6. Filtering BMPs

Filtering BMPs treat urban runoff as it flows through a filtering medium, such as sand or an organic material, and are generally used on small drainage areas (5 acres or less). Filtering BMPs are designed only for pollutant removal, and do not reduce peak flows for flood control or channel protection. These BMPs have not been widely applied in cold climates (CWP, 1997), but some filtering systems have the potential to be valuable BMPs in these regions.

6.1 Types of Filtering BMPs

Stormwater filtering BMPs can be divided in to several groups, based on filtering medium and other factors. The five filtering BMPs presented in Table 6.1 and Figure 6.1 represent general categories. An important concept in this section is the distinction between "on-line" and "off-line" systems (Figure 6.2). In on-line systems, all of the runoff from an area flows through the system. In off-line systems, on the other hand, only a portion of the runoff is diverted from the stormwater system, and the BMP only treats this portion of the runoff.

TABLE 6.1 CHARACTERISTICS OF FILTERING BMPS

	Filtering Media/ Pollutant Removal mechanism	Flow Regulation	Uses
Surface Filters	Sand or Organic Grass Surface Cover	Off-line	• Parking Lots • Commercial Areas • Rooftops
Underground Sand Filter	Sand	Off-Line	• Parking Lots • Commercial Areas • Rooftops
Perimeter Filter	Sand	Off-Line or On-Line	• Parking Lots • Commercial Areas • Rooftops
Bioretention	Soil Surface Vegetation	On-Line with Overflow	• Parking Lots • Roads • Residential Areas • Rooftops
Submerged Gravel Wetland	Gravel Wetland Vegetation	Off-Line	• Commercial Areas • Parking Lots

FIGURE 6.1 TYPES OF STORMWATER FILTERING SYSTEMS

(SOURCE: MODIFIED FROM CLAYTOR AND SCHUELER, 1996)

