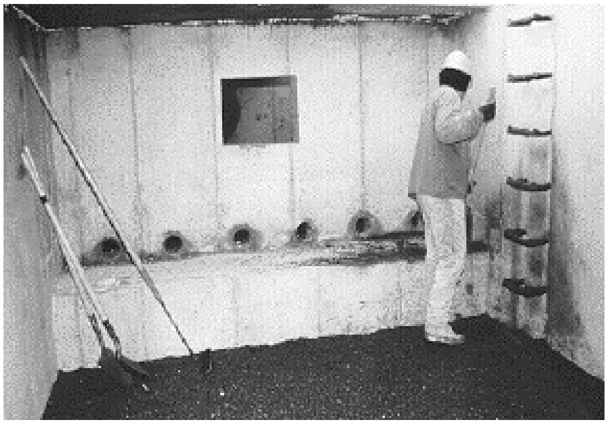
2F-3 Underground Sand Filter



BENEFITS Low = <30% Medium = 30-65% High = 65-100%			
	Low	Med	High
Suspended Solids			■
Nitrogen	■		
Phosphorous		■	
Metals		■	
Bacteriological		■	
Hydrocarbons		■	

Description: Multi-chamber structure designed to treat stormwater runoff through filtration, using a sediment forebay and a sand bed as its primary filter media. In some cases, a third chamber collects filtered runoff. Typically, an underdrain is used to return the filtered runoff to the conveyance system.
Typical Uses: High density/ultra-urban location where available land is restricted, such as a receiving area for runoff from an impervious site.
Advantages/benefits:
- Stormwater filters have their greatest applicability for small development sites – drainage areas of up to 5 surface acres.
- Good for highly impervious areas; good retrofit capability – good for areas with extremely limited space.
- Can provide runoff quality control, especially for smaller storms; generally provide reliable rates of pollutant removal through careful design and regular maintenance.
- High removal rates for sediment, BOD, and fecal coliform bacteria.
- Precast concrete shells available, which decreases construction costs.
- No restrictions on soils at installation site, if filtered runoff is returned to the conveyance system.

Disadvantages/limitations:
- Intended for space-limited applications.
- High maintenance requirements.
- Not recommended for areas with high sediment content in stormwater, or areas receiving significant clay/silt runoff.
- Relatively costly.
- Possible odor problems.
- Porous soil required at site, if filtered runoff is to be exfiltrated back into the soil.
- Not recommended for residential developments due to higher maintenance burden.

Maintenance requirements
- Inspect for clogging – rake first inch of sand.
- Remove sediment from forebay/chamber.

A. Description

The underground sand filter is a design variant of the sand filter located in an underground vault designed for high-density land use or ultra-urban applications where there is not enough space for a surface sand filter or other structural stormwater control. It is intended primarily for extremely space-limited and high-density areas. In this design, the sand filter is placed in a three-chamber underground vault accessible by manholes or grate openings (Figure 2). The vault can be either on-line or off-line in the storm drain system. Of the three chambers, the initial chamber is a sedimentation (pre-treatment) chamber that temporarily stores runoff and utilizes a wet pool to capture sediment. The sedimentation chamber is connected to the sand filter chamber by a submerged wall that protects the filter bed from oil and debris. The filter bed is 18-24 inches deep, and may have a protective screen of gravel or permeable geotextile to limit clogging. During a storm, the water quality volume (WQv) is temporarily stored in both the first and second chambers. Flows in excess of the filter's capacity are diverted through an overflow weir. The sand filter chamber also includes an underdrain system with inspection and cleanout wells. Perforated drain piping under the sand filter bed extends into a third chamber that collects filtered runoff. Flows beyond the filter capacity are diverted through an overflow weir.

Due to its location below the surface, underground sand filters have a high maintenance burden and should only be used where adequate inspection and maintenance can be ensured. For this reason, the underground is considered a limited-application structural BMP.

B. Pollutant removal capabilities

Underground sand filter pollutant removal rates are similar to those for surface and perimeter sand filters (see Section 2F-1).

C. Design criteria

1. Underground sand filters are typically used on highly impervious sites of 1 acre or less. The maximum drainage area that should be treated by an underground sand filter is 5 acres.

2. Maintain a minimum of 2-foot separation from seasonal high groundwater level and the bottom of the filter.

3. Use a three-chamber system as shown in Figures 1, 2, and 3.

4. Initial chamber serves as sedimentation (pre-treatment) to temporarily store runoff and utilizes a wet pool to capture sediment. One foot of sediment storage is recommended.

