CHAPTER

WATER QUALITY
BEST MANAGEMENT PRACTICES 8

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8.1 Non-Structural BMPs

8.1.1 Introduction

Best management practices (BMPs) are the basic mitigation measures used in the stormwater quality management plans to control pollutants within DeKalb County. Section 8.2 of this chapter presents the details of structural best management practices and their use within the county drainage system. The other major category of BMPs include the many non-structural or source control practices that can be used for pollution prevention and control of pollutants. In most cases it is much easier and less costly to prevent the pollutants from entering the drainage system than trying to control pollutants with structural BMPs. Thus within the "treatment train" concept, the non-structural BMPs should be the first line of defense in protecting the receiving streams. If used properly, the non-structural BMPs can be very effective in controlling pollutants and greatly reduce the need for structural BMPs. In addition, non-structural BMPs tend to be less costly, easier to design and implement and easier to maintain than structural BMPs. Non-structural BMPs normally do not have technical or engineering designs associated with them but are measures that the County or other agencies or groups might require or implement to assist in the management water quality and the control of pollutants within the County. Following is a brief discussion of some non-structural BMPs that can be used within a stormwater quality management plan for different portions of the DeKalb County Drainage System.

8.1.2 Public Education/Participation

Public education/participation is not so much a best management practice as it is a method by which to implement BMPs. Public education/participation are vital components of many of the individual source control BMPs. A public education and participation plan provides the County with a strategy for educating its employees, the public, and businesses about the importance of protecting stormwater from improper use, storage, and disposal of pollutants. County employees must be trained, especially those that work in departments not directly related to stormwater but whose actions affect stormwater. Residents must become aware that a variety of hazardous products are used in the home and that their improper use and disposal can pollute stormwater and groundwater supplies. Businesses, particularly smaller ones that may not be regulated by Federal, State, or local regulations, must be informed of ways to reduce their potential to pollute stormwater.

8.1.3 Land Use Planning/Management

This BMP presents an important opportunity to reduce the pollutants in stormwater runoff by using a comprehensive planning process to control or prevent certain land use activities in areas where water quality is sensitive to development. It is applicable to all types of land use and represents one of the most effective pollution prevention practices. Subdivision regulations, zoning ordinances, preliminary plan reviews and detailed plan reviews, are tools that may be used to mitigate stormwater contamination in newly developing areas. Also, master planning, cluster development, terracing and buffers are ways to use land use planning as a BMP in the normal design for subdivisions and other urban developments. Limiting impervious areas is one of the most effective land use management tools, since nationwide research has consistently documented increases in pollution loads with increases in impervious cover. In addition to controlling impervious area cover, directly connected impervious areas should be kept to a minimum. This is especially important for large impervious areas such as parking lots and highways and it can also be effective for small impervious areas such as roof drainage.

8.1.4 Material Use Controls

There are three major BMPs included in this category:

1. Housekeeping Practices
2. Safer Alternative Products
3. Pesticide/Fertilizer Use

In housekeeping practices, the goal is to promote efficient and safe practices such as storage, use, cleanup, and disposal, when handling potentially harmful materials such as fertilizers, pesticides, cleaning solutions, paint products, automotive products, and swimming pool chemicals. In addition, the use of less harmful products can be promoted. Alternatives exist for most product classes including fertilizers, pesticides, cleaning solutions, and automotive and paint products.

Pesticides and fertilizers have become an important component of land use and maintenance for municipalities, commercial land uses and residential land owners. Any usage of pesticides and fertilizers increases the potential for stormwater pollution. BMPs for pesticides and fertilizers include education in their use, control runoff from affected areas, control times when they are used, provide proper disposal areas, etc.

8.1.5 Material Exposure Controls

There are two major BMPs included in this category:

1. Material Storage Control
2. Vehicle Use Reduction

Material storage control is used to prevent or reduce the discharge of pollutants to stormwater from material delivery and storage by minimizing the storage of hazardous materials onsite, storing materials in a designated area, installing secondary containment, conducting regular inspections, and training employees and subcontractors.

Vehicle use reduction is used to reduce the discharge of pollutants to stormwater from vehicle use by high-lighting the stormwater impacts, promoting the benefits to stormwater of alternative transportation, and integrating initiatives with existing or emerging regulations and programs.

8.1.6 Material Disposal And Recycling

There are three major BMPs included in this category:

1. Storm Drain System Signs
2. Household Hazardous Waste Collection
3. Used Oil Collection

Stenciling of the storm drain system (inlets, catch basins, channels, and creeks) with prohibitive language/graphic icons discourages the illegal dumping of unwanted materials. Storm drain system signs act as highly visible source controls that are typically stenciled directly adjacent to storm drain inlets.

Household hazardous wastes are defined as waste materials which are typically found in homes or similar sources, which exhibit characteristics such as: corrosivity, ignitability, reactivity, and/or toxicity, or are listed as hazardous materials by the EPA. Household hazardous waste collection programs are a preventative rather than curative measure and may reduce the need for more elaborate treatment controls. Programs can be a combination of permanent collection centers, mobile collection centers, curbside collection, recycling, reuse, and source reduction.

Used oil recycling is a responsible alternative to improper disposal practices such as dumping oil in the sanitary sewer or storm drain system, applying oil to roads for dust control, placing used oil and filters in the trash for disposal to landfill, or simply pouring used oil on the ground. Commonly used oil collection alternatives are a temporary "drop off" site on designated collection days or the use of private collectors such as automobile service stations, quick oil change centers and auto parts stores.

8.1.7 Spill Prevention And Cleanup

There are two major BMPs included in this category:

1. Vehicle Spill Control
2. Aboveground Tank Spill Control

The purpose of a vehicle spill control program is to prevent or reduce the discharge of pollutants to stormwater from vehicle leaks and spills by reducing the chance for spills by preventive maintenance, stopping the source of spills, containing and cleaning up spills, properly disposing of spill materials, and training employees. It is also very important to respond to spills quickly and effectively.

Aboveground tank spill control programs prevent or reduce the discharge of pollutants to stormwater by installing safeguards against accidental releases, installing secondary containment, conducting regular inspections, and training employees in standard operating procedures and spill cleanup techniques.

8.1.8 Dumping Controls

This BMP addresses the implementation of measures to detect, correct, and enforce against illegal dumping of pollutants on streets and into the storm drain system, streams, and creeks. Substances illegally dumped on streets and into the storm drain system and creeks include paints, used oil and other automotive fluids, construction debris, chemicals, fresh concrete, leaves, grass clippings, and pet wastes.

8.1.9 Connection Controls

There are three major BMPs included in this category:

1. Illicit Connection Prevention
2. Illicit Connection Detection and Removal
3. Leaking Sanitary Sewer Control

Illicit connection protection tries to prevent unwarranted physical connections to the storm drain system from sanitary sewers, floor drains, etc., through regulation, regular inspection, testing, and education. In addition, programs include implementation control procedures for detection and removal of illegal connections from the storm drain conveyance system. Procedures include field screening, follow-up testing, and complaint investigation.

Leaking sanitary sewer control includes implementing control procedures for identifying, repairing, and remediating infiltration, inflow, and wet weather overflows from sanitary sewers into the storm drain conveyance system. Procedures include field screening, testing, and complaint investigation.

8.1.10 Street/Storm Drain Maintenance

There are seven major BMPs included in this category:

1. Roadway Cleaning
2. Catch Basin Cleaning
3. Vegetation Controls
4. Storm Drain Flushing
5. Roadway/Bridge Maintenance
6. Detention/Infiltration Device Maintenance
7. Drainage Channel/Creek Maintenance

Roadway cleaning may help reduce the discharge of pollutants to stormwater from street surfaces by conducting cleaning on a regular basis. However, cleaning often removes the larger sizes of pollutants but not the smaller sizes. Most pollutants are deposited within three feet of the curb which is where the roadway cleaning should be concentrated. Catch basin cleaning on a regular basis also helps reduce pollutants in the storm drain system, reduces high pollutant concentrations during the first flush of storms, prevents clogging of the downstream conveyance system and restores the catch basins' sediment trapping capacity.

Vegetation control typically involves a combination of chemical (herbicide) application and mechanical methods. Mechanical vegetation control includes leaving existing vegetation, cutting less frequently, hand-cutting, planting low maintenance vegetation, mulching, collecting and properly disposing of clippings and cuttings, and educating employees.

Storm drains can be "flushed" with water to suspend and remove deposited materials. Flushing is particularly beneficial for storm drain pipes with grades too flat to be self-cleansing. Flushing helps ensure pipes convey design flow and removes pollutants from the storm drain system. However, flushing will only push the pollutants into downstream receiving waters unless the discharge from the flushing is captured and removed from the drainage system.

Roadway/bridge maintenance is used to prevent or reduce the discharge of pollutants to stormwater by paving as little are as possible, designing bridges to collect and convey stormwater to proper locations, using measures to prevent runoff from entering the drainage system, properly disposing of maintenance wastes, and training employees.

