			SR-78/I-5 Park & Ride			
	2	Central Valley	I-5 near Mountain Gate	Two seasons of monitoring complete. Monitoring to continue through the 04/05 wet season.	Anticipated 2006.	10
			Mt. Shasta Maintenance Station	Two seasons of monitoring complete. Monitoring to begin in the 04/05 wet season.		
Biofiltration Strips (3)	7	Los Angeles	Altadena Maintenance Station	Study complete.	4	5, 6, 7, 8
	7	Los Angeles	605/91 interchange	Study complete.	4	5, 6, 7, 8
	11	San Diego	Carlsbad Maintenance Station	Study complete.	4	5, 6, 7, 8

Study	Dist	RWQCB	Location	Status as of Summer 2004	Final Report Reference No.	Professional Paper Ref. No.
Biofiltration Strips: Roadside Vegetated Treatment Sites (RVTS) (8)	2	Central Valley	SR-299 EB PM 26.0	Two years of monitoring complete. Additional monitoring planned for 2006/2007.	11	12, 13
			I-5 SB PM 1.5			
	3		I-5 NB PM 13.5			
	4	San Francisco	US-101 NB PM 15.0			
	8	Santa Ana	SR-60 EB PM 14.0			
	11	San Diego	I-5 NB PM 70.4			
	12	Santa Ana	SR-91 EB PM 15.0			
			I-405 NB PM 2.5			
Biofiltration Swales (6)	7	Los Angeles	Cerritos Maint Station	Study complete.	4	5, 6, 7, 8
			I-5/I-605			
			I-605/Carson & Del Amo			
			I-605/SR-91 Interchange			
	11	San Diego	Melrose Dr./SR-78			
			I-5/Palomar Airport			
Bioretention (3)	4	San Fran	I-80 Toll Plaza at Oakland	Under design.	Anticipated 2010	
	12	Santa Ana	SR-73	Under construction and establishment.	Anticipated 2008.	
	4	San Francisco Bay	Between I-80 and I-580	Under design.	Anticipated 2010	
Chemical addition	3	Lahontan	Meyers Maintenance Station	Fourth year monitoring season (03/04) draft report is available.	3	
Compost StormFilter™ (CSF) (3)	12	San Diego	SR-73 -- various locations	Three years of monitoring complete. Vector monitoring is ongoing.	14	

Study	Dist	RWQCB	Location	Status as of Summer 2004	Final Report Reference No.	Professional Paper Ref. No.
Constructed Wetlands	12	Santa Ana or San Diego	One location along SR-73	Project cancelled.	n/a	
Continuous Deflection Separators (4)	7	Pacoima	I-210/East Orcas Ave.	Three years of monitoring complete. Vector monitoring continues.	4	5, 6, 7, 8
			I-210/East of Filmore St.			
	11	San Diego	SR-56	Two years water quality monitoring complete. Monitoring to continue in following three wet seasons.	Anticipated in 2009.	
			SR-56			
Delaware Filters	11	San Diego	Escondido Maintenance Station	Three years of monitoring complete.	4	5, 6, 7, 8, 9
Detention Basins-conventional (5)	7	Los Angeles	I-5/I-605	Three years of monitoring complete.	4	5, 6, 7, 8, 15
			I-605/SR91			
	11	San Diego	I-5/SR-56			
			SR-78/I-5			
			I-5/Manchester Ave.			
Detention Basins - bypass (4)	12	San Diego, Santa Ana	SR-73	Monitoring to begin in 04/05.	Anticipated in 2008.	
Detention Basins – floating skimmer (4)	12	San Diego	SR-73	Monitoring will begin in 04/05 for 3 of 4 basins. Fourth basin under design.		
Detention Basins - inlet (2)	12	San Diego	SR-73	Monitoring started in 03/04.		
Detention Basins – overflow (4)	12	Santa Ana	SR-73	Monitoring to begin in 04/05.		
Detention Basins - semi-batch (4)	12	San Diego	SR-73	Monitoring to begin in 04/05.		

Study	Dist	RWQCB	Location	Status as of Summer 2004	Final Report Reference No.	Professional Paper Ref. No.
Drain Inlet Insert (6)	7	Los Angeles	Foothill Maint Station (a)	StreamGuard® installed. Three years of monitoring complete.	4	5, 6, 7, 8, 16
			Foothill Maint Station (b)	FossilFilter® installed. Three years of monitoring complete.		
			Las Flores Maint Station (a)	StreamGuard® installed. Three years of monitoring complete.		
			Las Flores Maint Station (b)	FossilFilter® installed. Three years of monitoring complete.		
			Rosemead Maint Station (a)	StreamGuard® installed. Three years of monitoring complete.		
			Rosemead Maint Station (b)	FossilFilter® installed. Three years of monitoring complete.		
GSRD: Baffle Box(2)	7	Los Angeles	I-210/Christy (being replaced)	Study is complete. Installation replaced with Inclined screen configuration #4.	17	
	7	Los Angeles	I-405/Leadwell (being replaced)	One year monitoring complete (02/03). One more wet season monitoring to begin (04/05).	17	
GSRD: Inclined Screen, configuration 1	7	Los Angeles	SR-170/Burbank	Study is complete.	17	
GSRD: Inclined Screen Device configuration 2 (2)	7	Los Angeles	US-101/Gaviota	Study is complete.	17	
			I-210/Orcas			

Study	Dist	RWQCB	Location	Status as of Summer 2004	Final Report Reference No.	Professional Paper Ref. No.
GSRD: Inclined Screen Device, Configuration 3 (2)	7	Los Angeles	I-10/Halm	Study is complete.	17	
	12	Santa Ana	SR-73	GSRD on basin 1180R: Construction complete. Final year of monitoring is the wet season 2006/2007.	Anticipated in 2006.	
GSRD: Inclined Screen, Configuration 4	7	Los Angeles	I-210/Christy	Study complete.	18	
GSRD: Linear Radial Device, Configuration 2 (2)	7	Los Angeles	I-5/Garber	Study is complete.	17	
			I-210/Glenada			
GSRD: Linear Radial Device, Configuration 1			I-10/Rosemead	Study is complete.	17	
GSRD: Litter Inlet Deflector (3)	7	Los Angeles	SR-60/Garfield	Study is complete.	19	
			SR-60/Garfield			
			SR-60/Wilcox			
GSRD: Linear Radial Configuration (3)	7	Los Angeles	U.S. 101	Gross solids removal device pilot study Phase IV, 2004-2005 CTSW-RT-05-130.03.2	20	
GSRD: V-Screen, Configuration 1 (2)	7	Los Angeles	I-405/Leadwell	Study complete (02/03). One more wet season monitoring to begin (04/05).	18	
	12	Santa Ana	SR-73	GSRD on basin 1085L: One year monitoring complete (02/03). One more wet season monitoring to begin (04/05).		
GSRD: V-Screen, Configure.2 (2)	7	Los Angeles	SR-91/Ardmore	Study Complete.	18	
	12	Santa Ana	SR-73	Study On Going	Anticipated in 2009.	

Study	Dist	RWQCB	Location	Status as of Summer 2004	Final Report Reference No.	Professional Paper Ref. No.
Infiltration Basins (2)	7	Los Angeles	I-605/SR91	Study complete.	4	5, 22, 6, 7, 8
	11	San Diego	I-5/La Costa Ave.	Study complete.		
Infiltration Trench (2)	7	Los Angeles	Altadena Maintenance Station (b)	Study complete.	4	5, 22, 6, 7, 8
	11	San Diego	Carlsbad Maintenance Station	Study complete.	4	
Multi-Chamber Treatment Train (3)	7	Los Angeles	Metro Maintenance Station	Construction complete. No water quality monitoring.	n/a	
			Via Verde Park and Ride	Study complete.	4	5, 6, 7, 8
			Lakewood Park and Ride	Study complete.		
Oil/Water Separator	7	Los Angeles	Alameda Maintenance Station	Study complete.	4	5, 6, 7, 8, 16
Sand filters	3	Lahontan	Meyers Maintenance Station	Study complete.	23	
Sand Traps (2)	3	Lahontan	Hwy 50 Echo Summit	Study complete.	24	
			Hwy 50 at Lake Tahoe Airport			
Sand Traps with Filter Fabric (4)	3	Lahontan	SR-267 within Tahoe Basin	Construction complete. Monitoring ongoing.	Anticipated 2008.	
Storm Filter (Perlite/ Zeolite)	11	San Diego	Kearney Mesa Maintenance Station	Study complete. Vector monitoring is ongoing.	4	5, 6, 7, 8
Wet Basin	11	San Diego	I-5/La Costa	Study complete. Vector monitoring is ongoing.	3	5, 6, 7, 8, 25, 26

3.0 REFERENCES

1. Caltrans, 2003. Statewide Storm Water Management Plan. May 2003. CTSW-RT-03-008

2. Caltrans, 2002. Storm Water Planning and Design Guide. September 2002. www.dot.ca.gov/hq/oppd/stormwtr/PPDG-stormwater-2002.pdf

3. Caltrans, 2005, Caltrans Lake Tahoe Storm Water Small-Scale Pilot Treatment Project, Fourth Year Report, First Draft. August 2005, CTSW-RT-05-129.05.01-D1

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10. Larsen, Laura and Alderete, David, July 28-31, 2003 "Design and Construction Experiences With Three Variations Of Austin Style Sand Filters In The Transportation Environment," presented at StormCon 2003, San Antonio.

11. Caltrans, 2003. Roadside Vegetated Treatment Sites (RVTS) Study. Final Report, November 2003. CTSW-RT-03-028.

12. Lantin, Anna and Alderete, David, August 12-15, 2002. "Effectiveness of Existing Highway Vegetation as Biofiltration Strips," presented at StormCon 2002, San Marco Island, FL.

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15. Taylor, Scott M., et al, May 20-24, 2001. "Assessment of Costs and Benefits of Detention for Water Quality Enhancement," presented at American Society of Civil Engineers (ASCE) World Water & Environmental Resources Congress 2001, Orlando, FL.

16. Othmer, Edward F., Jr., et al, May 20-24, 2001. "Performance Evaluation of Structural BMPs: Drain Inlet Inserts (Fossil Filter and StreamGuard) and Oil/Water Separator," presented at American Society of Civil Engineers (ASCE) World Water & Environmental Resources Congress 2001, Orlando, FL.

17. Caltrans, 2003, Phase I Gross Solids Removal Devices Pilot Study: 2000-2002 Final Report, October 2003. CTSW-RT-03-72.31.22

18. Caltrans, 2005, Phase III Gross Solids Removal Devices Pilot Study. 2002-2005 Final Report, December 2005. CTSW-RT-05-130-03.1.

19. Caltrans, 2003, Phase IV Gross Solids Removal Device Pilot Study, 2004-2005, CTSW-RT-05-130.03.2.

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26. Taylor, Scott, et al, August 28, 2001. "Stormwater Treatment with a Wet Pond: A Case Study," presented at American Society of Civil Engineers (ASCE) Wetland Engineering and River Restoration Conference, Reno, NV.

27. Caltrans, 2000. Guidance Manual: Stormwater Monitoring Protocols. July 2000. CTSW-RT-00-005

28. Caltrans, 2004. Discharge Characterization Study Report. November 2003. CTSW-RT-03-065. www.dot.ca.gov/hq/env/stormwater

4.0 INDEX OF TREATMENT BMPS

This list includes both proprietary and non-proprietary BMPs. Proprietary BMPs are listed by product name, rather than the type of BMP. The page numbers correspond to the location of the fact sheets in Appendices B, C, and D.

Technology Name	Appendix Page No.
Corrugated Pipe--various suppliers	B-23
CrystalStream™	B-179
Cultec Contactor and HVLV™	B-147
Curb Inlet Basket	B-41
Delaware Sand Filter	D-9
Detention Basin, Outlet Improvements - Bladder Valve	C-5
Detention Basin, Outlet Improvements - Skimmer	C-7
Detention Basins	D-11
Downstream Defender™	B-127
Drain Diaper™	B-67
Drain Guard™	B-69
DrainPac™	B-71
Dry Weather Flow Diversions	D-13
Dual Media Austin Filter	C-13
Dual-Vortex	B-129
EcoSep®	B-181
Ecosol RSF 100/GSP	B-43
EcoStorm®	B-131
EcoStormPlus®	B-133
Enviro-Drain®	B-79
Enviropod	B-45
Envirosafe	B-81
Filterra®	B-15
FloGard Plus	B-47
FossilFilter™ (note: old model was tested)	C-9
GAC Columns	B-5
GAC or IX Media With Detention/Sedimentation BMPs	B-7
GAC Sandwich Filter and Blanket	B-9

Technology Name	Appendix Page No.
Grate Inlet Skimmer Box	B-49
Gross Pollutant Trap (GPT)	B-161
GSR Basket (Mechanically Removed)	B-51
GSRD- V-screen	C-23
GSRD-Baffle Box	C-19
GSRD-Inclined Screen	D-15
GSRD-Linear Radial	D-17
GSRD-Litter Inlet Deflector	C-21
Hancor®-Storm Water Quality Unit	B-183
Hydro-Cartridge	B-39
Hydro-Kleen™	B-83
Hydroscreen	B-99
Inceptor	B-53
Infiltration Basins	D-19
Infiltration Trenches	D-21
Ion Exchange Column	B-11
Kasco Aeration	B-13
Kleerwater™	B-185
Linear Bioretention Trench	B-109
Linear Filter Trench	B-111
Linear Infiltration Filter Trench	B-153
Manhole Filter	B-171
Matrix™	B-149
Media Filtration System	B-111
Multi-Chambered Treatment Trains (MCTTs)	D-23
Net Cassette	B-163
Nutrient Separating Baffle Box	B-165
OARS® Passive Skimmer	B-63

Technology Name	Appendix Page No.
Outlet Improvement	B-27
Ozone	B-35
Piranha	B-55
Plate and Tube Settlers (note: similar to MCTT in Appendix C-34)	B-29
Polyacrylimide	B-21
Porous Asphalt Pavement	B-173
PSI Separator	B-187
Puristorm	B-113
Rainstore3	B-151
Raynfiltr™	B-85
SeaLife Saver™	B-57
Sewer Eco-Collar	B-73
SIFT Filter	B-87
SNOUT®	B-189
SolarBee	B-13
StormBasin®	B-89
Stormcell®	B-153
Stormceptor	B-135
StormChamber™	B-155
StormFilter™	C-17
Stormgate Separator™	B-191
Storm-Klear™	B-19
StormPlex®	B-115
StormScreen™	B-167
Stormtech	B-157
StormTrap™, DoubleTrap™	B-25
StormTreat™	B-199
StormVault™	B-193

APPENDIX A: BMP FACT SHEET DESCRIPTION AND FORMAT

Appendix A describes the standard format used for fact sheets to facilitate comparison among the BMP types. Each fact sheet is divided into a standard series of discussion topics, which are discussed below.

A.1 BMP Description

A description of the BMP is presented at the top of each fact sheet. The description provides a summary of the configuration of the BMP and a general overview of the treatment process, how the BMP operates, and considerations that need to be addressed to promote maximum treatment effectiveness and functionality.

A.2 Constituent Removal

The relative degree each BMP is able to remove selected groups of constituents from storm water runoff is provided in the fact sheets. The groups of constituents examined were selected based on the likelihood of occurrence in the Department's runoff at levels that would require treatment consideration. The constituent groups, removal efficiency, and confidence levels used in each fact sheet are discussed below.

A.2.1 Constituent Groups

Estimates of the technology's performance removal abilities are made for each of the following constituent groups:

- Sediment (Total Suspended Solids [TSS])
- Nutrients
- Pesticides
- Total Metals
- Dissolved Metal
- Microbiological (including pathogens)
- Litter
- Biochemical Oxygen Demand (BOD)
- Total Dissolved Solids (TDS)

A.2.2 Constituent Group Removal Efficiency

The fact sheets report relative removal efficiencies for each of the nine general categories of constituents. This is general guidance as removal efficiencies often depend on the conditions of the test. Results based on conditions atypical of highway runoff are not included in the fact sheets. Constituent removal percentages were derived from a review of the literature.

Removal efficiencies were assessed in terms of being high, medium or low. Constituent removal was quantified by first calculating the average removal percentage for all constituents within a given constituent category. The overall assessment was then defined using the following criteria:

- *High*: average removal percentage was equal to or greater than 75 percent
- *Medium*: average removal percentage was between 40 and 75 percent
- *Low*: average removal percentage was less than or equal to 40 percent

The fact sheets provide notes with additional information regarding how the removal assessment was assigned to a given BMP.

A.2.3 Level of Confidence

The level of confidence in the constituent removal data found in the literature depended on the type and quality of the data. Assessing constituent removal from storm water BMPs is not precise; water quality monitoring studies have demonstrated the wide variability in water quality concentrations in storm water runoff. To ensure that data are of the highest quality, storm event monitoring protocols require that samples be collected according to standard procedures, such as the *Guidance Manual: Stormwater Monitoring Protocols* (24 Caltrans 2000) or equivalent procedures. The level of confidence was assessed in terms of being high, medium or low. The criteria applied for defining the confidence level were:

- *High*: The information came from either the Department's research study or a study that met the Department's quality assurance and quality control monitoring protocols *and* the probability that the influent and effluent concentrations are not actually different is less than 10% (p-value < 0.1) *and* the test conditions were typical of the Department's facilities such as having influent concentrations similar to those summarized in the Caltrans Discharge Characterization Study Report (25 Caltrans 2004).
- *Medium*: Constituent removal rates were established from the results of a scientific monitoring study or studies conducted independently of equipment manufacturers, and:
  - the BMP technology has a documented history of application for treating storm water; or
  - the treatment process was a "known" technology for treating other types of wastewater discharges; or
  - the BMP technology provided "no discharge" to surface waters under design conditions; constituent removal was assumed to be 100 percent removal although it was recognized that certain large storm events would not receive treatment.
- *Low*: Data does not meet the above criteria or the BMP monitoring program used to quantify the removal percentages and the monitoring protocols applied could not be substantiated by the literature reviewed.

A.3 key design elements

This section identifies important design considerations that have been highlighted by vendors or discovered through testing. Ancillary facilities are also listed in this section. They are assumed to be used in conjunction with the technology are also listed in this section. An example would be including a detention basin downstream of a chemical treatment technology to capture flocculated particles.

A.4 Schematic

If appropriate, a schematic figure is provided to depict a typical design plan or cross-section with major components identified.

A.5 relative cost effectiveness

This section provides an assessment of cost and pollutant removal effectiveness relative to detention basins. This section is for general comparisons of overall cost effectiveness and not for cost effectiveness comparison for treatment of an individual constituent. A detention basin was chosen because it is a common BMP that has relatively well established cost and performance information. Relative cost assessments include the cost to build, operate, and maintain each BMP. Two pieces of information are provided on BMP costs:

- Level of confidence in the available data
- General assessment of the BMP's overall costs compared to detention basins.

A.5.1 Level of Confidence

The level of confidence in the costs to build and operate a BMP depends on the type and quantity of information found in the literature. Use of cost information developed for municipal storm water programs was not considered to be directly relevant to the Department's facilities. The right-of-way costs and construction costs of major highway transportation projects are typically much greater than the typical suburban street or arterial road that might be constructed by a municipal public works department. Furthermore, operations and maintenance costs of facilities along major freeways is typically much more expensive than similar municipal facilities because of limited access and the need for traffic control. The level of confidence was assessed in terms of being high, medium or low. The criteria applied for defining the confidence level of the cost estimates were:

- *High:* Unit cost information was available from a facility constructed by the Department or a similar state department of transportation.
- *Medium*: Cost information was available from several similar facilities constructed under municipal storm water programs.
- *Low*: No cost information was available from a similar BMP facility that could be independently verified. Construction costs were extrapolated from available pricing information.

A.5.2 Cost Effectiveness Assessment

The cost for each BMP was assessed in terms of its equivalent uniform annual cost (EUAC) relative to a detention basin. Effectiveness for each BMP was also assessed in terms of its overall constituent removal expectations relative to a detention basin. A four-quadrant system was used as a tool to rate each BMP (ie). One of the four quadrants was colored based on the rating key.

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Figure A-1. Rating key for cost effectiveness.

The cost estimates were defined by first calculating the typical range of costs for constructing or operating BMPs on a per acre basis. The acres represented the drainage area served by the BMPs. Operation and maintenance costs were then added based on the BMPs design life. The EUAC for a particular BMP was estimated and then compared to that of a detention basin. If the EUAC was higher than a detention basin, then it was marked as a higher cost using the quadrant rating key.

The benefit of the BMP was evaluated relative to the performance of a typical detention basin. If the overall constituent removal was greater than that of a detention basin, then the BMP was marked as having a greater benefit.

A.6 Issues and Concerns

This section presents issues and concerns to be considered when evaluating the appropriateness of a BMP for any of the Department's facilities. This information is divided into two categories: maintenance and project development. Within each category is a standard set of topics. The same topics are included in every fact sheet to facilitate comparisons between BMPs.

A.6.1 Maintenance

- *Requirements:* Summarizes routine maintenance tasks required to keep the BMP functional.
- *Nuisance Controls:* Identifies whether the BMP has the potential to create odors, breed mosquitoes, or attract pests..
- *Specialty Training/Equipment:* Identifies the special training required to perform the maintenance. Identifies specialty equipment.

A.6.2 Project Development

- *Right-of-Way Requirements:* Identifies relative space requirements to install the BMP.
- *Siting Constraints:* Identifies unique siting considerations and limitations, such as soil types, slope of the land, distance from existing infrastructure or other natural features,

and regulatory requirements. Common siting constraints such as maintenance access are not listed.

- *Construction:* Identifies unique construction precautions and requirements.

A.7 BMP Specific Advantages and Constraints

This section lists additional advantages and constraints of the BMP that were not covered in the previous sections. Information presented may include impacts from hydrologic characteristics and weather conditions in California, experiences from actual installations, and expansion of particular points discussed in previous sections of the fact sheet.

A.8 Sources

The fact sheets also include sources of information where appropriate (e.g., for proprietary technologies, vendor contact information is provided).

APPENDIX B: TECHNOLOGY FACT SHEETS

Appendix B presents fact sheets for technologies that have not been pilot tested by the Department and therefore are not yet approved or rejected. Technology evaluations in the attached fact sheets are ongoing, and the assessment of these technologies may be revised in future reports. The evaluations that appear were derived from a review of information that was frequently limited to manufacturer's claims. Treatment BMP technologies are presented in the following order:

Technology Type	Available Storm Water Products	Page No.

Drain Inlet Inserts

Technology Type	Available Storm Water Products	Page No.

Filtration

Hydrodynamic Separators

Infiltration

Litter and Debris Removal

Technology Type	Available Storm Water Products	Page No.

Manhole Insert

Basket Box	Manhole Filter	B-177

Porous Surfaces

	Porous Asphalt Pavement	B-179

Water Quality Inlets (Oil/Water Separators)

Water quality inlets (WQIs), also commonly called oil/grit separators or oil/water separators, consist of a series of chambers that promote sedimentation of coarse materials and separation of free oil (as opposed to emulsified or dissolved oil) from storm water. Most WQIs also contain screens to help retain larger or floating debris, and many of the newer designs also include a coalescing unit that helps to promote oil/water separation. WQIs typically capture only the first portion of runoff for treatment and are generally used for pretreatment before discharging to other best management practices (BMPs). Source: www.epa.gov	BaySaver®	B-181
	BioSTORM™	B-183
	CrystalStream™	B-185
	EcoSep®	B-187
	Hancor®-Storm Water Quality Unit	B-189
	Kleerwater™	B-191
	PSI Separator	B-193
	SNOUT®	B-195
	Stormgate Separator™	B-197
	StormVault™	B-199
	VortClarex	B-201

Wetland Systems

Constructed Wetland	non-proprietary	B-203
StormTreat Wetland Systems	StormTreat™	B-205

Adsorption/Ion Exchange -- Granular Activated Carbon Columns

Description:

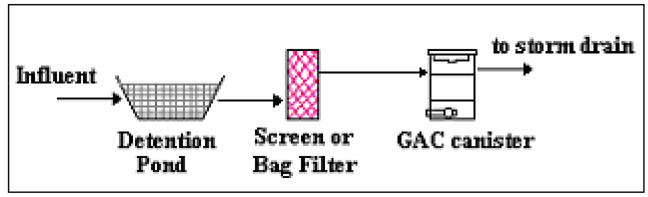
Granulated Activated Carbon (GAC) adsorption is typically used to remove volatile organic compounds (VOCs) in water for potable uses. In addition to a removal efficiency greater than 99% for VOCs, it is also effective for treatment of synthetic organic chemicals. With GAC treatment, contaminated water passes through a column of GAC where organic compounds are removed by adsorption onto the carbon granule surface. Once the carbon can no longer adsorb pollutants from the water, it must be regenerated or replaced with fresh new carbon. Two types of designs are commonly employed for GAC: the pressurized contactor unit and the gravity-flow unit (which is similar to the gravity media filter). For storm water application, a GAC canister could be placed at the outlet of a detention basin, and the basin effluent would be allowed to flow through it by gravity. Though typically designed for pressurized flow, the GAC system can be designed to operate by gravity. Performance of the GAC canister at a sedimentation pond outlet will depend highly on the performance of the pretreatment. The sedimentation pond will also provide flow equalization to the GAC canisters.

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	◒	○
Nutrients	○	○
Pesticides	●	○
Total Metals	●	○
Dissolved Metals	●	○
Microbiological	◒	○
Litter	○	○
BOD	◒	○
TDS	○	○

Notes:

- No performance data encountered in field demonstrations or in literature.



Key Design Elements:

1. Absorption media type and depth
2. Container and hydraulic system

<u>Ancillary Facilities</u>

Requires pretreatment such as a detention/sedimentation BMP.

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
▝	○

Cost includes cost of pretreatment.

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- Requirements: The mechanical equipment needs to be maintained. Spent GAC will have to be replaced or regenerated periodically.
- Nuisance Control: Standing water will occur when column is clogged.
- Specialty Training/Equipment: Requires training for inspection and maintenance of GAC canister.

Project Development:

- Right-of-Way Requirements: Small footprint if the pretreatment (e.g. sedimentation BMP) is pre-existing. Total system has large space requirements.
- Siting Constraints: High head requirement.
- Construction: No unique requirements identified.

Advantages:

- Compact system at the detention basin outlet.
- Reduces pesticides.
- Consistent effluent quality.
- Can be retrofitted to existing detention basins with sufficient downstream head

Constraints:

- Potential clogging of the GAC if pretreatment does not remove enough suspended solids, oil and grease.
- Spent GAC has the potential of being considered a hazardous material and will need to be disposed of properly.
- The carbon must be shipped off-site for regeneration or disposal by a licensed company. One option would be to dispose of the spent GAC and replace it with new GAC. Regeneration of the GAC onsite is considered to be technically unfeasible and cost prohibitive. Another is to replace regenerated GAC cylinders and regenerate spent cylinders at an off-site location, which is commonly done by small-scale commercial and industrial users.
- GAC may promote considerable microbial growth on the carbon surface.
- Disinfection prior to GAC adsorption is not viable since the GAC removes disinfectants.

Sources:

- Evans, Max. Mailed Correspondence. Oil or Gas Recovery from Parking Areas. Culligan Water.
- Macpherson, John. Phone Conversation. GAC Quilted Blanket Filter. The IT Group, (425) 486-5515 ext. 232.
- McMillen, Brent. Faxed document. Activated Carbon Contaminants and Costs. CPL Carbon Link Corporation.
- Nitchman, Craig. Faxed Document. Carbon Usage Rate. Calgon Carbon Corporation.
- Wilburn, Tom. Phone Conversation. GAC Quilted Blanket Filter Production. D. R. Shannon Company, (800) 255-1032
- Mercado, Shery or Jimmy Lam. GAC Stormwater Application. Calgon Carbon Corporation. www.calgoncarbon.com
- Jaubert, Michael. GAC Cost Estimates. Waterlink Barnebey Sutcliffe: Pur Air Division www.waterlink.com
- Mercado, Shery and Jimmy Lam. Activated Charcoal Cloth. Calgon Carbon Corporation. www.calgoncarbon.com/product/charcoalcloth.htm

Literature Sources of Performance Demonstrations:

- Wanielista, M. P., et al. Evaluation of the Stormwater Treatment Facility at the Lake Angel Detention Pond, Orange County, Florida. Florida State Department of Transportation and University of Central Florida, Gainesville. June 1991.

Adsorption/Ion Exchange - GAC or IX Media With Detention/Sedimentation BMPs

Description:

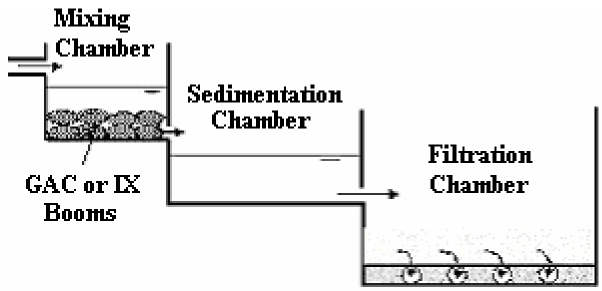
Influent storm water could be mixed with granular activated carbon (GAC), ion exchange (IX) resin or both at the inlet of a detention basin or a sedimentation chamber preceding a sand filter. A structure can be installed at the inlet flow distribution system of a sedimentation basin for mixing. As the storm water enters the mixing chamber tank, it comes in contact with GAC and IX. After mixing, the storm water flows to the sedimentation basin. The GAC and IX is in suspension with the storm water until it settles with other solids in the sedimentation tank. As an alternative, the detention pond influent storm water could flow over a bag or sack filled with GAC or IX resin, or both. These sacks could be placed in detention pond inlets or other structures.

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	◒	○
Nutrients	○	○
Pesticides	●	○
Total Metals	●	○
Dissolved Metals	●	○
Microbiological	◒	○
Litter	○	○
BOD	◒	○
TDS	○	○

Notes:

- No performance data encountered in literature.
- Removal efficiency approximated for a combination of IX and GAC
- Suspended solids and other constituents attached to the solids settle out in the pond. Heavy metals that are not dissolved but attached to particles might be removed with the settled solids.



Key Design Elements:

1. Media type and dosing rate
2. Media feed and storage systems

<u>Ancillary Facilities</u>

Sedimentation and/or filtration facilities downstream.

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
◳	○

Cost includes cost of pretreatment.

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- <u>*Requirements*</u>: Maintenance of filtration chamber is similar to the Austin sand filter. Also needs replacement of spent GAC/IX powder and maintenance of the media dosing system. The replacement frequency of the GAC/IX powder would depend on storm water flow and constituent concentrations. The replacement will be easier for the option using a bag than for the option using powder.
- <u>*Nuisance Control:*</u> Standing water will occur when filter is clogged.
- <u>*Specialty Training/Equipment*</u>*:* Requires training for inspection and maintenance of the media dosing system and filtration chamber.

Project Development:

- <u>*Right-of-Way Requirements*</u>: Likely high for this three chambered system.
- <u>*Siting Constraints*</u>: High head requirement.
- <u>*Construction*</u>*:* No unique requirements identified.

Advantages:

- This BMP will enhance removal of dissolved constituents compared to detention basins or sand filters.

Constraints:

- The GAC/IX powder will accumulate in the sedimentation chamber unless the design is such that the influent flows over a GAC/IX bag.
- Powder media may cause frequent clogging of filter.

Sources:

- Mercado, Shery or Jimmy Lam. GAC Stormwater Application. Calgon Carbon Corporation, www.calgoncarbon.com

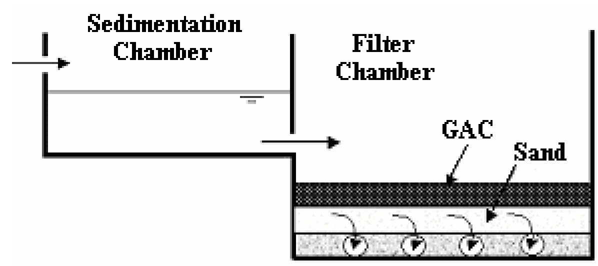
Literature Sources of Performance Demonstrations:

- None identified.

Adsorption/Ion Exchange -- GAC Sandwich Filter and Blanket

Description:

To help remove organics from storm water, GAC has been proposed to be added to the treatment train of existing or proposed sand filters. A GAC layer could supplement the current sand media filter and would act as both a filtering media and adsorption layer. This option would require a detention pond upstream of the filter to provide sufficient pretreatment. One approach to consider is the GAC Sandwich Filter from Calgon Carbon Corporation (patent-pending), which removes a broad spectrum of pesticides and herbicides. This vendor claims to improve the effectiveness of slow sand filters by using a layer of GAC between two layers of sand. The system retains the advantages of traditional slow sand filtration while incorporating GAC's ability to remove organic compounds. Existing slow sand filters can be used for retrofit applications, which eliminates the need for a major capital investment and substantially reduces the time required to install GAC facilities.



Key Design Elements:

1. Adsorption media type and depth
2. Sand specifications and depth

Ancillary Facilities

Upstream sedimentation facilities required.

Normally the GAC layer would be used in conjunction with a sand filter.

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	◒	○
Nutrients	○	○
Pesticides	●	○
Total Metals	●	○
Dissolved Metals	●	○
Microbiological	◒	○
Litter	○	○
BOD	◒	○
TDS	○	○

Notes:

- Nitrate and nitrite levels may actually increase due to nitrification.
- Performance data from Lake Angel Detention Pond in Orange County (University of Central Florida and State DOT, June 1991).

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
◳	○

Cost includes cost of pretreatment.

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: Routine maintenance may include periodic sediment and debris removal as well as spent GAC disposal/regeneration. Layered media may complicate maintenance.
- *Nuisance Control:* Standing water will occur when filter is clogged.
- *Specialty Training/Equipment:* Requires training for GAC removal/replacement and sand removal/replacement.

Project Development:

- *Right-of-Way Requirements*: Space requirements are relatively high for sedimentation basin and sand filter.
- *Siting Constraints*: Similar to full sedimentation Austin sand filters (about 1.2 meter minimum head requirement).
- *Construction:* No unique requirements identified.

Advantages:

- The GAC layer will act as both an adsorption layer and a filtering media. This option will provide removal of some organic constituents.
- Can be retrofitted to existing sand filters.

Constraints:

- Frequent clogging and short bedlife.
- Bacterial growth.
- Spent GAC may be a hazardous waste.

Sources:

- Mercado, Shery or Jimmy Lam. GAC Stormwater Application. Calgon Carbon Corporation., wwwcalgoncarbon.com

Literature Sources of Performance Demonstrations:

- GAC has already been used as a media filter to treat storm water during a study in Florida (University of Central Florida and State Department of Transportation, June 1991). This study describes the use of GAC filer beds in series to reduce the potential concentration of total trihalomethane at the Lake Angel Detention Pond in Orange County. The pond accepted runoff from an interstate highway and a commercial area.

Adsorption/Ion Exchange - Ion Exchange Column

Description:

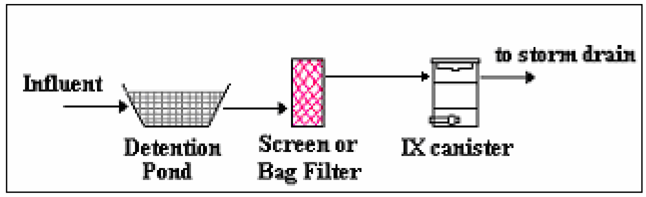
Ion exchange (IX) is a sorption process whereby a medium such as a resin removes one ion from a solution and replaces it with another. Resins are comprised of fixed ionic groups that are balanced by counter-ions of opposite charge to maintain electro neutrality. These counter-ions exchange with the ions in solution. As water passes through the resin bed in a storm water treatment system, contaminant ions in the water are exchanged with ions on the resin surface, thus removing the contaminant ions from the water and concentrating them on the resin. The resin is frequently regenerated to remove the contaminant from the resin surface and replenish the resin with the original exchange ion. A sedimentation basin and possibly a media filter will be needed in front of the resin bed to remove particles and prevent clogging of the IX resin. A media filter may also be necessary after the sedimentation basin and in front of the IX resin. The IX resin could either be placed in pressure vessels or in a canister at the pond outlet.

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	◒	○
Nutrients	◒	○
Pesticides	◒	○
Total Metals	●	○
Dissolved Metals	●	○
Microbiological	◒	○
Litter	○	○
BOD	◒	○
TDS	◒	○

Notes:

- No performance data encountered in field demonstrations or in literature.



Key Design Elements:

1. Ion exchange resin type, size, and depth
2. Container and hydraulic system

<u>Ancillary Facilities</u>

Requires pretreatment such as a detention/sedimentation BMP.

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
◳	●

Cost includes cost of pretreatment.

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

● High	◒ Medium	○ Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: Resin must be periodically inspected. Spent resin or regenerant brines must be removed and disposed of properly. Measures must be taken to make sure that the resins do not dry out during dry season. Mechanical equipment must be maintained. Because of the constraints, on-site regeneration is not considered feasible. The IX resin must be shipped off-site for regeneration or disposal by a licensed company.
- *Nuisance Control:* Standing water will occur when column is clogged.
- *Specialty Training/Equipment:* Requires training for inspection and maintenance of ion exchange column and handling and disposal of waste products.

Project Development:

- *Right-of-Way Requirements:* Small footprint if the pretreatment (e.g. sedimentation BMP) is pre-existing. Total system has large space requirements.
- *Siting Constraints*: High head requirement.
- *Construction:* No unique requirements identified.

Advantages:

- They provide a compact system at the detention basin outlet.
- Removal of dissolved pollutants.

Constraints:

- Potential clogging of the resin if pretreatment does not remove enough suspended solids, oil and grease.
- Exhausted IX has potential to be considered a hazardous material and will need to be disposed of properly.
- IX resins could dry out if not kept wet.
- May require monitoring to determine when the IX unit should be replaced.

Sources:

- Monat, J. Synergies Between Ultrafiltration & Ion Exchange. http://www.kochmembrane.com/technical_info/separation.htm. April 2000.

Literature Sources of Performance Demonstrations:

- Clifford, D.A., Department of Civil and Environmental Engineering, University of Houston, Texas, Water Quality and Treatment: A Handbook of Community Water Supplies 4th edition, 1990.
- Montgomery, James M, Consulting Engineers, Inc. Water Treatment Principles and Design, 1985.

Description:

Aeration raises dissolved oxygen levels in water. This can be used in conjunction with wet basins to allow BOD removal while minimizing depression of dissolved oxygen levels. It is not a stand-alone stormwater technology; therefore all available types of aeration are addressed in this fact sheet:

Waterfalls
Fountains
Aerators
Circulators
Diffusers
Propellers

Source: Kasco Marine, INC.

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	○	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	○	○
BOD	◒	◒
TDS	○	○

Notes:

- Removal of BOD is dependent on several parameters including retention time, temperature, and power/size of the aeration system.

Key Design Elements:

1. Power requirements
2. Dissolved oxygen requirements
3. Basin Size

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
▗	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: Varies by type of aeration.
- *Nuisance Control:* Ponds that have permanent standing water need mosquito controls.
- *Specialty Training/Equipment:* Training needed for timers, operation system, power supply operation, and mechanical system maintenance..

Project Development:

- *Right-of-Way Requirements*: None-used within a wet pond.
- *Siting Constraints*: Requires power.
- *Construction:* No unique requirements identified.

Advantages:

- Can be aesthetically pleasing and increase public acceptance of the storm water treatment systems.

Constraints:

- Limited pollutant removal

Sources:

- Airmaster Aerator, Turbo, www.airmasteraerator.com
- Aqua Control Inc., www.aquacontrol.com
- Aqua Master®, www.aquamasterfountains.com
- Kasco® Aeration, www.kascomarine.com
- SolarBee, www.solarbee.com
- Stamford Scientific International, Inc., Microgen™, www.stamfordscientific.com

Literature Sources of Performance Demonstrations:

- None identified for storm water applications.

Description:

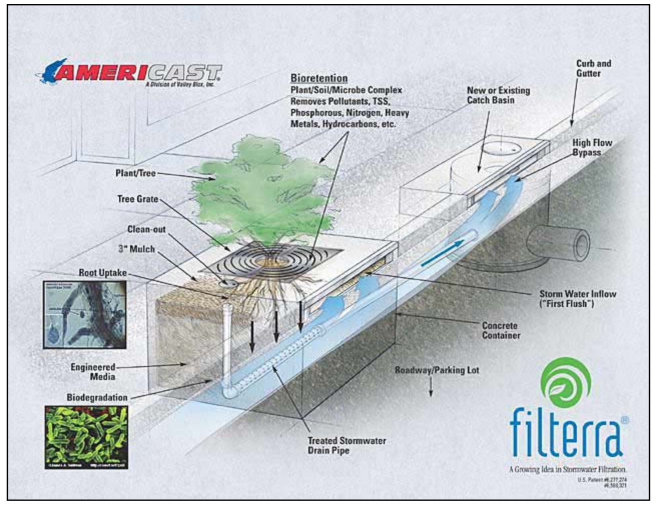
Filterra® is a modular bioretention system that has been used in urban areas as an alternative to traditional curb-side landscape plantings. It functions similarly to non-proprietary designs.

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	●	○
Nutrients	◒	◒
Pesticides	◒	○
Total Metals	●	◒
Dissolved Metals	◒	○
Microbiological	●	○
Litter	●	○
BOD	○	○
TDS	○	○

Notes:

- Testing by University of Virginia (Dr. Shaw Yu).



Source: www.americastusa.com

Key Design Elements:

1. Size
2. Vegetation
3. Underground drain system
4. Ponding depth
5. Drainage area
6. Flow capacity

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
Benefit ↑ Cost ↑	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: Vegetation management is required.
- *Nuisance Control:* The bioretention facility may promote mosquito breeding if clogged.
- *Specialty Training/Equipment:* No special requirements identified.

Project Development:

- *Right-of-Way Requirements*: Space requirements are relatively high to accommodate shallow water quality storage depths.
- *Siting Constraints*: May need supplemental irrigation in dry areas, depending on plant selection. Large head requirement.
- *Construction:* Vegetation establishment period may be required.

Advantages:

- Pollutant removal effectiveness is typically high, accomplished primarily by physical filtration of particulates through the soil profile; and adsorption of constituents by the soil.
- It can provide an aesthetic vegetated appearance.
- Reduces water discharge by soil retention and evapotransporation.

Constraints:

- May not be appropriate along highways where safety considerations preclude use ofplantings that obscure sight lines.
- In areas with prolonged dry periods, maintenance of trees, shrubs and grass between rainfalls may require irrigation.
- If located along a shoulder or median, maintenance activities may require traffic control

Sources:

- Americast, Filterra®, www.americastusa.com

Literature Sources of Performance Demonstrations:

- University of Virginia, Dr. Shaw Yu performed a two-year research study on the pollutant removal efficiency of the filter soil/plant media, www.americastusa.com/filterra.html

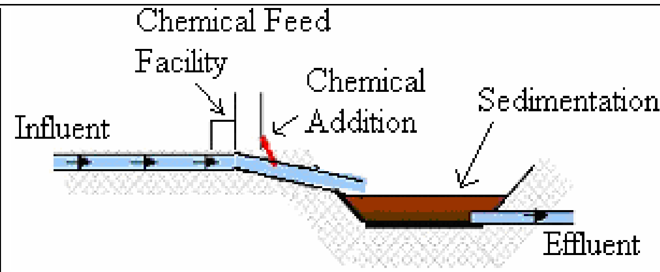
Chemical Treatment-Alum

Description:

Adding chemical coagulants to storm water influent is one way to remove more sediment and associated contaminants in a detention basin. For alum ($Al_2(SO4)_3 18H_2O$), the aluminum hydroxide precipitate, $Al(OH)_3$, forms a floc that attracts and absorbs colloidal particles, thus clarifying the treatment water. Removal of additional dissolved phosphorus occurs. Alum can be injected into major storm sewer lines on a flow-weighted basis during rain events. When added to runoff, alum forms non-toxic precipitates that combine with phosphorus, suspended solids and heavy metals, causing them to be rapidly removed from the treated water. In a typical alum storm water treatment system, the coagulant is injected into the storm water by a variable-speed chemical metering pump on a flow-weighted basis so the same dose is added regardless of the storm sewer discharge rate.
Since Al^{+3} can be toxic to aquatic life, floc formation takes approximately 45 to 60 seconds and should be complete before treated storm water is discharged to receiving water. Alum injection locations must be carefully selected to allow at least 60 seconds of travel time after alum is added to the storm water and before discharge to the watershed.

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	●	○
Nutrients	●	○
Pesticides	◒	○
Total Metals	●	○
Dissolved Metals	◒	○
Microbiological	◒	○
Litter	●	○
BOD	◒	○
TDS	○	○



Key Design Elements:

1. Chemical dose
2. Chemical feed and storage facilities
3. Mixing Facilities

Ancillary Facilities

Detention basin must be provided downstream to capture flocculated particles.

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
	○

Cost includes cost of sedimentation.

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

● High	◒ Medium	○ Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- <u>*Requirements*</u>: Mechanical equipment must be inspected and maintained on a regular basis. Sludge might need to be removed periodically.
- <u>*Nuisance Control*</u>*:* Depends on type of BMP it is used with.
- <u>*Specialty Training/Equipment*</u>*:* Crews must be trained to maintain chemical addition system.

Project Development:

- <u>*Right-of-Way Requirements*</u>: Small footprint for chemical addition system, but downstream detention requirement increases footprint.
- <u>*Siting Constraints*</u>: May require access to electricity and be large enough for a central housing unit and storage tank. Need enough head for mixing.
- <u>*Construction*</u>*:* No unique requirements identified.

Advantages:

- The observed accumulation rate of alum floc in sediments of receiving waters is low due to floc consolidation over time and incorporation of alum floc into existing sediment.
- Alum treatment achieves high nutrient, heavy metal and fecal coliform removals.
- Dry alum sludge has chemical characteristics suitable for general land application or in agricultural sites.
- Construction costs for alum storm water treatment feed systems are largely independent of the drainage area to be treated and depend primarily upon the number of outfalls to be retrofitted.

Constraints:

- The pH must be maintained within a range of 5.5 to 7.5 to prevent formation of Al^{+3}, which has toxic effects on aquatic life.
- Sludge removal frequency and method will have to be studied.
- Alum forms voluminous metal hydroxides that are very difficult to dewater.
- Safety issues related to the chemical storage facility need to be considered.
- Appropriate mixing must be provided at the point of chemical addition.
- Optimum alum dose may vary with each storm.

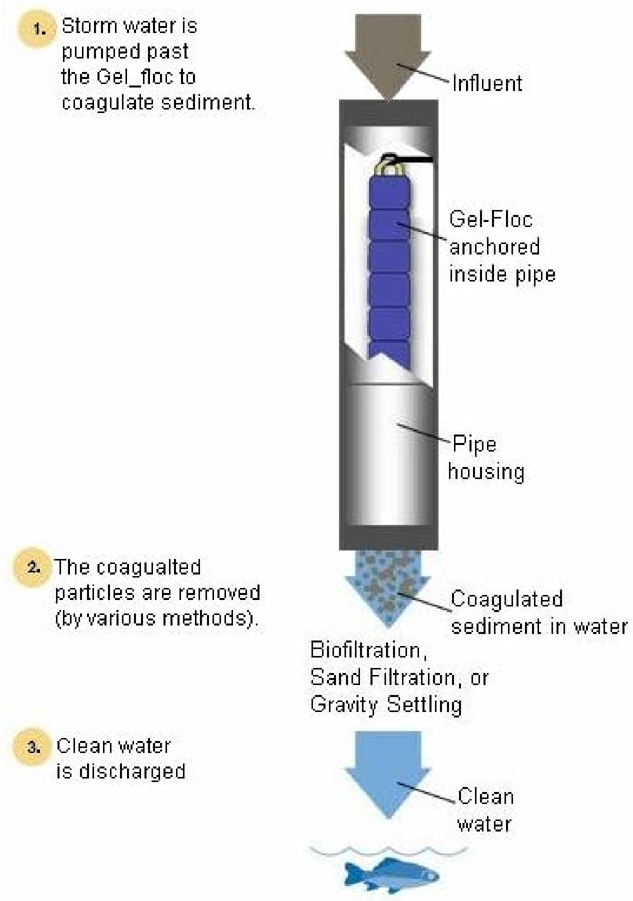
Sources: None identified.

Literature Sources of Performance Demonstrations:

- Harper, H. H., et al. Alum Treatment of Stormwater: The First Ten Years Environmental Research & Design. 1997.
- Harper, H. H., et al. Alum Treatment of Stormwater Runoff: An Innovative BMP for Urban Runoff Problems. Environmental Research & Design, Inc. 1996.
- Harper, H. H., et al. "An Assessment of An In-Line Alum Injection Facility Used To Treat Stormwater Runoff in Pinellas County, Florida." Sixth Biennial Stormwater Research and Watershed Management Conference. September 14, 1999.
- Harper, H. H., et al. "The Evaluation & Design of an Alum Stormwater Treatment System to Improve Water Quality in Lake Maggiore in St. Petersburg, Florida." Fifth Biennial Storm water Research Conference. Nov 5 to 7, 1997.
- Harper, H. H., et al. "Removal of Microbial Indicators from Stormwater Using Sand Filtration, Wet Detention, & Alum Treatment Best Management Practices." Sixth Biennial Stormwater Research and Watershed Management Conference. September 14, 1999.
- Harper, H. H, " Long-Term Performance Evaluation of the Alum Stormwater Treatment System at Lake Ella, Florida." Final Report Submitted to the Florida Department of Environmental Regulation, Project WM339. December 1990.
- Price, F. A. & D. R. Yonge. Enhancing Containment Removal in Stormwater Detention Basins by Coagulation. Washington State University: Department of Civil and Environmental Engineering.
- Yonge, D. & F. Price. Stormwater Contaminant Removal by Chemicals: Enhancing Contaminant Removal in Stormwater Detention Basins by Coagulation. Research Project T9234-11. Washington State Department of Transportation (WSDOT). April 1995.

