STORM DRAINAGE MASTER PLAN

APRIL 1999

Prepared for:
City of Coburg, Oregon
P.O. Box 8316
Coburg, OR 97401

EXPIRES: 12/31/2000

Prepared by:

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City of Coburg
Storm Drainage Master Plan

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CHAPTER 1
INTRODUCTION

1.1 AUTHORIZATION

On April 8, 1997, the City of Coburg amended the contract with KCM, Inc. to develop a *Storm Drainage Master Plan* for the area contained within the City's urban growth boundary(UGB). The Oregon Economic Development Department is funding the plan with a Technical Assistance Grant through the Special Public Works Fund.

1.2 PURPOSE

The purpose of this study is to evaluate optional drainage measures and recommend a plan for solving existing storm drainage problems and provide guidance for implementation of future storm drainage improvements within the City of Coburg.

The study consists of the following tasks:

- Task 1 - Project Management: This task involves meetings and coordination with City of Coburg and Lane County staff to discuss Coburg Road storm drainage alternatives and discussion of alternatives in other areas of the City.

- Task 2 - Existing System Review: This task includes identification of existing drainage problems and evaluation of alternatives for application in various service areas within the City.

- Task 3 - Identify Recommended Improvements: This task identifies the recommended improvements or types of drainage measures to be implemented by the City and/or new development, according to various service areas.

- Task 4 - Prepare Master Plan : This task includes documentation of the previous tasks in a draft plan for City review and comment, and preparation of a Final Storm Drainage Master Plan.

CHAPTER 2
STUDY AREA CHARACTERISTICS

2.1 STUDY AREA

Currently, very few storm drainage facilities exist in the City of Coburg. For consideration of future drainage service, the following service areas have been defined based upon similarity in land use characteristics and are shown on Figure 2.1:

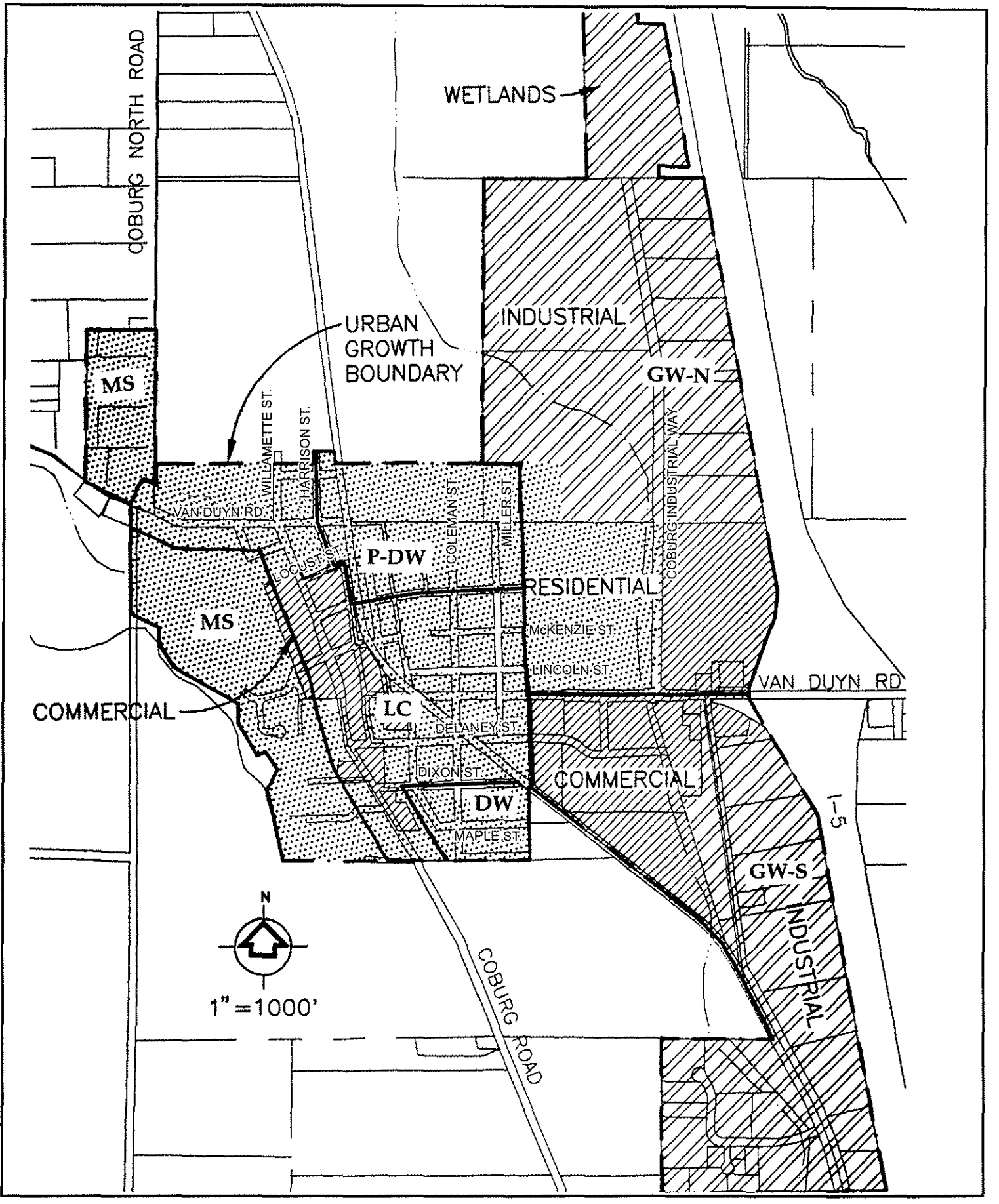
- **Area MS**: The area west of Coburg Road comprised primarily of residential zoning and projected to be served by Mill Slough for drainage.
- **Area LC**: The area adjacent to Coburg Road and Van Duyn Road to be served by Lane County's storm drainage piping system.
- **Area DW**: The area south of Dixon Street and east of Coburg Road comprised primarily of residential zoning and projected to be served by dry wells.
- **Area P-DW**: The area north of Mill Street and east of Harrison Street comprised primarily of residential zoning and projected to be served by a combination of new piping system and dry wells.
- **Area GW-N**: The area north of Van Duyn Road and west of Interstate 5 comprised primarily of Light Industrial and Highway Commercial zoning and projected to be served by infiltration facilities.
- **Area GW-S**: The area south of Van Duyn Road and west of Interstate 5 comprised primarily of Light Industrial and Highway Commercial zoning and projected to be served by infiltration facilities.

The future-conditions service area is defined as the entire area within the UGB.

2.2 CLIMATE AND RAINFALL PATTERNS

The Coburg study area is located between the Coast Range to the west and the Cascades to the east. The Coast Range protects the area from weather generated over the Pacific Ocean. The Cascade Range is large and steep and provides protection from continental air moving from the east to the west. The Cascade Range is steep enough that moist air entering the Willamette Valley rises up the slopes and produces moderate rainfall.

An average of 35 to 40 inches of precipitation falls annually in Coburg. The majority of the rainfall occurs during the winter months, with over 80 percent typically occurring between October and May. Extended winter periods of very low temperatures are uncommon, although freezing temperatures occur periodically. Freezing temperatures sometimes combine with rain to produce hazardous icy conditions. Summers are usually mild with little precipitation.



2530038/zoning.fh8

KCM 7080 SW Fir Loop Portland, Oregon 97223	City of Coburg Storm Drainage Master Plan	FIGURE 2.1 Zoning/Service Areas

2.3 TOPOGRAPHY

Lands within Coburg's UGB are very flat. Land surface slopes are typically less than 1% throughout the City. This makes implementation of surface discharging stormwater facilities very difficult.

2.4 SOILS AND GEOLOGY

Much of the Coburg area is comprised of well-drained soils. Generally, dry wells have historically been an adequate means of stormwater removal. Roadside drainage has also been able to accommodate stormwater runoff through infiltration and percolation. Soil series in the study area are primarily represented by Malabon-Urban land complex, Malabon silty clay loam, and Salem gravelly silt loam. These soils are predominantly well-drained soils.

2.5 LAND USE

Current zoning, which defines allowable development within the City of Coburg Urban Growth Boundary (UGB), is shown in Figure 2.1. Existing land use, defined as the actual development of the area rather than the allowable development, was estimated using aerial photography. Table 2.1 summarizes the developed area for each kind of land use under existing conditions, based on the aerial photography.

TABLE 2.1
EXISTING LAND USE (Developed Acres)

Land Use	Acres	% Total
Residential	110	31
Central Business	15	4
Highway Commercial	25	7
Industrial	185	52
Open Space	20	6
Total	355	100

Future land use for this study is defined as full buildout within the urban growth boundary to the limits defined by existing zoning, which is shown in Figure 2.1. The totals within the UGB are summarized in Table 2.2.

TABLE 2.2
FUTURE LAND USE

Land Use	Acres	% Total
Residential, low density	140	23
Residential, high density	80	13
Central Business	20	3
Highway Commercial	35	6
Industrial	247	42
Unzoned	58	10
Open Space	20	3
Total	**600**	**100**

2.5.1 Population

The 1990 population of the City of Coburg was 763, according to the 1990 Census. Only about 50 percent of the area zoned for residential land use is currently developed, so the population could double within current land use designation limits.

In recent years the City has seen rapid development in the commercial and industrial sectors of the City, and it is beginning to see similar trends in residential development. It is reasonable to expect the City's population to continue to grow given the increase in job base in the industrial area.

Population projections were based on annual increases of 2.5 percent, using the 1990 population of Coburg for a starting point. This growth rate is typical for small communities experiencing rapid industrial development. The projections through the year 2015 are shown in Table 2.3. The City's estimated 2015 population is 1,260 people, almost double the 1990 population.

TABLE 2.3
POPULATION PROJECTIONS

Year	Population
1990	680
1995	770
2000	870
2005	985
2010	1,115
2015	1,415

2.5.2 Residential Development

The residential development in Coburg is primarily situated around the central business district. Their are approximately 250 single family residences within the City of Coburg.

With the rate of residential development occurring in Lane County it is reasonable to assume that the development of residentially zoned land in the City of Coburg will follow the same trends. This trend has been evident in Coburg with the residential development that has occurred in the same time frame.

It would be prudent to expect that all vacant land within the urban growth boundary of the City would be developed within the next 20 years (by the year 2015).

CHAPTER 3
EXISTING SYSTEM AND PROBLEM AREAS

3.1 INTRODUCTION

The Coburg study area currently relies on Mill Slough, the Muddy Creek Irrigation Canal, dry wells, and roadside infiltration for stormwater runoff conveyance and removal. As land development continues, the City of Coburg needs guidance for which of these systems and stormwater control measures have long-term reliability.

3.2 EXISTING SYSTEM

Mill Slough provides drainage service for the western portion of the study area (generally west of Coburg Road). This open natural drainageway is a reliable system for long-term stormwater runoff control when adequately maintained and vegetation managed for hydraulic capacity. There is a designated floodplain in this area and new developments should be reviewed for adequate grading and building slab heights to account for this.

Dry wells (infiltration) currently serve portions of the Coburg study area south of Van Duyn Road and east of Coburg Road. Historically, this means of stormwater removal has been adequate, however routine maintenance is needed to keep these systems functioning reliably. Also, retrofitting of dry wells (or sumps) should be incorporated into these systems to include a two stage system for sedimentation, oil and grease trapping and spill containment to ensure adequate water quality control and reliable hydraulic capacity.

Portions of the light industrial area and highway commercial zoning have used combinations of discharge to the Muddy Creek Irrigation Canal and on-site infiltration facilities for stormwater control.

Residential areas north of Van Duyn Road and east of Coburg Road have no defined stormwater runoff facilities or flow routes.

3.3 EXISTING PROBLEM AREAS

Currently, the only known flooding problem is near the vicinity of Miller Street and Mill Street. Inundation of the streets in this area has created nuisance flooding problems for traffic as well as yard and crawl space flooding to several (5 to 6) homes in the area.

Occasional stormwater discharges to Muddy Creek Irrigation Canal have resulted in concerns related to stormwater quality.

CHAPTER 4
DRAINAGE ALTERNATIVES

4.1 INTRODUCTION

The purpose of this chapter is to present the range of alternative stormwater control measures, and the location where various measures are most feasible for implementation.

4.2 DESCRIPTION OF ALTERNATIVES

There are many stormwater control alternatives for consideration within the City of Coburg. The following presents a brief description of alternatives considered:

1) *Construct storm sewers and discharge to Lane County's future storm piping system in Coburg Road and Van Duyn Road* - This alternative consists of making connection to Lane County's future storm drainage system and for purposes of this study is assumed to include area LC as shown in Figure 2.1 (or equivalent peak discharge amount).

2) *Discharge stormwater runoff to Mill Slough* - This alternative consists of discharging stormwater directly to Mill Slough. In order to provide protection of this natural resource water quality control facilities on site, or at end of pipe prior to discharge to the slough should also be included.

3) *Discharge stormwater runoff to Muddy Creek Irrigation Canal* - This alternative consists of discharging stormwater directly to the canal. However, due to the flat slopes in the area, the canal could only serve areas adjacent to the canal. In addition, due to water quality concerns in the canal, provisions for water quality control and spill containment must be included in this option.

4) *Discharge stormwater to dry wells* - This alternative consists of constructing and/or retrofitting existing dry wells in a two-stage manner, to provide sedimentation, oil and grease trapping and spill containment, prior to discharging into the dry well.

5) *Discharge stormwater to infiltration facilties* - This alternative consists of constructing infiltration basins or trenches where stormwater runoff can temporarily be stored during storm events and drawndown through infiltration between storms.

6) *Construct storm sewer system* - This alternative consists of constructing new piping to convey and remove stormwater runoff.

4.3 APPLICATION OF ALTERNATIVES

For the Coburg study area, each of the previously described alternatives should be applied according location in the system, with the exception of storm sewer system construction. On a City-wide basis this approach is not practical given the lack of available slope, lack of existing system, and the overall costs required to change existing streets to curb and gutter systems, and costs for storm drainage piping.

1) *Area MS* - The area west of Coburg road comprised primarily of residential zoning should be served by Mill Slough with on-site or end-of-pipe water quality control prior to discharging stormwater to Mill Slough.

2) *Area LC* - The area identified as LC in Figure 2.1. The area within this boundary should be served by Lane County's future storm drainage piping system in Coburg Road and Van Duyn Road.

3) *Area DW* - The area south of Van Duyn Road and east of Coburg Road comprised primarily of residential zoning should be served by existing and new, two-stage dry wells. New dry wells should be implemented on an as-needed basis.

4) *Area P-DW* - The area north of Van Duyn Road and east of Coburg Road comprised primarily of residential zoning should be served with a new 24-inch reinforced concrete pipe running from near Miller and Mill Street, south along Miller Street to the County' storm system in Van Duyn Road. This project is recommended in order to resolve existing flooding problems in this area. The remaining portion of this area should be served by new dry wells on an as-needed basis.

5) *Area GW-N* - The area north of Van Duyn Road and west of Interstate 5 comprised primarily of Light Industrial and Highway Commercial lands should be served by infiltration facilities (e.g. basins, trenches) to store and treat stormwater runoff prior to discharge to the ground.

6) *Area GW-S* - The area south of Van Duyn Road and west of Interstate 5 comprised primarily of Light Industrial and Highway Commercial lands should be served by infiltration facilities (e.g. basins, trenches) to store and treat stormwater runoff prior to discharge to the ground.

CHAPTER 5
MANAGEMENT PRACTICES

5.1 INTRODUCTION

The purpose of this chapter is to present background and guidance for nonstructural issues related to management of storm drainage systems. Specifically, the following sections address design standards, maintenance issues, legal/liability issues and funding issues related to storm drainage in Coburg.

5.2 DESIGN STANDARDS

Based on a review of existing drainage design criteria for other similar communities, the following sections present suggested design criteria and approaches for future use by the City of Coburg.

Design Storm Recurrence Interval -
The magnitude of the recommended design storm is a function of the level of protection desired and the relative costs of facilities that could be damaged. The level of required hydrologic and hydraulic analysis is also directly related to the size of the drainage area and the selected design storm.

For sizing of storm drains with a contributing area of 200 acres or less, it is suggested that a 5-year design storm be used. For contributing areas greater than 200 acres and for highway crossings, a 25-year design storm should be used. For sizing of detention storage volumes *(where downstream hydraulic capacity is limited)*, a 25-year storm under developed conditions should be used for determination of inflow volume, with the outlet restricted to a 5-year predeveloped flow, consistent with sizing criteria for downstream storm drains.

For sizing of drainage facilities with a contributing area of 640 acres (1 square mile) or greater, a 100-year storm event should be used. It should also be noted that Federal Emergency Management Agency requirements for flood insurance studies apply to drainage areas greater than 1 square mile.

Sheet Flow Escape Routes-
Also, in addition to the above described criteria, sheet flow escape routes should be investigated for situations in which storms of greater than design magnitude are encountered or when the downstream drainage system becomes clogged. For example, during design of improvements or development review, site grading should be checked and modified where necessary to ensure that excess flows or volumes have a route for escape without endangering property or jeopardizing public safety.

Minimum Flow Velocity -
The suggested minimum flow velocity for improvements to the drainage system is 3 feet per second. This velocity should be adequate for removing the majority of sand, rocks and debris normally entering the drainage system. It will also ensure that pipes will remain relatively self-cleaning and thereby not require long-term frequent maintenance.

Catch Basins and Manholes -
It is suggested that the City continue using sediment trapping catch basins and not inlets. This will facilitate maintenance of the system, ensure that pipe capacity is not reduced by inflowing debris, and will likely be a long-term benefit to water quality. Most of the surface water pollutants are held within the solids that enter the drainage system, and catch basins will allow for easy removal.

Dry Wells -
Dry wells, or stormwater sumps, are an alternative means of stormwater disposal which discharge to the ground. However, dry wells should use a two-stage system to minimize maintenance requirements. Dry wells require regular cleaning and maintenance to ensure proper functioning during storm events.

In addition, potential discharge of pollutants could occur over long periods of time and be unnoticed. While dry wells are not strictly prohibited, Oregon Administrative Rules (OAR 340-44-050) contain provisions under which dry wells should be considered/not considered feasible. (See Appendix A and B)

Open/Natural Drainage-
As part of the development review and approval process it is suggested that the City require a minimum drainage buffer width of 25 feet on both sides from the defined top of bank. To the greatest extent practicable, open and natural drainages should be kept open for water quality, open space and environmental aesthetics.

Minimum Storm Drain Pipe Size -
To minimize long-term maintenance and allow for reliable system capacity, it is suggested that the City require a minimum pipe diameter of 18 inches for all new pipe improvements.

Pipe Material -
Suitable pipe materials are primarily related to suggested design life. Suitable materials include concrete, aluminum, PVC, ADS, or corrugated metal pipe.

Pipe Design Life -
The suggested design life for new pipe materials is 75 years.

Hydrologic Computations -
As mentioned in previous sections *(Design Storm Recurrence Interval)*, size of drainage area should dictate both the design storm recurrence interval and the required level of hydrologic and hydraulic analysis. For drainage areas less than or equal to 200 acres in size, the Rational Method can be applied with sufficient accuracy. For drainage areas greater than 200 acres but less than 640 acres, U.S. Geological Survey (USGS) regional regression relationships should be

used. For drainage areas greater than 640 acres (1 square mile), unit hydrograph analysis or other methods approved by the City Engineer (or City-designated representative) should be used.