Proper maintenance and silt removal is required on both a routine and corrective basis to promote effective stormwater pollutant removal efficiency for wet and dry detention ponds and infiltration devices. Also, regularly removing illegally dumped items and material from storm drainage channels and creeks will reduce pollutant levels.

8.1.11 Permanent Erosion Control

There are three major BMPs included in this category:

1. Erosion Control - Permanent Vegetation
2. Erosion Control - Flow Control
3. Erosion Control - Channel Stabilization

Vegetation is a highly effective method for providing long term, cost effective erosion protection for a wide variety of conditions. It is primarily used to protect the soil surface from the impact of rain and the energy of the wind. Vegetation is also effective in reducing the velocity and sediment load in runoff sheet flow.

Channel stabilization addresses the problem of erosion due to concentrated flows. Concentrated flows occur in channels, swales, creeks, rivers and other water courses in which a substantial drainage area drains into a central point. Overland sheet flow begins to collect and concentrate in the form of rills and gullies after overland flow of as little as 100 feet. Erosion due to concentrated flow is typically extensive, causing large soil loss, undermining foundations and decreasing the flow capacity of watercourses.

Proper selection of ground cover is dependent on the type of soil, the time of year of planting, and the anticipated conditions that the ground cover will be subjected. In addition, mulching is a form of erosion protection that is commonly used in conjunction with establishment of vegetation. It typically improves infiltration of water, reduces, runoff, holds seed, fertilizer and lime in place, retains soil moisture, helps maintain temperatures, aids in germination, retards erosion and helps establish plants in disturbed areas.

Once flow is allowed to concentrate, it is more difficult to control erosion problems. Thus every effort should be made to maintain sheet flow conditions for runoff. Where concentrated flows are unavoidable, the following techniques can be used to control erosion and resulting water quality problems.

- Rip Rap
- Gabions
- Check Dams
- Level Spreaders
- Armor Protection
- Diversions

For more information on erosion control consult the publication, Manual For Erosion and Sediment Control in Georgia, available from the Georgia Soil and Water Conservation Commission.

8.1.12 Vegetated Filtering Facilities

Filtering storm runoff through vegetation before it enters the downstream drainage system is an acceptable BMP for water quality and quantity control. Although precise design data and criteria are not available, designs are acceptable if they contain control structures that will result in sheet flow conditions through the vegetation and do not contain channels or pipes that will by pass the filtering process. Acceptable BMP's that utilize vegetated filtering facilities include residential yards and open space where the runoff will sheet flow through at least 50 feet of vegetation before entering a channel, pipe, or stream, and sheet flow through stream buffer zones.

8.2 Structural BMP Specifications

8.2.1 Introduction

To provide some guidance in the design and use of different structural BMP's this section gives specifications and performance standards for several BMP's that could find application within the DeKalb County.

Following are the general specifications, recommended specifications, and operation and maintenance requirements, for eight different structural BMP's. For the design of extended detention ponds and retention ponds refer to the Storage Facilities Chapter for examples of storage design. For grassed swales refer to the Open Channel Design Chapter for examples of channel design. For example designs of the infiltration facilities included in this chapter, see the publication Stormwater Infiltration Structure Design, 1994.

Extended Detention Ponds	Retention Ponds
Sand Filters	Constructed Wetlands
Infiltration Trenches	Filter Strips and Flow Spreaders
Grassed/Biofiltration Swales	Oil/Grit Separators

The general design criteria for DeKalb County is to design for the runoff from the first 1.2 inches of rainfall, from the development site or drainage area that drains through the BMP.

8.2.2 Sediment Forebay

For many of the BMPs included in this chapter, especially ponds and infiltration facilities, sediment forebays or equivalent upstream pretreatment should be included. Following are the general criteria to be used for sediment forebay design.

- The forebay should consist of a separate cell, formed by an acceptable barrier.
- The forebay should be sized to contain 0.1 inches of runoff per impervious acre of contributing drainage. The forebay storage volume counts toward the total water quality storage requirements.
- Exit velocities from the forebay should be non-erosive.
- Direct maintenance access for appropriate equipment should be provided to the forebay.
- The bottom of the forebay may be hardened (e.g., using concrete, paver blocks, etc.) to make sediment removal easier.
- A fixed vertical sediment depth maker should be installed in the forebay to measure sediment deposition over time.
- Forebay sediment removal should occur when 50% of the total capacity has been lost.

8.2.3 Extended Detention Ponds

<u>Specifications For Extended Detention Ponds</u>

<u>General Specifications</u>

Extended detention ponds should be designed with a detention time of 24 hours or greater, or discharge the runoff through a filtering device (e.g., rock covered perforated pipe). If the extended detention pond is to be designed for only water quality purposes, then the pond should be designed to capture the runoff from the first 1.2 inches of rainfall from the entire drainage area above the facility.

- A pilot channel should be used that will not cause erosion control problems. Size such that any event runoff will overflow the low flow channel onto the pond floor.
- The floor of the basin should be sloped toward the low flow channel.
- Flowpaths from inflow points to outlets should be maximized. Flowpaths of 1.5:1 (length relative to width) and irregular shapes are recommended.
- Side slopes should be no greater than 3:1 if mowed.
- Inlet and outlet located to maximize flow length.
- Design for full development upstream of control.
- Rip-rap protection (or other suitable erosion control means) should be provided for the outlet and all inlet structures into the pond.
- One (1) foot minimum freeboard above peak stage for top of embankment.
- Emergency spillway designed to pass the 100-year storm event (must be paved in fill areas).
- Each pond should have an emergency drain that can drain the pond within 24 hours.
- Provide maintenance access easement.
- Trash racks, filters or other debris protection provided on outlet.
- Anti-vortex plates should be used on outlet.
- Insure no outlet leakage and use anti-seep collars.
- Provide benchmark for sediment removal.

Recommended Specifications

- Two stage design (Top stage – intended to be dry except for stormwater runoff from larger, infrequent storm events. Bottom stage – sized to store up to 50% of the water quality volume.)
- Top stage should have slopes between 2% and 5% and a depth of 2 to 5 feet.
- Bottom stage have depth from 1.5 to 3 feet deep with a shallow wetland or pool (6 to 12 in.).
- Manage buffer and pond as meadow.
- Provide buffer zone around pool.
- Provide disposal areas for two sediment removal cycles.
- Anti-seep collars or filter diaphragms should be used on barrel of principal spillway.
- Design as off-line pond to bypass larger flows.
- Design as sediment settling basin for pretreatment of the larger particles.

Operation And Maintenance Recommendations

Maintenance considerations should be included in the facility design with maintenance responsibility designated to some person, organization, corporation, etc., unless accepted by DeKalb County for county maintenance.

- Extended dry ponds are used where lack of water or other multi-use considerations preclude the use of wet ponds or constructed wetlands.
- Operation and maintenance is the same as for detention ponds (see storage chapter).
- Maintenance activities include keeping the outlets unclogged, control of vegetation, removal of sediment deposits, keep aesthetics of area acceptable.

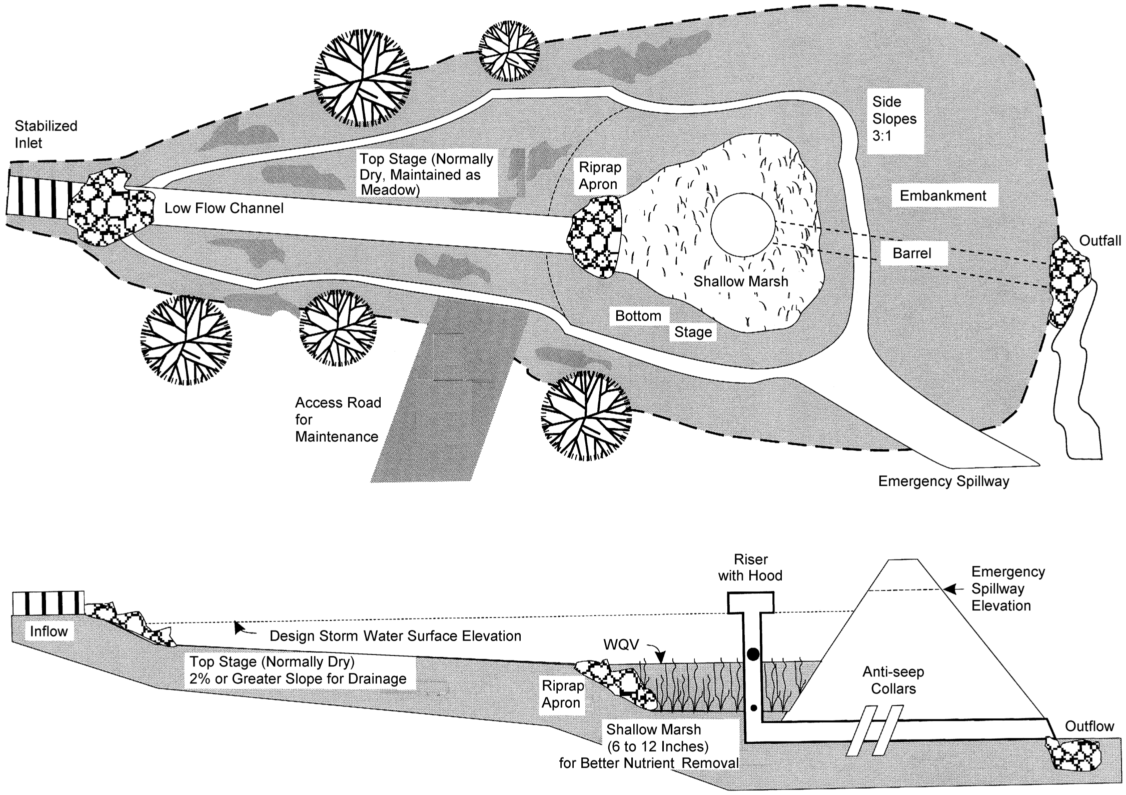

Figure 8-1 Extended Detention Pond

Source: Controlling Urban Runoff

8.2.4 Retention Ponds

<u>Specifications For Retention (Wet) Ponds</u>

<u>General Specifications</u>

Retention detention ponds should be designed with a minimum detention time of 24 hours or discharge the runoff through a filtering device (e.g., rock covered perforated pipe). If the retention pond is to be designed for only water quality purposes, then the pond should be designed to capture the runoff from the first 1.2 inches of rainfall from the development site or drainage area that drains through the BMP.