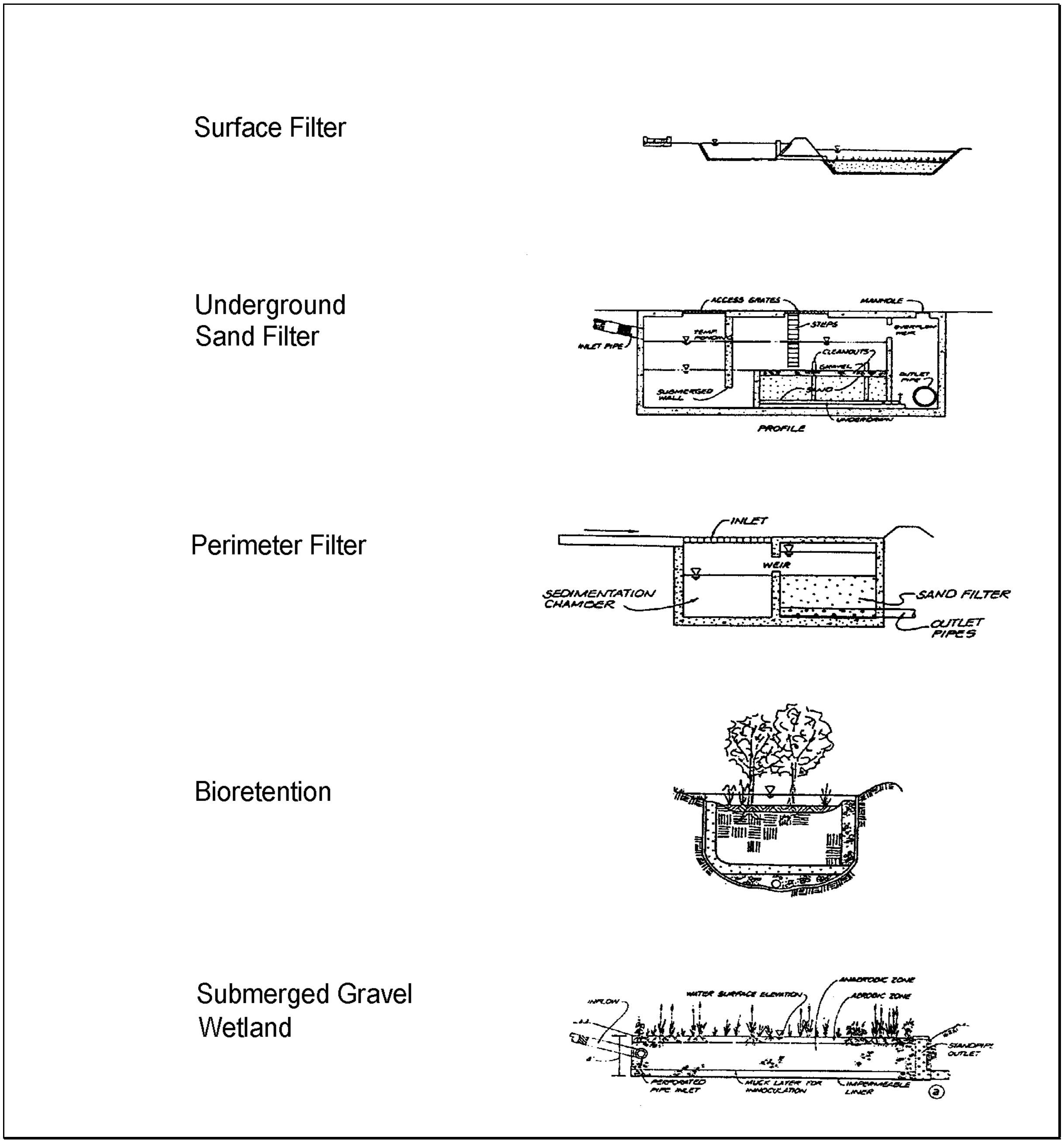
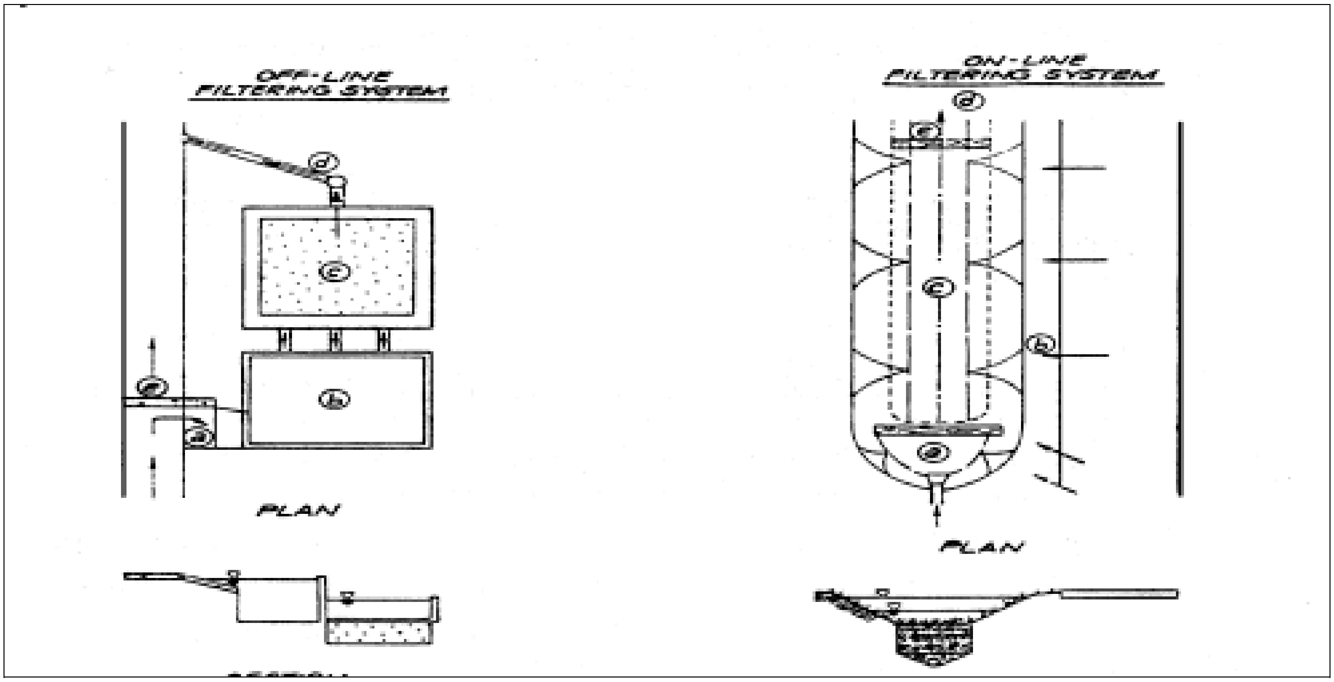


