Volume

1

BAYSAVER TECHNOLOGIES, INC.

BayFilter™ System

Technical and Design Manual

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BAYFILTER™ SYSTEM

Technical and Design Manual

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Introduction

Founded in 1997, BaySaver Technologies, Inc. is a manufacturer of stormwater treatment technologies. BayFilter™ is a stormwater filtration device designed to remove fine sediments, heavy metals, and phosphorus from stormwater runoff.

BayFilter™ relies on a spiral wound media filter cartridge with approximately 43 square feet of active filtration area. The filter cartridges are housed in a concrete structure that evenly distributes the flow between cartridges. System design is offline with an external bypass that routes high intensity storms away from the system to prevent sediment resuspension. Flow through the filter cartridges is gravity driven and self-regulating, which makes the BayFilter™ system a low maintenance, high performance stormwater treatment technology.

The BayFilter™ system has been extensively tested, and has consistently shown more than 80% removal of suspended sediment from influent water. The system also demonstrated the capability to remove more than 50% of the total phosphorus influent load, including a portion of the dissolved phosphorus.

This manual provides detailed technical information on the BayFilter™ system including its capabilities and limitations. The manual describes the steps involved in designing a BayFilter™ system as well as the installation and maintenance requirements of the system.

BaySaver Technologies is a complete stormwater solutions provider. We are always willing to assist design professionals to achieve the most efficient, economical systems for their clients and projects. Please call BaySaver Technologies Inc. Engineering Department at 1.800.229.7283 for assistance.

Principles of Operation

The BayFilter™ system removes contaminants from stormwater runoff via media filtration. This Technical and Design Manual describes the principles by which the BayFilter™ system works to improve the quality of the environment throughout the United States.

Media Filtration

Media filtration has long been used in drinking water and wastewater treatment processes. This technology has proven effective at removing sediments, nutrients, heavy metals, and a wide variety of organic contaminants. The target pollutants, hydraulic retention time, filter media, pretreatment, and flow rate all affect the removal efficiency of the filter.

Mechanisms of Removal

The BayFilter™ removes pollutants from water by two mechanisms: 1) interception/attachment and 2) adsorption. Interception occurs when a pollutant becomes trapped within the filter media. A sediment particle, for example, may be carried into the filter media by the water and become stuck in the interstices of the media. Such a particle will typically remain trapped within the media until the media is removed or the filter is backwashed.

Attachment occurs when pollutants bind themselves to the surface of the filter media, and this happens primarily through adsorption. Adsorption is a surface process by which dissolved ions are removed from a solution and chemically bind themselves to the surface of the media. This occurs when the surface of the filter media particle contains sites that are chemically attractive to the dissolved ions. The BayFilter™ system uses a proprietary media containing activated alumina to enhance adsorption of anions such as phosphates.

The BayFilter™ Cartridge

The main building block of the BayFilter™ stormwater filtration system is the BayFilter™ cartridge (BFC), shown in Figure 1. The BFCs are housed in a structure which may be a vault, manhole or other structure. This structure contains the inlet and outlet pipes as well as an internal manifold that delivers treated water to the outlet of the BayFilter™ system.

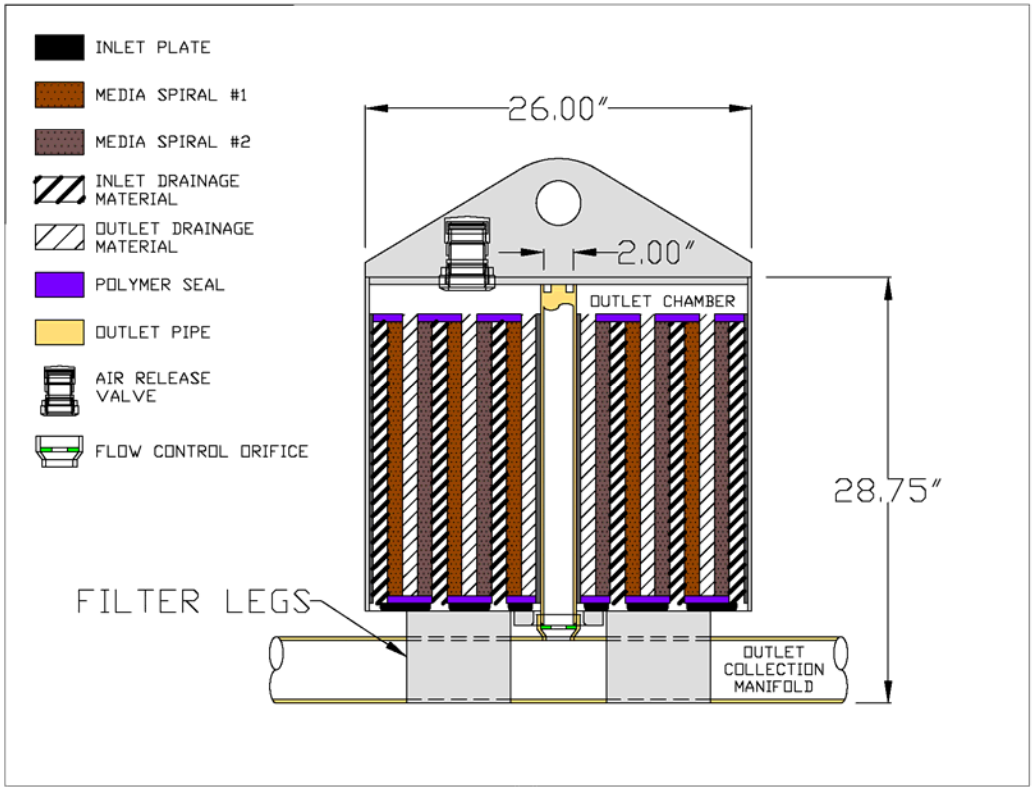


Figure 1: BayFilter™ Cartridge

Stormwater runoff enters the manhole or concrete structure via an inlet pipe and begins to fill the structure. An energy dissipator at the vault inlet slows the influent water and allows coarse sediments to settle within the structure. When the water surface elevation in the vault/manhole reaches operating level, water flows through the BFC driven by a hydrostatic head. Within the BFC, the water flows through a proprietary filter media and drains via a vertical pipe. The vertical drain is connected to the underdrain system which conveys filtered water to the outfall.

During a typical storm event, the BayFilter™ system has four cycles:

1. Vault fill and air release;

2. Uniform bed load hydrodynamic filtration;

3. Uniform bed load siphon filtration; and

4. Siphon break and hydrodynamic backwash.

A detailed depiction of the BFC operating sequence is given in Appendix A.

The Drain Down Cartridge Filter

Each BayFilter™ Stormwater Treatment System will include a number of standard BFCs and one or more drain down filter cartridges depending on site conditions. The drain down cartridge which has a flow capacity of 1 gpm, will allow the manhole/vault to empty after the siphon has broken and the standard BFCs are no longer operating. The drain down filter cartridge prevents the system from retaining standing water between storm events, thereby reducing the chance of mosquitoes or other disease vectors breeding within the system and preventing the system from becoming anaerobic during dry periods. This cartridge also uses the same media as the BFC and has a removal efficiency in excess of 90 percent.

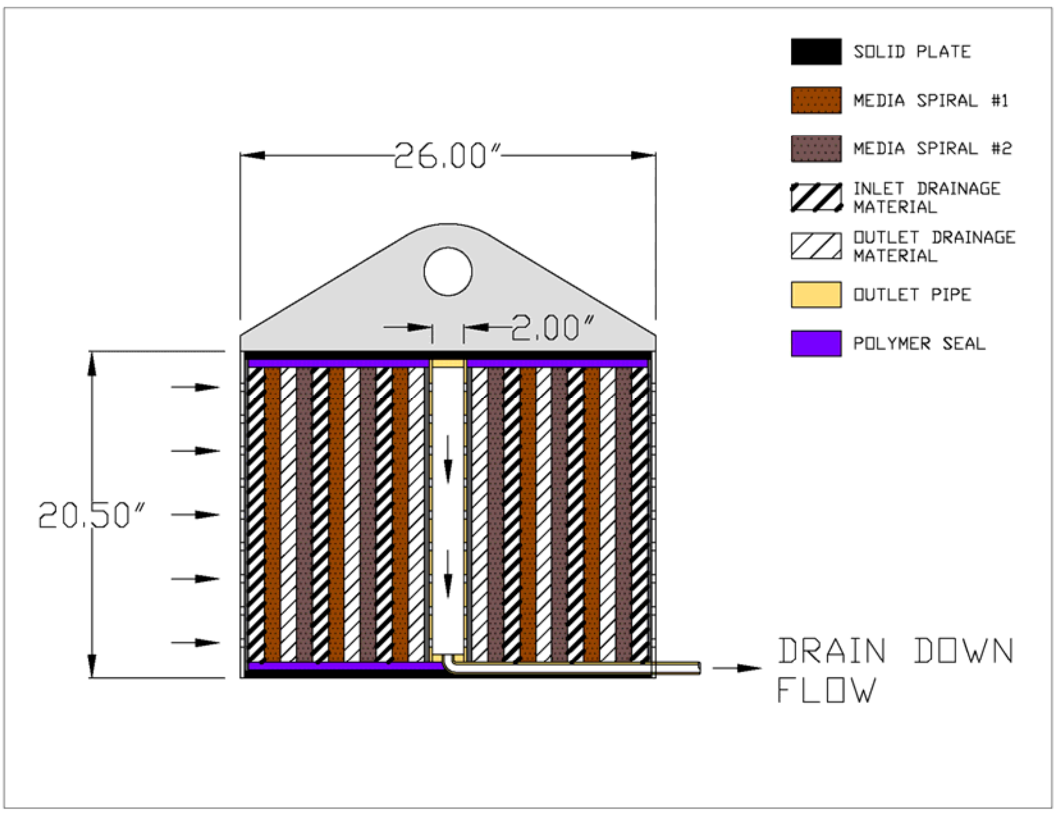


Figure 2: Drain Down Cartridge

Performance Characteristics

The BayFilter™ has been extensively tested in the laboratory. This testing has been carried out using SIL-CO-SIL 106 as a sediment source. SIL-CO-SIL 106 is a silica product containing approximately 90% fine sediments (d_{50} = 23 microns), and is widely accepted as a sediment source for stormwater simulations by regulatory agencies such as the Washington State Department of Ecology (TAPE) program, New Jersey Department of Environmental Protection (TARP), as well as other leading agencies.