- Minimum length to width ratio of 3:1 (preferably expanding outward toward the outlet). Irregular shorelines for larger ponds also provide visual variety.
- Inlet and outlet located to maximize flow length. Use baffles if short circuiting cannot be prevented with inlet-outlet placement. Long flowpaths and irregular shapes are recommended.
- Minimum depth of permanent pool 2 to 3 feet, maximum depth of 6 to 8 feet. Average depth should be 3 to 7 feet.
- Design for full development upstream of control.
- Side slopes should be no greater than 3:1 if mowed.

- Rip-rap protection should be provided (or other suitable erosion control means) for the outlet and all inlet structures into the pond. Individual boulders or baffle plates can work for this.
- Minimum drainage area of 10 acres.
- Anti-seep collars or filter diaphragms should be provided on barrel of principal spillway.
- If reinforced concrete pipe is used for the principal spillway, O-ring gaskets (ASTM C361) should be used to create watertight joints.
- One (1) foot minimum freeboard above peak stage for top of embankment.
- Emergency drain; i.e. sluice gate, drawdown pipe; capable of draining within 24 hours should be installed.
- Emergency spillway designed to pass the 100-year storm event.
- Trash racks, filters, hoods or other debris control provided on riser.
- Principal spillway/riser should incorporate anti-floatation, anti-vortex, and trash-rack designs.
- Provide maintenance access.
- Provide benchmark for sediment removal.

Recommended Specifications

- Multi-objective use such as amenities or flood control.
- Landscaping management of buffer as meadow.
- Design for multi-function as flood control and extended detention.
- Minimum length to width ratio of 3:1 to 4:1 (preferably wedge shaped).
- Use reinforced concrete instead of corrugated metal for pipes.
- Sediment forebay for larger ponds (often designed for 5 to 15 percent of total volume). Forebay should have separate drain for de-watering. Grass biofilters for smaller ponds.
- Consider artificial mixing for small sheltered ponds.
- Provision should be made for vehicle access at a 4:1 slope.
- Impervious soil boundary to prevent drawdown may be needed.
- Shallow marsh area around fringe 25 to 50 percent of area (including aquatic vegetation) should be established.
- A safety bench with a minimum width of 10 feet should be provided around the permanent pool.
- The perimeter of all deep permanent pool areas (four feet or greater in depth) should be surrounded by two benches with a combined minimum width of 15 feet:
  - A safety bench that extends outward from the normal water edge to the toe of the pond side slope. The maximum slope of the safety bench should be 6%.
  - An aquatic bench that extends inward from the normal shoreline and has a maximum depth of eighteen inches below the normal pool water surface elevation. An aquatic bench is not required in forebays.
- Disposal areas, for two sediment removal cycles, should be provided and protected from runoff.
- An oil and grease skimmer may be needed for sites with high production of pollutants.

Operation And Maintenance Recommendations

- Sediment to be removed when 20% of storage volume of the facility is filled (design storage volume must account for volume lost to sediment storage).
- Sediment traps should be cleaned out when filled.
- No woody vegetation should be allowed on the embankment without special designs.
- Vegetation over 18 inches high should be cut unless it is part of planned landscaping.
- Debris should be removed from blocking inlet and outlet structures and from areas of

potential clogging.

- The outlet control should be kept structurally sound, free from erosion, and functioning as designed.
- Periodic removal of dead vegetation should be accomplished.
- Inspection requirements should be outlined in the design.
- The site should be inspected and debris removed after every major storm.
- Maintenance considerations should be included in the facility design with maintenance responsibility designated to some person, organization, corporation, etc.
- Mow embankment and side slopes at least twice a year.
- Consider chemical treatment by alum if algal blooms are a problem.

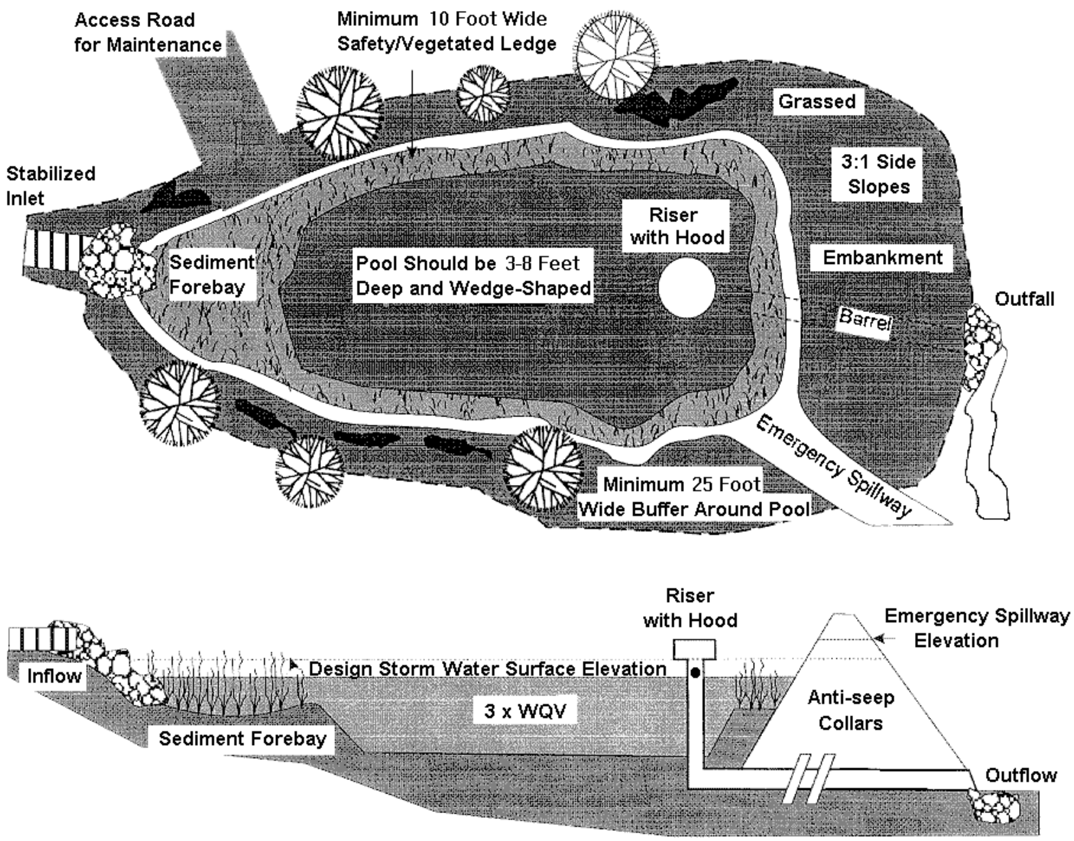

Figure 8-2 Retention (Wet) Pond

Source: Controlling Urban Runoff

8.2.5 Sand Filters

Specifications For Sand Filters

General Specifications

- Maximum contributing drainage area to an individual stormwater filtering system is usually less than 10 acres.
- Accommodate the runoff from the first 1.2 inches of rainfall from the development site or drainage area that drains through the BMP.
- Adequate pretreatment (e.g., filter strips) is required to prevent sediment from overloading the filters.
- Most stormwater filters normally require one to six feet of head.
- Designed to completely empty in 36 hours.
- Inlet structure should be designed to spread the flow uniformly across the surface of the filter media.
- Stone riprap or other dissipation devices should be installed to prevent gouging of the sand media and to promote uniform flow.
- Final sand bed depth should be at least 18 inches.
- Underdrain pipes should consist of main collector pipes and perforated lateral branch pipes.
- The underdrain piping should be reinforced to withstand the weight of the overburden.
- Internal diameters of lateral branch pipes should be 4 inches or greater (6 inches preferred) and perforations should be 3/8 inch.
- Maximum spacing between rows of perforations should not exceed 6 inches.
- All piping should be schedule 40 polyvinyl chloride or greater strength.
- Minimum grade of piping should be 1/8 inch per foot (1% slope).
- Access for cleaning all underdrain piping should be provided.
- Surface filters may have a grass cover to aid in pollution adsorption.
- Vegetation should be established over the contributing drainage areas before runoff can be accepted into the facility.