Runoff Coefficients -
Rational Method runoff coefficients are based on land use types and are given previously in the ODOT Hydraulics Manual (Reference 11, Chapter 2, Page 11).

Minimum Time of Concentration -
The suggested minimum time of concentration for use with the Rational Method is 10 minutes. This minimum is consistent with previous drainage planning for Coburg.

Rainfall Intensity-Duration-Frequency (IDF) Relationship -
The suggested I-D-F relationship for the City of Coburg is taken from Oregon Department of Transportation(ODOT) Highway Division, Hydraulics Manual. The I-D-F relationship for ODOT Zone #7/8 is given in the ODOT Hydraulics Manual (Reference 11, Chapter 2, Page 11).

Manning's Roughness Coefficient -
Suggested roughness coefficients for various pipe types are given in the ODOT Hydraulics Manual (Reference 11, Chapter 3, Page 27).

The City should use the above described guidelines for drainage improvements or develop design standards for design and implementation of drainage improvements throughout the City's urban growth boundary (UGB). The standards provided herein should be viewed as guidance for design, implementation, and construction of public drainage improvements.

5.3 MAINTENANCE ISSUES

To ensure that the City's storm drainage system will continue to function effectively, and to make full utilization of the existing storm drainage system capacity, a regular program of maintenance is suggested. In summary, catch basins and dry well systems should be inspected and or cleaned annually, all pipes should be inspected and/or cleaned annually, and other portions of the system should be repaired and replaced on and as-needed basis using a small works set aside in the maintenance budget.

5.4 LEGAL/LIABILITY ISSUES

This section presents a general background on drainage-related legal/liability issues and should not be used in lieu of advice from the City's legal counsel. Therefore, the following items present a basis for further investigation by the City into potential liabilities with storm drainage master planning and implementation of improvements. Historically, the basis for stormwater litigation has been a tort action, as follows:

> A municipality undertaking a public drainage improvement is treated like a private party (Harbison v. City of Hillsboro) and is liable for damage resulting from negligence or an omission of duty. *(Reference 6)*

Municipalities are generally under no legal duty to construct drainage improvements unless public improvements require drainage facilities (Denver v. Mason) *(Reference 7)*

Municipalities are not liable for damages due to overflow of its drainage system in cases of extraordinary/unforseeable rains or floods. (McQuillan) *(Reference 8)*

Municipalities will likely be liable in cases where they take responsibility for collection of surface waters which are then released onto private property which has not historically received runoff; where dams/diversions cause an overflow onto anothers land; or where there is failure to exercise reasonable care in the maintenance and repair of drainage improvements. *(Reference 8)*

In the State of Oregon, the civil law doctrine of drainage applies. Under this doctrine, adjoining landowners are entitled to have the normal course of natural drainage maintained. The lower owner must accept water which naturally comes to his land from above, but he is entitled not to have the normal drainage changed or substantially increased. The lower landowner may not obstruct the runoff from the upper land, if the upper landowner is properly discharging the water. *(Reference 11)*

Summary
While instances of public water traversing private property occasionally occurs in Coburg, a policy of purchasing right-of-way, constructing public drainage improvements and providing long-term maintenance is likely not cost-effective for the City of Coburg. This situation is true for many Oregon communities. It is suggested that a more cost-effective approach is to apply Oregon's civil law doctrine of drainage on a case-by-case basis to situations as they arise.

5.5 FUNDING ISSUES

This section describes the range of alternative funding sources that municipalities have used in implementing drainage improvements.

State/Federal Grants and Loans
Various grant/loan programs are available at both the federal and state level. However, no single grant/loan program is available on a consistent, on-going basis for funding of local stormwater management. With communities competing on both a state-wide and even nation-wide basis, and with constraints on how grant/loan money is to be used, these sources can only serve to supplement an existing local funding program for stormwater management.

Debt Financing
General obligation bonds and revenue bonds are two commonly used forms of debt financing for public infrastructure improvements. General obligation bonds, primarily used for major capital improvements, are subject to voter approval and are backed by the full credit of the government issuing them. Revenue bonds, on the other hand, may be sold and secured only by those specific revenue sources which are earmarked for their payment.

System Development Charges
These charges are imposed on new development as a way of recovering costs for that portion of existing system capacity solely attributable to new development or for that portion of required system up-sizing. System development charges can begin to answer questions of who should pay for required up-sizing of the stormwater system due to new development, or how historical payers into the system can recover their costs in over-sizing facilities that enable future growth.

Fee-In-Lieu of On-Site Detention
These fees afford a land developer the option of either constructing an on-site stormwater detention facility in accordance with established design criteria, or paying a fee into a fund dedicated to the construction of an off-site or regional stormwater detention facility serving multiple properties. These fees tend to promote siting and construction of regional versus on-site detention facilities. However, cash flow necessary for a regional stormwater detention facility may not necessarily coincide with the required construction timing.

Improvement Districts and Special Assessments
The concept of deriving funding from local improvement or special assessment districts is founded on quantifying benefits. For water, sewer or street improvements, these benefits can often be easily identified and thus quantified. However, drainage differs in the respect that upstream or hillside properties that are major contributors of runoff may not be specific recipients of benefits.

Plan Review and Inspection Fees
These fees are intended to recover the expense of examining development plans to ensure consistency with comprehensive land use and stormwater master plans, and to ensure that construction standards and regulations are met at the construction site. These fees are not intended to be a primary revenue generating source.

Stormwater Service Charges
Another method gaining popularity for financing stormwater management is the utility-based service charge. Historically, the concept of considering stormwater as a public utility attracted very few communities. However, as other more conventional funding sources became difficult to obtain, and as federal requirements increase, the service charge concept has generated greater appeal. Service charges for stormwater management reflect a rationale that those who contribute to stormwater problems should logically contribute to the costs of providing mitigative services.

In Oregon, recent court rulings have jeopardized the concept and implementation of stormwater service charges or stormwater utilities. Rulings against the cities of Gresham and Roseburg have held that stormwater charges are a "tax" and not a "fee for a service", and therefore are subject to the limitations of Measure 5 (Oregon Property Tax Limitation).

Ad Valorem Taxes
Ad valorem taxes are taxes levied on a property as a direct result of *"value added"* to the subject property. However, with stormwater there is no clear correlation between property value and contribution of runoff. Ad valorem taxes could provide a significant source of revenue,

however with the apparent lack of equity, should not be considered a primary source for funding stormwater programs.

CHAPTER 6
CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

As a result of review of current conditions in Coburg, field reconnaissance, and review of other published documents, the following conclusions are made:

1) Currently there are very few stormwater facilities in the City of Coburg. Coburg relies primarily upon natural drainageways and some dry wells to carry and remove stormwater runoff.

2) Currently there are very few flooding problems within Coburg's UGB. The only known flooding problem exists near Miller Street and Mill Street.

3) Currently there is no predictable, reliable source of funding for stormwater related maintenance and capital needs.

4) Historically, dry wells have been an adequate means of stormwater removal for much of the area within the UGB.

5) Implementation of surface discharging stormwater facilities is very difficult and impractical from a cost standpoint due to the lack available slope on lands within Coburg's urban growth boundary.

6) With adequate means of pretreatment and provisions for spill containment, stormwater infiltration facilities can be implemented to effectively control stormwater on-site, at the source, for individual new developments.

7) Lane County's future storm drainage system in Coburg and Van Duyn Road could be used as a point of stormwater discharge for a portion of the Coburg study area.

6.2 RECOMMENDATIONS

The following recommendations are made to assist the City with resolution of existing drainage and to provide guidance for the implementation of stormwater facilities.

1) Enter into an agreement with Lane County to discharge stormwater to the County's system in Coburg and Van Duyn Roads.

2) Determine the feasibility of implementation and projected rates for a City-wide stormwater utility. Considering the current makeup of residential and industrial lands, a stormwater utility should be capable of generating annual funds for maintenance and small works needs in the range of $25,000.

3) Set aside funds for annual maintenance needs and small capital projects from the general fund or from a new stormwater utility.

4) Prepare and apply stormwater design standards for new development.

5) Implement Miller Street/Mill Street project in coordination with Lane County, to resolve existing flooding problems in the area. Total project costs assuming a 24-inch diameter pipeline for 1100 feet, @ $5 per inch-diameter-foot, and a 50% markup for contingency and engineering, are estimated at $200,000.

6) Implement new two-stage dry wells on an as-needed basis using stormwater utility funds or general funds.

REFERENCES

1. The City of Coburg Comprehensive Plan, prepared by City of Coburg.

2. Lane County Irving Road Drainage Predesign Report, prepared by KCM, September 1994.

3. The City of Coburg Wastewater Facilities Plan (DRAFT), prepared by KCM, June 1997.

4. Lane County Coburg Road Stormwater Study (DRAFT), prepared by EMCON, July 1997.

5. Sewer Design Manual, Bureau of Environmental Services, City of Portland, Oregon, 1991.

6. Drainage Management Study and Financial Program, City of Gresham, Oregon, prepared by KCM, December 1981.

7. Kelly Creek Basin, Storm Drain Master Plan, City of Gresham, Oregon, prepared by URS, September 1988.

8. Comprehensive Storm Drainage Master Plan, City of Hillsboro, prepared by URS, July 1988.

9. King County Surface Water Design Manual, prepared by King County Department of Public Works, January 1990.

10. Stormwater Management Manual for the Puget Sound Basin, prepared by Washington State Department of Ecology, February 1992.

11. Hydraulics Manual, Oregon Department of Transportation, Highway Division, prepared by the Hydraulics Unit, January 1990.

12. Soil Survey of Lane County, Oregon, Soil Conservation Service, U.S. Department of Agriculture, 1987.

13. Coburg, Junction City, Eugene East and Eugene West, 7.5 minute quadrangle maps, United States Geological Survey, 1967, photorevised 1986.

14. Base flood elevations for Coburg Estates Subdivision, Phase I, prepared for City of Coburg by Branch Engineering, August 1993.

Flow Chart Summary
Waste Disposal Wells for Surface Drainage
OAR 340-44-050

Is there an adequate confinement barrier or filtration medium between the proposed dry well and an underground source of drinking water?

<=== Yes <===

===> No ===>

Is construction of surface discharging storm sewers practical?

<=== No <===

===> Yes ===>

Is the proposed dry well deeper than 100 feet?

No <===

===> Yes ===>

Dry wells are feasible in this area

Is the proposed dry well within 500 feet of a domestic water well?

<=== No <===

===> Yes ===>

Is the proposed dry well for agricultural drainage?

<=== No <===

===> Yes ===>

Are toxic chemicals or petroleum products stored or handled in the area to be served by the proposed dry well?

<=== No <===

===> Yes ===>

Is there a means by which the owner can temporarily plug or block the proposed dry well in the event of an accident or spill?

<=== Yes <===

No ===>

Dry wells should not be considered in this area

Are there parking lots in the area to be served by the proposed dry well?

<=== No <===

===> Yes ===>

KCM

DIVISION 44

CONSTRUCTION AND USE OF WASTE DISPOSAL WELLS OR OTHER UNDERGROUND INJECTION ACTIVITIES

Definitions

340-44-005 As used in these regulations unless the context requires otherwise:

(1) "Aquifer" means an underground stratum holding water which is capable of yielding a significant amount of water to a well or spring.

(2) "Authorized Representatives" means the staff of the Department or of the local unit of government performing duties for and under agreement with the Department as authorized by the Director to act for the Department.

(3) "Commission" means the Environmental Quality Commission.

(4) "Construction" includes installation or extension.

(5) "Department" means the Department of Environmental Quality.

(6) "Director" means the Director of the Department of Environmental Quality.

(7) "Exempted Aquifer" means an aquifer which contains water with fewer than 10,000 mg/l total dissolved solids, is not currently used as a source of drinking water, and has been excluded as a possible source of drinking water because of one or more of the following:

(a) Its mineral content, hydrocarbon content or physical characteristics, such as temperature, makes its use for drinking water impractical;

(b) It is situated at a depth or location which makes recovery of water for drinking water purposes economically or technologically impractical; or

(c) The water or aquifer exhibit other characteristics which makes the aquifer unusable for drinking water.

(8) "Municipal Sewerage System" means any part of a sewage collection, transmission, or treatment facility that is owned and operated by an incorporated city.

(9) "Municipal Sewer Service Area" means an area which has been designated by an incorporated city for sewer service and for which preliminary sewer planning has been completed.

(10) "Municipality" means an incorporated city only.

(11) "Owner" means:

(a) Any person who alone, or jointly, or severally with others:

(A) Has legal title to any lot, dwelling, or dwelling unit; or

(B) Has care, charge, or control of any real property as agent, executor, executrix, administrator, administratrix, trustee, lessee or guardian of the estate of the holder of legal title; or

(C) Is the contract purchaser of real property.

(b) Each such person as described in paragraphs (a)(B) and (C) of this section, thus representing the holder of legal title, is bound to comply with the provisions of these minimum standards as if he were the owner.

(12) "Person" means the United States and agencies thereof, any state, any individual, public or private corporation, political subdivision, governmental agency, municipality, industry, copartnership, association, firm, trust, estate or any other legal entity whatsoever.

(13) "Property" means any structure, dwelling or parcel of land that contains or uses a waste disposal well for disposing of wastes.

(14) "Public Health Hazard" means a condition whereby there are sufficient types and amounts of biological, chemical, or physical, including radiological, agents relating to water or sewage which are likely to cause human illness, disorders, or disability. These include, but are not limited to, pathogenic viruses and bacteria, parasites, toxic chemicals, and radioactive isotopes. A malfunctioning or surfacing subsurface sewage disposal system constitutes a public health hazard.

(15) "Public Waters" means lakes, bays, ponds, impounding reservoirs, springs, wells, rivers, streams, creeks, estuaries, marshes, inlets, canals, the Pacific Ocean within the territorial limits of the State of Oregon, and all other bodies of surface or underground waters, natural or artificial, inland or coastal, fresh or salt, public or private (except those private waters which do not combine or effect a junction with natural surface or underground waters), which are wholly or partially within or bordering the state or within its jurisdiction.

(16) "Seepage Pit" means a lined pit which receives partially treated sewage which seeps into the surrounding soil through perforations in the lining.

(17) "Sewage" means the water-carried human or animal waste from residences, buildings, industrial establishments or other places, together with such groundwater infiltration and surface water as may be present. The admixture with sewage as above defined of industrial wastes or wastes shall also be considered "sewage" within the meaning of these rules.

(18) "Sewage Drain Hole" means a specialized type of waste disposal well consisting of a drilled or hammered well or natural lava crack or fissure used for sewage disposal in the lava terrain of Central Oregon; but does not include a conventional seepage pit regulated by OAR 340-71-335.

(19) "Standard On-Site Sewage Disposal System" means a drainfield or approved alternative disposal system that complies with the requirements of OAR Chapter 340 Division 71.

(20) "Underground Injection Activity" means any activity involving underground injection of fluids including, but not limited to, waste disposal wells, petroleum enhanced recovery injection wells, liquid petroleum storage wells, in situ mining wells, groundwater recharge wells, saltwater intrusion barrier wells, sand backfill wells, and subsidence control wells.

(21) "Underground Source of Drinking Water" means an aquifer or its portion which supplies drinking water for human consumption, or is an aquifer in which the groundwater contains fewer than 10,000 mg/L total dissolved solids, and is not an exempted aquifer.

(22) "Waste Disposal Well" means any bored, drilled, driven or dug hole, whose depth is greater than its largest surface dimension which is used or is intended to be used for disposal of sewage, industrial, agricultural or other wastes and includes drain holes, drywells, cesspools and seepage pits, along with other underground injection wells, but does not apply to single family residential cesspools or seepage pits nor to nonresidential cesspools or seepage pits which receive solely sanitary wastes and serve less than 20 persons per day.

(23) "Wastes" means sewage, industrial wastes, agricultural wastes, and all other liquid, gaseous, solid, radioactive or other substances which will or may cause pollution or tend to cause pollution of any waters of the state.

(24) "WPCF Permit" means a permit as defined in Division 45.

Stat. Auth.: ORS Ch. 183 & 468
Hist: SA 41, f. 5-15-69; DEQ 35-1979, f. & ef. 12-19-79; DEQ 15-1983, f. & ef. 3-26-83

Policy

340-44-010 Whereas the discharge of untreated or inadequately treated sewage or wastes to waste disposal wells and particularly to waste disposal wells in the lava terrain of Central Oregon constitutes a threat of serious, detrimental and irreversible pollution of valuable groundwater resources and a threat to public health, it is hereby declared to be the policy of

the Commission to restrict, regulate or prohibit the further construction and use of waste disposal wells in Oregon and to phase out completely the use of waste disposal wells as a means of disposing of untreated or inadequately treated sewage or wastes as rapidly as possible in an orderly and planned manner.

Stat. Auth.: ORS Ch. 468
Hist: SA 41, f. 5-15-69; DEQ 35-1979, f. & ef. 12-19-79

Construction or Use of Waste Disposal Wells Restricted

340-44-015 (1) After the effective date of these rules, no person shall construct, place in operation, or operate any waste disposal well without first obtaining a WPCF permit from the Department, unless the waste disposal well is exempted by section (2) of this rule.

(2) The following types of waste disposal wells do not require a WPCF permit, although they are regulated as indicated:

(a) Cesspool and seepage pits of less than 5,000 gallons per day capacity (See OAR 340-71-335);

(b) Storm water drains from residential or commercial areas, which are not affected by toxic or industrial wastes (See OAR 340-44-050);

(c) Sewage drain holes serving less than 20 persons per day, (See prohibitions and other limitations in sections (5), (7), (9) and (10) of this rule).

(3) In addition to those waste disposal wells in section (2) of this rule which are exempt from a WPCF permit, the following types of waste disposal wells may be exempted from the permit requirement on a case-by-case basis:

(a) All cesspools and seepage pits which were constructed before January 1, 1982, and which dispose of only domestic waste;

(b) All sewage drain holes which were constructed before January 1, 1980, and which dispose of only domestic waste;

(c) Geothermal reinjection wells which return uncontaminated water to the same aquifer or to one of equivalent quality; and

(d) Reinjection of air conditioning water or heat pump transfer water to the same aquifer or one of equivalent quality.

(4) The following types of underground injection activities are prohibited:

(a) Wells used to dispose of hazardous waste, as defined in OAR 340 Division 63, or radioactive waste, as defined in ORS 469.300, into, above, or below a formation which contains an underground source of drinking water within one quarter (1/4) mile of the disposal well hole;

(b) Wells used to dispose of other industrial or municipal wastewater into or below a formation which contains an underground source of drinking water within one quarter (1/4) mile of the disposal well hole, excluding wells used for injection of salt water brought to the surface as a result of oil or gas production.

(c) Wells used for underground injection activities, other than disposal, which cause or tend to cause pollution of underground waters of the state. These activities include liquid hydrocarbon storage and injection of fluids for mineral extraction.

NOTE: Because of the widespread availability of usable underground waters in the state, the Department has determined that these underground injection activities are a potential threat to underground waters in all parts of the state and are, therefore, all subject to regulation by the Department. If, at some future date, there is a demonstrated need for any of these other underground injected activities, the Department will initiate procedures to remove the prohibition, provided a program and procedures for adequately protecting underground waters from the activity has been adopted.