The BFC needs only 28" of depth of water to begin full flow operation. Once the full flow operation has been achieved, the BFC will operate to a depth of 6" at which time the siphon will break and the system will backwash. At this point the only flow is from the drain down cartridge which will drain the vault to a depth below 1".

Each BFC has a maximum nominal flow of 30 gpm. At this flow, each cartridge can treat 150 lbs of the total sediment load before maintenance. In addition, through the use of different size flow control orifice(s), the BFC flow is regulated. As the flow is lowered, the treated sediment load increases. For example, when the flow is lowered to 15 gpm, the cartridge is able to treat 300 lbs of the total sediment load before maintenance.

A chart of the flows and total sediment loads can be found on Table 1.

Flow Through (Full Flow) Filtration Systems

These systems are used in situations where a certain flow rate must be treated. Usually these are smaller projects where extended detention is either not feasible or not required. The treatment flow rate must be determined by the engineer. From this, the minimum number of BFCs is very simple to determine. Usually full flow systems require a large number of cartridges and because of this the maintenance cycles may be longer but more costly. The life of the cartridges can further be extended through the use of pretreatment with a BaySeparator™.

For these systems, use 30 gpm design flow per BFC for treated sediment loads up to 150 lbs. To use higher cartridge sediment loads of up to 300 lbs per BFC, see Table 1 for the appropriate flow-load relationships. A minimum head of 40" (for full flow) is required, as measured from the floor, to achieve the 30 gpm and the target sediment removal. Higher sediment loads can be achieved by including pretreatment of the stormwater. Consult BaySaver Technologies, Inc. Engineering Department for more information.

Post Extended Detention Filtration Systems

These systems are used as a final measure of water treatment after it has been detained. In this configuration the BayFilter™ system acts also as the controlled release mechanism for the extended detention system.

Since these systems usually release and treat the water at relatively slow rates, the most common configuration for the BayFilter™ system is to control the flow below 15 gpm, which accommodates 300 lbs per cartridge of treated sediment load. In many cases to accommodate the total annual sediment load of the system, in a post extended detention application, the BFC flow rate will be between 5 and 10 gpm. The sediment capacity will usually be the limiting factor in these applications.

As can be seen from Table 1, the design flow rate is determined by the target amount of solids to be removed. For example, if the designer's goal is to treat a cartridge sediment load of 150 lbs at 80% efficiency, the design flow rate would be approximately 30 gpm (0.067 CFS) per BFC. In another case, if the engineer is targeting a much heavier cartridge sediment load of 250 pounds; the design flow rate per BFC would then be 20 gpm (0.045 CFS). The different sediment removal/design flow rate relationships are achieved with minimum total heads of 40 inches as measured from the floor level, where the BFCs are installed (shown in Table 1). Consult BaySaver Technologies, Inc. Engineering Department for more information.

At each design flow rate the BayFilter™ cartridge will achieve a suspended sediment removal efficiency of over 80% at the rated flow rate. This 80% sediment removal efficiency is based on laboratory testing using the SIL-CO-SIL 106 sediment gradation.

The BayFilter™ cartridge has the capability to remove 50% of the total phosphorus load since most of the total phosphorus is typically found in particulate form. Consult the BaySaver Technologies, Inc. Engineering Department for project specific information and details regarding phosphorus removal requirements since they may vary considerably from site-to-site.

Table 1
Design Guidelines for BayFilter™ Cartridges
BaySaver Technologies, Inc.

Design Flow per BFC- gpm Nominal	Treated Sediment Load for 80% Sediment Removal - Lbs	Total System Head at Design Flow - Inches
30	150	40
23	200	40
20	250	40
15	300	40

(*) Sediment with d_{50} = 23 microns

Other key operating parameters of BayFilter™ systems include:

1. Minimum head for the BFC to begin full flow is 28";

2. Minimum head for the BFC to operate after full flow is 6" (below the head the siphon will be broken);

3. Minimum water level for DDC operation is approximately 1"; and

4. Full flow head is at 40".

Chapter 2

Design Guidelines for the BayFilter™ System

Designing a BayFilter™ system is done in four phases: (1) determine the treatment train design; (2) locate the system on the site and incorporate it into the plans; (3) determine the number of cartridges necessary; and (4) select a system configuration. It is important to realize that the design process can be iterative until the desired design parameters are satisfied. Again, it is important to note that the BayFilter™ systems are designed offline. This section details the design process and provides examples for each of the three steps. During the design process, the engineer must consider factors in addition to regulatory requirements. These include:

- Site specific constraints
- Proposed system location
- System configuration (flow through or extended detention)
- Pretreatment
- Efficiency requirements
- Pollutant loading (sediment load)
- Treatment flow rates and hydraulics
- Maintenance intervals

BayFilter™ Treatment Train Design

On-line and Off-line Systems

BayFilter™ systems are usually designed to treat moderate to low flow rates. In the vast majority of applications, the peak design flow through the storm drain system will be significantly greater than the treatment design flow through BayFilter™. Because of this difference, a bypass structure is required for most BayFilter™

installations. Therefore, BayFilter™ systems are installed offline, utilizing an external bypass to route high flows around the system.

A schematic of an offline BayFilter™ system is shown in Figure 3 below. The bypass structure diverts low flows to the BayFilter™ system and allows high flows to pass to a separate outfall. The bypass structure will feature flow controls designed by an engineer to ensure that the required treatment flows are sent to the BayFilter™. The two effluent streams (the treated effluent from the BayFilter™ and the high intensity bypass) may be combined into a single stream or discharged to separate outfalls. These configurations typically involve higher flow per cartridge, but reduced treated sediment load per cartridge. These configurations are, however, usually limited more by flow sediment capacity.

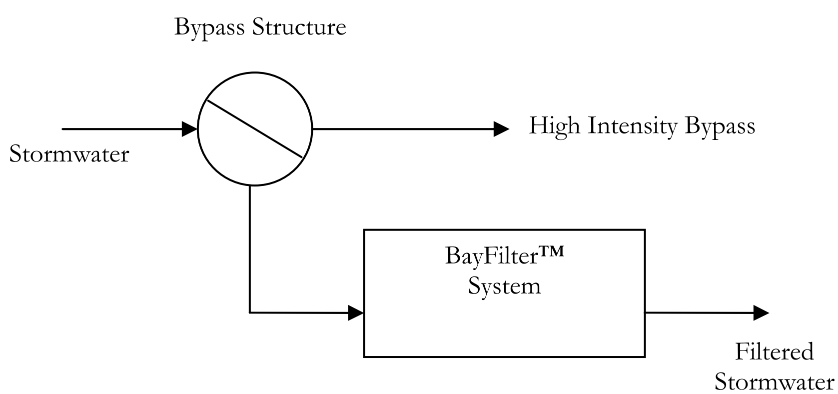


Figure 3: Offline BaySaver Technologies, Inc. System

In BayFilter™ installations sediment will accumulate in the vault as well as in the filter cartridges. In offline installations high intensity flows are routed away from the vault minimizing the risk of resuspending this accumulated sediment. In online applications it is possible for high flows to mobilize and release this sediment.

Pretreatment

The BayFilter™ system is designed to remove a minimum of 80% of suspended sediments and 50% of the total phosphorus load. If the anticipated sediment load is particularly heavy or if there will be a significant oil load the system may require pretreatment. Pretreatment may also be required by local regulations.

Pretreatment systems will remove a portion of the influent pollutant load. BaySaver Technologies, Inc. BaySeparator™ system is an ideal hydrodynamic separator that removes sediments and floatables from stormwater runoff.

Figure 4 shows a schematic of a typical BayFilter™ installation with pretreatment. Note that the pretreatment structure is downstream from the bypass. The system will work as long as 28" of head is achieved to activate the cartridge flow and will continue to work until it reaches the siphon break level (6"). Consult BaySaver Technologies, Inc. Engineering Department for verification based on your particular site conditions.

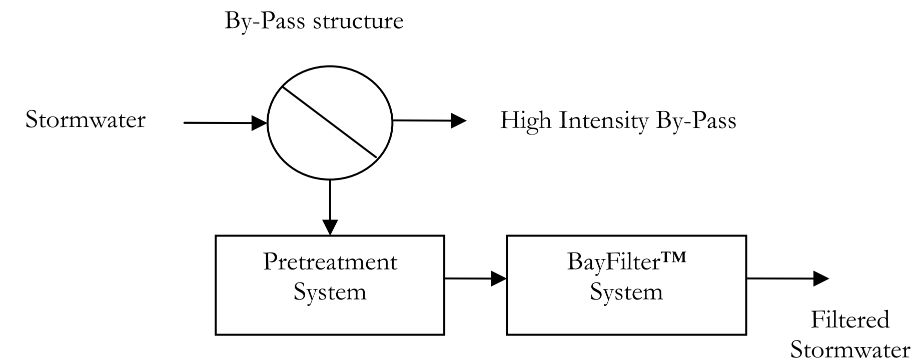


Figure 4: Off line BayFilter™ System with Pretreatment

Extended Detention Systems

In some applications, BayFilter™ systems will be installed in conjunction with extended detention systems. Extended detention systems attenuate peak flow rates within the storm drain system. In these cases, the BayFilter™ is placed downstream from an extended detention system, as shown in Figure 5.