Recommended Specification

- Two sand bed configurations are recommended for use:

1) Sand Bed with Gravel Layer;
   - Top layer of sand should be a minimum of 18 inches of 0.02 - 0.04 inch diameter sand (smaller sand size is acceptable).
   - A layer of one-half to 2-inch diameter gravel under the sand should be provided for a minimum of 2 inches of cover over the top of the under-drain lateral pipes.
   - No gravel is required under the lateral pipes.
   - The sand and gravel should be separated by a layer of geotextile fabric (permeable filter fabric).

2) Sand Bed with Trench Design;
   - Top layer of sand is to be 12-18 inches of 0.02 - 0.04 inch diameter sand (smaller size is acceptable).
   - Laterals to be placed in trenches with a covering of one-half to 2-inch gravel and geotextile fabric.

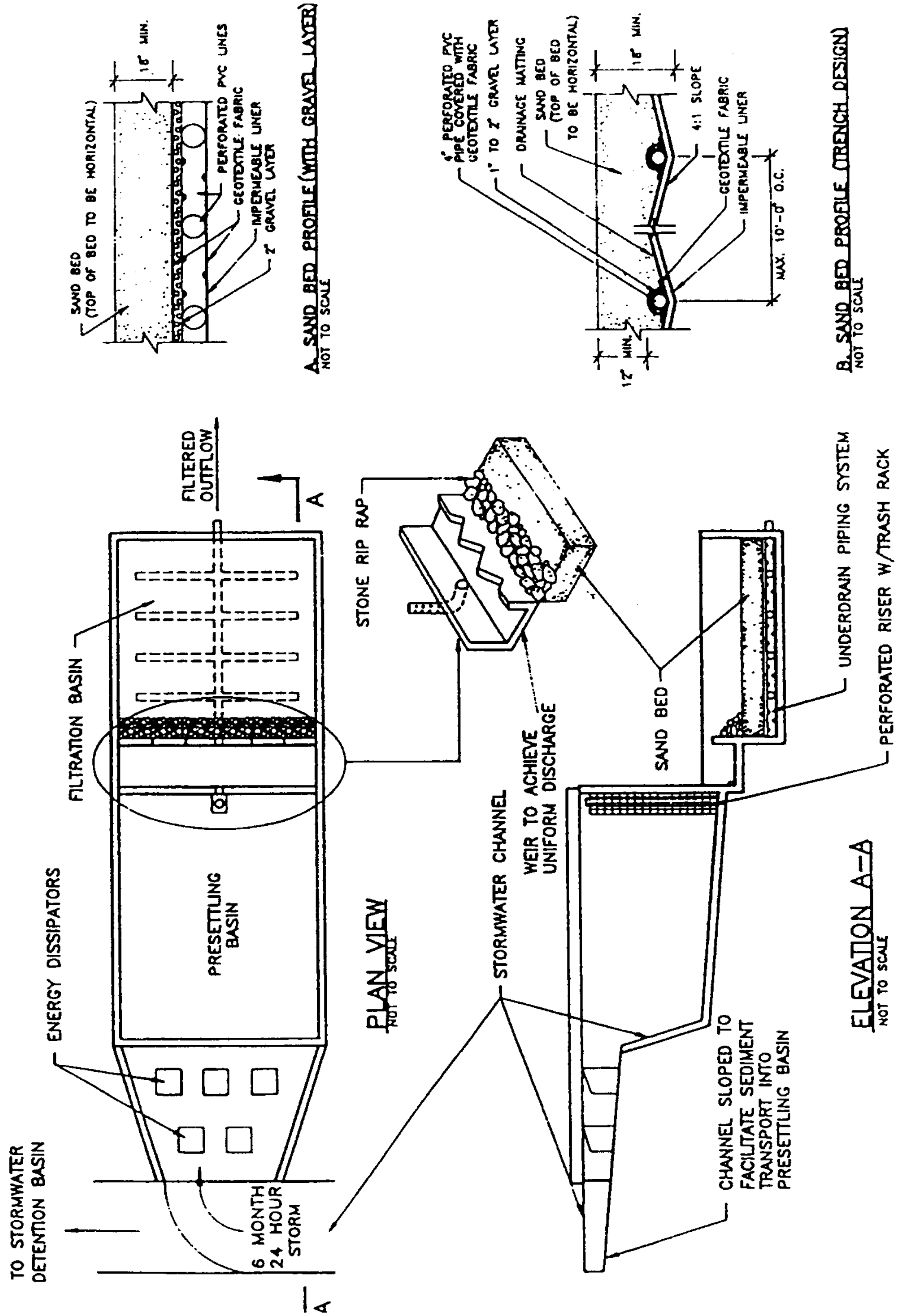

Figure 8-3 Sand Filtration Basin

Source: Stormwater Management Manual For The Puget Sound Basin

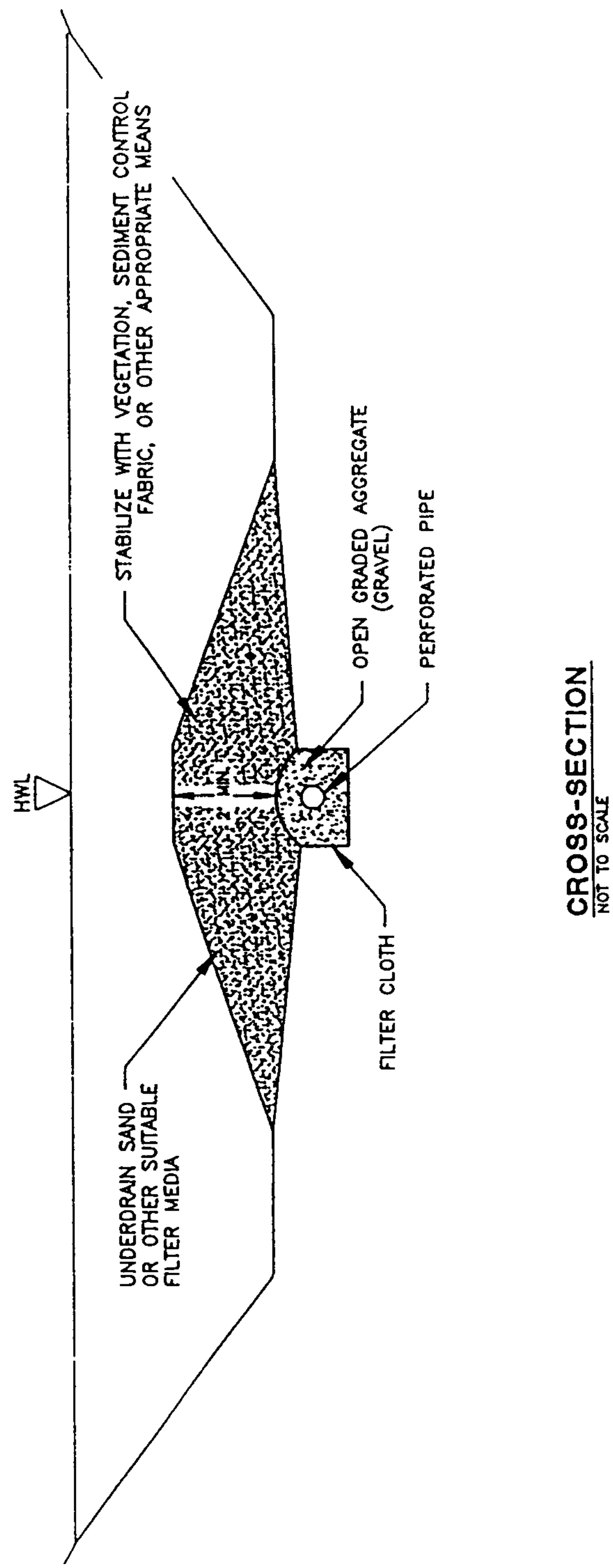

Figure 8-4 Cross-Section Of Elevated Sand Filter

Source: Florida Erosion And Sediment Control Handbook

- The lateral pipes are to be underlain by a layer of drainage matting.

- A presettling basin and/or biofiltration swale is recommended to pretreat runoff discharging to the sand filter.
- A maximum spacing of 10 feet between lateral underdrain pipes is recommended.

Operation And Maintenance Recommendations

- Maintenance considerations should be included in the facility design with maintenance responsibility designated to some person, organization, corporation, etc.
- Scrape off sediment layer buildup during dry periods with steel rakes or other devices.
- Replace some or all of the sand when permeability of the filter media is reduced to unacceptable levels which should be specified in the design of the facility. A minimum infiltration rate of 0.5 inches per hour should be used for all infiltration designs.