Description:

Adding chemical coagulants to storm water influent is one way to remove more sediment and associated contaminants and nutrients in a detention Basin (DB) without physically modifying the basin. Several coagulants have been developed for this application such as chitosan.



Source: www.naturalsitesolutions.com

Constituent Removal:

Constituent Group	***Removal Efficiency***	***Level-of-Confidence***
Total Suspended Solids	●	○
Nutrients	●	○
Pesticides	◒	○
Total Metals	◒	○
Dissolved Metals	○	○
Microbiological	◒	○
Litter	●	○
BOD	◒	○
TDS	○	○

Notes:

- Do not leave chitosan submerged in water when not in use as the chitosan will continue to dissolve.
- Nutrient removal efficiency is based on phosphorus but not nitrogen.
- Constituent removal efficiencies assume use with a detention basin.

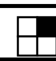
Key Design Elements:

1. Dosing rate
2. Flow variation
3. Detention time

<u>Ancillary Facilities</u>

Detention basin must be provided downstream to capture flocculated particles.

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	***Level-of-Confidence***
	○

Cost includes cost of sedimentation or filtration.

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: Difficult to predict. The frequency of inspection depends upon the loading rate. Increased inspection frequency over detention basins. Access to the chemical storage facility will be needed for deliveries.
- *Nuisance Control:* Depends on type of BMP it is used with.
- *Specialty Training/Equipment:* Depends on type of BMP it is used with; training required for inspection and replacement of Gel-Floc.

Project Development:

- *Right-of-Way Requirements*: Small footprint for chemical addition system, but downstream BMP requirement increases footprint.
- *Siting Constraints*: Need enough head for mixing.
- *Construction*: No unique requirements identified.

Advantages:

- May decrease the size of detention basins.
- Increases performance of detention basins.

Constraints:

- Storm-Klear is designed to treat specific flow rates and quantities of storm water, evaluation of the site is essential to fit the site with the correct number of units.
- Chitosan effectively treats runoff containing a pH between 6.5 and 8.5. If pH is outside this range, the storm water will need to be neutralized before the chitosan.
- Inspection and maintenance increases are unknown.
- Consistent dosing for a variety of flows may be difficult.

Sources:

- Natural Site Solutions, www.naturalsitesolutions.com

Literature Sources of Performance Demonstrations:

- none identified

Chemical Treatment – Polyacrylimide

Description:

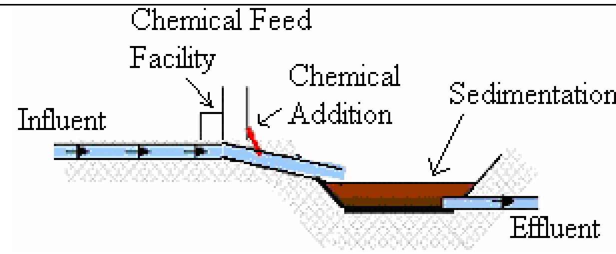
Adding chemical coagulants to storm water influent is one way to remove more sediment and associated contaminants and nutrients in a detention basin. Polyacrylamide (PAM) is one of several water-soluble coagulants that have demonstrated proficiency at reducing soil erosion when added at low concentrations to irrigation water. This reduction is accomplished by improving the stability of soil aggregates and flocculating suspended solids. When added to storm water, PAM reduces sediments, phosphorus, and pesticides. PAM could be used in a gel log or composite block placed in a basket or nylon mesh bag.

Constituent Removal:

Constituent Group	***Removal Efficiency***	***Level-of-Confidence***
Total Suspended Solids	●	○
Nutrients	◒	○
Pesticides	◒	○
Total Metals	◒	○
Dissolved Metals	○	○
Microbiological	◒	○
Litter	●	○
BOD	◒	○
TDS	○	○

Notes:

- No performance data encountered in field demonstrations.



Key Design Elements:

1. Chemical dose
2. Delivery and storage system
3. Mixing facilities

<u>Ancillary Facilities</u>

Detention basin must be provided downstream to capture flocculated particles.

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	***Level-of-Confidence***
▝	●

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: Mechanical equipment must be inspected and maintained on a regular basis. Sludge might need to be removed periodically. After each storm the sedimentation basin and the dosing systems should be inspected. The sedimentation basin would need to be cleaned when necessary. The dosing system should be recharged with PAM or PAM/$CaCO_3$ composite mixture when there is no residual gel.
- *Nuisance Control:* Depends on type of BMP it is used with.
- *Specialty Training/Equipment:* Staff and equipment necessary to replenish PAM supply. Depends on type of BMP it is used with; training required for inspection and replacement of PAM.

Project Development:

- *Right of Way Requirements:* Small footprint for chemical addition system, but downstream BMP requirement increases footprint.
- *Siting Constraints*: Need enough head for mixing.
- *Construction*: No unique requirements identified.

Advantages:

- Effective dose for anionic PAM is 3 to 50 times less than inorganic flocculants such as alum and ferric chlorides.
- Treating storm water with PAM does not require power or mechanical dosing equipment.
- Anionic PAM produces a large, stable floc, which settles much more rapidly than floc generated from voluminous metal hydroxides that are very difficult to dewater.
- PAM works over a very wide range of pH values, while inorganic flocculants are pH-sensitive and must be adjusted to be effective. Inorganic flocculants consume alkalinity and lower system pH, while PAM has a negligible effect on system pH.
- When collected, pond sediments may be used as road fill or taken to disposal sites where excavated (clean) soils are usually deposited. These options assume that the concentrations of metals and other contaminants associated with sediments are low enough to be disposed of in these conditions.

Constraints:

- Consistent dosing for a variety of flows may be difficult. PAM dissolves very slowly before reaching full hydration and activation. Polymer activation is also a critical step that requires appropriate mixing. PAM must be added to storm water where turbulence is high enough to simulate a rapid-mix system.
- Aqueous PAM concentrations are limited to about 3% active ingredient because viscosity increases so rapidly.
- An odorless, free-flowing crystalline called acrylamide (AMD) is a chemical intermediate in the production and synthesis of PAM. AMD is regulated under National Primary Drinking Water Regulations, CFR 141.32(e)(23). To ensure compliance, it will be necessary to estimate AMD concentrations in the pond effluent and in the groundwater at sites where infiltration occurs.

Sources:

- Applied Polymer Systems, INC. Floc Log®, www.siltstop.com
- PAM Research Project Washington State Department of Transportation (WSDOT). www.wsdot.wa.gov/eesc/environmental/pam.htm. April 2000.

Literature Sources of Performance Demonstrations:

- McElhiney M. & Osterli P. An Integrated Approach for Water Quality: The PAM Connection, West Stanislaus HUA, CA, Managing Irrigation-Induced Erosion and Infiltration with Polyacrylamide. University of Idaho Miscellaneous Publication No.101-96, 1996.
- Solka R.E & Lentz R.D. A PAM Primer: A brief history of PAM-related issues, Managing Irrigation-Induced Erosion and Infiltration with Polyacrylamide. University of Idaho Miscellaneous Publication No.101-96, 1996.
- Washington State Department Of Transportation (WSDOT). "Polyacrylamide (PAM) for Soil Erosion & Flocculation of Stormwater Detention Ponds at Highway Construction Sites." WSDOT High Runoff Manual, Section 4.4: WSDOT Experimental BMP-Quality Assurance/ Quality Control Plan. WAC 173-270-030.6.a.

Description:

Below grade storage are storm water detention systems using subsurface piping. Detained water can be reused or drained to the storm sewer or surface drainage. Corrugated pipe systems accomplish capture volume by interconnecting plastic or metal corrugated pipe.

Source:
www.epa.gov/region1/assistance/ceitts/stormwater/techs/adssystems.html

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	●	○
Nutrients	○	○
Pesticides	○	○
Total Metals	◒	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	●	○
BOD	○	○
TDS	○	○

Notes:

- Performance may be similar to detention basins depending on the outlet structure and storage size. Load removal may be less due to lack of infiltration.

Key Design Elements:

1. Cover requirements
2. Storage capacity
3. Class V injection well determination if designed to infiltrate
4. Filter fabric or equivalent to prevent migration of fines

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: Unknown frequency. Sediment removal may require confined space entry.
- *Nuisance Control:* System may be difficult to completely drain.
- *Specialty Training/Equipment:* Likely vactor equipment with the ability to clean horizontal lines. Equipment and training needed for confined space entry.

Project Development:

- *Right-of-Way Requirements*: Large area requirements, but area above storage system can be used if constructed properly.
- *Siting Constraints*: A minimum cover requirement in a non-traffic installation site is 12" (top of pipe to the top of grade). If traffic is present with a flexible pavement the minimum cover is 12" (top of pipe to the bottom of bituminous) for a pipe up to 36" in diameter, and 24" (top of pipe to the bottom of bituminous) for a pipe of 42"-60" in diameter. If traffic is present with a rigid pavement the minimum cover is 36" (top of pipe to top of pavement) for a pipe up to 36" in diameter, and 24" (top of pipe to top of pavement) for a pipe of 42"-60" in diameter. Buried systems may be difficult to drain completely. Not feasible for high groundwater areas.
- *Construction:* Proper compaction and backfill required to support overhead loading.

Advantages:

- May use area above storage system.
- No aesthetic impact.

Constraints:

- Difficult to inspect and maintain because it is buried.
- Standing water may create mosquito habitat.
- High construction cost.

Sources:

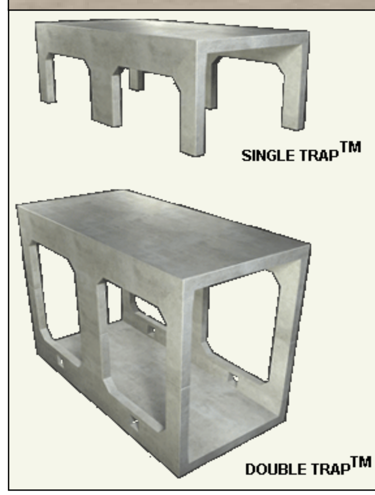
- Advanced Drainage Systems, Inc., www.ads-pipe.com
- Baughman Tile Co., www.baughmantile.com
- Contech Construction Products Inc. www.contech-cpi.com
- Lane-Enterprises, www.lane-enterprises.com
- U.S. Environmental Protection Agency, www.epa.gov/region1/assistance/ceitts/stormwater/techs/adssystems.html

Literature Sources of Performance Demonstrations:

- none identified

Description:

Below grade storage are storm water detention systems using subsurface piping. Detained water can be reused or drained to the storm sewer or surface drainage. StormTrap™ is a modular system designed to support overhead loads.



Source:
www.stormtrap.com

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	●	○
Nutrients	○	○
Pesticides	○	○
Total Metals	◒	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	●	○
BOD	○	○
TDS	○	○

Notes:

- Performance may be similar to detention basins depending on the outlet structure and storage size. Load removal may be less due to lack of infiltration.

Key Design Elements:

1. Cover requirements
2. Storage capacity
3. Class V injection well determination if designed to infiltrate
4. Filter fabric or equivalent to prevent migration of fines

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
▗	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: Unknown frequency. Sediment removal may require confined space entry.
- *Nuisance Control:* System may be difficult to completely drain.
- *Specialty Training/Equipment:* Most likely vactor equipment with the ability to clean horizontal lines. Equipment and training needed for confined space entry.

Project Development:

- *Right-of-Way Requirements*: Large area requirements, but area above storage system can be used if constructed properly.
- *Siting Constraints*: Not feasible for high groundwater areas.
- *Construction:* Proper compaction required to support overhead loading.

Advantages:

- May use area above storage system.
- No aesthetic impact.

Constraints:

- Difficult to inspect and maintain because it is buried.
- High construction costs.
- Standing water may create mosquito habitat.
- Buried systems may be difficult to assure complete draining.

Sources:

- StormTrap™, DoubleTrap™, www.stormtrap.com

Literature Sources of Performance Demonstrations:

- None identified.

Description:

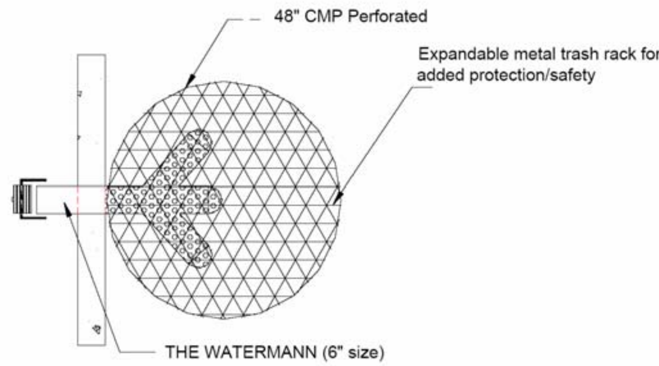
The Watermann is an outlet improvement for detention basins. It sits inside a 48” perforated section of pipe. It is secured in the wall of the outlet control structure and is grouted into place inside and outside of the outlet control structure in order to prevent leaking. Underneath the Watermann is a concrete or gravel base. The Watermann is completely exposed for inspection and maintenance. Surrounding the perforated section pipe is #4 stone which is used as added filtration for the water before entering the Watermann. Inside the structure, attached to the Watermann, is a removable end cap where the water quality orifice is drilled in the invert of the cap. As stormwater enters the pond it travels to the outlet control structure, through the #4 stone and the perforated section of pipe into the Watermann and out of the water quality orifice.

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	●	○
Nutrients	○	○
Pesticides	◒	○
Total Metals	◒	○
Dissolved Metals	○	○
Microbiological	◒	○
Litter	●	○
BOD	○	○
TDS	○	○

Notes:

- No water quality monitoring studies have been conducted to evaluate the treatment effectiveness of the Watermann.
- No increase in performance is expected over current outlet designs.
- Performance based on detention basin (Fact D-11)



Key Design Elements:

1. Device used to treat the first 1.2” of rainfall in Extended Dry Detention Ponds
2. Completely exposed to easy inspection and maintenance

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
N.A.	N.A.

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

● High	◒ Medium	○ Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Notes:

- Cost and performance expected to be roughly equivalent to current Caltrans designs.
- Range of unit cost: :$350

Issues and Concerns:

Maintenance:

- Requirements: None identified. None beyond normal detention basin.
- Nuisance Control: None beyond normal detention basin.
- Specialty Training/Equipment: No special requirements identified.

Project Development:

- Right-of-Way Requirements: Equivalent to detention basin.
- Siting Constraints: None identified. Equivalent to detention basin.
- Construction: No special requirements identified.

Advantages:

- Potentially increases surface area for water intake.
- Potentially increases flow direction.
- Potentially increases cleanout availability.
- Potentially increases ease of inspection/maintenance.

Constraints:

- None Identified

Sources:

- www.watermannwaterquality.com/index.htm

Literature Sources of Performance Demonstrations:

none

Detention/Sedimentation - Plate and Tube Settlers

Description:

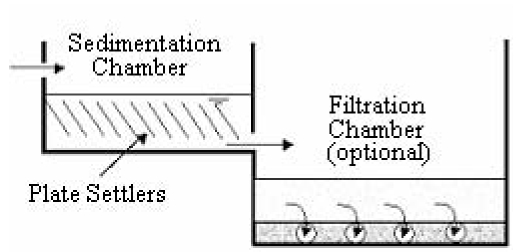
Improving sedimentation in the first chamber of an Austin filter or in a concrete detention basin can be achieved by installing plate or tube settlers in this chamber. Sedimentation of aqueous suspensions is accelerated by decreasing the distance particles must fall prior to removal. This can be achieved by making the basin shallower, but this is limited by practical aspects. One approach is to provide parallel plates or inclined tubes that permit solids to reach the plate or tube after only short distances of settling.

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	●	○
Nutrients	○	○
Pesticides	○	○
Total Metals	◒	○
Dissolved Metals	◒	○
Microbiological	◒	○
Litter	●	○
BOD	○	○
TDS	○	○

Notes:

- Removal efficiencies assumed plate and tube settlers used in conjunction with a detention basin.
- No performance data encountered in field demonstrations.
- The tube or plate settlers will enhance the sedimentation of fine particles.
- The Multi-Chambered Treatment Train (MCTT) includes a sedimentation chamber with tube settlers.



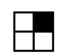
Key Design Elements:

1. Effective overflow rate (for sizing the sedimentation chamber)
2. Size and mounting of plates or tubes
3. Sludge collection and removal facilities

<u>Ancillary Facilities</u>

Necessary installed in a sedimentation basin that may or may not precede a filter.

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- Requirements: Cleaning and maintenance of the plate or tube settlers may require removing the plate settler structure. Litter may get trapped in the tube settler structure.
- *Nuisance Control:* None identified if designed to gravity drain.
- *Specialty Training/Equipment:* May require confined space training and equipment required to remove settlers.

Project Development:

- *Right-of-Way Requirements*: Similar to detention basins - less area may be required due to enhanced settling.
- *Siting Constraints*: Similar to detention basins.
- *Construction*: No unique requirements identified.

Advantages:

- Enhances particle removal of detention/sedimentation BMPs.

Constraints:

- Maintenance is more difficult than an open basin.
- Water must be introduced so that it flows through the settlers.

Sources:

- None identified.

Literature Sources of Performance Demonstrations:

- Harper, H. H., et al. "Performance Evaluation of Dry Detention Stormwater Management Systems." Sixth Biennial Stormwater Research Watershed Management Conference. September 1999.
- High-Rate Sedimentation, WWF Plan Project Number 4.19. EPA Urban Watershed Management Branch. http://www.epa.gov/ednnrmrl/projects/control/high.htm. April 2000.
- James M. Montgomery Consulting Engineers, Inc, Water Treatment Principles and Design. 1985.
- Keblin, Michael, et al. Effectiveness of Permanent Highway Runoff Controls: Sedimentation/Filtration Systems. October 1997.
- Meinholtz, T. L., et al. Screening/Floatation Treatment of Combined Sewer Outflows, Volume II: Full-Scale Operation Racine, Wisconsin. EPA-600/2-79-106a. Aug 1979.
- Pitt, R., et al. Stormwater Treatment at Critical Areas, Vol. 1: The Multi-Chambered Treatment Train. Cincinnati: US EPA. 1997.
- Robert Bein, William Frost and Associates, Scoping Study, Retrofit Pilot Program, Caltrans District 11. February 1998.
- United States Department of Transportation, Federal Highway Administration, Office of Environmental Planning: Evaluation and Management of Highway Runoff Water Quality, Washington, DC. June 1996.

Description:

Biocide fabrics are a form of antimicrobial filtration media, typically incorporated into the stormwater treatment devices like Drain Inlet Inserts. During low flow conditions, biocide filtration may be added to post construction stormwater systems to control bacterial pollutants. The woven or pressed media has an antimicrobial element that kills bacteria while the fabric filters out course sediment. In the case of X-TEX-AM (as shown) an antimicrobial nano-structure with covalent bonding is woven into the fibers, which kill off single cell organisms.

Source: www.spillcontainment.com/index.htm

Constituent Removal:

Constituent Group	***Removal Efficiency***	***Level-of-Confidence***
Total Suspended Solids	○	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	○	○
BOD	○	○
TDS	○	○

Notes:

- The microbial reductions reported by the manufacturer require much longer contact time than allowed by current use of filter fabrics in stormwater control.

Key Design Elements:

1. Proprietary design
2. Media Type

Cost Effectiveness Relative to Detention Basins:

Cost Efficiency	***Level-of-Confidence***
	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: Unknown replacement frequency.
- *Nuisance Control:* None identified.
- *Specialty Training/Equipment:* None identified.

Project Development:

- *Right-of-Way Requirements*: None identified.
- *Siting Constraints*: None identified.
- *Construction:* None identified.

Advantages:

- Natural process that disinfects without chemicals.
- Low maintenance requirements.
- Suitable for retrofit to existing facilities.

Constraints:

- No chemical residual for continued disinfection.
- Debris and sediment may exceed filter capacity depending on design.
- Requires long contact time (hours).

Sources:

- Ultra-Tech International, Inc., X-Tex-Am, www.attitudetechnology.com

Literature Sources of Performance Demonstrations:

- None identified

Disinfection – Chlorination/Hypochlorite

Description:

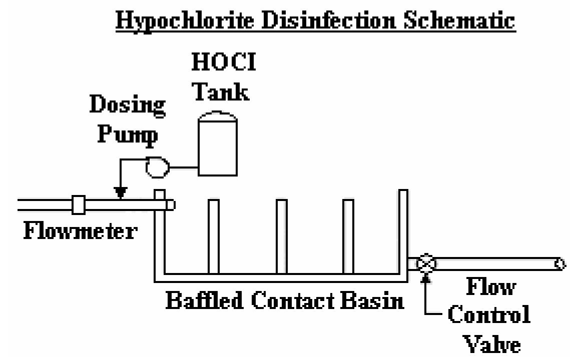
This technology consists of chemical disinfection of storm water using hypochlorous acid solution. The product of concentration (C) and contact time (t) may be adjusted to achieve various levels of disinfection as defined by the U.S. EPA. This process has proven successful for many years at inactivating pathogens and other microbial contaminants in drinking water and wastewater. The hypochlorous solution is to be injected at the end of the pipe before the baffled contact chamber or existing sedimentation basin. A chemical storage tank and chemical feed system capable of adjusting feed based on pipe flow is required. Hypochlorous acid dosing sufficient to achieve the desired Ct value is necessary. A contact chamber will be designed to achieve desired Ct value at high flows. Chlorine residual will be monitored. Dechlorination may be needed prior to discharge to receiving waters.

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	○	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	●	○
Litter	○	○
BOD	○	○
TDS	○	○

Notes:

- No long-term water quality monitoring studies have been conducted to evaluate treatment effectiveness for storm water.
- Some organics may be converted to other (possibly more harmful) products.



Key Design Elements:

1. Chlorine dose and contact time (Ct)
2. Chemical feed and storage facilities
3. Mixing facilities

<u>Ancillary Facilities</u>

Pretreatment to remove particles is required to achieve reliable disinfection. This will normally require sedimentation and filtration facilities upstream. Contact time must be provided in a contact basin of sedimentation basin downstream. Dechlorination system.

Cost Effectiveness Relative to Detention Basins:

Cost Efficiency	*Level-of-Confidence*
▝	◒

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: Mechanical equipment must be maintained. Chemicals must be replenished.
- *Nuisance Control:* None identified.
- *Specialty Training/Equipment:* Trained staff is required for mechanical equipment maintenance. Requires flow measurement device designed for a large range of flow conditions.

Project Development:

- *Right-of-Way Requirements*: Space requirements will depend on size of contact chamber needed to accommodate design flow. Pretreatment space requirement may be high.
- *Siting Constraints*: Restricted to sites with available power.
- *Construction*: May have start-up and testing requirements.

Advantages:

- Specific use guidelines available and proven effectiveness on microbial contaminants.
- Insect vectors not an issue with chlorinated water.

Constraints:

- Harmful to receiving water biota.
- Formation of disinfection by-products (DBPs).
- Pre-treatment (e.g., removal of suspended solids) required.
- Requires special handling procedures and chemical storage tank on site.
- Substantial excavation is needed.
- May require special permitting and discharge water quality monitoring.
- May result in unnatural looking conditions.

Sources:

- www.jajagroup.com
- www.ionics.com

Literature Sources of Performance Demonstrations:

- None available.

Description:

Ozone is used in water treatment for disinfection and oxidation. An ozone treatment system has four basic components: a gas feed system, an ozone generator, an ozone contactor, and an off-gas destruction system. The gas feed system provides a clean, dry source of oxygen to the generator. The ozone contactor transfers the ozone-rich gas into the water to be treated, and provides contact time for disinfection (or other reactions). The final process step, off-gas destruction, is required as ozone is toxic in the concentration present in the off-gas. A quench chamber to remove ozone residual in solution may also be added to the treatment train.

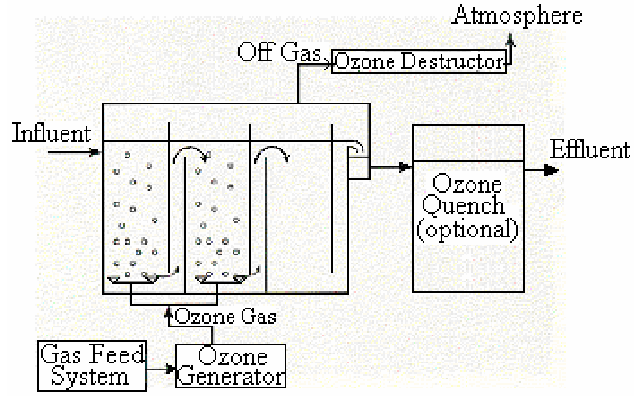
The ozone feed system uses air, high purity oxygen, or a mixture of the two. Ozone systems are most applicable for continuous flow. For wet weather intermittent flow, a water sensor will be needed to start the ozone generator, but the first flush of the runoff would not be treated unless an equalization/storage basin is provided.

Constituent Removal:

Constituent Group	***Removal Efficiency***	***Level-of-Confidence***
Total Suspended Solids	○	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	●	◒
Litter	○	○
BOD	○	○
TDS	○	○

Notes:

- The bacterial loads in the water upon leaving the contact chamber (City of Malibu, California Bioxide Technology) have been reduced to allowable U.S. EPA "recreational use" limits.



Key Design Elements:

1. Ozone dose and contact time (Ct)
2. Gas feed and ozone production equipment
3. Contact facilities
4. Quench tank

<u>Ancillary Facilities</u>

Pretreatment to remove particles is required to achieve reliable disinfection. This will normally require sedimentation and filtration facilities upstream. Contact time must be provided in a contact basin of sedimentation basin downstream.

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	***Level-of-Confidence***
▝	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- <u>*Requirements*</u>: Generators should be checked daily when in operation. Manual start-up of the ozone generator is preferable since it needs to be purged before each start-up. Filters and desiccant in air preparation systems should be changed periodically.
- <u>*Nuisance Control*</u>: None identified.
- <u>*Specialty Training/Equipment*</u>*:* The ozone system operation is to be performed by an operator with a water treatment background. Maintenance on the generators requires skilled technicians. This work can also be done by the equipment manufacturer if trained maintenance staff is not available.

Project Development:

- <u>*Right-of-Way Requirements*</u>*:* Space requirements will depend on size of contract chamber needed to accommodate design flow. Pretreatment space requirement may be high.
- <u>*Siting Constraints*</u>: Restricted to sites with available power.
- <u>*Construction*</u>*:* Avoid sediments in the contact chamber during construction. May have start-up and testing requirements.

Advantages:

- Ozone is a strong disinfectant and has a limited number of by-products.
- Low doses are required to complete disinfection.
- The process does not provide residual ozone concentration in the treated effluent. This will then minimize the impact on the receiving watershed.
- Even though ozone systems are complex, using highly technical instruments, the process is highly automated and very reliable.

Constraints:

- The ozone must be produced on site because it cannot be stored.
- Ozonation technology has a very high energy requirement.
- Some ozonation by-products may be harmful to the receiving water.
- In the presence of many compounds commonly encountered in water treatment, ozone decomposition forms hydroxyl free radicals.
- Ozone escaping to atmosphere may contribute to air pollution problems.
- The ozone diffusers can easily be damaged by debris and sediments. The pre-treatment step will have to remove most of the sediments as well as the oil and grease.

Sources:

- EPA Guidance Manual, Alternative Disinfectants and Oxidants, April 1999.
- Bioxide Corporation, Vanguard Stormwater Treatment System, www.bioxide.com/water.htm.
- PCI-Wedeco Environmental Technologies, Inc. One Fairfield Crescent, West Caldwell, NJ 07006.

Literature Sources of Performance Demonstrations:

- The City of Malibu, California, approved the use of Bioxide's technology to treat their runoff before it reaches the lagoon near the beach for a "dry-flow" run.

Description:

Ultraviolet (UV) light disinfects water by altering the genetic material (DNA) in the cells so bacteria, viruses and other microorganisms can no longer reproduce or infect. In UV disinfection systems, the light is produced by germicidal lamps (200 to 300 nanometers) enclosed in a pressure vessel or submerged in a water channel. As the water flows past the UV lamps, the microorganisms are exposed to a lethal dose of UV energy. The UV dose is the product of the light intensity and contact time.

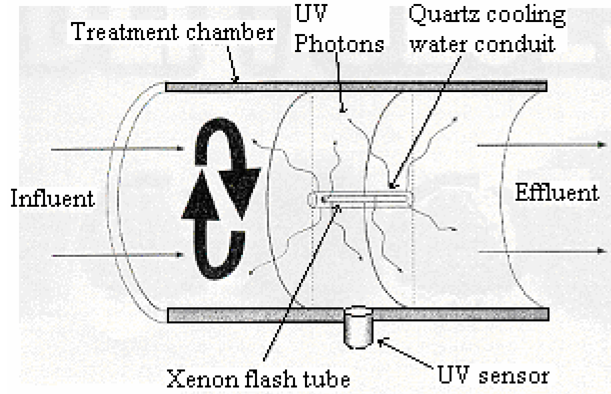
The UV disinfection treatment is an in-line device downstream of another treatment process. Potential applications could be downstream of a BMP such as a multiple chamber treatment train (MCTT); sedimentation basin or media filter.

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	○	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	●	○
Litter	○	○
BOD	○	○
TDS	○	○

Notes:

- Efficiency does not include required pretreatment.
- Removal efficiency depends on the UV dose applied to storm water.
- Factors affecting disinfection efficiency by UV light include: turbidity or suspended solids in the water, light-absorbing characteristics of the water, flow distribution across the UV lamps, contact time of water with UV light.
- Presence of some compounds in the storm water may reduce UV efficiency such as: dissolved or suspended matter may shield microorganisms from UV radiation; high turbidity of surface water can impact disinfection efficiency. Some chemical substances can decrease UV transmission. Color also reduces transmission within a UV contactor.



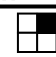
Key Design Elements:

1. Light intensity and contact time
2. Hydraulic system for moving water past lamps
3. Facilities for cleaning lamps

<u>Ancillary Facilities</u>

Pretreatment to remove particles is required to achieve reliable disinfection. This will normally require sedimentation and filtration facilities upstream.

Cost Effectiveness Relative to Detention Basins:

Cost Efficiency	*Level-of-Confidence*
	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◐	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: Each lamp must be cleaned periodically – typically every two weeks for wastewater discharges, but probably less frequently for intermittent storm water discharges. Pumps must be maintained.
- *Nuisance Control:* None identified.
- *Specialty Training/Equipment:* Highly trained staff is required for mechanical equipment maintenance.

Project Development:

- *Right-of-Way Requirements*: May be compact, but pretreatment space requirement may be high.
- *Siting Constraints*: Restricted to sites with available nearby power.
- *Construction:* Significant start-up and testing requirements.

Advantages:

- Natural process that disinfects without chemicals.
- Low maintenance requirements.
- Automated operations and controls.
- Compact system, small footprint compared to other disinfection technologies.
- Suitable for retrofit to existing facilities.
- No impact on other processes following UV treatment.
- UV disinfection can meet water quality standards that have stringent requirements for total and fecal coliform (from 2 to 200 MPN/100ml) without generating disinfection by-products (DBPs) or handling chemicals.

Constraints:

- No chemical residual for continued disinfection.
- Pretreatment requirement may be substantial.
- Clumping microorganism and turbidity can impact disinfection by harboring pathogens in the aggregates.
- Specific design parameters vary for individual waters (UV transmittance).
- Under certain conditions, some organisms are capable of repairing damaged DNA and reverting back to an active state to reproduce again (photoreactivation). This can be minimized by shielding the process stream or limiting the exposure of disinfected water to sunlight immediately following disinfection.
- Organic and inorganic fouling usually occurs on UV lamp sleeves. Inorganic fouling, which is related to the high temperature of the lamp, is the most difficult to clean because inorganics such as iron and manganese bind to the quartz sleeve.
- High power requirement.

Sources:

- Hanovia Ltd, www.hanovia.com
- PCI-Wedeco Environmental Technologies, Inc. One Fairfield Crescent, West Caldwell, NJ 07006

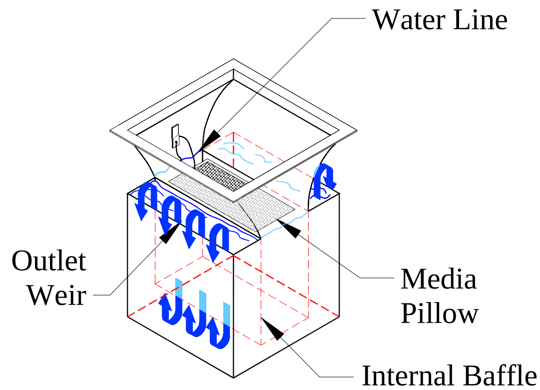
Literature Sources of Performance Demonstrations:

- Barrett, M. E. & J. F. Malina Jr. Stormwater Disinfection Research Work Plan. Center for Research in Water Resources: University of Texas, Austin. June 1999.
- EPA Guidance Manual, Alternative Disinfectants and Oxidants. April 1999.

Description:

The Hydro-Cartridge is a box with baffles that force water to flow upwards before it is discharged. The unit is fabricated with flanges that rest on the recess of the drain inlet. Complete in-line design requires flood flows to pass through the insert where pollutants are retained.

A modified version of this insert allows water to drain out the bottom between storms. It is called the Hydro-Cartridge Plus. It uses a float system to close the bottom of the insert during flow conditions. There are no known installations of this model.



Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	○	◒
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	○	○
BOD	○	○
TDS	○	○

Notes:

- Removal efficiency based on laboratory tests using ground silica (Sil-co-sil 106) (CIWMB, 2005).
- Laboratory tests using street sweepings resulted in 5 to 60 percent removal of TSS (Morgan, et. al., 2004).

Key Design Elements:

1. Provision for overflow or bypass to avoid flooding when the insert is full or clogged.

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
▖	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

● High	◒ Medium	○ Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: If there is high solids loading (often caused by vegetation within the drainage area), frequent inspection and maintenance is required.
- *Nuisance Control:* Holds a permanent pool of water so vector monitoring may be required.
- *Specialty Training/Equipment:* The larger units generally requires removal of sediment from the device with a vacuum truck.

Project Development:

- *Right-of-Way Requirements*: Installed within a storm water inlet.
- *Siting Constraints*: Requires a grated drop inlet.
- *Construction:* A watertight installation of the product is important to capture low flows.

Advantages:

- The devices can be installed relatively easily in new and existing facilities without structural modification.

Constraints:

- Holds standing water.
- High flows may flush accumulated material.
- If located along a shoulder or median, maintenance activities may require traffic control.
- Capacity (size of basket) is constrained by the size of the drain inlet to be retrofitted.
- Debris and litter may exceed drain inlet insert capacity.

Sources:

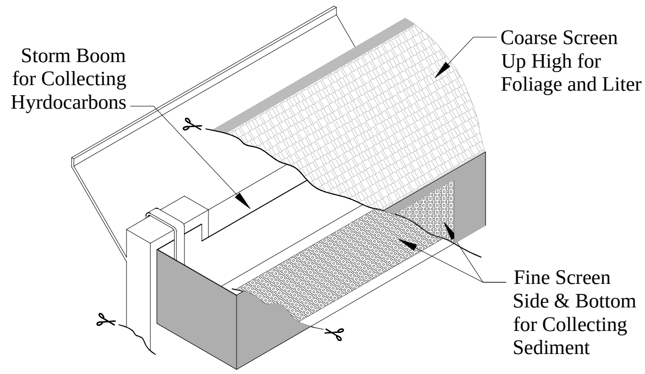
- Advanced Aquatic Products Int'l, Inc., www.hydro-cartridge.com

Literature Sources of Performance Demonstrations:

- Edwards, Findlay, Kristofor Brye, Robert Morgan, and Steven Burian. "Evaluation of Stormwater Catchbasin Inserts for Transportation Facilities." *In Proceedings of Transportation Research Board 2004 Annual Meeting*. January 11-15, 2004. Washington D.C. 2004.
- California Integrated Waste Management Board Used Oil Demonstration Grant by CSUS Office of Water Programs. "Laboratory Evaluation of Four Storm Drain Inlet Filters for Oil Removal," April 2005.

Description:

The Curb Inlet Basket is attached to the sidewall of the drain inlet. An oil boom may be added. Flood flow bypass occurs by overtopping the basket.



Source: www.suntreetech.com

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	○	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	●	◒
BOD	○	○
TDS	○	○

Notes:

Key Design Elements:

1. Proprietary devices
2. Hydraulic capacity and pollutant storage capacity
3. Provision for overflow or bypass to avoid flooding when the insert is full or clogged

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
▖	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- Requirements: If there is high solids loading (often caused by vegetation within the drainage area), frequent inspection and maintenance is required.
- *Nuisance Control:* None identified.
- *Specialty Training/Equipment:* No special requirements identified.

Project Development:

- *Right-of-Way Requirements*: Installed within a storm water inlet.
- *Siting Constraints*: Requires a curb inlet.
- *Construction:* Attached to sidewalls required, not a "drop in" device. A watertight installation of the product is important to capture low flows.

Advantages:

- There is a range of sizes that can be retrofitted to storm drain requirements. They are easy to install and clean. Maintenance can be simple and quick. Adsorption booms can be attached.

Constraints:

- Debris and litter may exceed drain inlet insert capacity.
- Capacity (size of basket) is constrained by the size of the drain inlet to be retrofitted.
- If located along a shoulder or median, maintenance activities may require traffic control.

Sources:

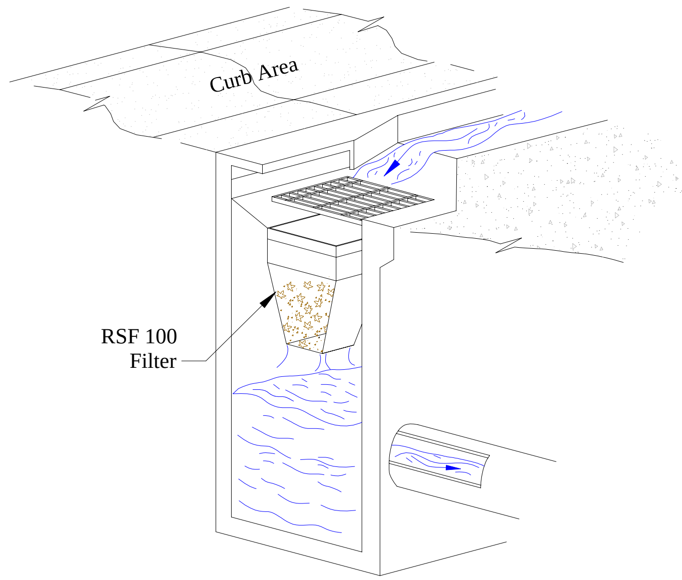
- Suntree Technologies Inc., www.suntreetech.com/catalog1/page6.html

Literature Sources of Performance Demonstrations:

- None identified.

Description:

The Ecosol™ Rapid Stormwater Filtration (RSF) uses a basket to separate debris from stormwater. The basket is attached to weir splash plates that attach to the side walls of the drain inlet. Flood flow bypass is accomplished by overtopping the basket.



Source: Ecosol™ Wastewater Filtration Systems

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	○	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	●	◒
BOD	○	○
TDS	○	○

Notes:

- Limited to trapping material 1.5mm and greater (www.ecosol.com.au).

Key Design Elements:

1. Proprietary devices
2. Hydraulic capacity and pollutant storage capacity
3. Provision for overflow or bypass to avoid flooding when the insert is full or clogged

Cost Effectiveness Relative too Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
▖	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- Requirements: If there is high solids loading (often caused by vegetation within the drainage area), frequent inspection and maintenance is required.
- *Nuisance Control:* None identified.
- *Specialty Training/Equipment:* No special requirements identified.

Project Development:

- *Right-of-Way Requirements*: Installed within a storm water inlet.
- *Siting Constraints*: Requires a grated curb or drop inlet.
- *Construction:* Attached to sidewalls required, not a "drop in" device. A watertight installation of the product is important to capture low flows.

Advantages:

- There is a range of sizes that can be retrofitted to storm drain requirements. They are easy to install and clean. Maintenance can be simple and quick. Adsorption booms can be attached.

Constraints:

- Debris and litter may exceed drain inlet insert capacity.
- Capacity (size of basket) is constrained by the size of the drain inlet to be retrofitted.
- If located along a shoulder or median, maintenance activities may require traffic control.

Sources:

- Ecosol^{TM} Wastewater Filtration Systems, www.ecosol.com.au
- www.sydneycoastalcouncils.com.au/stormwater/SWFeb2002.htm

Literature Sources of Performance Demonstrations:

- www.uprct.nsw.gov.au/cleanstreams/results.htm

Description:

Enviropod™ is a lined basket attached to the side walls of a drain inlet. Flood flow bypass is accomplished by overtopping the basket.

Source: www.ingalenviro.com

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	◒	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	●	◒
BOD	○	○
TDS	○	○

Notes:

- One installation at the Caltrans Kearny Mesa maintenance station is being monitored by the manufacturer.
- Installations throughout Australia and New Zealand.
- Report by the manufacturer indicates an average of 78% removal of TSS (Enviropod™ Filter Wairau Rd Trail).

Key Design Elements:

1. Proprietary devices
2. Hydraulic capacity and pollutant storage capacity
3. Provision for overflow or bypass to avoid flooding when the insert is full or clogged

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
◱	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- Requirements: If there is high solids loading (often caused by vegetation within the drainage area), frequent inspection and maintenance is required.
- *Nuisance Control:* None identified.
- *Specialty Training/Equipment:* No special requirements identified.

Project Development:

- *Right-of-Way Requirements*: Installed within a storm water inlet.
- *Siting Constraints*: Requires a grated drop inlet.
- *Construction:* A watertight installation of the product is important to capture low flows.

Advantages:

- There is a range of sizes that can be retrofitted to storm drain requirements. They are easy to install and clean. Maintenance can be simple and quick. Adsorption booms can be attached.

Constraints:

- Debris and litter may exceed drain inlet insert capacity.
- Capacity (size of basket) is constrained by the size of the drain inlet to be retrofitted.
- If located along a shoulder or median, maintenance activities may require traffic control.

Sources:

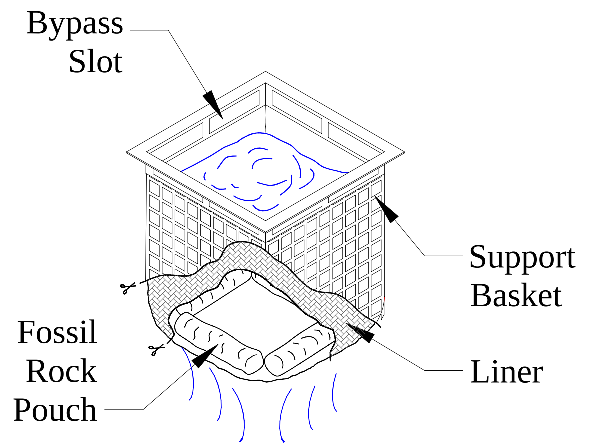
- Ingal Environmental Services, www.ingalenviro.com/enviropod.asp

Literature Sources of Performance Demonstrations:

- Enviropod^{TM} Filter Wairau Rd Trail, http://www.ingalenviro.com/enviropod.asp
- Evaluation of ENVIROPOD stormwater treatment units, www.ingalenviro.com/enviropod.asp

Description:

The FloGard Plus is a basket system that is attached to splash plates that rests on the recess of a drain inlet. The basket is lined with fabric mesh. Oil absorbing pillows can be placed in the basket. Flood flow bypass is accomplished by overtopping the basket and flowing under the splash plates.



Source: www.kristar.com

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	◒	◒
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	●	◒
BOD	○	○
TDS	○	○

Notes:

- Removal efficiency based on laboratory tests using ground silica (Sil-co-sil 106) (CIWMB, 2005).
- Testing by City of Los Angeles by data collection was incomplete.

Key Design Elements:

1. Proprietary devices
2. Hydraulic capacity and pollutant storage capacity
3. Provision for overflow or bypass to avoid flooding when the insert is full or clogged

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
▖	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- Requirements: If there is high solids loading (often caused by vegetation within the drainage area), frequent inspection and maintenance is required.
- *Nuisance Control:* None identified.
- *Specialty Training/Equipment:* No special requirements identified.

Project Development:

- *Right-of-Way Requirements*: Installed within a storm water inlet.
- *Siting Constraints*: Requires a grated drop inlet.
- *Construction:* A watertight installation of the product is important to capture low flows.

Advantages:

- There is a range of sizes that can be retrofitted to storm drain requirements. They are easy to install and clean. Maintenance can be simple and quick. Adsorption booms can be attached.

Constraints:

- Debris and litter may exceed drain inlet insert capacity.
- Capacity (size of basket) is constrained by the size of the drain inlet to be retrofitted.
- If located along a shoulder or median, maintenance activities may require traffic control.

Sources:

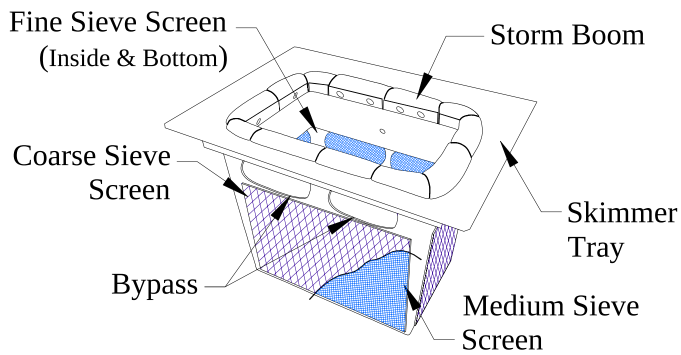
- KriStar Enterprises, http://kristar.com/level2/products/hicap.html

Literature Sources of Performance Demonstrations:

- UCLA (University of California Los Angeles). 2000. *Test of Fossil Filter Basin Insert.* October 2000.
- California Integrated Waste Management Board Used Oil Demonstration Grant by CSUS Office of Water Programs. “Laboratory Evaluation of Four Storm Drain Inlet Filters for Oil Removal,” April 2005.

Description:

The Grate Inlet Skimmer Box has large cutouts that are covered with expanded metal screens that retain litter and debris. The box has weirs that hold absorbent booms. The weirs hang from the recess oh the storm drain. Flood flow bypass occurs by overtopping the box.



Source: www.suntreetech.com

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	○	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	●	◒
BOD	○	○
TDS	○	○

Notes:

- Sediment removal tests sponsored by manufacturer do not seem typical of stormwater because of dumping of sediment near inlet and subsequent washing into the inlet.

Key Design Elements:

1. Proprietary devices
2. Hydraulic capacity and pollutant storage capacity
3. Provision for overflow or bypass to avoid flooding when the insert is full or clogged

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
▝	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: If there is high solids loading (often caused by vegetation within the drainage area), frequent inspection and maintenance is required.
- *Nuisance Control:* Pooled water unlikely.
- *Specialty Training/Equipment:* No special requirements identified.

Project Development:

- *Right-of-Way Requirements*: Installed within a storm water inlet.
- *Siting Constraints*: Requires a grated drop inlet.
- *Construction:* A watertight installation of the product is important to capture low flows.

Advantages:

- The devices can be installed relatively easily in new and existing facilities without structural modification.
- There are options to install fine sediment screens.

Constraints:

- If located along a shoulder or median, maintenance activities may require traffic control.

Sources:

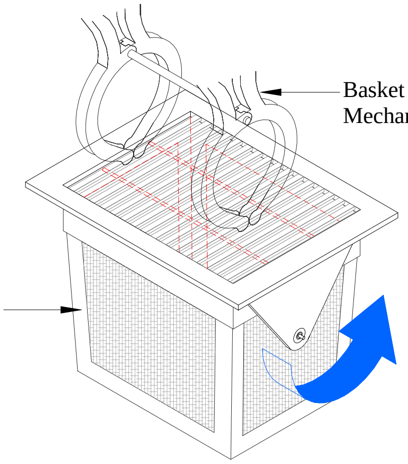
- Suntree Technologies, Inc., www.suntreetech.com

Literature Sources of Performance Demonstrations:

- Creech Engineers, 2001. Pollutant Removal Testing For Suntree Technologies Grate Inlet Skimmer Box. Prepared for Suntree Technologies, Inc. Available on www.suntreetech.com

Description:

This device is similar to other basket inserts that rests on the sidewalls of standard drain inlets. This insert has a unique design that allows for automated removal of the entire basket similar to mechanisms used by garbage trucks. Flood flow bypass occurs through ports on the sides of the basket.



Concept by OWP

Constituent Removal:

Constituent Group	***Removal Efficiency***	***Level-of-Confidence***
Total Suspended Solids	○	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	●	○
BOD	○	○
TDS	○	○

Notes:

Key Design Elements:

1. Non-proprietary devices
2. Hydraulic capacity and pollutant storage capacity
3. Provision for overflow or bypass to avoid flooding when the insert is full or clogged

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	***Level-of-Confidence***
	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- _Requirements_: If there is high solids loading (often caused by vegetation within the drainage area), frequent inspection and maintenance is required.
- _Nuisance Control_: None identified.
- _Specialty Training/Equipment_: Special modified garbage trucks. A cushion truck may also be required to protect roadside maintenance activities.

Project Development:

- _Right-of-Way Requirements_: Installed within a storm water inlet.
- _Siting Constraints_: Requires a curb inlet.
- _Construction_: Replaces the inlet gate.

Advantages:

- Maintenance can be simple and quick.
- No space requirement. May allow TMDL compliance where end-of-pipe GSRDs are not feasible.

Constraints:

- Debris and litter may exceed drain inlet insert capacity.
- Capacity (size of basket) is constrained by the size of the drain inlet to be retrofitted.
- If located along a shoulder or median, maintenance activities may require traffic control.

Sources:

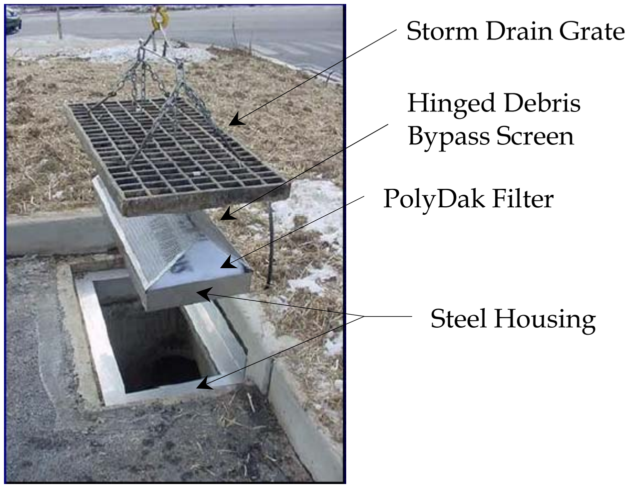
- None Available

Literature Sources of Performance Demonstrations:

- None identified.