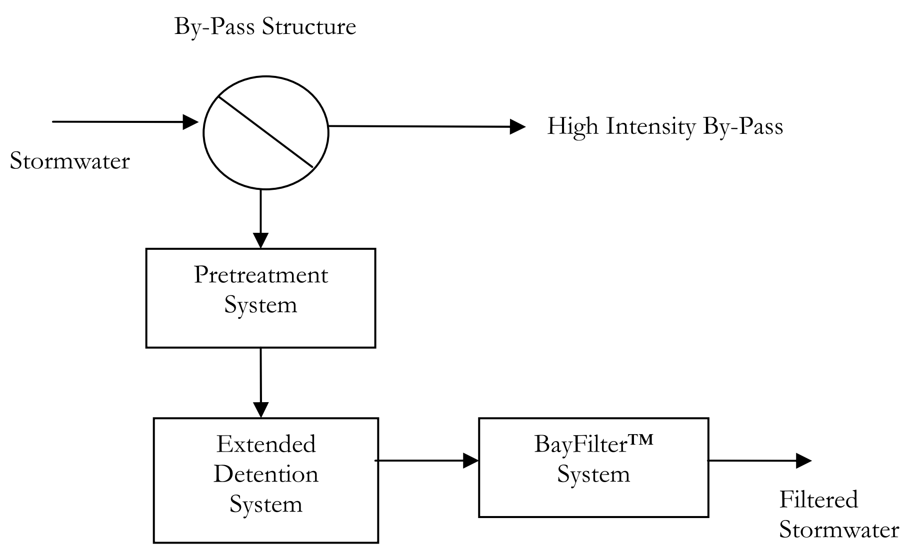


Figure 5: Offline BayFilter™ System with Extended Detentions

Systems with smaller drops can be designed as well. The system will work as long as 28" of head is achieved to activate the cartridge flow and will continue to work until it reaches the siphon break level (6"). Consult BaySaver Technologies, Inc. Engineering Department for verification based on your particular site conditions.

Preparing Site Plans for the BayFilter™ System

Once the BayFilter™ system has been selected, the chosen system must be included on the site plans. The hydraulics of the system must be considered as well as the water surface elevation of the receiving water. Finally, the system must be placed in a suitable location on the site.

Location

The location of BayFilter™ on the site will be determined by several factors; maintenance access, the unit's footprint, available drop, available depth, and the surface elevation of the receiving waters must all be considered when selecting the system's location.

The BayFilter™ system must be installed in an area that is accessible to maintenance equipment. The annual maintenance of a BayFilter™ system requires a vacuum truck as well as the removal and replacement of the filter cartridges. The manhole covers of the BayFilter™ must be placed in locations that can be easily reached by such a vehicle.

The BayFilter™ should be placed in a location that minimizes its interference with other existing or planned underground utilities.

Selecting the Number of cartridges

Each BayFilter™ system relies on a collection of individual cartridges to achieve the desired removal efficiency and it is important to correctly determine the number of filter cartridges required. Too few cartridges will result in a system that does not meet the performance specifications while too many cartridges will result in a system larger than necessary for the site.

To accurately determine the number of cartridges required for a BayFilter™ installation, three factors must be considered:

- **The flow capacity of the system**
- **Treated sediment load of the system**
- **Jurisdiction – specific sizing requirements (filter area-based)**

Each of the above factors when evaluated will determine a minimum of cartridges required to address that design parameter. Calculations for all three factors need to be done to determine which design parameter is the limiting factor. In each case it will be the computation that results in the highest minimum number of cartridges, the one that will determine the cartridge count. In other words, whichever item requires the most cartridges to meet any one particular design parameter will determine the minimum number of cartridges required for the system.

Required Data

To ensure that the correct number of cartridges are specified for the BayFilter™ system, the designer must be aware of the local regulatory requirements for stormwater treatment.

Depending on the jurisdiction in which the project site is located, the engineer may have to meet minimum treatment flow rates, treatment volumes or some other criteria such as filter bed area. Some jurisdictions specify a methodology for calculating a minimum treatment flow rate for a given site. Other jurisdictions may require extended detention upstream from the filtration system or have volume-based rather than flow-based requirements.

Flow Capacity

At many sites regulatory requirements will specify a minimum treatment flow rate (Q_{TRT}) that must be passed through the stormwater treatment system. These regulatory requirements may also specify pretreatment or extended detention practices that need to be included in the site design. Some jurisdictions specify that the stormwater filtration systems be designed on the basis of filter area following prescribed methodologies.

In some cases the BayFilter™ system will have to be placed downstream from an extended detention facility or local regulations will specify a treatment volume rather than a treatment flow rate. In these cases the minimum number of BFCs may not be determined using the treatment flow rate calculation. Instead, the minimum number of cartridges for this system depends on the controlled discharge rate Q_{TRT} from the upstream detention facility or the filtration system.

In most cases pretreatment can be provided by a hydrodynamic separator like the BaySaver Technologies, Inc. BaySeparator™ system. Regardless of the pretreatment design, the minimum number of BayFilter™ cartridges can be determined by dividing the treatment flow rate by 30 gpm (0.067 cfs) and rounding up to the next whole number using Equation 1. This calculation provides the *minimum* number of BFCs that will be necessary to fully treat the water quality flow from the site. This computation does not take into account the sediment load portion of the design, which needs to be performed as well. The design flow per cartridge will ultimately be determined by the cartridge sediment load (Table 1). The step-by-step procedure is shown below.

1. Determine the required treatment flow rate (Q_{TRT}) based on locally approved methodologies for the project site. This may involve the use of the Rational Method, TR-55 or another locally specified hydrologic model. If a locally approved methodology is not specified, BaySaver Technologies, Inc. recommends using one of these commonly accepted models.

2. Using the treatment flow rate, calculate the minimum numbers of BayFilter™ cartridges required to treat that flow using Equation 1.

$$\#Cartridges = \frac{Q_{TRT}(cfs) * 448.8\frac{gpm}{cfs}}{Q_{BFC}}$$ *Equation 1*

The minimum number of BFCs is equal to the maximum treatment flow rate divided by Q_{BFC}, rounded up to the next whole number. In most cases, Q_{BFC} will be 30 gpm (0.067 cfs) per cartridge.

Sediment Load Capacity

Once the minimum number of BFCs required to treat the flow is known, the engineer must ensure that the number of BFCs specified will be capable of handling the sediment load from the site. BayFilter™ systems are typically designed around a maintenance cycle. It is important to note that the number of BFCs required to treat the anticipated total system sediment load is a *minimum* number. For any site, it is necessary to calculate the minimum number of BFCs required to treat both the peak flow rate and the total system sediment load (as discussed in this section). The number of BFCs required for the site is the *greater* of the calculated numbers.

To ensure that the BayFilter™ will function acceptably with annual maintenance, it is necessary to calculate the incoming annual sediment load from the site.

1. Calculate the annual treated runoff volume according to Equation 2. In Equation 3, V_{TRT} is the annual treated runoff volume, P is the

$$V_{TRT}\left(ft^3\right) = P * A * c * \frac{1\,ft}{12in} * \frac{43560\,ft^2}{acre} * \%\,Capture$$ *Equation 2*

average annual precipitation (in inches), A is the area of the site (in acres), c is the runoff coefficient of the site (c is dimensionless), and *% Capture* is the fraction of the total runoff that is treated by the stormwater quality system. If *% Capture* is not otherwise specified, a default value of 0.90 can be used.

2. Using the annual treated runoff volume, calculate the anticipated total system sediment load to BayFilter™ according to Equation 3. In Equation 3, L is the mass of sediment that BayFilter™ is exposed to annually (in pounds), V_{TRT} is the annual treated runoff volume as calculated in step 1 (in ft^3), and TSS_{IN} is the influent concentration of TSS in the runoff (in mg/L). The influent TSS concentration (TSS_{IN})

$$L = V_{TRT} * TSS_{IN} * \frac{28.3L}{ft^3} * \frac{kg}{10^6 mg} * \frac{2.2lbs}{kg} \qquad \textit{Equation 3}$$

depends greatly on the site and the surrounding land use. In the absence of readily available data, BaySaver Technologies, Inc. recommends using a minimum event mean concentration (EMC) TSS value of 60 mg/l. The impact of the on the filter cartridge will also be less if the filtration system is preceded by pretreatment. In these cases, the influent TSS to the BayFilter™ system need to be reduced to reflect pretreatment sediment removal. The BaySaver Technologies' Engineering Department can assist with these calculations.

3. Once the total annual system sediment load (L) is calculated, the engineer must ensure that the number of cartridges specified will be able to remove that sediment load at the specified design flow rate. Divide the total system sediment load L by the capacity of each BFC and note the associated BFC flowrate. Round up to the next whole number to get the minimum number of BFCs required to treat this sediment load at the required flow rate per BFC.