FIGURE 6.2 ON-LINE VERSUS OFF-LINE FILTERS
(SOURCE: CLAYTOR AND SCHUELER, 1996)



Surface Filters
Surface sand filters are the most commonly used filtering BMPs. Runoff flows through a pretreatment chamber, where large particles settle out. It is then treated as it flows through the sand bed, collected in the underdrain and returned to the drainage network or receiving water. Alternative materials, such as peat or compost, can be used in place of sand.

Underground Sand Filter
In these systems, runoff is diverted to a two-chambered, underground vault. In the first chamber, large particles settle out. Then the runoff flows into the second, sand-filled chamber where the runoff is filtered. This system saves space compared to surface filters, but is more expensive to construct.

Perimeter Filter
Perimeter filters are two parallel trench-like chambers installed along the perimeter of a parking lot or other impervious area. Runoff enters the first chamber, which acts as a pretreatment device. The runoff then flows through the second chamber, where a sand bed filters the runoff. The filtered runoff is then collected by an underdrain system which discharges to a protected outflow.

Bioretention
Bioretention systems are modifications of the traditional parking lot island, designed to provide stormwater treatment. Runoff from impervious areas is directed toward the landscape bioretention areas. The bioretention systems provide treatment for the water quality volume by filtering the runoff through a soil bed and then collecting it in an underdrain system for discharge. Plants provide additional pollutant uptake in these systems.

Submerged Gravel Wetland

Submerged gravel wetlands filter runoff through a rock bed that has wetland vegetation at the surface. The wetland vegetation creates an aerobic layer at the top, while most of the rock bed is anaerobic. The mixture of aerobic and anaerobic zones promotes denitrification.

6.2 Base Criteria

Base criteria for filtering systems (see Table 6.2) ensure that an adequate volume of water is treated for water quality, without overwhelming these relatively small systems. Provisions are also included to prevent clogging of the filtering media, and ensure sufficiently rapid drawdown within the systems. Design criteria for stormwater filtering are presented in Table 6.2. These base criteria apply in both cold and moderate climates.

TABLE 6.2 BASE CRITERIA FOR FILTERING BMPS

- Stormwater filters require a minimum head generally ranging from 2 to 6 feet (the perimeter sand filter can be designed to function with a head a low as 12 inches).
- The maximum contributing area to an individual stormwater filtering system is recommended to be less than 10 acres
- Sites with imperviousness less than 75% will require full sedimentation pretreatment techniques.
- If runoff is delivered to filtering practices in a storm drain pipe or along the main conveyance system, the BMP should be designed as an off-line practice.
- An overflow should be provided within the practice to pass a percentage of the WQ_V to a stabilized water course.
- Stormwater filters should be equipped with a minimum 6" perforated pipe underdrain in a gravel layer.
- Dry or wet pretreatment should be provided prior to filter media equivalent to at least 25% of the computed WQv.
- For bioretention systems, a grass filter strip below a level spreader, gravel diaphragm and mulch layer can be substituted for the pretreatment volume.
- The entire treatment system (including pretreatment) should temporarily hold at least 75% of the WQv.
- The filter bed typically has a minimum depth of 18" (the perimeter filter may have a minimum filter bed depth of 12").
- The filter area shall be sized based on the principles of Darcy's Law.
- Bioretention systems consist of: A four foot deep planting soil bed, a surface mulch layer, and a 6" deep surface ponding area.
- A dense and vigorous vegetative cover should be established for pervious drainage areas
- Surface filters (e.g., surface sand and organic) have a grass cover to aid in the pollutant adsorption.
- Native plants are preferred for bioretention areas
- Maintenance includes removal of sand and silt and periodic mowing in the sediment chamber for surface sand filters
- When the capacity of the filter begins to substantially diminish (i.e., when water ponds on the surface of the filter bed for more than 48 hours), manual removal of the top few inches of discolored material is needed.
- A stone drop of at least six inches should be provided at the inlet of bioretention facilities.

6.3 Cold Climate Modifications

In cold climates, stormwater filtering systems need to be modified to protect the systems from freezing and frost heaving. Measures can also be taken to preserve the infiltration capacity of filtering systems.