Description:

Inceptors are stainless steel baskets that suspend from drain inlet grates. The frame contains a “PolyDak” filter pillow. Flood flow bypass is accomplished by overtopping the basket.



Source: www.stormdrains.com

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	●	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	●	◒
BOD	○	○
TDS	○	○

Notes:

- Laboratory test information appears to contain only one data point for determining metals removal efficiency; in addition, reported bench test values for TSS of over 2,000 mg/L are higher than typically found in stormwater runoff (EPA NE).

Key Design Elements:

1. Proprietary devices
2. Hydraulic capacity and pollutant storage capacity
3. Provision for overflow or bypass to avoid flooding when the insert is full or clogged

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
▖	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: If there is high solids loading (often caused by vegetation within the drainage area), frequent inspection and maintenance is required. Manufacturer recommends annual replacement of filter pillow.
- *Nuisance Control:* None identified.
- *Specialty Training/Equipment:* Basket is retrieved by pulling the drain inlet grate.

Project Development:

- *Right-of-Way Requirements*: Installed within a storm water inlet.
- *Siting Constraints*: Requires a grated drop inlet.
- *Construction:* A watertight installation of the product is important to capture low flows.

Advantages:

- There is a range of sizes that can be retrofitted to storm drain requirements. They are easy to install and clean. Maintenance can be simple and quick.

Constraints:

- Debris and litter may exceed drain inlet insert capacity.
- Capacity (size of basket) is constrained by the size of the drain inlet to be retrofitted.
- It is unclear that low flows will be captured by the suspended filter assembly.
- If located along a shoulder or median, maintenance activities may require traffic control.

Sources:

- Stormdrain Solutions, Devon, PA. www.stormdrains.com

Literature Sources of Performance Demonstrations:

- EPA NE Storm Water-Inceptor, U.S. Environmental Protection Agency website, January 2006, www.epa.gov/region1/assistance/ceitts/stormwater/techs/inceptor.html

Description:

Piranha are stainless steel baskets that suspend from drain inlet grates. The frame contains a filter pillow and refuse bag. Flood flow bypass is accomplished by overtopping the basket.

Source: www.go-tsm.com

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	○	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	●	○
BOD	○	○
TDS	○	○

Notes:

- Oil removal data is available from the manufacturer.
- Litter removal estimated from claims of similarly designed drain inlet inserts.

Key Design Elements:

1. Proprietary devices
2. Hydraulic capacity and pollutant storage capacity
3. Provision for overflow or bypass to avoid flooding when the insert is full or clogged

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: If there is high solids loading (often caused by vegetation within the drainage area), frequent inspection and maintenance is required.
- *Nuisance Control:* None identified.
- *Specialty Training/Equipment:* Basket is retrieved by pulling the drain inlet grate.

Project Development:

- *Right-of-Way Requirements*: Installed within a storm water inlet.
- *Siting Constraints*: Requires a grated drop inlet.
- *Construction:* A watertight installation of the product is important to capture low flows.

Advantages:

- There is a range of sizes that can be retrofitted to storm drain requirements. They are easy to install and clean. Maintenance can be simple and quick.

Constraints:

- Debris and litter may exceed drain inlet insert capacity.
- Capacity (size of basket) is constrained by the size of the drain inlet to be retrofitted.
- It is unclear that low flows will be captured by the suspended filter assembly.
- If located along a shoulder or median, maintenance activities may require traffic control.

Sources:

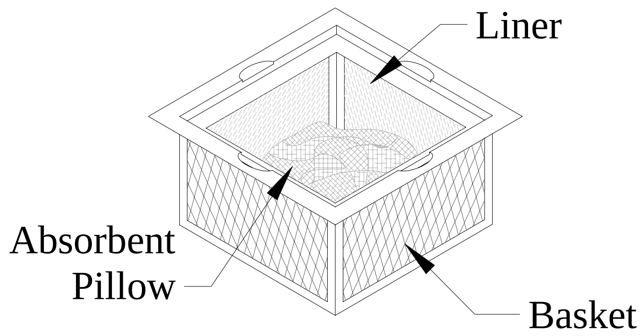
- Pollution Solution Inc., www.psiyes.com/links.htm

Literature Sources of Performance Demonstrations:

- None

Description:

Sea Life Saver™ inserts is a basket that hangs from a flange that rests on the drain inlet recess. The basket is stuffed with absorbent pads. Flood flow bypass is accomplished through slots in the side of the basket.



Source: www.sealifesaver.com

Constituent Removal:

Constituent Group	***Removal Efficiency***	***Level-of-Confidence***
Total Suspended Solids	○	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	●	◒
BOD	○	○
TDS	○	○

Notes:

Key Design Elements:

1. Proprietary devices.
2. Hydraulic capacity and litter storage capacity.
3. Provision for overflow or bypass to avoid flooding when the insert is full or clogged.

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	***Level-of-Confidence***
▖	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: If there is high solids loading (often caused by vegetation within the drainage area), frequent inspection and maintenance is required.
- *Nuisance Control:* None identified.
- *Specialty Training/Equipment:* No special requirements identified.

Project Development:

- *Right-of-Way Requirements*: Installed within a storm water inlet.
- *Siting Constraints*: Requires a grated drop inlet.
- *Construction:* A watertight installation of the product is important to capture low flows.

Advantages:

- There is a range of sizes that can be retrofitted to storm drain requirements. They are easy to install and clean. Maintenance can be simple and quick. Adsorption booms can be attached.

Constraints:

- Debris and litter may exceed drain inlet insert capacity.
- Capacity (size of basket) is constrained by the size of the drain inlet to be retrofitted.
- If located along a shoulder or median, maintenance activities may require traffic control.

Sources:

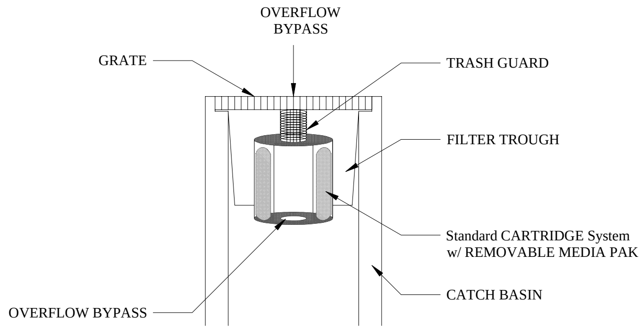
- Lucas Environmental Stormwater Services, Inc., www.sealifesaver.com

Literature Sources of Performance Demonstrations:

- None identified.

Description:

The Trash Guard TG-Series is a basket designed to capture large debris.



Source: http://remfilters.com

Key Design Elements:

1. Proprietary devices
2. Hydraulic capacity and pollutant storage capacity
3. Provision for overflow or bypass to avoid flooding when the insert is full or clogged

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	○	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	●	○
BOD	○	○
TDS	○	○

Notes:

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
▖	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- _Requirements_: If there is high solids loading (often caused by vegetation within the drainage area), frequent inspection and maintenance is required.
- _Nuisance Control:_ None identified.
- _Specialty Training/Equipment:_ No special requirements identified.

Project Development:

- _Right-of-Way Requirements_: Installed within a storm water inlet.
- _Siting Constraints_: Requires a grated drop inlet.
- _Construction:_ A watertight installation of the product is important to capture low flows.

Advantages:

- They are easy to install and clean. Maintenance can be simple and quick. Adsorption booms can be attached.

Constraints:

- Debris and litter may exceed drain inlet insert capacity.
- Capacity (size of basket) is constrained by the size of the drain inlet to be retrofitted.
- If located along a shoulder or median, maintenance activities may require traffic control.

Sources:

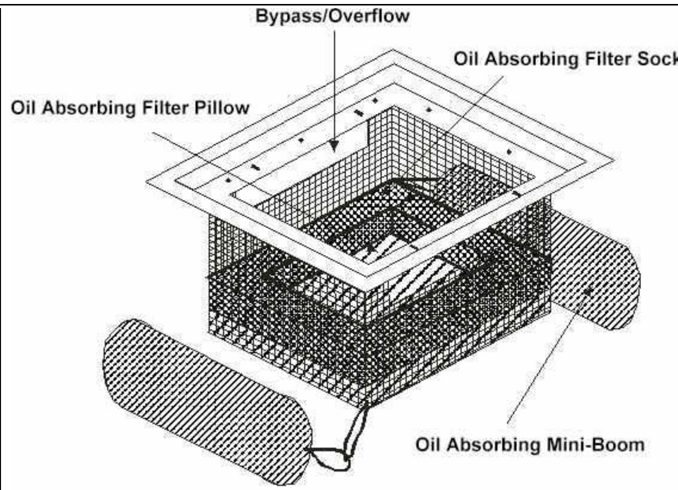
- Revel Environmental Manufacturing, Inc., http://www.remfilters.com

Literature Sources of Performance Demonstrations:

- None identified

Description:

Wire catch basin inserts are simple basket type inserts with a flood bypass slot cut just underneath the top support frame from witch the basket hangs. This frame has flanges that sit in the recess of a drain inlet. Oil absorbing filter socks can be place in the basket. Booms are available to tether to the outside.



Source: www.gullywasher.com/litter,.htm

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	○	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	●	◒
BOD	○	○
TDS	○	○

Notes:

Key Design Elements:

1. Proprietary devices
2. Hydraulic capacity and pollutant storage capacity
3. Provision for overflow or bypass to avoid flooding when the insert is full or clogged

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: If there is high solids loading (often caused by vegetation within the drainage area), frequent inspection and maintenance is required.
- *Nuisance Control:* None identified.
- *Specialty Training/Equipment:* No special requirements identified.

Project Development:

- *Right-of-Way Requirements*: Installed within a storm water inlet.
- *Siting Constraints*: Requires a grated drop inlet.
- *Construction:* A watertight installation of the product is important to capture low flows.

Advantages:

- There is a range of sizes that can be retrofitted to storm drain requirements. They are easy to install and clean. Maintenance can be simple and quick. Adsorption booms can be attached.

Constraints:

- Debris and litter may exceed drain inlet insert capacity.
- Capacity (size of basket) is constrained by the size of the drain inlet to be retrofitted.
- If located along a shoulder or median, maintenance activities may require traffic control.

Sources:

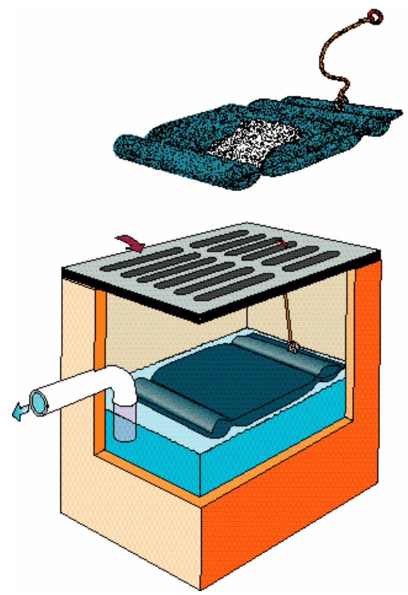
- Advanced Environmental Solutions, Inc., www.advenvironmental.com, formerly known as Gullywasher, www.gullywasher.com

Literature Sources of Performance Demonstrations:

- None identified.

Description:

Passive Skimmers float directly on the water surface and absorb floating hydrocarbons. Hydrocarbons are transformed into manageable solid waste. Besides drain inlet inserts passive skimmers can float in storm water catch basins, sumps, vaults, holding tanks, and oil/water separators.



Source:
www.epa.gov/region1/assistance/ceitts/stormwater/techs/streamguardskimmer.html

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	○	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	○	○
BOD	○	○
TDS	○	○

Notes:

- This device removes floatable hydrocarbons.

Key Design Elements:

None identified.

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
▖	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- _Requirements_: Must be regularly inspected. Maintenance consists of pulling the skimmer out and replacing it.
- _Nuisance Control:_ None identified.
- _Specialty Training/Equipment:_ No special requirements identified.

Project Development:

- _Right of Way Requirements_: None identified.
- _Siting Constraints_: None identified.
- _Construction_: Simple installation.

Advantages:

- They "lock up" absorbed hydrocarbons and will not leak or leach, so they can remain in place for long periods.
- Maintenance is quick and easy.
- Requires no structural modifications to existing drainage structures or oil/water separators.

Constraints:

- Skimmers only trap hydrocarbons, and do not contribute to sediment control.
- If a skimmer has adsorbed to its maximum capacity, hydrocarbons will not be captured until the device is replaced.
- If located along a shoulder or median, maintenance activities may require traffic control.

Sources:

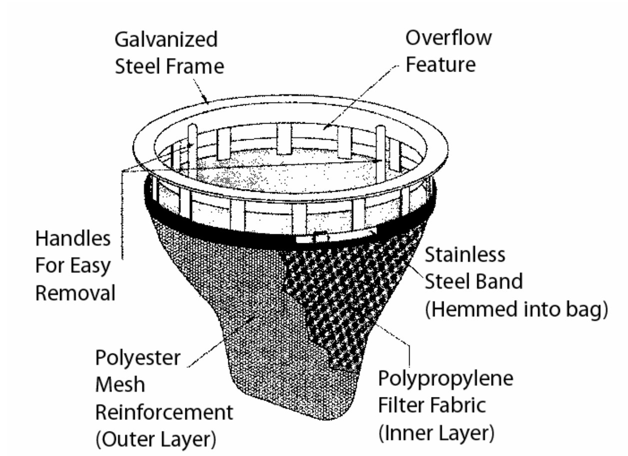
- AbTech Industries, www.abtechindustries.com, [see OARS® Passive Skimmer].
- Bowhead Manufacturing Company, LLC., www.bmccatalog.com, [see StreamGuard™ Passive Skimmer].

Literature Sources of Performance Documentation:

- Environmental Protection Agency, www.epa.gov/region1/assistance/ceitts/stormwater/techs/streamguardskimmer.html
- Environmental Protection Agency, www.epa.gov/region1/assistance/ceitts/stormwater/techs/abtechskimmer.html

Description:

The Catch-All uses a steel frame to sit on the recess of a storm drain inlet and holds a polypropylene filter fabric bag. The bag is reinforced by a polyester shell. The bags are attached to the steel support by a steel band. Flood flow surcharges are accomplished through opening the steel support frame. A hydrocarbon filtering pillow is available that fits inside the bag.



Source: www.marathonmaterials.com

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	○	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	●	○
BOD	○	○
TDS	○	○

Notes:

- Caltrans tested a fabric drain inlet insert. See Fact Sheet C-9.

Key Design Elements:

1. Proprietary devices
2. Hydraulic capacity and pollutant storage capacity
3. Provision for overflow or bypass to avoid flooding when the insert is full or clogged

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
▖	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: If there is high solids loading (often caused by vegetation within the drainage area), frequent inspection and maintenance is required.
- *Nuisance Control:* None identified.
- *Specialty Training/Equipment:* It may be a challenge for one person to lift up the storm grate and remove a full sock beneath it.

Project Development:

- *Right-of-Way Requirements*: Installed within a storm water inlet.
- *Siting Constraints*: Requires a grated drop inlet.
- *Construction:* A watertight installation of the product is important to capture low flows.

Advantages:

- Easy to install and maintain.

Constraints:

- If the socks become too full they may be difficult to lift out of the drain to clean/replace.
- Excess debris may affect drain inlet capacity.
- If located along a shoulder or median, maintenance activities may require traffic control.
- Debris and litter may exceed drain inlet insert capacity.
- Capacity (size of basket) is constrained by the size of the drain inlet to be retrofitted.

Sources:

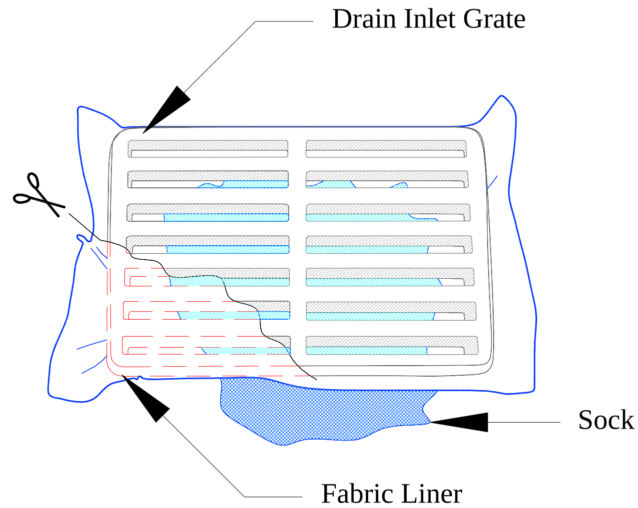
- Marathon Materials, www.marathonmaterials.com

Literature Sources of Performance Demonstrations:

- None Identified

Description:

The Drain Diaper™ is a fabric bag that is held in place by the drain inlet grate.



Source: www.petromarinecompany.com

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	○	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	●	○
BOD	○	○
TDS	○	○

Notes:

- Caltrans tested a fabric drain inlet insert. See Fact Sheet C-9.

Key Design Elements:

1. Proprietary devices
2. Hydraulic capacity and pollutant storage capacity
3. Provision for overflow or bypass to avoid flooding when the insert is full or clogged

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
▖	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

● High	◒ Medium	○ Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: If there is high solids loading (often caused by vegetation within the drainage area), frequent inspection and maintenance is required.
- *Nuisance Control:* None identified.
- *Specialty Training/Equipment:* It may be a challenge for one person to lift up the storm grate and remove a full sock beneath it.

Project Development:

- *Right-of-Way Requirements*: Installed within a storm water inlet
- *Siting Constraints*: Requires a grated drop inlet.
- *Construction:* Bag may slip under the weight of water and debris if not tightly held by inlet grate. Shims may be required.

Advantages:

- Easy to install and maintain.

Constraints:

- If the socks become too full they may be difficult to lift out of the drain to clean/replace.
- If located along a shoulder or median, maintenance activities may require traffic control.
- Debris and litter may exceed drain inlet insert capacity.
- Capacity (size of basket) is constrained by the size of the drain inlet to be retrofitted.

Sources:

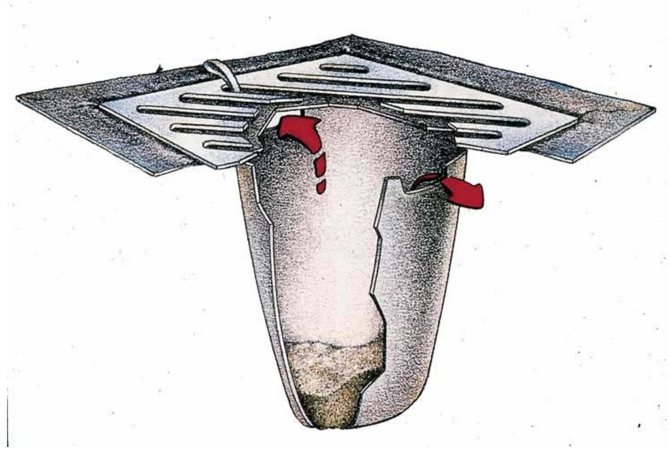
- Petro-Marine, Inc., www.petromarinecompany.com/petro-marine/noname.html

Literature Sources of Performance Demonstrations:

- None identified

Description:

The Drain Guard™ is a fabric bag that is held in place by the drain inlet grate.



Source: www.stormwater-products.com

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	○	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	●	○
BOD	○	○
TDS	○	○

Notes:

- This technology closely resembles that of StreamGuard (fact sheet C-9) previously tested by Caltrans.
- Conflicting performance data. EPA reports up to 80% removal while Caltrans test of a similar unit showed less than 30%.

Key Design Elements:

1. Proprietary devices
2. Hydraulic capacity and pollutant storage capacity
3. Provision for overflow or bypass to avoid flooding when the insert is full or clogged

Cost Effectiveness Relative to Detention Basins::

Cost Effectiveness	*Level-of-Confidence*
▖	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- Requirements: If there is high solids loading (often caused by vegetation within the drainage area), frequent inspection and maintenance is required.
- *Nuisance Control:* None identified.
- *Specialty Training/Equipment:* It may be a challenge for one person to lift up the storm grate and remove a full sock beneath it.

Project Development:

- *Right-of-Way Requirements*: Installed within a storm water inlet.
- *Siting Constraints*: Requires a grated drop inlet.
- *Construction:* Bag may slip under the weight of water and debris if not tightly held by inlet grate. Shims may be required.

Advantages:

- Easy to install and maintain. Some designs have a pop-up capacity Indicator that alerts maintenance personnel that the sock needs to be replaced or emptied.

Constraints:

- If the socks become too full they may be difficult to lift out of the drain to clean/replace.
- If located along a shoulder or median, maintenance activities may require traffic control.
- Debris and litter may exceed drain inlet insert capacity.
- Capacity (size of basket) is constrained by the size of the drain inlet to be retrofitted.

Sources:

- Advanced Environmental Solutions, Inc., www.advenvironmental.com

Literature Sources of Performance Demonstrations:

- Environmental Protection Agency, www.epa.gov/region1/assistance/ceitts/stormwater/techs/ultradrainguard.html

Description:

The Drain Pac™ is a polypropylene non-woven bag that is attached to a metal frame. This frame rests on the recess of a drain inlet. Buoyant flaps cover holes in the bag that provide flood flow surcharge.

Source: www.unitedstormwater.com

Constituent Removal:

Constituent Group	***Removal Efficiency***	***Level-of-Confidence***
Total Suspended Solids	○	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	●	○
BOD	○	○
TDS	○	○

Notes:

- DrainPac™: Bourelle, Andy, Tahoe Keys Installs DrainPacs™, *Tahoe Tribune*, November 5, 1999; Grate Inlet Skimmer Box: Happel, Tom, Reedy Creek Report 3, December 23, 1999; many field tests have been performed, but not officially published.
- Caltrans tested a fabric drain inlet insert. See Fact Sheet C-9.
- Currently being laboratory tested by CSUS Office of Water Programs for oil removal.

Key Design Elements:

1. Proprietary devices
2. Hydraulic capacity and pollutant storage capacity
3. Provision for overflow or bypass to avoid flooding when the insert is full or clogged

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	***Level-of-Confidence***
▖	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: If there is high solids loading (often caused by vegetation within the drainage area), frequent inspection and maintenance is required.
- *Nuisance Control:* None identified.
- *Specialty Training/Equipment:* It may be a challenge for one person to lift up the storm grate and remove a full sock beneath it.

Project Development:

- *Right-of-Way Requirements*: Installed within a storm water inlet.
- *Siting Constraints*: Requires a grated drop inlet.
- *Construction:* A watertight installation of the product is important to capture low flows.

Advantages:

- Easy to install and maintain.

Constraints:

- If the socks become too full they may be difficult to lift out of the drain to clean/replace.
- If located along a shoulder or median, maintenance activities may require traffic control.
- Debris and litter may exceed drain inlet insert capacity.
- Capacity (size of basket) is constrained by the size of the drain inlet to be retrofitted.

Sources:

- PacTec, Inc., www.unitedstormwater.com

Literature Sources of Performance Demonstrations:

- Morgan, Robert, Findlay Edwards, Kristofor Brye, and Steven Burian. "Evaluation of Stormwater Catchbasin Inserts for Transportation Facilities" TRB 2004 Annual Meeting
- NELP, "Completes Stormwater Catch Basin Insert Evaluation Study," December 2003, www.mayportnelp.com/succedd/press_releases?StormWater.html (21 August 2003).
- Drain Pac Filter Insert Results (Michael K. Stenstorm, personal communication, September 25, 1998).

Description:

The Sewer Eco-Collar has bags that are suspended from troughs. The troughs are attached to the side walls of the drain inlet and they direct flow to the bags. As a spill response, hooks on the trough allow for temporary use of buckets to capture accidental spills.

Source: www.swp3.com

Key Design Elements:

1. Proprietary devices
2. Hydraulic capacity and pollutant storage capacity
3. Provision for overflow or bypass to avoid flooding when the insert is full or clogged

Constituent Removal:

Constituent Group	***Removal Efficiency***	***Level-of-Confidence***
Total Suspended Solids	○	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	●	○
BOD	○	○
TDS	○	○

Notes:

- No performance data encountered in field demonstrations or in literature.

Cost Effectiveness Relative to Detention Basins::

Cost Effectiveness	***Level-of-Confidence***
▖	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- _Requirements_: If there is high solids loading (often caused by vegetation within the drainage area), frequent inspection and maintenance is required.
- _Nuisance Control:_ None identified.
- _Specialty Training/Equipment:_ It may be a challenge for one person to lift up the storm grate and remove a full sock beneath it.

Project Development:

- _Right-of-Way Requirements_: Installed within a storm water inlet.
- _Siting Constraints_: Requires a grated drop inlet.
- _Construction:_ A watertight installation of the product is important to capture low flows.

Advantages:

- Easy to install and maintain.

Constraints:

- Excess debris may affect drain inlet capacity.
- If located along a shoulder or median, maintenance activities may require traffic control.
- Debris and litter may exceed drain inlet insert capacity.
- Capacity (size of basket) is constrained by the size of the drain inlet to be retrofitted.

Sources:

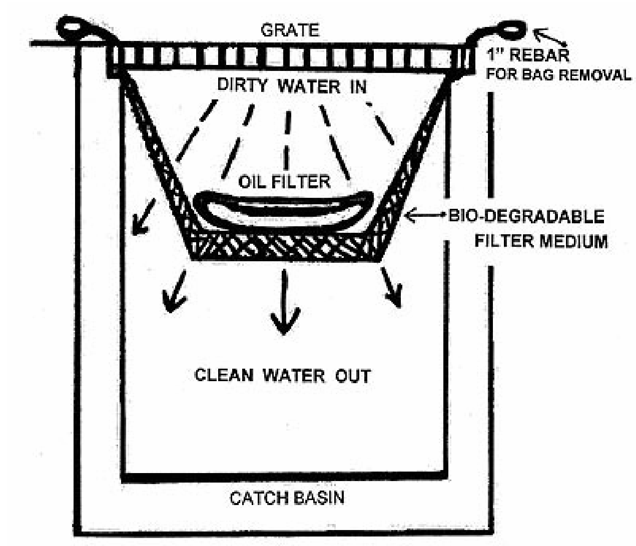
- Sewer Eco-Collar, www.swp3.com

Literature Sources of Performance Demonstrations:

- None identified

Description:

StreamSaver™ is held in place by the drain inlet grate. The insert is made of cellulose fiber. Flood flow bypass is accomplished via slats in the side of the insert near the grate. StreamSaver™ is also available in a double bag configuration. This side-by-side model is the "Double G Series."



Source: www.emeraldseedandsupply.com

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	○	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	●	◒
BOD	○	○
TDS	○	○

Notes:

- Manufacturer reports 70% reduction of sediment, through tests of other fabric inserts indicate low sediment removal (see fact sheet C-9).

Key Design Elements:

1. Proprietary devices
2. Hydraulic capacity and pollutant storage capacity
3. Provision for overflow or bypass to avoid flooding when the insert is full or clogged
4. The size of the debris must be estimated accurately so that the wire mesh can be sized accordingly

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
Benefit ↓ Cost ↓	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

● High	◒ Medium	○ Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: If there is high solids loading (often caused by vegetation within the drainage area), frequent inspection and maintenance is required.
- *Nuisance Control:* None identified.
- *Specialty Training/Equipment:* It may be a challenge for one person to lift up the storm grate and remove a full sock beneath it.

Project Development:

- *Right-of-Way Requirements*: Installed within a storm water inlet.
- *Siting Constraints*: Requires a grated drop inlet.
- *Construction*: Simple installation. A watertight installation of the product is important to capture low flows.

Advantages:

- There is a range of sizes that can be retrofitted to storm drain requirements. They are easy to install and clean. Maintenance can be simple and quick.

Constraints:

- Debris and litter may exceed drain inlet insert capacity.
- Capacity (size of basket) is constrained by the size of the drain inlet to be retrofitted.
- If located along a shoulder or median, maintenance activities may require traffic control.

Sources:

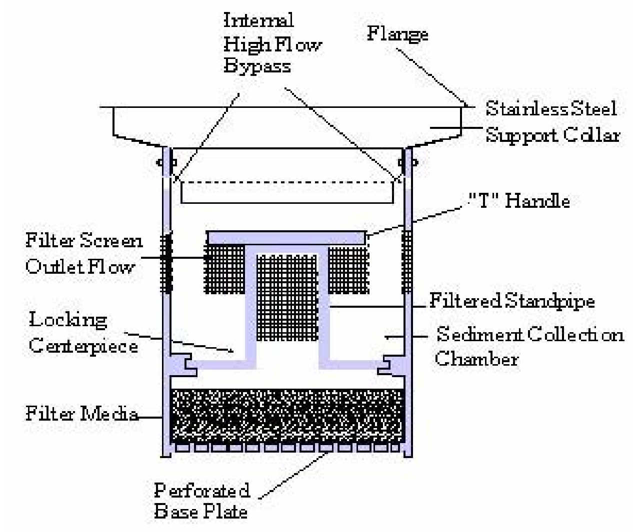
- Zymark, Inc., www.streamsaver.net

Literature Sources of Performance Demonstrations:

- None identified.

Description:

Aqua-Guard™ is an insert that uses a combination of screens and filter media. Screens remove larger particles and debris, which collects in a chamber to prevent filter clogging.



Source: www.aquashieldinc.com

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	○	◒
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	●	○
BOD	○	○
TDS	○	○

Notes:

- TSS removal based on laboratory tests using street sweepings dosed at around 200 mg/L (Morgan, et. al., 2004)

Key Design Elements:

1. Proprietary device
2. Hydraulic capacity and litter storage capacity
3. Provision for overflow or bypass to avoid flooding when the insert is full or clogged
4. The size of the debris must be estimated accurately so that the wire mesh can be sized accordingly

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: If there is high solids loading (often caused by vegetation within the drainage area), frequent inspection and maintenance is required.
- *Nuisance Control:* None identified.
- *Specialty Training/Equipment:* No special requirements identified.

Project Development:

- *Right-of-Way Requirements*: Installed within a storm water inlet.
- *Siting Constraints*: Requires a grated drop inlet.
- *Construction:* A watertight installation of the product is important to capture low flows.

Advantages:

- There is a range of sizes that can be retrofitted to storm drain requirements. They are easy to install and clean. Maintenance can be simple and quick. Adsorption booms can be attached.

Constraints:

- Debris and litter may exceed drain inlet insert capacity.
- Capacity of insert is constrained by the size of the drain inlet to be retrofitted.
- Morgan et. al. noted that bypass occurs at relatively low flow 0.00038 m^3/s (6 gpm).
- If located along a shoulder or median, maintenance activities may require traffic control.

Sources:

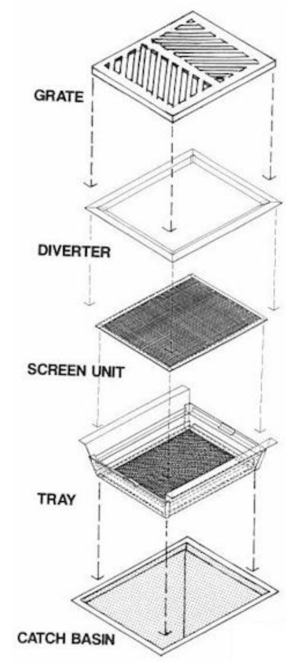
- AquaShield™ Inc., www.aquashieldinc.com

Literature Sources of Performance Demonstrations:

- U.S. Environmental Protection Agency, www.epa.gov/region1/assistance/ceitts/stormwater/techs/aquaguard.html
- Morgan, Robert, Findlay Edwards, Kristofor Brye, and Steven Burian. "Evaluation of Stormwater Catchbasin Inserts for Transportation Facilities", TRB 2004 Annual Meeting
- NELP, "Completes Stormwater Catch Basin Insert Evaluation Study," December 2003, www.mayportnelp.com/success/press_releases/stormwater.htm, (21 August 2003).

Description:

Enviro-Drain® is a series of screens and trays of filtration media that are supported by bars. The bars are loaded with the trays and placed into the box that is hung from the recess of the drain inlet. The trays may be loaded with any type of granular media. Up to three screens or trays may be used.



Source: www.enviro-drain.com

Constituent Removal:

Constituent Group	***Removal Efficiency***	***Level-of-Confidence***
Total Suspended Solids	○	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	○	○
BOD	◒	○
TDS	○	○

Notes:

Key Design Elements:

1. Proprietary devices
2. Media type
3. Hydraulic capacity and litter storage capacity
4. Provision for overflow or bypass to avoid flooding when the insert is full or clogged

Cost Effectiveness Relative to Detention Basins

Cost Effectiveness	***Level-of-Confidence***
▖	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: If there is high solids loading (often caused by vegetation within the drainage area), frequent inspection and maintenance is required.
- *Nuisance Control*: Water can pool if clogged.
- *Specialty Training/Equipment*: No special requirements.

Project Development:

- *Right of Way Requirements*: Installed within a storm water inlet.
- *Siting Constraints*: Requires a grated drop inlet.
- *Construction:* A watertight installation of the product is important to capture low flows.

Advantages:

- The system is easy to install.
- The trays can be recharged with different media.

Constraints:

- Excess litter can cause flow to bypass the media.
- If located along a shoulder or median, maintenance activities may require traffic control.
- Debris and litter may exceed drain inlet insert capacity.
- Capacity (size of basket) is constrained by the size of the drain inlet to be retrofitted.

Sources:

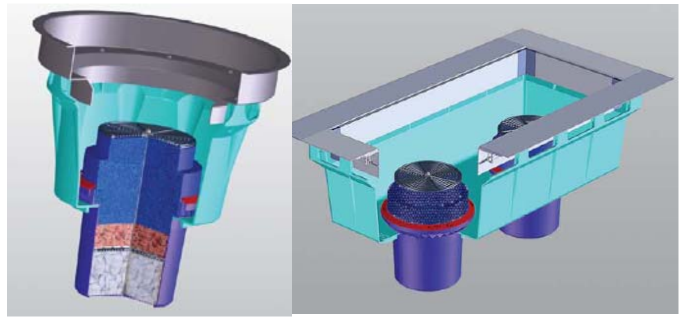
- Enviro-Drain®, Inc., www.enviro-drain.com

Literature Sources of Performance Documentation:

- Savelle, Jon, Catching Water Pollutants at the Source, *Journal Environment*, September 15, 1998.

Description:

Envirosafe™ is a canister type filter that retains captured pollutants as stormwater passes through filter cartridges. The basic canister design can be fitted to either round or rectangular drain inlets. Water flows through an open-cell foam that restricts sediment and debris prior to a series of optional filtration media. Oil absorbing pads collect oil, grease, and other petroleum based chemicals, while Mycelx™ and Fablite II filtration media collect dissolved metals before water is sent out of the system. High volume flows are allowed to by-pass the system through outlet holes at the top inlet insert.



Source: www.transpo.com/envirosafe.htm

Key Design Elements:

1. Proprietary devices
2. Media type and depth
3. Hydraulic capacity and litter storage capacity
4. Provision for overflow or bypass to avoid flooding when the insert is full or clogged

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	◒	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	○	○
BOD	○	○
TDS	○	○

Notes:

- Small surface area of filter seems likely to clog.
- Field tests had TSS concentrations over two times higher than typical highway concentration (influent was around 350 to 450 mg/L). Data insufficient to draw strong statistical conclusions.

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
▖	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

● High	◒ Medium	○ Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- _Requirements_: If there is high solids loading (often caused by vegetation within the drainage area), frequent inspection and maintenance is required.
- _Nuisance Control_: Water can pool if clogged.
- _Specialty Training/Equipment_: No special requirements identified.

Project Development:

- _Right of Way Requirements_: Installed within a storm water inlet.
- _Siting Constraints_: Requires a grated drop inlet.
- _Construction:_ A watertight installation of the product is important to capture low flows.

Advantages:

- The system is easy to install.

Constraints:

- Potential for clogging may cause frequent bypass.
- If located along a shoulder or median, maintenance activities may require traffic control.
- Debris and litter may exceed drain inlet insert capacity.
- Capacity (size of basket) is constrained by the size of the drain inlet to be retrofitted.

Sources:

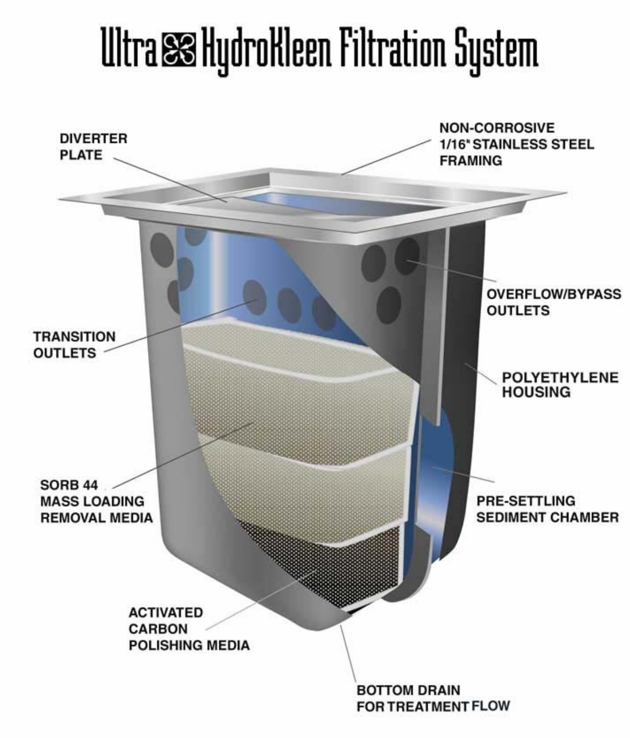
- Transpo® Industries, Inc., New Rochelle, NY, www.transpo.com

Literature Sources of Performance Documentation:

- AEGIS Environments, "*A New Technology for Producing Stability Foams Having Antimicrobial Activity*," Midland, MI, January 2005. www.aegismicrobeshield.com
- Contaminated Land Assessment & Remediation Research Centre (CLARRC), "*Contract Research Report Laboratory and Field Testing of PermaKleen*," June 21, 2005. www.transpo.com/envirosafe.htm
- Consolidated Edison, Co., Environmental Testing Labs, Inc., "*Testing on Total Petroleum Hydrocarbons (TPH)*," www.transpo.com/envirosafe.htm

Description:

The Hydro-Kleen™ is a box and baffle system that uses a series of filter media. Bypass of flood flows occurs through the baffle system and discharges prior to the filter beds.



Source: www.hydrocompliance.com

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	○	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	●	○
BOD	○	○
TDS	○	○

Notes:

Key Design Elements:

1. Proprietary device
2. Provision for overflow or bypass to avoid flooding when the insert is full or clogged
3. Hydraulic capacity and litter storage capacity

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: If there is high solids loading (often caused by vegetation within the drainage area), frequent inspection and maintenance is required.
- *Nuisance Control:* Holds a permanent pool of water so vector monitoring may be required.
- *Specialty Training/Equipment:* Unclear if openings are large enough to allow vactor truck cleaning.

Project Development:

- *Right-of-Way Requirements*: Installed within a storm water inlet.
- *Siting Constraints*: Requires a grated drop inlet.
- *Construction:* A watertight installation of the product is important to capture low flows.

Advantages:

- The devices can be installed relatively easily in new and existing facilities without much structural modification.

Constraints:

- Holds standing water.
- Solids accumulated in the baffle section may be flushed out by high flows.
- If located along a shoulder or median, maintenance activities may require traffic control.
- Debris and litter may exceed drain inlet insert capacity.
- Capacity (size of basket) is constrained by the size of the drain inlet to be retrofitted.

Sources:

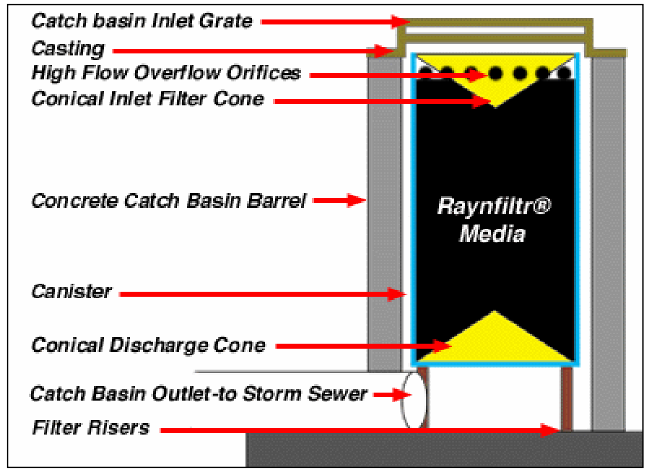
- Hydro Compliance Management, Inc., www.hydrocompliance.com

Literature Sources of Performance Demonstrations:

- None identified.

Description:

The RaynFiltr® is a canister of media that is supported by risers that rests on the bottom of the drain inlet. Overflow orifices on the top of the canister accommodate flood flows. The media is peat-based to remove metals and phosphorus and it reportedly has properties to remove organics.



Source: www.raynfiltr.org

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	○	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	○	○
BOD	○	○
TDS	○	○

Notes:

- It appears that low flows may by pass the filter.
- It also appears that the size of the canister may substantially reduce the drain inlet capacity because of a tight fit into the inlet.

Key Design Elements:

1. Proprietary device
2. Media type and depth
3. Hydraulic capacity and litter storage capacity
4. Provision for overflow or bypass to avoid flooding when the insert is full or clogged

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- <u>*Requirements*</u>: If there is high solids loading (often caused by vegetation within the drainage area), frequent inspection and maintenance is required.
- <u>*Nuisance Control*</u>: Water can pool if clogged.
- <u>*Specialty Training/Equipment*</u>: Need hoist to remove unit when replacing media.

Project Development:

- <u>*Right of Way Requirements*</u>: Installed within a storm water inlet.
- <u>*Siting Constraints*</u>: Requires a grated drop inlet.
- <u>*Construction*</u>*:* Confined space entry may be an issue. A watertight installation of the product is important to capture low flows.

Advantages:

- The system is easy to install.
- Performance may be enhanced compared to other filters because of a greater media depth.

Constraints:

- Low debris storage capacity may cause high maintance requirements if solids loading is high (typical of drainage areas with vegetations, erosion,etc.).
- Potential for clogging and flooding due to insufficient flood bypass.
- Potential clogging may cause frequent bypass of media.
- If located along a shoulder or median, maintenance activities may require traffic control.
- Debris and litter may exceed drain inlet insert capacity.
- Capacity (size of basket) is constrained by the size of the drain inlet to be retrofitted.

Sources:

- Enviromental Filtration, Inc., www.raynfiltr.org

Literature Sources of Performance Documentation:

- none identified

Description:

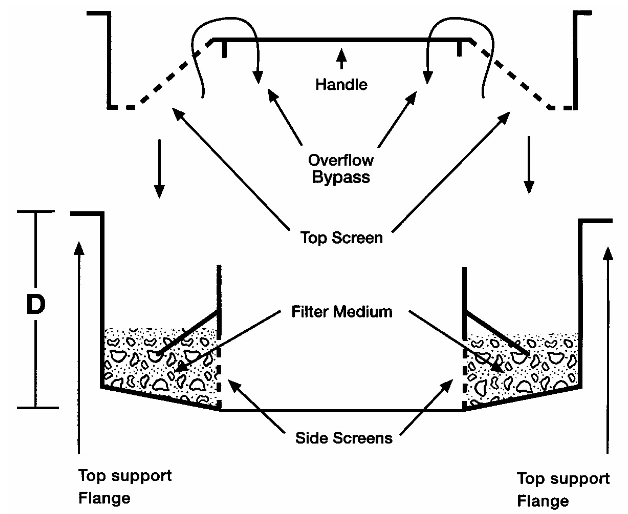
The S.I.F.T. Filter™ uses trays to hold filter media. The insert rests on the recess of the drain inlet. Flood flow bypass occurs by an opening in the center of the insert.

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	○	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	○	○
BOD	○	○
TDS	○	○

Notes:

- Similar to the early model Fossil Filter tested by Caltrans (see App C-9).



Source: Revel Environmental Marketing, Inc.

Key Design Elements:

1. Proprietary device
2. Provision for overflow or bypass to avoid flooding when the insert is full or clogged
3. Hydraulic capacity and litter storage capacity

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

● High	◒ Medium	○ Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: S.I.F.T. Filter™ should be inspected for trash and debris that could interfere with the normal functioning of the inlets, or debris that tends to accumulate on top of the trays, deflecting runoff water. The S.I.F.T. Filter™ adsorbent should be replaced when significant oil and grease are present on the absorbent granules. The media should be replaced annually.
- *Nuisance Control:* Can pool water if clogged.
- *Specialty Training/Equipment:* No special requirement identified.

Project Development:

- *Right-of-Way Requirements*: Installed within a storm water inlet.
- *Siting Constraints*: Requires a grated drop inlet.
- *Construction:* A watertight installation of the product is important to capture low flows.

Advantages:

- S.I.F.T. Filter™ are relatively inexpensive to install.
- Easily retrofitted to existing drain inlets.

Constraints:

- If located along a shoulder or median, maintenance activities may require traffic control.
- Debris and litter may exceed drain inlet insert capacity.
- Capacity (size of basket) is constrained by the size of the drain inlet to be retrofitted.

Sources:

- Revel Environmental Marketing, Inc.

Literature Sources of Performance Demonstrations:

- None identified.

Description:

StormBasin® (and closely related StormPod®) are canister type filters. Water hits a splash plate and enters through louvers that support the splash plate. Flood flows are accommodated by slots in the support structure that rests on the recess of the drain inlets.

Source: www.fabco-industries.com

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	○	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	○	○
BOD	○	○
TDS	○	○

Notes:

- Very similar to StormPod®, which is made by the same manufacturer.
- Small surface area of filter seems likely to clog.

Key Design Elements:

1. Proprietary devices
2. Media type and depth
3. Hydraulic capacity and litter storage capacity
4. Provision for overflow or bypass to avoid flooding when the insert is full or clogged

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
▖	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- _Requirements_: If there is high solids loading (often caused by vegetation within the drainage area), frequent inspection and maintenance is required.
- _Nuisance Control_: Water can pool if clogged.
- _Specialty Training/Equipment_: No special requirements identified.

Project Development:

- _Right of Way Requirements_: Installed within a storm water inlet.
- _Siting Constraints_: Requires a grated drop inlet.
- _Construction:_ A watertight installation of the product is important to capture low flows.

Advantages:

- The system is easy to install.

Constraints:

- Potential for clogging may cause frequent bypass.
- If located along a shoulder or median, maintenance activities may require traffic control.
- Debris and litter may exceed drain inlet insert capacity.
- Capacity (size of basket) is constrained by the size of the drain inlet to be retrofitted.

Sources:

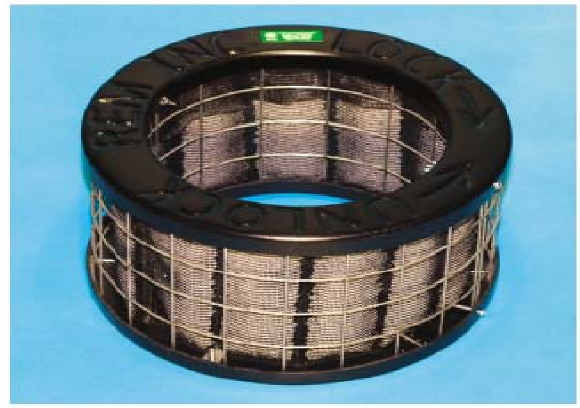
- Fabco Industries Inc., www.fabco-industries.com

Literature Sources of Performance Documentation:

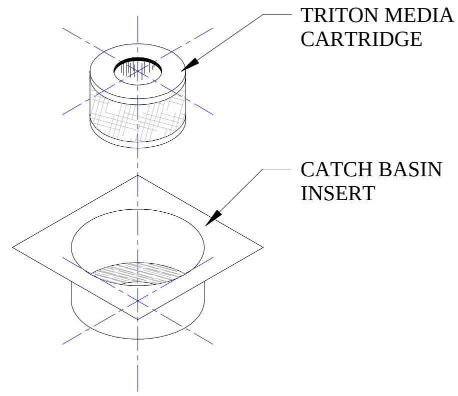
- None identified.

Description:

Triton Catch Basin Filter™ is a filter cartridge that removes hydrocarbons and other contaminants such as antifreeze, metals, sand, silt and litter from storm water runoff. High density polyethylene plastic cartridges in various shapes (round, square, rectangular, and custom) filter out hydrocarbons and other pollutants by means of single and double walled Media Pak. Disposable cartridge Media Pak's are constructed from durable geo-textile polypropylene fabric.



(TR14 - CARTRIDGE SHOWN ABOVE)



Source: www.remfilters.com

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	○	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	○	○
BOD	○	○
TDS	○	○

Notes:

- No performance data encountered in field demonstrations or in literature.

Key Design Elements:

1. Proprietary devices
2. Filter cartridge
3. High nominal flow and over flow capacities
4. Cartridge can be changed to meet varying conditions

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: If there is high solids loading (often caused by vegetation within the drainage area), frequent inspection and maintenance is required.
- *Nuisance Control*: Water can pool if clogged.
- *Specialty Training /Equipment*: No special requirements identified.

Project Development:

- *Right of Way Requirements*: Installed within a storm drain inlet.
- *Siting Constraints*: Requires a grated drop inlet.
- *Construction/Installation*: A watertight installation of the product is important to capture low flows.

Advantages:

- The system is easy to install.
- Filter cartridges can be recharged.
- Filter media can easily be site-specific.

Constraints:

- Debris and litter may exceed drain inlet insert capacity.
- Capacity (size of basket) is constrained by the size of the drain inlet to be retrofitted.
- If located along a shoulder or median, maintenance activities may require traffic control.