8.2.6 Constructed Wetlands

Specifications For Constructed Wetlands

General Specifications

- Inflow of water must be greater than that leaving the basin by infiltration or exfiltration.
- A water balance should be performed to demonstrate that the wetland can withstand a thirty day drought at summer evaporation rates without completely drawing down.
- Designed for an extended detention time of 24 hours or discharge the runoff through a filtering device (e.g., rock covered perforated pipe) for the design volume of runoff from the first 1.2 inches of rainfall.
- The orifices used for extended detention will be vulnerable to blockage from plant material or other debris that will enter the basin with stormwater runoff. Therefore, some form of protection against blockage should be installed (such as some type of non-corrodible wire mesh).
- Surface area of the wetland should account for a minimum of 1 percent of the area of the watershed draining into it (1.5 percent for a shallow marsh design).
- The length to width ratio should be at least 2 to 1.
- A soil depth of at least 4 inches should be used for shallow wetland basins.
- A minimum of 35 percent of the total surface area should have a depth of six inches or less and at least 65 percent of the total surface area should be shallower than 18 inches.
- The deeper area of the wetland should include the outlet structure so outflow from the basin is not interfered with by sediment buildup.
- A forebay should be established at the pond inflow points to capture larger sediments and be 4 to 6 feet deep. Direct maintenance access to the forebay should be provided. Sediment depth markers should be provided.
- If high water velocity is a potential problem, some type of energy dissipation device should be installed.
- The designer should maximize use of existing- and post-grading pondscaping design to create both horizontal and vertical diversity and habitat.
- A minimum of 2 aggressive wetland species (primary species - Figure 8-5) of vegetation should be established in quantity on the wetland.
- Three additional wetland species (secondary species- Figure 8-5) of vegetation should be planted on the wetland, although in far less numbers than the two primary species.
- 30 to 50 percent of the shallow (12 inches or less) area of the basin should be planted with wetland vegetation. The optimal depth requirements for several common species of emergent wetland plants are often six inches of water or less.
- Approximately 50 individuals of each secondary species should be planted per acre; set

out in 10 clumps of approximately 5 individuals and planted within 6 feet of the edge of the pond in the shallow area leading up to the ponds edge; spaced as far apart as possible, but no need to segregate species to different areas of the wetland.

- Wetland mulch, if used, should be spread over the high marsh area and adjacent wet zones (-6 to +6 inches of depth) to depths of 3 to 6 inches.
- A buffer zone, for all but pocket wetlands, should be established and planted with riparian and upland vegetation (50 foot buffer if wildlife habitat value required in design). In addition, an additional 15 feet setback to structures should be included.
- Surrounding slopes should be stabilized by planting in order to trap sediments and some pollutants and prevent them from entering the wetland.
- The wetland should be maintained to prevent loss of area of ponded water available for emergent vegetation due to sedimentation and/or accumulation of plant material.
- Local assistance should be obtained for information concerning plants to be used, planting schedule, soil requirements, mulch requirements, etc.

Recommended Specification

- It is recommended that the frequently flooded zone surrounding the wetland be located within approximately 10 to 20 feet from the edge of the permanent pool.
- Soil types conducive to wetland vegetation should be used during construction.
- The wetland should be designed to allow slow percolation of the runoff through the substrate (add a layer of clay for porous substrates).
- The depth of the forebay should be in excess of 3 feet and contain approximately 10 percent of the total volume of the normal pool.
- As much vegetation as possible and as much distance as possible should separate the basin inlet from the outlet.
- Of the 75 percent of the wetland that should be 12 inches deep or less, it is recommended that approximately 25 percent range from 6 inches deep to 12 inches deep, and that the remaining 50 percent be 6 inches or less in depth.
- The water should gradually get shallower about 10 feet from the edge of the pond.
- The planted areas should be made as square as possible within the overall design of the wetland, rather than long and narrow.
- The only site preparation that is necessary for the actual planting (besides flooding the basin) is to ensure that the substrate is soft enough to permit relatively easy insertion of the plants.

Operation And Maintenance Recommendations

- Maintenance considerations should be included in the facility design with maintenance responsibility designated to some person, organization, corporation, etc., with more intense activity for the first three years after construction.
- The wetland should be maintained to prevent loss of area of ponded water available for emergent vegetation due to sedimentation and/or accumulation of plant material.
- Sediment forebays should be cleaned every 2 to 5 years except for pocket wetlands without forebays which are cleaned after a six inch accumulation of sediment.

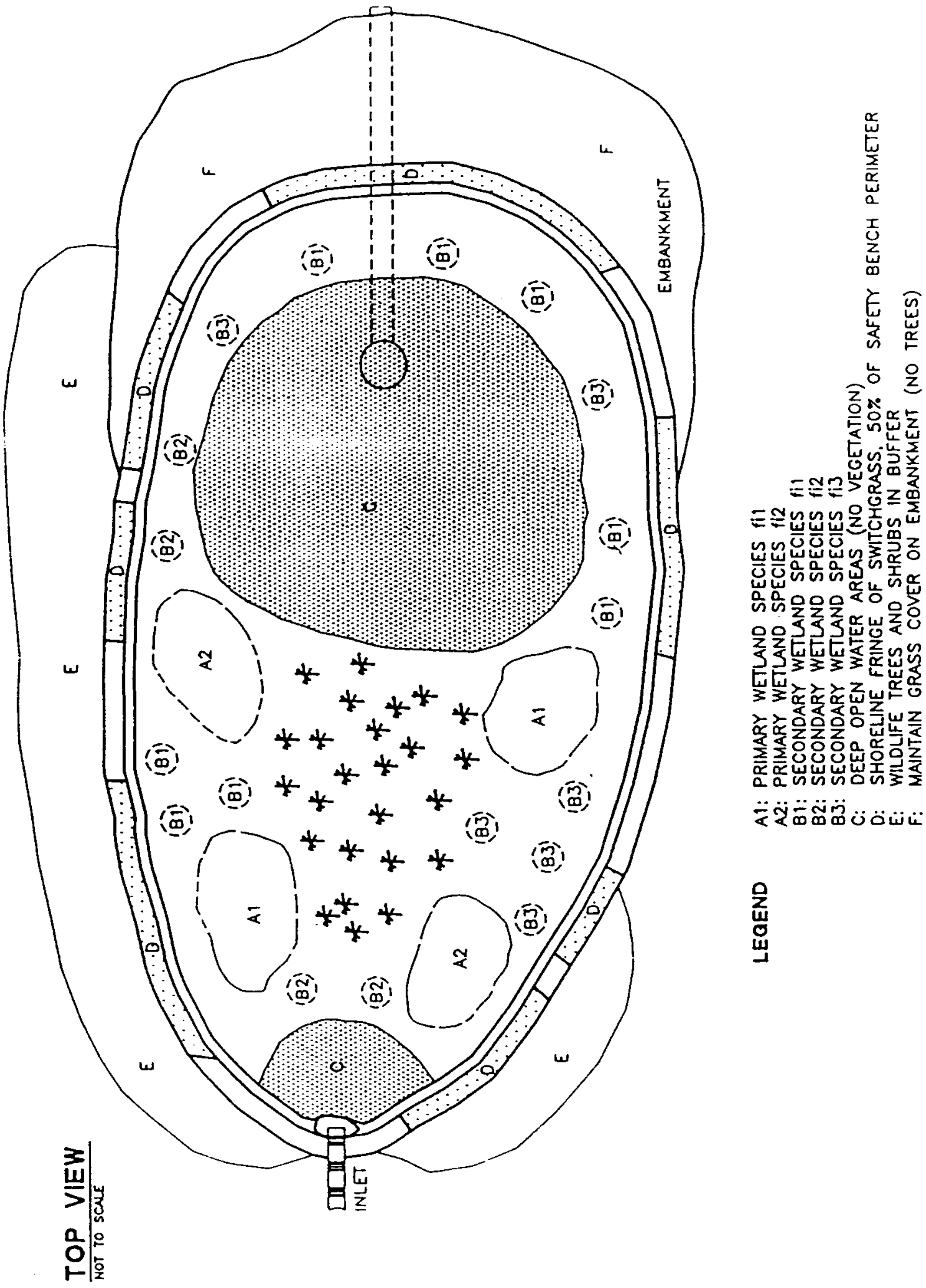

Figure 8-5 Shallow Marsh Planting Strategies

Source: Controlling Urban Runoff

- The ponded water area may be maintained by raising the elevation of the water level in the permanent pond, by raising the height of the orifice in the outlet structure, or by removing accumulated solids by excavation.

- Water levels may need to be supplemented or drained periodically until vegetation is fully established.
- It may be desirable to remove contaminated sediment bottoms or to harvest above ground biomas and remove it from the site in order to permanently remove pollutants from the wetland.