6.3.1 Feasibility

All filtering systems rely on the ability of water to flow through a filtering medium. In frozen conditions, the efficiency of these systems is reduced, particularly that of surface filters. The following general guidelines determine BMP feasibility:

- Surface sand filters will not provide treatment during the winter season in areas with long, cold winters (i.e., T_{max} for January below freezing).
- Underground filters not effective during the winter season unless the filter bed can be placed below the frost line. In regions with very deep frost lines (i.e., deeper than 6'), this may not be practical.
- Peat and compost media are ineffective during the winter in cold climates. These filters retain water, and consequently can freeze solid and become completely impervious during the winter.

Although filtering systems are not as effective during the winter in the above conditions, they are often effective at treating *storm events* in areas where other BMPs are not practical, such as in highly urbanized regions. Thus, they may be a good design option, even if winter flows cannot be treated. It is also important to remember that these BMPs are designed for highly impervious areas. If the snow from their contributing areas is transported to another area, such as a pervious infiltration area, their performance during the winter season is not important.

6.3.2 Conveyance

Five modifications are proposed to the conveyance systems in cold climates (Table 6.3). They generally prevent freezing of the conveyance systems and the filter itself. The first three conveyance modifications are illustrated in Figure 6.3.

TABLE 6.3 CONVEYANCE MODIFICATIONS FOR STORMWATER FILTERING BMPS

	Purpose(s)
Minimum 8" Underdrain Diameter	• Encourage rapid draining to retain filtering capacity • Prevent damage from freezing
Underdrain Slope >1%	• Encourage rapid draining to retain filtering capacity
18" of Gravel at Base	• Encourage rapid draining to retain filtering capacity • Prevent damage from freezing
Inflow Pipes at least 2% slope, 12" diameter	• Prevent frost damage
Replace Standpipes with Weirs	• Prevent frost damage

- Minimum 8" underdrain diameter

  All filtering systems, with the exception of the submerged gravel wetland, release treated water to the conveyance system or a downstream point through an underdrain at the base of the filter.

In cold climates, this underdrain pipe may freeze during the winter. By increasing the diameter of the underdrain, freezing is less likely. In addition, a larger diameter underdrain has a greater capacity to drain standing water from the filter. This increased drainage capacity prevents the filtering medium from becoming saturated, thus decreasing the impact of freezing on the permeability of the filter.

- Underdrain pipe slope greater than 1%

  This is a slight increase over the 0.5% proposed for moderate climates. The greater slope increases the velocity at which flow passes through the underdrain system. Thus, the underdrain is less likely to freeze and the filtering medium is less likely to clog.

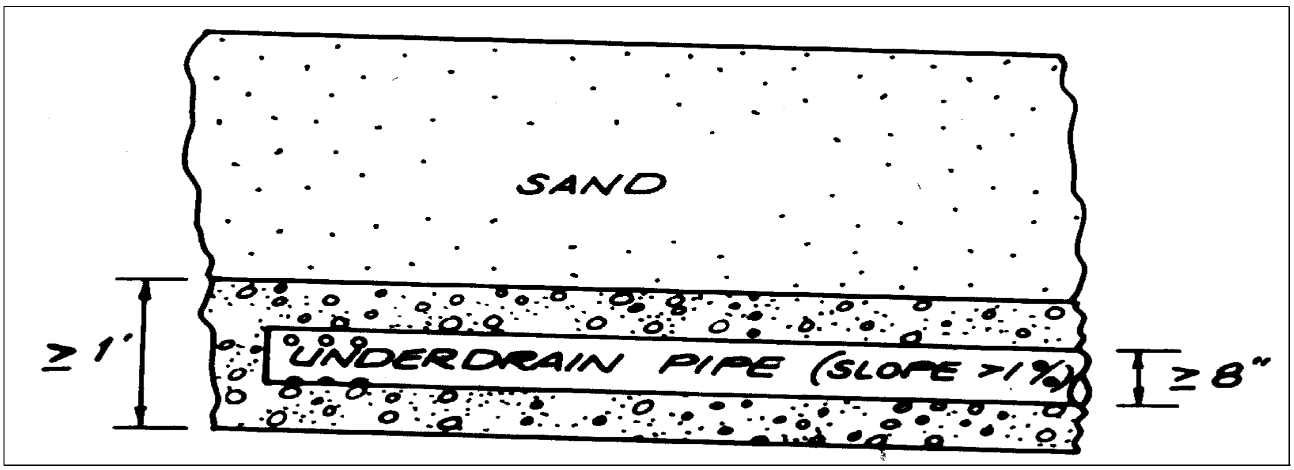
- Eighteen inches of gravel at the base of the filter

  The porous gravel prevents standing water in the system by promoting drainage. Gravel is also less susceptible to frost heaving than finer grained media (See Chapter 1).