(d) Wells used for underground injection activities that allow the movement of fluids into an underground source of drinking water if such fluids may cause a violation of any primary drinking water regulation promulgated under the Federal Safe Drinking Water Act or may otherwise create a public health hazard or have the potential to cause significant degradation of public waters.

(5) After January 1, 1983, use of sewage drain holes is prohibited unless the disposal well is outside the boundaries of an incorporated city, sanitary district, or county service district and municipal sewer service is not available to the property; or unless the Director grants a waiver pursuant to section (6) of this rule.

(6) Within 90 days following written notification by the Department that sewer service is available to a property, the owner of that property shall make connection to the sewer and shall abandon and plug the sewage drain hole in accordance with OAR 340-44-040. Sewer service shall be deemed available to a property when a sewer is extended to within seventy-five (75) feet from the property boundary. On a case-by-case basis, the Director may waive the requirement to connect to sewer if he determines that connection to the sewer is impracticable or unreasonably burdensome. Any waiver granted by the Director shall be temporary and may be revoked when or if the use of the waste disposal well is modified or expanded.

(7) Construction and use of new sewage drain holes is prohibited except those new sewage drain holes that meet the following conditions:

(a) The sewage drain hole is constructed to augment a failing on-site disposal system which was constructed before January 1, 1979; the failing on-site system cannot reasonably be corrected by expansion or replacement with an approved alternative system; all possible leach field area has been fully utilized and water conservation measures instituted; and, there is no reasonable alternative available to dispose of sewage on the lot or adjacent property.

(b) Where conditions warrant, the Department may require additional sewage treatment before a new sewage drain hole will be permitted. In addition, new sewage drain holes shall be constructed within the following limitations:

(A) Sewage drain holes shall not be constructed closer than five hundred (500) feet from a natural stream or lake;

(B) Sewage drain holes shall not be constructed greater than one hundred (100) feet deep;

(C) Sewage drain holes shall not be closer than one thousand (1000) feet from a domestic water well; and

(D) Any new sewage drain hole shall terminate at least 100 feet above any known groundwater aquifer.

(c) Any sewage drain hole constructed shall be abandoned and plugged whenever a feasible alternative on-site system or off-site sewers become available, unless a waiver is granted by the Director pursuant to section (6) of this rule. No authorization for construction of a sewage drain hole within a sewer service area will be granted unless the property owner agrees in writing not to remonstrate against connection to the sewer and abandonment of the sewage drain hole when notified that sewer service is available. This agreement shall be recorded in county deed records and shall run as a covenant with the land.

(8) A permit to construct a waste disposal well shall not be issued if the Director or his authorized representative, determines that the waste disposal well has the potential to cause significant degradation of public waters or create a public health hazard.

(9) Without first obtaining written authorization from the Director or his authorized representative, no person shall modify any structure or change or expand any use of a structure or property that utilizes a sewage drain hole. Except as allowed in section (10) of this rule, the authorization shall not be issued unless:

(a) The property cannot qualify for a standard on-site sewage disposal system including the reserve area requirement; and

(b) The property is inside a designated, municipal sewer service area; and

(c) The owner of the property and the municipality having jurisdiction over the municipal sewer service area shall enter into a written agreement. The agreement shall include the owner's irrevocable consent to connect to the municipal sewerage service when it becomes available and to not remonstrate against formation of and inclusion into a local improvement district if such a district is deemed necessary by the municipality to finance sewer construction to the property; and

(d) The property is a single family dwelling that is not closer than one hundred (100) feet to a municipal sewerage system. (The proposed changes or expansion of the use of the waste disposal serving the single family dwelling shall not be for the purpose of serving a commercial establishment or multiple-unit dwelling); or

(e) The property is not a single-family dwelling, is not closer than 300 feet from a municipal sewerage system, and the proposed change or expansion of the use of the waste disposal well would not create an increased waste flow; or

(f) The property is not a single-family dwelling; existing sewer is not deemed available based upon the criteria established in Oregon Administrative Rules 340-71-160 and based upon the total average daily flow estimated from the property after the proposed modification or expansion of the use of the waste disposal well and a municipality has committed in writing to provide sewers to the property within two (2) years.

(10) The Director shall grant authorization to connect a replacement structure to a sewage drain hole if:

(a) The waste disposal well previously served a structure that was unintentionally destroyed by fire on other calamity; and

(b) The property cannot qualify for a standard on-site sewage disposal system, including the reserve area requirement; and

(c) There is no evidence that the waste disposal well had been failing; and

(d) The replacement structure is approximately the same size as the destroyed structure and the use has not been significantly changed.

Stat. Auth.: ORS Ch. 468
Hist: SA 41, f. 5-15-69; DEQ 35-1979, f. & ef. 12-19-79; DEQ 22-1981, f. & ef. 9-2-81; DEQ 15-1983, f. & ef. 8-26-83

Repairs of Existing Sewage Drain Holes

340-44-017 (1) Without first obtaining a Waste Disposal Well Repair Permit from the Director or his representative, no person shall repair or attempt to repair a plugged or otherwise failing sewage drain hole.

(2) The Director or his authorized representative shall not issue a Waste Disposal Well Repair Permit and shall require connection to a municipal sewerage system if, for a single-family dwelling, the property is within one hundred (100) feet from the municipal sewerage system or if, for other than a single-family dwelling, the property is within three hundred (300) feet from the municipal sewerage system.

(3) The Director or his authorized representative shall not issue a Waste Disposal Well Repair Permit if the property can successfully accommodate a standard on-site sewage disposal system. If the Director or his authorized representative determines that a drainfield can be installed and that it can be expected to function satisfactorily for an extended period of time, the property owner shall install a drainfield and abandon the waste disposal well. The Director or his authorized representative may waive the requirement to install a standard on-site sewage disposal system if a municipality provides written commitment to provide sewers to the property within two (2) years and if the failing waste disposal well can be repaired or operated without causing a public health hazard.

(4) A Disposal Well Repair Permit shall be a written document and shall specify those methods by which the waste disposal well may be repaired. Possible methods for repair shall include, but not be limited to, introduction of caustic or acid, use of explosives, or deepening the waste disposal well. Deepening the waste disposal well shall be limited to a maximum depth of one hundred (100) feet and shall only be permitted if:

(a) The property served by the failing waste disposal well shall be inside a recognized urban growth boundary; and

(b) There is a written agreement between the owner of the property and the municipality having jurisdiction over the urban growth boundary. The written agreement shall include the property owner's irrevocable consent to connect to a sewer when it becomes available and to abandon the waste disposal well. The agreement shall also include the owner's irrevocable consent to participate in the formation and be included in a local improvement district if the municipality determines that such a district is necessary to finance extension of sewer to the property.

Stat. Auth.: ORS Ch. 468
Hist: DEQ 35-1979, f. & ef. 12-19-79; DEQ 15-1983, f. & ef. 8-26-83

Schedules for Eliminating Waste Disposal Wells Inside Incorporated Cities, Sanitary Districts, and County Service Districts

340-44-019 [DEQ 35-1979, f. & ef. 12-19-79; Repealed by DEQ 15-1983, f. & ef. 8-26-83]

Issuance of Permits Without Director Approval Prohibited

340-44-020 After the effective date of these rules, no person shall issue permits for the construction, modification, maintenance, or use of waste disposal wells unless that permit has been approved by the Director.

Stat. Auth.: ORS Ch. 468
Hist: SA 41, f. 5-15-69; DEQ 35-1979, f. & ef. 12-19-79; DEQ 15-1983, f. & ef. 8-26-83

Waste Disposal Well Permit Areas

340-44-025 [SA 41, f. 5-15-69; Repealed by DEQ 35-1979, f. & ef. 12-19-79]

Waste Disposal Wells Prohibited Where Better Treatment or Protection is Available

340-44-030 Permits shall not be issued for construction, maintenance or use of waste disposal wells where any other treatment or disposal method which affords better protection of public health or water resources is reasonably available or possible.

Stat. Auth.: ORS Ch. 468
Hist: SA 41, f. 5-15-69

Permit Conditions

340-44-035 (1) Permits for construction or use of waste disposal wells shall include, in addition to other reasonable provisions, minimum conditions relating to their location, construction or use and a time limit for authorized use of said waste disposal wells.

(2) Permits for construction or use of waste disposal wells used to inject salt water produced as a result of oil or gas extraction shall include conditions as necessary to prevent migration of fluids into an underground source of drinking

water. These conditions could include casing and cementing requirements, fluid and fluid pressure monitoring requirements, and maximum injection pressure limitations. If other existing wells penetrate the zone which may be affected by the injection activity, conditions will also be included to ensure than these other wells will not serve as a conduit for the movement of fluids into an underground source of drinking water.

Stat. Auth.: ORS Ch. 468
Hist: SA 41, f. 5-15-69; DEQ 15-1983, f. & ef. 8-26-83

Abandonment and Plugging of Waste Disposal Wells

340-44-040 (1) A waste disposal well upon discontinuance or use or abandonment shall immediately be rendered completely inoperable by plugging and sealing the hole to prevent the well from being a channel allowing the vertical movement of water and a possible source of contamination of the groundwater supply.

(2) All portions of the well which are surrounded by "solid wall" formation shall be plugged and filled with cement grout or concrete.

(3) The top portion of the well must be effectively sealed with cement grout or concrete to a depth of at least 18 feet below the surface of the ground, or wherever this method of sealing is not practical, effective sealing must be accomplished in a manner approved in writing by the Director or his authorized representative.

Stat. Auth.: ORS Ch. 468
Hist: SA 41, f. 5-15-69; DEQ 35-1979, f. & ef. 12-19-79

Construction or Use of Waste Disposal Wells Prohibited After January 1, 1980

340-44-045 [SA 41, f. 5-15-69; Repealed by DEQ 35-1979, f. & ef. 12-19-79]

Waste Disposal Wells for Surface Drainage

340-44-050 (1) Waste disposal wells for storm drainage shall only be used in those areas where there is an adequate confinement barrier or filtration medium between the well and an underground source of drinking water; and where construction of surface discharging storm sewers is not practical.

(2) New storm drainage disposal wells shall be as shallow as possible but shall not exceed a depth of 100 feet.

(3) They shall not be located closer than 500 feet of a domestic water well.

(4) Using a waste disposal well for agricultural drainage is prohibited.

(5) Using a waste disposal well for surface drainage in areas where toxic chemicals or petroleum products are stored or handled is prohibited, unless there is containment around the product area which will prevent spillage or leakage from entering the well.

(6) Any owner or operator of a waste disposal well for storm drainage shall have available a means of temporarily plugging or blocking the well in the event of an accident or spill.

(7) Any parking lot which is drained by waste disposal wells shall be kept clean of petroleum products and other organic or chemical wastes as much as practicable to minimize the degree of contamination of the storm water drainage.

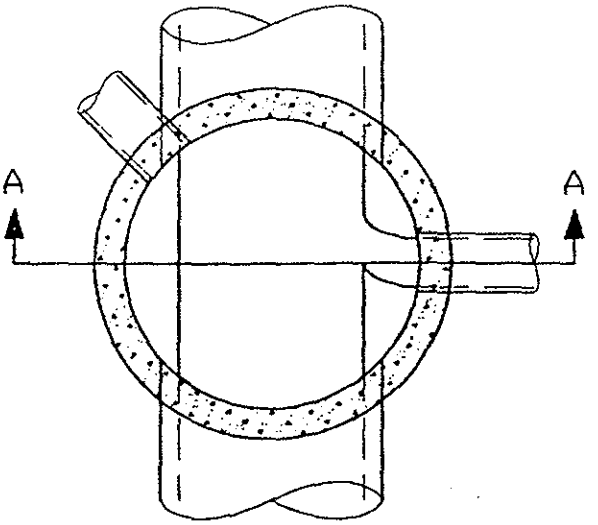
Stat. Auth.: ORS Ch. 468
Hist: DEQ 15-1983, f. & ef. 8-26-83

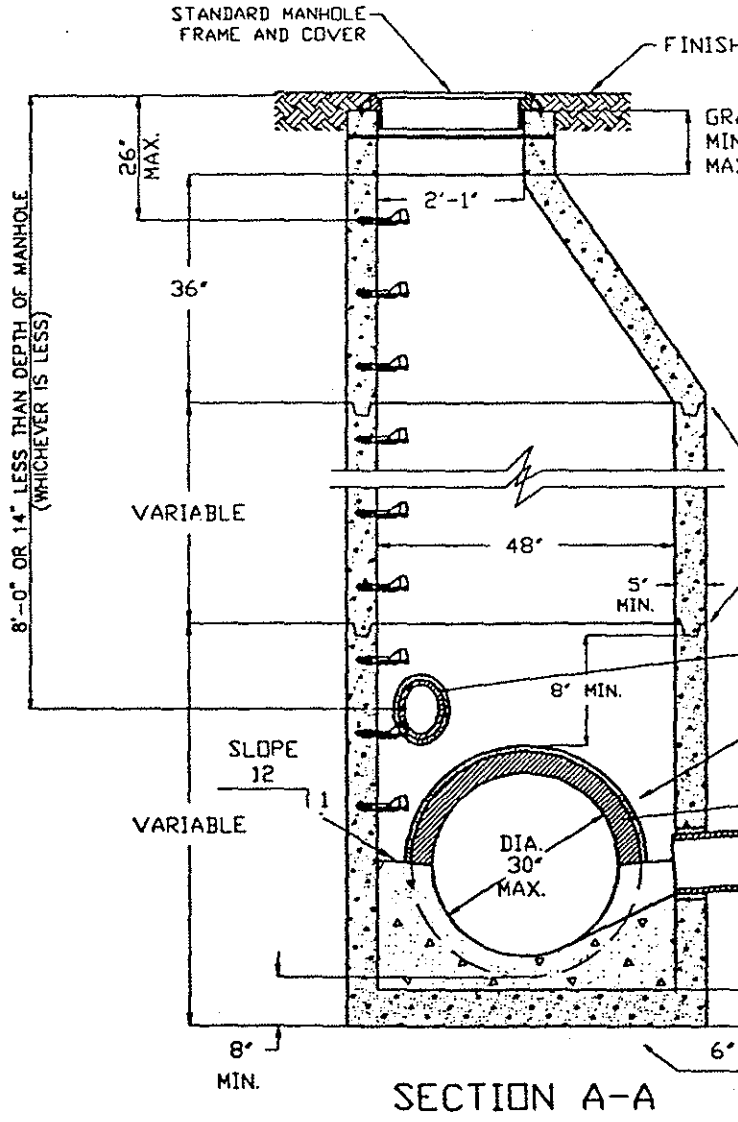
Other Underground Injection Activities

340-44-055 (1) Any underground injection activity which may cause, or tend to cause, pollution of groundwater must be approved by the Director, in addition to other permits or approvals required by other federal, state, or local agencies.

(2) Except for construction and use of waste disposal wells, the Director may enter into an agreement with another state agency which stipulates that the agency's approval of a type of underground injection activity will also constitute his approval, provided he determines that their approval and control program contains adequate safeguards to protect groundwaters from pollution.

Stat. Auth.: ORS Ch. 468
Hist: DEQ 15-1983, f. & ef. 8-26-83





NOTES:
ALL PRECAST SECTIONS SHALL CONFORM TO REQUIREMENT OF ASTM C-478. ALL POURED IN PLACE CONCRETE SHALL HAVE A 28 DAY STRENGTH OF 3,000 PSI AND 2" TO 4" SLUMP. SEE CITY OF PORTLAND STANDARD DRAWING NO. 4-16 FOR MH STEP DETAIL.
ALL CONNECTING PIPE SHALL HAVE A FLEXIBLE JOINT WITHIN 18" OF MANHOLE WALL.

FILL JOINTS WITH CEMENT GROUT OR APPROVED MASTIC

STREET INLET CONNECTION 12" PIPE OR SMALLER.

BLOCK OUT OR SAW CUT 1" MIN. - 4" MAX. CLEAR

REMOVE UPPER HALF OF SEWER PIPE INSIDE OF MANHOLE.

INSTALL MANHOLE BASE ON 6" (MIN) DEPTH OF 1"-0" OR 3/4"-0" CRUSHED ROCK.

SECTION A-A

DEPARTMENT OF PUBLIC WORKS **CITY OF PORTLAND, OREGON**

TITLE OF STANDARD PLAN

PRECAST CONCRETE MANHOLE WITH PRECAST BASE

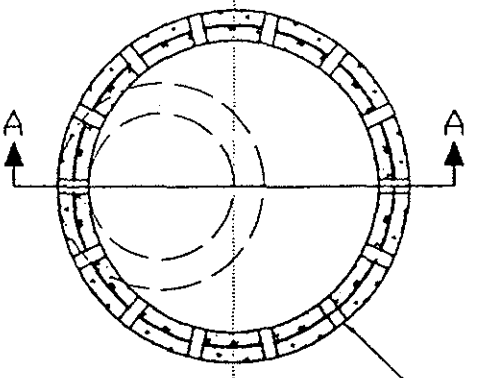
STANDARD PLAN NO.

4-06-3

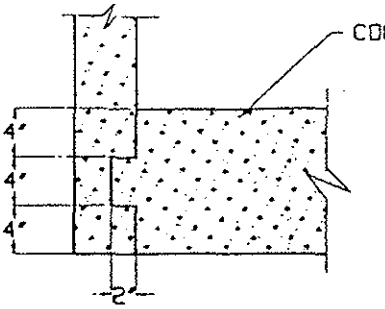
APPROVED

CITY ENGINEER 4/7/98 DATE

NO.	REVISIONS	DATE	BY

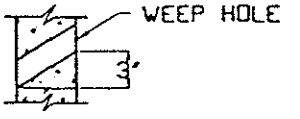


PLAN

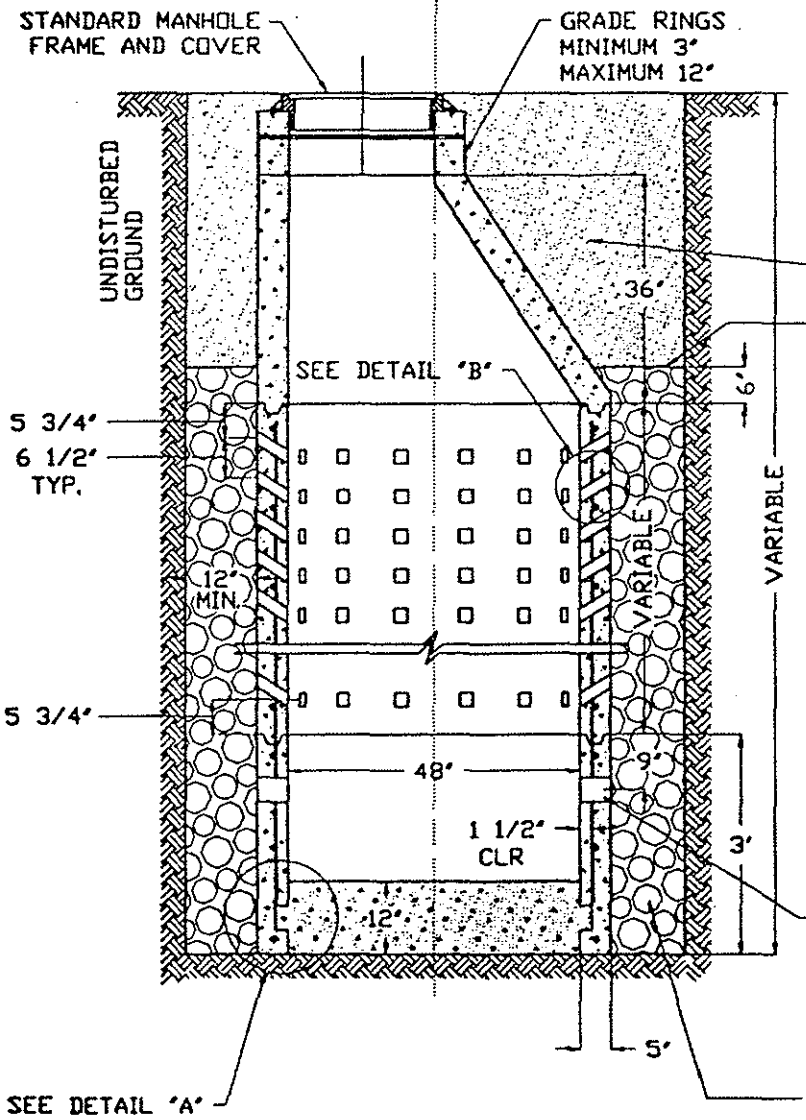


DETAIL "A"

WEEP HOLE
14-2 1/4" SQUARE OR 2 3/8" ROUND HOLES, EQUALLY SPACED OR APPROVED EQUAL.