5. Underground filter components:

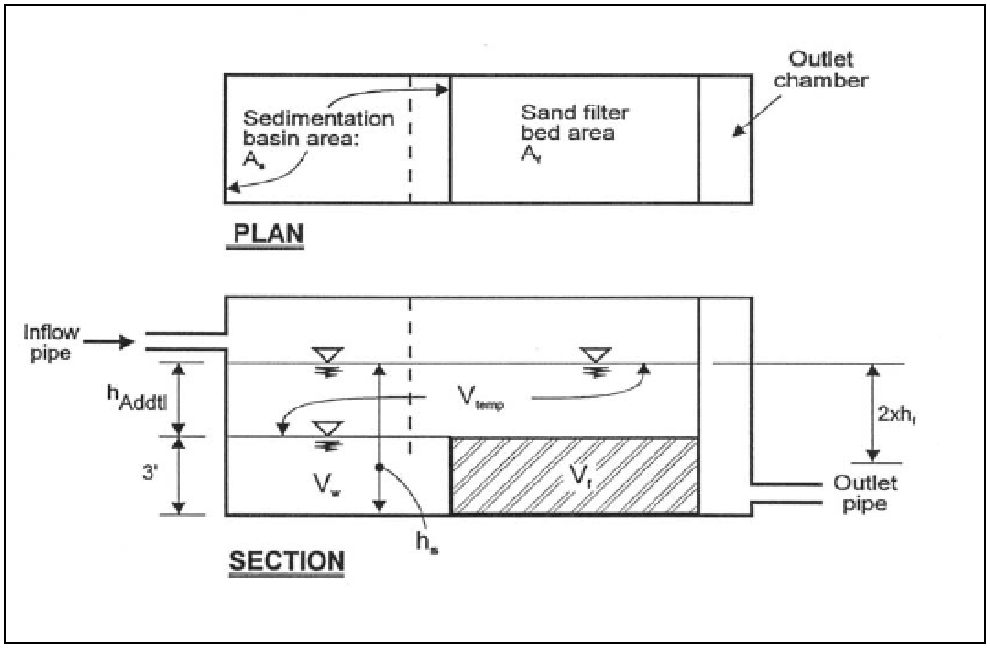
   - Wet retention basin
   - Wet volume: (Vw) = A_s x depth (3 feet deep, minimum permanent pool storage)
   - Total minimum volume: V_{min} = 0.75 x WQv
   - V_{min} split between volume within filter bed (voids), wet volume within sedimentation chamber, volume above wet volume, and volume above sand bed.

6. Overflow weir elevation (in filter chamber) set at design treatment volume, sized to pass 2/3 of WQv peak flow.

7. Flows above the filter capacity are diverted through an overflow weir.

8. Consult the design criteria for the perimeter sand filter (see Section 2F-2) for the rest of the underground filter sizing and design steps.

Figure 1: Underground sand filter volumes



Source: Claytor and Schueler, 1996

9. Sedimentation chamber connected to the sand filter by a submerged wall that protects the filter bed from oil and debris. It should extend 1 foot above and below the design flow water level, and be spaced a minimum of 5 feet horizontally from the inlet. In the event of plugging, provide for bypass of flows. Access must be provided to both sides of the baffle.

10. A maximum of 6 inches between the top of the flow spreader and the top of the sand bed is recommended to reduce sand disturbance. A flow spreader or pipe and manifold system (minimum pipe diameter of 8 inches) can be used.

11. Filter bed is typically 18-24 inches deep; may have a protective screen of gravel or permeable geotextile on top to limit clogging (King County, 1998).

12. The sand filter chamber also includes an underdrain system with inspection and cleanout wells. Perforated drainpipes under the sand filter bed extend into a third chamber that collects filtered runoff. Internal diameters of underdrain piping are a minimum of 6 inches and two rows of ½-inch holes spaced a maximum of 6 inches apart longitudinally, with rows 120 degrees apart (set with holes downward). Maximum perpendicular separation between feeder pipes is 15 feet. All piping is Schedule-40 PVC or greater wall thickness.

13. Drain rock is a clean washed ¾-inch to 1.5-inch rock or limestone aggregate (Iowa DOT #3), free of silt and clay fines and organic material.

14. To prevent anoxic conditions, a minimum of 24 ft^2 of ventilation grate is provided for each 250 ft^2 of sand bed area.

15. The underground vault should be tested for water tightness prior to placement of filter layers.

16. Underground sand filters are typically constructed on-line, but can be constructed off-line. For off-line construction, the overflow between the second and third chambers is not included.