Sources:

- Revel Environmental Manufacturing Inc www.remfilters.com

Literature Sources of Performance Documentation:

- None available

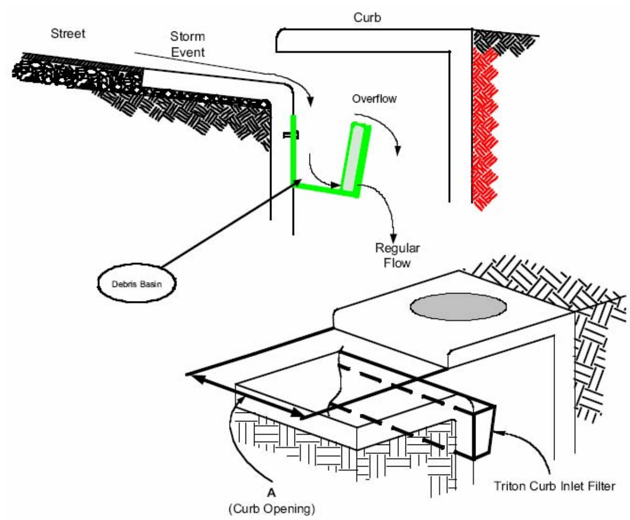
Description:

The TRITON FILTER™ is designed to eliminate hydrocarbons and other contaminants using a disposable media cartridge

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	○	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	●	◒
BOD	○	○
TDS	○	○

Notes:

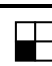


Source: www.remfilters.com

Key Design Elements:

1. Non-reactive High Impact Polystrene plastic. (durable)
2. Disposable media cartridge
3. 40% recycled plastic content

Cost Effectiveness Relative to Detention Basins

Cost Effectiveness	*Level-of-Confidence*
	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

● High	◒ Medium	○ Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: Regular maintenance is required to meet local and State BMPs.
- *Nuisance Control*: Water can pool if clogged.
- *Specialty Training/Equipment*: No special requirements.

Project Development:

- *Right of Way Requirements*: Installed in existing storm drain filters
- *Sitting Constraints*: Requires a curb inlet
- *Construction:* Exterior cage of cartridge shall be made of stainless steel Type 304, having .063 gauge welded 1" square openings

Advantages:

- The system is easy to install.
- The trays can be changed with different media.
- Range of sizes can be retrofitted to storm drain

Constraints:

- Excess litter can cause flow to bypass the media.
- If located along a shoulder or median, maintenance activities may require traffic control.
- Debris and litter may exceed drain inlet insert capacity.

Sources:

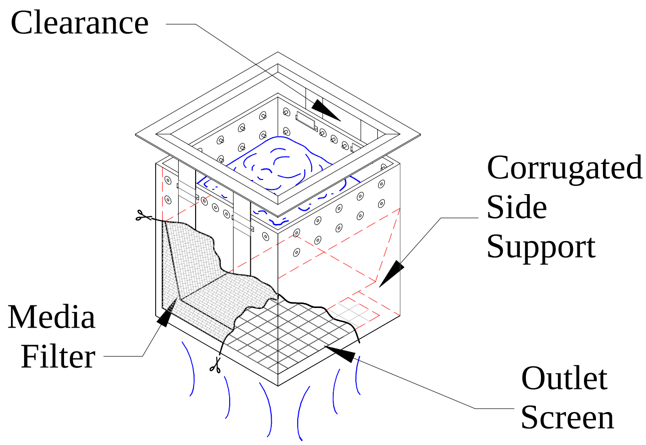
- Revel Environmental Manufacturing, Inc., www.remfilter.com

Literature Sources of Performance Documentation:

- None identified

Description:

The Ultra-Urban Filter is a box with media built into the bottom and two opposite sides of the box. The box is suspended from splash plates that rest on the drain inlet recess. Flood flow bypass is accomplished by overtopping the box.



Source: www.abtechindustries.com

Constituent Removal:

Constituent Group	***Removal Efficiency***	***Level-of-Confidence***
Total Suspended Solids	Low	Medium
Nutrients	Low	Low
Pesticides	Low	Low
Total Metals	Low	Low
Dissolved Metals	Low	Low
Microbiological	High	Low
Litter	Low	Low
BOD	Low	Low
TDS	Low	Low

Notes:

- Up to 80% hydrocarbon removal reported by UCLA.
- Sil-Co-Sil 106 laboratory tests resulted in 11% removal (Galicki et. Al. 2003)
- Laboratory tests using street sweepings resulted in 15 to 60% removal of TSS (Morgan et. Al., 2004).
- Removal efficiency based on laboratory tests using ground silica (Sil-co-sil 106) (CIWMB, 2005).
- Microbiological analysis is based on lab efficiency testing and field results.

Key Design Elements:

1. Proprietary devices
2. Media type and depth
3. Hydraulic capacity and pollutant storage capacity
4. Provision for overflow or bypass to avoid flooding when the insert is full or clogged

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	***Level-of-Confidence***
Benefit ↓ Cost ↓	Low

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- <u>*Requirements*</u>: If there is high solids loading (often caused by vegetation within the drainage area), frequent inspection and maintenance is required.
- <u>*Nuisance Control*</u>: Water can pool if clogged.
- <u>*Specialty Training/Equipment*</u>: No special requirements identified.

Project Development:

- <u>*Right of Way Requirements*</u>: Installed within a storm water inlet.
- <u>*Siting Constraints*</u>: Requires a grated drop inlet.
- <u>*Construction*</u>*:* A watertight installation of the product is important to capture low flows.

Advantages:

- The system is easy to install.

Constraints:

- Potential for clogging and bypass of media.
- If located along a shoulder or median, maintenance activities may require traffic control.
- Debris and litter may exceed drain inlet insert capacity.
- Capacity (size of basket) is constrained by the size of the drain inlet to be retrofitted.

Sources:

- AbTech Industries, www.abtechindustries.com

Literature Sources of Performance Documentation:

- Environmental Protection Agency, www.epa.gov/region1/assistance/ceitts/stormwater/techs/abtechfilter.html
- Galicki, Stan, Alan Johnson, and Allison Williams, Final Report, Sediment Removal from Stormwater Runoff AbTech Industries Ultra-Urban® Filter Series in Laboratory Flume Tests, Millsaps College, June 31, 2003. Available on www.abtechindustries.com
- Morgan, Robert, Findlay Edwards, Kristofor Brye, and Steven Burian. "Evaluation of Stormwater Catchbasin Inserts for Transportation Facilities" TRB 2004 Annual Meeting
- California Integrated Waste Management Board Used Oil Demonstration Grant by CSUS Office of Water Programs. "Laboratory Evaluation of Four Storm Drain Inlet Filters for Oil Removal," April 2005.
- Asbury Environmental Stormwater Division, "*Smart Sponge® Plus Antimicrobial Technology, Background & Field Test Results*" February 26, 2004

Description:

The ClearWater BMP uses a series of screens, baskets, and baffles. The unit is attached to the side of the drain inlet just below the curb inlet. The initial screens divert large debris to the baskets. Water passes through this screen and into a baffle system with finer built in screens.

Source: www.clearwaterbmp.com

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	●	○
Nutrients	○	○
Pesticides	○	○
Total Metals	◒	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	●	○
BOD	○	○
TDS	○	○

Notes:

San Diego State University laboratory tested. Limitations on confidence level due to no particles < 75u, unknown duration, and one sample for each of four flow rates. Reported efficiency: TSS 97, Cu 28, Pb 81, Zn 83. Zinc concentrations over triple (792 ug/L versus 187 ug/L) typical highway values (Table 3-2, CTSW-RT-03-065.51.42).

Key Design Elements:

1. Proprietary devices
2. Provision for overflow or bypass to avoid flooding when the insert is clogged

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
▖	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: If there is high solids loading (often caused by vegetation within the drainage area), frequent inspection and maintenance is required.
- *Nuisance Control:* Baffles create standing water so vector monitoring may be required.
- *Specialty Training/Equipment:* Confined space entry may be an issue if the unit can not be serviced from above ground (see schematic).

Project Development:

- *Right of Way Requirements*: Installed within a storm water inlet.
- *Siting Constraints*: Requires a curb inlet.
- *Construction*: Attached to sidewalls required, not a “drop in” device. A watertight installation of the product is important to capture low flows.

Advantages:

- Requires no structural modifications to existing drainage structures.

Constraints:

- Causes standing water.
- If located along a shoulder or median, maintenance activities may require traffic control.
- Debris and litter may exceed drain inlet insert capacity.
- Capacity (size of basket) is constrained by the size of the drain inlet to be retrofitted.

Sources:

- ClearWater Solutions, www.clearwaterbmp.com

Literature Sources of Performance Documentation:

- “The Clear Water BMP”, Dept. of Civil and Environmental Engineering San Diego State University. November 25th, 2003

Description:

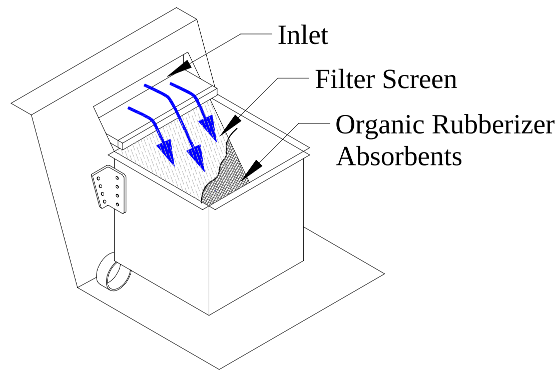
Hydroscreen is a slanted screen made of wedge wire. Water flows through the screen while litter and debris are collected on top. Flood flow bypass is accomplished by overtopping the box that holds the screen. The box is attached to the side of the drain inlet just under the curb inlet.

Constituent Removal:

Constituent Group	***Removal Efficiency***	***Level-of-Confidence***
Total Suspended Solids	○	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	●	○
BOD	○	○
TDS	○	○

Notes:

- Hydroscreen is a small version of the GSRD-Inclined Screen approved by Caltrans (fact sheet D-15)



Source: www.hydroscreen.com

Key Design Elements:

1. Proprietary devices
2. Provision for overflow or bypass to avoid flooding when the insert is clogged

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	***Level-of-Confidence***
▖	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

● High	◒ Medium	○ Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: If there is high solids loading (often caused by vegetation within the drainage area), frequent inspection and maintenance is required.
- *Nuisance Control:* None identified.
- *Specialty Training/Equipment:* No special requirements.

Project Development:

- *Right of Way Requirements*: Installed within a storm water inlet.
- *Siting Constraints*: Requires a curb inlet.
- *Construction*: Attached to sidewalls required, not a "drop in" device. A watertight installation of the product is important to capture low flows.

Advantages:

- Maintenance is quick and easy.

Constraints:

- Captured litter may escape over the top of the basket during higher flows.
- If located along a shoulder or median, maintenance activities may require traffic control.
- Debris and litter may exceed drain inlet insert capacity.
- Capacity (size of basket) is constrained by the size of the drain inlet to be retrofitted.

Sources:

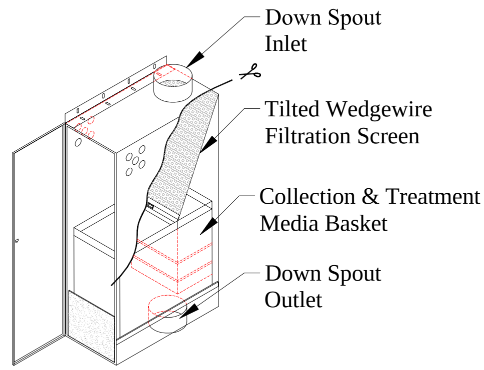
- Hydroscreen, LLC., www.hydroscreen.com

Literature Sources of Performance Documentation:

- None identified

Description:

The SuperFlo is designed for installation on downspouts. A box contains a screen made of wedge wire. Water flows through the screen while debris is collected in a side compartment that is accessible by a door in the box.



Source: www.stormfilters.com

Constituent Removal:

Constituent Group	***Removal Efficiency***	***Level-of-Confidence***
Total Suspended Solids	○	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	●	○
BOD	○	○
TDS	○	○

Notes:

Key Design Elements:

1. Proprietary devices
2. Provision for overflow or bypass to avoid flooding when the insert is clogged

Cost Effectiveness Relative to Basins:

Cost Effectiveness	***Level-of-Confidence***
	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basin

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *<u>Requirements</u>*: If there is high solids loading (often caused by vegetation within the drainage area), frequent inspection and maintenance is required.
- *<u>Nuisance Control</u>:* None identified.
- *<u>Specialty Training/Equipment</u>:* No special requirements.

Project Development:

- *<u>Right of Way Requirements</u>*: Can be attached to bridge column or building structure.
- *<u>Siting Constraints</u>*: Requires a down spout.
- *<u>Construction</u>*: Attaches to a wall or other vertical support.

Advantages:

- Maintenance is quick and easy.

Constraints:

- May not fit into drain inlets without modification.
- If located along a shoulder or median, maintenance activities may require traffic control.
- Debris and litter may exceed drain inlet insert capacity.

Sources:

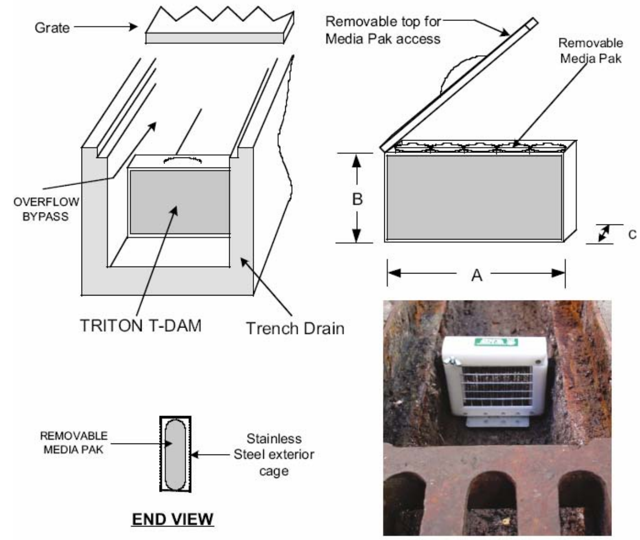
- Storm Water Systems, www.stormfilters.com

Literature Sources of Performance Documentation:

- None identified

Description:

The Triton T- Dam Filter™ is designed to fit into a trench drain. The filter treats waste flowing in the trench. A primary and secondary sand/silt dam is followed by T-Dam Filter™. High flow bypass is accomplished by overtopping the filter. Media is designed to capture hydrocarbons and metals.



(T-Dam installed in trench)

Source: www.stormfilters.com

Key Design Elements:

1. Non-reactive HDPE
2. Filter Media easily removed

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	○	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	○	○
BOD	○	○
TDS	○	○

Notes:

- Limited performance is expected due to small size.

Cost Effectiveness Relative to Basins:

Cost Effectiveness	*Level-of-Confidence*
▖	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basin

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: If there is high solids loading (often caused by vegetation within the drainage area), frequent inspection and maintenance is required.
- *Nuisance Control:* None identified.
- *Specialty Training/Equipment:* Vactor cleaning of the trench drain may be preferred over hand removal.

Project Development:

- *Right of Way Requirements*: Installed in existing trench drain
- *Siting Constraints*: None identified.
- *Construction*: None identified

Advantages:

- Easy to install.

Constraints:

- Seems prone to clogging because of small filter area.

Sources:

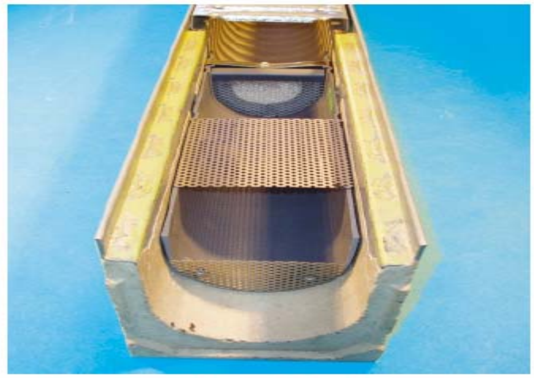
- Revel Environmental Manufacturing, Inc., www.remfilter.com

Literature Sources of Performance Documentation:

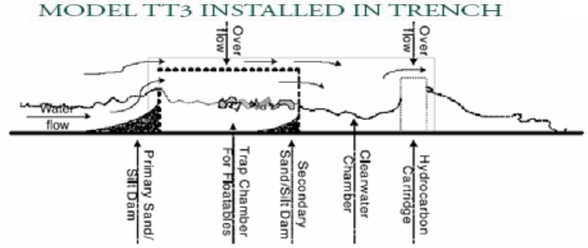
- None identified

Description:

The Triton Trench Drain Filter™ Insert is designed to help eliminate hydrocarbons and other contaminates such as metals, sand, silt, and litter from stormwater runoff entering trench drains.



MODEL TT3 INSTALLED IN TRENCH



Source: www.remfilters.com

Key Design Elements:

1. Non-reactive high impact polystyrene plastic

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	○	○
Nutrients	○	○
Pesticides	○	○
Total Metals	◒	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	○	○
BOD	○	○
TDS	○	○

Notes:

Cost Effectiveness Relative to Basins:

Cost Effectiveness	*Level-of-Confidence*
	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basin

● High	◒ Medium	○ Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: If there is high solids loading (often caused by vegetation within the drainage area), frequent inspection and maintenance is required.
- *Nuisance Control:* None identified.
- *Specialty Training/Equipment:* No special requirements.

Project Development:

- *Right of Way Requirements*: Installed in existing trench drain
- *Siting Constraints*: None identified.
- *Construction*: None identified

Advantages:

- Maintenance is quick and easy.

Constraints:

- May not fit into existing trenches without modification.

Sources:

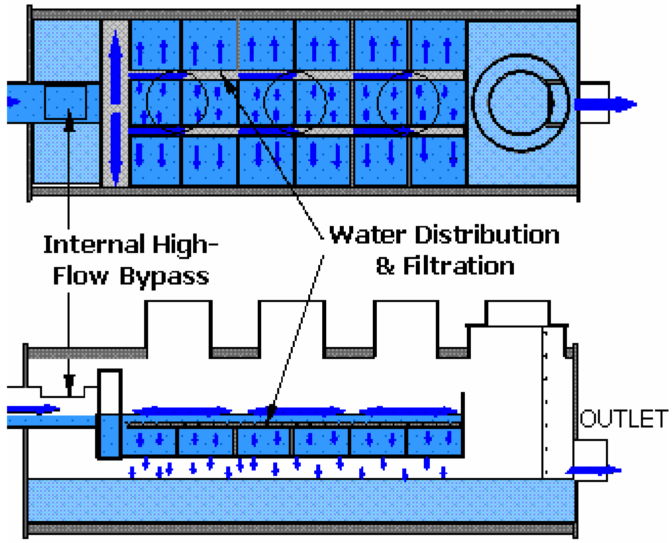
- Revel Environmental Manufacturing, Inc., www.remfilter.com

Literature Sources of Performance Documentation:

- None identified

Description:

The Aqua-Filter™ is a open-bed filter suspended above the insert of the vault by attachment to the sidewalls. It has an internal high flow bypass. It appears to retain standing water but lowering the outlet pipe may remedy this.



Filtration Chamber

AquaShield

Source: www.aquashieldinc.com

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	●	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	○	○
BOD	○	○
TDS	○	○

Notes:

- Upstream litter, debris and sediment removal is recommended.

Key Design Elements:

1. Peak Flow
2. Offline vs. Online
3. Water quality design flow
4. Residence time (BMP sizing vs. Water quality flow rate)
5. Type of media

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: Inspection and replacement of media when clogged.
- *Nuisance Control:* Vector inspections may be required if units hold a permanent pool of water.
- *Specialty Training/Equipment:* Training required for filter bed inspection and maintenance.

Project Development:

- *Right-of-Way Requirements*: Space requirements depend on sizing criteria, typically smaller than basins.
- *Siting Constraints*: Head requirement for gravity drain.
- *Construction:* No unique requirements identified.

Advantages:

- Typically smaller than basin type BMPs.

Constraints:

- Standing water may create mosquito habitat.

Sources:

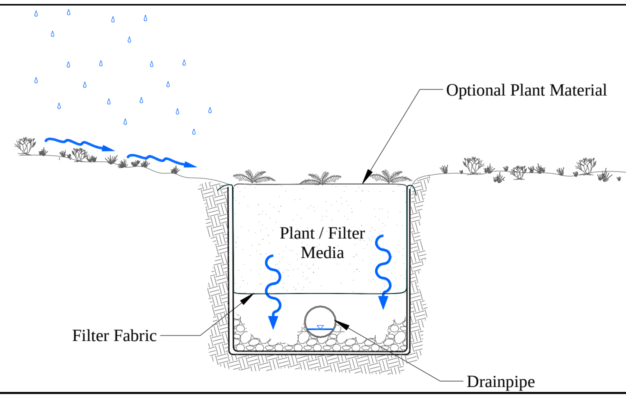
- AquaShield, Inc., www.aquashieldinc.com

Literature Sources of Performance Demonstrations:

- U.S. Environmental Protection Agency, www.epa.gov/region1/assistance/ceitts/stormwater/techs/aquafiltersys.html

Description:

Linear Bioretention Trenches are relatively flat vegetated areas that accept sheet flow from storm water runoff. These are essentially bioretention BMP designs that are confined to linear spaces. Removal mechanisms include filtration and infiltration. Strips can be used as pretreatment.



Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	●	○
Nutrients	◒	◒
Pesticides	◒	○
Total Metals	●	◒
Dissolved Metals	◒	○
Microbiological	●	○
Litter	●	○
BOD	○	○
TDS	○	○

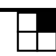
Notes:

- Assumes the same treatment a traditional bioretention basins.

Key Design Elements:

1. Locate, size, and shape bioretention relative to site conditions.
2. Specify vegetation that occurs naturally to minimize establishment and maintenance.
3. Underground drain system
4. Ponding depth
5. Drainage area
6. Flow capacity

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: Vegetation management is required. *Nuisance Control:* The bioretention facility may promote mosquito breeding if clogged.
- *Specialty Training/Equipment:* No special requirements identified.

Project Development:

- *Right-of-Way Requirements*: Total space requirements may be relatively high to accommodate shallow water quality storage depths. Alternatively, flow-basis design should be investigated.
- *Siting Constraints*: May need supplemental irrigation in dry areas, depending on plant selection.
- *Construction:* Vegetation establishment period may be required.

Advantages:

- Pollutant removal effectiveness is typically high, accomplished primarily by physical filtration of particulates through the soil profile; and adsorption of constituents by the soil.
- It can provide an aesthetic vegetated appearance.
- Reduces water discharge by soil retention and evapotransporation.

Constraints:

- May not be appropriate along highways where safety considerations preclude use ofplantings that obscure sight lines.
- In areas with prolonged dry periods, maintenance of trees, shrubs and grass between rainfalls may require irrigation.
- If located along a shoulder or median, maintenance activities may require traffic control

Sources:

None identified

Literature Sources of Performance Demonstrations:

- University of Virginia, Dr. Shaw Yu performed a two-year research study on the pollutant removal efficiency of the filter soil/plant media, www.americastusa.com/filterra.html

Description:

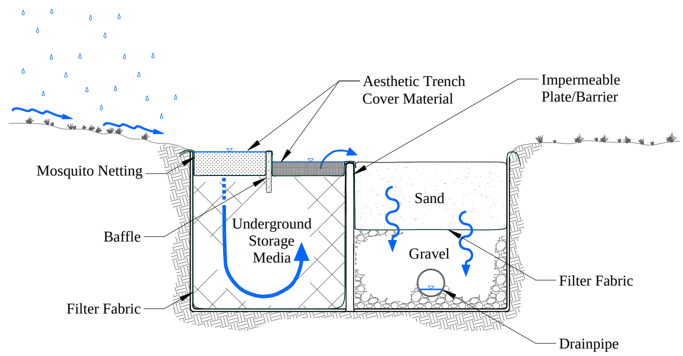
Linear Filter Trenches are similar to Delaware sand filters. These filtration beds are often located at the curbside edge of a paved area or parking lot. Two parallel trench/chambers: a sedimentation chamber and a sand media filter chamber. The sedimentation chamber holds a permanent pool of water. The sedimentation basin removes the coarse suspended solids and prevents premature clogging of the filter media surface. The sedimentation effluent discharges over a weir into the sand filter chamber where water is filtered through a 12 to 18-inch sand filter, geotextile layer, and into an underdrain. Linear Filter Trenches are on-line facilities; they process all runoff leaving the site up to the point where the overflow limit is reached.

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	●	●
Nutrients	○	◒
Pesticides	○	●
Total Metals	●	●
Dissolved Metals	◒	●
Microbiological	◒	◒
Litter	●	◒
BOD	○	○
TDS	○	○

Notes:

- All scores are based on the Delaware sand filter monitoring.
- Nitrate concentrations increase by 78%.
- High dissolved Zn removal efficiency.



Key Design Parameters:

1. As recommended for Delaware, unit should be designed and installed according to the guidelines described by Young et al. (1996). It should be noted that if a Delaware filter is designed according to these guidelines, there is only storage in the unit for 5 mm of runoff (0.2 inches); consequently the unit acts as a flow-through device. The filter is sized using unit values for the sedimentation chamber volume and filter bed area per acre of tributary area treated.

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
▝	●

Information from Caltrans Cost Summary report CTSW-RT-01-003. An average of 20 field hours per year were spent on operation and maintenance of the Delaware sand filter during the Caltrans BMP retrofit pilot program.

Issues and Concerns:

Maintenance:

- <u>*Requirements*</u>: Maintenance for smaller filters is usually best done manually. Normal maintenance requirements include disposal of accumulated trash and replacement of the upper few inches of sand when the filter clogs.
- <u>*Nuisance Control*</u>*:* The gravel and screens on the storage chamber needs maintenance to prevent mosquito access.
- <u>*Specialty Training/Equipment*</u>*:* Training required for media removal.

Project Development:

- <u>*Right-of-Way Requirements*</u>: Lower than most approved BMPs.
- <u>*Siting Constraints*</u>: Delaware sand filters should not be sited where runoff from bare soil or construction activities will be allowed to enter the filter. Minimum head requirement of 1.0 meters.
- <u>*Construction*</u>*:* No special requirements identified.

Advantages:

- They are similar in performance to the Austin design with the principal advantage being smaller in size.
- Waste media from the filters does not appear to be toxic and is likely to be environmentally safe for landfill disposal.
- The filters can reduce the potential for groundwater contamination if they are designed with an impermeable basin liner.

Constraints:

- Sand filters have only limited pollutant removal capability for nutrients.
- The sedimentation basin holds a permanent pool of water and has the potential to provide breeding opportunities for mosquitoes.

Sources:

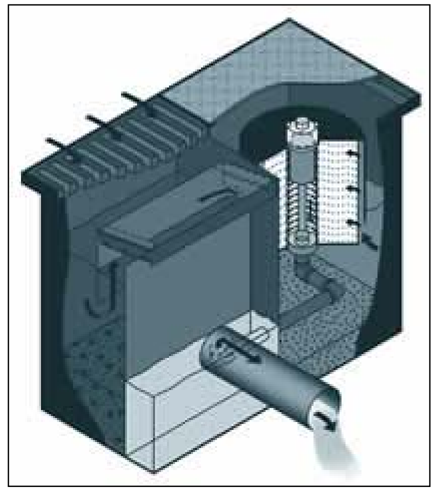
- www.epa.gov/owm/mtb/sandfltr.pdf has information on design, performance, operation, maintenance, and costs of sand filters.
- www.enviro.nfesc.navy.mil/p2library/cgi-bin/p2h_datasheet.cfm?itemID=230
- www.webcentral.bts.gov/ntl/DOCS/RUNOFF.html

Literature Sources of Performance Demonstrations:

- Caltrans, 2004. BMP Retrofit Pilot Program Final Report, CTSW-RT-01-050 available at www.dot.ca.gov/hq/env/stormwater
- The US Department of Transportation. *Evaluation and Management of Highway Runoff Water Quality*. Young et al. 1996 contains information on the citing, design, and performance of Delaware sand filters.
- W. Bell, L. Stokes, L. J. Gavan, T. N. Nguyen. 1995. *Assessment of the Pollutant Removal Efficiencies of Delaware Sand Filter BMP's*. Department of Transportation and Environmental Services. Alexandria, V.A. 140pp.
- R. R. Horner and C. R. Horner. 1995. *Design, Construction, and Evaluation of a Sand Filter Stormwater Treatment System*. Part III. Performance monitoring. Report to Alaska Marine Lines, Seattle, WA.
- E. Shaver and R. Baldwin. 1991. *Sand Filter Design for Water Quality Treatment*. Delaware Dept. of Natural Resources and Environmental Control. Dover, DE. 14pp.

Description:

The CatchBasin StormFilter™ is a combination of a small water quality inlet (baffle system) with a single float actuated canister filter. Filter media can vary. Flood flow bypass allowance is unclear.



Source: www.stormwaterinc.com

Key Design Elements:

1. Proprietary design
2. High flow bypass
3. Media type

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	◒	○
Nutrients	○	○
Pesticides	○	○
Total Metals	◒	○
Dissolved Metals	◒	○
Microbiological	○	○
Litter	●	○
BOD	○	○
TDS	◒	○

Notes:

- Canister is similar to those used by the StormFilter™ (see fact sheet C-15).

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
▗	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: Inspecting the facility, removing litter and sediment and all spent filter cartridges, repairing or replacing inoperative controls, valve or filter canister, and cleaning the filter cartridges and canister if necessary.
- *Nuisance Control:* Standing water requires vector monitoring.
- *Special Training/Equipment:* Crews must be trained to repair or replace any cartridge filter or part associated with the facility or contract for maintenance.

Project Development:

- *Right- of-Way Requirements*: Space requirements depend on sizing criteria, typically smaller than basins.
- *Siting Constraints*: Must have sufficient hydraulic head.
- *Construction:* No unique requirements identified.

Advantages:

- Smaller footprint than for conventional sedimentation/gravity sand filter.

Constraints:

- Removal of fine sediment in cartridge filters is not as effective as in open bed media filters.
- Vector concerns.

Sources:

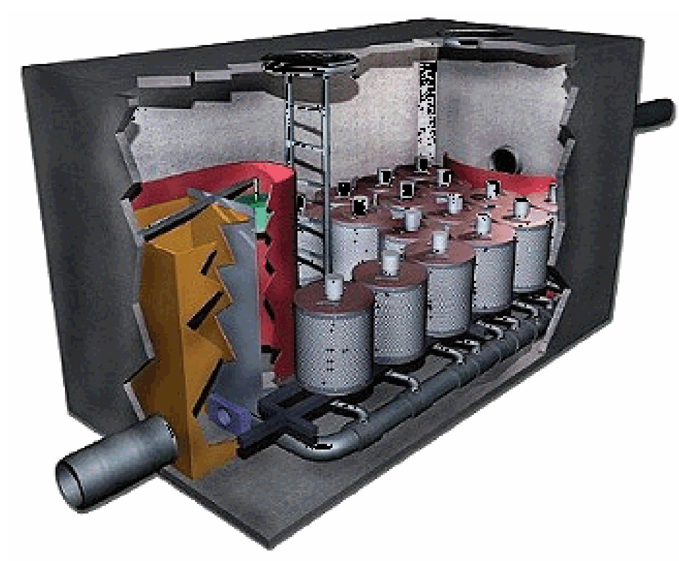
- Stormwater Management, www.stormwaterinc.com
- U.S. Environmental Protection Agency, www.epa.gov/region1/assistance/ceitts/stormwater/techs/stormfilter.html

Literature Sources of Performance Demonstrations:

- Keblin, M.V., et al. The Effectiveness of Permanent Highway Runoff Controls: Sedimentation/Filtration Systems Center for Research in Water Resource. 1997.

Description:

The CDS media filtration system doses the filter in batches by using a single float assembly on the effluent. The unit fills until the float is raised which opens the effluent pipe to the filters.



Source: www.cdstech.com.au/us/

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	○	○
Nutrients	○	○
Pesticides	○	○
Total Metals	◒	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	●	○
BOD	○	○
TDS	○	○

Notes:

- Removal efficiencies were based on field tests for other canister systems (see fact sheet C-15).

Key Design Elements:

1. Proprietary design
2. Power requirements
3. Hydraulic capacity and litter storage capacity

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
◲	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- Requirements: Inspecting the facility, removing litter and sediment and all spent filter cartridges, repairing or replacing inoperative controls, valve or filter canister, and cleaning the filter cartridges and canister if necessary.
- Nuisance Control: May have standing water if filters do not drain completely
- *Specialty Training/Equipment:* Crews must be trained to repair or replace any cartridge filter or part associated with the facility.

Project Development:

- *Right- of-Way Requirements*: Space requirements depend on sizing criteria, typically smaller than basins.
- *Siting Constraints*: Must have sufficient hydraulic head.
- *Construction:* No special requirements identified.

Advantages:

- Smaller footprint than for conventional sedimentation/gravity sand filters.

Constraints:

- Removal of fine sediment in cartridge filters is not as effective as in open bed media filters.

Sources:

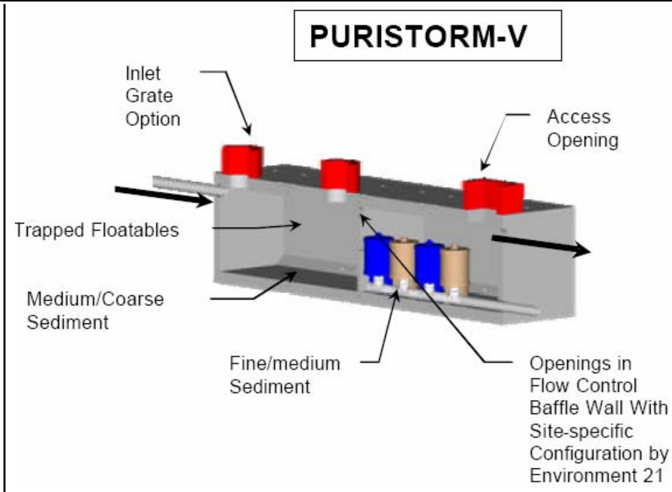
- CDS Technologies, Inc., www.cdstech.com.au/us/

Literature Sources of Performance Demonstrations:

- Keblin, M.V., et al. The Effectiveness of Permanent Highway Runoff Controls: Sedimentation/Filtration Systems Center for Research in Water Resource. 1997.
- Roy, John R. AquaLogic Stormwater Abatement Filter System. SWAF, Inc- P.O. Box 701745, San Antonio, Texas 78270, Tel: (210) 602 8121. April 2000.

Description:

The PURISTORM™ is a standard pre-cast concrete vault with a filter cartridge system. Outlet flow is a two-stage system with low head loss (less than 0.2 ft) that does not require flow bypassing.



Source: www.env21.com

Constituent Removal:

Constituent Group	***Removal Efficiency***	***Level-of-Confidence***
Total Suspended Solids	◒	○
Nutrients	○	○
Pesticides	○	○
Total Metals	◒	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	●	○
BOD	○	○
TDS	○	○

Notes:

- Removal efficiencies were based on field tests for other canister systems (see fact sheet C-15).

Key Design Elements:

1. Detention time
2. Pollutant storage capacity
3. Flow capacity (flood and water quality flow)

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	***Level-of-Confidence***
▖	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: If there is high solids loading (often caused by vegetation within the drainage area), frequent inspection and maintenance is required.
- *Nuisance Control:* None identified.
- *Specialty Training /Equipment:* Spent filter cartridges are to be replaced as warranted.

Project Development:

- *Right-of-Way Requirements*: Relatively small footprint
- *Siting Constraints*: Requires a curb or drop inlet.
- *Construction:* No unique requirements identified.

Advantages:

- Small footprint.

Constraints:

- Vector concerns

Sources:

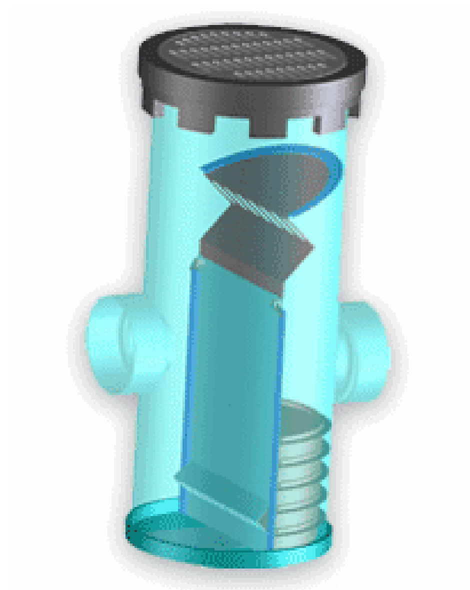
- Environmental 21, LLC, www.env21.com

Literature Sources of Performance Demonstrations:

- None identified.

Description:

The StormPlex® uses a baffle and filter. The unit can accept pipe flow as well as grate inlet flow. Units may be installed in series. Water flow under the baffle and up through a media called Fablite. High flows pass over the baffle through a screen.



Source: www.fabco-industries.com

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	○	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	○	○
BOD	○	○
TDS	○	○

Notes:

- Bypass has a screen that may be blinded by floating debris.
- Unit seems to retain standing water.

Key Design Elements:

1. Proprietary devices
2. Media type
3. Hydraulic capacity and pollutant storage capacity
4. Provision for overflow or bypass to avoid flooding when the insert is full or clogged

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- Requirements: Unknown. May require confined space entry.
- Nuisance Control: Water appears to be retained which may require vector control.
- Specialty Training/Equipment: No special requirements identified.

Project Development:

- Right of Way Requirements: Same as drop inlets.
- Siting Constraints: Same as drop inlets.
- Construction: No special requirements identified.

Advantages:

- The device can be installed in parallel to increase treatment capacity.
- Filters can be recharged.
- Delivered precast.

Constraints:

- Potential for blinding of bypass.

Sources:

- Fabco Industries Inc., StormPlex®, www.fabco-industries.com

Literature Sources of Performance Documentation:

- None identified.

Description:

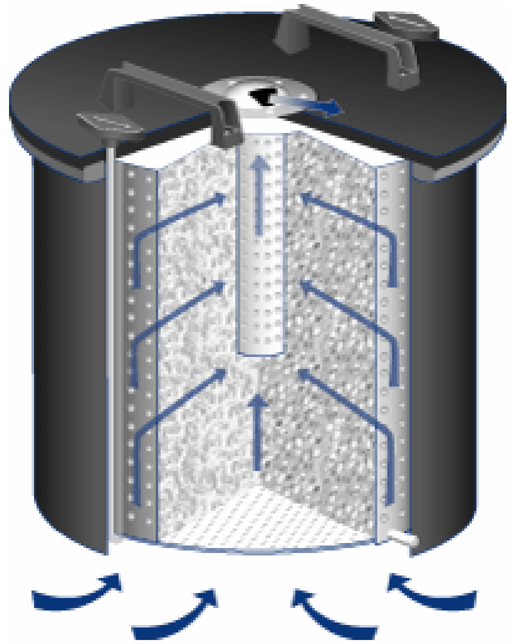
The VortFilter™ has an outer cylinder that acts as a baffle and an inner cylinder that holds the media. It is unclear how the unit is installed within the storm drain system.

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	○	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	○	○
BOD	○	○
TDS	○	○

Notes:

- Removal efficiencies were based on field tests for other canister systems (see fact sheet C-15).
- Manufacturer reports 85% particle removal in laboratory tests.



Source: www.vortechnics.com

Key Design Elements:

1. Proprietary devices
2. Media type
3. Hydraulic capacity
4. Provision for overflow or bypass to avoid flooding when the insert is full or clogged

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: Unknown. May require confined space entry.
- *Nuisance Control*: Unknown.
- *Specialty Training /Equipment*: No special requirements identified.

Project Development:

- *Right of Way Requirements*: Potentially small footprint.
- *Siting Constraints*: Unknown.
- *Construction:* Unknown.

Advantages:

- Potentially small footprint.

Constraints:

- Unknown.

Sources:

- Vortechnics, Inc., www.vortechnics.com

Literature Sources of Performance Documentation:

- none identified.

Description:

CaptureFlow™ is an alternative catch basin system with drain-inlet-insert style filters and a secondary filter at the outflow. The flood flow bypass system claims to filter 1/8 inch material.

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	○	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	○	○
BOD	○	○
TDS	○	○

Notes:

- No performance data encountered in field demonstrations or in literature.

Source: www.carsonind.com

Key Design Elements:

1. Proprietary devices
2. Media type
3. Hydraulic capacity and litter storage capacity
4. Provision for overflow or bypass to avoid flooding when the insert is full or clogged

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
◩	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: If there is high solids loading (often caused by vegetation within the drainage area), frequent inspection and maintenance is required.
- *Nuisance Control*: Water can pool if clogged.
- *Specialty Training /Equipment*: No special requirements identified.

Project Development:

- *Right of Way Requirements*: Same as drop inlets.
- *Siting Constraints*: Same as drop inlets.
- *Construction/Installation*: Confined space situations may be an issue.

Advantages:

- The system is easy to install.
- The device can be installed in parallel to increase treatment capacity.
- Water can pass through freely (if void of solids).
- Some filter cartridges can be recharged.
- Filter media can easily be site-specific.
- Some devices are delivered precast.

Constraints:

- Potential for clogging and flooding road. Especially with a bypass system that only passes system that only passes material smaller than 1/8 inch.
- It may be no more efficient than drain inlet insert technologies, yet construction is more complicated.

Sources:

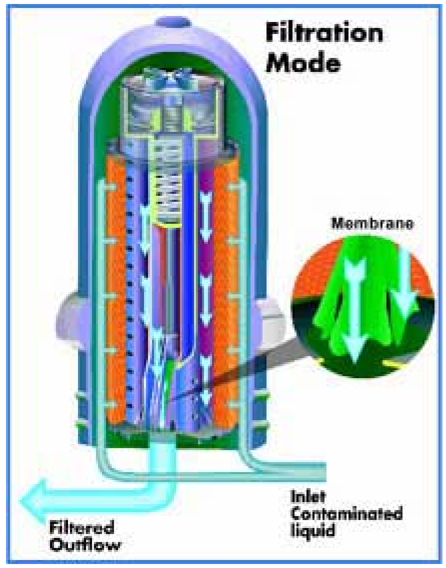
- Carson Industries LLC, www.carsonind.com

Literature Sources of Performance Documentation:

- None available

Description:

A disc filtration device, one of such designed by Arkal Filtration Systems/Zeta Technologies, is referred to as a Spin Klin. The Spin Klin self-backwashing disc filter was designed for filtration of solids from irrigation water, but may be applicable on pressurized pipes downstream of storm water sedimentation basins. The filter consists of a spring-loaded spine that holds a number of stacked, diagonally-grooved polyproplylene discs enclosed in a corrosion and pressure-resistant housing. The stacked discs create a filtration element with a statistically significant series of valleys and traps. During filtration, the discs are compressed by the spring and the differential pressure of the water, which flows from the peripheral end to the core of the element. Backwashing involves release of the compression spring and high-pressure flow of clean water through nozzles at the center of the spine. The discs spin free and solids are efficiently flushed out through the drain. Modular batteries allow for easy expansion of system in various space-saving configurations. (Source:www.arkal-filters.com)



Source: www.arkal-filters.com

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	●	◒
Nutrients	○	○
Pesticides	○	○
Total Metals	◒	◒
Dissolved Metals	○	○
Microbiological	○	○
Litter	○	○
BOD	○	○
TDS	○	○

Notes:

- No long-term water quality monitoring studies have been discovered in literature to evaluate treatment effectiveness.
- Level of confidence is not higher because no p-values were found in literature to warrant a high level of confidence (EPA, 2006).
- Litter and debris removal must be accomplished prior to this unit

Key Design Elements:

1. Power requirements
2. Flow rate
3. Upstream equalization volume

<u>Ancillary Facilities</u>

Litter and debris capture required upstream.
Backwash water storage and disposal facilities.

Cost Effectiveness Relative to Detention Basin:

Cost Effectiveness	*Level-of-Confidence*
◳	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- _Requirements_: Mechanical equipment maintenance.
- _Nuisance Control_: None identified.
- _Specialty Training/Equipment_: Crews would need to be trained to maintain equipment. Service contract may be preferred.

Project Development:

- _Right-of-Way Requirements_: Building may be required to house the unit.
- _Siting Constraints_: Needs power.
- _Construction_: No unique requirements identified.

Advantages:

- Micron-precise filtration of solids. Claimed by the manufacturer to retain large amount of solids for long filtration cycles (Note: solids in irrigation water may differ from those of settled storm water). Low maintenance self-backwashing design. Self-contained.

Constraints:

- Removes only solids-associated contaminants. Limited application.
- Designed for installation on pressurized pipes. Not designed to remove larger solids so upstream litter and debris would be needed. May not be suitable for use at side of freeway.

Sources:

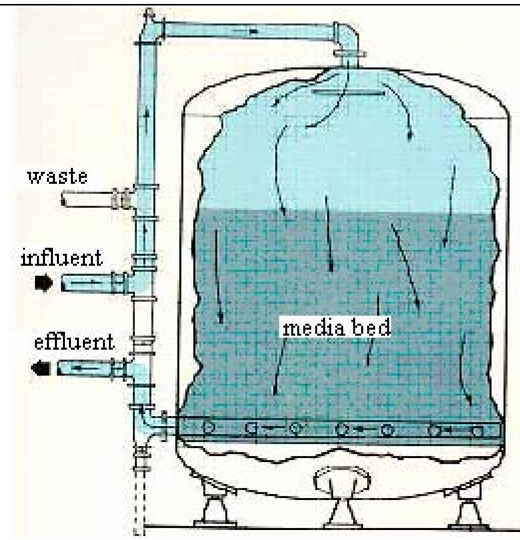
- Arkal Filtration Systems, www.arkal-filters.com

Literature Sources of Performance Demonstrations:

- EPA January 2006, Environmental Protection Agency http://www.epa.gov/etv/pdfs/vrvs/09_vs_arkal.pdf.

Description:

Media filters treat water primarily by physical filtration of undissolved pollutants as the fluid passes through granular media or compressed media (fuzzy filter). Strainers can be added prior to the filter to remove trash and debris. Pressure filter systems use pressure provided by an external pump to force water through the filter. Solids collect at the top of the sand media as the storm water passes through the media bed. The treated effluent exits the bottom of the filter and is discharged to receiving water. Pressure filters also require backwashing, a process that requires water to be forced through the media bed by an external pump. The backwash wastewater containing sediments trapped during filtration can be discharged to a sanitary sewer or a drying bed for disposal.



Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	●	◒
Nutrients	○	○
Pesticides	○	○
Total Metals	◒	◒
Dissolved Metals	◒	○
Microbiological	◒	○
Litter	○	○
BOD	○	○
TDS	○	○

Notes:

- Litter and debris removal must be accomplished prior to this unit

Key Design Elements:

1. Filtration rate
2. Media type and depth
3. Backwash cycle
4. Facilities for containing media and passing water through the filter bed

<u>Ancillary Facilities</u>

Capture volume facilities required upstream. Backwash water storage and disposal facilities.

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
◳	◒

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- _Requirements_: Residual handling. Mechanical equipment must be maintained.
- _Nuisance Control_: None identified.
- _Specialty Training /Equipment:_ Crews will need to be trained to maintain equipment.

Project Development:

- _Right-of Way-Requirements_: Not Available.
- _Siting Constraints_: Restricted to sites with available nearby power and possibly a sewer connection.
- _Construction:_ No unique requirements identified.

Advantages:

- The use of pressure, rather than gravity, to force water through a media bed allows a smaller footprint. Backwashing cycle cleans sediment from the filter media as opposed to periodically excavating a portion of the media as required for slow sand gravity filters. Pressure filter technology uses pumps, which allow more layout flexibility than gravity filtration.

Constraints:

- Connection to sewer or drying bed for backwash waste water is needed.
- Connection to a potable water supply or backwash water tank for backwashing is needed.
- Electric power supply for pump is required.
- Potentially higher capital costs due to pump and pressure tank.
- More maintenance is needed for a pressure filter than for a gravity filter because of the use of mechanical equipment.

Sources:

- Arkal Filtration Systems, www.arkal-filters.com
- Huber Technologies, www.huber.de/produktee/cfsfe.htm, [see Contiflow Sand Filter]
- Infilco Degremont, Inc., www.infilcodegremont.com
- Schreiber Wastewater Treatment Technologies, [see “Fuzzy Filter”]
- US Filter, www.usfilter.com/water
- Baker Filtration, www.bakerfiltration.com
- Rain for Rent, www.rainforrent.com

Literature Sources of Performance Demonstrations:

- Bachhuber, J. A. Pressurized Filtration System for Treatment of Urban Stormwater Pollution. Earth Tech. Inc. 1999.

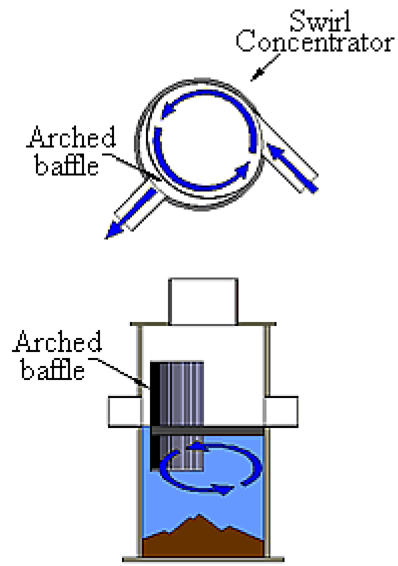
- Caliskaner O., Tchobanoglous G., Evaluation of the Fuzzy Filter for the Filtration of Secondary Effluent, Department of Civil and Environmental Engineering, University of California, Davis. September 1996.

- Fuzzy Filter: High Rate Filtration System. Schreiber Wastewater Treatment Technologies, www.schreiberwater.com/eqfuzzy.htm April 2000

- Shepard, John. Cost Estimate. Fuzzy Filter: Compressible Media Filter Data. April 2000.

Description:

The Aqua-Swirl™ uses an inlet pipe that introduces water tangentially to the cylindrical unit. A baffle is used at the outlet pipe to discourage short circuiting.