- Inflow pipes with a minimum 2% slope and 12" diameter

  Many communities require that stormwater conveyance pipes be located below the frost line. See Chapter 3 for a detailed discussion of this requirement.

FIGURE 6.3 CONVEYANCE MODIFICATIONS TO A STORMWATER FILTER



- Replace standpipes with weirs

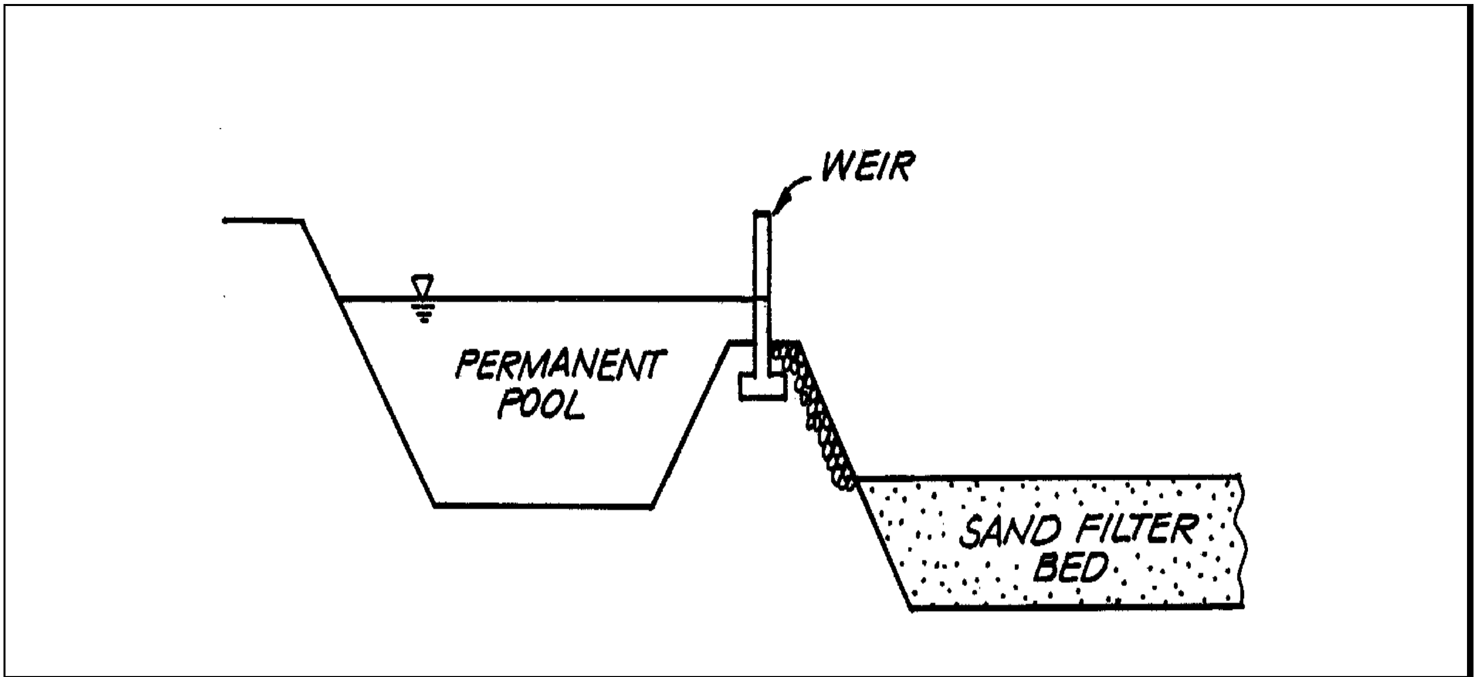
  In moderate climates, a standpipe structure is often used to provide detention in the pretreatment chamber of the filtering system. In cold climates, these pipes are susceptible to freezing. One option is to replace these pipes with weirs, which are “frost free” (Figure 6.4). Although weir structures will not provide detention, they can provide retention storage (i.e., storage with a permanent pool) in the pretreatment chamber. This modification is not necessary if the filter is placed below the frost line.