Jurisdictional Filter Requirements

This procedure is used when the filtration area is defined by regulations. To determine the number of cartridges based on a filtration area requirement dictated by regulations the following steps are followed:

1. Determine the required total minimum filtration area Af in ft^2 based on the locally mandated methodology for the project site. Next determine the number of Drain Down Cartridges required and their area contribution based 29 ft^2 per Drain Down Cartridge (DDC) and one (1) DDC per 1,300 ft^2 of filter area requirement. Round up to the next whole number to obtain the number of DDCs.

$$\#DDCs = \frac{Af\,(ft^2)}{1{,}300\,ft^2 / DDC} \qquad \textit{Equation 4}$$

2. Calculate the required filter area from the BFCs by subtracting the DDC area from the total area filtration area. Determine the minimum number of BFCs needed by dividing the required are by 43 ft^2/BFC.. Round up to the next whole number to obtain the number of BFCs.

$$BFC\ Area = Af\,(ft^2) - \left(\#\,DDCs * \frac{29\,ft^2}{DDC}\right) \qquad \textit{Equation 5}$$

$$\#\ of\ BFCs = BFC\ Area * \frac{BFC}{43\ ft^2} \qquad \textit{Equation 6}$$

Summary

After the above calculations are complete the limiting factor will be the largest number of cartridges that these three (3) calculations determined (flow, sediment load, and jurisdictional/area, if applicable). These results then define the final number of BayFilter™ cartridges required for the system. Examples of typical calculations are provided below.

Example 1
Flow Capacity Calculations
Determines the minimum number of BFCs required to treat the design flow rate.

Step 1:

Determine the required treatment flow rate (Q_{TRT}) based on locally approved methodologies for the project site.

Q_{TRT} = 2.38 *cfs*

Step 2:

Using Q_{TRT}, calculate the minimum number of BFCs required using Equation 1.

$$\#\text{ of Cartridges} = \frac{2.38cfs * \left(\frac{448.8gpm}{cfs}\right)}{\frac{30gpm}{BFC}}$$

\# of Cartridges = 35.6 cartridges

Round up to the nearest whole number. The minimum number of BayFilter™cartridges required to treat the design treatment flow from this site is 36 cartridges.

Result: 36 BayFilter™ Cartridges plus two (2) Drain Down Cartridges

Example 2:
Determine the minimum number of BFCs required for a project site based on a controlled rate

Step 1:
Determine the controlled release rate (CCR) of the system given a storage volume based on a locally approved methodology

V_{TRT} =	26,572	ft^3	volume that need treatment
V_{TRT} =	198,759	gallons	volume that need treatment
Draindown Time =	40	hours	
CCR =	198, 759 gallons / (40 hrs * 60 min/hr)		
CCR =	82.8	gpm	

Step 2:
Determine the minimum number of BFCs required based on the CCR and a 30 gpm/BFC flow rate

# of BFCs required =	82.8 gpm / (30 gpm/BFC)	
# of BFCs required =	2.76	BFCs

Round up to the next whole number. The minimum number of BFCs required is then 3

Result = 3 BFCs

This system will consist of 3 BFCs minimum and 1 DDC

Example 3:
Sediment Load Calculations
Determines the minimum number of BFCs required to handle the anticipated annual sediment load from the project site.

Step 1:
Calculate the annual treatment volume (V_{TRT}) according to Equation 3.

P =	43.8	inches per year
A =	3.42	acres
c =	0.85	
% Capture =	0.90	

$$V_{TRT} = (43.8")(3.42 acres)(0.85)\left(\frac{1 ft}{12"}\right)\left(\frac{43560 ft^2}{acre}\right)(0.90)$$

V_{TRT} = 415,976 ft^3 per year

Step 2:
Using V_{TRT}, calculate the anticipated total sediment load to BayFilter™ using Equation 4.

V_{TRT} =	415,976	ft^3
TSS_{IN} =	80	mg/l

$$L = (415{,}976 ft^3)\left(\frac{80 mg}{l}\right)\left(\frac{28.3 l}{ft^3}\right)\left(\frac{kg}{10^6 mg}\right)\left(\frac{2.2 lbs}{kg}\right)$$

L = 2,072 pounds total annual sediment load

Step 3:
For example, if the cartridge sediment load per BFC is 150 lbs/cartridge (see Table 1, BFC flow is 30 gpm), divide the annual sediment load L by 150 lbs/cartridge and round up to the next whole number.

# of Cartridges = 13.8 cartridges

Result: 14 BayFilter™ Cartridges plus one (1) Drain Down Cartridge

*The % capture is the fraction of the total runoff that is treated by the stormwater quality system.

Example 4:
Filter Bed Area Calculations
Determines the minimum number of BFCs required for a project site based on a regulatory driven filtration area requirement.

Step 1:
Determine the required total minimum filtration area based on the locally mandated methodology for the project site

$$A_f = 1{,}643 \text{ ft}^2$$

Step 2:
Determine the number of Drain Down Cartridges required and their area contribution based on 43 ft^2 per BayFilter™ cartridge (BFC) and 29 ft2 per Drain Down Cartridge (DDC) and one (1) DDC per 1,300 ft^2 of filter area requirement

# of DDC required = 1.26

Round up to the next whole number. Number of DDCs required is then two(2)

Result : 2 DDCs

Filtration area provided by the DDC = 58 ft^2

Step 3:
Determine the number of BFCs required based on the next filtration area requirements by subtracting the DDC area from total area filtration area

Total Filtration Area Required	A_f =	1,643	ft^2
DDC Filtration Area	=	58	ft^2
BFC Filtration Area Requirement	=	1,585	ft^2

Step 4:
Determine the minimum number of BFCs based on the BFC Filtration Area Requirement

# of BFCs required = 36.9 BayFilter™ Cartridges

Round up to the next whole number. The minimum number of BFCs required is then 37

Result : 37 BFCs

This system will consist of 37 BFCs and 2 DDCs

It is important to note that the BFC and DDC count is the minimum requirement and other factors might make the above figures larger, therefore all designs constraints need to be taken into account to arrive at the final design cartridge count. Contact BaySaver Technologies Inc. Engineering Department at 1.800.229.7283 for design assistance.

BayFilter™ System Configuration

The BayFilter™ Stormwater Treatment Systems are available in three different configurations:

- Manhole filter
- Precast vault filter
- Cast-in-place vault filter

This section details the capabilities of each of these configurations, and provides guidance for selecting the most suitable configuration for a site.

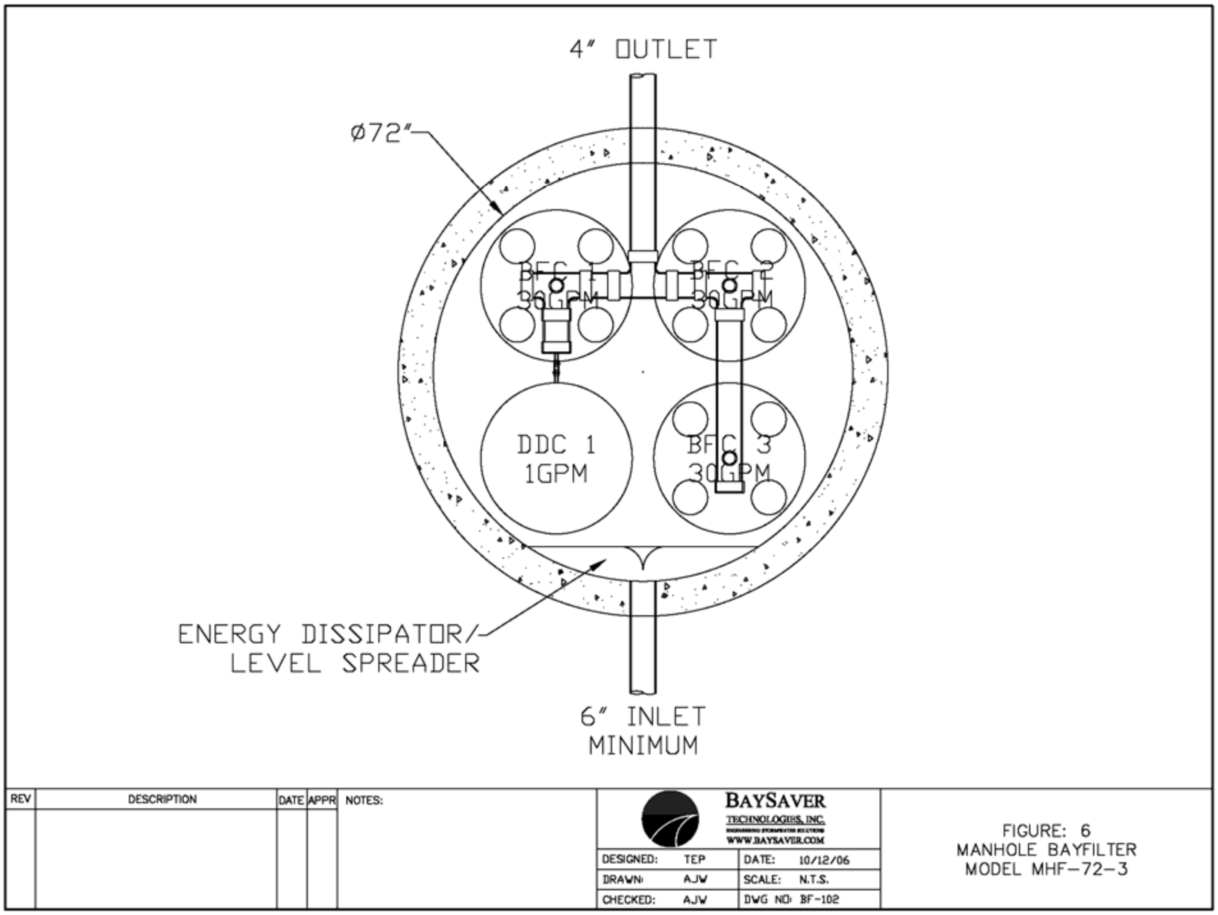
Manhole BayFilter™

The manhole configuration BayFilter™ system is the most economical BayFilter™ system available. It is usually used for small drainage areas, and has a treatment capacity ranging from 60 gpm (0.13 cfs) for a 60" manhole to 330 gpm (0.74 cfs) for a 120" manhole. Filter cartridges, underdrain components, and manholes are supplied by BaySaver Technologies, Inc. as a complete system. Manhole BayFilter™ sizes and flow capacities are shown in Table 2. The minimum system drop is typically determined on a site specific basis by BaySaver Technologies, Inc. in conjunction with the engineer.