DETAIL "B"



SECTION A-A

NOTES:

1. ALL PRECAST SECTIONS SHALL CONFORM TO REQUIREMENTS OF ASTM C 478.
2. ALL PIPING TO AND FROM PRECAST SUMP SHALL HAVE AT LEAST 6" OF 1"-0" OR 3/4"-0" CLEAN CRUSHED ROCK COVER CONTINUOUSLY AROUND PIPE WHERE DRAIN ROCK WOULD OTHERWISE BE IN CONTACT WITH PIPE. GEOTEXTILE FABRIC SHALL BE USED AS MEDIUM BETWEEN CRUSHED ROCK COVER AND DRAIN ROCK.
3. INVERT SHALL BE LEVEL AND SMOOTH.
4. PRECAST MANHOLE BASE AS SHOWN ON PLAN 4-06-3 MAY BE SUBSTITUTED FOR BASE SHOWN.

DEPARTMENT OF PUBLIC WORKS **CITY OF PORTLAND, OREGON**

TITLE OF STANDARD PLAN

PRECAST SUMP

STANDARD PLAN NO.

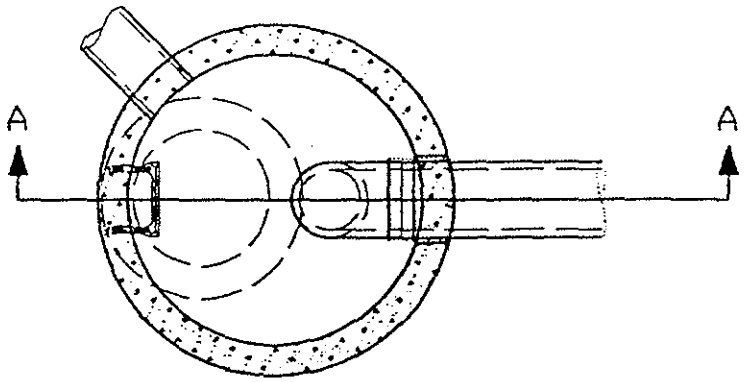
4-10

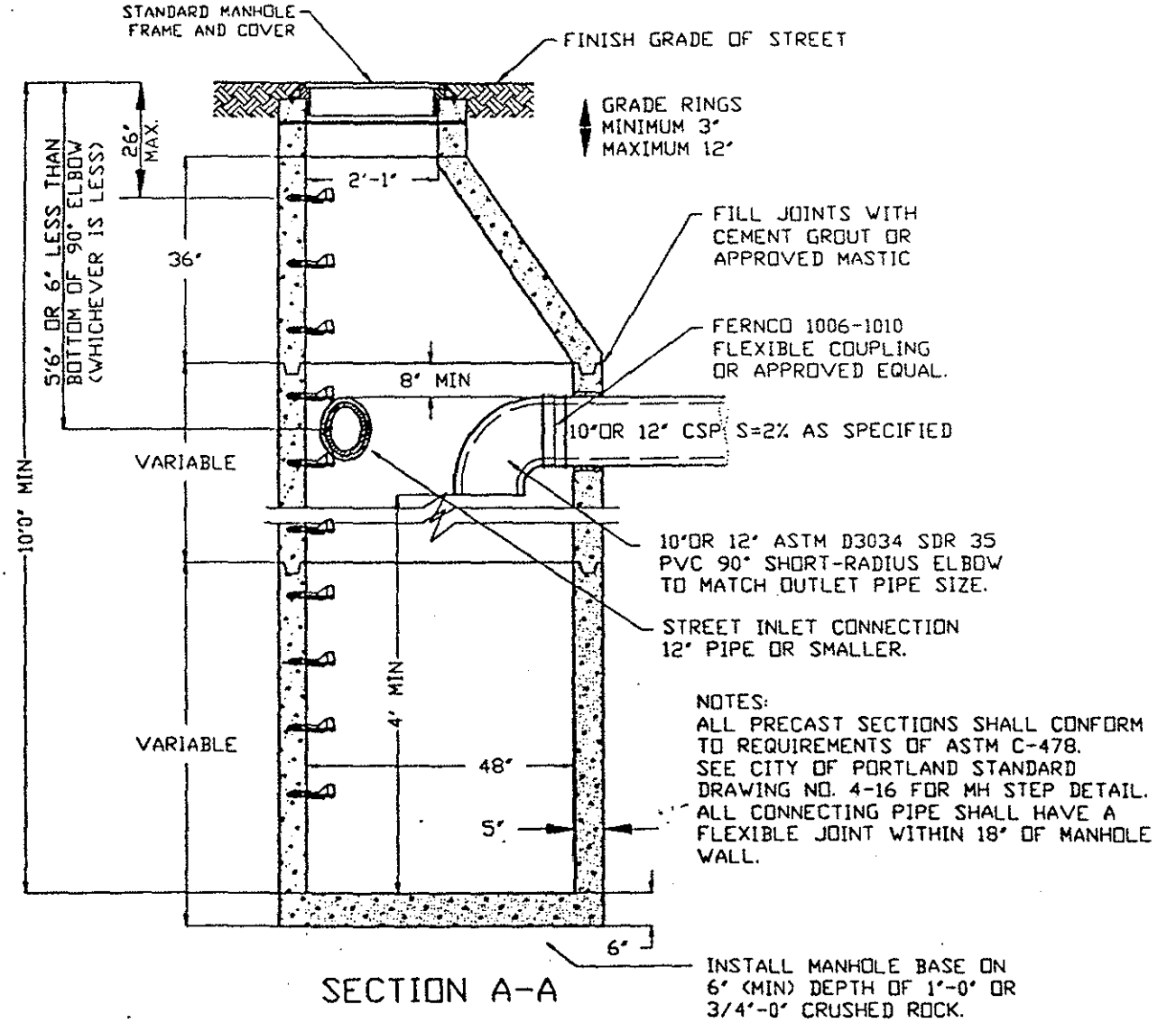
APPROVED

CITY ENGINEER

DATE 4/7/83

NO.	REVISIONS	DATE	BY





NOTES:
ALL PRECAST SECTIONS SHALL CONFORM TO REQUIREMENTS OF ASTM C-478.
SEE CITY OF PORTLAND STANDARD DRAWING NO. 4-16 FOR MH STEP DETAIL.
ALL CONNECTING PIPE SHALL HAVE A FLEXIBLE JOINT WITHIN 18" OF MANHOLE WALL.

SECTION A-A

DEPARTMENT OF PUBLIC WORKS **CITY OF PORTLAND, OREGON**

TITLE OF STANDARD PLAN

SEDIMENTATION MANHOLE

STANDARD PLAN NO.

4-11

APPROVED

Mark F. Ries 4/7/93

CITY ENGINEER DATE

NO.	REVISIONS	DATE	BY

III-3.5.2 Construction

Regardless of the type of infiltration/filtration practice to be constructed, careful consideration must be given in advance of construction to the effects of the work sequence, techniques, and the equipment employed during construction of the facility. Serious maintenance problems can be averted, or in large part mitigated, by the adoption of relatively simple measures during construction.

Previous experience with infiltration and filtration practices in the States of Maryland and Texas has shown that these BMPs must not be put into use, or preferably even constructed, until the drainage areas that contribute runoff to the structure have been adequately stabilized. When this precaution is not taken, infiltration/ filtration structures often become clogged with sediment from upland construction and thus fail to operate properly from the outset. It cannot be emphasized enough how important it is to protect these facilities from sediment deposition at all times.

Care must also be taken to not compact soils during the construction phase as this can seriously affect infiltration and filtration rates. If vehicles must be driven over the infiltration/filtration BMP during construction only those with large tracks shall be used.

Specific construction methods and specifications are provided for each infiltration and filtration BMP in Sections III-3.6 and III-3.7

III-3.5.3 Maintenance

The maintenance requirements of infiltration and filtration BMPs are an important aspect which is often not addressed in the planning and design of these structures. Infiltration and filtration basins can be visually inspected and easily maintained. The surface of an infiltration/filtration trench or roof downspout system can also be visually inspected and maintained, but the subsurface storage area cannot. It is therefore a requirement to install an observation well in practices such as these in order to have an observation mechanism available.

Infiltration and filtration practices must be regularly inspected. Specific maintenance specifications and recommendations are provided for each infiltration and filtration BMP in Sections III-3.6 and III-3.7.

III-3.6 STANDARDS AND SPECIFICATIONS FOR INFILTRATION BMPs

III-3.6.1 Overview

This section presents detailed standards and specifications for the following infiltration best management practices:

BMP RI.05 Water Quality (WQ) Infiltration Basin
BMP RI.06 Streambank Erosion Control (SBEC) Infiltration Basin
BMP RI.10 Water Quality (WQ) Infiltration Trench
BMP RI.11 Streambank Erosion Control Infiltration Trench
BMP RI.15 Roof Downspout System
BMP RI.20 Water Quality (WQ) Porous Pavement
BMP RI.21 Streambank Erosion Control (SBEC) Porous Pavement
BMP RI.30 Water Quality (WQ) Concrete Grid and Modular Pavement
BMP RI.31 Streambank Erosion Control (SBEC) Concrete Grid and Modular Pavement

The standards and specifications for each of the above BMPs contains, where appropriate, information on the following topics:

- Purpose and Definition
- Planning Considerations
- Design Criteria
- Construction and Maintenance Criteria

III-3.6.2 BMP RI.05 Water Quality (WQ) Infiltration Basin

Purpose and Definition

This BMP is a vegetated open impoundment which is designed primarily for runoff treatment purposes and not streambank erosion control. Runoff conveyed to the basin is infiltrated into the underlying soil, where pollutant removal by the soil and vegetative root system takes place. The underlying soil will likely have insufficient permeability to be used for streambank erosion control. Infiltration basins are made by constructing a dam or an embankment, or by excavating a pit or a dugout.

Figure III-3.7 illustrates an infiltration basin.

Planning Considerations

Appropriate soil conditions and the protection of ground water are among the important considerations which may limit the use of the BMP. See Section III-3.3 for a description of General Limitations.

This BMP will typically be located off-line from the primary conveyance/detention system because streambank erosion control is generally not provided. Water Quality Infiltration BMPs must always be preceded by a pretreatment BMP to remove suspended solids that could clog the infiltration soils.

Drainage areas can be up to 50 acres for Water Quality Infiltration Basins. Basin depths are generally from 3 - 12 feet.

Design Criteria

The design procedure described in Section III-3.4 should be used to design an infiltration basin.

- General - The construction of structures, materials allowed, accessibility for maintenance, safety measures, easements, and hydraulic design methods shall be the same as those required for detention basins in Chapter III-4.

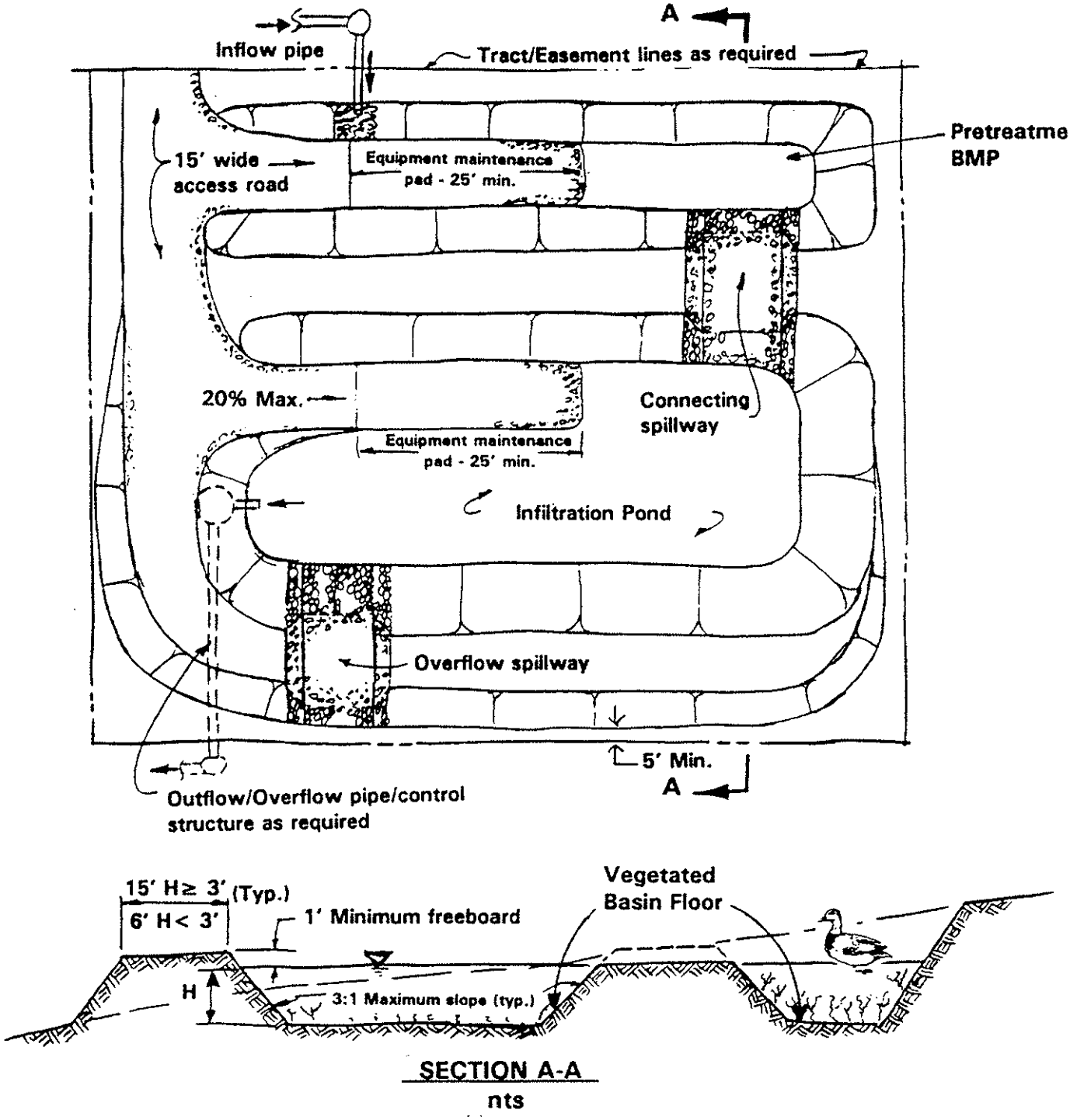
- Soils Investigation - A minimum of one soils log shall be required for each 5,000 square feet of infiltration basin area (plan view area) and in no case less than three soils logs per basin. Each soils log shall extend a minimum of 3 feet in depth below the bottom of the proposed basin, describe the SCS 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 shall be determined.

- The design infiltration rate, f_d, will be equal to one-half the infiltration rate found from the soil textural analysis.

- Pretreatment - Water Quality Infiltration Basins must be preceded by a pretreatment BMP. See Chapter I-4 for selecting appropriate pretreatment BMPs.

- Slopes - Basins should be a minimum of 50 feet from any slope greater than 15 percent. A geotechnical report should address the potential impact of the basin infiltration upon the steep slope.

Figure III-3.7
Infiltration Basin



SECTION A-A
nts

Note: Detail is schematic representation only. Actual configuration will vary depending on specific site constraints and applicable design criteria.

- Buildings - Basins should be a minimum of 100 feet upslope and 20 feet downslope from any building.
- Surface Area - The infiltration surface area (A_s) used for sizing the basin shall be computed by measuring the surface area (plan view area) below the maximum design water surface.
- Drawdown Time - Water Quality Infiltration basins shall be designed to completely drain stored runoff within one day following the occurrence of the 6-month, 24-hour design storm. Thus, a maximum allowable drawdown time of 24 hours shall be used. This will ensure that the necessary aerobic conditions exists in order to provide effective treatment of pollutants. If a Presettling Basin (BMP RD.10) precedes the infiltration basin, the *combined* drawdown time for both BMPs should be 24 hours.
- Vegetation - The basin floor and side banks are to be vegetated. See Volume II for criteria on establishing permanent vegetation.

Construction and Maintenance Criteria

Construction Schedule

The sequence of various phases of basin construction shall be coordinated with the overall project construction schedule. A program should schedule rough excavation of the basin with the rough grading phase of the project to permit use of the material as fill in earthwork areas. The partially excavated basin could serve as a temporary sediment trap or pond in order to assist in erosion and sediment control during construction. However, basins near the final stages of excavation should never be used prematurely for runoff disposal. Drainage from untreated, freshly constructed slopes within the watershed area would load the newly formed basin with a heavy concentration of fine sediment. This could seriously impair the natural infiltration characteristics of the basin floor. Final grade of an infiltration basin shall not be attained until after its use as a sediment control basin is completed.

Specifications for basin construction should state the earliest point in construction progress when storm drainage may be directed to the basins, and the means by which this delay in use should be accomplished. Due to the wide variety of conditions encountered among projects, each should be separately evaluated in order to postpone use as long as is reasonably possible.

Excavation

Initial basin excavation should be carried to within 1 foot of the final elevation of the basin floor. Final excavation to the finished grade should be deferred until all disturbed areas in the watershed have been stabilized or protected. The final phase of excavation should remove all accumulated sediment. Relatively light-tracked equipment is recommended for this operation to avoid compaction of the basin floor. After the final grading is completed, the basin floor should be deeply tilled by means of rotary tillers or disc harrows to provide a well-aerated, highly porous surface texture.

Lining Material

A healthy stand of vegetation is to be established on the basin floor and side slopes. This vegetation will not only prevent erosion and sloughing, but will also provide a natural means of maintaining infiltration rates and will provide additional pollution removal. Erosion protection of inflow points to the basin shall also be provided (e.g., riprap, flow spreaders, energy dissipators). Removal

of accumulated sediment is a problem only at the basin floor. Little maintenance is normally required to maintain the infiltration capacity of side slope areas.

Selection of suitable vegetative materials for the basin floor and side slopes to be stabilized, and application of correct amounts of fertilizer and mulches shall be done in accordance with Volume II, Standards and Specifications for Soil Erosion and Sediment Control. Local extension agencies should also be consulted.