8.2.7 Infiltration Trenches

Specifications For Infiltration Trenches

General Specifications

- Used in small drainage areas less than 5 acres.
- Designed to drain the water volume from the first 1.2 inches of rainfall in 24 hours or discharge the runoff through a filtering device (e.g., rock covered perforated pipe).
- A minimum of one soils boring is required for every 50 feet of trench length, and no less than 2 soils logs for each proposed trench location. Borings should be taken to a depth of at least five feet below the trench depth.
- Each soils boring should extend a minimum of 3 feet below the bottom of the trench, describe the NRCS series of the soil, the textural class of the soil horizon(s) through the depth of the log, and note any evidence of high ground water level, such as mottling. In addition, the location of impermeable soil layers or dissimilar soil layers should be determined.
- For runoff treatment, the soil infiltration rate should be between 0.5 and 2.4 inches per hour.
- Soil textures with minimum infiltration rates of 0.5 inches per hour or less are not suitable for infiltration trenches.
- Soils should have a clay content of less than 15 percent and a silt/clay content of less than 40 percent.
- Soils that have a 30 percent or greater clay content are not suitable for infiltration trenches.
- Soils that are suitable for infiltration systems are silt loam, loam, sandy loam, loamy sand, and sand.
- The use of infiltration systems on fill is not allowed due to the possibility of creating an unstable subgrade.
- A minimum of 3 feet difference is required between the bottom of the infiltration trench and the groundwater table and to bedrock.
- Site slope must be less than 20 percent, and the trench must be horizontal.
- The proximity of building foundations should be at least 25 feet horizontally.
- A minimum distance of 100 feet from water supply wells should be maintained when the runoff is from industrial or commercial areas.
- The design infiltration rate should be equal to one-half the infiltration rate found from the soil textural analysis.
- Water quality infiltration trenches must be preceded by a pretreatment BMP.
- If the trench is preceded by a presettling basin, then the combination of both BMPs must be designed to drain the design water volume within 48 hours.
- The aggregate material for the trench should consist of a clean aggregate with a maximum diameter of 3 inches and a minimum diameter of 1.5 inches.
- Stone aggregate backfill material for the trench should have a maximum diameter of 3 inches and a minimum diameter of 1.5 inches. For design purposes, void space for these

aggregates may be assumed to be in the range of 30 percent to 40 percent. Void ratio of .40 should be used to design stone reservoirs for infiltration practices.

- The aggregate should be completely surrounded with an engineering filter fabric. If the trench has an aggregate surface, filter fabric should surround all aggregate fill material except for the top one foot.
- Runoff must infiltrate through at least 18 inches of soil.
- An observation well should be installed for every 50 feet of trench length.
- The observation well should consist of perforated PVC pipe, 6 inches in diameter, located in the center of the structure, and be constructed flush with the ground elevation of the trench.
- The top of the observation well should be capped to discourage vandalism and tampering.
- Bypass larger flows

Recommended Specifications

- Infiltration trenches work well for residential lots, commercial areas, parking lots, and open space areas.
- Can be installed under a swale to increase the storage of the infiltration system.
- Infiltration systems should not be constructed until all construction areas draining to them are fully stabilized.
- An analysis should be made to determine any possible adverse effects of seepage zones when there are nearby building foundations, basements, roads, parking lots, or sloping sites.

Operation And Maintenance Recommendations

- Maintenance considerations should be included in the facility design with maintenance responsibility designated to some person, organization, corporation, etc.
- The trench should be monitored after every large storm (rainfall greater than 1 inch in 24 hours) for the first year after completion of construction and be monitored quarterly thereafter.
- Sediment buildup in the top foot of stone aggregate or the surface inlet should be monitored on the same schedule as the observation well.

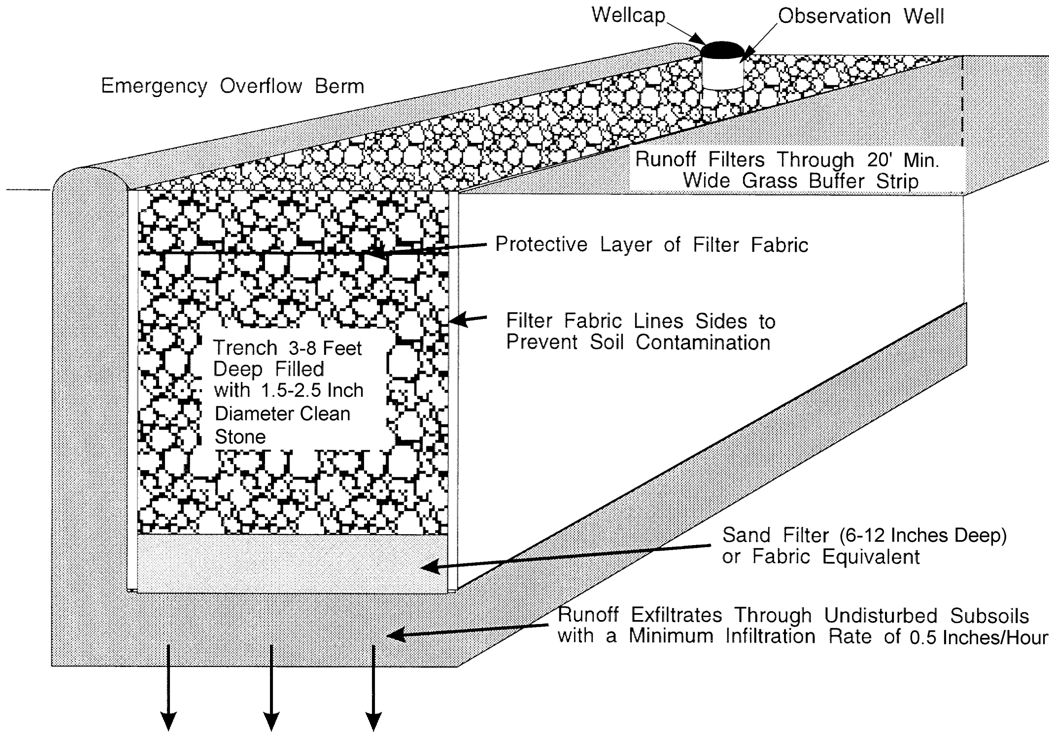

Figure 8-6 Infiltration Trench

Source: Stormwater Management Manual For The Puget Sound Basin

8.2.8 Filter Strips And Flow Spreaders

Standard Specifications For Filter Strips And Flow Spreaders

General Specifications

- The use of filter strips and flow spreaders should be limited to drainage areas of 10 acres or less with the optimal size being less than 5 acres.
- Capacity of the spreader and/or filter strip length (perpendicular to flow) should be determined by estimating the volume of flow that is diverted to the spreader for water quality control.
- Drainage area into spreader should be restricted so that maximum flow will not exceed 30 cfs.
- Channel grade for the last 20 feet of the dike or diversion entering the level spreader should be less than or equal to 1% and designed to provide a smooth transition into spreader.
- Grade of a level spreader should be 0%.
- Depth of a level spreader as measured from the lip should be at least 6 inches.
- Appropriate length, width, and depth of flow spreader should be selected from the following table.

Design Flow (cfs)	Entrance Width (ft)	Depth (ft)	End Width (ft)	Length (ft)

0 - 10	10	0.5	3	10
10 - 20	16	0.6	3	20
20 - 30	24	0.7	3	30

- The level spreader lip should be constructed on undisturbed soil (not fill material) to uniform height and zero grade over length of the spreader.
- The released runoff to the outlet should be on undisturbed stabilized areas in sheet flow and not allowed to reconcentrate below the structure.
- Slope of the filter strip from a level spreader should not exceed 10 percent.
- All disturbed areas should be vegetated immediately after construction.
- Filter strip width to be a minimum of 20 feet.

Recommended Specifications

- Top edge of filter strip should directly abut the contributing impervious area and follow the same elevational contour line.
- Runoff water containing high sediment loads to be treated in a sediment trapping device before release in a flow spreader.
- Spreader lip to be protected with erosion resistant material, such as fiberglass matting or a rigid non-erodible material for higher flows, to prevent erosion and allow vegetation to be established.
- Wooded filter strips are preferred to gravel strips.

Operation And Maintenance Recommendations

- Maintenance considerations should be included in the facility design with maintenance responsibility designated to some person, organization, corporation, etc. The maintenance considerations should require the owner of the filter strip/flow spreader to periodically clean the structure.
- Flow spreader should be inspected after every rainfall until vegetation is established, and needed repairs made promptly.
- After area is stabilized, inspections should be made quarterly.
- Vegetation should be kept in a healthy, vigorous condition.
- Filter strip and flow spreader should be maintained in a manner to achieve sheet flow.