Source: www.aquashieldinc.com

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	◒	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	◒	○
BOD	○	○
TDS	○	○

Notes:

Key Design Elements:

1. Detention time
2. Bypass of scouring flows
3. Storage capacity

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
▖	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- _Requirements_: Initially the site should be monitored frequently in order to determine the required cleaning frequency.
- _Nuisance Control_: Standing water requires vector monitoring.
- _Specialty Training /Equipment_: Vactor equipment recommended for cleaning.

Project Development:

- _Right-of-Way Requirements_: Relatively small footprint
- _Siting Constraints_: Check for underground utility conflicts.
- _Construction_: No unique requirements identified.

Advantages:

- Small footprint, all underground, and no additional ROW or easement required, low head requirement.

Constraints:

- Scour may limit effectiveness.
- Vector concerns.

Sources:

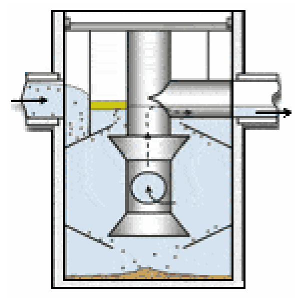
- AquaShield, www.aquashieldinc.com
- U.S. Environmental protection Agency, www.epa.gov/region1/assistance/ceitts/stormwater/techs/aquaswirl.html

Literature Sources of Performance Demonstrations:

- None identified.

Description:

Downstream Defender™ uses a system of deflector plates and cones to encourage sedimentation and discourage resuspension.



Source: www.hil-tech.com

Key Design Elements:

1. Detention time
2. Bypass of scouring flows
3. Storage capacity

Constituent Removal:

Constituent Group	***Removal Efficiency***	***Level-of-Confidence***
Total Suspended Solids	◒	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	◒	○
BOD	○	○
TDS	○	○

Notes:

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	***Level-of-Confidence***
▖	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: Initially the site should be monitored frequently in order to determine the required cleaning frequency.
- *Nuisance Control:* Standing water requires vector monitoring.
- *Specialty Training /Equipment:* Vactor equipment recommended for cleaning.

Project Development:

- *Right-of-Way Requirements*: Relatively small footprint
- *Siting Constraints*: Similar to drop inlets.
- *Construction:* No unique requirements identified.

Advantages:

- Small footprint, all underground, and no additional ROW or easement required, low head requirement.

Constraints:

- Scour may limit effectiveness.
- Vector concerns.

Sources:

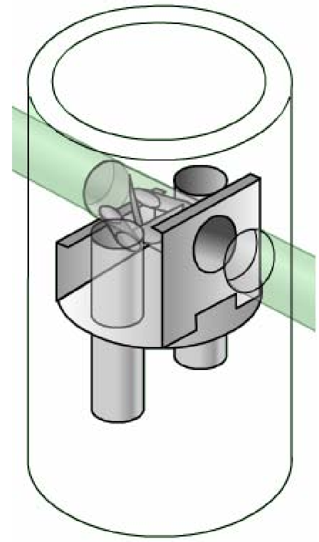
- HIL Technology, Inc., www.hil-tech.com
- U.S. Environmental Protection Agency, www.epa.gov/region1/assistance/ceitts/stormwater/techs/downstreamdefender.html

Literature Sources of Performance Demonstrations:

- None identified.

Description:

The Dual-Vortex™ uses a system of pipe to direct flow to two tubes that are designed to enhance sedimentation. Flood flow bypass is accomplished through a riser attached to the top of the inlet pipe.



Source: www.kristar.com

Constituent Removal:

Constituent Group	***Removal Efficiency***	***Level-of-Confidence***
Total Suspended Solids	◒	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	◒	○
BOD	○	○
TDS	○	○

Notes:

Key Design Elements:

1. Detention time
2. Bypass of scouring flows
3. Storage capacity

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	***Level-of-Confidence***
▖	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: Initially the site should be monitored frequently in order to determine the required cleaning frequency.
- *Nuisance Control*: Standing water requires vector monitoring.
- *Specialty Training /Equipment*: Vactor equipment recommended for cleaning.

Project Development:

- *Right-of-Way Requirements*: Relatively small footprint
- *Siting Constraints*: Similar to drop inlets.
- *Construction*: No unique requirements identified.

Advantages:

- Small footprint, all underground, and no additional ROW or easement required, low head requirement.

Constraints:

- Scour may limit effectiveness.
- Vector concerns.

Sources:

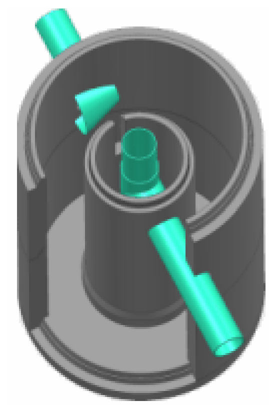
- KriStar Enterprises, Inc., www.kristar.com

Literature Sources of Performance Demonstrations:

- None identified

Description:

EcoStorm® has an outer cylinder where flow is introduced tangentially. Water enters an interior cylinder by a vertical slot. Low flows leave the inner cylinder via the bottom of a "T" pipe. High flow discharges over the top of the "T" section.



Source: www.royalenterprises.net

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	◒	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	◒	○
BOD	○	○
TDS	○	○

Notes:

Key Design Elements:

1. Detention time
2. Pollutant storage capacity
3. Flow capacity (flood and water quality flow)

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
▖	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: Initially the site should be monitored frequently in order to determine the required cleaning frequency.
- *Nuisance Control:* Standing water requires vector monitoring.
- *Specialty Training/Equipment:* Vector equipment recommended for cleaning.

Project Development:

- *Right-of-Way Requirements*: Relatively small footprint
- *Siting Constraints*: Similar to drop inlets.
- *Construction:* No unique requirements identified.

Advantages:

- Small footprint.

Constraints:

- Vector concerns.

Sources:

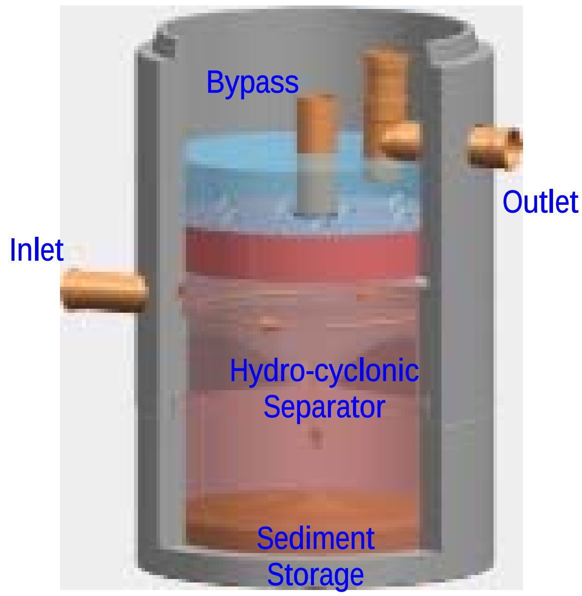
- Royal Environmental Systems, Inc., www.royalenterprises.net

Literature Sources of Performance Demonstrations:

- None identified.

Description:

EcoStorm Plus® is a cylinder that introduces storm water flows tangentially creating a vortex within the chamber. Gravity separation cause heavy sediments to collect at the bottom, while other pollutants are trapped as they are forced through a filtration system at the top. A high flow bypass and maintenance access is located in the center of the chamber.



Source: www.royalenterprises.net

Constituent Removal:

Constituent Group	***Removal Efficiency***	***Level-of-Confidence***
Total Suspended Solids	◒	○
Nutrients	○	○
Pesticides	○	○
Total Metals	◒	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	◒	○
BOD	○	○
TDS	○	○

Notes:

- Based on summarized field test data. Full report is being requested for review.

Key Design Elements:

1. Detention time
2. Pollutant storage capacity
3. Flow capacity (flood and water quality flow)

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	***Level-of-Confidence***
▖	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

● High	◒ Medium	○ Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: Initially the site should be monitored frequently in order to determine the required cleaning frequency.
- *Nuisance Control:* Standing water requires vector monitoring.
- *Specialty Training/Equipment:* Vactor equipment recommended for cleaning.

Project Development:

- *Right-of-Way Requirements*: Relatively small footprint
- *Siting Constraints*: Similar to drop inlets.
- *Construction:* No unique requirements identified.

Advantages:

- Small footprint.

Constraints:

- Vector concerns.

Sources:

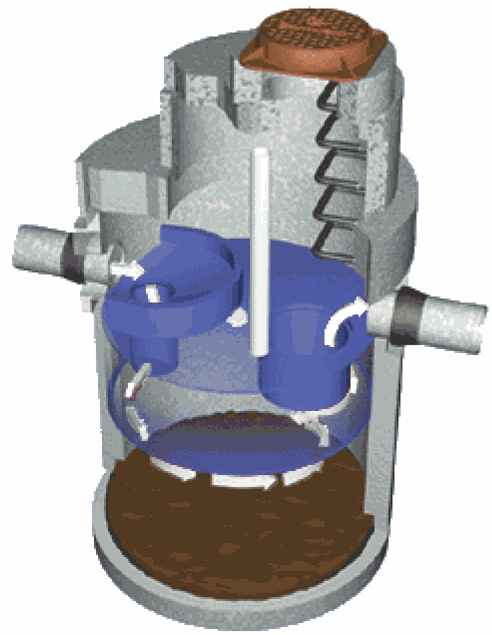
- Royal Environmental Systems, Inc., www.royalenterprises.net

Literature Sources of Performance Demonstrations:

- Ecotechnic GmnH & Co KG, "*EcoStorm Plus® Stormwater Treatment Process,*" www.ecotechnic.at, (January 2006)

Description:

The Stormceptor® introduces flow into a tube that is designed to settle material into an area protected from high flows. Water circulates back up through the clean-out access port.



Source: www.rinkermaterials.com/stormceptor

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	◒	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	◒	○
BOD	○	○
TDS	○	○

Notes:

Key Design Elements:

1. Detention time
2. Bypass of scouring flows
3. Storage capacity

Cost Effectivness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
▖	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: Initially the site should be monitored frequently in order to determine the required cleaning frequency.
- *Nuisance Control:* Standing water requires vector monitoring.
- *Specialty Training /Equipment:* Vactor equipment recommended for cleaning.

Project Development:

- *Right-of-Way Requirements*: Relatively small footprint
- *Siting Constraints*: Similar to drop inlets.
- *Construction:* No unique requirements identified.

Advantages:

- Small footprint, all underground, and no additional ROW or easement required, low head requirement.

Constraints:

- Scour may limit effectiveness.
- Vector concerns.

Sources:

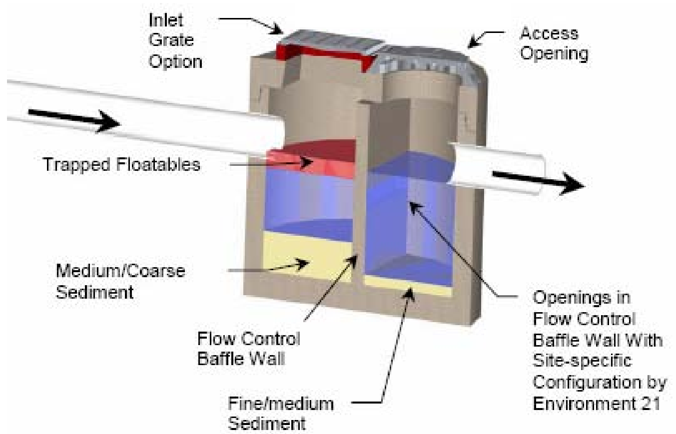
- Stormceptor, Inc., www.rinkermaterials.com/stormceptor/
- U.S. Environmental Protection Agency, www.epa.gov/region1/assistance/ceitts/stormwater/techs/stormceptor.html

Literature Sources of Performance Demonstrations:

- None identified

Description:

The Unistorm™ is a dual in-line tank system with no internal by-pass. Surface water enters the first of two cylindrical tanks trapping floatables in a filtration media while heavy sediment settles on the bottom. Fine to medium sediment then passes through a baffle wall that controls flow entering the second tank before leaving the system.



Source: www.env21.com

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	◒	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	◒	○
BOD	○	○
TDS	○	○

Notes:

Key Design Elements:

1. Detention time
2. Pollutant storage capacity
3. Flow capacity (flood and water quality flow)

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
▖	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: Initially the site should be monitored frequently in order to determine the required cleaning frequency.
- *Nuisance Control:* Standing water requires vector monitoring.
- *Specialty Training /Equipment:* Vactor equipment recommended for cleaning.

Project Development:

- *Right-of-Way Requirements*: Relatively small footprint
- *Siting Constraints*: Similar to drop inlets.
- *Construction:* No unique requirements identified.

Advantages:

- Small footprint.

Constraints:

- Vector concerns

Sources:

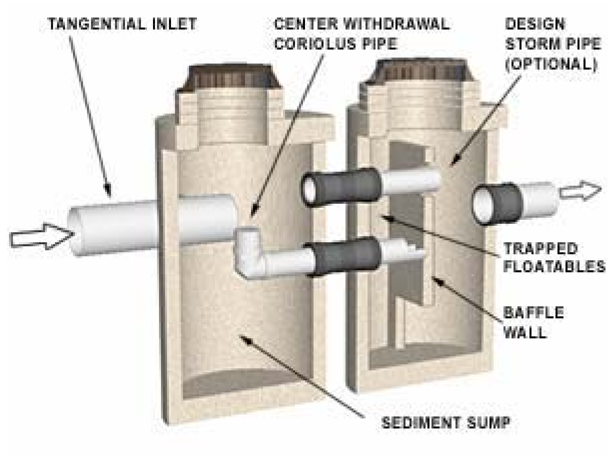
- Environmental 21, LLC, www.env21.com
- U.S. Environmental Protection Agency, www.epa.gov/region1/assistance/ceitts/stormwater/techs/v2b1.html

Literature Sources of Performance Demonstrations:

- None identified.

Description:

The V2B1™ is a dual tank in-line system. Surface water enters the first of two cylindrical tanks by means of a tangential inlet pipe. Heavy sediment is collected in the sediment sump of the first chamber as water is decanted off the top by an upturned pipe. The second "floatables" chamber restrains lighter floating oil and organic debris through the use of a baffle wall before surface water is directed out of the system. During high flow events an optional second pipe, located higher in the first chamber, allows water to internally bypass the system.



Source: www.env21.com

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	◒	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	◒	○
BOD	○	○
TDS	○	○

Notes:

Key Design Elements:

1. Detention time
2. Pollutant storage capacity
3. Flow capacity (flood and water quality flow)

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
▖	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: Initially the site should be monitored frequently in order to determine the required cleaning frequency.
- *Nuisance Control*: Standing water requires vector monitoring.
- *Specialty Training /Equipment*: Vactor equipment recommended for cleaning.

Project Development:

- *Right-of-Way Requirements*: Relatively small footprint
- *Siting Constraints*: Similar to drop inlets.
- *Construction*: No unique requirements identified.

Advantages:

- Small footprint.

Constraints:

- Vector concerns

Sources:

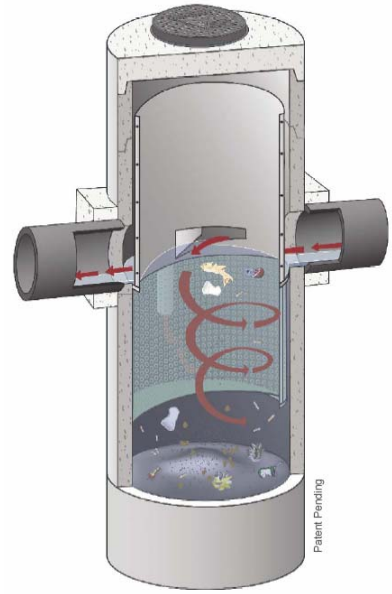
- Environmental 21, LLC, www.env21.com
- U.S. Environmental Protection Agency, www.epa.gov/region1/assistance/ceitts/stormwater/techs/v2b1.html

Literature Sources of Performance Demonstrations:

- None identified.

Description:

VortCapture™ is a screen and sump system that is designed to capture sediment and debris without clogging the screen. Flow enters the treatment chamber tangentially and continuously swirls through the chamber. The unit is designed to capture all material ≥ 5 mm. Some smaller particles are also retained. A standing pool of water helps minimize head requirements and scour. Low flow exits through the screen and excess flow bypass the treatment unit.



Source: www.vortechnics.com

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	◒	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	◒	○
BOD	○	○
TDS	○	○

Notes:

Key Design Elements:

1. Detention time
2. Pollutant storage capacity
3. Flow capacity (flood and water quality flow)

Equivalent Uniform Annual Costs:

Cost Effectiveness	*Level-of-Confidence*
▖	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: Initially the site should be monitored frequently in order to determine the required cleaning frequency.
- *Nuisance Control:* Standing water requires vector monitoring.
- *Specialty Training /Equipment:* Vactor equipment recommended for cleaning.

Project Development:

- *Right-of-Way Requirements*: Relatively small footprint.
- *Siting Constraints*: Low head requirements.
- *Construction:* No special requirements identified.

Advantages:

- Small footprint
- All underground
- No additional ROW or easement required
- Low head requirement.

Constraints:

- Vector concerns.

Sources:

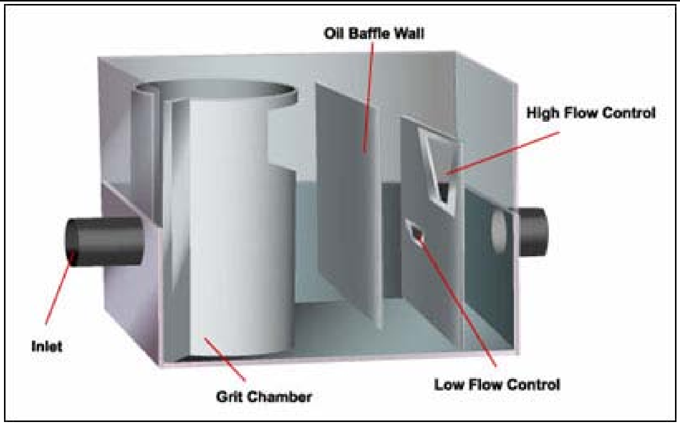
- U.S. Environmental Protection Agency, www.epa.gov/region1/assistance/ceitts/stormwater/techs/vortechs.html
- Vortechnics®, Inc., www.vortechnics.com

Literature Sources of Performance Demonstrations:

- none

Description:

Vortechs® is similar to a water quality inlet that uses hydrodynamic separation at the influent. High flows are designed to flow through the unit.



Source: www.vortechnics.com

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	◒	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	◒	○
BOD	○	○
TDS	○	○

Notes:

- Field test are based on TSS influent concentrations 3 to 8 times higher than typical highway concentrations (around 100mg/L) so removal efficiencies were estimated.

Key Design Elements:

1. Detention time
2. Bypass of scouring flows
3. Storage capacity

Equivalent Uniform Annual Costs:

Cost Effectiveness	*Level-of-Confidence*
▖	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: Initially the site should be monitored frequently in order to determine the required cleaning frequency.
- *Nuisance Control:* Standing water requires vector monitoring.
- *Specialty Training /Equipment:* Vactor equipment recommended for cleaning.

Project Development:

- *Right-of-Way Requirements*: Relatively small footprint
- *Siting Constraints*: Similar to drop inlets.
- *Construction:* No unique requirements identified.

Advantages:

- Small footprint, all underground, and no additional ROW or easement required, low head requirement.

Constraints:

- Scour may limit effectiveness.
- Vector concerns.

Sources:

- U.S. Environmental Protection Agency, www.epa.gov/region1/assistance/ceitts/stormwater/techs/vortechs.html
- Vortechnics®, Inc., www.vortechnics.com

Literature Sources of Performance Demonstrations:

- Board, Susan Mary, "Vortechnics Treatment Of Parking Lot Runoff," University of Connecticut, 2001.

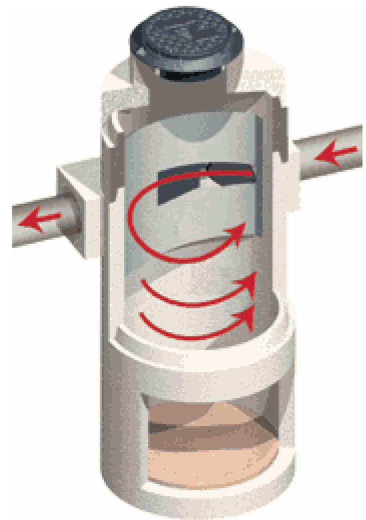
- Greenway, A. Roger, "Stormwater Treatment Demonstration Project Oil Water/Grit Separation followed by a Sand Filter," RTP Environmental Associates, Inc., 2000.

- Vortechnics®, "Vortechs® Stormwater Treatment System Field Testing Report," March 2000.

- West, Tracy A., James W. Sutherland, Jay A. Bloomfield, Donald W. Lake Jr., "A Study of the Effectiveness of a Vortechs™ Stormwater Treatment System for Removal of Total Suspended Solids and Other Pollutants in the Marine Village Watershed, Village of Lake George, New York," New York State Department of Environmental Conservation, January 2001.

Description:

The VortSentry™ uses vanes to direct the incoming flow downward. The water then flows under a baffle before discharging the unit. Flood flows are passed internally by overtopping a flow partition on the inlet.



Source: www.vortechnics.com

Key Design Elements:

1. Detention time
2. Bypass of scouring flows
3. Storage capacity

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	◒	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	◒	○
BOD	○	○
TDS	○	○

Notes:

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
▖	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: Initially the site should be monitored frequently in order to determine the required cleaning frequency.
- *Nuisance Control:* Standing water requires vector monitoring.
- *Specialty Training /Equipment:* Vactor equipment recommended for cleaning.

Project Development:

- *Right-of-Way Requirements*: Relatively small footprint
- *Siting Constraints*: Similar to drop inlets.
- *Construction:* No unique requirements identified.

Advantages:

- Small footprint, all underground, and no additional ROW or easement required, low head requirement.

Constraints:

- Scour may limit effectiveness.
- Vector concerns.

Sources:

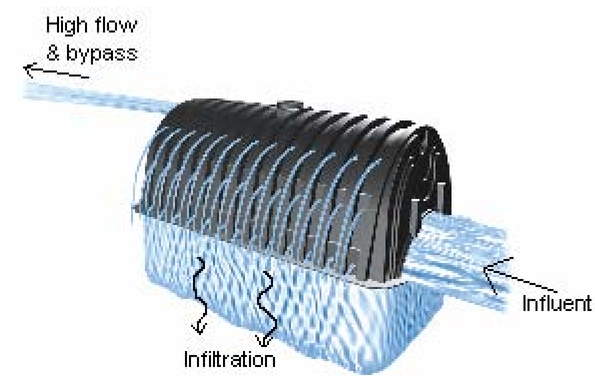
- Vortechnics, Inc., www.vortechnics.com

Literature Sources of Performance Demonstrations:

- None identified

Description:

The Cultec Contactor™ and Recharger™ plastic leaching systems are examples of subsurface storm water management. Sometimes they replace conventional pipe systems and retention ponds. Cultec chambers provide an open bottom interface. The storm water is leached into the surrounding backfill or directly absorbed into the soil. High flow bypasses can be incorparated for overflow conditions.



Source: www.cultec.com

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	●	◒
Nutrients	●	◒
Pesticides	●	◒
Total Metals	●	◒
Dissolved Metals	●	◒
Microbiological	●	◒
Litter	●	◒
BOD	●	◒
TDS	●	◒

Notes:

- Chambers can be placed in either trench or bed configurations by utilizing the patented interlocking rib connection.
- Removal efficiency for infiltration is assumed to be 100% for the design water quality volume since no water is discharged to surface waters.

Key Design Elements:

- Distance to groundwater
- Permeability of soils
- Class V injection well determination
- Minimum cover
- Overhead load bearing capacity

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
◳ (Benefit ↑ Cost ↑)	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: Sediment removal. Rehabilitation is required when system clogs.
- *Nuisance Control:* None identified, if water infiltrates within 72 hours.
- *Specialty Training /Equipment:* Likely vactor equipment with the ability to clean horizontal lines. Equipment and training needed for confined space entry.

Project Development:

- *Right-of-Way Requirements*: Large area requirements, but area above grade can be used if constructed properly.
- *Siting Constraints*: Permeable soils, adequate separation groundwater
- *Construction:* Unexpected soil characteristics or water table location may scrape the project. Must avoid clogging the filter by compaction from vehicles or by fines introduced during or after construction. Bypass water until drainage is stabilized.

Advantages:

- These BMPs prevent the design surface runoff from reaching receiving water (i.e., they are "no surface discharge BMPs").
- Total drainage interface averages more than 60% higher than conventional PVC pipe and stone system of comparable size.
- Infiltration address all pollutants.

Constraints:

- Vulnerable to clogging.
- Must be placed on permeable soil.
- Must avoid high groundwater
- Must avoid areas prone to spills of groundwater contaminents.
- Must addres EPA class V injection well regulations
- Higher construction costs per capture volume than basins.
- Maintenance of underground systems is difficult.
- Water percolation may disrupt roadway foundation or fill slope stability.

Sources:

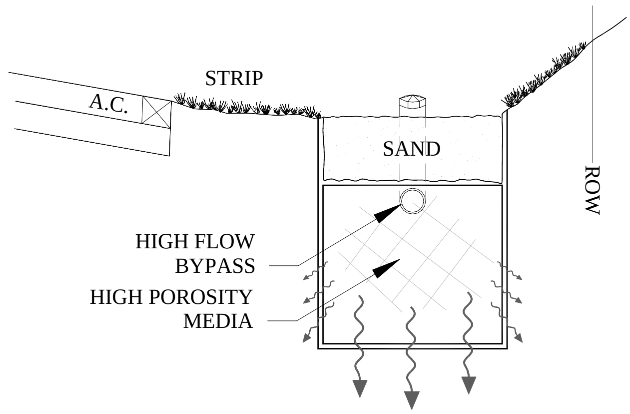
- Cultec, Inc., www.cultec.com
- U.S. Environmental Protection Agency, "When Are Storm Water Discharges regulated As Class V Wells?", www.epa.gov/safewater/uic/pdfs/fact_class5_stormwater.pdf

Literature Sources of Performance Demonstrations:

- None identified

Description:

The Linear Infiltration Filter Trench is a non-proprietary device in which stormwater flows through a sand filter prior to entering the drainage trench. Pretreatment within the sand layer reduces clogging of the trench. The trench is backfilled with a high porosity media that is available from several suppliers.



Key Design Elements:

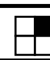
- Distance to groundwater
- Permeability of soils
- Class V injection well determination, if horizontal piping is used.
- Overhead load bearing capacity For errant vehicles.

Constituent Removal:

Constituent Group	***Removal Efficiency***	***Level-of-Confidence***
Total Suspended Solids	●	◒
Nutrients	●	◒
Pesticides	●	◒
Total Metals	●	◒
Dissolved Metals	●	◒
Microbiological	●	◒
Litter	●	◒
BOD	●	◒
TDS	●	◒

Notes:

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	***Level-of-Confidence***
	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

● High	◒ Medium	○ Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: Sediment removal. Rehabilitation is required when system clogs.
- *Nuisance Control:* None identified, if water infiltrates within 72 hours.
- *Specialty Training /Equipment:* None identified.

Project Development:

- *Right-of-Way Requirements*: Less than approved BMPs..
- *Siting Constraints*: Permeable soils, adequate separation groundwater
- *Construction:* Unexpected soil characteristics or water table location may scrape the project. Must avoid clogging the filter by compaction from vehicles or by fines introduced during or after construction. Bypass water until drainage is stabilized.

Advantages:

- These BMPs prevent the design surface runoff from reaching receiving water (i.e., they are "no surface discharge BMPs").
- Infiltration address all pollutants.

Constraints:

- Vulnerable to clogging.
- Must be placed on permeable soil.
- Must avoid high groundwater
- Must avoid areas prone to spills of groundwater contaminants.
- Must address EPA class V injection well regulations
- May have higher construction costs per capture volume than basins.
- Maintenance of underground systems is difficult.
- Water percolation may disrupt roadway foundation or fill slope stability.

Sources:

High porosity products include:

- Matrix™
- Rainstore®
- Stormcell®
- Versicell

Literature Sources of Performance Demonstrations:

- None identified

Description:

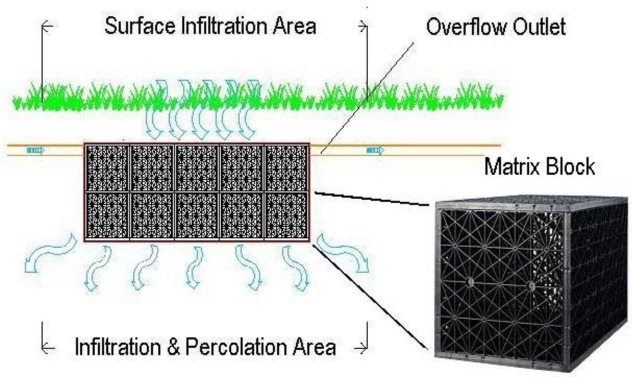
The Matrix™ is a high void space storage system for below grade infiltration systems. Siting and operational considerations may limit their use as an urban water quality BMP. They include: the need for a soil substrate with relatively high infiltration rates; the high incidence of clogging for this technology, especially when pollutant loads from construction are allowed to enter the facility; the potential threat to local groundwater; and the expense of remediation for a clogged trench.

Constituent Removal:

Constituent Group	***Removal Efficiency***	***Level-of-Confidence***
Total Suspended Solids	●	◒
Nutrients	●	◒
Pesticides	●	◒
Total Metals	●	◒
Dissolved Metals	●	◒
Microbiological	●	◒
Litter	●	◒
BOD	●	◒
TDS	●	◒

Notes:

- Removal efficiency for infiltration is assumed to be 100% for the design water quality volume since no water is discharged to surface waters.



Source: www.atlantiscorp.com.au

Key Design Elements:

1. Sizing based on infiltration rate
2. Class V injection well determination

<u>Ancillary Facilities</u>

Pretreatment to remove particles is required to avoid clogging the infiltration surface. This will normally require sedimentation and filtration facilities upstream.

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	***Level-of-Confidence***
	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- <u>*Requirements*</u>: Rehabilitation is required when the system clogs. Infiltration trenches may require reconstruction every ten years (Young et. al. Evaluation and Management of Highway Runoff Water Quality, June 1996).
- <u>*Nuisance Control:*</u> None identified, if water infiltrates within 72 hours.
- <u>*Specialty Training/Equipment*</u>*:* Rehabilitation requires construction equipment.

Project Development:

- <u>*Right-of-Way Requirements*</u>: Space requirements are reduced rock filled compared to trenches. Pretreatment is required.
- <u>*Siting Constraints*</u>: Restricted to sites with appropriate soil characteristics and low water table.
- <u>*Construction*</u>*:* Unexpected soil characteristics or water table location may scrape the project. Must avoid clogging the filter by compaction from vehicles or by fines introduced during or after construction. Bypass water until drainage is stabilized.

Advantages:

- These BMPs prevent the design surface runoff from reaching receiving water (i.e., they are "no surface discharge BMPs").
- They are not limited to a length-to-width ratio and can be fitted along the road in the freeway right-of-way; and layout and design are based on available space and drainage surface area.
- Infiltration trenches offer lesser chance for mosquito breeding and vector propagation. As an underground BMP, trenches have few negative visual aesthetic impacts. They do not require power, making them good candidates for retrofitting in the freeway right-of-way. Few or no mechanical devices would be needed, depending on the pretreatment device selected.

Constraints:

- Rehabilitation cost per unit of treated water volume is high
- Water percolation may disrupt roadway foundation or fill slope stability.
- Vulnerable to clogging.
- Must be placed on permeable soil.
- Must avoid high groundwater
- Must avoid areas prone to spills of groundwater contaminants.
- Must address EPA class V injection well regulations
- Higher construction costs per capture volume than basins.
- Maintenance of underground systems is difficult.

Sources:

- Atlantis Water Management, Matrix™, www.atlantiscorp.com.au
- U.S. Environmental Protection Agency, "When Are Storm Water Discharges regulated As Class V Wells?", www.epa.gov/safewater/uic/pdfs/fact_class5_stormwater.pdf

Literature Sources of Performance Demonstrations:

- ASCE, Manual and Report on Engineering Practice No. 87. 1998.
- Sansalone, J. J., et al. "Infiltration Device as a Best Management Practice for Immobilizing Heavy Metals in Urban Highway Runoff."
- Young, G. Kenneth, Stuart Stein, Pamela Cole, Traci Kammer, Frank Graziano, Fred Bank, "Evaluation and Management of Highway Runoff Water Quality," Federal Highway Administration, June 1996.

Description:

The Rainstore[3] is a high void space storage system for below grade infiltration systems. Siting and operational considerations may limit their use as an urban water quality BMP. They include: the need for a soil substrate with relatively high infiltration rates; the high incidence of clogging for this technology, especially when pollutant loads from construction are allowed to enter the facility; the potential threat to local groundwater; and the expense of remediation for a clogged trench.

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	●	◒
Nutrients	●	◒
Pesticides	●	◒
Total Metals	●	◒
Dissolved Metals	●	◒
Microbiological	●	◒
Litter	●	◒
BOD	●	◒
TDS	●	◒

Notes:

- Removal efficiency for infiltration is assumed to be 100% for the design water quality volume since no water is discharged to surface waters.

For trench layout see Fact Sheet C-28
Source: www.invisiblestructures.com

Key Design Elements:

1. Sizing based on infiltration rate
2. Class V injection well determination

<u>Ancillary Facilities</u>

Pretreatment to remove particles is required to avoid clogging the infiltration surface. This will normally require sedimentation and filtration facilities upstream.

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
⊞	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: Rehabilitation is required when the system clogs. Infiltration trenches may require reconstruction every ten years (Young et. al. Evaluation and Management of Highway Runoff Water Quality, June 1996).
- *Nuisance Control:* None identified, if water infiltrates within 72 hours.
- *Specialty Training/Equipment:* Rehabilitation requires construction equipment.

Project Development:

- *Right-of-Way Requirements*: Space requirements are reduced rock filled compared to trenches. Pretreatment is required.
- *Siting Constraints*: Restricted to sites with appropriate soil characteristics and low water table.
- *Construction:* Unexpected soil characteristics or water table location may scrape the project. Must avoid clogging the filter by compaction from vehicles or by fines introduced during or after construction. Bypass water until drainage is stabilized.

Advantages:

- These BMPs prevent the design surface runoff from reaching receiving water (i.e., they are “no surface discharge BMPs”).
- They are not limited to a length-to-width ratio and can be fitted along the road in the freeway right-of-way; and layout and design are based on available space and drainage surface area.
- Infiltration trenches offer lesser chance for mosquito breeding and vector propagation. As an underground BMP, trenches have few negative visual aesthetic impacts. They do not require power, making them good candidates for retrofitting in the freeway right-of-way. Few or no mechanical devices would be needed, depending on the pretreatment device selected.

Constraints:

- Rehabilitation cost per unit of treated water volume is high
- Water percolation may disrupt roadway foundation or fill slope stability.
- Vulnerable to clogging.
- Must be placed on permeable soil.
- Must avoid high groundwater
- Must avoid areas prone to spills of groundwater contaminants.
- Must address EPA class V injection well regulations
- Higher construction costs per capture volume than basins.
- Maintenance of underground systems is difficult.

Sources:

- Invisible Structures, Inc., www.invisiblestructures.com
- U.S. Environmental Protection Agency, “When Are Storm Water Discharges regulated As Class V Wells?”, www.epa.gov/safewater/uic/pdfs/fact_class5_stormwater.pdf

Literature Sources of Performance Demonstrations:

- ASCE, Manual and Report on Engineering Practice No. 87. 1998.
- Sansalone, J. J., et al. “Infiltration Device as a Best Management Practice for Immobilizing Heavy Metals in Urban Highway Runoff.”
- Young, G. Kenneth, Stuart Stein, Pamela Cole, Traci Kammer, Frank Graziano, Fred Bank, “Evaluation and Management of Highway Runoff Water Quality,” Federal Highway Administration, June 1996.

Description:

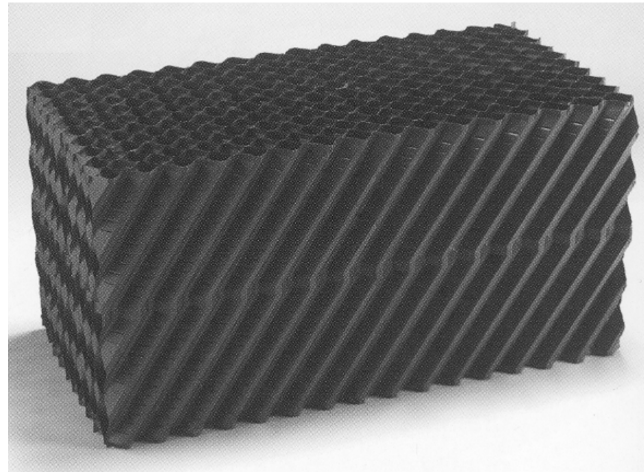
The Stormcell® is a high void space storage system for below grade infiltration systems. Siting and operational considerations may limit their use as an urban water quality BMP. They include: the need for a soil substrate with relatively high infiltration rates; the high incidence of clogging for this technology, especially when pollutant loads from construction are allowed to enter the facility; the potential threat to local groundwater; and the expense of remediation for a clogged trench.

Constituent Removal:

Constituent Group	***Removal Efficiency***	***Level-of-Confidence***
Total Suspended Solids	●	◒
Nutrients	●	◒
Pesticides	●	◒
Total Metals	●	◒
Dissolved Metals	●	◒
Microbiological	●	◒
Litter	●	◒
BOD	●	◒
TDS	●	◒

Notes:

- Removal efficiency for infiltration is assumed to be 100% for the design water quality volume since no water is discharged to surface waters.



Source: www.hydro-international.biz

Key Design Elements:

1. Sizing based on infiltration rate
2. Class V injection well determination.

Ancillary Facilities

Pretreatment to remove particles is required to avoid clogging the infiltration surface. This will normally require sedimentation and filtration facilities upstream.

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	***Level-of-Confidence***
	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: Rehabilitation is required when the system clogs. Infiltration trenches may require reconstruction every ten years (Young et. al. Evaluation and Management of Highway Runoff Water Quality, June 1996).
- *Nuisance Control:* None identified, if water infiltrates within 72 hours.
- *Specialty Training/Equipment:* Rehabilitation requires construction equipment.

Project Development:

- *Right-of-Way Requirements*: Space requirements are reduced rock filled compared to trenches. Pretreatment is required.
- *Siting Constraints*: Restricted to sites with appropriate soil characteristics and low water table.
- *Construction:* Unexpected soil characteristics or water table location may scrape the project. Must avoid clogging the filter by compaction from vehicles or by fines introduced during or after construction. Bypass water until drainage is stabilized.

Advantages:

- These BMPs prevent the design surface runoff from reaching receiving water (i.e., they are “no surface discharge BMPs”).
- They are not limited to a length-to-width ratio and can be fitted along the road in the freeway right-of-way; and layout and design are based on available space and drainage surface area.
- Infiltration trenches offer lesser chance for mosquito breeding and vector propagation. As an underground BMP, trenches have few negative visual aesthetic impacts. They do not require power, making them good candidates for retrofitting in the freeway right-of-way. Few or no mechanical devices would be needed, depending on the pretreatment device selected.

Constraints:

- Rehabilitation cost per unit of treated water volume is high
- Water percolation may disrupt roadway foundation or fill slope stability.
- Vulnerable to clogging.
- Must be placed on permeable soil.
- Must avoid high groundwater
- Must avoid areas prone to spills of groundwater contaminants.
- Must address EPA class V injection well regulations
- Higher construction costs per capture volume than basins.
- Maintenance of underground systems is difficult.

Sources:

- Hydro International, www.hydro-international.biz
- U.S. Environmental Protection Agency, “When Are Storm Water Discharges regulated As Class V Wells?”, www.epa.gov/safewater/uic/pdfs/fact_class5_stormwater.pdf

Literature Sources of Performance Demonstrations:

- ASCE, Manual and Report on Engineering Practice No. 87. 1998.
- Sansalone, J. J., et al. “Infiltration Device as a Best Management Practice for Immobilizing Heavy Metals in Urban Highway Runoff.”
- Young, G. Kenneth, Stuart Stein, Pamela Cole, Traci Kammer, Frank Graziano, Fred Bank, “Evaluation and Management of Highway Runoff Water Quality,” Federal Highway Administration, June 1996.

Description:

The StormChamber™ plastic leaching systems is an example of subsurface storm water management. Sometimes StormChamber™ may replace conventional pipe systems and retention ponds. StormChamber™ provides an open bottom interface. The storm water is leached into the surrounding backfill or directly absorbed into the soil. High flow bypasses can be incorparated for overflow conditions.

Source: www.hydrologicsolutions.com

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	●	◒
Nutrients	●	◒
Pesticides	●	◒
Total Metals	●	◒
Dissolved Metals	●	◒
Microbiological	●	◒
Litter	●	◒
BOD	●	◒
TDS	●	◒

Notes:

- Chambers can be placed in either trench or bed configurations by utilizing the patented interlocking rib connection.
- Removal efficiency for infiltration is assumed to be 100% for the design water quality volume since no water is discharged to surface waters.

Key Design Elements:

- Distance to groundwater
- Permeability of soils
- Class V injection well determination
- Minimum cover
- Overhead load bearing capacity

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
▝	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- <u>*Requirements*</u>: Sediment removal.
- <u>*Nuisance Control:*</u> None identified, if water infiltrates within 72 hours.
- <u>*Specialty Training/Equipment*</u>*:* Likely vactor equipment with the ability to clean horizontal lines. Equipment and training needed for confined space entry.

Project Development:

- <u>*Right-of-Way Requirements*</u>: Large area requirements, but area above grade can be used if constructed properly.
- <u>*Siting Constraints*</u>: Permeable soils, adequate separation groundwater
- <u>*Construction*</u>*:* Unexpected soil characteristics or water table location may scrape the project. Must avoid clogging the filter by compaction from vehicles or by fines introduced during or after construction. Bypass water until drainage is stabilized.

Advantages:

- These BMPs prevent the design surface runoff from reaching receiving water (i.e., they are "no surface discharge BMPs").
- Total drainage interface averages more than 60% higher than conventional PVC pipe and stone system of comparable size.
- Infiltration address all pollutants.

Constraints:

- Vulnerable to clogging.
- Must be placed on permeable soil.
- Must avoid high groundwater
- Must avoid areas prone to spills of groundwater contaminents.
- Must addres EPA class V injection well regulations
- Higher construction costs per capture volume than basins.
- Maintenance of underground systems is difficult.
- Water percolation may disrupt roadway foundation or fill slope stability.

Sources:

- HydroLogic Solutions, www.hydrologicsolutions.com
- U.S. Environmental Protection Agency, "When Are Storm Water Discharges regulated As Class V Wells?", www.epa.gov/safewater/uic/pdfs/fact_class5_stormwater.pdf

Literature Sources of Performance Demonstrations:

- none identified

Description:

The Stormtech® is a plastic leaching system of chambers, typical of a subsurface storm water management. They may be able to replace conventional pipe systems and detention/retention ponds. The storm water is leached into the surrounding backfill or directly absorbed into the soil. High flow bypasses can be incorporated for overflow conditions.

Constituent Removal:

Constituent Group	***Removal Efficiency***	***Level-of-Confidence***
Total Suspended Solids	●	◒
Nutrients	●	◒
Pesticides	●	◒
Total Metals	●	◒
Dissolved Metals	●	◒
Microbiological	●	◒
Litter	●	◒
BOD	●	◒
TDS	●	◒

Notes:

- Chambers can be placed in either trench or bed arrangements by interlocking rib connections.
- Removal efficiency for infiltration is assumed to be 100% for the design water quality volume since no water is discharged to surface waters.

Source: /www.ads-pipe.com/us/en/technical/stormtech.shtml

Key Design Elements:

- Distance to groundwater
- Permeability of soils
- Class V injection well determination
- Minimum cover
- Overhead load bearing capacity

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	***Level-of-Confidence***
Benefit ↑ Cost ↑	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: Sediment removal. Rehabilitation is required when system clogs.
- *Nuisance Control:* None identified, if water infiltrates within 72 hours.
- *Specialty Training /Equipment:* Likely vactor equipment with the ability to clean horizontal lines. Equipment and training needed for confined space entry.

Project Development:

- *Right-of-Way Requirements*: Large area requirements, but area above grade can be used if constructed properly.
- *Siting Constraints*: Permeable soils, adequate separation groundwater
- *Construction:* Unexpected soil characteristics or water table location may scrape the project. Must avoid clogging the filter by compaction from vehicles or by fines introduced during or after construction. Bypass water until drainage area is stabilized.

Advantages:

- These BMPs prevent the design surface runoff from reaching receiving water (i.e., they are “no surface discharge BMPs”).
- Total drainage interface averages more than 60% higher than conventional PVC pipe and stone system of comparable size.
- Infiltration address all pollutants.

Constraints:

- Vulnerable to clogging.
- Must be placed on permeable soil.
- Must avoid high groundwater
- Must avoid areas prone to spills of groundwater contaminents.
- Must addres EPA class V injection well regulations
- Higher construction costs per capture volume than basins.
- Maintenance of underground systems is difficult.
- Water percolation may disrupt roadway foundation or fill slope stability.

Sources:

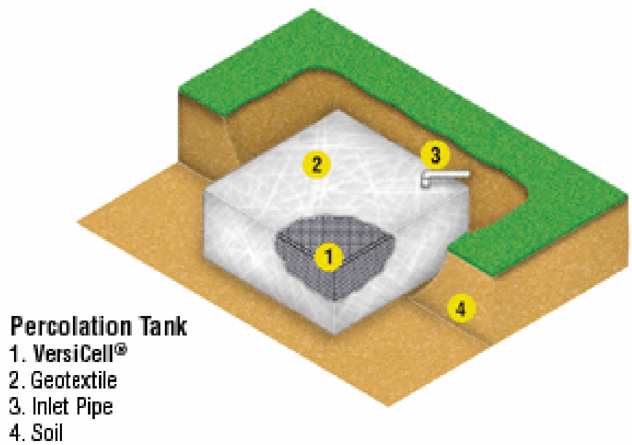
- Stormtech, Subsurface Stormwater Mangement, www.StormTech.com
- Advanced Drainage Systems, Inc., www.ads-pipe.com/us/en/technical/stormtech.shtml

Literature Sources of Performance Demonstrations:

- None identified

Description:

The VersiCell® is a high void space storage system for below grade infiltration systems. Siting and operational considerations may limit their use as an urban water quality BMP. They include: the need for a soil substrate with relatively high infiltration rates; the high incidence of clogging for this technology, especially when pollutant loads from construction are allowed to enter the facility; the potential threat to local groundwater; and the expense of remediation for a clogged trench.



Source: www.vesproinc.com/VersiCell/

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	●	◒
Nutrients	●	◒
Pesticides	●	◒
Total Metals	●	◒
Dissolved Metals	●	◒
Microbiological	●	◒
Litter	●	◒
BOD	●	◒
TDS	●	◒

Notes:

- Removal efficiency for infiltration is assumed to be 100% for the design water quality volume since no water is discharged to surface waters.

Key Design Elements:

1. Sizing based on infiltration rate
2. Class V injection well determination

Ancillary Facilities
Pretreatment to remove particles is required to avoid clogging the infiltration surface. This will normally require sedimentation and filtration facilities upstream.

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
◳	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

● High	◒ Medium	○ Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: Rehabilitation is required when the system clogs. Infiltration trenches may require reconstruction every ten years (Young et. al. Evaluation and Management of Highway Runoff Water Quality, June 1996).
- *Nuisance Control:* None identified, if water infiltrates within 72 hours.
- *Specialty Training/Equipment:* Rehabilitation requires construction equipment.

Project Development:

- *Right-of-Way Requirements*: Space requirements are reduced rock filled compared to trenches. Pretreatment is required.
- *Siting Constraints*: Restricted to sites with appropriate soil characteristics and low water table.
- *Construction:* Unexpected soil characteristics or water table location may scrape the project. Must avoid clogging the filter by compaction from vehicles or by fines introduced during or after construction. Bypass water until drainage is stabilized.

Advantages:

- These BMPs prevent the design surface runoff from reaching receiving water (i.e., they are "no surface discharge BMPs").
- They are not limited to a length-to-width ratio and can be fitted along the road in the freeway right-of-way; and layout and design are based on available space and drainage surface area.
- Infiltration trenches offer lesser chance for mosquito breeding and vector propagation. As an underground BMP, trenches have few negative visual aesthetic impacts. They do not require power, making them good candidates for retrofitting in the freeway right-of-way. Few or no mechanical devices would be needed, depending on the pretreatment device selected.

Constraints:

- Rehabilitation cost per unit of treated water volume is high
- Water percolation may disrupt roadway foundation or fill slope stability.
- Vulnerable to clogging.
- Must be placed on permeable soil.
- Must avoid high groundwater
- Must avoid areas prone to spills of groundwater contaminants.
- Must address EPA class V injection well regulations
- Higher construction costs per capture volume than basins.
- Maintenance of underground systems is difficult.

Sources:

- U.S. Environmental Protection Agency, "When Are Storm Water Discharges regulated As Class V Wells?", www.epa.gov/safewater/uic/pdfs/fact_class5_stormwater.pdf

Literature Sources of Performance Demonstrations:

- ASCE, Manual and Report on Engineering Practice No. 87. 1998.
- Sansalone, J. J., et al. "Infiltration Device as a Best Management Practice for Immobilizing Heavy Metals in Urban Highway Runoff."
- Young, G. Kenneth, Stuart Stein, Pamela Cole, Traci Kammer, Frank Graziano, Fred Bank, "Evaluation and Management of Highway Runoff Water Quality," Federal Highway Administration, June 1996.

Litter and Debris Removal – Breakaway Bags

Gross Pollutant Trap (GPT)

Description:

A breakaway litter bag installed at the storm water outfall is designed to capture litter. When the bag fills up, it is pushed off the pipe and ties off automatically. It can be used as a stand-alone litter removal device or as inlet to an extended detention basin.