BayFilter™ Model	Manhole Size (inches)	Maximum Number of BFCs	Maximum Treatment Flow gpm (cfs)
MHF-60-2	60	2	60 (0.13)
MHF-72-3	72	3	90 (0.20)
MHF-84-4	84	4	120 (0.27)
MHF-96-6	96	6	180 (0.40)
MHF-120-11	120	11	330 (0.74)

Table 2: Manhole BayFilter™ Capacities

A 72" Manhole BayFilter™ Model MHF-72-3 is shown in Figure 6. The 72" Manhole BayFilter™ contains 3 BFCs for a maximum treatment flow of 90 gpm (0.20 cfs), as well as a single drain down filter cartridge (the lower left cartridge in Figure 11, labeled DDC1) as described in Chapter 2 of this manual. The drain down filter, which has a flow rate of 1 gpm (0.002 cfs), allows the manhole to be dewatered between storms after the siphon is broken and the standard BFCs stop filtering stormwater. The inlet and outlet pipes of the 72" Manhole BayFilter™ are each 4" PVC; these pipes are connected to the manhole using watertight boots to prevent leakage when the filter is operating. In the Manhole BayFilter™, the PVC outlet pipe is directly connected to the outlet manifold. Engineering drawings of each available Manhole BayFilter™ can be found in Appendix C.



The Manhole BayFilter™ includes an energy Dissipator/Level Spreader at the inlet to the structure. This component spreads the influent water evenly through the structure and prevents high flows from impacting the BFCs directly.

Manhole BayFilter™ systems have a small footprint, and can be fit into site plans easily without interfering with other underground utilities. Manhole BayFilter™ systems are ideal for applications downstream from extended detention structures. Please consult with the BaySaver Technologies, Inc. Engineering Department for more details.

Access to the Manhole BayFilter™ for inspection or maintenance is achieved through a minimum 30" frame and cover. In each Manhole BayFilter™ system, the BFCs are arranged so that a maintenance worker can stand on the floor of the manhole while installing or removing the cartridges. Please refer to Appendix C for engineering drawings showing the available Manhole BayFilter™ configurations.

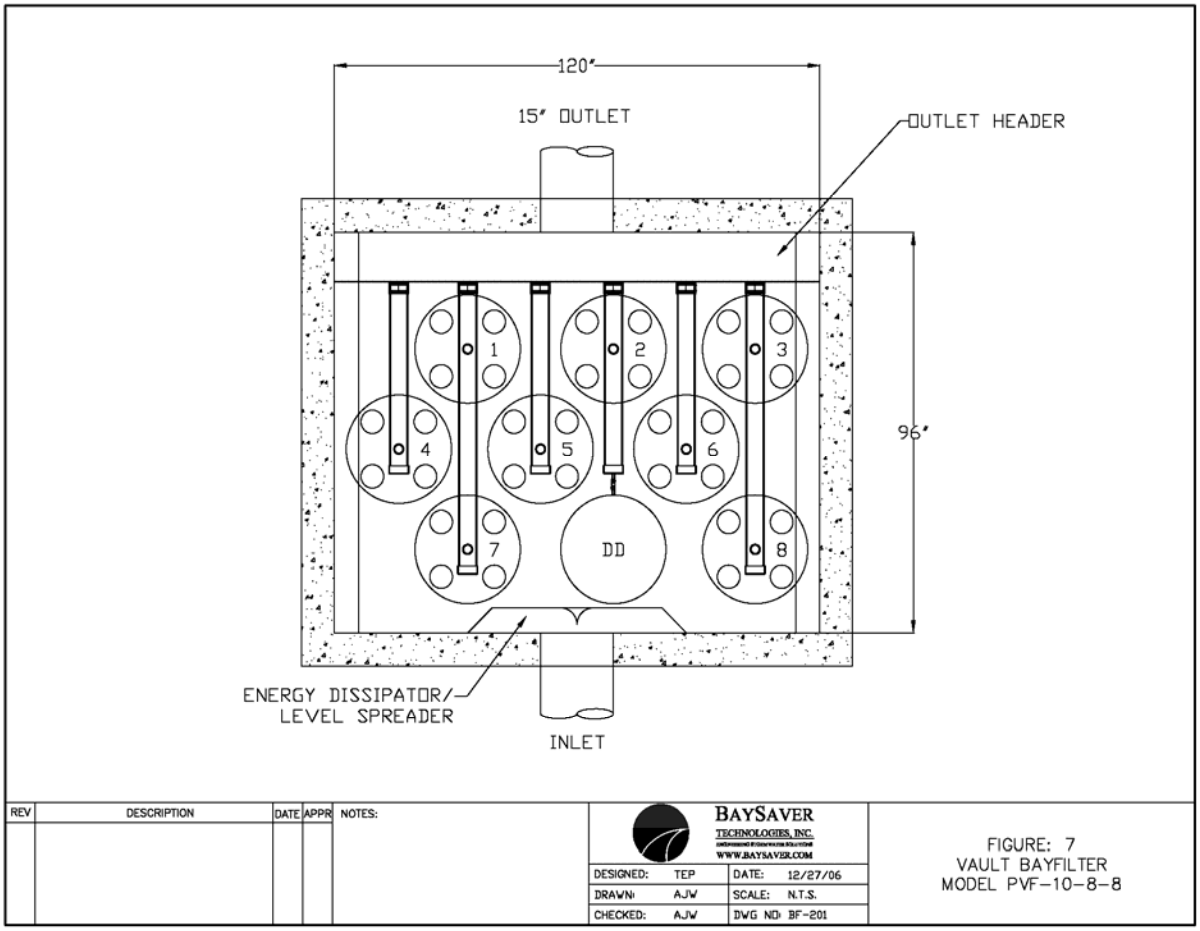
Precast Vault BayFilter™

When more BFCs are required, Precast Vault BayFilter™ systems may be used on larger sites or sites with more impervious area. The Precast Vault BayFilter™ system is larger than the Manhole BayFilter™. Constructed within a precast concrete vault, it has a treatment capacity ranging from 240 gpm (0.53 cfs) in an 8' x 10' vault to 2,010 gpm (4.48 cfs) in a 10' x 48' vault. Should precast vaults of the dimensions outlined in Table 3 not be available locally, these structures can be cast in place. Table 3 shows the available Precast Vault BayFilter™ systems, along with the maximum number of filter cartridges and treatment capacities. The minimum system drop is typically addressed on a site specific basis by BaySaver Technologies, Inc. in conjunction with an engineer.

BayFilter™ Model	Vault Size (ft x ft)	Maximum Number of BFCs	Maximum Treatment Flow gpm (cfs)
PVF-10-8-8	8' x 10'	8	240 (0.53)
PVF-10-16-20	10' x 16'	20	600 (1.34)
PVF-10-24-31	10' x 24'	31	960 (2.14)
PVF-10-32-43	10' x 32'	43	1290 (2.87)
PVF-10-40-55	10' x 40'	55	1650 (3.68)
PVF-10-48-66	10' x 48'	66	2010 (4.48)

Table 3: Precast Vault BayFilter™ Capacities

Figure 7 shows the layout of a PVF-10-8-8, an 8' x 10' Precast Vault BayFilter™ system. The system comprises eight standard BFCs and a single drain down filter. Like the Manhole BayFilter™, the Precast Vault BayFilter™ also includes an energy dissipator/level spreader to evenly distribute the water through the structure. Unlike the Manhole BayFilter™, the outlet manifold in the Precast Vault BayFilter™ does not connect directly to the outlet pipe. Instead, each of the six underdrain lines enters an HDPE outlet manifold and discharges filtered water to an outlet chamber. The outlet pipe drains this outlet chamber.



Like the Manhole BayFilter™, access to the Precast Vault BayFilter™ is provided through the hinged access hatch. The Precast Vault BayFilter™ is constructed in 10' x 8' sections. Each vault has at least one access hatch. The BFCs and outlet manifolds are arranged to allow maintenance personnel to stand on the concrete floor while working inside the structure. The BayFilter™ cartridges and underdrain manifold components are supplied by BaySaver Technologies, Inc. together with the precast vaults. Please refer to Appendix C for a complete set of Precast Vault BayFilter™ configurations.

Cast-in-place BayFilter™

For sites requiring more than 66 BFCs or for projects on which a large Precast Vault BayFilter™ is not feasible, BaySaver Technologies, Inc. can supply custom-designed BayFilter™ systems. These custom systems utilize a cast in place vault or other system, and can be designed around specific site constraints. High flow rates, shallow installations, very flat sites, limited footprints, and other design considerations can be addressed with a cast in place system. For more information on custom BayFilter™ designs, please contact BaySaver Technologies, Inc. directly.

Chapter

3

Installation of the BayFilter™ System

BayFilter™ systems are installed along with the storm drain. Installation procedures vary depending on the configuration of the BayFilter™ system. Installation instructions for Manhole BayFilter™ systems and Precast Vault BayFilter™ Systems are contained in this section.

Custom BayFilter™ systems may have particular installation issues that will be addressed during the design. Installation instruction for the custom BayFilter™ will be included with the custom design documents.

Installation of a Manhole BayFilter™

1. Contact utility locator to mark any nearby underground utilities and make sure it is safe to excavate.

2. Reference the site plan and stake out the location of the BayFilter™ manhole.

3. Excavate the hole, providing any sheeting and shoring necessary to comply with all federal, state and local safety regulations.