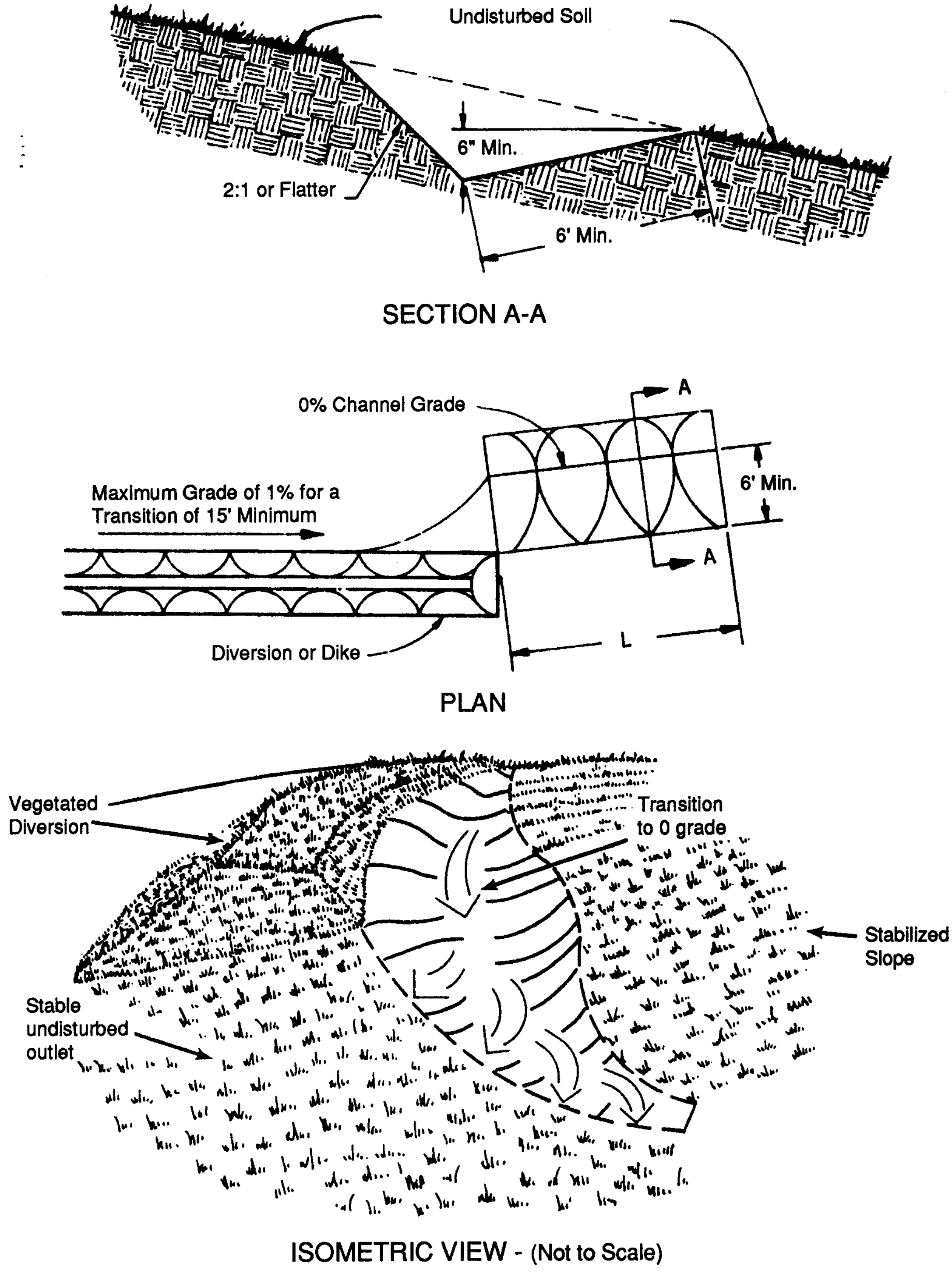

Figure 8-7 Flow Spreader

Source: North Carolina Erosion And Sediment Control Planning And Design Manual, 1988

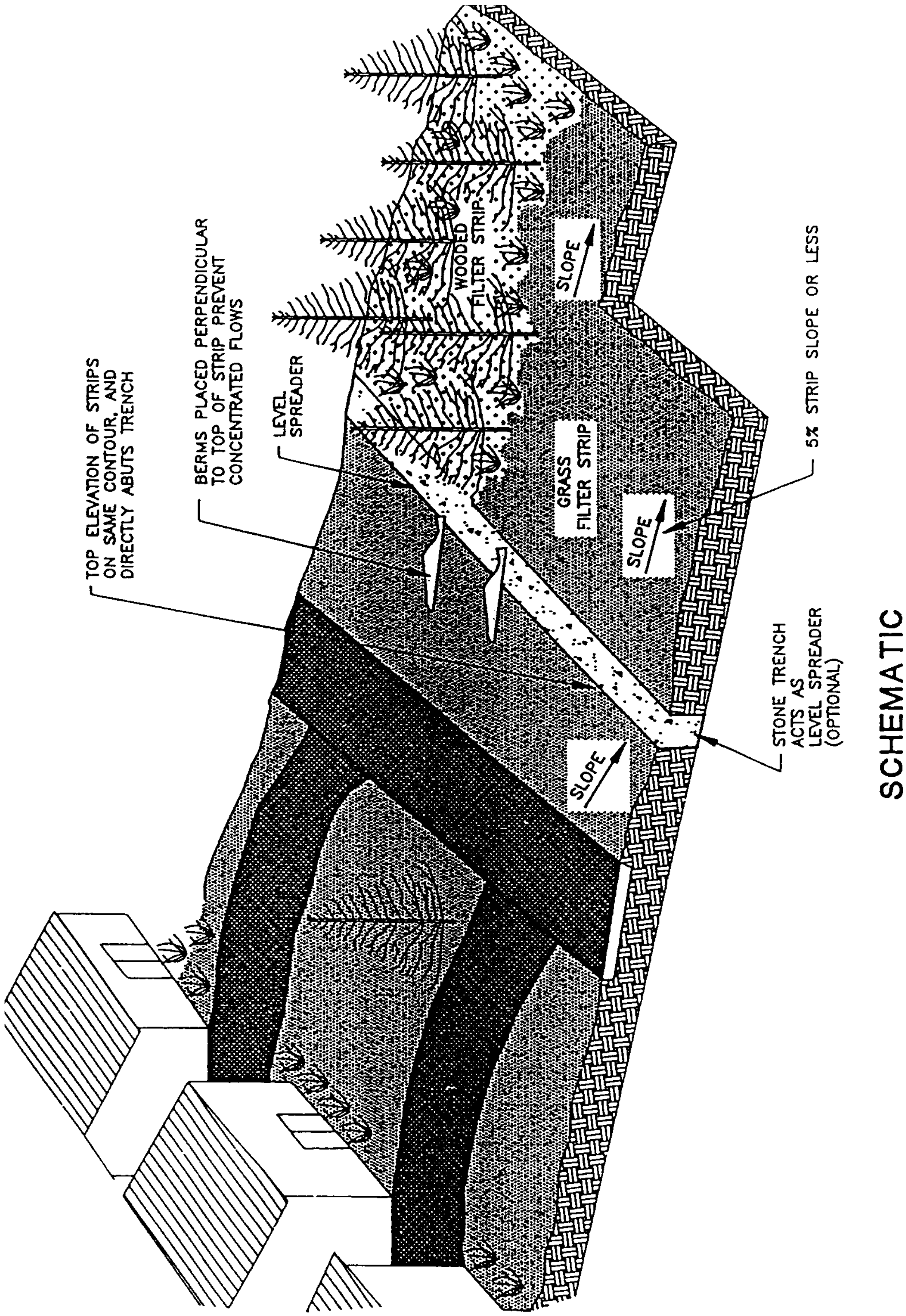

Figure 8-8 Schematic Of A Filter Strip

Source: Controlling Urban Runoff

8.2.9 Grassed/Biofiltration Swales

Standard Specifications For Grassed Swales

Grassed swales are also described as biofiltration swales with the major difference being that grassed swales often have check dams where biofiltration swales do not.

General Specifications

- Grassed swale should only convey standing or flowing water following a storm.
- As a water quality BMP, grass swales should be designed for the water quality volumes that can be expected from the first 1.2 inches of rainfall.
- Limited to peak discharges generally less than 5 to 10 cfs.
- Limited to runoff velocities less than 2.5 ft/s.
- Maximum design flow depth to be 1 foot.
- Swale slopes should be graded as close to zero as drainage will permit.
- Swale slope should not exceed 4 percent (2 percent is preferred).
- Swale cross-section should have side slopes of 3:1 (h:v) or flatter.
- Underlying soils should have a high permeability (fc > 0.5 inches per hour).
- Swale area should be tilled before grass cover is established.
- Dense cover of a water tolerant, erosion resistant grass should be established.
- To obtain credit as a water quality BMP, grassed swales must have a minimum length of 100 feet.

Recommended Specifications

- As a BMP, grassed swales are limited to residential or institutional areas where percentage of impervious area is relatively small.
- Seasonally high water table to be greater than 3 feet below the bottom of the swale.
- Check dams can be installed in swales to promote additional infiltration. Recommended method is to sink a railroad tie halfway into the swale. Riprap stone should be placed on the downstream side to prevent erosion.
- Maximum ponding time behind check dam to be less than 48 hours. Minimum ponding time of 30 minutes is recommended to meet water quality goals.

Operation And Maintenance Recommendations

- Maintenance considerations should be included in the facility design with maintenance responsibility designated to some person, organization, corporation, etc. The maintenance considerations should require the owner of the grassed swale to periodically clean the structure.
- Grass swale should be maintained to keep grass cover dense and vigorous.
- Maintenance should include periodic mowing, occasional spot reseeding, and weed control.
- Swale grasses should never be mowed close to the ground. Grass heights in the 4 to 6 inch range are recommended.
- Fertilization of grass swale should be done when needed to maintain the health of the grass, with care not to over-apply the fertilize.