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	○	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	●	○
BOD	○	○
TDS	○	○

Notes:

- The Breakaway litter bags are not assumed to provide storm water pollutant removal.
- No long-term water quality monitoring studies have been conducted to evaluate treatment effectiveness

Source: www.nettech.com.au

Key Design Elements:

1. Proprietary device
2. Bag capacity

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: Requires access road for maintenance. Frequent inspections may be required to check on the nets.
- *Nuisance Control:* None identified.
- *Specialty Training/Equipment:* No special requirements identified.

Project Development:

- *Right-of-Way Requirements*: Minimal.
- *Siting Constraints:* Little or no site development needed to implement.
- *Construction****:*** Patented devices are required but various manufacturers are available.

Advantages:

- Requires minor site work
- Low maintenance cost
- Low construction cost
- Ability to retrofit onto storm water outfalls, pipe culverts and channels of any shape

Constraints:

- Breakaway litter bags are proprietary patented devices.
- Regular and possibly frequent maintenance/ inspections are required
- Possibility of mosquito breeding and litter decomposition.

Sources:

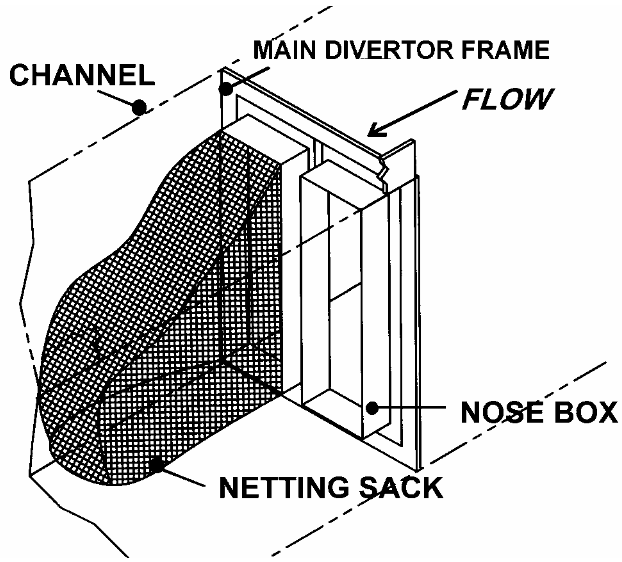
- KriStar Enterprises, Inc., www.kristar.com
- Nettech Environmental Solutions, www.nettech.com.au

Literature Sources of Performance Documentations:

- None identified.

Description:

Net Cassette™ is a netting system for capturing litter and debris. Configurations include in-line, end-of-pipe, and floating applications.



Source: www.pjhannah.com

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	○	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	●	○
BOD	○	○
TDS	○	○

Notes:

- No long-term water quality monitoring studies have been conducted to evaluate treatment effectiveness

Key Design Elements:

1. Ease of use
2. Simple Installation
3. Low maintenance

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

● High	◒ Medium	○ Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- _Requirements_: Maintenance expected to be similar to the other litter and debris removal BMP's.
- _Nuisance Control:_ None identified.
- _Specialty Training/Equipment:_ For routine maintenance, requires staff and equipment to remove and replace bags.

Project Development:

- _Right-of-Way Requirements_: Requires access for maintenance.
- _Siting Constraints_: Minimal head loss requirement.
- _Construction:_ No special requirements identified.

Advantages:

- Easy maintenance
- Requires minor site work
- Low construction cost

Constraints:

- Proprietary device
- Regular maintenance and inspection is required

Sources:

- P.J. Hannah Equipment Sales Corp., www.pjhannah.com/

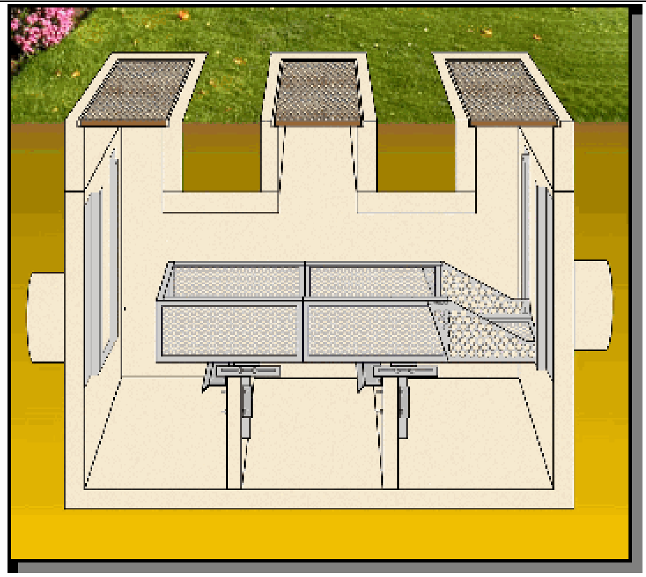
Literature Sources of Performance Demonstrations:

- None identified.

Nutrient Separating Baffle Box

Description:

The Nutrient Separating Baffle Box uses an elevated basket to capture litter and debris. The basket is above the permanent pool of water to reduce the decomposition of captured material into dissolved and fine-particle material that commonly escape treatment BMPs. Baffles are designed to enhance sediment removal and reduce scour. It appears to retain standing water but lowering the outlet pipe may remedy this.



Source: www.suntreetech.com

Constituent Removal:

Constituent Group	***Removal Efficiency***	***Level-of-Confidence***
Total Suspended Solids	◒	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	●	○
BOD	○	○
TDS	○	○

Notes:

Key Design Elements:

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	***Level-of-Confidence***
▖	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- <u>*Requirements*</u>: Maintenance expected to be similar to the other litter and debris removal BMP's.
- <u>*Nuisance Control*</u>*:* Vector inspections may be required if units hold a permanent pool of water.
- <u>*Specialty Training/Equipment*</u>*:* Vactor equipment may be required.

Project Development:

- <u>*Right-of-Way Requirements*</u>: Requires access for maintaince.
- <u>*Siting Constraints*</u>: Minimum system head loss of 0.6096m, (2ft).
- <u>*Construction:*</u> No special requirements identified.

Advantages:

- Multiple stainless steel screens; protective hood covers; siphon-actuated self cleaning mechanism; minimal excavation depth; optional dewatering system for reducing BOD, vector incubation, etc.; easily replaced screens.

Constraints:

- Although the screen is able to remove particles greater than the pore size (2.4mm) the system relies on finer sediments attaching to larger sediment for removal. Recommended use for gross pollutant removal, absorbents may need to accompany for additional petroleum hydrocarbon removal.
- Appears that the device may hold standing water.

Sources:

- Bio Clean Environmental Services, INC., www.biocleanenvironmental.net
- Suntree Technologies Inc., www.suntreetech.com

Literature Sources of Performance Demonstrations:

- None identified.

Description:

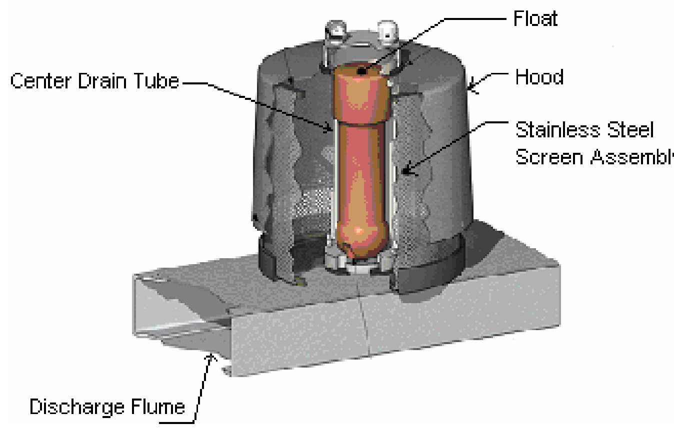
The StormScreen™ is a passive, high-flow screening system used for removal of trash and debris. The system uses a float-actuated, radial flow cartridge constructed of stainless steel screen. The cartridge is designed to operate at 225gpm at 80% or more occusion to the screen surface. This system also incorporates a high flow bypass for peak flow diversion.

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	○	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	●	◒
BOD	○	○
TDS	○	○

Notes:

- StormWater™'s Drain-Down™ system can be incorporated with StormScreen.
- StormScreen and StormFilter systems can be used in combination for larger sites with a high flow rate or volume that need to be treated or a large amount of trash and debris that needs to be captured.



Cylinder installation similar to StormFilter
(see StormFilter C-17)
Source: www.stormwaterinc.com

Key Design Elements:

StormScreen™ is sized to treat the peak flow from the design storm. The peak flow is determined based on the watershed area and design storm magnitude. StormScreen™ canisters are designed to treat 0.5 cfs (225gpm) each.

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
▖	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

● High	◒ Medium	○ Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- <u>*Requirements*</u>: Maintenance expected to be similar to the other litter and debris removal BMP's.
- <u>*Nuisance Control*</u>*:* Vector inspections may be required if units hold a permanent pool of water. Design can incorporate a "drain-down system", but tendency to clog is unknown.
- <u>*Specialty Training/Equipment*</u>*:* For routine maintenance, requires staff and equipment to remove sediment and debris.

Project Development:

- <u>*Right-of-Way Requirements*</u>: Requires access for maintenance.
- <u>*Siting Constraints*</u>: Minimum system head loss of 2ft.
- <u>*Construction*</u>*:* No special requirements identified.

Advantages:

- Multiple stainless steel screens; protective hood covers; siphon-actuated self cleaning mechanism; minimal excavation depth; optional dewatering system for reducing vector incubation.
- Screens can be replaced easily.

Constraints:

- The pore size (2.4mm) may limit the system removal to gross pollutants.

Sources:

- StormWater Management INC., www.stormwaterinc.com

Literature Sources of Performance Demonstrations:

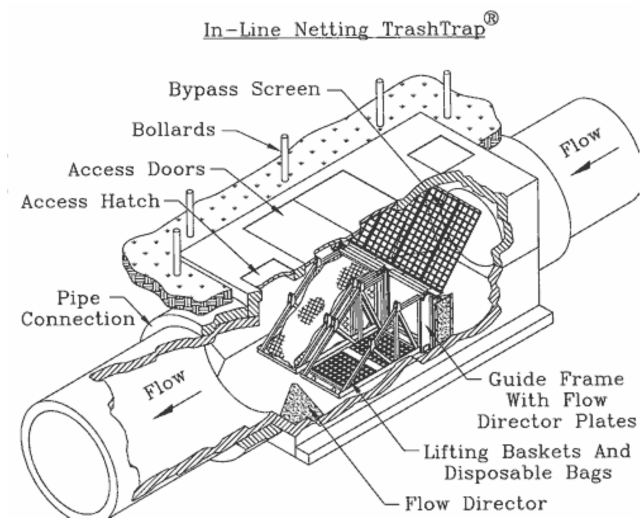
- None identified.

Litter And Debris Removal – Screens

Netting Trash Trap^{TM}

Description:

The Netting Trash Trap^{TM} is a system that uses replaceable bags to capture litter and debris while bypassing higher flows.



Source: www.freshcreek.com

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	○	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	●	○
BOD	○	○
TDS	○	○

Notes:

Key Design Elements:

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: Maintenance expected to be similar to the other litter and debris removal BMP's.
- *Nuisance Control:* None identified.
- *Specialty Training/Equipment:* For routine maintenance, requires staff and equipment to remove and replace bags.

Project Development:

- *Right-of-Way Requirements*: Requires access for maintenance.
- *Siting Constraints*: Minimal head loss requirement.
- *Construction:* No special requirements identified.

Advantages:

- Easy maintenance.

Constraints:

- none identified.

Sources:

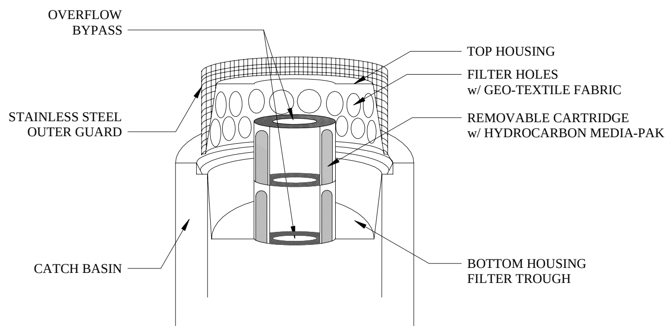
- Fresh Creek Technologies, Inc., www.freshcreek.com

Literature Sources of Performance Demonstrations:

- None identified.

Description:

The MANHOLE FILTER by Revel Environmental Manufacturing, Inc. is designed to filter contaminants entering storm water drainage through manholes using a removable sand/silt media filter, hydrocarbon media filter, and a filter trough. An overflow bypass system is also included for large flows. The filter is installed on a manhole in place of the catch basin grate. It protrudes above the top of the manhole.



Source: www.remfilters.com

Key Design Elements:

1. Proprietary devices
2. Overflow Bypass System
3. Sand/Silt Media combined with Hydrocarbon Media

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	○	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	○	○
BOD	○	○
TDS	○	○

Notes:

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

● High	◒ Medium	○ Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: If there is high solids loading (often caused by vegetation within the drainage area), frequent inspection and maintenance is required.
- *Nuisance Control:* None identified.
- *Specialty Training/Equipment:* No special requirements identified.

Project Development:

- *Right-of-Way Requirements*: Installed on top of an existing a manhole inlet.
- *Siting Constraints*: Requires a circular drain inlet manhole
- *Construction*: A watertight installation of the product is important to capture low flows.

Advantages:

- There are 24" and 36" diameter sizes that can be retrofitted to manholes. Maintenance can be simple and quick.

Constraints:

- If located along a shoulder or median, maintenance activities may require traffic control.

Sources:

- Revel Environmental Manufacturing, Inc. www.remfilters.com

Literature Sources of Performance Demonstrations:

- Non identified

Description:

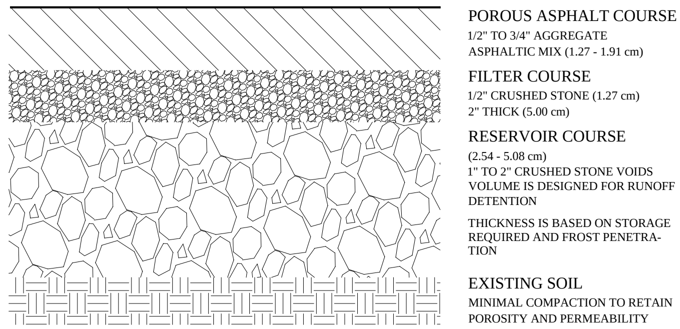
Porous asphalt pavement, with a life span of 20 years or more, provides stormwater storage and infiltration. Porous asphalt pavement is compromised of a permeable asphalt surface placed over a granular "choke" course on top of a reservoir of large stone. The asphalt surface is made permeable by designing it as an open-graded friction course. The lower reservoir layer is designed for load requirements and for water storage capacity. An overflow mechanism is recommended in case of clogging. The pavement may also be designed to receive off-site runoff.

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	●	◒
Nutrients	●	◒
Pesticides	●	◒
Total Metals	●	◒
Dissolved Metals	●	◒
Microbiological	●	◒
Litter	●	◒
BOD	●	◒
TDS	●	◒

Notes:

- Low permeable subgrade that increase runoff through the over will decrease removal efficiency.



Source: www.landdevelopmenttoday.com/Article331.htm

Key Design Elements:

1. Adsorption media type and depth
2. Sand specifications and depth

<u>Ancillary Facilities</u>
Upstream sedimentation facilities required.

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
▝	○

Cost includes cost of pretreatment.

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: All porous pavements should be inspected several times in the first few months after construction, and at least annually thereafter.
- *Nuisance Control*: Inspection should be conducted after large storms to check for surface ponding that might indicate possible clogging.
- *Specialty Training / Equipment*: Vacuum style street sweepers are recommended.

Project Development:

- *Right-of-Way Requirements*: Under pavement design requires no additional ROW.
- *Siting Constraints*: Similar to infiltration BMPs. Some considerations are depth to groundwater, subgrade permeability, and soil type.
- *Construction*: Construction requires special care and some changes to normal practices and scheduling. Sub-grade compaction should be avoided to prevent reducing the permeability. Erosion control should be in place until vegetation established before installation. Recommended last item of construction.

Advantages:

- Reduces or eliminates space needed for other BMPs.

Constraints:

- Not feasible where traction sand is applied.
- Durability affected by temperature.
- More costly that traditional asphalt concrete.

Sources:

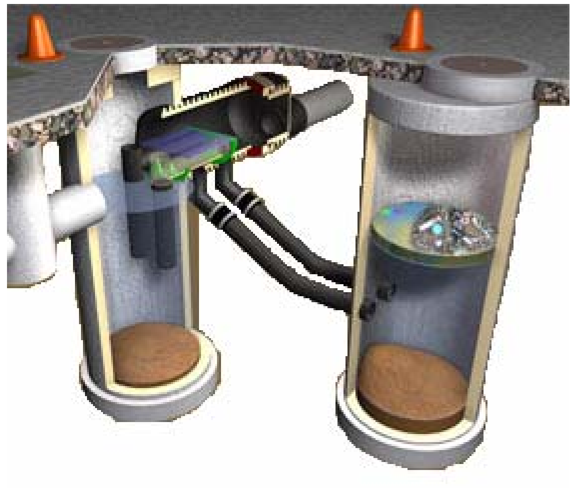
- National Asphalt Pavement Association (NAPA) Porous Asphalt Pavement. www.hotmix.org/
- Land Development Today, "*From the Ground Up,*" Aug. 8, 2005, Article #331, Accessed Jan. 2006, www.landdevelopmenttoday.com/Article331.htm
- Cahill Associates, "*Porous Asphalt with Subsurface Infiltration/Storage Bed*," Jan 2006, www.thcahill.com/pasphalt.html
- Uni Eco-Stone®, Uni-Group U.S.A., Jan 2006, www.uni-groupusa.org
- SF-Rima™, SF Matoro®-Drain, SF-Eco®-Duct, SF Concrete Technology Inc., www.sfconcrete.com

Literature Sources of Performance Demonstrations:

- Brattebo, B. O. and D. B. Booth, Draft 7/1/2003, "*Long-Term Stormwater Quality and Quality Performance of Permeable Pavement Systems,*" http://depts.washington.edu/cwws/Research/Reports/permeableparking.pdf, Accessed Jan 2006, Center for Water and Watershed Studies Dept. of Civil & Environmental Engineering., University of Washington.

Description:

The BaySaver® is a dual tank system. Low flows are diverted to the offline tank. High flow passes through the primary tank.



Source:www.baysaver.com

Constituent Removal:

Constituent Group	***Removal Efficiency***	***Level-of-Confidence***
Total Suspended Solids	◒	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	○	○
BOD	○	○
TDS	○	○

Notes:

- It appears that some floating litter may accumulate in the primary tank and discharge during high flows.

Key Design Elements:

1. Detention time
2. Pollutant storage capacity
3. Flow capacity (flood and water quality flow)

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	***Level-of-Confidence***
◱	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: Initially the site should be monitored frequently in order to determine the required cleaning frequency.
- *Nuisance Control:* Standing water requires vector monitoring.
- *Specialty Training/Equipment:* Vector equipment recommended for cleaning.

Project Development:

- *Right-of-Way Requirements*: Relatively small footprint.
- *Siting Constraints*: Minimal head requirement.
- *Construction:* No special requirements identified.

Advantages:

- Small footprint.

Constraints:

- Vector concerns.

Sources:

- BaySaver, Inc., www.baysaver.com
- U.S. Environmental Protection Agency, www.epa.gov/OW-OWM.html/mtb/wtrqlty.pdf
- U.S. Environmental Protection Agency, www.epa.gov/region1/assistance/ceitts/stormwater/techs/baysaver.html

Literature Sources of Performance Demonstrations:

- none identified.

Description:

The bioSTORM™ is a double vault system that uses coalescing plates in the second tank. Despite its name, there does not appear to be any biological component to the system. It is designed as an offline device so high flows bypass the system

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	◒	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	●	○
BOD	○	○
TDS	○	○

Notes:

Source: www.biomicrobics.com

Key Design Elements:

1. Detention time
2. Flow capacity

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
▖	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: Initially the site should be monitored frequently in order to determine the required cleaning frequency.
- *Nuisance Control:* Standing water requires vector monitoring.
- *Specialty Training/Equipment:* Vactor equipment recommended for cleaning.

Project Development:

- *Right-of-Way Requirements*: Relatively small footprint.
- *Siting Constraints*: Check for underground utility conflicts.
- *Construction:* No special requirements identified.

Advantages:

- Small footprint.

Constraints:

- Vector concerns.

Sources:

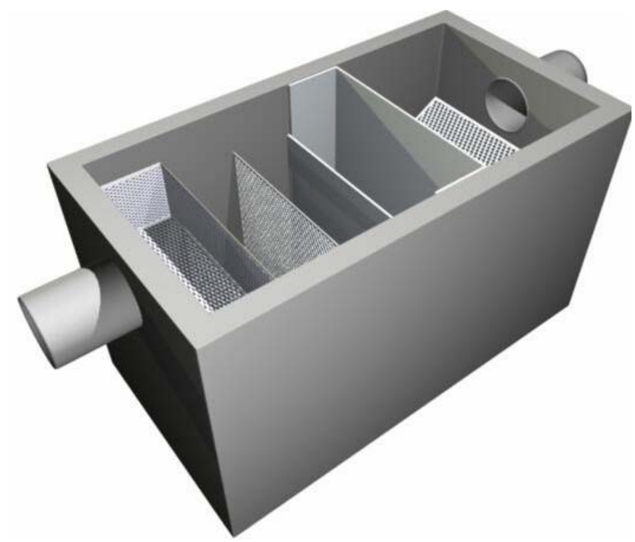
- Bio-Microbics, Inc., www.biomicrobics.com

Literature Sources of Performance Demonstrations:

- none identified.

Description:

CrystalStream™ is a system of baffles and screens contained within a concrete vault. A trash basket is followed by two baffles and a reservoir for captured oil. Water then passes through a fiber mesh before leaving the unit. All these components are removable. It is unclear how high flows are passed through the unit without going through the mesh.



Source: www.crystalstream.com

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	○	◒
Nutrients	○	◒
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	●	○
BOD	○	○
TDS	○	○

Notes:

Key Design Elements:

1. Detention time
2. Pollutant storage capacity
3. Flow capacity (flood and water quality flow)

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
▖	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: Initially the site should be monitored frequently in order to determine the required cleaning frequency.
- *Nuisance Control:* Standing water requires vector monitoring.
- *Specialty Training/Equipment:* Vactor equipment recommended for cleaning.

Project Development:

- *Right-of-Way Requirements*: Relatively small footprint.
- *Siting Constraints*: Minimal head requirement.
- *Construction:* No special requirements identified.

Advantages:

- Small footprint.

Constraints:

- Vector concerns.

Sources:

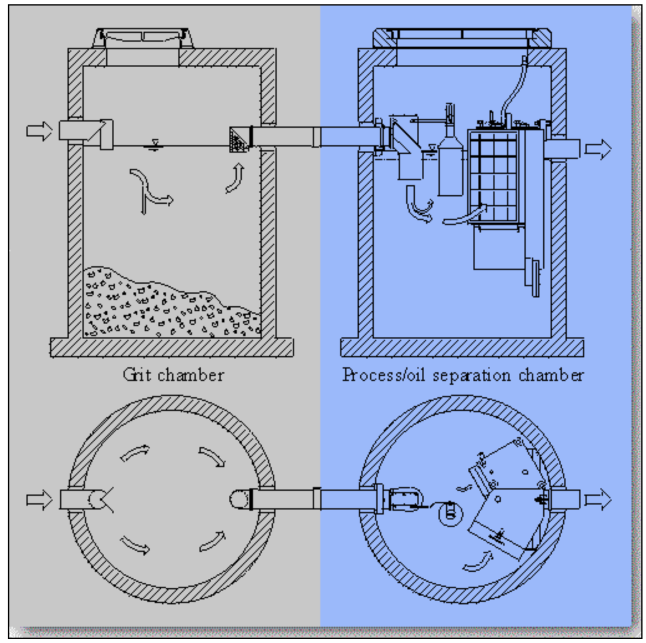
- CrystalStream™ Technologies, www.crystalstream.com

Literature Sources of Performance Demonstrations:

- Environmental Technology Verification Program, http://www.epa.gov/etv/pdfs/vrvs/09_vr_pbm.pdf

Description:

EcoSep® is a two chambered system. Water enters the first cylinder and hits a flow splitter. Water leaves the chamber through a down turned elbow. The final chamber has a coalescing outlet structure. Ability to pass high flow is unclear. The unit may need to be installed off-line.



Source: www.royalenterprises.net

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	◒	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	●	○
BOD	○	○
TDS	○	○

Notes:

Key Design Elements:

1. Detention time
2. Pollutant storage capacity
3. Flow capacity (flood and water quality flow)

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
▗	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- _Requirements_: Initially the site should be monitored frequently in order to determine the required cleaning frequency.
- _Nuisance Control_: Standing water requires vector monitoring.
- _Specialty Training/Equipment_: Vactor equipment recommended for cleaning.

Project Development:

- _Right-of-Way Requirements_: Relatively small footprint.
- _Siting Constraints_: Minimal head requirement.
- _Construction_: No special requirements identified.

Advantages:

- Small footprint.

Constraints:

- Vector concerns.

Sources:

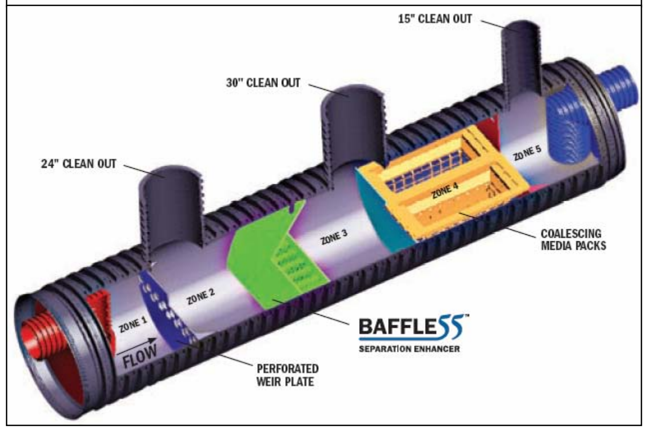
- Royal Environmental Systems, Inc., www.royalenterprises.net

Literature Sources of Performance Demonstrations:

- none identified.

Description:

The Hancor® storm water quality unit has five sections within a horizontal cylinder. The first three sections are separated by a weir and a unique baffle system mounted at an incline. The fourth compartment has coalescing media. Water discharges the final section via a down turned elbow. Ability to pass high flow is unclear. The unit may need to be installed offline.



Source: www.hancor.com

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	◒	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	●	○
BOD	○	○
TDS	○	○

Notes:

Key Design Elements:

1. Detention time
2. Pollutant storage capacity
3. Flow capacity (flood and water quality flow)

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
▖	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *<u>Requirements</u>*: Initially the site should be monitored frequently in order to determine the required cleaning frequency.
- *<u>Nuisance Control</u>:* Standing water requires vector monitoring.
- *<u>Specialty Training/Equipment</u>:* Vactor equipment recommended for cleaning.

Project Development:

- *<u>Right-of-Way Requirements</u>*: Relatively small footprint.
- *<u>Siting Constraints</u>*: Minimal head requirement.
- *<u>Construction</u>:* No special requirements identified.

Advantages:

- Small footprint.

Constraints:

- Vector concerns.

Sources:

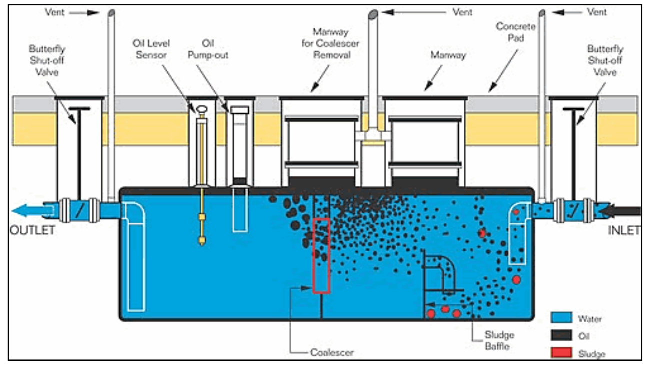
- Hancor, Inc., www.hancor.com

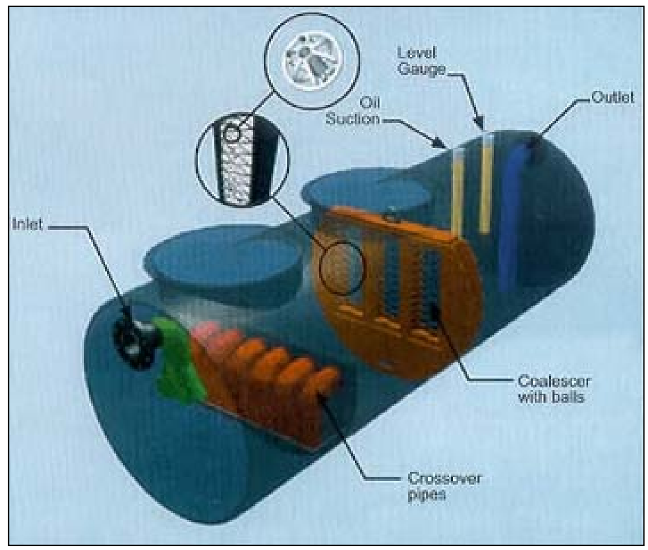
Literature Sources of Performance Demonstrations:

- none identified.

Description:

Kleerwater™ is a baffle and coalescer. Water enters and leaves the unit via down turned pipes.





Source: www.kleerwater.net

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	◒	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	●	○
BOD	○	○
TDS	○	○

Notes:

Key Design Elements:

1. Detention time
2. Pollutant storage capacity
3. Flow capacity (flood and water quality flow)

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
▖	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: Initially the site should be monitored frequently in order to determine the required cleaning frequency.
- *Nuisance Control:* Standing water requires vector monitoring.
- *Specialty Training/Equipment:* Vector equipment recommended for cleaning.

Project Development:

- *Right-of-Way Requirements*: Relatively small footprint.
- *Siting Constraints*: Minimal head requirement.
- *Construction:* No special requirements identified.

Advantages:

- Small footprint.

Constraints:

- Vector concerns.

Sources:

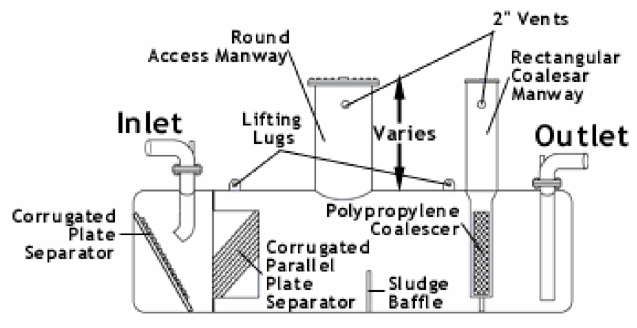
- Kleerwater Technologies, LLC, www.kleerwater.net
- U.S. Environmental Protection Agency, www.epa.gov/region1/assistance/ceitts/stormwater/techs/kleerwater.html

Literature Sources of Performance Demonstrations:

- none identified.

Description:

PSI Separator is a coalescing type separator that uses a down-turned outlet pipe to trap oil within the unit.



Source: www.psinternational.com

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	◒	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	●	○
BOD	○	○
TDS	○	○

Notes:

Key Design Elements:

1. Detention time
2. Pollutant storage capacity
3. Flow capacity (flood and water quality flow)

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
▖	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

● High	◒ Medium	○ Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: Initially the site should be monitored frequently in order to determine the required cleaning frequency.
- *Nuisance Control:* Standing water requires vector monitoring.
- *Specialty Training/Equipment:* Vactor equipment recommended for cleaning.

Project Development:

- *Right-of-Way Requirements*: Relatively small footprint.
- *Siting Constraints*: Minimal head requirement.
- *Construction:* No special requirements identified.

Advantages:

- Small footprint.

Constraints:

- Vector concerns.

Sources:

- PS International, Inc., www.psinternational.com

Literature Sources of Performance Demonstrations:

- None identified.

Description:

The SNOUT® is a hood that fits on the outlet of a trapping catch basin or other structures that holds a permanent pool of water.

Constituent Removal:

Constituent Group	***Removal Efficiency***	***Level-of-Confidence***
Total Suspended Solids	○	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	○	○
BOD	○	○
TDS	○	○

Notes:

Source: www.epa.gov

Key Design Elements:

1. none identified

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	***Level-of-Confidence***
	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: Depends on existing structure.
- *Nuisance Control:* Depends on existing structure.
- *Specialty Training/Equipment:* Depends on existing structure.

Project Development:

- *Right of Way Requirements*: none.
- *Siting Constraints*: none.
- *Construction:* No special requirements identified.

Advantages:

- Easy to install.

Constraints:

- The existing structure retrofitted with the SNOUT® may create mosquito habitat.

Sources:

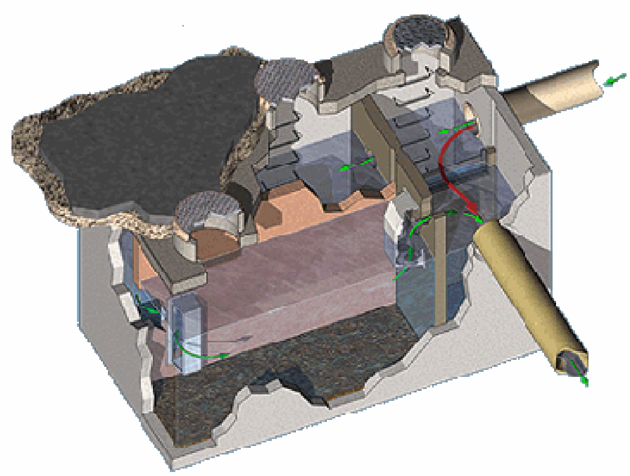
- Best Management Products, Inc., www.bestmp.com
- U.S. Environmental Protection Agency, www.epa.gov/region1/assistance/ceitts/stormwater/techs/snout.html

Literature Sources of Performance Demonstrations:

- none identified.

Description:

The Stormgate Separator™ is a flow diversion structure that directs lower flow into a series of two settling chambers. High flows overtop the diversion weir and exit the unit through the outlet chamber.



Source: www.stormwaterinc.com

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	◒	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	○	○
BOD	○	○
TDS	○	○

Notes:

- Performance information used a manufactured sand with no silt or clay fraction. TSS influent was 2 to 5 times greater than typical highway concentrations (about 100 mg/L).

Key Design Elements:

1. Detention time
2. Pollutant storage capacity
3. Flow capacity (flood and water quality flow)

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
▖	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: Initially the site should be monitored frequently in order to determine the required cleaning frequency.
- *Nuisance Control:* Standing water requires vector monitoring.
- *Specialty Training/Equipment:* Vactor equipment recommended for cleaning.

Project Development:

- *Right-of-Way Requirements*: Relatively small footprint.
- *Siting Constraints*: Minimal head requirement.
- *Construction:* No special requirements identified.

Advantages:

- Small footprint.

Constraints:

- Vector concerns.

Sources:

- Stormwater Management Inc., www.stormwaterinc.com

Literature Sources of Performance Demonstrations:

- Stormwater Management Inc., "Evaluation of the Stormgate Separator™ for the removal of OK-110, a synthetically graded sand material." available at www.stormwaterinc.com

Description:

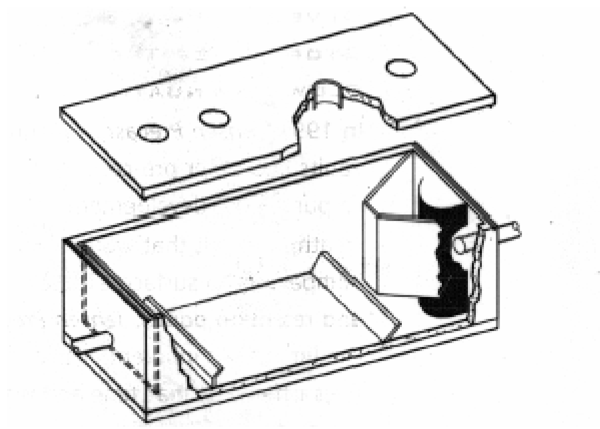
The StormVault™ is a vault with baffles and a screen which protects the orifice and outlet.

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	◒	◒
Nutrients	○	○
Pesticides	○	○
Total Metals	◒	◒
Dissolved Metals	○	○
Microbiological	○	○
Litter	●	○
BOD	○	○
TDS	○	○

Notes:

- TSS efficiency based on reports of TSS load removal of 25% to 80% for the Virginia study and 51% for the California Study. Influent concentrations were often less than half of average highway concentrations (100 mg/L), but some cases influent was over 800 mg/L.
- Total Metals efficiency based on reports of Zinc load removal of 50% for the California study. Copper removal was only 10% and lead removal was 39%.



Source: www.stormvault.com

Key Design Elements:

1. Detention time
2. Pollutant storage capacity
3. Flow capacity (flood and water quality flow)

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
▖	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: Initially the site should be monitored frequently in order to determine the required cleaning frequency.
- *Nuisance Control:* Standing water requires vector monitoring.
- *Specialty Training/Equipment:* Vector equipment recommended for cleaning.

Project Development:

- *Right-of-Way Requirements*: Relatively small footprint.
- *Siting Constraints*: Minimal head requirement.
- *Construction:* No special requirements identified.

Advantages:

- Small footprint.

Constraints:

- Vector concerns.

Sources:

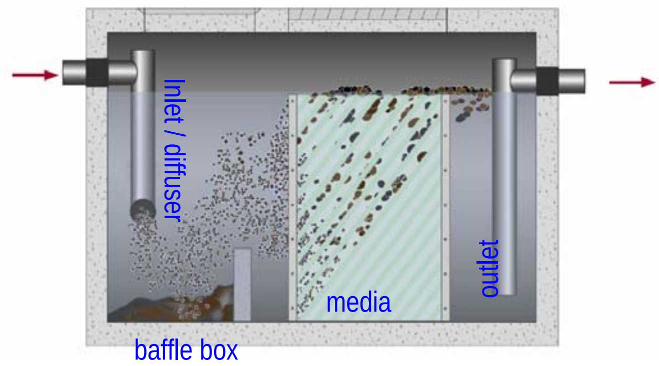
- Conspan®, www.stormvault.com
- U.S. Environmental Protection Agency, www.epa.gov/region1/assistance/ceitts/stormwater/techs/stormvault.html

Literature Sources of Performance Demonstrations:

- Wright Water Engineers, Inc., CH2M HILL, "Testing Of The Jensen Precast StormVault™, Paratransit Bus Lot Sacrament, Ca, 2001 Monitoring Report." February 2002.
- Wright Water Engineers, Inc., "Testing Of The Jensen Precast StormVault™, Albemarle County Office Building Parking Lot Charlottesville, Va., 2001 Monitoring Report." March 2002.

Description:

VortClarex™ employs baffles and coalescing media for storm water treatment. Flow enters the pre-cast concrete vault and is diffused allowing heavy sediment to settle. Lighter water & pollutants travel over a baffle and pass through a coalescing media that traps oil & other pollutants before leaving the chamber.



Source: www.vortechnics.com

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	◒	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	○	○
BOD	○	○
TDS	○	○

Notes:

Key Design Elements:

1. Detention time
2. Pollutant storage capacity
3. Flow capacity (flood and water quality flow)

Equivalent Uniform Annual Costs:

Cost Effectiveness	*Level-of-Confidence*
▖	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

● High ◒ Medium ○ Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: Initially the site should be monitored frequently in order to determine the required cleaning frequency.
- *Nuisance Control:* Standing water requires vector monitoring.
- *Specialty Training /Equipment:* Vactor equipment recommended for cleaning.

Project Development:

- *Right-of-Way Requirements*: Relatively small footprint.
- *Siting Constraints*: Low head requirements.
- *Construction:* No special requirements identified.

Advantages:

- Small footprint
- All underground
- No additional ROW or easement required
- Low head requirement.

Constraints:

- Vector concerns.

Sources:

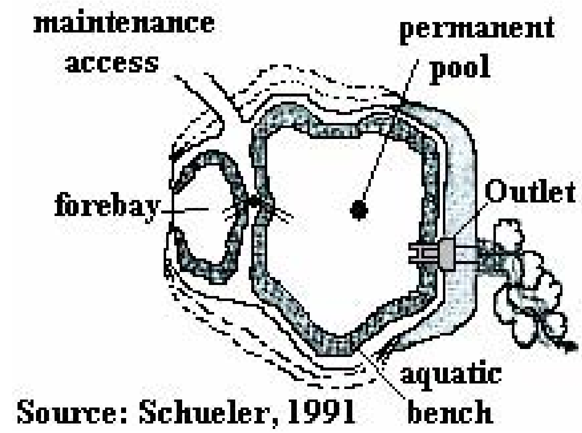
- U.S. Environmental Protection Agency, www.epa.gov/region1/assistance/ceitts/stormwater/techs/vortechs.html
- Vortechnics®, Inc., www.vortechnics.com

Literature Sources of Performance Demonstrations:

- none

Description:

Constructed wetlands attempt to replicate some of the conditions in natural wetlands. Constructed wetlands for stormwater treatment typically are shallow (less than 2 meters) ponds with a variety of wetland plant species. The ponds often incorporate forebays to localize sediment accumulation, shallow zones to encourage filtration by plant material, and deeper zones to allow further sedimentation. The water quality benefits of treatment in natural or constructed wetlands include nutrient cycling and removal, and reduction in suspended solids (TSS), total dissolved solids (TDS), trace metals, and BOD.



Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	●	◒
Nutrients	◒	◒
Pesticides	○	○
Total Metals	◒	◒
Dissolved Metals	○	○
Microbiological	○	○
Litter	●	◒
BOD	◒	◒
TDS	◒	◒

Notes:

Key Design Elements:

1. Sediment forebays are recommended to decrease the velocity and sediment loading to the wetland. The forebay should contain at least 10 percent of the wetlands treatment volume and should be 4 to 6 feet deep.
2. The wetland design should include a buffer to separate the wetland from surrounding land.
3. Above ground berms or high marsh wedges should be placed at 50 foot intervals.
4. A four-to-six foot deep micropool should be included in the design to prevent the outlet from clogging.
5. Site must have adequate water flow and appropriate underlying soils.

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
▝	◒

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: Active management of the hydrology and vegetation during the first few years or growing seasons is necessary. Vegetation thinning or removal may be necessary for vector control. Wildlife may limit activities or limit them to a particular season.
- *Nuisance Control:* The constructed wetland facility can promote mosquito breeding.
- *Specialty Training/Equipment:* No special requirements identified.

Project Development:

- *Right-of-Way Requirements*: High area requirements.
- *Siting Constraints*: Low permeable soil is required if a liner is not used. Dry weather flow may be required to keep vegetation alive.
- *Construction:* Plant establishment period is recommended. If a liner is used, it must be carefully constructed to avoid punctures.

Advantages:

- Enhances aesthetics
- Enhances wildlife habitat.
- Good pollutant removal.

Constraints:

- May be difficult to maintain vegetation under a variety of flow conditions
- Relatively high construction costs in comparison to other BMP's
- Species may restrict maintenance.

Sources:

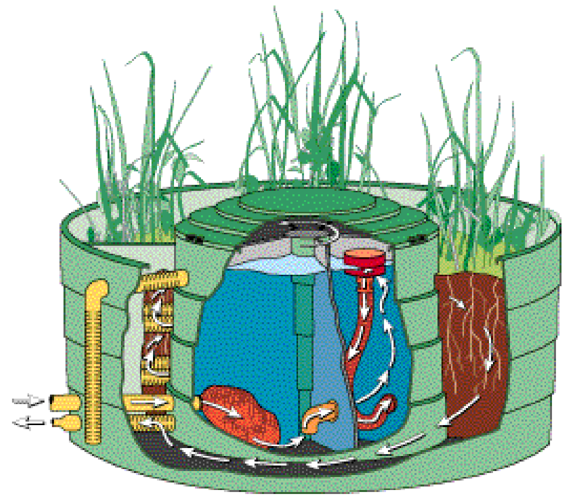
- Schueler, T.R., "Design of Stormwater Pond Systems". Metropolitan Washington Council of Governments, Washington, DC.
- Schueler, Thomas R., 1987. "Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMP's. July.

Literature Sources of Performance Demonstrations:

- Kadlec and Knight, 1996, "Treatment Wetlands", Lewis Publishers, NY, NY.
- Schueler T. R., et al., 1992. "A Current Assessment of Urban Best Management Practices.
- Techniques for Reducing Non-Point Source Pollution in the Coastal Zone". 126pp.
- Schueler, T.R., F.J. Galli, L. Herson, P. Kumble and D.Shepp, 1991. "Developing Effective BMP Systems for Urban Watersheds". Urban Non-Point Workshops, New Orleans, Louisiana. January 27-29, 1991.
- Strecker, E.W; J.M. Kersnar; and E.D. Driscoll, 1992. "The Use of Wetlands for Controlling Stormwater Pollution; Final Report", Prepared for Region 5 Water Division, Wetlands and Watershed Section, Watershed Management Unit, USEPA, Chicago, IL. Prepared by Woodward Clyde Consultants, Portland OR. 66 pp.plus appendix.
- Washington State Department of Ecology, 2000. "Stormwater Management Manual for Western Washington, Volume V, Runoff Treatment BMP's. 251 pp. August.
- D. L. Hey, A. L. Kenimer, and K. R. Barrett. 1994a. "Water Quality Improvement by Four Experimental Wetlands." *Ecological Engineering* 3:381-397.
- D. L. Hey, K. R. Barrett, and C. Biegen. 1994b. "The Hydrology of Four Experimental Constructed Wetlands." *Ecological Engineering* 3:319-343.
- W. J. Mitsch, J. K. Cronk, X. Wu, R. W. Nairm, and D. L. Hey. 1995. "Phosphorus Retention in Constructed Freshwater Riparian Marshes." *Ecological Applications* 5(3):830-845.
- W. Sanvilleand W. J. Mitsch (eds). 1994. "Creating Freshwater Marshes in a Riparian Landscape: Research at the Des Plains River Wetlands Demonstration Project." *Ecological Engineering 3, special issue.*

Description:

The StormTreat™ System (STS) consists of a series of sedimentation chambers and constructed wetlands. These wetlands are contained within a modular, 2.9-meter (9.5) ft diameter recycled-polyethylene tank that is roughly four feet in height. Unlike most constructed wetlands systems, STS conveys the storm water directly into the subsurface of the wetland and through the root zone. Pollutants are then removed through filtration, adsorption, and biochemical reactions. Storm water is retained in the wetlands for five to ten days prior to discharge when flows to the unit is restricted..



Source: www.stormtreat.com

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	●	◒
Nutrients	●	◒
Pesticides	●	◒
Total Metals	◒	◒
Dissolved Metals	○	○
Microbiological	●	◒
Litter	○	○
BOD	◒	◒
TDS	◒	○

Notes:

- Data collected over a two-year period by clients, analyzed by state-certified labs and verified by the Commonwealth of Massachusetts.
- Thirty-three samples were collected over eight independent storm events during both winter and summer conditions.

Key Design Elements:

1. Modular, 2.9-meter (9.5-foot) diameter recycled-polyethylene tank containing a series of sedimentation chambers and constructed wetlands
2. Flow is conveyed from the final sedimentation chamber through four, slotted PVC outlet pipes, each 10-cm (4 inches) in diameter, into the wetland
3. Mature vegetation in the outer ring should have roots that extend into the permanent 15-cm (6 inches) of water in the bottom of the tank
4. Effluent from the wetland is discharged through a 5-cm (2-inch) diameter pipe that is controlled by a valve

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
▝	◒

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

● High	◒ Medium	○ Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- <u>*Requirements*</u>: Annual inspections and replacement of grit filter bag and sediment pumping once every three to five years using standard septic system pumper.
- <u>*Nuisance Control:*</u> Standing water may require vector control.
- <u>*Specialty Training/Equipment*</u>*:* May need equipment to remove grit filter bag and septic haulers to pump sediment from the tank.

Project Development:

- <u>*Right-of-Way Requirements*</u>: Moderate
- <u>*Siting Constraints*</u>: The systems size and modular configuration make it adaptable to a wide range of site constraints and watershed sizes. The system can be used to treat runoff from highways, parking lots, airports, marinas, and commercial, industrial, and residential areas. The STS system is not designed to be used directly in wastewater streams.
- <u>*Construction*</u>*:* No special requirements identified.

Advantages:

- Protects groundwater by removing pollutants prior to infiltration.
- The spill contamination feature can capture an upstream release and lessen the spill impact on the environment.

Constraints:

- May need to be tested in geographical locations move typical of California.
- Small flow rate capacity (average outflow of 1-5 gpm).