Maintenance

Inspection Schedule

- When infiltration basins are first placed into use they should be inspected on a monthly basis, and more frequently if a large storm occurs in between that schedule. During the period October 1 through March 31 inspections shall be conducted monthly. Thereafter, once it is determined that the basin is functioning in a satisfactory manner and that there are no potential sediment problems, inspection can be reduced to a semi-annual basis with additional inspections following the occurrence of a large storm. This inspection shall include investigation for potential sources of contamination.

Sediment Control

- The basin should be designed with maintenance in mind. Access should be provided for vehicles to easily maintain the forebay (presettling basin) area and not disturb vegetation, or resuspend sediment any more than is absolutely necessary.

- Grass bottoms in infiltration basins seldom need replacement since grass serves as a good filter material. If silty water is allowed to trickle through the turf, most of the suspended material is strained out within a few yards of surface travel. Well established turf on a basin floor will grow up through sediment deposits forming a porous turf and preventing the formation of an impenetrable layer. Grass planted on basin side slopes will also prevent erosion.

Vegetation Maintenance

- Maintenance of vegetation established on the basin floor and side slopes is necessary in order to promote dense turf with extensive root growth which enhances infiltration, prevents erosion and consequent sedimentation, and prevents invasive weed growth. Bare spots are to be immediately stabilized and revegetated.

- The use of low-growing, stoloniferous grasses will permit long intervals between mowings. Mowing twice a year is generally satisfactory. Fertilizers should be applied only as necessary and in limited amounts to avoid contributing to the pollution problems, including ground water pollution, that the infiltration basin is there to solve. Consult the local extension agency for appropriate fertilizer types and application rates.

III-3.6.3 BMP RI.06 Streambank Erosion Control (SBEC) Infiltration Basin

Purpose and Definition

This BMP is similar in design to the Water Quality Infiltration Basin (BMP RI.05) except that it is designed to provide only streambank erosion control; the soils underlying this BMP will be too coarse for runoff treatment purposes. Stormwater must always be treated prior to discharge to this BMP.

Figure III-3.7 illustrates an infiltration basin.

Planning Considerations

Appropriate soil conditions and the protection of ground water are among the important considerations which may limit the use of the BMP. See Section III-3.3 for a description of General Limitations.

Unlike the Water Quality Infiltration Basin, this basin will typically be located "on-line" and be an integral component of the primary conveyance/detention system. The 6-month, 24-hour design storm must be completely treated prior to runoff being discharged to this BMP.

Drainage areas can be up to 50 acres for Water Quality Infiltration Basins. Basin depths are generally from 3 - 12 feet.

Design Criteria

The design procedure described in Section III-3.4 should be used to design an infiltration basin.

- General - The construction of structures, materials allowed, accessibility for maintenance, safety measures, easements, and hydraulic design methods shall be the same as those required for detention basins in Chapter III-4.
- Soils Investigation - A minimum of one soils log shall be required for each 5,000 square feet of infiltration basin area (plan view area) and in no case less than three soils logs per basin. Each soils log shall extend a minimum of 3 feet in depth below the bottom of the proposed basin, describe the SCS 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 shall be determined.
- The design infiltration rate, f_d, will be equal to one-half the infiltration rate found from the soil textural analysis.
- Overflow route - An overflow route must be identified in the event that the basin capacity is exceeded. This overflow route should be designed to meet Minimum Requirement #2 (Preservation of Natural Drainage Systems).
- Runoff Treatment - Runoff from the 6-month, 24-hour design storm is to be completely treated prior to discharge to this BMP.
- Slopes - Basins should be a minimum of 50 feet from any slope greater than 15 percent. A geotechnical report should address the potential impact of the basin infiltration upon the steep slope.
- Buildings - Basins should be a minimum of 100 feet upslope and 20 feet downslope from any building.

- The infiltration surface area (A_s) used for sizing the basin shall be computed by measuring the surface area (plan view area) below the maximum design water surface.

- Spillways - The bottom elevation of the low-stage orifice should be designed to coincide with the one-day infiltration capacity of the basin. All other aspects of the principal spillway design and the emergency spillway shall follow the details provided for detention basins in Chapter III-4.

- Drawdown Time - Streambank Erosion Control Infiltration Basins shall be designed to completely drain stored runoff within one day following the occurrence of the 10-year, 24-hour design storm and within two days of the 100-year, 24-hour design storm (with appropriate correction factors as discussed in Chapter III-1). Thus, a maximum allowable drawdown time of 48 hours is permissible.

- Vegetation - The embankment, emergency spillways, spoil and borrow areas, and other disturbed areas shall be stabilized and planted in accordance with Minimum Requirement #1 (Erosion and Sediment Control).

Construction and Maintenance Criteria

Construction Schedule

The sequence of various phases of basin construction shall be coordinated with the overall project construction schedule. A program should schedule rough excavation of the basin with the rough grading phase of the project to permit use of the material as fill in earthwork areas. The partially excavated basin could serve as a temporary sediment trap or pond in order to assist in erosion and sediment control during construction. However, basins near the final stages of excavation should never be used prematurely for runoff disposal. Drainage from untreated, freshly constructed slopes within the watershed area would load the newly formed basin with a heavy concentration of fine sediment. This could seriously impair the natural infiltration characteristics of the basin floor. Final grade of an infiltration basin shall not be attained until after its use as a sediment control basin is completed.

Specifications for basin construction should state the earliest point in construction progress when storm drainage may be directed to the basins, and the means by which this delay in use should be accomplished. Due to the wide variety of conditions encountered among projects, each should be separately evaluated in order to postpone use as long as is reasonably possible.

Excavation

Initial basin excavation should be carried to within 1 foot of the final elevation of the basin floor. Final excavation to the finished grade should be deferred until all disturbed areas in the watershed have been stabilized or protected. The final phase of excavation should remove all accumulated sediment. Relatively light-tracked equipment is recommended for this operation to avoid compaction of the basin floor. After the final grading is completed, the basin floor should be deeply tilled by means of rotary tillers or disc harrows to provide a well-aerated, highly porous surface texture.

Lining Material

Infiltration basins can be open or be lined with a 6 to 12-inch layer of filter material such as coarse sand or a suitable filter fabric to help prevent the buildup of impervious deposits on the soil surface. The filter layer can be replaced or cleaned when/if it becomes clogged. When a 6-inch layer of organic material is specified for disking or spading into the basin floor to increase the permeability

of the soil, the basin floor should be soaked or inundated for a brief period and then allowed to dry subsequent to this operation. This induces rapid decay in the organic material and prevents the organic matter from becoming hydrophobic, loosening the upper soil layer.

Establishing a healthy stand of vegetation on the basin side slopes and floor is recommended. This vegetation will not only prevent erosion and sloughing, but will also provide a natural means of maintaining relatively high infiltration rates. Erosion protection of inflow points to the basin shall also be provided. Removal of accumulated sediment is a problem only at the basin floor. Little maintenance is normally required to maintain the infiltration capacity of side slope areas.

Selection of suitable vegetative materials for the side slopes and all other areas to be stabilized, and application of correct amounts of fertilizer and mulches shall be done in accordance with Volume II, Erosion and Sediment Control. Local extension agencies should also be consulted.

Maintenance

Inspection Schedule

- When infiltration basins are first placed into use they should be inspected on a monthly basis, and more frequently if a large storm occurs in between that schedule. During the period October 1 through March 31 inspections shall be conducted monthly. Thereafter, once it is determined that the basin is functioning in a satisfactory manner and that there are no potential sediment problems, inspection can be reduced to a semiannual basis with additional inspections following the occurrence of a large storm (e.g. approximately 1 inch in 24 hours). This inspection shall include investigation for potential sources of contamination.

Sediment Control Effect on Vegetated Basins

- The basin should be designed with maintenance in mind. Access should be provided for vehicles to easily maintain the forebay (presettling basin) area and not disturb vegetation, or resuspend sediment any more than is absolutely necessary.

- Cleanout frequency of infiltration basins will depend on whether they are vegetated or non-vegetated and will be a function of their storage capacity, recharge characteristics, volume of inflow, and sediment load.

- Grass bottoms in infiltration basins seldom need replacement since grass serves as a good filter material. If silty water is allowed to trickle through the turf, most of the suspended material is strained out within a few yards of surface travel. Well established turf on a basin floor will grow up through sediment deposits forming a porous turf and preventing the formation of an impenetrable layer. Grass filtration works well with long, narrow, shoulder-type depressions (swales, ditches etc.) where highway runoff flows down a grassy slope between the roadway and the basin. Grass planted on basin side slopes will also prevent erosion.

Sediment Removal From Non-Vegetated Basins

- Sediment is most easily removed when the basin floor (or presettling basin) is completely dry and after the silt layer has mud-cracked and separated from the basin floor. It is recommended that hand raking and removal be done if possible to avoid compaction of the infiltration media by equipment. Large-tracked vehicles should not be used in order to prevent compaction of the basin floor.

Tilling of the Non-Vegetated Basin Floor

- All accumulated sediment must be removed prior to tilling operations. As tilling is required periodically, and at least once annually, the frequency of sediment removal will be reduced to small operations on a regular basis.

- Tilling may be necessary to restore the natural infiltration capacity by overcoming the effects of surface compaction, and to control weed growth on the basin floor.

- Rotary tillers or disc harrows will normally serve this purpose. Light tractors should be employed for these operations. In the event that heavy equipment has caused deeper than normal compaction of the surface, these operations should be preceded by deep plowing. In its final condition after tilling, the basin floor should be level, smooth, and free of ridges and furrows to ease future removal of sediment and minimize the material to be removed during future cleaning operations. A levelling drag, towed behind the equipment on the last pass will accomplish this.

- In the spring the basin surface may be quite porous due to the effects of frost and subsequent thawing. The infiltration capacity diminishes rapidly thereafter. To enhance infiltration capacity, tilling should be done once each season from late June through September. To control vegetative growth, an additional light tillage may be necessary during the growing season. Precautions must be observed to avoid working any of the sediment accumulation into the basin floor as a part of a light cultivation for weed control. ANY cultivation or tilling operation must be preceded in all cases by careful sediment removal.

Side Slope Maintenance

- Maintenance of side slopes is necessary to promote dense turf with extensive root growth which enhances infiltration through the slope surface, prevents erosion and consequent sedimentation of the basin floor, and prevents invasive weed growth.

- Seed mixtures should be the same as those recommended in the Erosion and Sediment Control Volume.

- The use of low-growing, stoloniferous grasses will permit long intervals between mowings. Mowing twice a year is generally satisfactory. Fertilizers should be applied only as necessary and in limited amounts to avoid contributing to the pollution problems, including ground water pollution, that the infiltration basin is there to solve. Consult the local extension agency for appropriate fertilizer types and application rates.

III-3.6.4 BMP RI.10 Water Quality (WQ) Infiltration Trench

Purpose and Definition

This BMP is a shallow excavated trench designed primarily to provide runoff treatment but not streambank erosion control. The soils underlying this BMP must be capable of removing pollutants from runoff and will likely have insufficient permeability to be used for streambank erosion control. Trenches are generally 2 to 10 feet in depth backfilled with a coarse stone aggregate, allowing for temporary storage of storm runoff in the voids between the aggregate material. Stored runoff then gradually infiltrates into the surrounding soil. The surface of the trench can be covered over with grating and/or consist of stone, gabion, sand, or a grassed covered area with a surface inlet.

One alternative design is to install a pipe in the trench and surround it with coarse stone; this will increase the temporary storage capacity of the trench. A second alternative design is to build a vault or tank without a bottom (see BMP RD.15 for details). An infiltration vault/tank is equivalent to a detention vault with the bottom acting as the outlet, instead of having a control structure.

Figures III-3.8 illustrates a Water Quality Infiltration Trench, located off-line from the primary conveyance/detention system. Figure III-3.9 shows a schematic of a typical infiltration trench. Figures III-3.10 through III-3.15 illustrate other variations of trench designs.

Planning Considerations

Appropriate soil conditions and the protection of ground water are among the important considerations which may limit the use of this BMP. See Section III-3.3 for a description of General Limitations. One advantage of trenches is that they have less tendency to become clogged with sediment than do other infiltration BMPs.

This BMP will typically be located "off-line" from the primary conveyance/detention system in order to effectively treat pollutants and protect the infiltration soils from clogging. Water Quality Infiltration BMPs must always be preceded by a pretreatment BMP to remove sediments that could clog the infiltration soils.

An infiltration trench will generally be used in relatively small drainage areas (usually less than 15 acres). This practice can be used in residential lots, commercial areas, parking lots and open space areas. Trenches are one of the few BMPs that are relatively easy to fit into the margin, perimeter, and other less-utilized areas of developed sites, making them particularly suitable for retrofitting. A trench may also be installed under a swale to increase the storage of the infiltration system.

Design Criteria

The procedure described in Section III-3.4 should be used to design an infiltration trench. Trenches are assumed to have rectangular cross-sections, thus the infiltration surface area (sides and bottom) can be readily calculated from the trench geometry. The storage volume of the trench must take into account the volume of backfill material placed in the trench (i.e., void ratio).

The same general criteria that were presented for Water Quality Infiltration Basins (BMP RI.05) shall apply to trenches; the following information is also provided for guidance:

- Soils Investigation - A minimum of one soils log shall be required for every 50 feet of trench length, and in no case less than two soils logs for each proposed

trench location. Each soils log should extend a minimum of 3 feet below the bottom of the trench, describe the SCS 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 shall be determined.

- The design infiltration rate, f_d, will be equal to one-half the infiltration rate found from the soil textural analysis.

- Pretreatment - Water Quality Infiltration Trenches must be preceded by a pretreatment BMP. See Chapter I-4 for selecting appropriate pretreatment BMPs.

- Drawdown Time - Infiltration trenches shall be designed to empty the 6-month, 24-hour storm event within one day (24 hours). This will ensure that the necessary aerobic conditions exists in order to provide effective treatment of pollutants. If a Presettling Basin (BMP RD.10) precedes the infiltration trench, the *combined* drawdown time for both BMPs should be 24 hours.

- Backfill Material - The aggregate material for the infiltration trench shall consist of a clean aggregate with a maximum diameter of 3 inches and a minimum diameter of 1.5 inches. The aggregate should be graded such that there will be few aggregates smaller than the selected size. Void space for these aggregates is assumed to be in the range of 30 percent to 40 percent.

- Filter Fabric - The aggregate fill material shall be completely surrounded as shown in Figure III-3.9 with an engineering filter fabric. In the case of an aggregate surface, filter fabric should surround all of the aggregate fill material except for the top one foot.

- Overflow Channel - In general, because of the small drainage areas controlled by an infiltration trench, an emergency spillway is not necessary. In all cases, the overland flow path of surface runoff exceeding the capacity of the trench should be evaluated to preclude the development of uncontrolled, erosive, concentrated flow. A nonerosive overflow channel leading to a stabilized watercourse shall be provided.

- Seepage Analysis and Control - An analysis shall be made to determine any possible adverse effects of seepage zones when there are nearby building foundations, basements, roads, parking lots or sloping sites. Developments on sloping sites often require the use of extensive cut and fill operations. The use of infiltration trenches on fill sites is not permitted.

- Buildings - Infiltration trenches should be located 20 feet downslope and 100 feet upslope from building foundations.

- Observation Well - An observation well shall be installed for every 50 feet of infiltration trench length. The observation well will serve two primary functions: it will indicate how quickly the trench dewaters following a storm and it will provide a method of observing how quickly the trench fills up with sediments. Figure III-3.16 illustrates observation well details.

  The observation well should consist of perforated PVC pipe, 4 to 6 inches in diameter. It should be located in the center of the structure and be constructed flush with the ground elevation of the trench as shown in Figure III-3.9. The top of the well should be capped to discourage vandalism and tampering.

Construction and Maintenance Criteria

Construction Timing

An infiltration trench shall not be constructed or placed into service until all of the contributing drainage area has been stabilized and approved by the responsible inspector.

Trench Preparation

Excavate the trench to the design dimensions. Excavated materials shall be placed away from the trench sides to enhance trench wall stability. Care should also be taken to keep this material away from slopes, neighboring property, sidewalks and streets. It is recommended that this material be covered with plastic if it is to be left in place for more than 30 days (see BMP E1.20 in Volume II).

Fabric Laydown

The filter fabric roll must be cut to the proper width prior to installation. The cut width must include sufficient material to conform to the trench perimeter irregularities and for a 12 inch minimum top overlap.

Place the fabric roll over the trench and unroll a sufficient length to allow placement of the fabric down into the trench. Stones or other anchoring objects should be placed on the fabric at the edge of the trench to keep the lined trench open during windy periods. When overlaps are required between rolls, the upstream roll should overlap a minimum of 2 feet over the downstream roll in order to provide a shingled effect. The overlap insures fabric continuity and allows the fabric to conform to the excavated surface during aggregate placement and compaction.

Stone Aggregate Placement and Compaction

The stone aggregate should be placed in lifts and compacted using plate compactors. As a rule of thumb, a maximum loose lift thickness of 12 inches is recommended. The compaction process ensures fabric conformity to the excavation sides, thereby reducing potential soil piping, fabric clogging, and settlement problems.

Overlapping and Covering

Following the stone aggregate placement, the filter fabric shall be folded over the stone aggregate to form a 12 inch minimum longitudinal overlap. The desired fill soil or stone aggregate shall be placed over the lap at sufficient intervals to maintain the lap during subsequent backfilling.

Potential Contamination

Care shall be exercised to prevent natural or fill soils from intermixing with the stone aggregate. All contaminated stone aggregate shall be removed and replaced with uncontaminated stone aggregate.

Voids Behind Fabric

Voids may be created between the fabric and excavation sides and shall be avoided. Removing boulders or other obstacles from the trench walls is one source of such voids. Natural soils should be placed in these voids at the most convenient time during construction to ensure fabric conformity to the excavation sides. Soil piping, fabric clogging, and possible surface subsidence will be avoided by this remedial process.

Unstable Excavation Sites

Vertically excavated walls may be difficult to maintain in areas where the soil moisture is high or where soft or cohesionless soils predominate. These conditions require laying back of the side slopes to maintain stability; trapezoidal rather than rectangular cross-sections may result. This is acceptable, but any change in the shape of the stone reservoir needs to be taken into consideration in size calculations.

Traffic Control

Heavy equipment and traffic shall be restricted from travelling over the infiltration areas to minimize compaction of the soil. The trench should be flagged or marked to keep equipment away from the area.

Observation Well

An observation well, as described in the previous section on design criteria and shown in Figure III-3.16 shall be provided. The depth of the well at the time of installation will be clearly marked on the well cap.

Maintenance

Inspection Schedule

- The observation well should be monitored periodically. For the first year after completion of construction, the well should be monitored after every large storm (>1 inch in 24 hours), and, during the period October 1 through March 31 inspections shall be conducted monthly. From April 1 through September 30, the facility should be monitored on a quarterly basis. A log book shall be maintained by the responsible person designated by the local government indicating the rate at which the facility dewaters after large storms and the depth of the well for each observation. Once the performance characteristics of the structure have been verified, the monitoring schedule can be reduced to an annual basis unless the performance data indicate that a more frequent schedule is required.

Sediment Removal

- Sediment buildup in the top foot of stone aggregate or the surface inlet should be monitored on the same schedule as the observation well. A monitoring well in the top foot of stone aggregate shall be required when the trench has a stone surface. Sediment deposits shall not be allowed to build up to the point where it will reduce the rate of infiltration into the trench.