6.3.3 Pretreatment

When filters drain street or parking lot runoff, sand in runoff may cause some clogging of the filter, or "choking" of vegetation in the case of bioretention or surface sand filters. Two design modifications can counteract these potential problems.

- For sand and gravel filters, the pretreatment chamber should be equal to 40% of the treatment volume. The total treatment volume includes both the pretreatment and treatment volumes. Thus, increasing the pretreatment volume does not increase the total volume of the system.
- For bioretention systems, a grass strip, such as a swale, of at least twenty five feet in length, should convey flow to the system.

FIGURE 6.4 STANDPIPE REPLACED WITH A WEIR



6.3.4 Treatment

In cold climates, treatment can be improved by protecting the filtering bed from frost damage. Alternatively, another BMP option can be used as a backup to filtering systems, to provide treatment during the winter.

TABLE 6.4 TREATMENT DESIGN OPTIONS FOR FILTERING BMPS IN COLD CLIMATES

Design Option	Applicable Filters	Drawbacks
Place filter bed below the frost line	Underground	May result in pumping water to the drainage system, or burying drainage pipes deeper.
Place the filter indoors	Surface/ Perimeter	Expensive. Only applicable in specific instances.
Use redundant treatment	All	Increases the cost of BMP use.

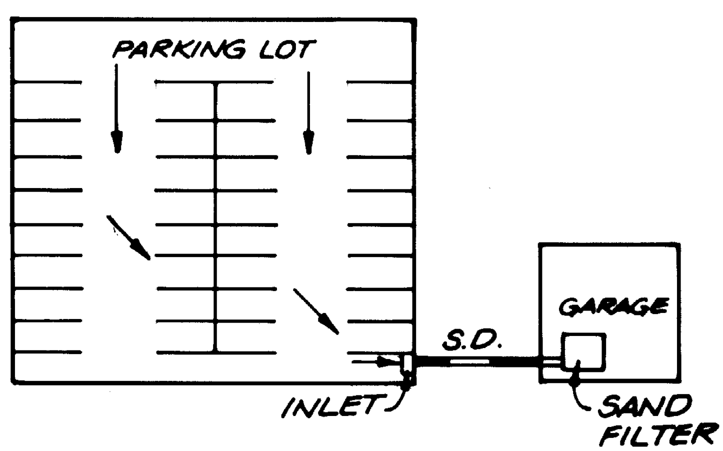
- Place the filter bed below the frost line

  To prevent the filtering medium from freezing during the winter, the filter bed of underground filters should be below the frost line. Since the outflows of these systems may lead to major drainage systems, it may be difficult to achieve this goal in areas of low relief. That is, in order to achieve the necessary head necessary to operate the filter, the drainage pipes must be at a lower elevation than the bottom of the filter bed. Alternatively, outflow from these systems can be pumped to the drainage system.

- Place filters indoors

  Underground sand filters can be located in the basement of a building, such as a parking garage (Figure 6.5). This method has been used in moderate climates, primarily because of the ease of access for maintenance and monitoring. In cold climates, this design can prevent the filter from freezing and protect it from frost heave as well. Extra care should be taken to ensure that leaking does not occur, causing flooding.

FIGURE 6.5 "INDOOR" SAND FILTER



- Use redundant treatment

  A designer may decide that filtering systems are desirable, but not feasible or effective during the winter. For example, bioretention may be desirable in an extremely cold climate even if it does not function during the winter. In these cases, an alternative downstream treatment, such as a wet extended detention pond, may be used to treat winter runoff.

6.3.5 Maintenance

In addition to the regular maintenance of filtering systems, an inspection should be conducted in the spring. Removal of sand from abrasives, and repair of damage to the filtering system, may be necessary after the winter season.

6.3.6 Landscaping

When deicing salts in runoff are directed to surface stormwater filters or bioretention facilities, salt tolerant species should be planted. See Table 4.5 in Section 4.3.5 for some example cold climate plant species.