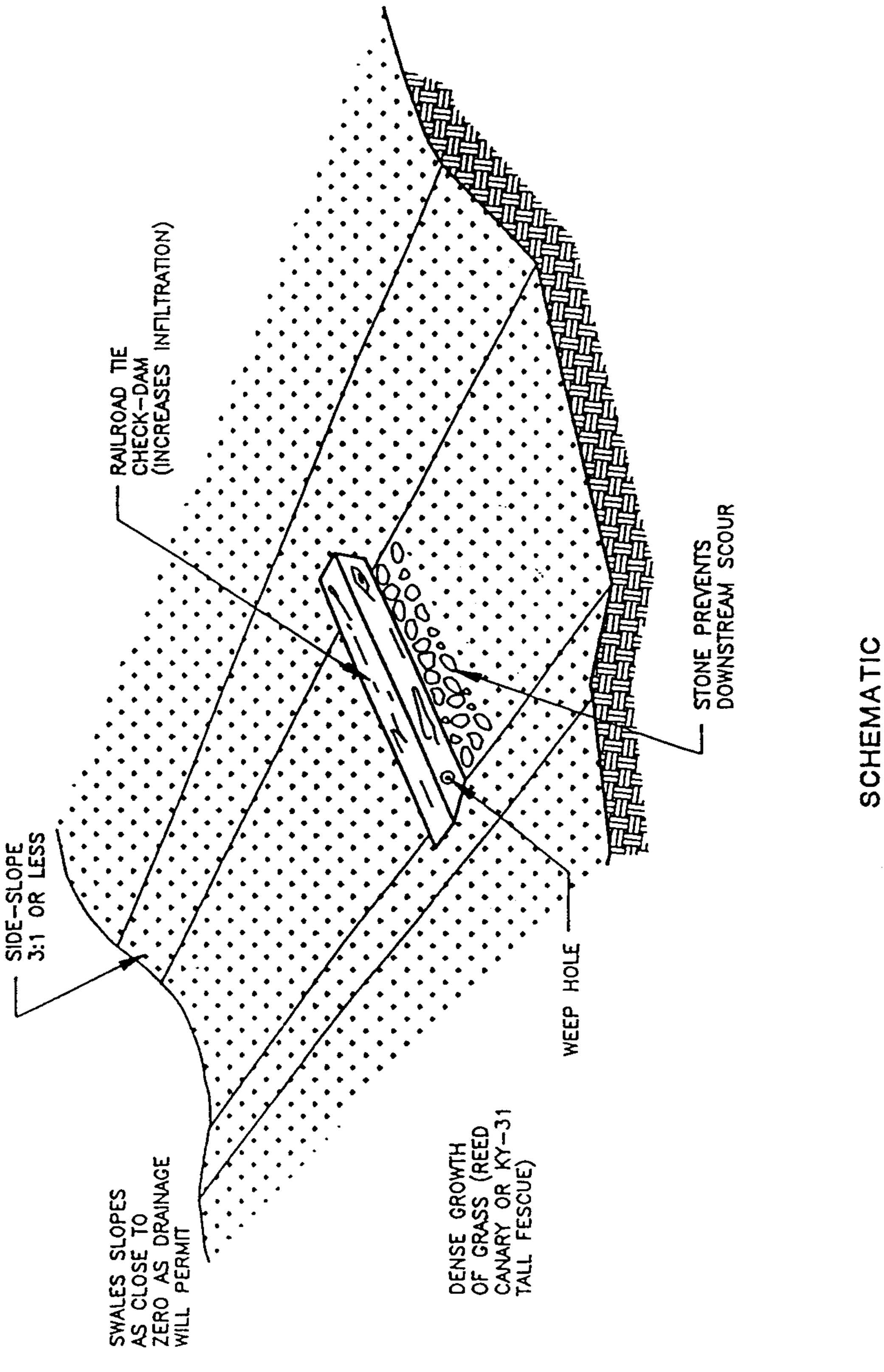

Figure 8-9 Schematic Of A Grass Swale

Source: Controlling Urban Runoff

8.2.10 Oil/Grit Separators

Standard Specifications For Oil/Grit Separators

General Specifications

- Separators should be sized for the design water volume from the first 1.2 inches of rainfall.
- Separator should be structurally sound and designed for acceptable traffic loadings where subject to traffic loadings.
- Separator should be designed to be water tight.
- Volume of separator should be at least 400 cubic feet per acre tributary to the facility (first two chambers).
- Forebay or first chamber should be designed to collect floatables and larger settleable solids. Its surface area should not be less than 20 square feet per 10,000 square feet of drainage area.
- Oil absorbent pads, oil skimmers, or other approved methods for removing accumulated oil should be provided.
- Separator pool should be at least 4 feet deep.
- Weirs, openings, and pipes should be sized to pass as a minimum a 25-year storm.
- Manholes should be provided to each chamber to provide access for cleaning.

Recommended Specifications

- Oil absorbent pads, oil skimmers, or other approved methods for removing accumulated oil should be provided.
- Separator to be located close to the source before pollutants are conveyed to storm sewers or other BMPs.
- Use only on sites of less than one acre.
- Provide perforated covers as trash racks on orifices leading from first to second chamber.
- Use three chambers for treatment similar to Figure 8-10.
- Center chamber may contain a coalescing medium to enhance the gravity separating process.
- Storm drain inlet in third chamber to be located above floor to permit additional settling.
- Stormwater from rooftops and other impervious areas not likely to be polluted with oil should not discharge to the separator.
- Design to bypass flows above 400 cubic feet per acre.

Operation And Maintenance Recommendations

- Maintenance considerations should be included in the facility design with maintenance responsibility designated to some person, organization, corporation, etc. The maintenance considerations should require the owner to periodically clean the structure.
- Cleaning quarterly should be a minimum schedule with more intense land uses such as gas stations requiring cleaning as often as monthly.
- Cleaning should include pumping out waste water and grit and having the water processed to remove oils and metals.

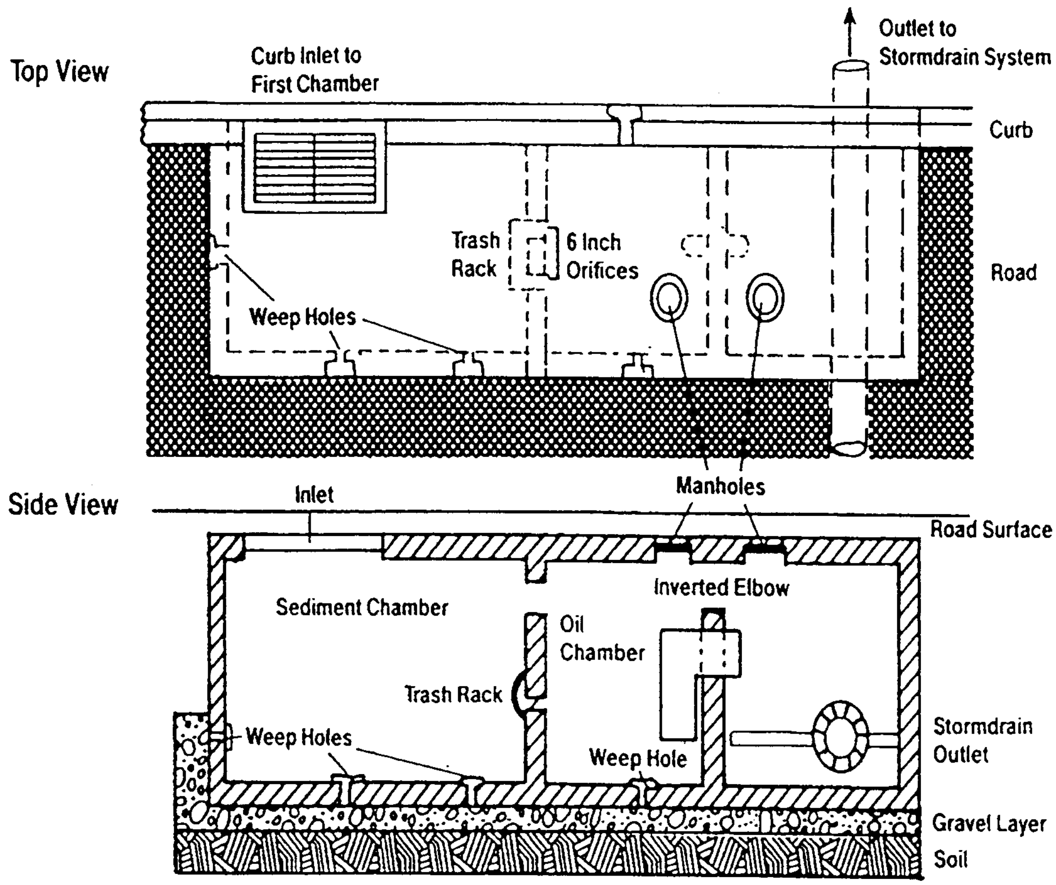

Figure 8-10 Oil/Grit Separator

Source: City of Rockville, MD

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