Figure III-3.8
Water Quality Infiltration Trench System

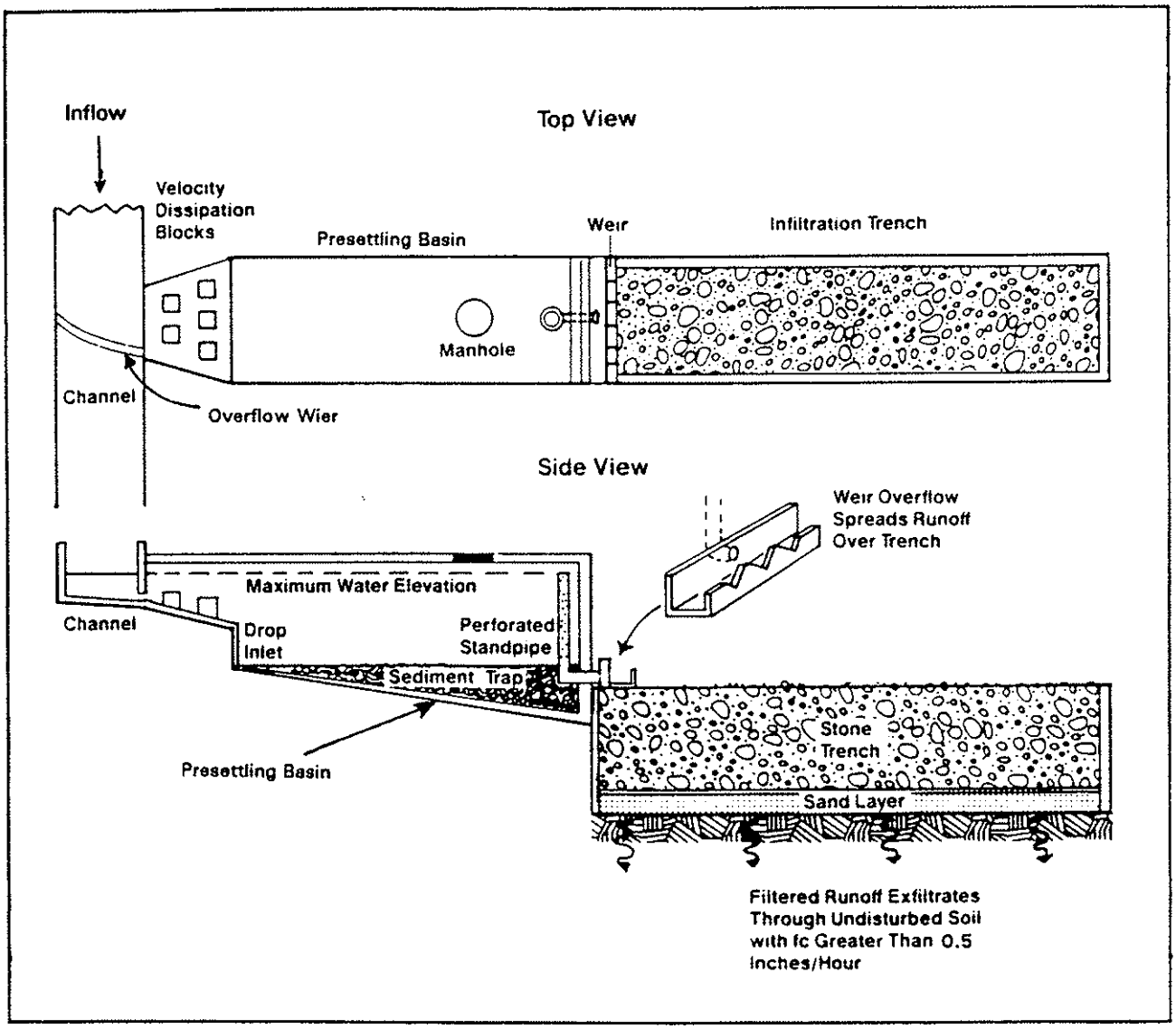


Figure III-3.9 Schematic of an Infiltration Trench
(Reproduced with permission from Schueler (16))

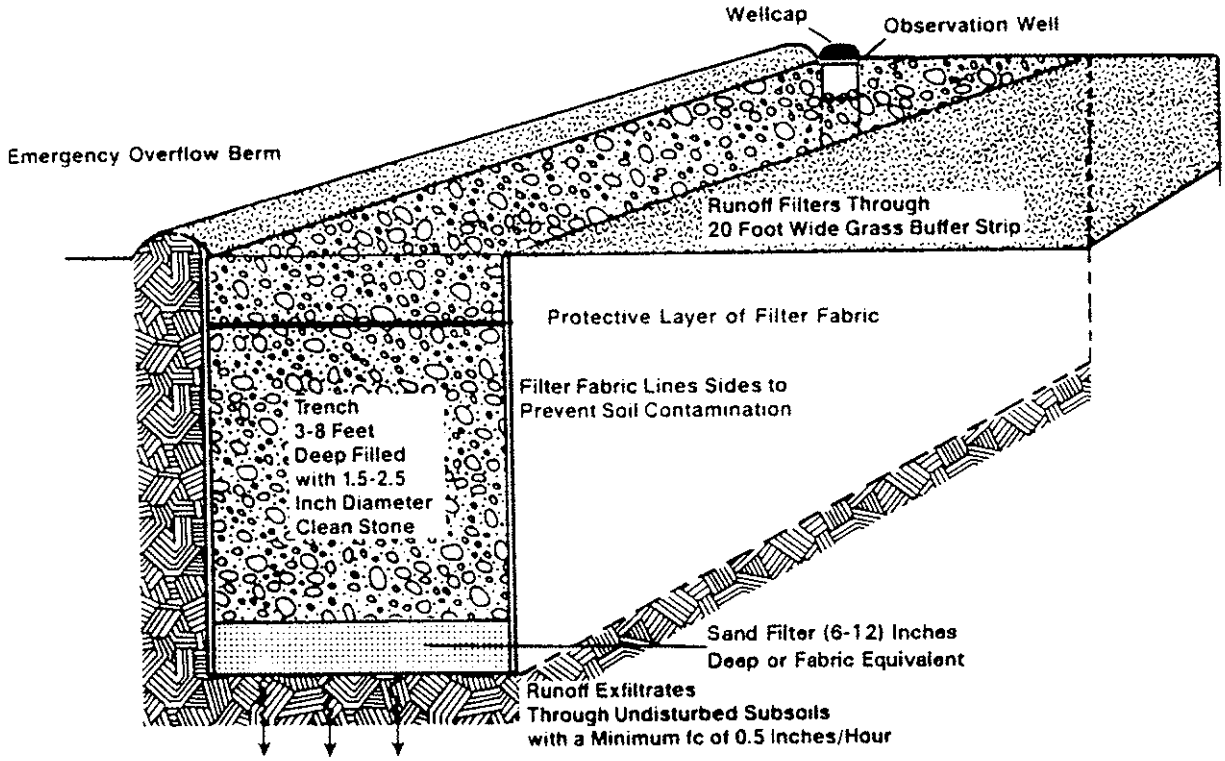


Figure III-3.10 Median Strip Trench Design
(Reproduced with permission from Schueler (16))

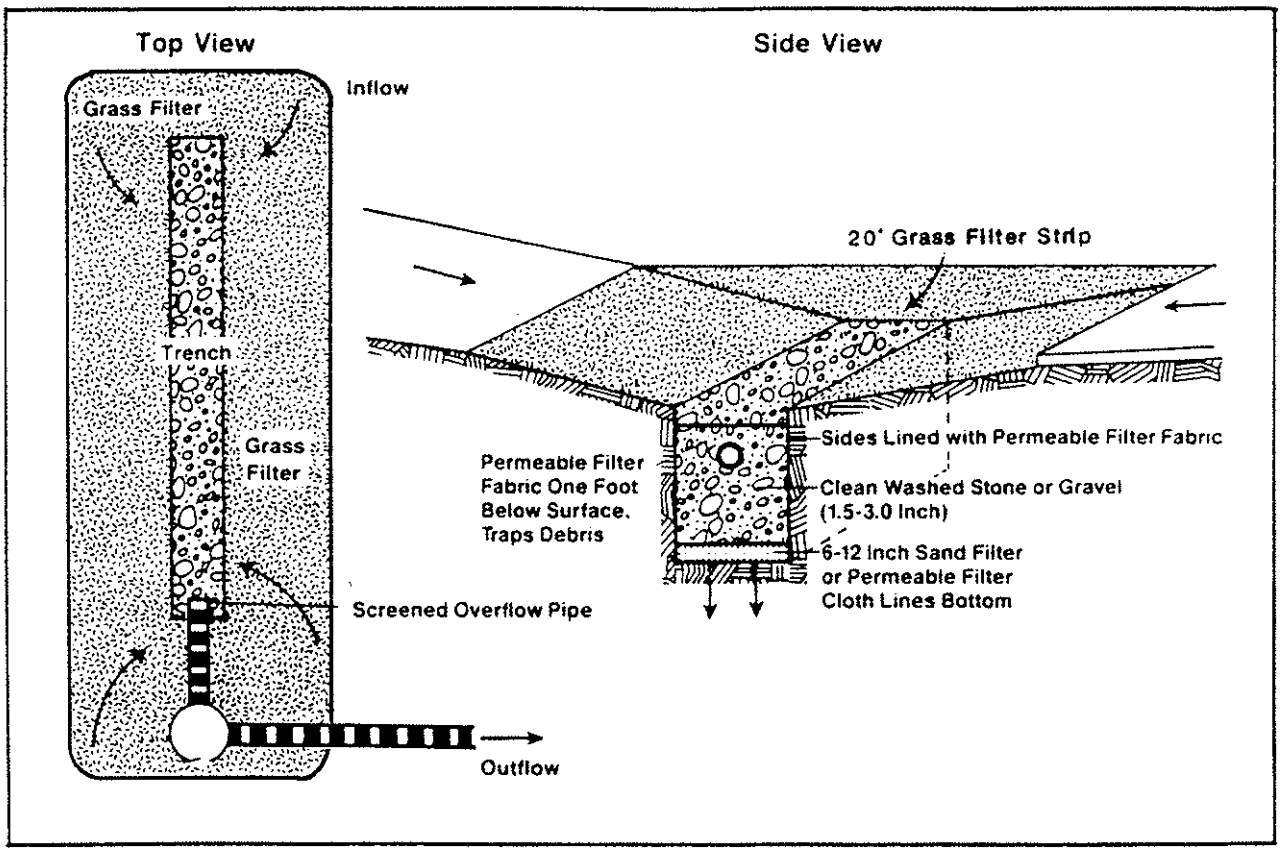


Figure III-3.11 Parking Lot Perimeter Trench Design
(Reproduced with permission from Schueler (16))

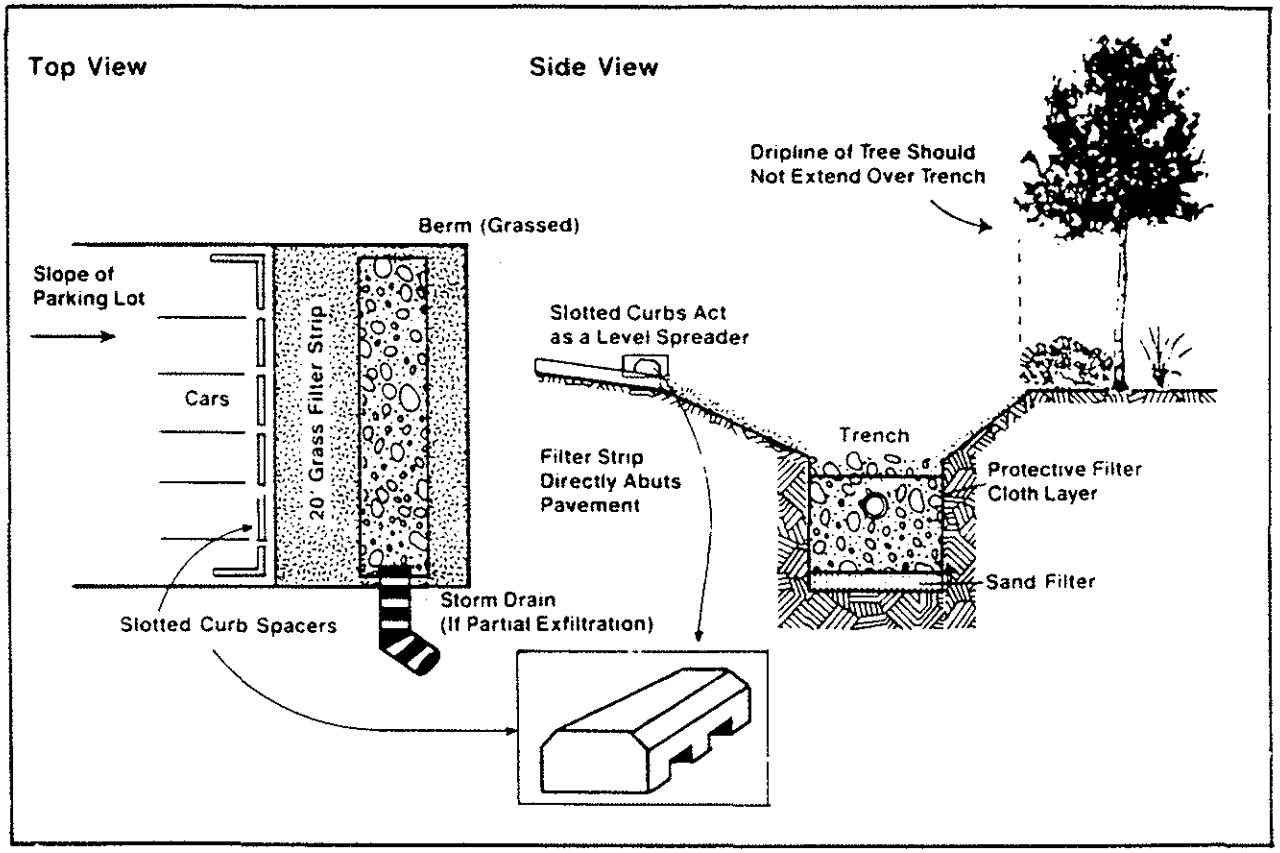


Figure III-3.12 Oversized Pipe Trench Design
(Reproduced with permission from Schueler (16))

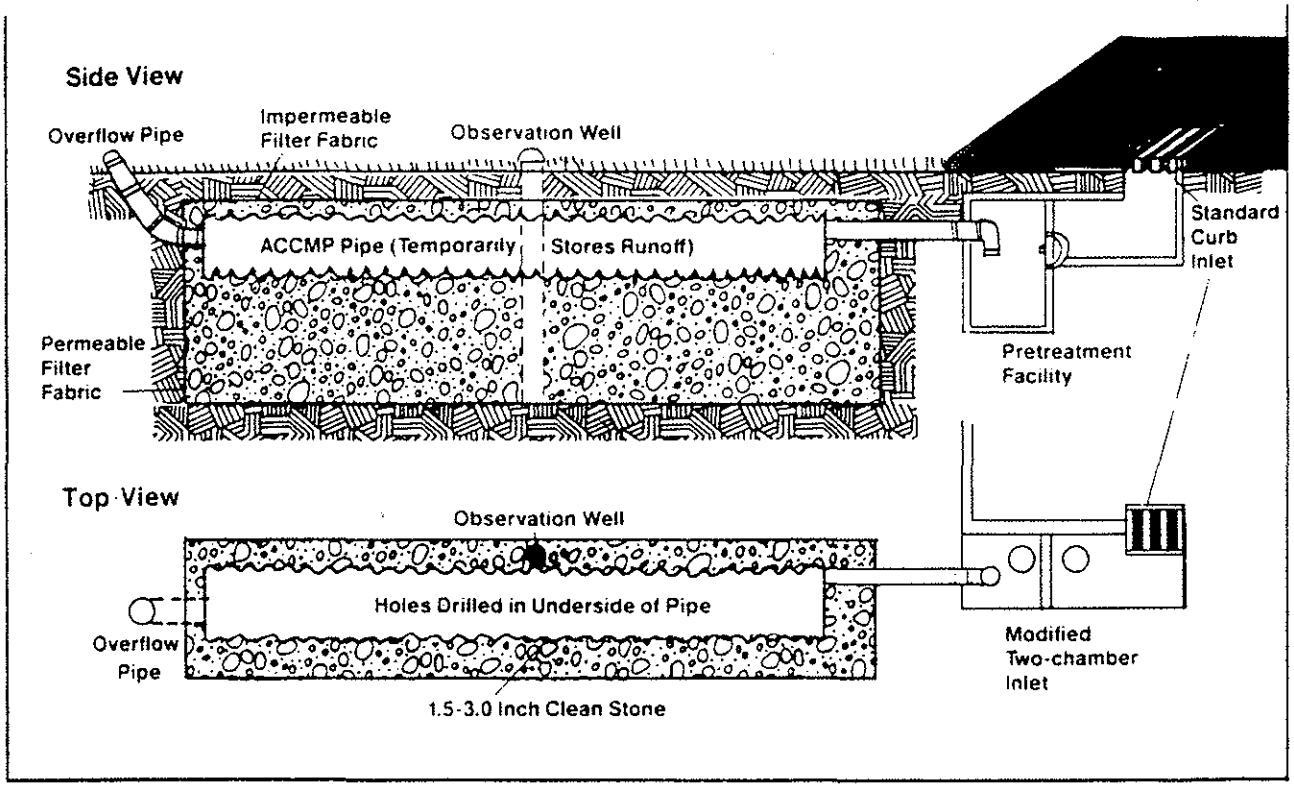


Figure III-3.13 Swale/Trench Design
(Reproduced with permission from Schueler (16))