4. Level the subgrade to the proper elevation. Verify the elevation against the manhole dimensions, the invert elevations, and the site plans. Adjust the base aggregate, if necessary.

5. Have the soil bearing capacity verified by a licensed engineer for the required load bearing capacity. On solid subgrade, set the base of the BayFilter™ manhole.

6. Check the level and elevation of the base unit to ensure it is correct before adding any riser sections.

7. Add watertight seal (either mastic rope or rubber gasket) to the base unit of the BayFilter™ manhole. Set riser section(s) on the base unit.

8. Install the PVC watertight outlet manifold within the BayFilter™ manhole.

9. Install the inlet pipe to the BayFilter™ manhole.

10. Install the energy dissipator/level spreader at the system inlet location.

11. After the site is stabilized, remove any accumulated sediment or debris from the manhole and install the BayFilter™ cartridges.

Installation of Precast Vault BayFilter™

1. Contact utility locator to mark any nearby underground utilities and make sure it is safe to excavate.

2. Reference the site plan and stake out the location of the BayFilter™ vault.

3. Excavate the hole, providing any sheeting and shoring necessary to comply with all federal, state and local safety regulations.

4. Level the subgrade to the proper elevation. Verify the elevation against the manhole dimensions, the invert elevations, and the site plans. Adjust the base aggregate, if necessary.

5. Have the soil bearing capacity verified by a licensed engineer for the required load bearing capacity. On solid subgrade, set the first section of the BayFilter™ precast vault.

6. Check the level and elevation of the first section to ensure it is correct before adding any riser sections.

7. If additional section(s) are required, add a watertight seal to the first section of the BayFilter™ vault. Set additional section(s) of the vault, adding a watertight seal to each joint.

8. Install the PVC outlet manifold and outlet chamber system.

9. Install the PVC outlet pipe in BayFilter™ vault.

10. Install the inlet pipe to the BayFilter™ vault.

11. Install the energy dissipator/level spreader at the inlet pipe.

12. After the site is stabilized, remove any accumulated sediment or debris from the vault and install the BayFilter™ cartridges.

Chapter
4

Maintenance of the BayFilter™ System

The BayFilter™ system requires periodic maintenance to continue operating at the design efficiency. The maintenance process comprises the removal and replacement of each BayFilter™ cartridge and the cleaning of the vault or manhole with a vacuum truck. BayFilter™ maintenance should be performed by a BaySaver Technologies, Inc. certified maintenance contractor.

The maintenance cycle of the BayFilter™ system will be driven mostly by the actual solids load on the filter. The system should be periodically monitored to be certain it is operating correctly. Since stormwater solids loads can be variable, it is possible that the maintenance cycle could be more or less than the projected duration.

When a BayFilter™ system is first installed, it is recommended that it be inspected every six (6) months. When the filter system exhibits flows below design levels the system should be maintained. Filter cartridge replacement should also be considered when sediment levels are at or above the level of the 4 collector pipes to the manifold. Please contact the BaySaver Technologies Inc. Engineering Department for maintenance cycle estimations or assistance at 1.800.229.7283.

Maintenance Procedures

1. Remove the manhole covers and open all access hatches.

2. Before entering the system make sure the air is safe per OSHA Standards or use a breathing apparatus. Use low O_2, high CO, or other applicable warning devices per regulatory requirements.

3. Using a vacuum truck remove any liquid and sediments that can be removed prior to entry.

4. Using a small lift or the boom of the vacuum truck, remove the used cartridges by lifting them out.

5. Any cartridges that cannot be readily lifted can be slid along the floor to a location where they can be lifted via a boom lift.

6. When all cartridges are removed, remove the balance of the solids and water; then loosen the stainless clamps on the Fernco couplings for the manifold and remove the drain pipes as well. Carefully cap the manifold and the Fernco's and rinse the floor removing the balance of the collected solids.

7. Clean the manifold pipes, inspect, and reinstall.

8. Install the exchange cartridges and close all covers.

9. The used cartridges must be sent back to BaySaver Technologies, Inc. for exchange/recycling and credit on undamaged units.

Chapter

5

BayFilter™ System Costs and Availability

BayFilter™ systems are available throughout the United States from BaySaver Technologies, Inc. or from an authorized representative. Material, installation, and maintenance costs can vary significantly with location. For BayFilter™ pricing in your area, please contact BaySaver Technologies, Inc. at 1-800-229-7283 (800-BAYSAVE) or an authorized representative directly.

BayFilter™ cartridges and outlet components can be shipped anywhere in the continental United States. Manholes and precast vaults are also supplied by BaySaver Technologies, Inc. as part of a complete stormwater filtration system.

Appendix

A

BayFilter™ Detailed Operating Sequence

The cycle operation of a BayFilter™ is as follows:

A. Vault Fill and Air Release: As water fills the BayFilter™ stormwater filtration system vault, it enters through an inlet pipe to an energy dissipator/level spreader. This allows for even flow into the vault and limits any high velocity scouring of the sediment. As the water fills the vault, influent water passes through the inlet plate.

As the level rises in the vault, air from inside the BFC is exhausted via an air release valve. This operation is critical for the proper functioning of the siphon, which drives the BayFilter™ during periods of low water level in the vault. (Refer to Figure A-1 for details on this operation).

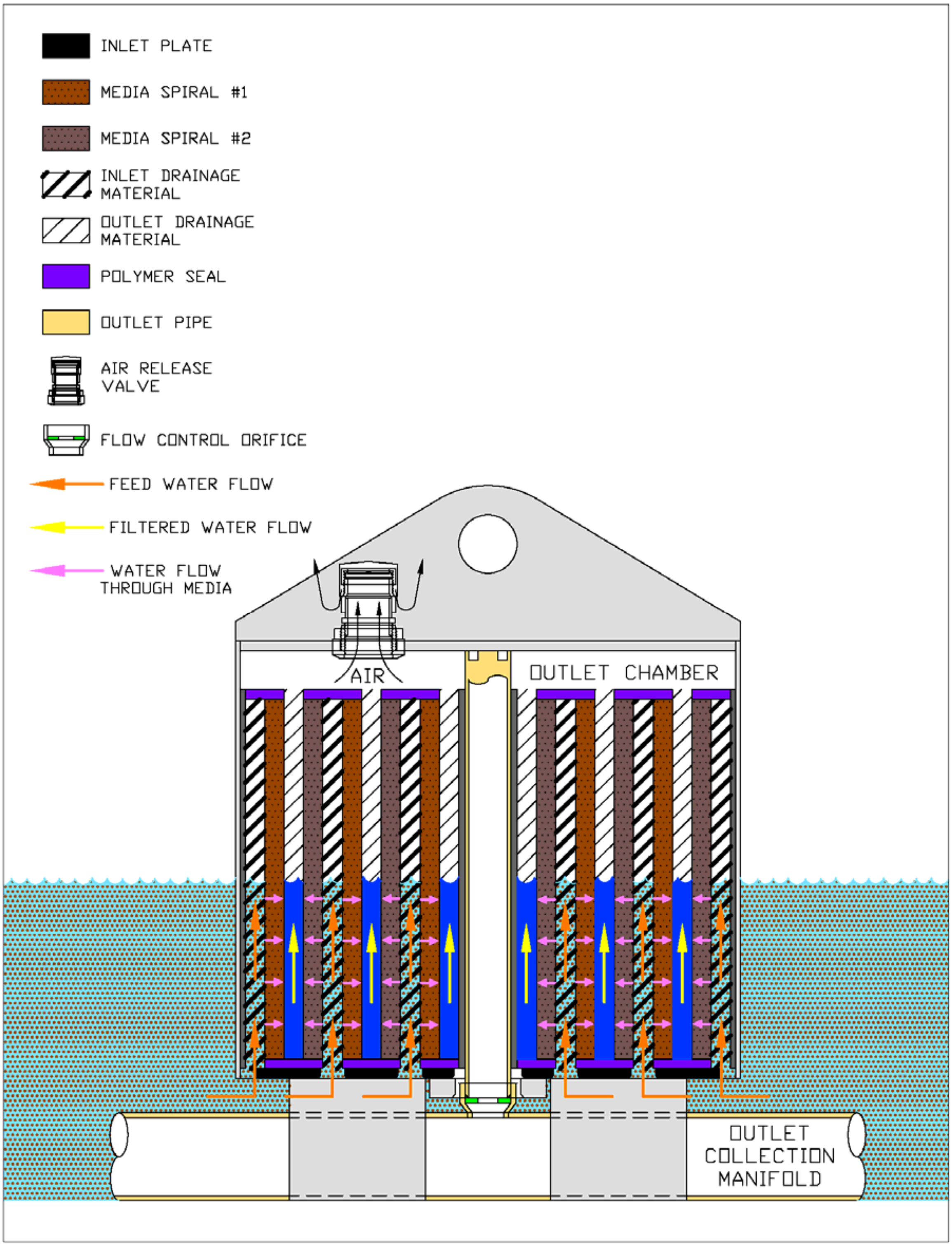


Figure A-1: Vault fill operation and release

B. Filtration: As water enters the inlet drainage spiral, which is one continuous spiral, the air is exhausted. Water then flows horizontally through the engineered media. Next it flows to the outlet drainage spiral, which is also one single spiral of outlet material. The filtered water then flows vertically to the outlet chamber located on the inside top of the filter. Finally, the filtered water flows to the center outlet drain and out through the outlet manifold below the inlet plate. (Figure A-2)