17. Adequate maintenance access must be provided to the sedimentation and filter bed chambers:

    a. At grade access panels are provided for the entire length of the sand bed.

    b. A dewatering valve is provided just above the sand bed. To assist with maintenance of the sand filter, an inlet shut-off/bypass valve is provided.

    c. Cleanout wyes with caps or junction boxes are provided at both ends of the collector pipes. Cleanouts must extend to the surface of the filter. A valve box is provided for access to the cleanouts. Access for cleaning all underdrain piping is provided.

D. Inspection and maintenance requirements

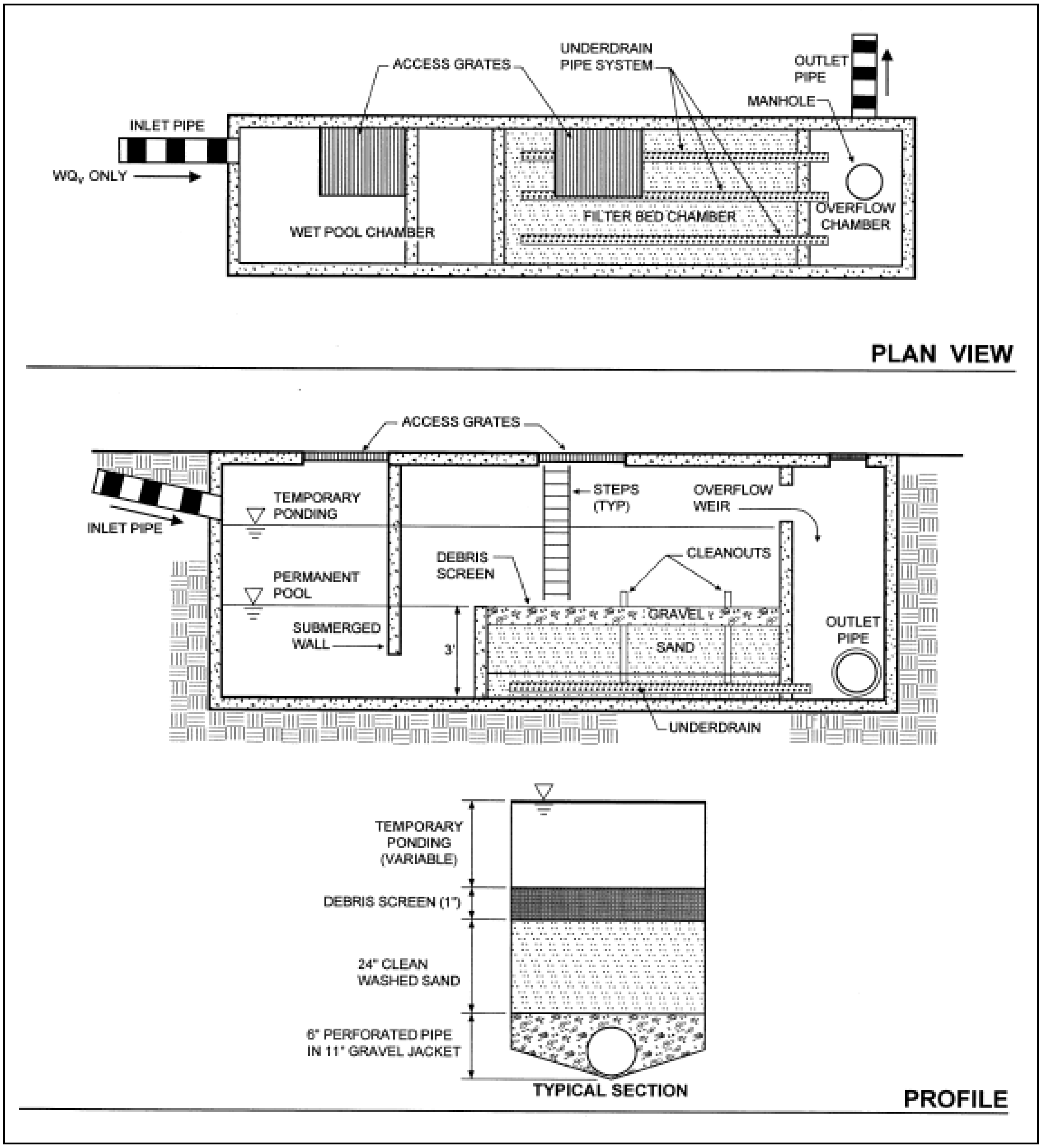
Table 1: Typical maintenance activities for underground sand filters