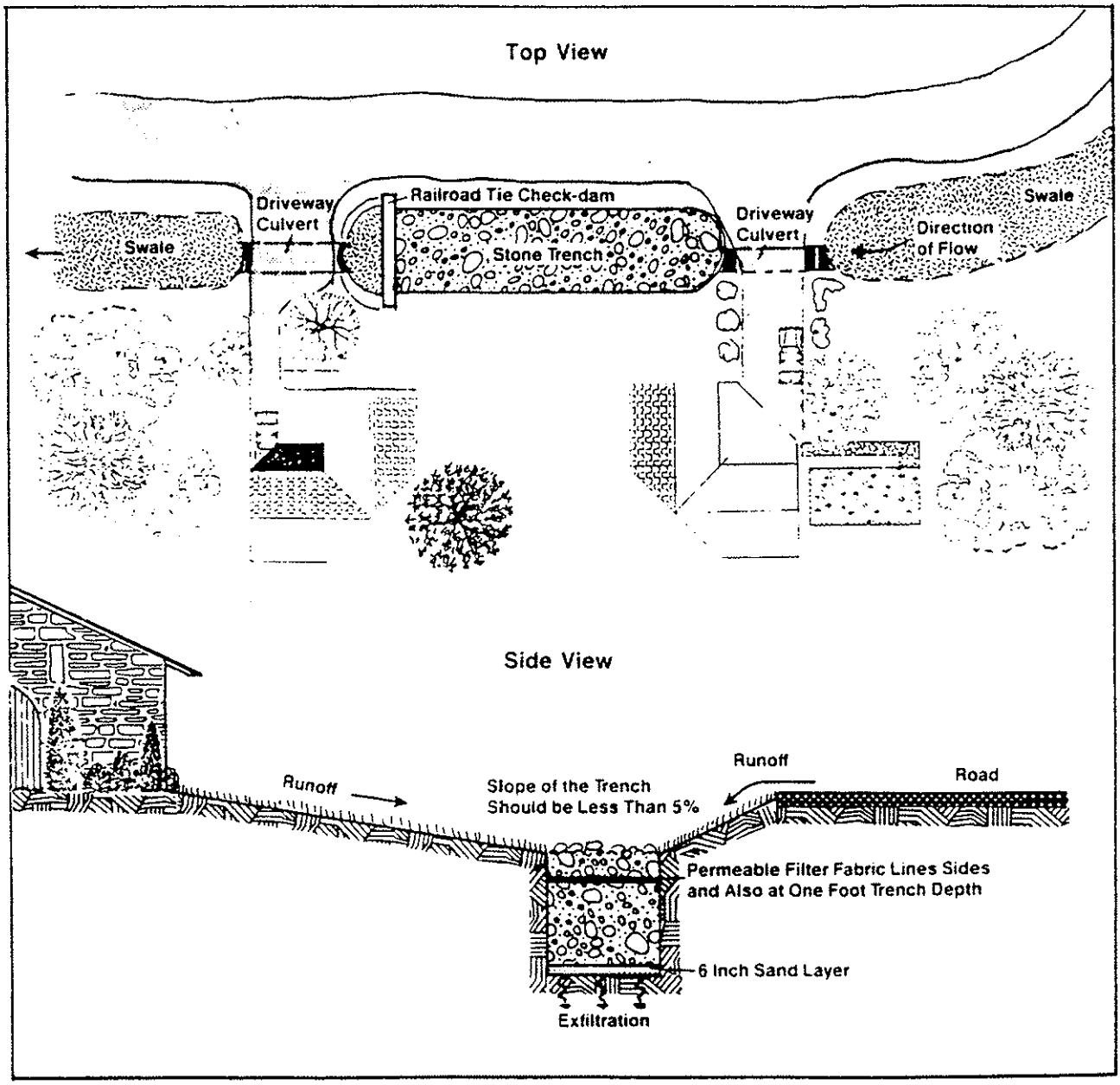


Figure III-3.14 Under-the-Swale Trench Design
(Reproduced with permission from Schueler (16))

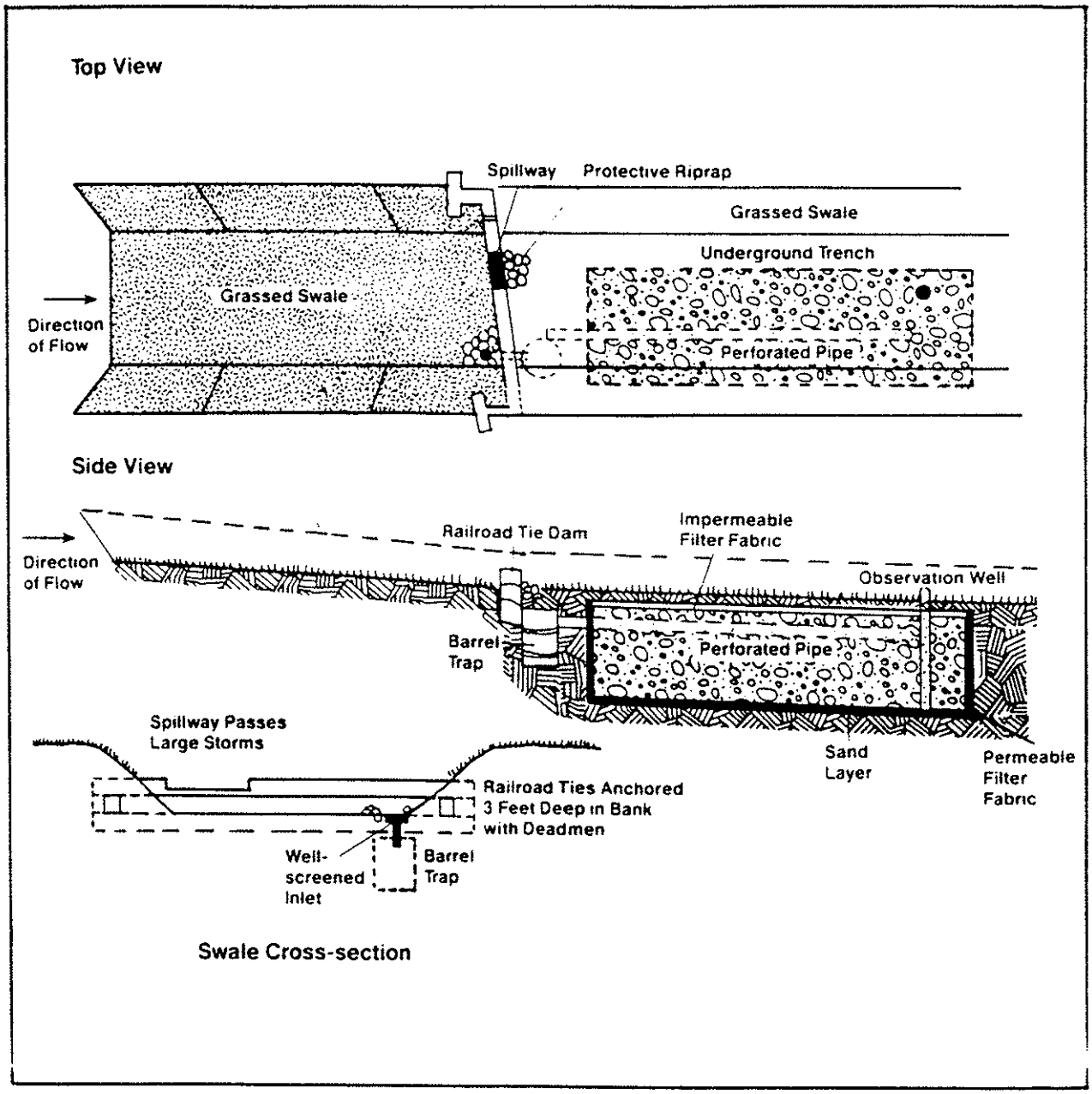


Figure III-3.15 Underground Trench with Oil/Grit Chamber
(Reproduced with permission from Schueler (16))

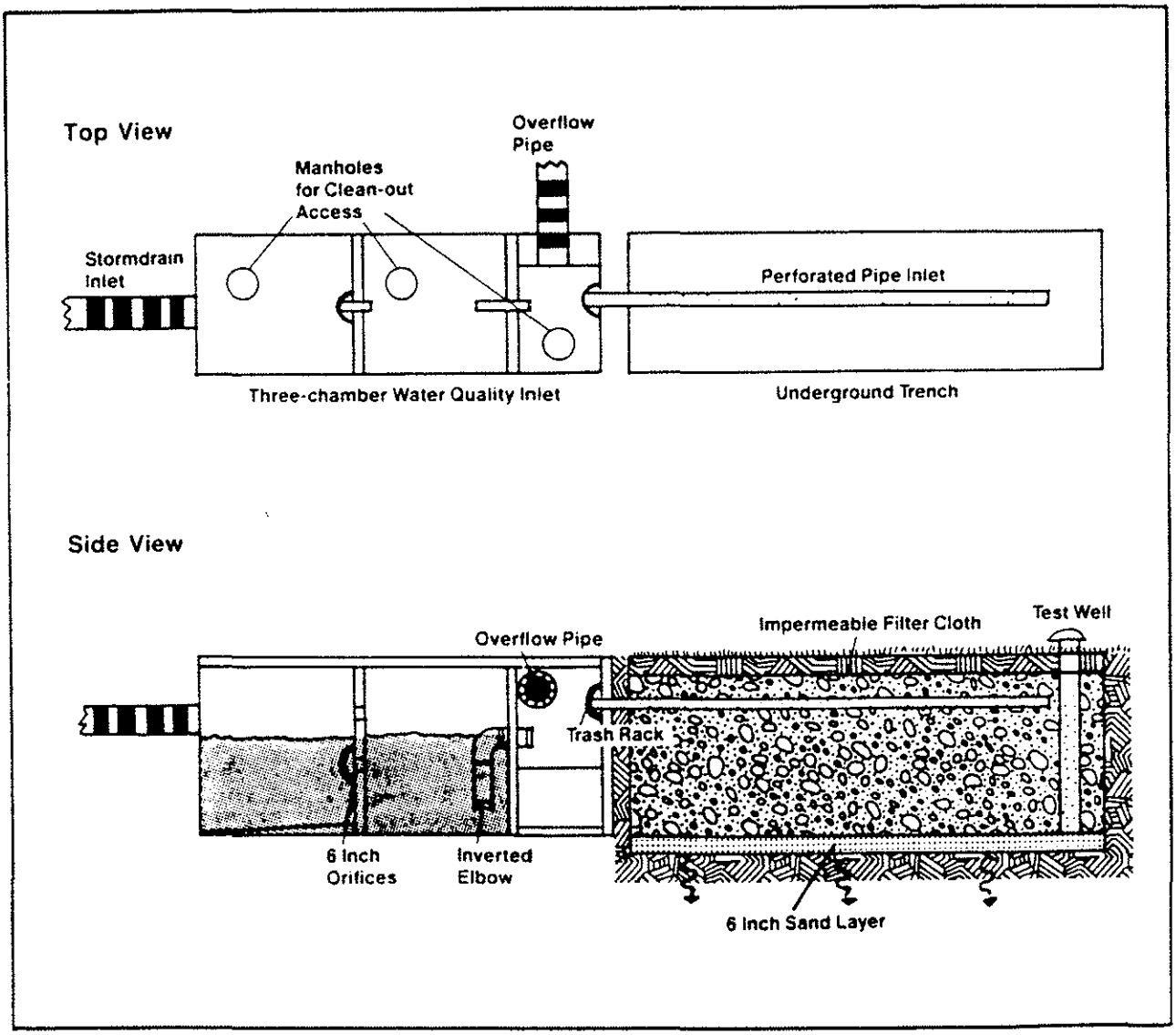
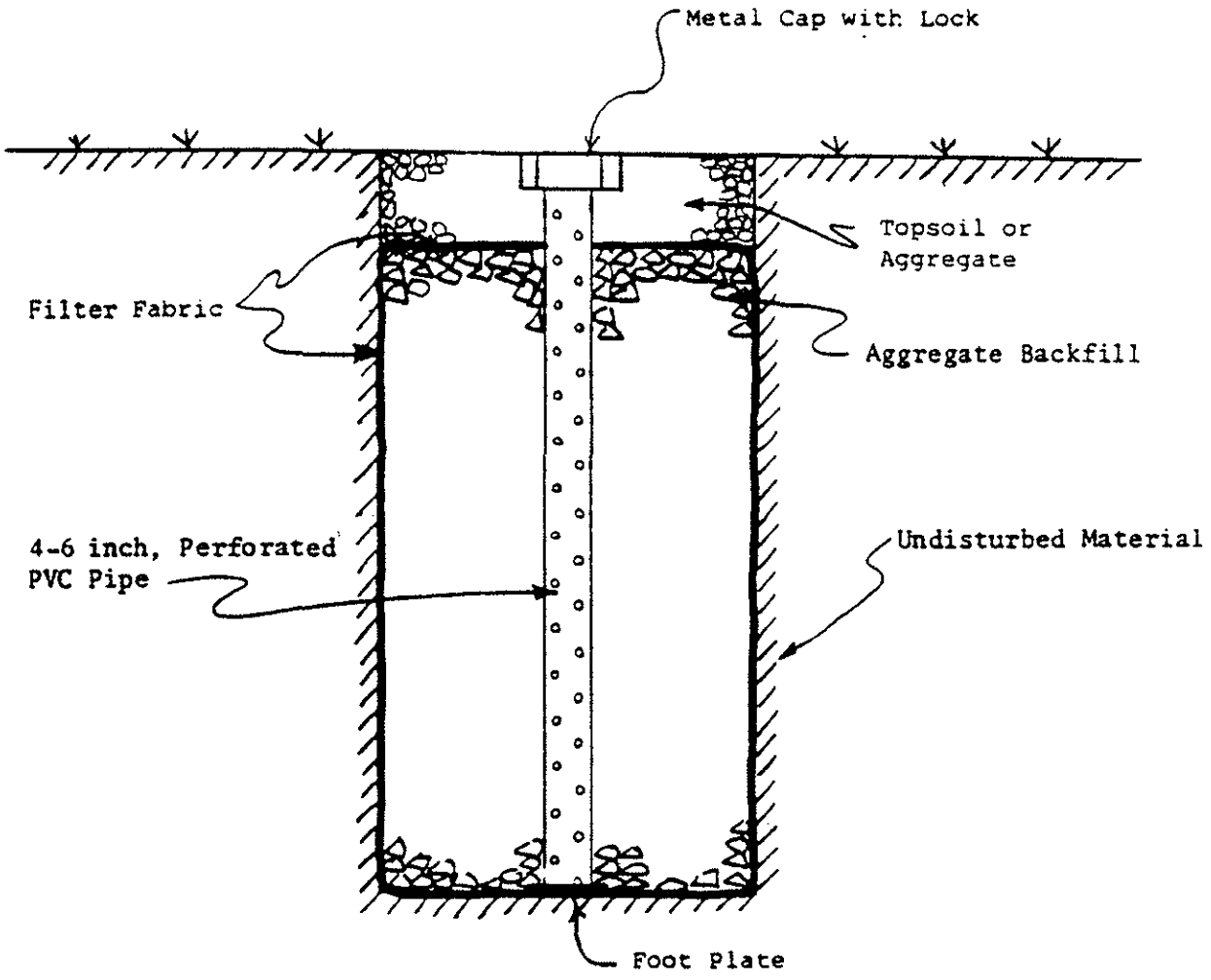


Figure III-3.16
Observation Well Details



III-3.6.5 BMP RI.11 Streambank Erosion Control (SBEC) Infiltration Trench

Purpose and Definition

This BMP is a shallow excavated trench designed to provide streambank erosion control but not runoff treatment. The soils underlying this BMP will be too coarse for pollution removal and stormwater must be treated prior to discharge to this BMP. While physically resembling the Water Quality Infiltration Trench (BMP RI.10) the design criteria for this BMP more closely resembles that used for the Streambank Erosion Control Infiltration Basin (BMP RI.06).

Figures III-3.9 through III-3.15 illustrate infiltration trench designs.

Planning Considerations

Appropriate soil conditions and the protection of ground water are among the important considerations which may limit the use of this BMP. See Section III-3.3 for a description of General Limitations.

This BMP will typically be located on-line with the primary conveyance/detention system. The 6-month, 24-hour design storm must be completely treated prior to runoff being discharged to this BMP.

An infiltration trench will generally be used on relatively small drainage areas. This practice can be used in residential lots, commercial areas, parking lots and open space areas. Trenches are one of the few BMPs that are relatively easy to fit into the margin, perimeter, and other less-utilized areas of developed sites, making them particularly suitable for retrofitting. A trench may also be installed under a swale to increase the storage of the infiltration system.

Drainage areas are generally limited to less than 15 acres.

One advantage of trenches is that they have less tendency to become clogged with sediment than other infiltration BMPs.

Design Criteria

The procedure described in Section III-3.4 should be used to design an infiltration trench. Trenches are assumed to have rectangular cross-sections, thus the infiltration surface area (sides and bottom) can be readily calculated from the trench geometry. The storage volume of the trench must take into account the volume of backfill material placed in the trench (i.e., void ratio).

General Criteria

- Soils Investigation - A minimum of one soils log shall be required for every 50 feet of trench length, and in no case less than two soils logs for each proposed trench location. Each soils log should extend a minimum of 3 feet below the bottom of the trench, describe the SCS 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 shall be determined.

- The design infiltration rate, f_d, will be equal to one-half the infiltration rate found from the soil textural analysis.

- Runoff Treatment - Runoff from the 6-month, 24-hour design storm is to be completely treated prior to discharge to this BMP.

- Drawdown Time - Streambank Erosion Control Infiltration Trenches shall be designed to completely drain stored runoff within one day following the occurrence of the 10-year, 24-hour design storm and within two days of the 100-year, 24-hour design storm (with appropriate correction factors as discussed in Chapter III-1). Thus, a maximum allowable drawdown time of 48 hours is permissible.

- Surface Area - The infiltration surface area (A_s) used for sizing the trench shall be computed by measuring the surface area (plan view area) below the maximum design water surface.

- Slopes - Trenches should be a minimum of 50 feet from any slope greater than 15 percent. A geotechnical report should address the potential impact of the trench infiltration upon the steep slope.

- Backfill Material - The aggregate material for the infiltration trench shall consist of a clean aggregate with a maximum diameter of 3 inches and a minimum diameter of 1.5 inches. The aggregate should be graded such that there will be few aggregates smaller than the selected size. Void space for these aggregates is assumed to be in the range of 30 percent to 40 percent.

- Filter Fabric - The aggregate fill material shall be completely surrounded as shown in Figure III-3.9 with an engineering filter fabric. In the case of an aggregate surfaced trench, filter fabric should surround all of the aggregate fill material except for the top one foot, which is placed over the filter fabric. See Figure III-3.9 for details.

- Overflow route - An overflow route must be identified in the event that the trench capacity is exceeded. This overflow route should be designed to meet Minimum Requirement #2 (Preservation of Natural Drainage Systems).

- Spillways - The bottom elevation of the low-stage orifice should be designed to coincide with the one-day infiltration capacity of the trench. All other aspects of the principal spillway design and the emergency spillway shall follow the details provided for detention basins in Chapter III-4.

- Seepage Analysis and Control - An analysis shall be made to determine any possible adverse effects of seepage zones when there are nearby building foundations, basements, roads, parking lots or sloping sites. Developments on sloping sites often require the use of extensive cut and fill operations. The use of infiltration trenches on fill sites is not permitted.

- Buildings - Infiltration trenches shall be located 20 feet downslope and 100 feet upslope from building foundations.

- Observation Well - An observation well shall be installed for every 50 feet of infiltration trench length. The observation well will serve two primary functions: it will indicate how quickly the trench dewaters following a storm and it will provide a method of observing how quickly the trench fills up with sediments. Figure III-3.16 illustrates observation well details.

  The observation well should consist of perforated PVC pipe, 4 to 6 inches in diameter. It should be located in the center of the structure and be constructed flush with the ground elevation of the trench as shown in Figure III-3.9. The top of the well should be capped to discourage vandalism and tampering.

Construction and Maintenance Criteria

Construction Timing

An infiltration trench shall not be constructed or placed into service until all of the contributing drainage area has been stabilized and approved by the responsible inspector.

Trench Preparation

Excavate the trench to the design dimensions. Excavated materials shall be placed away from the trench sides to enhance trench wall stability. Care should also be taken to keep this material away from slopes, neighboring property, sidewalks and streets. It is recommended that this material be covered with plastic if it is to be left in place for more than 30 days (see BMP E1.20 in Volume II).

Fabric Laydown

The filter fabric roll must be cut to the proper width prior to installation. The cut width must include sufficient material to conform to the trench perimeter irregularities and for a 12 inch minimum top overlap.

Place the fabric roll over the trench and unroll a sufficient length to allow placement of the fabric down into the trench. Stones or other anchoring objects should be placed on the fabric at the edge of the trench to keep the lined trench open during windy periods. When overlaps are required between rolls, the upstream roll should overlap a minimum of 2 feet over the downstream roll in order to provide a shingled effect. The overlap insures fabric continuity and allows the fabric to conform to the excavated surface during aggregate placement and compaction.