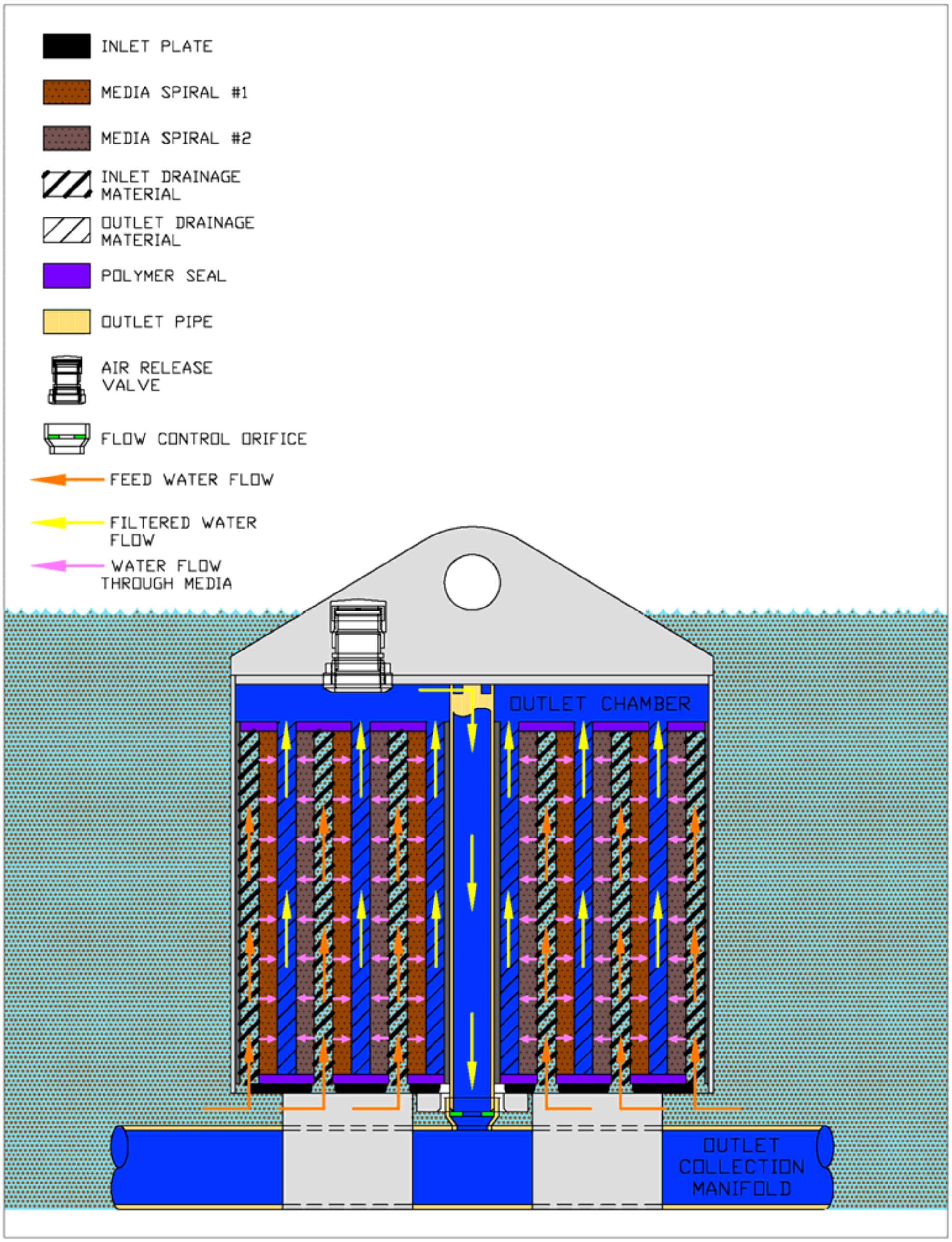


Figure A-2: Normal filter operation

C. Siphon Filtration: After the water level in the vault falls below the top of the filter, a siphon is established and water will continue to flow (Figure A-3) until the siphon is broken. During siphon flow the level in the vault will decrease until it reaches the base of the BFC; air enters the filter, breaks the siphon, filtration flow stops, and the hydrodynamic backwash begins.

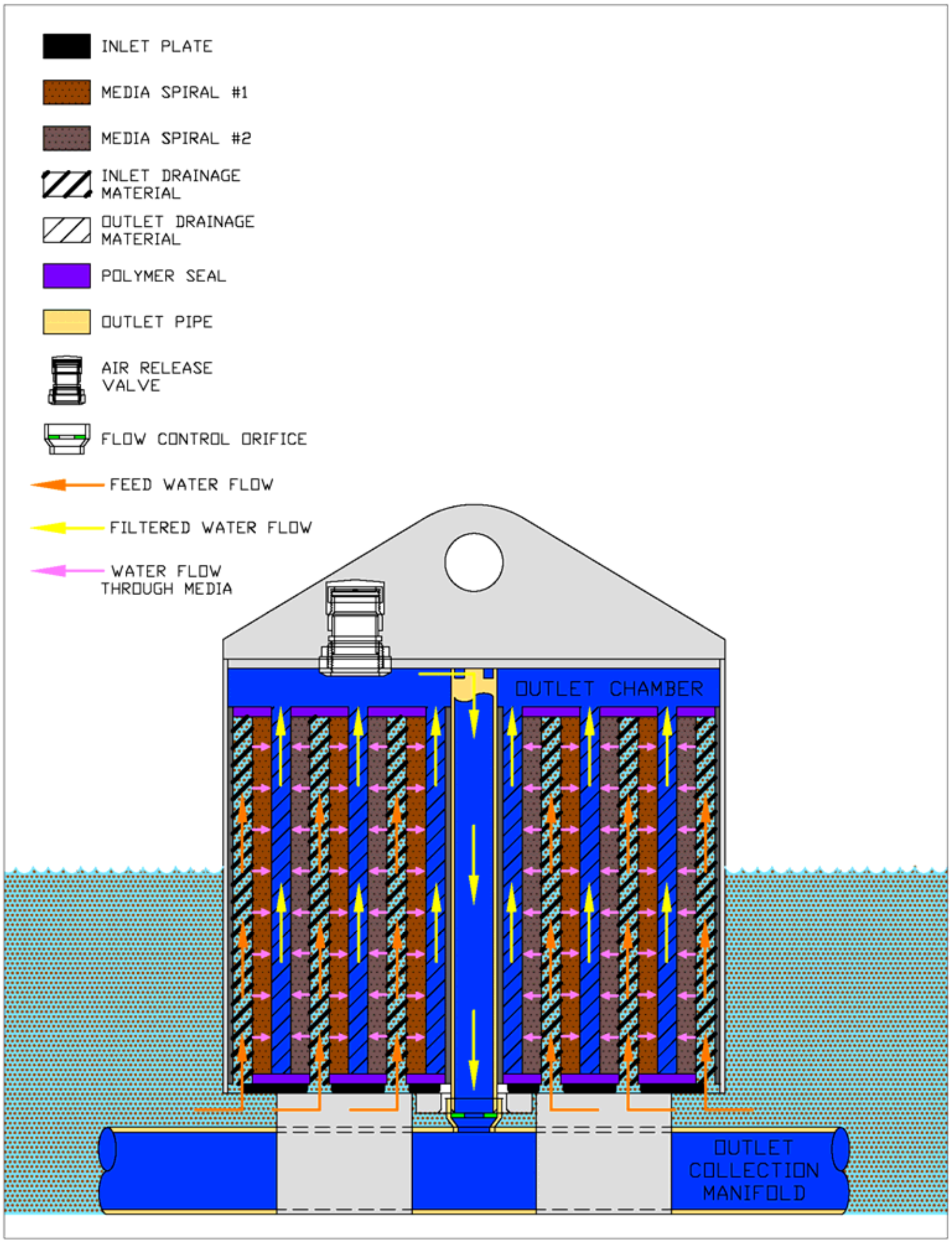


Figure A-3: Siphon filtration

D. When air enters the filter, the siphon breaks (Figure A-4), and a gravity-driven backwash occurs with all of the water flowing from the outlet chamber backwards through the filter (Figure A-5). This backwash has the effect of dislodging particles captured in the filtration layers and re-establishing porosity. Dislodged particles are transported by the backwash and accumulate on the vault floor.