Maintenance Activity	Schedule
Monitor water level in sand filter chamber	Quarterly and following large storm events
Sedimentation chamber should be cleaned out when the sediment depth reaches 12-inches	As needed
Remove accumulated oil and floatables in sedimentation chamber	As needed (typically every 6 months)

Source: Claytor and Schuler, CRC, 1996

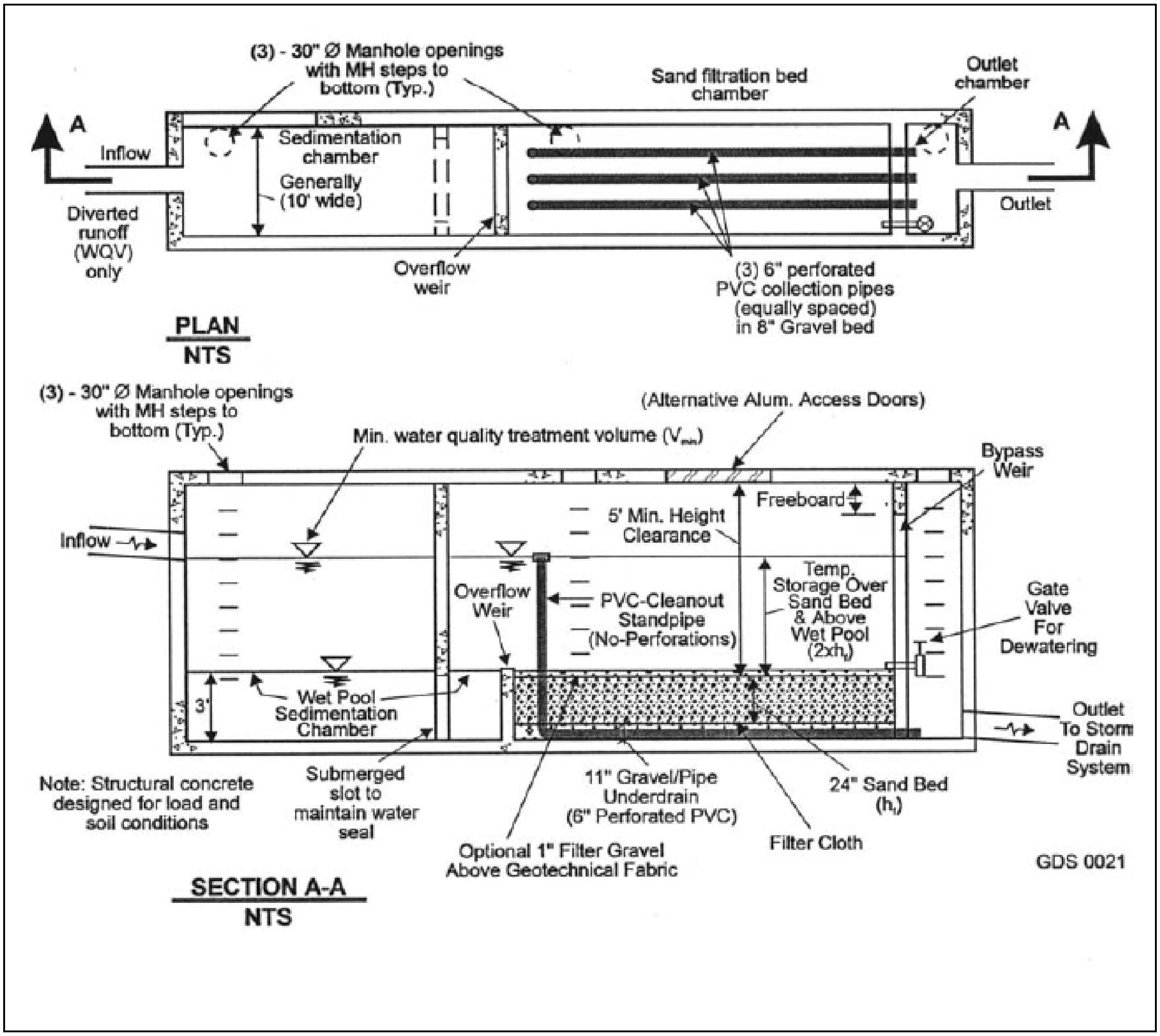
Additional inspection and maintenance requirements for underground filters are similar to those for surface sand filter facilities (Section 2F-2).

Figure 2: Underground sand filter



Source: Adapted from Claytor & Schueler, CRC, 1996

Figure 3: Underground sand filter components



Source: Adapted from Claytor & Schueler, CRC, 1996