Sources:

- StormTreat™ Systems, Inc., www.stormtreat.com

Literature Sources of Performance Demonstrations:

- U.S. Environmental Protection Agency, http://www.epa.gov/region1/assistance/ceitts/stormwater/techs/stormtreat.html

APPENDIX C: PILOT STUDY FACT SHEETS

Appendix C presents fact sheets for the full-scale BMP pilot studies listed in Section 2.2, Table 2-1. Technology evaluations in the attached fact sheets are ongoing, and the assessment of these technologies may be revised in future reports. The evaluations were derived from available literature and information gathered from the pilot studies. Unapproved treatment BMP technologies that have been or are being tested by Caltrans are presented in the following order:

Description:

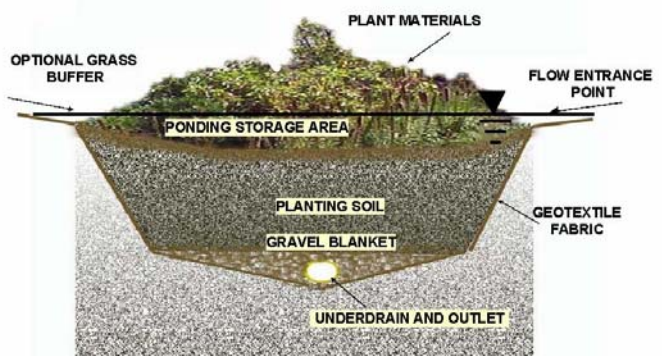
Bioretention facilities are designed to capture and retain the storm water quality volume in a shallow, offline, vegetated retention area. They are typically used to treat small (0.25 to 1.0 acre), highly impervious surfaces such as parking areas. Bioretention facilities are intended to promote infiltration, evaporation and evapotranspiration of the water quality volume. Bioretention basins are smaller and less obtrusive than infiltration basins. Bioretention basins may have an under drain connected to the storm drain if native soils are not sufficiently permeable. Careful landscaping and planting can provide a positive aesthetic appeal. Runoff should enter the facility in a sheet-flow manner across a grassed buffer to minimize introduction of sediment into the retention basin. Maximum ponding depths should be chosen in conjunction with measured infiltration/transportation rates to ensure that the facility will be dry within 72 hours to prevent mosquito propagation. Some manuals suggest saturated soil conditions be no greater than 24 hours to avoid plant damage Biorentention is well-suited for use where a vegetated buffer area may provide screening and an aesthetic element is desirable to adjacent property owners.

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	●	○
Nutrients	○	◒
Pesticides	◒	○
Total Metals	●	◒
Dissolved Metals	◒	○
Microbiological	●	○
Litter	●	○
BOD	○	○
TDS	○	○

Notes:

- Testing by University of Virginia.



Source: Maryland Water Resources Research Center, Jan 2006.

Key Design Elements:

1. Size
2. Vegetation
3. Underground drain system
4. Ponding depth.
5. Drainage area
6. Flow capacity

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
◳	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: Regular vegetation management is required.
- *Nuisance Control:* The bioretention facility may promote mosquito breeding if clogged.
- *Specialty Training/Equipment:* No special requirements identified.

Project Development:

- *Right-of-Way Requirements*: Space requirements are relatively high to accommodate shallow water quality storage depths.
- *Siting Constraints*: May need supplemental irrigation in dry areas, depending on plant selection.
- *Construction:* Vegetation establishment period is recommended. Water should bypass until construction is complete and the drainage area is stabilized.

Advantages:

- Pollutant removal effectiveness is typically high, accomplished primarily by physical filtration of particulates through the soil profile; and adsorption of constituents by the soil.
- It can provide an aesthetic vegetated appearance.

Constraints:

- May not be appropriate along highways where safety considerations preclude use of large trees or plantings that obscure sight lines.
- In areas with prolonged dry periods, maintenance of trees, shrubs and grass between rainfalls may require irrigation.
- As with any infiltration/filtration facility, clogging can cause water ponding and associated nuisance and vector problems.
- Use of planting soil to fill the basin may increase costs compared to infiltration basins.
- It takes time for bioretention facilities to become established while vegetation develops, though filtering still occurs.
- Possible contamination of groundwater can be associated with an unlined bioretention facility.

Sources:

- Americast, Filterra®,www.americastusa.com
- Center for Watershed Protection (CWP), 1996. Design of Stormwater Filtering Systems Center for Watershed Protection. December 1996.
- Engineering Technologies Associates, Inc. (ETA)., *Design Manual for Use of Bioretention in Stormwater Management*, prepared for Prince George's County, Maryland, Department of Environmental Resources.
- Loomis & Moore et al 1998. Draft Integrated Solutions Development Study Watersheds Master Plan, Prepared for the City of Austin Watershed Protection Dept.
- Maryland Dept of the Environment and Center for Watershed Protection 2000. Maryland Storm water Design Manual, Volumes I & II.
- Schueler, T. R. et al. Draft Maryland Storm water Design Manual, Maryland Department of the Environment in Cooperation with the Maryland Department of Natural Resources Coastal Zone Management Program. 1998.

Literature Sources of Performance Demonstrations:

- Davis, A., M. Shokouhian, H. Sharma and C. Minami. 1998. *Optimization of Bioretention for Water Quality and Hydrological Characteristics*. Final Report: 01-4-31032. University of Maryland Department of Civil Engineering, Prince George's County Department of Environmental Resources. Landover, MD. 237 pp.
- Sharkey, Lucas J., William F. Hunt III, *Case Studies On The Performance Of Bioretention Areas in North Carolina*, presented at StormCon 2004.

Detention Basin, Outlet Improvements – Bladder Valve

Description:

A valve with an inflated bladder can be used to increase detention time. The pneumatic bladder located in the sedimentation chamber outlet drain is inflated when sensors detect rain to provide a set sedimentation time.

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	●	○
Nutrients	○	○
Pesticides	◒	○
Total Metals	◒	○
Dissolved Metals	○	○
Microbiological	◒	○
Litter	●	○
BOD	○	○
TDS	○	○

Notes:

- No performance data encountered in field demonstrations or in literature.

Key Design Elements:

1. Hydraulic capacity
2. Means of removing water when skimmer is at its lowest position
3. Power and controls system for operating outlet bladder or valve

<u>Ancillary Facilities</u>

Extended detention basin.

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
▝	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- _Requirements_: Mechanical skimmer or bladder will require inspection and periodic replacement.
- _Nuisance Control_: None beyond normal detention basin.
- _Specialty Training/Equipment_: Training required to inspect and maintain outlet.

Project Development:

- _Right-of-Way Requirements_: Equivalent to detention basin.
- _Siting Constraints_: Equivalent to detention basin. May require power.
- _Construction_: No special requirements identified.

Advantages:

- Potentially increased removal of suspended solids.

Constraints:

- Maintenance costs for sedimentation basins will be increased slightly since more sediments will accumulate in the sedimentation basin.
- May require draining the basin if the outlet fails.

Sources:

- www.epa.gov/ednnrmrl/projects/control/high.htm. April 2000.

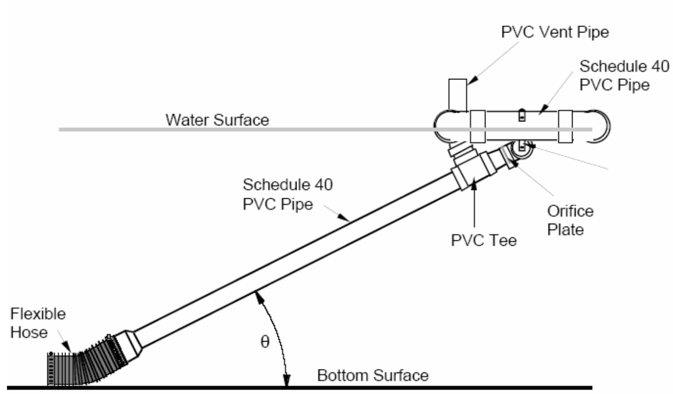
Literature Sources of Performance Demonstrations:

- No performance data.

Detention Basin, Outlet Improvements – Skimmer

Description:

The improved detention basin outlet drains water from the top of the basin to improve the sedimentation efficiency by assuring that settled particles are not accidentally sucked into the discharge. The sedimentation process could be improved by adding an outflow device composed of a skimmer, drainage hose and float to the current BMP design of the Austin Filter for the detention basin outlet or to the outlet of a stand-alone detention basin. The tank will be drained or "decanted" from the surface in order to allow more time for the sedimentation process. With the improved sedimentation process, less sediment will be collected on the media filter, reducing maintenance and extending the life of the sand filter.



Source: www.abe.psu.edu

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	●	○
Nutrients	○	○
Pesticides	◒	○
Total Metals	◒	○
Dissolved Metals	○	○
Microbiological	◒	○
Litter	●	○
BOD	○	○
TDS	○	○

Notes:

- No performance data encountered in field demonstrations or in literature.

Key Design Elements:

1. Hydraulic capacity
2. Means of removing water when skimmer is at its lowest position
3. Power and controls system for operating outlet bladder or valve

<u>Ancillary Facilities</u>

Extended detention basin.

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
▝	○

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- _Requirements_: Mechanical skimmer or bladder will require inspection and periodic replacement.
- _Nuisance Control:_ None beyond normal detention basin.
- _Specialty Training/Equipment:_ Training required to inspect and maintain outlet.

Project Development:

- _Right-of-Way Requirements_: Equivalent to detention basin.
- _Siting Constraints_: None identified. Equivalent to detention basin.
- _Construction:_ No special requirements identified.

Advantages:

- Potentially increased removal of suspended solids.

Constraints:

- Unless the skimmer can drain all the water from the detention pond, a secondary outlet should be provided at the bottom of the basin to avoid water stagnation and the potential for mosquito propagation.
- Maintenance costs for sedimentation basins will be increased slightly since more sediments will accumulate in the sedimentation basin.
- May require draining the basin if the outlet fails.

Sources:

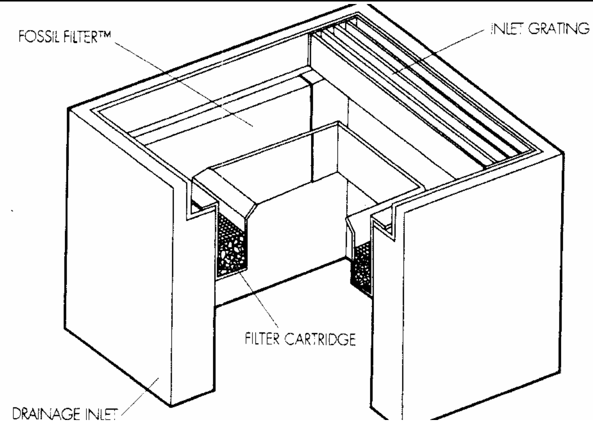
- www.epa.gov/ednnrmrl/projects/control/high.htm. April 2000.

Literature Sources of Performance Demonstrations:

- Harper, H. H., et al. “Performance Evaluation of Dry Detention Stormwater Management Systems.” Sixth Biennial Stormwater Research Watershed Management Conference. September 1999.
- Keblin, Michael, et al. Effectiveness of Permanent Highway Runoff Controls: Sedimentation/Filtration Systems. October 1997.
- Meinholtz, T. L., et al. Screening/Floatation Treatment of Combined Sewer Outflows, Volume II: Full-Scale Operation Racine, Wisconsin. EPA-600/2-79-106a. Aug 1979.
- Roy, John R. Corporate information packet. AquaLogic Stormwater Abatement Filter System. SWAF Inc. April 2000.
- United States Department of Transportation, Federal Highway Administration, Office of Environmental Planning: Evaluation and Management of Highway Runoff Water Quality, Washington, DC. June 1996.

Description:

FossilFilter™ inserts are proprietary devices that contain filter media (Amorphous Alumina Silicate) just under the grates of the storm water system's catch basins. The water runoff flows into the inlet, through the filter where the target contaminants are removed, and then into the drainage system. This model was discontinued.



Source: KriStar Enterprises, Inc.

Constituent Removal:

Constituent Group	***Removal Efficiency***	***Level-of-Confidence***
Total Suspended Solids	○	●
Nutrients	○	○
Pesticides	○	○
Total Metals	○	●
Dissolved Metals	○	○
Microbiological	○	○
Litter	○	○
BOD	○	○
TDS	○	○

Notes:

- Three FossilFilter™ DIIs were sited, constructed, and monitored as part of the Caltrans BMP retrofit pilot program.
- There was initial litter capture, but bypassed flows allowed litter to escape.

Key Design Parameters:

FossilFilter™ should be installed into the inlet of the storm drain according to the manufacturer's recommendations. Even sheet flow to all sites of the inlet is optimal. Concentrated flow (as in a swale) creates a jet entering the inlet which can result in by-pass. The design loading rate is 12 gpm per foot of filter.

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	***Level-of-Confidence***
▖	●

Information from Caltrans Cost Summary report CTSW-RT-01-003. An average of 29 field hours were spent operating and maintaining each FossilFilter™ DII in the 1999/2000 season.

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: FossilFilter™ should be inspected for trash and debris that could interfere with the normal functioning of the inlets, or debris that tends to accumulate on top of the trays, deflecting runoff water. The FossilFilter™ adsorbent should be replaced when significant oil and grease are present on the absorbent granules. The media should be replaced annually.
- *Nuisance Control*: None identified.
- *Specialty Training/Equipment:* No special requirements identified.

Project Development:

- *Right-of-Way Requirements*: Space requirements are very small.
- *Siting Constraints*: Requires a grated drop inlet.
- *Design Complexity*: Proprietary device.
- *Construction:* The edge where the device tray meets the inlet wall must be sealed to prevent runoff from by-passing the tray.

Advantages:

- FossilFilter™ are relatively inexpensive to install.
- Easily retrofitted to existing drain inlets.

Constraints:

- Maintenance is dispersed rather than centralized at the storm drain outlet.
- They are not suitable for locations such as freeway shoulders where maintenance access is hazardous.
- Potential for clogging and bypass of media.

Sources:

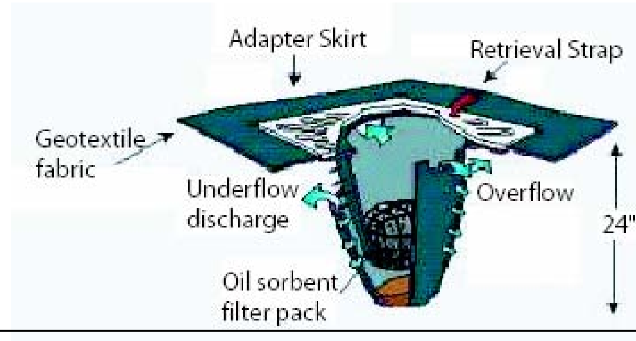
- FossilFilter™ is a proprietary device. Information provided by manufacturer can be found on their website at http://www.kristar.com/
- KriStar Enterprises, Inc.
  P.O. Box 7352
  Santa Rosa, CA 95407-0352
  (800) 579-8819 FAX: (707) 524-8186

Literature Sources of Performance Demonstrations:

- Caltrans, 2004. BMP Retrofit Pilot Program Final Report, CTSW-RT-01-050 available at www.dot.ca.gov/hq/env/stormwater

- Othmer, Edward F., Jr., et al, May 20-24, 2001. "Performance Evaluation of Structural BMPs: Drain Inlet Inserts (Fossil Filter and StreamGuard) and Oil/Water Separator," presented at American Society of Civil Engineers (ASCE) World Water & Environmental Resources Congress 2001, Orlando, FL.

Description:
StreamGuard™ is placed in the inlet to a storm drain where storm water flows through the insert, and the geotextile fabric absorbs oil and retains sediment and gross pollutants. The body of the unit fills with storm water and sediment, and gross pollutants are collected in the bottom of the insert. Floating oil and grease are absorbed by the filter pack contained in a poly-net bag fixed within the unit.



Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	○	●
Nutrients	○	○
Pesticides	○	○
Total Metals	○	●
Dissolved Metals	○	○
Microbiological	○	○
Litter	○	○
BOD	○	○
TDS	○	○

Notes:

- Three StreamGuard™ DIIs were sited, constructed, and monitored as part of the Caltrans BMP retrofit pilot program.

Key Design Parameters:
StreamGuard™ should be installed into the inlet of the storm drain according to the manufacturer's recommendations. A tight seal is necessary between the frame of the drain inlet and the insert. The insert should have a high-flow bypass to prevent resuspension and washout.

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
▖	●

Information from Caltrans Cost Summary report CTSW-RT-01-003. An average of 17 field hours were spent operating and maintaining each StreamGuard™ in the 1999/2000 season.

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

● High ◒ Medium ○ Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: Sediment should be removed when accumulation is more than 6 inches. StreamGuard™ should be inspected for trash and debris that could interfere with the normal functioning of the inlets. The StreamGuard™ adsorbent should be replaced when significant oil and grease are present on the absorbent polymer. The media should be replaced annually.
- *Nuisance Control*: None identified.
- *Specialty Training/Equipment:* No special requirements identified.

Project Development:

- *Right-of-Way Requirements*: Minimal space requirements for drain inlet insert.
- *Siting Constraints*: Requires a grated drop inlet.
- *Design Complexity*: Proprietary device.
- *Construction:* Bag may slip under the weight of water and debris if not tightly held by inlet grate. Shims may be required.

Advantages:

- StreamGuard™ DIIs are relatively inexpensive to install, and are easily retrofitted to existing drain inlets.

Constraints:

- Constituent removal is relatively small.

Sources:

- Foss Environmental
  PO Box 80327
  Seattle, Washington 98108 USA
  Tel (800) 909-3677 fax (888) 234-3677
  e-mail fossenv@fossenv.com
- StreamGuard™ is a proprietary device. Information provided by manufacturer can be found on their website at http://www.fossenv.com/

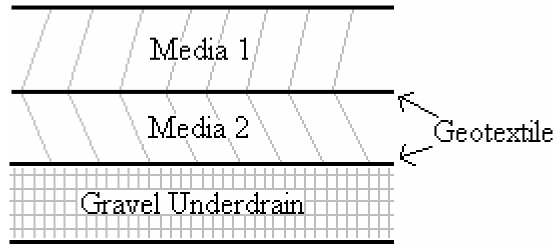
Literature Sources of Performance Demonstrations:

- Othmer, Edward F., Jr., et al, May 20-24, 2001. "Performance Evaluation of Structural BMPs: Drain Inlet Inserts (Fossil Filter and StreamGuard) and Oil/Water Separator," presented at American Society of Civil Engineers (ASCE) World Water & Environmental Resources Congress 2001, Orlando, FL.

- Caltrans, 2004. BMP Retrofit Pilot Program Final Report, CTSW-RT-01-050 available at www.dot.ca.gov/hq/env/stormwater

Description:

The Dual Media Austin Filter is similar to an Austin Sand Filter. In the filter, the water passes through two media layers, a geotextile layer, and 6" of gravel. Particulate removal is achieved primarily by physical filtration of pollutants through the filtration media and settling of solids in the sedimentation basin. Dissolved pollutants are absorbed to the media. The second media typically has properties conducive to absorption. The arrangement tested by Caltrans consists of 0.4m (12") of Activated Alumina overlain by 0.2m (0.6") of sand. The sand on top will clog first. Replacement of clogged sand will be less expensive than if the entire filter where activated alumina.



See Austin Sand Filter fact sheet (C-2) for overall schematic.

Constituent Removal:

Constituent Group	***Removal Efficiency***	***Level-of-Confidence***
Total Suspended Solids	●	◒
Nutrients	◒	◒
Pesticides	○	◒
Total Metals	◒	◒
Dissolved Metals	○	◒
Microbiological	●	◒
Litter	●	◒
BOD	○	◒
TDS	○	◒

Notes:

- Data based on Caltrans Retrofit Pilot Program for five Austin sand filters and based on the small-scale Tahoe pilot studies.

Key Design Parameters:

1. Design volume for the sedimentation basin should be increased to account for reduction in storage volume due to deposition of solids
2. Orifice plate on the outlet riser should be sized so that the sedimentation basin drains from a full basin condition in 24 hours
3. The underdrain piping should consist of a main collector pipe and two or more lateral branch pipes with a minimum slope of 1%

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	***Level-of-Confidence***
▝	●

Five Austin sand filters were constructed for retrofit and monitored. An average of 45 field hours/year was spent on O&M for each sand filter. Caltrans BMP Retrofit Final Report CTSW-RT-01-050

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

● High	◒ Medium	○ Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: A maintenance ramp should be incorporated to allow equipment into the sedimentation basin and filter basin for routine cleaning sediment and debris.
- *Nuisance Control:* The spreader ditch in the filtration chamber holds water and can provide breeding habitat for mosquitoes. The spreader ditch may be omitted from the traditional design if another energy dissipation method is provided in front of the riser outlet to the filter bed.
- *Specialty Training/Equipment:* Training required for media removal.

Project Development:

- *Right-of-Way Requirements*: Space requirements are relatively high for sedimentation basin and sand filter.
- *Siting Constraints*: Should not be sited where runoff from bare soil or construction activities will be allowed to enter the filter. Head requirement of 1.2 meters. Sand filters should be sited where enough vertical clearance (head) is provided, about 1.5 meters. Detailed geotechnical investigation prior to construction is recommended.
- *Construction:* No special requirements identified.

Advantages:

- The Austin filters have good constituent removal for suspended solids, total metals, and bacteria. They can provide consistent pollutant removal when properly maintained.
- They can treat runoff from drainage areas up to 20 hectares.
- They can reduce the potential for groundwater contamination if they are designed with an impermeable basin liner.
- They can be added to retrofit highly developed existing sites.

Constraints:

- Sand filters can be relatively expensive to construct and maintain.
- Limited pollutant removal for nutrients.
- If sufficient head is not available, the use of pumps may be required, which result in higher costs and more frequent maintenance.

Sources:

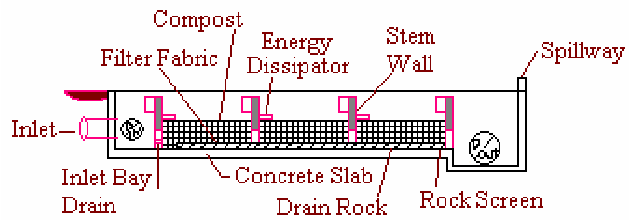
- M. Barrett, University of Texas at Austin
- http://www.epa.gov/owm/mtb/sandfltr.pdf

Literature Sources of Performance Demonstrations:

- The US Department of Transportation "Evaluation and Management of Highway Runoff Water Quality" Young et al. 1996 – contains info. on siting, design, and performance.
- Glick, Roger Chang, George C., and Barrett, Michael E., Monitoring and evaluation of stormwater quality control basins, in Watershed Management: Moving from Theory to Implementation, Denver, CO, May 3-6, 1998, pp. 369-376.

Description:

This filter is conceptually similar to the Austin Sand Filter (see page D-3, Appendix D), but uses a composted leaf filter media instead. Stormwater Management, Inc. has stopped manufacturing systems and now supplies a canister arrangement (see Fact Sheet C-17 StormFilter™. The filter is open to the atmosphere and requires a sedimentation basin upstream. The media is typically housed in a large below-grade vault. In some designs the vault is sectioned off by removable weirs, and under high flow conditions the storm water will overflow the first filter section to be treated in the subsequent ones. The filter media is reported to remove sediment, oil, particulate and dissolved metals, and a variety of organic contaminants. The assumption is that, compared to sand, these systems will have enhanced removal for many pollutant compounds due to the increased cation exchange capacity of organic matter. This technology is designed for use at the storm water pipe outlet. Currently available configurations use cylindrical filter modules to save space and reduce filter clogging.



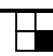
Key Design Elements:

1. Proprietary design

<u>Ancillary Facilities</u>

Sedimentation facilities required upstream of filter

Cost Effectiveness Relative to Detention Basins:

Cost Efficiency	***Level-of-Confidence***
	●

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

● High	◒ Medium	○ Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Constituent Removal:

Constituent Group	***Removal Efficiency***	***Level-of-Confidence***
Total Suspended Solids	○	●
Nutrients	○	◒
Pesticides	○	○
Total Metals	●	◒
Dissolved Metals	◒	○
Microbiological	○	●
Litter	●	◒
BOD	○	◒
TDS	○	◒

Notes:

- High level of confidence was based on 95% confidence results reported in CTSW-RT-03-036.

Issues and Concerns:

Maintenance:

- *Requirements*: Sediment accumulation in filters and vegetation growth may occur. Nutrient concentrations (especially nitrates and phosphate) have been shown to increase. Media clogging issues may increase maintenance.
- *Nuisance Control:* Standing water may provide a breeding place for mosquitoes and other vectors.
- *Specialty Training /Equipment:* Training required for media removal.

Project Development:

- *Right-of-Way Requirements:* Space requirements depend on sizing criteria, typically smaller than basins.
- *Siting Constraints*: Safety barrier surrounding open basin. Open basins may not be suitable close to freeways.
- *Construction:* No special requirements identified.

Advantages:

- Sedimentation shown to occur. May reduce concentrations of many metals, turbidity, suspended solids, BOD, and ammonia.

Constraints:

- Nutrient leaching.

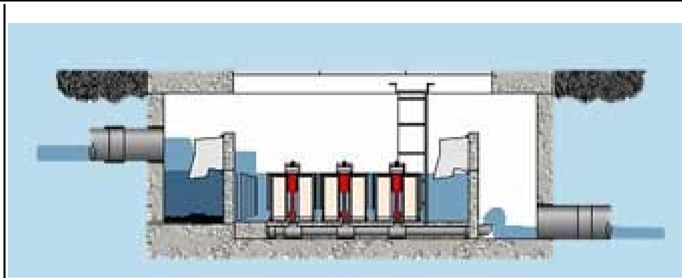
Sources:

- Jim Lenhardt, Stormwater Management Inc.
- www.stormwatermgt.com

Literature Sources of Performance Demonstrations:

- Compost Storm Water Filter System Monitoring Report , State Route 73 CSTW-RT-03-036 http://www.dot.ca.gov/hq/env/stormwater/special/newsetup/index.htm

Description:
StormFilter™ is a flow-through system consisting of a vault with canisters filled with filter media. The media traps particulate and adsorbs pollutants such as suspended solids, oil and grease, some metals, nutrients and organics. Various media can be specified (depending on the constituent of concern) including perlite, composted leaf media, zeolite, fabric inserts, GAC, and iron-infused media.



Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	◒	●
Nutrients	○	◒
Pesticides	○	○
Total Metals	◒	●
Dissolved Metals	○	◒
Microbiological	○	◒
Litter	●	○
BOD	○	○
TDS	◒	○

Notes:

- A StormFilter™ was sited as part of the Caltrans BMP retrofit pilot program. The canisters contained a mixture of perlite and zeolite.

Key Design Parameters:
StormFilter™ is sized to treat the peak flow from the design storm. The peak flow is determined based on the watershed area and design storm magnitude StormFilter™ canisters are designed to treat 0.033 cfs each or 30 media canisters per c.f.s. of storm water runoff

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
▗	●

Cost information obtained from Caltrans Cost Summary report CTSW-RT-01-003. An average of 30 field hours per year was spent on operation and maintenance of the StormFilter™ during the Caltrans BMP retrofit pilot program.

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- <u>*Requirements*</u>: Periodic maintenance is required to remove sediment that accumulates in the vaults.
- <u>*Nuisance Control*</u>*:* A permanent pool of water is held in the pretreatment vault that provides breeding habitat for mosquitoes. Design can incorporate a "drain-down system", but tendency to clog is unknown.
- <u>*Specialty Training/Equipment*</u>*:* The use of equipment is needed to remove media canisters and to clean out pretreatment vault. Crews must be trained to repair or replace any cartridge filter or part associated with the facility or contract for maintenance.

Project Development:

- <u>*Right of Way Requirements*</u>: Space requirements depend on sizing criteria, typically smaller than basins.
- <u>*Siting Constraints*</u>: Runoff from bare soil or construction activities should not be allowed to enter the filter. Sufficient hydraulic head is needed to operate the filter, about 0.7-m. StormFilter is a proprietary system.
- <u>*Construction*</u>*:* No special requirements identified.

Advantages:

- StormFilter™ has moderate constituent removal for suspended solids, nutrients, and metals. It can be applied in confined urban areas and areas with limited space since it is an underground vault.

Constraints:

- StormFilter™ can be expensive to construct.
- A permanent pool of water is held in the pretreatment vault that provides breeding opportunities for mosquitoes.
- Major maintenance may be costly due to the large number of filter canisters required (72 canisters for a 1.5 acre drainage area).

Sources:

- Stormwater Management Inc.
  2035 NE Columbia Blvd.
  Portland, OR 97211
  800-548-4667
- EPA website includes information on design and performance of StormFilter™ www.epa.gov/region01/steward/ceit/tech_cos/sto.html
- StormFilter™ is a proprietary system, check the manufacturers website for information on the product. www.stormwatermgt.com.

Literature Sources of Performance Demonstrations:

- Caltrans, 2004. BMP *Retrofit Pilot Program Final Report*, CTSW-RT-01-050 available at www.dot.ca.gov/hq/env/stormwater

BMP Fact Sheet
GSRD Baffle Box

Description:

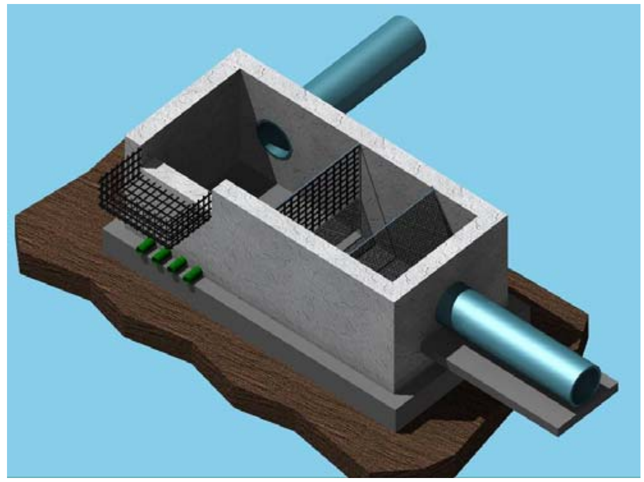
The baffle box Gross Solids Removal Device (GSRD) is a non-proprietary device whose primary function is to remove gross solids (litter and vegetative material) from storm water runoff. The Baffle Box applies a two-chamber concept: the first chamber utilizes an underflow wire to trap floatable gross solids; and the second chamber utilizes a bar rack to screen out any material that passes through from the first chamber.

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids		
Nutrients		
Pesticides		
Total Metals		
Dissolved Metals		
Microbiological		
Litter	●	●
BOD		
TDS		

Notes:

- Litter and vegetative material are the target constituents for the device.
- No long-term water quality monitoring studies have been conducted to evaluate the treatment effectiveness of the baffle box on other water quality constituents.



Key Design Parameters:

1. Hydraulic Head
2. Annual Estimated Gross Solids Loading Rate
3. Baffle boxes should be sized to hold gross solids to be deposited during a 1-year period and pass the design flow (e.g., 25-year flow).

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
	●

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements:* Periodic inspections required to ensure that the device is functional. Routine maintenance may include sediment/debris removal.
- *Nuisance Control:* Design should eliminate standing water that may provide breeding habitat for vectors.
- *Specialty Training/Equipment:* No special requirements identified.

Project Development:

- *Right-of-Way Requirements*: Small footprint.
- *Siting Constraints*: Must provide sufficient hydraulic head to operate by gravity.
- *Construction:* Traffic control may be required for retrofits due to close proximity to roadway.

Advantages:

- Baffle box is a "small footprint device" that can be installed in existing right of way.
- Based on pilot studies, when regular maintenance is supplied, the device removes nearly all the gross solids from storm water runoff.

Constraints:

- Based on pilot studies, regular maintenance is required to keep the device functioning properly.
- Subject to clogging. Maintenance required to unclog screens and drainage fixtures

Sources:

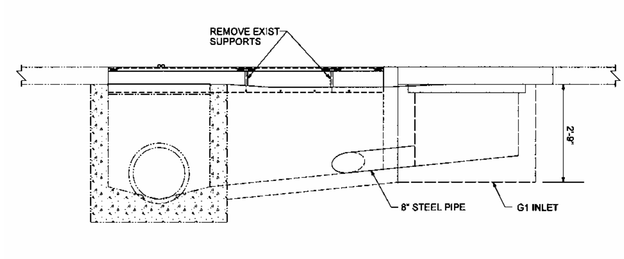
- none identified

Literature Sources of Performance Demonstrations:

- California Department of Transportation, Phase I Gross Solids Removal Devices Pilot Study: 2000-2002, Final Report. CTSW-RT-03-072.31.22

Description:

Standard Caltrans inlet and grate is replaced with a curb inlet and flap gate.



Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	○	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	◒	◒
BOD	○	○
TDS	○	○

Notes:

- No performance data encountered in literature
- Field evaluation of prototype is currently being conducted on Highway 60 in the Los Angeles area.

Key Design Parameters:

1. Curbed roadway is required

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
◱	●

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: Flab gate requires periodic clean-out.
- Nuisance Control: None identified.
- *Specialty Training/Equipment:* No special requirements identified.

Project Development:

- *Right-of-Way Requirements*: Small-footprint.
- *Siting Constraints*: Curbed roadway is required.
- *Construction:* No special requirements identified.

Advantages:

- Keeps dry-weather deposition out of storm water conveyance system and allows most gross pollutants to be collected by the street sweeper. Most effective in arid or semi-arid climates.

Constraints:

- Larger items can enter the LID than the standard inlet grate during storms.
- Flap gate may require maintenance and system clean out.

Sources:

- URS, 1615 Murray Canyon Road, Suite 1000, San Diego, CA 92108 619•294•9400
  - David Marx (davis_marx@urscorp.com)
  - Kim Walter (kim_walter@urscorp.com)

Literature Sources of Performance Demonstrations:

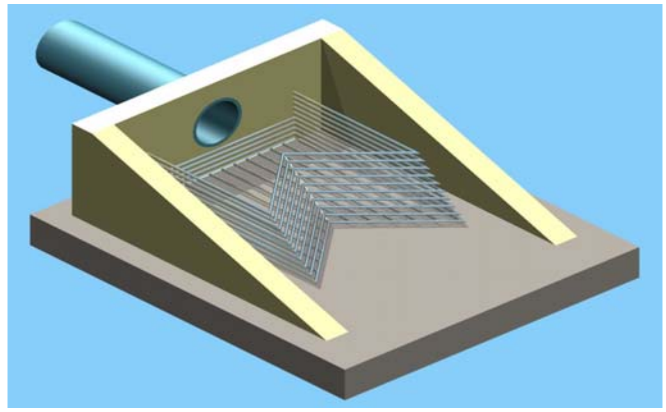
- None identified.

Description:

The V-Screens (VS) Gross Solids Removal Devices (GSRDs) are non-proprietary devices whose primary function is to remove gross solids (litter and vegetative material) from storm water runoff. Currently, there are two configurations of VS GSRDs:

Configuration #1. This VS GSRD utilizes a forward sloping V-shaped 5 mm wedge-wire screen. The screen is sloped forward so that the top of the screen is downstream from the bottom of the screen. Configuration #1 is not pictured.

Configuration #2. This VS GSRD utilizes a reverse sloping V-shaped 5 mm wedge-wire screen. The screen is sloped backward (or reverse) so that the bottom of the screen is downstream from the top of the screen. See picture to the right.



Constituent Removal:

Constituent Group	***Removal Efficiency***	***Level-of-Confidence***
Total Suspended Solids		
Nutrients		
Pesticides		
Total Metals		
Dissolved Metals		
Microbiological		
Litter	●	●
BOD		
TDS		

Notes:

- Litter and vegetative material are the target constituents for the device.
- No long-term water quality monitoring studies have been conducted to evaluate treatment effectiveness of the VS GSRDs on other water quality constituents.

Key Design Parameters:

1. Hydraulic Head
2. Annual Estimated Gross Solids Loading Rate
3. VS GSRDs should be sized to hold gross solids to be deposited during a 1-year period and pass the design flow (e.g., 25-year flow).

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	***Level-of-Confidence***
▖	●

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

● High	◒ Medium	○ Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: Periodic inspections required to ensure that the device is functional. Routine maintenance may include sediment/debris removal.
- *Nuisance Control:* Design should eliminate standing water that may provide breeding habitat for vectors.
- *Specialty Training/Equipment:* Routine maintenance requires staff and equipment to clear the screen module if it becomes clogged and remove accumulated sediment.

Project Development:

- *Right-of-Way Requirements*: Small footprint.
- *Siting Constraints*: Must provide sufficient hydraulic head to operate by gravity.
- *Construction:* No special requirements identified.

Advantages:

- The IS GSRDs are a "small footprint device" that can be installed in existing right of way.
- Based on pilot studies, the devices remove nearly all the gross solids from storm water runoff with minimal maintenance requirements.

Constraints:

- Hydraulic head requirement.

Sources:

- none identified

Literature Sources of Performance Demonstrations:

- California Department of Transportation, Phase III Gross Solids Removal Devices Pilot Study: 2002-2003, Interim Report. CTSW-RT-03-099.31.24.

Description:

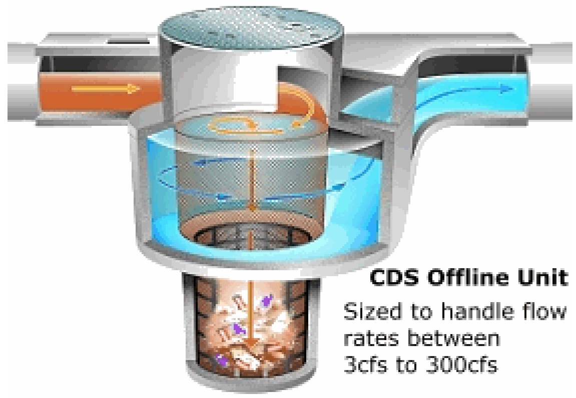
Continuous Deflective Separation (CDS™) units are placed downstream of drain inlets to capture sediment, trash, and debris (gross pollutants). The units create a vortex of water that allows the water to escape through a screen while contaminants are contained in the unit sump. The vortex action of the water tends to keep the screen clear from trash and debris. A storm by-pass weir is incorporated to allow excess flows to bypass the system, rather than entering the CDS™ unit. This is to prevent the unit from flooding or losing its captured material.

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	○	◒
Nutrients	○	◒
Pesticides	○	○
Total Metals	○	◒
Dissolved Metals	○	◒
Microbiological	○	◒
Litter	●	●
BOD	○	○
TDS	○	○

Notes:

- Information based on chemistry data from the Caltrans BMP Retrofit Pilot Program. Manufacturer reports 2400 micron screen can remove:
  - 100% of particles 425 um or greater
  - 96 % of particles 300-425 um
  - 76 % of particles 150-300 um
  - 42 % of particles 75-150 um
- 4700 micron screen can remove:
  - 100% of particles 2,350 um or greater
  - 93 % of particles 1,551-2,350 um
  - 50 % of particles 940-1,551um
- Two CDS™ units are currently being tested as part of the Caltrans BMP retrofit pilot program. Performance evaluation is currently not available.
- There have been about 160 installations of CDS units in Australia and the Untied States.
- Five studies have been performed on CDS™ units. These studies focused on characteristics of litter and sediments rather than efficiency.



Key Design Parameters:

Storm water units that will treat a 1 to 300 CFS flow range. Contact manufacturer for customization of units to meet site specific needs for flow capacities and sump sizes Flow must be subcritical entering the unit. Sites with continuous dry weather flow are not recommended.

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
▖	●

Information from Caltrans Cost Summary report CTSW-RT-01-003. Manufacturer can supply cost data for unit only. An average of 63 field hours per year were spent on operation and maintenance of each CDS™ during the Caltrans BMP retrofit pilot program.

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- <u>*Requirements*</u>: The CDS™ units are designed to retain captured pollution over multiple rain events. The CDS™ unit should be inspected, floatables should be removed, and the sump cleaned when the sump is above 85% full. There are three methods for cleaning out a CDS™ unit - vactor truck, removable basket, and underflow pump.
- <u>*Nuisance Control*</u>*:* Vector inspections are required since the unit holds a permanent pool of water.
- <u>*Specialty Training/Equipment*</u>*:* Vactor equipment recommended for cleaning.

Project Development:

- <u>*Right-of-Way Requirements*</u>: Small footprint.
- <u>*Siting Constraints*</u>: Low head requirement.
- <u>*Design Complexity*</u>: Proprietary device.
- <u>*Construction*</u>*:* No special requirements identified.

Advantages:

- Storm water can be treated at the end of pipe, and therefore storm water treatment devices are not needed at each storm drain inlet. The unit is non-mechanical, non-electrical, reducing maintenance issues related to mechanical and electrical devices. Relatively limited head is needed to operate the device (0.5 ft).

Constraints:

- Unit is developed for the removal of gross pollutants only.
- Permanent pool of water is maintained, creating a breeding opportunity for mosquitoes.

Sources:

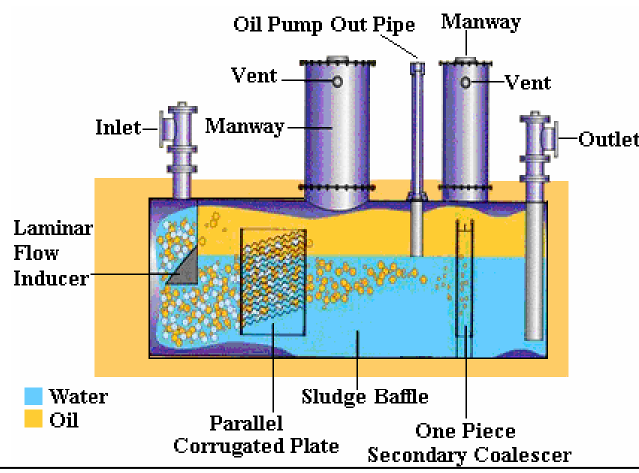
- US Head Office - West Coast
  CDS Technologies
  16360 South Monterey Road, Suite 250
  Morgan Hill, CA 95037
  Toll Free: 888 535 7559
  Phone: 408 779 6363
  Fax: 408 782 0721
  email: cds@cdstech.com
- www.CDStech.com.au/articles/StenstromReport.pdf
- www.CDStech.com.au/articles/Coarse&Medium-FineSedimentRemoval.pdf
- www.stormwater-resources.com/Library/065BCDSFinal.pdf

Literature Sources of Performance Demonstrations:

- Caltrans, 2004. BMP *Retrofit Pilot Program Final Report*, CTSW-RT-01-050 available at www.dot.ca.gov/hq/env/stormwater

Description:

Oil/Water Separators are designed to remove free oil and grease from storm water runoff. Oil droplets collide and coalesce to become larger globules that are captured in the separator. Oil/Water separators are typically manufactured units. They consist of a baffled vault containing several inclined corrugated plates stacked and bundled together. The plates are equally spaced and reduce the vertical distance oil droplet must rise to separate from the storm water. With current technology and design, coalescing plate separator type oil/water separators are capable of reducing effluent concentrations of free oil and grease to 10 - 15 mg/L, and should be used where concentrations of oil and grease are high.



Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	◒	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	○	○
BOD	○	○
TDS	○	○

Notes:

- One oil/water separator was sited as part of the Caltrans BMP Retrofit Pilot Program. Concentration reductions for TSSpresented are those found in the study. Level of confidence is low because TSS was done by grab samples with only 4 events.

Key Design Parameters:

To design the coalescing plate separator the "effective separation area" required for the plate media needs to be determined given a design flow. The specific vault sizing will then depend on the manufacturer's plate media design. The specific design, analysis, configuration, and specifications for coalescing plates are empirically based and variable. Refer to manufacturer recommendations. An oil/water separator typically consists of three compartments divided by baffles: a forebay, an oil separation cell, and an afterbay. Sediments are trapped and collected in the forebay. The oil separation cell is used to capture and hold oil. The afterbay allows a relatively oil-free exit cell before the outlet.

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
◲	●

Information from Caltrans Cost Summary report CTSW-RT-01-003. Twenty-seven field hours were spent operating and maintaining the oil/water separator in the 1999/2000 season.

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

● High	◒ Medium	○ Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: Oil/Water separators require regular inspection. The separator plates require cleaning when sufficient oil and grease have accumulated and their effectiveness is reduced. Inspection and cleaning should follow manufacturers recommendations. Accumulated sediment should be removed frequently to prevent resuspension. Sediment removal also removes the oil and grease since these pollutants bind to the sediment.
- *Nuisance Control*: None
- *Specialty Training/Equipment:* Vactor equipment recommended for cleaning.

Project Development:

- *Right-of-Way Requirements*: Small footprint.
- *Siting Constraints*: Low head requirement.
- *Design Complexity*: Separators should precede all other stormwater treatment. Appropriate removal covers must be provided that allows access for observation and maintenance. Any pump mechanism should be installed downstream of the separator to prevent oil emulsification.
- *Construction:* No special requirements identified.

Advantages:

- Oil/water separators are installed underground so they are not an aesthetic problem. Where high concentrations of free oil are present they can provide significant reduction.

Constraints:

- Accumulated sediment must be removed or cleaned out frequently to prevent resuspension.
- The concentrations of free oil and grease typically found in storm water runoff are generally too low to benefit from treatment by this device.
- Significant excavation is required for construction.

Sources:

- Gnesys, Inc., Hydrasep®,www.hydrasep.com
- Highland Tank
  One Highland Road
  Stoystown, PA 15563
  814-893-5701
  FAX 814-893-6126
- Lantec Products, HD Q-PAC®, www.lantecp.com

Literature Sources of Performance Demonstrations:

- Caltrans, 2004. BMP Retrofit Pilot Program Final Report, CTSW-RT-01-050 available at www.dot.ca.gov/hq/env/stormwater

APPENDIX D: CALTRANS APPROVED BMPS

Appendix D presents fact sheets for BMPs approved for installation on Caltrans facilities. Implementation of these BMPs should follow the guidelines in the Storm Water Management Plan and the Storm Water Project Planning and Design Guide.

Description:

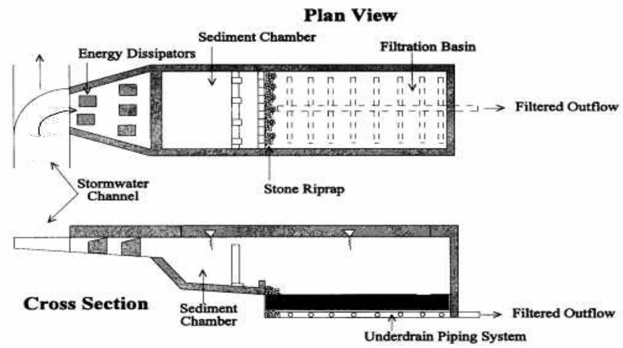
The Austin sand filter includes a sedimentation basin and a sand media filter. The sedimentation basin captures and detains the design water quality runoff volume (typically for 24 hrs.) prior to discharge to the filter chamber. The sedimentation basin removes floatable debris and coarse suspended solids and prevents premature clogging of the filter media surface. Sedimentation chamber effluent discharges to the sand filtration basin typically through a perforated riser. In the sand filter, the water passes through an 18” sand layer, a geotextile layer, and into a gravel underdrain. Pollutant removal is achieved primarily by physical filtration of pollutants through the filtration media and settling of solids in the sedimentation basin.

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	●	●
Nutrients	○	●
Pesticides	○	●
Total Metals	◒	●
Dissolved Metals	◒	◒
Microbiological	◒	◒
Litter	●	◒
BOD	○	○
TDS	○	○

Notes:

- Nitrate concentrations increase by 35%.
- Data obtained from Caltrans Retrofit Pilot Program. Five Austin sand filters were constructed and monitored.
- The removal of ortho-phosphates did not appear to be statistically significant (CTSW-RT-01-050).



Key Design Parameters:

1. Design volume for the sedimentation basin should be increased to account for reduction in storage volume due to deposition of solids
2. Orifice plate on the outlet riser should be sized so that the sedimentation basin drains from a full basin condition in 24 hours
3. The underdrain piping should consist of a main collector pipe and two or more lateral branch pipes with a minimum slope of 1%
4. Caltrans designers should follow the Project Planning and Design Guide

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
▝	●

Five Austin sand filters were constructed for retrofit and monitored. An average of 45 field hours/year were spent on O&M for each sand filter. Caltrans Cost Summary report CTSW-RT-01-003

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: A maintenance ramp should be incorporated to allow equipment into the sedimentation basin and filter basin for routine cleaning sediment and debris.
- *Nuisance Control:* The spreader ditch in the filtration chamber holds water and can provide breeding habitat for mosquitoes. The spreader ditch may be omitted from the traditional design if another energy dissipation method is provided in front of the riser outlet to the filter bed.
- *Specialty Training/Equipment:* Training required for media removal.

Project Development:

- *Right-of-Way Requirements*: Space requirements are relatively high for sedimentation basin and sand filter.
- *Siting Constraints*: Should not be sited where runoff from bare soil or construction activities will be allowed to enter the filter. Head requirement of 1.2 meters.
- *Construction:* No special requirements identified.

Advantages:

- The Austin sand filters have good constituent removal for suspended solids, total metals, and bacteria. They can provide consistent pollutant removal when properly maintained.
- They can treat runoff from drainage areas up to 20 hectares.
- They can reduce the potential for groundwater contamination if they are designed with an impermeable basin liner.
- They can be added to retrofit highly developed existing sites.

Constraints:

- Sand filters can be relatively expensive to construct and maintain.
- Limited pollutant removal for nutrients.

Sources:

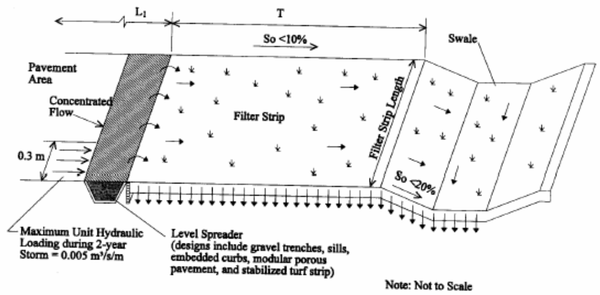
- Dr. M. Barrett, University of Texas at Austin
- www.epa.gov/owm/mtb/sandfltr.pdf
- www.enviro.nfesc.navy.mil/p2library/cgi-bin/p2h_datasheet.cfm?itemID=230
- www.webcentral.bts.gov/ntl/DOCS/RUNOFF.html

Literature Sources of Performance Demonstrations:

- Caltrans, 2004. BMP Retrofit Pilot Program Final Report, CTSW-RT-01-050 available at www.dot.ca.gov/hq/env/stormwater
- Glick, Roger, George C. Chang, and Michael E. Barrett, Monitoring and evaluation of stormwater quality control basins, in Watershed Management: Moving from Theory to Implementation, Denver, CO, May 3-6, 1998, pp. 369-376.
- The US Department of Transportation “Evaluation and Management of Highway Runoff Water Quality” Young et al. 1996 – contains info. on siting, design, and performance.

Description:

Biofiltration strip are relatively flat vegetated areas that accept sheet flow from storm water runoff. Removal mechanisms include filtration and infiltration. Strips can be used as pretreatment to infiltration trenches and basins, and sand filters.



Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	Medium	High
Nutrients	Low	Medium
Pesticides	Low	Low
Total Metals	High	High
Dissolved Metals	Medium	High
Microbiological	High	High
Litter	Low	Low
BOD	Low	Low
TDS	Low	Low

Notes:

- Three biofiltratin strips were sited, constructed, and monitored as part of the Caltrans BMP retrofit pilot program.

Key Design Parameters:

1. Locate, size, and shape biofiltration strips relative to topography and allow for extended flow paths to maximize treatment. Specify vegetation that occurs naturally to minimize establishment and maintenance costs. Install strips at a time when supplemental irrigation will not be needed to minimize establishment. Recommended slope of strips generally equal to or less than 20 percent.

2. Caltrans designers should follow the Project Planning and Design Guide

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
Benefit ↑ Cost ↓	High

An average of 131 field hours per year were spent operating and maintaining each biofiltration strip, which included 26 hours for vector control.

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

● High	◒ Medium	○ Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- Requirements: Maintenance requirements include regular inspections for side slope stability, debris and sediment accumulation, vegetation height, vegetative cover, and presence of burrowing animals. Woody vegetation is also removed. If acceptable cover is not achieved, re-seeding or some type of erosion control will be needed.
- Nuisance Control: Inspect for standing water during the wet season. No additional nuisance control necessary if drained properly.
- *Specialty Training/Equipment:* No special requirements identified.

Project Development:

- *Right-of-Way Requirements*: Space requirements are relatively low for biofiltration strips.
- *Siting Constraints*: Biofiltration strips require sheet flow, so site in areas where sheet flow predominates. Consider using as pretreatment for devices that may be prone to clogging, such as sand filters and infiltration basins or trenches.
- *Construction:* No special requirements identified.

Advantages:

- Requires less land space and incorporates well into the environment.
- Strips have high removal efficiencies for total suspended solids and total metals.
- Generally inexpensive relative to other BMPs to operate and maintain.

Constraints:

- Strips, in order to function, require sheet flow. Strips must be placed in areas with large amounts of sheet flow.
- Soil at project site needs to be amenable to selected vegetation. It may need to be conditioned to allow vegetation to establish.

Sources:

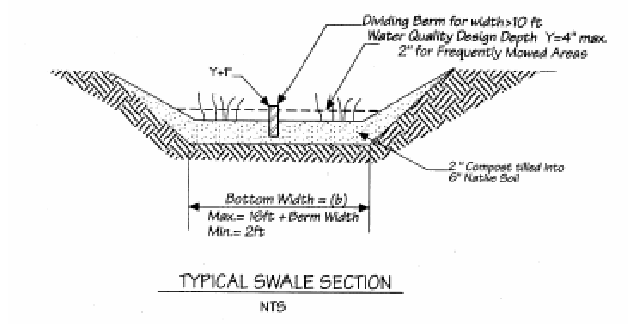
- www.epa.gov/owm/mtb/infltrenc.pdf
- http://h2osparc.wq.ncsu.edu/river/industrial/industri.html#cm
- www.stormwater-resources.com/Library/116BBMP%20Guide.PDF

Literature Sources of Performance Demonstrations:

- Caltrans, 2004. BMP Retrofit Pilot Program Final Report, CTSW-RT-01-050 available at www.dot.ca.gov/hq/env/stormwater
- Schueler, T.R., 1987. Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs, Department of Environmental Programs, Metropolitan Washington Council of Governments, Washington, DC.
- Young, G.K., et al. 1996, Evaluation and Management of Highway Runoff Water Quality, Publication No. FHWA-PD-96-032, U.S. Department of Transportation, Federal Highway Administration, Office of Environment and Planning.

Description:

Biofiltration swales are vegetated areas, similar to conveyance channels, which accept concentrated flow from storm water runoff via storm drain inlets. Removal mechanisms include filtration and infiltration as storm water flows through the grass.



Constituent Removal:

Constituent Group	***Removal Efficiency***	***Level-of-Confidence***
Total Suspended Solids	◒	●
Nutrients	○	○
Pesticides	○	○
Total Metals	◒	●
Dissolved Metals	◒	●
Microbiological	○	○
Litter	○	○
BOD	○	○
TDS	○	○

Notes:

- Six biofiltration swales were sited, constructed, and monitored as part of the Caltrans BMP retrofit pilot program.
- Only dissolved zinc was significantly removed.

Key Design Parameters:

1. Locate, size, and shape biofiltration strips relative to topography and allow for extended flow paths to maximize treatment. Swales constructed in cut are preferred to minimize gopher damage. Side slopes constructed of fill are not recommended, which are prone to gopher damage or other burrowing animals. Longitudinal slopes should be less than that which causes scour or transport of sediment. Energy dissipaters may be used, but do not use those that include standing water, as this could lead to vector problems. Use a mixture of drought-tolerant grass species, and select native vegetation to minimize establishment and maintenance costs.
2. Caltrans designers should follow the Project Planning and Design Guide

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	***Level-of-Confidence***
◱	●

An average of 133 field hours per year were spent operating and maintaining each biofiltration swale, which included 42 hours for vector control.

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

● High	◒ Medium	○ Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- Requirements: Maintenance requirements include regular inspections for side slope stability, debris and sediment accumulation, vegetation height, vegetative cover, and presence of burrowing animals. Woody vegetation is also removed. If acceptable cover is not achieved, re-seeding or some type of erosion control will be needed.
- Nuisance Control: Inspect for standing water during the wet season. No additional nuisance control necessary if drained properly.
- *Specialty Training/Equipment:* No special requirements identified.

Project Development:

- *Right-of-Way Requirements*: Space requirements are relatively low for biofiltration swales.
- *Siting Constraints*: Biofiltration swales should be placed in areas of natural lows or cut section to minimize damage caused by gophers or other burrowing animals.
- *Construction:* No special requirements identified.

Advantages:

- Requires less land space and incorporates well into the environment.
- Swales have good removal efficiencies for total suspended solids and total metals.
- Generally inexpensive relative to other BMPs to operate and maintain.
- Infiltration enhances reduction of pollutant load.

Constraints:

- Swales should be located in areas that are naturally low or in cut sections to minimize structural damage caused by gophers or burrowing animals.
- Soil at project site needs to be amenable to selected vegetation. It may need to be conditioned to allow vegetation to establish.

Sources:

- www.epa.gov/owm/mtb/infltrenc.pdf
- www.bae.ncsu.edu/programs/extension/wqg/
- www.stormwater-resources.com/ Library/116BBMP%20Guide.PDF

Literature Sources of Performance Demonstrations:

- Caltrans, 2004. BMP Retrofit Pilot Program Final Report, CTSW-RT-01-050 available at www.dot.ca.gov/hq/env/stormwater
- Schueler, T.R., 1987. Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs, Department of Environmental Programs, Metropolitan Washington Council of Governments, Washington, DC.
- Young, G.K., et al. 1996, Evaluation and Management of Highway Runoff Water Quality, Publication No. FHWA-PD-96-032, U.S. Department of Transportation, Federal Highway Administration, Office of Environment and Planning.

Description:

Delaware sand filters are often located at the curbside edge of a paved area or parking lot and include two parallel concrete chambers, a sedimentation chamber, and a sand media filter chamber. The sedimentation chamber holds a permanent pool of water. The sedimentation basin removes the coarse suspended solids and prevents premature clogging of the filter media surface. The sedimentation effluent discharges over a weir into the sand filter chamber where water is filtered through a 12- to 18-inch sand filter, geotextile layer, and into an underdrain. Delaware sand filters are on-line facilities; they process all runoff leaving the site up to the point where the overflow limit is reached.

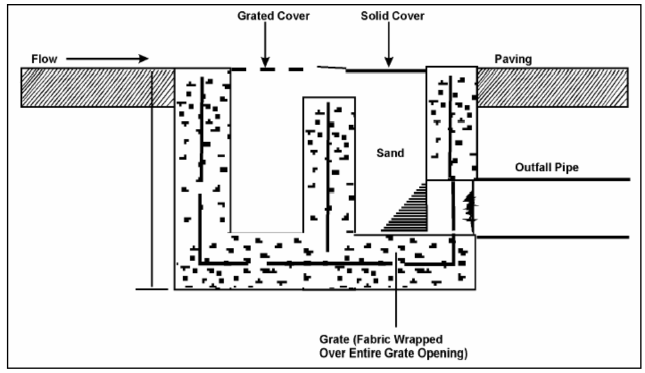
Delaware sand filters can be applied to confined urban areas and areas where space is limited. Parking lots are a common application for the Delaware sand filters.

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	●	●
Nutrients	○	◒
Pesticides	○	●
Total Metals	●	●
Dissolved Metals	◒	●
Microbiological	◒	◒
Litter	●	◒
BOD	○	○
TDS	○	○

Notes:

- Nitrate concentrations increase by 78%.
- High dissolved Zn removal efficiency.
- A Delaware sand filter was sited as part of the Caltrans BMP Retrofit Pilot Program. Although Delaware sand filters are not thought to be effective for removing dissolved constituent, some removal was observed.



Source: Shaver, 1991

Key Design Parameters:

1. The Delaware unit should be designed and installed according to the guidelines described by Young et al. (1996). It should be noted that if a Delaware filter is designed according to these guidelines, there is only storage in the unit for 5 mm of runoff (0.2 inches); consequently, if it is desired to treat a larger water quality volume, the unit must act as a flow-through device. The filter is sized using unit values for the sedimentation chamber volume and filter bed area per acre of tributary area treated.
2. Caltrans designers should follow the Project Planning and Design Guide

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
▝	●

Information from Caltrans Cost Summary report CTSW-RT-01-003. An average of 20 field hours per year were spent on operation and maintenance of the Delaware sand filter during the Caltrans BMP retrofit pilot program.

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- <u>*Requirements*</u>: Maintenance for smaller, underground filters is usually best done manually. Normal maintenance requirements include disposal of accumulated trash and replacement of the upper few inches of sand when the filter clogs.
- <u>*Nuisance Control*</u>*:* The spreader ditch in the filtration chamber holds water and can provide a breeding site for mosquitoes.
- <u>*Specialty Training/Equipment*</u>*:* Training required for media removal.

Project Development:

- <u>*Right-of-Way Requirements*</u>: Space requirements are relatively high for sedimentation basin and sand filter.
- <u>*Siting Constraints*</u>: Delaware sand filters should not be sited where runoff from bare soil or construction activities will be allowed to enter the filter. Minimum head requirement of 1.0 meters.
- <u>*Construction*</u>*:* No special requirements identified.

Advantages:

- Delaware sand filters can be installed underground in urban settings and be kept out of sight, or open for large drainage areas. They are similar in performance to the Austin design with the principal advantage being the preservation of the surface use.
- Waste media from the filters does not appear to be toxic and is likely to be environmentally safe for landfill disposal.
- The filters can reduce the potential for groundwater contamination if they are designed with an impermeable basin liner.

Constraints:

- Delaware sand filters are relatively expensive to construct.
- Sand filters have only limited pollutant removal capability for nutrients.
- The sedimentation basin holds a permanent pool of water and has the potential to provide breeding opportunities for mosquitoes.

Sources:

- www.epa.gov/owm/mtb/sandfltr.pdf has information on design, performance, operation, maintenance, and costs of sand filters.
- www.enviro.nfesc.navy.mil/p2library/cgi-bin/p2h_datasheet.cfm?itemID=230
- www.webcentral.bts.gov/ntl/DOCS/RUNOFF.html

Literature Sources of Performance Demonstrations:

- Caltrans, 2004. BMP Retrofit Pilot Program Final Report, CTSW-RT-01-050 available at www.dot.ca.gov/hq/env/stormwater
- The US Department of Transportation. *Evaluation and Management of Highway Runoff Water Quality*. Young et al. 1996 contains information on the citing, design, and performance of Delaware sand filters.
- W. Bell, L. Stokes, L. J. Gavan, T. N. Nguyen. 1995. *Assessment of the Pollutant Removal Efficiencies of Delaware Sand Filter BMP's*. Department of Transportation and Environmental Services. Alexandria, V.A. 140pp.
- R. R. Horner and C. R. Horner. 1995. *Design, Construction, and Evaluation of a Sand Filter Stormwater Treatment System*. Part III. Performance monitoring. Report to Alaska Marine Lines, Seattle, WA.
- E. Shaver and R. Baldwin. 1991. *Sand Filter Design for Water Quality Treatment*. Delaware Dept. of Natural Resources and Environmental Control. Dover, DE. 14pp.

BMP Fact Sheet
Detention Basins

Description:

Detention basins are impoundments that collect storm water from the highways via storm drain inlets. The basin captures and detains the design water quality runoff volume (typically for 48 hrs.) prior to discharge typically through a perforated riser. The basin removes floatable debris and coarse suspended solids. Pollutant removal is achieved primarily through settling of sediments and particulate forms of pollutants.

Constituent Removal:

Constituent Group	***Removal Efficiency***	***Level-of-Confidence***
Total Suspended Solids	◒	●
Nutrients	○	◒
Pesticides	○	○
Total Metals	◒	●
Dissolved Metals	○	◒
Microbiological	○	○
Litter	●	◒
BOD	○	○
TDS	○	○

Notes:

- Removal efficiencies result from unlined detention basins.
- Data obtained from Caltrans Retrofit Pilot Program.
- Five detention basins were constructed for retrofit and monitored
- An average of 72 field hours/year was spent on O&M for each detention basin. Caltrans Cost Summary report CTSW-RT-01-003.

Source: Caltrans Jan 2006

Key Design Parameters:

1. Locate, size, and shape detention basins relative to topography to maximize use of available space and enhance appearance
2. Use unlined basins where space is available because of lower initial cost and better constituent removal
3. Weep holes on the outlet riser should be sized so that the basin drains from a full basin condition in 24 hours. Maximum would be 72 hours to prevent vector problems
4. Use an outlet design with an orifice in a riser, surrounded by a screen mesh for debris control
5. Use earthen basin side slopes of 1:4 (V:H) or flatter. If steeper side slopes are used, consider slope stability measures where vegetation is difficult to establish.
6. For side slopes greater than 1:4 (V:H), incorporate access ramps and turnarounds to facilitate ease of maintenance activities.
7. Include energy dissipaters that do not allow standing water to persist for greater than 72 hours
8. Caltrans designers should follow the Project Planning and Design Guide

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	***Level-of-Confidence***
N/A	N/A

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: Maintenance requirements include regular inspections for standing water, side slope stability, debris and sediment accumulation, and vegetation height and vegetative cover. If vegetative cover of the basin invert or side slopes are not established to acceptable thresholds, re-seeding or erosion control measures may need to be implemented.
- *Nuisance Control*: None identified.
- *Specialty Training/Equipment:* No special requirements identified.

Project Development:

- *Right-of-Way Requirements*: Space requirements are relatively high for detention basins.
- *Siting Constraints*: Should not be sited where there may be insufficient hydraulic head to facilitate complete drainage, or in areas where groundwater contamination is a concern.
- *Construction:* No special requirements identified.

Advantages:

- The detention basins have good constituent removal for suspended solids, and total metals.
- Compared to other BMPs, detention basins are relatively easy to operate and maintain.
- Infiltration enhances reduction of pollutant load.

Constraints:

- Limited pollutant removal for nutrients and dissolved constituents.
- Can only be placed in areas with sufficient hydraulic head.
- Cannot be placed in areas where groundwater contamination is a concern.

Sources:

- Dr. M. Barrett, University of Texas at Austin
- www.epa.gov/owm/mtb/sandfltr.pdf
- www.enviro.nfesc.navy.mil/p2library/cgi-bin/p2h_datasheet.cfm?itemID=230
- www.webcentral.bts.gov/ntl/DOCS/RUNOFF.html

Literature Sources of Performance Demonstrations:

- Caltrans, 2004. BMP Retrofit Pilot Program Final Report, CTSW-RT-01-050 available at www.dot.ca.gov/hq/env/stormwater
- Caltrans, Jan 2006. Environmental Analysis Storm Water Program, Extended Detention Basins www.dot.ca.gov/hq/env/stormwater/ongoing/pilot_studies/bmps/details/ed_basins/
- Glick, Roger Chang, George C., and Barrett, Michael E., Monitoring and evaluation of stormwater quality control basins, in Watershed Management: Moving from Theory to Implementation, Denver, CO, May 3-6, 1998, pp. 369-376.
- The US Department of Transportation “Evaluation and Management of Highway Runoff Water Quality” Young et al. 1996 – contains info. on siting, design, and performance.

Description:

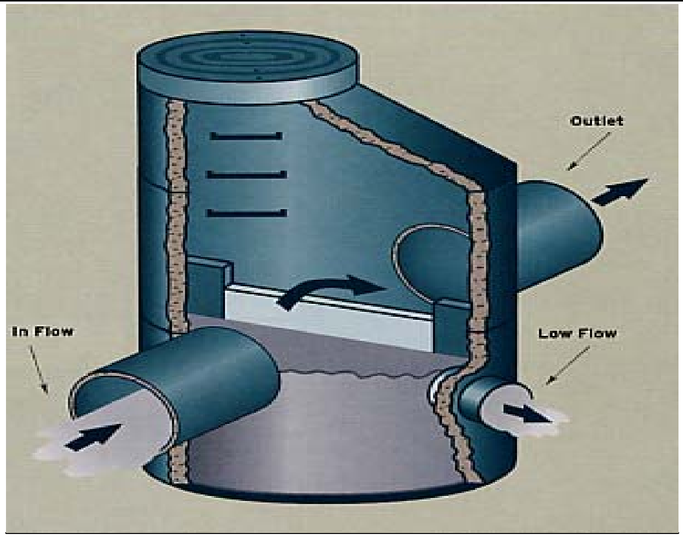
Low, dry weather flows in urban areas can be diverted from the storm drain system to the sanitary sewer system and conveyed to a publicly owned treatment works (POTW). During wet weather, this diversion is suspended since stormwater flows can be greater than normally managed by a POTW.

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	●	◒
Nutrients	●	◒
Pesticides	●	◒
Total Metals	●	◒
Dissolved Metals	●	◒
Microbiological	●	◒
Litter	●	◒
BOD	●	◒
TDS	●	◒

Notes:

- Does not treat storm water flows, however removal for non-storm water flows is considered complete up to the design flow that is diverted.



Source: Caltrans

Key Design Parameters:

1. Caltrans designers should follow the Project Planning and Design Guide

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
◰	○

Cost could greatly vary depending on site conditions.

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: Depends on complexity of diversion.
- *Nuisance Control:* Diversion may cause standing water.
- *Specialty Training/Equipment:* May require special training for inspection and maintenance of pumped diversions.

Project Development:

- *Right-of-Way Requirements*: Space requirements are relatively low for dry weather flow diversions.
- *Siting Constraints*: Must be able to convey diverted flow to POTW sewer.
- *Construction:* Coordination required with local POTW.

Advantages:

- Advanced treatment of the diverted flow.

Constraints:

- Must have agreement with POTW.
- Cost is highly variable depending site conditions.

Sources:

- www.epa.gov/owm/mtb/sandfltr.pdf
- www.enviro.nfesc.navy.mil/p2library/cgi-bin/p2h_datasheet.cfm?itemID=230
- www.webcentral.bts.gov/ntl/DOCS/RUNOFF.html
- Caltrans, 2002. Statewide Storm Water Management Plan. CTSW-RT-02-008. www.dot.ca.gov/hq/env/stormwater.
- Caltrans, Jan 2006, Division of Design, Manuals & Guidance, Stormwater, http://www.dot.ca.gov/hq/oppd/stormwtr/

Literature Sources of Performance Demonstrations:

- None available.

BMP Fact Sheet
GSRD Inclined Screen

Description:

The Inclined Screen (IS) Gross Solids Removal Devices (GSRDs) are non-proprietary devices whose primary function is to remove gross solids (litter and vegetative material) from storm water runoff. Currently, there are four configurations of IS GSRDs:

Configuration #1. This IS GSRD utilizes a 3 mm spaced parabolic wedge-wire screen. The device is configured with an influent trough to allow some solids to settle. See picture to the right.

Configuration #2. This IS GSRD utilizes 5 mm spaced parabolic bars. The device is configured with an influent trough to allow some solids to settle. Configuration #2 is not pictured.

Configuration #3. This IS GSRD utilizes the same screen as Configuration #1. However, Configuration #3 has been designed to be cleaned by a front-end loader instead of a Vactor Truck. Configuration #3 is not pictured.

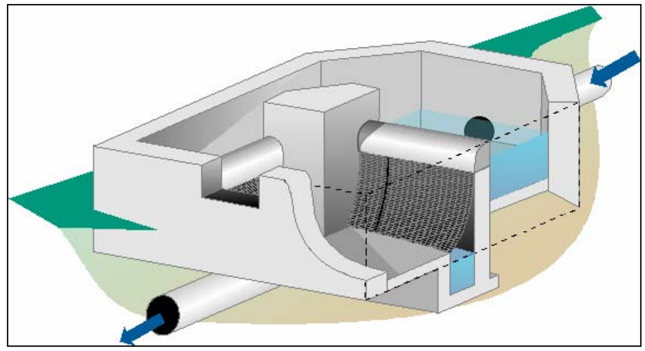
Configuration #4. This IS GSRD is similar to the Configuration #1 except that the screen is not parabolic and the influent trough has been removed from the design. Configuration #4 is not pictured.

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids		
Nutrients		
Pesticides		
Total Metals		
Dissolved Metals		
Microbiological		
Litter	●	●
BOD		
TDS		

Notes:

- Litter and vegetative material are the target constituents for the device.
- No long-term water quality monitoring studies have been conducted to evaluate treatment effectiveness of the inclined screen GSRDs on other water quality constituents.



Key Design Parameters:

1. Hydraulic Head
2. Annual Estimated Gross Solids Loading Rate
3. Caltrans designers should follow the Project Planning and Design Guide
4. Inclined screen GSRDs should be sized to hold gross solids to be deposited during a 1-year period and pass the design flow (e.g., 25-year flow).

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
	●

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◓	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- Requirements: Periodic inspections required to ensure that the device is functional. Routine maintenance may include sediment/debris removal.
- *Nuisance Control:* Design should eliminate standing water that may provide breeding habitat for vectors.
- *Specialty Training/Equipment*: Vactor equipment recommended for cleaning.

Project Development:

- *Right of Way Requirements*: Small footprint.
- *Siting Constraints*: Must provide sufficient hydraulic head to operate by gravity.
- *Construction:* Traffic control may be required for retrofits due to close proximity to roadway.

Advantages:

- The inclined screen GSRDs are a "small footprint device" that can be installed in existing right of way.
- Based on pilot studies, the devices remove nearly all the gross solids from storm water runoff with minimal maintenance requirements.

Constraints:

- Hydraulic head requirement.

Sources:

- none identified

Literature Sources of Performance Demonstrations:

- California Department of Transportation, Phase I Gross Solids Removal Devices Pilot Study: 2000-2002, Final Report. CTSW-RT-03-072.31.22
- California Department of Transportation, Phase II Gross Solids Removal Devices Pilot Study: 2001-2003, Final Report. CTSW-RT-03-097.31.22
- California Department of Transportation, Phase III Gross Solids Removal Devices Pilot Study: 2002-2003, Interim Report. CTSW-RT-03-099.31.24

BMP Fact Sheet
GSRD Linear Radial

Description:

The Linear Radial (LR) Gross Removal Devices (GSRDs) are non-proprietary devices whose primary function is to remove gross solids (litter and vegetative material) from storm water runoff. Currently, there are three configurations of LRDs:

Configuration #1. This LR GSRD utilizes a modular well casing with 5 mm x 64 mm louvers to serve as the screen. The LR GSRD is placed on a 2-percent slope. See picture to the right.

Configuration #2. This LR GSRD utilizes a modular 5 mm x 5 mm rigid mesh screen housing. Inside the rigid mesh screen are nylon mesh bags (5 mm mesh) that capture gross solids. Configuration #2 is not pictured.

Configuration #3. This LR GSRD is identical Configuration #1 except that it has been placed on an approximately 40-percent slope. Configuration #3 is not pictured.

Constituent Removal:

Constituent Group	***Removal Efficiency***	***Level-of-Confidence***
Total Suspended Solids		
Nutrients		
Pesticides		
Total Metals		
Dissolved Metals		
Microbiological		
Litter	●	●
BOD		
TDS		

Notes:

- Litter and vegetative material are the target constituents for the device.
- No long-term water quality monitoring studies have been conducted to evaluate treatment effectiveness of the linear radial GSRDs on other water quality constituents.

Key Design Parameters:

1. Annual Estimated Gross Solids Loading Rate
2. Caltrans designers should follow the Project Planning and Design Guide
3. Linear radial GSRDs should be sized to hold gross solids to be deposited during a 1-year period and pass the design flow (e.g., 25-year flow).

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	***Level-of-Confidence***
	●

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: Periodic inspections required to ensure that the device is functional. Routine maintenance may include sediment/debris removal.
- *Nuisance Control:* Design should eliminate standing water that may provide breeding habitat for vectors.
- *Specialty Training/Equipment:* Vactor equipment recommended for cleaning.

Project Development:

- *Right-of-Way Requirements*: Small footprint.
- *Siting Constraints*: Must provide sufficient area to accommodate the length of linear radial GSRD required. Low head requirement.
- *Construction:* Traffic control may be required for retrofits due to close proximity to roadway.

Advantages:

- The linear radial GSRDs are a "small footprint device" that can be installed in existing right of way.
- Based on pilot studies, the devices remove nearly all the gross solids from storm water runoff with minimal maintenance requirements.

Constraints:

- Surface area requirement.

Sources:

- Roscoe Moss Company, www.roscoemoss.com/gsrd.html

Literature Sources of Performance Demonstrations:

- California Department of Transportation, Phase I Gross Solids Removal Devices Pilot Study: 2000-2002, Final Report. CSTW-RT-03-072.31.22

Description:

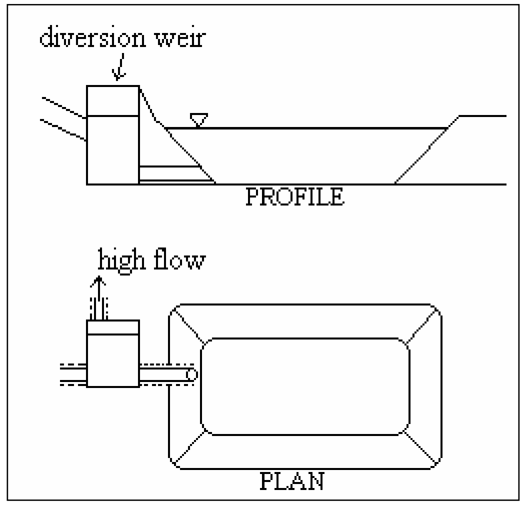
Infiltration basins are depressions used to detain storm water runoff until it percolates into the groundwater table. They are designed “off-line” where flow is diverted until the basin reaches capacity (typically the design water quality volume). Pollutant removal occurs through the infiltration of runoff and the adsorption of pollutants to the soil and vegetation. To prevent vector problems due to standing water, infiltration basins are designed to infiltrate within 72 hours. There needs to be sufficient space between the basin invert and the seasonally high groundwater elevation to allow infiltration to occur.

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	●	◒
Nutrients	●	◒
Pesticides	●	◒
Total Metals	●	◒
Dissolved Metals	●	◒
Microbiological	●	◒
Litter	●	◒
BOD	●	◒
TDS	●	◒

Notes:

- Performance is assumed based on infiltration.



Key Design Parameters:

1. Locate, size, and shape the infiltration basin relative to topography
2. Pretreatment may be required if high sediment loads are expected
3. Include energy dissipaters at the inlet that will not promote vector problems (i.e. standing water)
4. Include access ramps and turnarounds for ease of maintenance
5. Caltrans designers should follow the Project Planning and Design Guide

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
	●

Two infiltration basins were constructed for retrofit and monitored. An average of 106 field hours/year was spent on O&M for each infiltration basin. These hours do not include vector control hours.

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

● High ◒ Medium ○ Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: Include regular inspections for standing water, vegetation height, debris and sediment accumulation, and slope stability.
- *Nuisance Control:* None identified, if water infiltrates within 72 hours.
- *Specialty Training/Equipment:* Avoid rubber tired vehicles in basin. Tracked equipment recommended for major maintenance.

Project Development:

- *Right-of-Way Requirements*: Space requirements are relatively high for infiltration basins.
- *Siting Constraints*: Infiltration basins can only be placed in areas where soil type is RCS type "A", "B", or "C". Soil shall not have more than 30 percent clay or more than 40 percent clay and silt combined. Minimum infiltration rate of 12 mm/hr is preferred. Distance between the groundwater elevation and the basin invert should be at least 1.2 meters, but 3 meters is preferable
- *Construction:* Before construction begins, ensure that sufficient borings are conducted to determine the presence of any subsurface unsuitable materials, undocumented buried material and utility lines. Stabilize area draining into the facility. If possible, place a diversion berm to prevent sediment from entering the facility. Build the basin without driving heavy equipment over the infiltration surface. Any equipment should have "low pressure" treads or tires. After final grading, deeply till the infiltration surface. Use appropriate erosion control seed mix.

Advantages:

- Due to the infiltration of the entire water quality volume, the constituent removal is considered 100%.

Constraints:

- Infiltration basins are sited in areas with the appropriate soil type/content, and distance from the groundwater elevation to facilitate infiltration.
- Infiltration basins should not be sited in areas where groundwater contamination is a concern.

Sources:

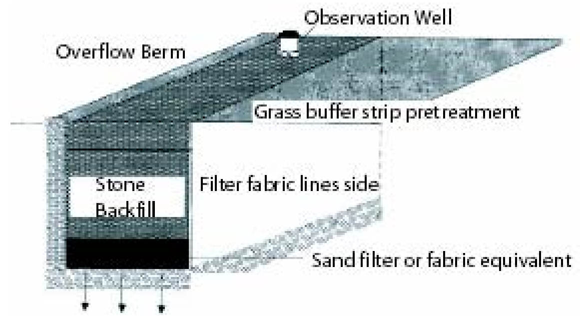
- Dr. M. Barrett, University of Texas at Austin
- www.epa.gov/owm/mtb/sandfltr.pdf
- www.enviro.nfesc.navy.mil/p2library/cgi-bin/p2h_datasheet.cfm?itemID=230
- www.webcentral.bts.gov/ntl/DOCS/RUNOFF.html

Literature Sources of Performance Demonstrations:

- Caltrans, 2004. BMP Retrofit Pilot Program Final Report, CTSW-RT-01-050 available at www.dot.ca.gov/hq/env/stormwater
- Glick, Roger Chang, George C., and Barrett, Michael E., Monitoring and evaluation of stormwater quality control basins, in Watershed Management: Moving from Theory to Implementation, Denver, CO, May 3-6, 1998, pp. 369-376.
- The US Department of Transportation "Evaluation and Management of Highway Runoff Water Quality" Young et al. 1996 – contains info. on siting, design, and performance.
- K. Hilding. 1993 *A Study of Infiltration Basins in the Puget Sound Region*. ME Thesis. Dept. of Biological and Agricultural Engineering. Univ. of California, Davis.
- J. Gaus. 1993. *Soils of Infiltration Basins in the Puget Sound Region*: Trace Metals and Concentrations. ME thesis. Univ. of Washington.

Description:

An infiltration trench is typically a long and narrow excavation that is lined with filter fabric and backfilled with stone aggregate or gravel to form an underground basin. Runoff is diverted to the trench and infiltrates into the soil. Pollutants are filtered out of the runoff as it infiltrates the surrounding soils. Infiltration trenches are best sited in areas where soils meet the minimum infiltration rate. Regulators may caution against installation in highly industrial areas or areas where highly soluble constituents may be discharged to the trench.



Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	●	◒
Nutrients	●	◒
Pesticides	●	◒
Total Metals	●	◒
Dissolved Metals	●	◒
Microbiological	●	◒
Litter	●	◒
BOD	●	◒
TDS	●	◒

Notes:

- Constituent removal is considered 100% for the design water quality volume since the entire water quality volume is infiltrated and no water is discharged to surface waters. However, groundwater contamination can occur from soluble constituents that may not be retained in the soil matrix.
- Two infiltration trenches were sited, constructed, and monitored as part of the Caltrans BMP retrofit pilot program.

Key Design Parameters:

1. An infiltration rate of at least 14 mm/hr is desired. This infiltration rate would be found in soils with low silt and clay content. The groundwater separation should be a minimum of 3.0 m. Trenches should be designed to drain within 72 hours to prevent potential vector problems. A large bottom surface area is desired because it allows an increased infiltration rate and reduces the amount of clogging. Use of a biofiltration strip as pretreatment to remove floatables and sediment from runoff before entering the infiltration trench is recommended. The trench volume should be determined by assuming the Water Quality Volume (WQV) will fill the void space based on the computed porosity of the rock matrix. Backfill material for the trench should be 1-in to 3-in rock or equivalent locally available material.

2. Caltrans designers should follow the Project Planning and Design Guide.

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
⊞	●

Costs include the construction of a pretreatment biofiltration strip. Cost information is from Caltrans Cost Summary report CTSW-RT-01-003. An average of 13 field hours were spent operating and maintaining each infiltration trench in the 1999/2000 season.

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: Trash and debris should be removed from the site on a regular basis. Sediment accumulation should be inspected and, if visible on top of the trench, the top layer of trench, silt, filter fabric, and stone should be removed. The stone should be washed and fabric and stone reinstalled in trench.
- *Nuisance Control*: None identified, if water infiltrates within 72 hours.
- *Specialty Training/Equipment:* For routine maintenance, requires staff and equipment to remove sediment and debris.

Project Development:

- *Right-of-Way Requirements*: Space requirements are relatively high for infiltration trenches.
- *Siting Constraints*: Infiltration trenches should not be sited within 30 meters of building or bridge foundations. Infiltration trenches sited within 30 meters would require detailed site structural and geotechnical investigation. Infiltration trenches are suitable for drainage areas up to 4 hectares. Trenches work best at sites with a upgradient drainage area slope of less then 5%. Trenches should be sited where infiltration rates are at least 14mm/hr and there is at least 3.0 meters separation between trench invert and the groundwater. Trenches are not recommended in industrial land use areas or in locations were soluble constituents may impact ground water quality.
- *Construction:* During excavation for trench construction, light equipment should be used to avoid compaction of the soil. Field conditions, such as structurally unsuitable soils, and existing utilities lines may be encountered, and detailed geotechnical investigation prior to construction is recommended. Retrofit of infiltration trenches at maintenance stations impacts the operation of the facility during construction. A geotechnical engineer must be present during the excavation to ensure that there are no anomalies encountered in the soil lithology that would inhibit infiltration. During design, sufficient borings are required to determine the presence of unsuitable materials. Stabilize the entire area draining to the facility before construction begins. If impossible, place a diversion berm around the perimeter of the infiltration site to prevent sediment entrance during construction. Stabilize the entire contributing drainage area before allowing any runoff to enter once construction is complete.

Advantages:

- Due to the infiltration of the entire water quality volume, the constituent removal is considered 100%. Infiltration trenches take up little land area and are not highly visible.

Constraints:

- Infiltration trenches must have soils with a high enough permeability rate and suitable groundwater separation.
- If not properly maintained they will prematurely clog.
- Pretreatment is required to reduce the amount of influent sediment.
- Major maintenance (removal and replacement of the rock matrix) is relatively costly.

Sources:

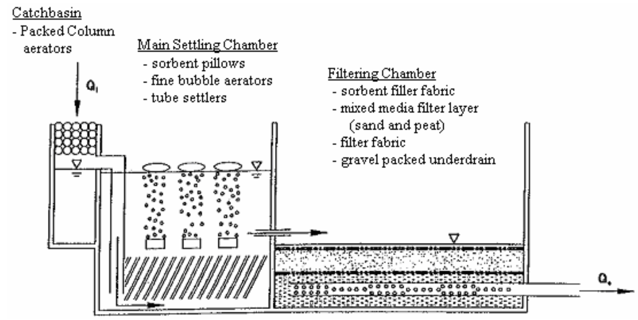
- http://www.epa.gov/owm/mtb/infltrenc.pdf
- http://h2osparc.wq.ncsu.edu/river/industrial/industri.html#cm
- http://www.stormwater-resources.com/Library/116BBMP%20Guide.PDF

Literature Sources of Performance Demonstrations:

- Caltrans, 2004. BMP Retrofit Pilot Program Final Report, CTSW-RT-01-050 available at www.dot.ca.gov/hq/env/stormwater
- Schueler, T.R., 1987. Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs, Department of Environmental Programs, Metropolitan Washington Council of Governments, Washington, DC.
- Young, G.K., et al. 1996, Evaluation and Management of Highway Runoff Water Quality, Publication No. FHWA-PD-96-032, U.S. Department of Transportation, Federal Highway Administration, Office of Environment and Planning.

Description:

Multi-Chambered Treatment Trains (MCTTs) use three treatment mechanisms. The first chamber is a catch basin used to remove large, grit-sized material. The second chamber is a settling chamber that removes settleable solids with plate separators and oil and grease with sorbent pads. The third chamber is a sand/peat filter. These devices were originally designed to reduce toxicity in the runoff from critical storm water source areas and can be implemented where toxicity in runoff is an identified problem.



Key Design Parameters:

1. MCTTs are designed as 3-stage devices. The first stage consists of a catch basin with a sump and packed column aerators. The volume of the catch basin is determined based on the desired maintenance frequency of the sump with the variables of discharge and influent TSS.
   The second stage is the main settling chamber. The design volume is highly dependent on local rainfall characteristics. Gravity draining can be used to transfer runoff from the main settling chamber to the filtration chamber.
   The filtration chamber consists of 450-mm filter media layer consisting of a 50/50 mixture of sand and peat moss. The layer is separated from a gravel-packed underdrain by a layer of filter fabric. The filter area is determined from the recommended solids loading rate of the peat/sand mixture of 5000 g TSS/m2/year. Gravity draining can be used to return the filtered runoff to the drainage system.
2. Caltrans designers should follow the Project Planning and Design Guide.

Constituent Removal:

Constituent Group	***Removal Efficiency***	***Level-of-Confidence***
Total Suspended Solids	◒	●
Nutrients	○	◒
Pesticides	○	○
Total Metals	◒	●
Dissolved Metals	○	◒
Microbiological	○	○
Litter	●	●
BOD	○	○
TDS	○	○

Notes:

- Nitrate concentrations increase by 62%.
- High dissolved Zn removal.
- Two MCTTs were sited, constructed, and monitored as part of the Caltrans' BMP retrofit pilot program. An analysis of the influent and effluent water quality data for the filters indicated that there was no significant difference among the sites for the constituents monitored; therefore, the data for all sites were treated as if they came from a single site.

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	***Level-of-Confidence***
▝	●

Information obtained from Caltrans Cost Summary report CTSW-RT-01-003 An average of 120 field hours per year were spent on operation and maintenance of each MCTT during the Caltrans BMP retrofit pilot program.

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: Periodic cleaning and replacement of media.
- *Nuisance Control:* The MCTTs maintain a permanent pool of water below the tops of the tube settlers; this pool of water provides a breeding site for mosquitoes.
- *Specialty Training/Equipment:* Training required for media replacement.

Project Development:

- *Right-of-Way Requirements*: Space requirements are relatively high for MCTTs.
- *Siting Constraints*: MCTTs should be sited where there is a small, impervious contributing watershed. They should not be sited where runoff from bare soil or construction activities will be allowed to enter the filter. MCTTs should be sited where enough vertical clearance (head) is provided, about 2 meters.
- *Design Complexity*: The sand is a special gradation requiring additional time and expense.
- *Construction:* Material availability for the filter, excavation for the device/unknown field conditions, and interface with existing activities at the site are the primary issues to be addressed in the construction of MCTTs. The tube settler system is a special-order item with a significant lead-time.

Advantages:

- The MCTTs have constituent removal for suspended solids, metals, and bacteria similar to that for an Austin Sand Filter. They can provide consistent pollutant removal when properly maintained. The target area for use of MCTTs are vehicle service facilities, parking areas, paved storage areas, and fueling stations with drainage areas up to 1 hectare.

Constraints:

- MCTTs are significantly more expensive to construct than gravity-drained Austin Sand Filters, which provide comparable performance.
- A permanent pool of water is maintained in the MCTT, which increases vector concerns.
- The presence of tube settlers in the sedimentation basin impedes maintenance activities.

Sources:

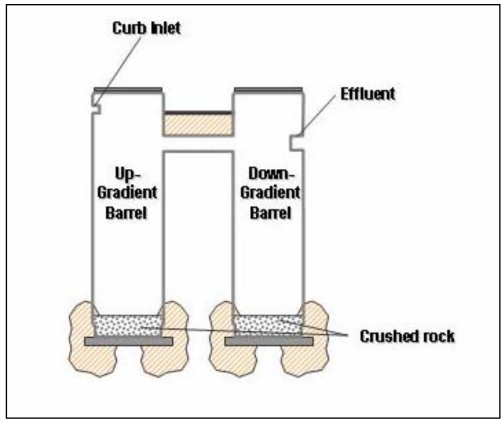
- None.

Literature Sources of Performance Demonstrations:

- Caltrans, 2004. BMP Retrofit Pilot Program Final Report, CTSW-RT-01-050 available at www.dot.ca.gov/hq/env/stormwater
- Design guidelines for MCTTs and performance evaluation are presented in the report entitled, Stormwater Treatment at Critical Areas, Volume 1: The Multi-Chambered Treatment Train (MCTT), by Robert Pitt, et. al., March 1999. EPA/600/R-99/017. http://lakes.chebucto.org/SWT/epa99017.PDF
- R. A. Claytor and T. Schueler. 1996. *Design of Stormwater Filtering Systems*. Center for Watershed Protection. Prepared for the Chesapeake Research Consortium. 250pp.
- S. S. Corsi Greb and R. Waschbusch. 1998. *Evaluation of Stormceptor and Multi-Chamber Treatment Train as Urban Retrofit Strategies*. Presented at Retrofit Opportunities for Water Resource Protection in Urban Environments. Westin Hotel. Chicago, IL. 10-Feb-98.
- R. M. Pitt. 1996. *The Control of Toxicants at Critical Source Areas*. The University of Alabama at Birmingham. 22pp. Paper presented at the ASCE/Engineering Foundation Conference, Snowbird, UT. Aug-96.
- T. Schueler. 1994 "Hydrocarbon Hotspots in the Urban Landscape-Can They Be Controlled?" *Watershed Protection Techniques* 1(1): 1-5.

Description:

Traction sand traps are depressions in the ground that temporarily detain runoff and allow traction sand to settle out, which was previously applied to snowy or icy roads.



Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	○	●
Nutrients	○	◒
Pesticides	○	○
Total Metals	○	◒
Dissolved Metals	○	◒
Microbiological	○	○
Litter	○	○
BOD	○	○
TDS	○	○

Notes:

- Two sand traps were monitored as part of the Tahoe Sand Trap Effectiveness Study
- One of two locations demonstrated statistically significant removal of two of three metals.

Key Design Parameters:

1. Locate, size, and shape the traction sand trap relative to topography and in areas with heavy snow or ice, or anywhere where traction sand is applied.
2. Caltrans designers should follow the Project Planning and Design Guide.

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
▖	●

Two traction sand traps were monitored as part of the Tahoe Sand Trap Effectiveness Study (CTSW-RT-03-054.36.02)

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- Requirements: Annual maintenance includes vactoring out the traction sand traps.
- Nuisance Control: If standing water persists for greater than 72 hours, vector control may be required during the warmer months. However, during the winter season, vector control may not be required since standing water in the sand traps has likely frozen.
- Specialty Training/Equipment: Vactor equipment recommended for cleaning.

Project Development:

- Right-of-Way Requirements: Space requirements are relatively low for traction sand traps.
- Siting Constraints: Low head requirement.
- Construction: No special requirements identified.

Advantages:

- Sand traps require very little land space.
- Requires very little or no hydraulic head to operate.

Constraints:

- Minimal pollutant reduction

Sources:

- www.epa.gov/owm/mtb/sandfltr.pdf
-
- www.enviro.nfesc.navy.mil/p2library/cgi-bin/p2h_datasheet.cfm?itemID=230
- www.webcentral.bts.gov/ntl/DOCS/RUNOFF.html

Literature Sources of Performance Demonstrations:

- Caltrans, 2003. Caltrans Tahoe Highway Runoff Characterization and Sand Trap Effectiveness Studies. CTSW-RT-03-054.36.02 www.dot.ca.gov/hq/env/stormwater
- The US Department of Transportation “Evaluation and Management of Highway Runoff Water Quality” Young et al. 1996 – contains info. on siting, design, and performance.

Description:

A wet basin holds a permanent pool of water designed to detain and treat a runoff water quality volume. The basins support plant species, which may provide constituent removal by biological processes. In addition, the vegetation may help reduce erosion of the sides slopes and help trap sediments. Sedimentation processes also occur in the basin. The basins are usually deep enough to prevent resuspension of particles. Wet basins should be sited where a permanent pool of water can be maintained from a dry weather flow source.

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	●	●
Nutrients	◒	◒
Pesticides	○	○
Total Metals	●	●
Dissolved Metals	◒	●
Microbiological	●	◒
Litter	●	○
BOD	○	○
TDS	●	○

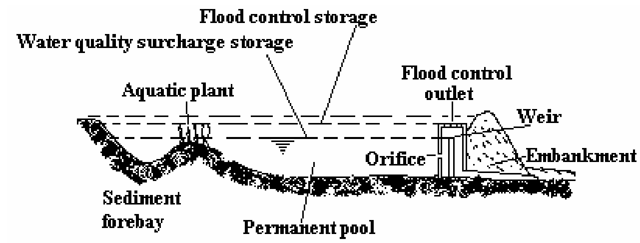
Notes:

- Nitrate concentrations from discharges after storm events was 132% greater than stormwater influent, however dry weather flow reductions caused a net annual removal of total nitrogen.
- 94% removal efficiency for dissolved Pb.
- A wet basin was sited as part of the Caltrans BMP Retrofit Pilot Program. Constituent reduction found during this study is comparable to those reductions found in other studies.
- Low phosphorus removal.

Key Design Parameters:

1. Wet basins should be sized to hold the permanent pool and the water quality volume required. In addition, a 10% increase should be provided for solid deposition storage. The water quality volume above the permanent pool should drain within 24-48 hours. The basin should have a minimum length to width ratio of 1:1 and a preferred ratio of 3:1. The maximum depth of 2.4 meters and average depth of 1-2 meters. The volume of the permanent pool should be one to three times the water quality volume. Basin side slopes should be 3:1 or flatter.
   Wet basin should include a sediment forebay and a main pool. The sediment forebay should be sized to be 15-25% of the permanent pool volume and at least 1 meter deep, separated from the main pool by a earthen berm, gabion, or loose riprap wall. The berm should have a 1.5-meter top width and an elevation 1-foot lower than the design water surface. Vegetation should be planted around the perimeter of the basin. For ponds designed as offline facilities, a splitter structure should be used.

2. Caltrans designers should follow the Project Planning and Design Guide.



(modified from Urbonas And STAHRE, 1993)

Cost Effectiveness Relative to Detention Basins:

Cost Effectiveness	*Level-of-Confidence*
	●

Cost information obtained from Caltrans Cost Summary report CTSW-RT-01-003. An average of 500 field hours per year was spent on operation and maintenance of the La Costa wet basin during the Caltrans BMP retrofit pilot program. This included 440 hours spent on harvesting of the vegetation and other vegetation management.

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness Relative to Detention Basins

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal Efficiency and Level-of-Confidence

Issues and Concerns:

Maintenance:

- *Requirements*: Inspections should be conducted to ensure that the structure operates as intended. The embankment should be checked for subsidence, erosion, leakage, cracking, and tree growth. Debris and litter should be removed from the basin to prevent clogging of the outlet. Sediment accumulation in the basin will reduce the storage capacity and removal performance of the basin. Sediment should be removed when it accumulates to 10% of the basin volume. Wet basin plant material should be harvested on an annual basis to maintain efficiency of mosquito fish.
- *Nuisance Control:* Wet basins provide a pool of water and dense vegetation that is ideal for mosquito breeding. The basins should be stocked with mosquito fish to control the population.
- *Specialty Training/Equipment:* Mechanical removal of vegetation was unsuccessful so hand removal with machetes were used.

Project Development:

- *Right-of-Way Requirements*: Space requirements are high for wet basins.
- *Siting Constraints*: Wet basins are best sited for highways in residential or commercial areas with a combined drainage area greater than 8 ha. Significant off-site drainage with year round base flow is needed. A wet basin usually has an area of 1 to 3 percent of the contributing drainage area. Since the basin required a permanent pool of water, the soil should have a low infiltration rate or be lined with a clay of geotextile liner. Wet basins should be sited where a permanent pool of water can be maintained from a dry weather flow source.
- *Construction:* Excavated soil surface should be suitable to support plant life. If a pond liner is used, it must be carefully constructed to avoid punctures.

Advantages:

- Wet basins have good removal efficiencies providing storm water quality benefits.
- They can also have recreational and aesthetic benefits.

Constraints:

- Wet basins must be properly maintained to prevent stratification and anoxic conditions, which would allow resuspension of solids and release of nutrients and metals.
- A permanent pool of water must be maintained and therefore may have limitations on siting.
- There are potential problems associated with mosquitoes and the device may become a regulated wetland if not consistently maintained per an established schedule.
- They require more area than an extended detention basin.

Sources:

- www.epa.gov/owm/mtb/
  wetdtnpn.pdf
- www.bae.ncsu.edu/programs/extension/wqg/

Literature Sources of Performance Demonstrations:

- Caltrans, 2004. BMP Retrofit Pilot Program Final Report, CTSW-RT-01-050 available at www.dot.ca.gov/hq/env/stormwater
- Information on design and performance of wet basins can be found in the following references:
- King County, 1996, Surface Water Design Manual (Draft), King County Surface Water Management Division, Washington.
- Schueler, T.R., 1987, Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs, Department of Environmental Programs, Metropolitan Washington Council of Governments, Washington, DC.
- Urbonas, B.R., et al., 1992, Urban Storm Drainage Criteria Manual, Volume 3 – Best Management Practices, Stormwater Quality, Urban Drainage and Flood Control District, Denver, CO.