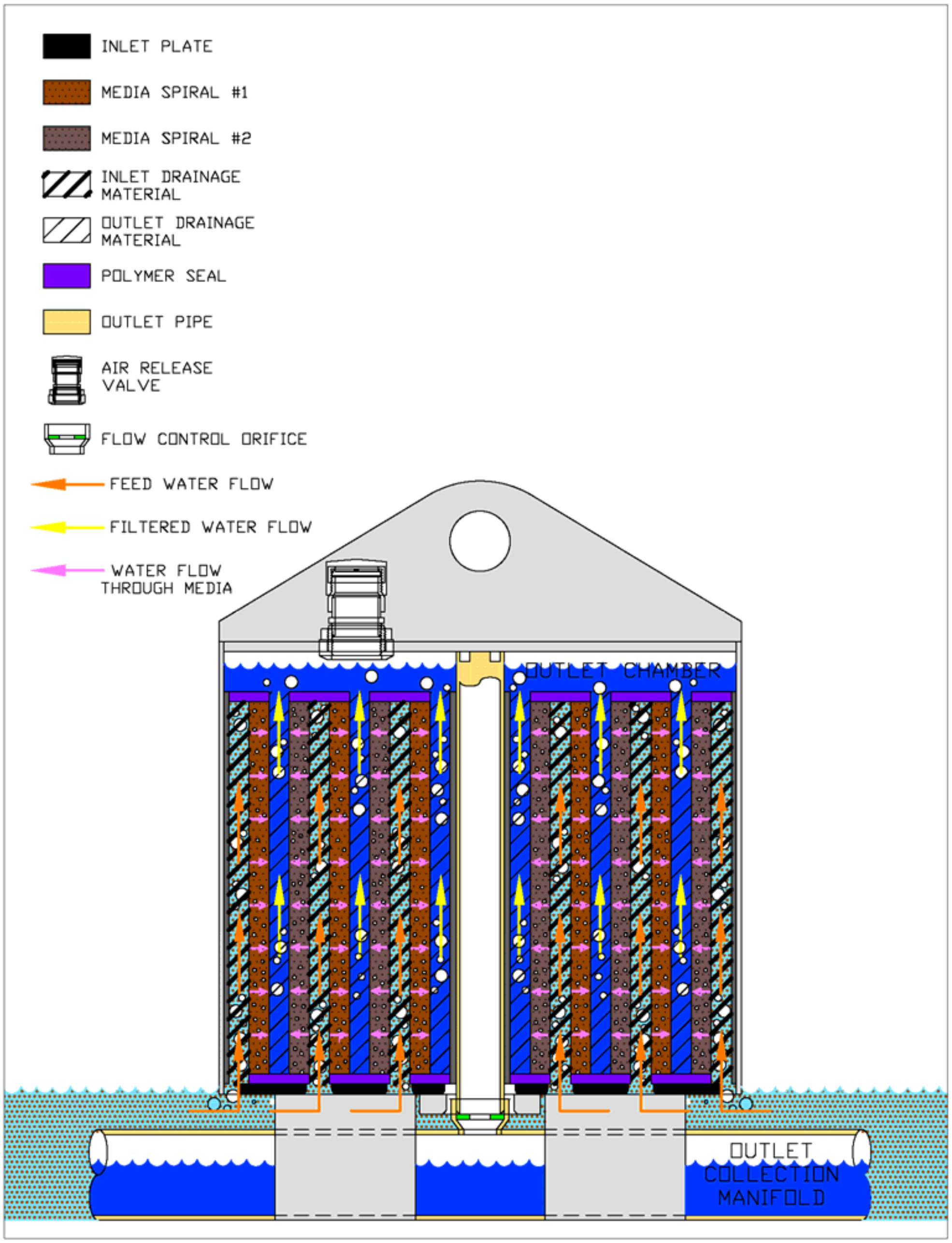


Figure A-4: Siphon Break

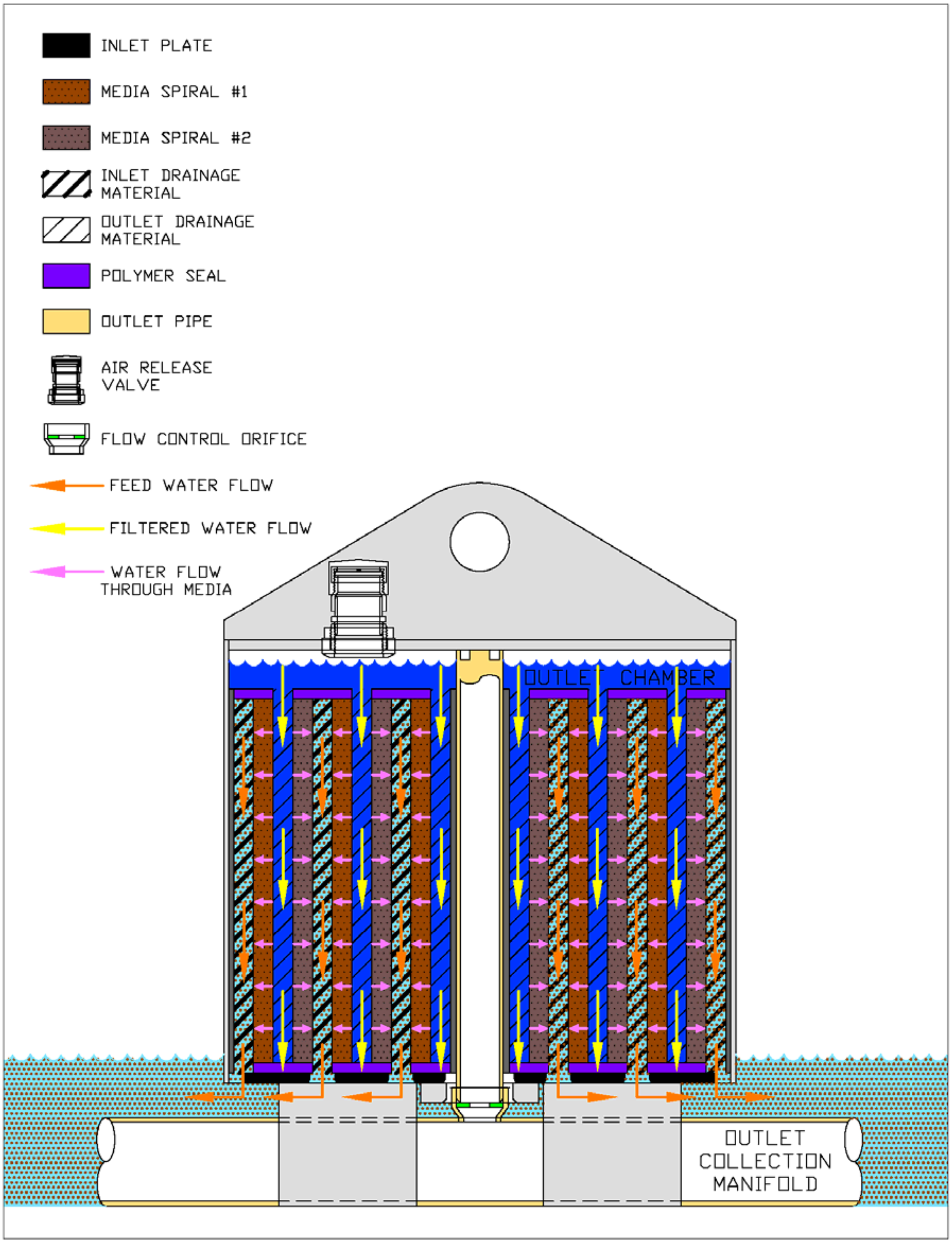


Figure A-5: Hydrodynamic Backwash

Appendix

B

General Checklist for Designing a BayFilter™ System

This list is provided for general informational purposes. BaySaver Technologies will work closely with the engineer to design the BayFilter™ System and produce a complete design package. For assistance, please contact BaySaver Technologies Inc. at **1.800.229.7283**.

1) Understand the constraints of the project:
   a) Governing Regulations on Configuration:
      (1) Flow or volume to be treated
      (2) Treatment efficiency
   b) Site Specific Limitations:
      (1) Available footprint
      (2) Available head
      (3) Pollutants and Loads
      (4) Other specific site issues

2) Determine the best configuration based on the above:
   a) Will there be pretreatment?
   b) Is Extended Detention possible or available?
   c) What configurations are available?
   d) What is the minimum maintenance cycle?

3) Determine the minimum number of cartridges:

   a) The system is then configured based on the determining the minimum number of cartridges on the following parameters. The largest minimum number of cartridges associated with an applicable parameter will be the minimum system configuration.

b.) The parameters to be computed are:
   (1) Filter Area(some jurisdictions evaluate based on this)
   (2) Full Flow Rate(if this configuration applies)
   (3) Treated Sediment load (always important to determine maintenance cycles)
   (4) Treated Sediment load w/ Pretreatment (increases treatable sed. load)
   (5) Controlled Flow Rate(if this applies)

4) <u>In order to compute the above items the following must be known about the site and the drainage area to the Filtration system:</u>

   (1) Site Area:
      (a) Impervious Area
      (b) Pervious Area
   (2) Treatment Flow Rate(if applicable)
   (3) Annual Sediment load (or) Annual Rainfall to be treated (and) Runoff coefficient for Impervious/Pervious Area
   (4) Extended Detention volume(if applicable)
   (5) Extended Detention Release Rate
   (6) Available head and/or elevation change available for the system including pretreatment and extended Detention

With this data the minimum number of BFC cartridges can be determined for a particular site.

Advantages and Disadvantages of System Configurations

		Advantages	**Disadvantages**
Full Flow Configuration	**Full flow treatment**	Easiest to configure	Costly configuration
		Smallest footprint	Most expensive maintenance and life cycle cost
	Full flow treatment with BaySeparator™ pretreatment	Simple to configure slightly larger footprint than without pretreatment, but still a small footprint	The most costly configuration at installation, but lower life cycle costs than the system without pretreatment
		Extended maintenance cycle	
		Reduced life cycle costs than above	
Controlled flow Configurations	**Treatment after Extended Detention without BaySeparator™ pretreatment**	Fewer cartridges and lower cost, even when the cost of the extended detention is accounted for	Extended detention usually significantly increases the foot print of the system
		Lower flow rates of each cartridge thereby increasing the sediment capacity per cartridge and the system	Usually requires additional available head(system drop)
		Because of the increase in head in the system more head is available to enhance the filter cartridge operation	
		Lower maintenance cost than the above options	
	Treatment after Extended Detention and Pretreatment	Lowest cost system, although the initial cost is slightly higher than without pretreatment, the life cycle costs are the lowest due to the increased maintenance interval because of the pretreatment system	Pretreatment adds additional footprint to the system making it the largest footprint of the BaySaver Technologies, Inc. treatment options(although still less than most other systems)
		Lower flow rates of each cartridge thereby increasing the sediment capacity per cartridge and the system	More costly than without pretreatment at the time of installation but this is quickly offset by the lifecycle cost reduction
		Because of the increase in head in the system more head is available to enhance the filter cartridge operation	
		Lowest maintenance cost than the all of the above options	

Note: This table is provided as a general reference only, since site specific conditions and other requirements or constraints may dictate a site specific design approach.

Appendix

C

System Drawings