Stone Aggregate Placement and Compaction

The stone aggregate should be placed in lifts and compacted using plate compactors. As a rule of thumb, a maximum loose lift thickness of 12 inches is recommended. The compaction process ensures fabric conformity to the excavation sides, thereby reducing potential soil piping, fabric clogging, and settlement problems.

Overlapping and Covering

Following the stone aggregate placement, the filter fabric shall be folded over the stone aggregate to form a 12 inch minimum longitudinal overlap. The desired fill soil or stone aggregate shall be placed over the lap at sufficient intervals to maintain the lap during subsequent backfilling.

Potential Contamination

Care shall be exercised to prevent natural or fill soils from intermixing with the stone aggregate. All contaminated stone aggregate shall be removed and replaced with uncontaminated stone aggregate.

Voids Behind Fabric

Voids may be created between the fabric and excavation sides and shall be avoided. Removing boulders or other obstacles from the trench walls is one source of such voids. Natural soils should be placed in these voids at the most convenient time during construction to ensure fabric conformity to the excavation sides. Soil piping, fabric clogging, and possible surface subsidence will be avoided by this remedial process.

Unstable Excavation Sites

Vertically excavated walls may be difficult to maintain in areas where the soil moisture is high or where soft or cohesionless soils predominate. These conditions require laying back of the side slopes to maintain stability; trapezoidal rather than rectangular cross-sections may result. This is acceptable, but any change in the size or the shape of the stone reservoir needs to be taken into consideration in size calculations.

Traffic Control

Heavy equipment and traffic shall be restricted from travelling over the infiltration areas to minimize compaction of the soil. The trench should be flagged or marked to prevent drive-on.

Observation Well

An observation well, as described in the previous section on design criteria and shown in Figure III-3.16 shall be provided. The depth of the well at the time of installation will be clearly marked on the well cap.

Maintenance

Inspection Schedule

- The observation well should be monitored periodically. For the first year after completion of construction, the well should be monitored on a quarterly basis and after every large storm. During the period October 1 through March 31 inspections shall be conducted monthly. A log book shall be maintained by the responsible person designated by the local government indicating the rate at which the facility dewaters after large storms and the depth of the well for each observation. Once the performance characteristics of the structure have been verified, the monitoring schedule can be reduced to an annual basis unless the performance data indicate that a more frequent schedule is required.

Sediment Removal

- Sediment buildup in the top foot of stone aggregate or the surface inlet should be monitored on the same schedule as the observation well. A monitoring well in the top foot of stone aggregate shall be required when the trench has a stone surface. Sediment deposits shall not be allowed to build up to the point where it will reduce the rate of infiltration into the trench.

III-3.6.6 BMP RI.15 Roof Downspout System

Purpose and Definition

A roof downspout system is an infiltration trench system intended only for use in infiltrating runoff from roof downspout drains. This BMP is not designed to directly infiltrate any surface water that could transport sediment or pollutants such as from paved areas. Because runoff from rooftops is relatively clean, no treatment is required prior to its discharge to the soil. Figure III-3.17 illustrates a typical roof downspout system.

Planning Considerations - none.

Conditions Where Practice Applies

Roof downspout systems may be used in any situation where it is acceptable to dispose of this runoff by avoiding or replacing the use of direct connections to storm or sanitary sewers, or where such facilities do not exist. Because of their small size, they are well suited for a retrofit in areas where additional runoff control becomes necessary.

Advantages

- In areas where such practices can be used, they may cause a significant reduction in the need for installation of storm sewers and other stormwater runoff control facilities.
- Roof downspout systems are small and relatively simple to install and can be retrofit into subdivisions as necessary.

Disadvantages/Problems

- As with all underground infiltration systems, these systems are difficult to monitor, and may be difficult to replace if they are installed under paved areas.
- If used on single family residences, provisions should be made for maintenance responsibility, perhaps through the homeowner's association.

Specific Limitations

- Roof downspout systems are meant only to be used in areas where there is no significant depositional air pollution. Advice on this should be sought from Ecology or local agencies responsible for managing air quality if the residence is near major sources of air pollution.

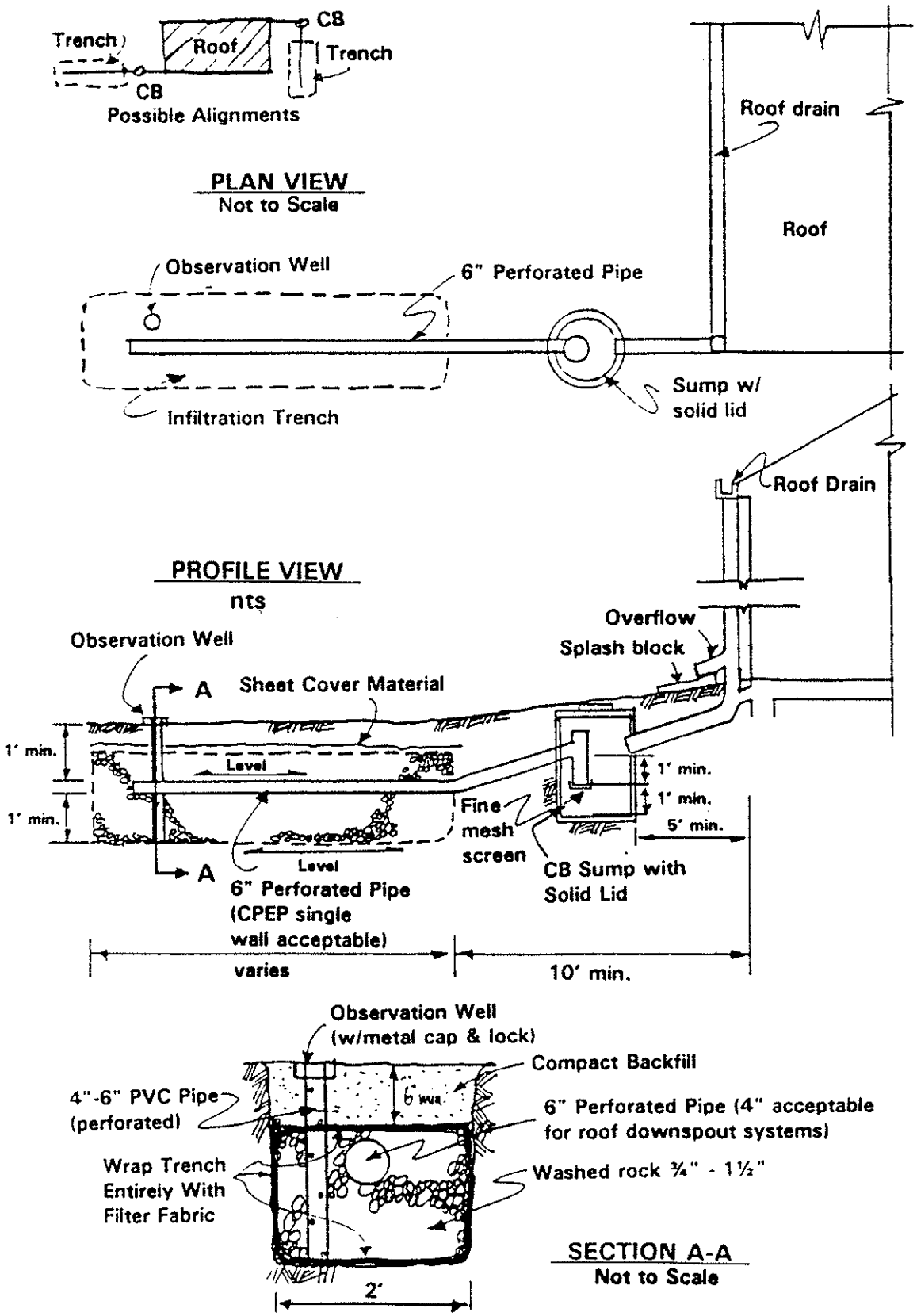
Design Criteria

The design criteria for infiltration trenches also applies to roof downspout systems with the following exceptions and/or additions:

Trenches Installed Under Pavement

- Trenches may be located under pavement provided that a small yard drain\ catchbasin with a grate cover is placed at the end of the trench pipe such that if the trench infiltration capacity is exceeded, the overflow would occur out of the catchbasin at an elevation at least 1 foot below that of any overlying pavement, and in a location which can accommodate the overflow and meet the requirements of Minimum Requirement #2 (Preservation of Natural Drainage Systems).

Figure III-3.17 Roof Downspout System



Other Requirements

- Roof downspout systems shall be a minimum of 10 feet from any structure, property line, or NGPE, and 30 feet from any septic tank or drainfield.
- Roof downspout systems shall be a minimum of 50 feet from any steep slope.
- The length of a roof downspout system should not exceed 100 feet from the inlet sump.
- Each roof downspout system shall have an observation well similar to that described for an infiltration trench. It should extend to the bottom of the trench and be located at a point approximately halfway in length.
- Filter fabric shall be wrapped entirely around the aggregate rock prior to backfilling.

Construction and Maintenance Criteria

Construction Specifications

Construction specifications are identical to those for infiltration trenches.

Maintenance

Maintenance procedures are identical for those of an infiltration trench. It is important to consider the fact that since these facilities are installed on individual structures, provision needs to be made for the maintenance of these structures, especially when the systems are installed on single family dwellings.

CHAPTER III-6

BIOFILTRATION SWALES AND VEGETATIVE FILTER STRIPS

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CHAPTER III-6

BIOFILTRATION SWALES AND VEGETATIVE FILTER STRIPS

Editor's Note: This edition of the manual has classified biofiltration swales and vegetative filter strips as two different BMPs. Though their pollutant removal mechanisms are similar, their planning and design criteria are different enough to warrant separation. However, this edition of the manual retains the previous edition's criteria; subsequent editions of this manual will likely reflect changes in planning and design criteria.

There are still uncertainties and differences of opinion on how to best design biofiltration swales and vegetative filter strips. In addition, the effectiveness of these BMPs, especially for the treatment of nutrients, is an unresolved issue. As a result of this and other issues, Ecology plans to convene a standing advisory group that will attempt to resolve key technical issues. A review of the latest findings from current biofilter monitoring projects will be conducted and recommendations made regarding the design methodology, planning considerations, construction, and maintenance of biofilters and vegetative filter strips. Subsequent editions of this manual will incorporate such findings.

III-6.1 INTRODUCTION

III-6.1.1 Background

Biofiltration swales and vegetative filter strips are two practices which have been used in stormwater management for some years. Only fairly recently have they been studied to determine their effectiveness at treating pollution from stormwater runoff and to assess their abilities to reduce peak flow rates. Because these two BMPs are non-structural, they are considered desirable alternatives to ponds, tanks, and vaults. At this time these two practices are assumed to provide runoff treatment but not streambank erosion control (the latter is an issue that needs further investigation, especially for less intensely developed sites).

III-6.1.2 Purpose and Scope

The purpose of this chapter is to present general and specific criteria for the evaluation, design, construction, and maintenance of biofiltration swales and vegetative filter strips. In particular, this chapter provides guidance on how BMPs can be designed to accomplish one of the two primary stormwater management objectives, *runoff treatment* and *streambank erosion control* (recall that *source control* is another objective which is required in all cases). While streambank erosion control is not generally provided by these BMPs, biofiltration swales can be designed to convey higher flows to BMPs used for streambank erosion control and thus may be incorporated into the primary conveyance/detention system.

Section III-6.2. should be read first as it gives a description of the pollutant removal mechanisms utilized by biofilters and vegetative filter strips to meet Ecology's runoff treatment standard. Sections III-6.3 and III-6.4 provide detailed planning, design, construction, and maintenance criteria for each BMP. A design procedure is described in Appendix AIII-6.1 for both BMPs with an example problem provided in Appendix AIII-6.2.

Figure III-6.1 Biofiltration Swale

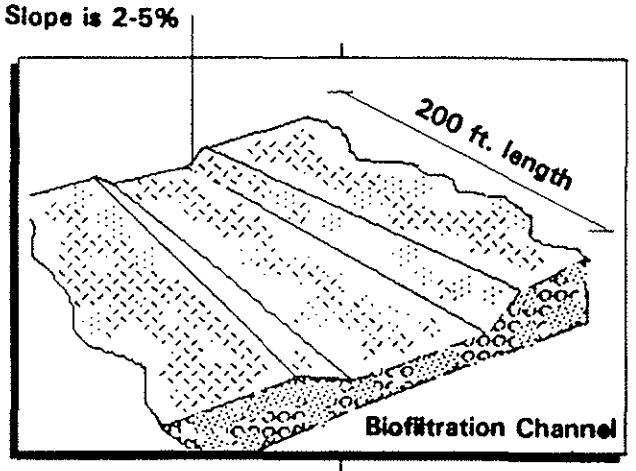
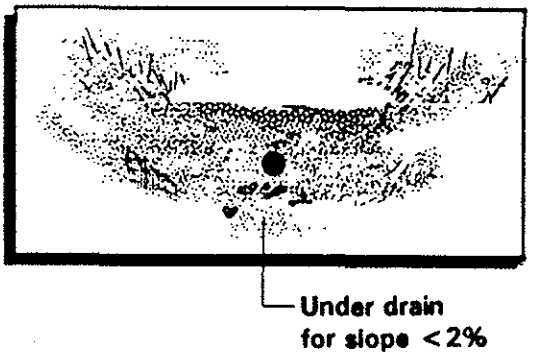


Figure III-6.2 Biofiltration Swale with Underdrain System



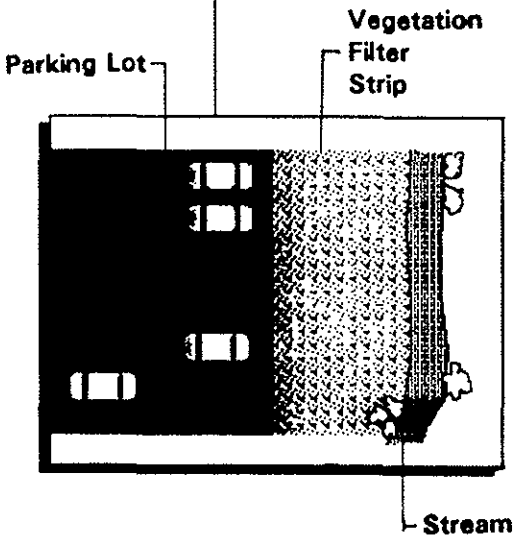


Figure III-6.3
Vegetated Filter Strip

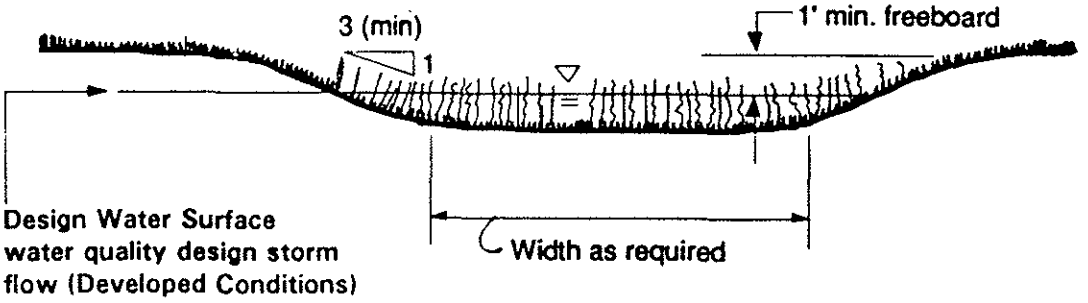


Figure III-6.4 Swale Design Showing Freeboard

III-6.2 RUNOFF TREATMENT AND CONVEYANCE

III-6.2.1 Overview

There are two types of biofiltration-type BMPs: the biofiltration swale (BMP RB.05) and the vegetated filter strip (BMP RB.10). Figures III-6.1 through III-6.4 illustrate these BMPs. A biofiltration swale is a vegetated channel that is sloped like a standard storm drain channel; stormwater enters at one end and exits at the other with treatment provided as the runoff passes through the channel. With vegetated filter strips the flow is distributed broadly along the width of the vegetated area; treatment is provided as runoff travels as sheet flow through the vegetation.

Which method to use depends upon the drainage patterns of the site. A vegetated strip would function well where the water can be spread along the length of a parking lot. Gaps in the lot curb provide the entry points. Of course, the grade of the parking lot must be flat immediately parallel to the strip.

For runoff treatment purposes, biofiltration swales and vegetative filter strips are to be designed to treat the 6-month, 24-hour design storm, as required by Minimum Requirement #4 (see Chapter I-2). *Note: This is a change from the previous edition of this manual. Formerly the design storm for biofilters was the 2-year, 24-hour event. The change has been made so that all runoff treatment BMPs will be designed in a consistent manner.*

III-6.2.2 Mechanisms of Pollutant Removal

Biofiltration swales and vegetative filter strips use similar pollutant removal mechanism, i.e., "biofiltration." The term "biofiltration" has been coined to describe the more-or-less simultaneous processes of filtration, infiltration, adsorption and biological uptake of pollutants in stormwater that take place when runoff flows over and through vegetated treatment facilities. Vegetation growing in these facilities acts as both a physical filter which causes gravity settling of particulates by regulating velocity of flow, and also as a biological sink when direct uptake of dissolved pollutants occurs. The former mechanism is probably the most important in western Washington where the period of major runoff coincides with the period of lowest biological activity.

Another means of removing pollutants occurs as the stormwater contacts the soil surface and infiltrates into the underlying soil. Dissolved pollutants are adsorbed onto soil particles. This is a potentially important removal mechanism for both dissolved heavy metals and phosphorus by undergoing ion exchange with elements in the soil. In addition, biological activity in the soil can metabolize organic contaminants. However, in highly porous soils stormwater can be a threat to shallow ground water since these soils have little treatment capacity. In such instances, biofilter BMPs must meet the General Limitations for infiltration BMPs (see Chapter III-3) or it may be necessary to install a liner to prevent infiltration.

The degree to which the above mechanisms operate will vary considerably depending upon many factors such as the depth and condition of the vegetation, the velocity of the water, the slope of the ground, and the texture of the underlying soil. However, the most important criterion that can be developed from these variables is the residence time of the stormwater in the biofilter, provided there is an adequate stand of vegetation and the underlying soil is of moderate texture. Therefore, to be effective, the biofilter must be designed such that the residence time is sufficient to permit most if not all of the particulates and at least some of the dissolved pollutants to be removed from the stormwater.

Design criteria that will maximize the effectiveness of biofiltration swales and strips are still in the developmental stage because their use for treating

stormwater locally has only been applied and investigated for a relatively short time. They have been largely based on work done in the early 1980s by researchers at the University of Washington for the Washington State Department of Transportation and have relied heavily on the finding that total suspended solids and lead were reduced by at least 80 percent in 200 feet of grass swale (1).

The most recent comprehensive publication dealing with biofiltration systems locally was prepared in 1988 by Horner (2) and the reader is referred to this document for further details including a review of the literature and a survey of operating biofilters.

III-6.3 BMP RB.05 BIOFILTRATION SWALE

Purpose and Definition

A biofiltration swale is designed to provide runoff treatment of conventional pollutants but not nutrients. It does not provide streambank erosion control but can be designed to convey runoff to BMPs designed for that purpose. Biofiltration swales, when used as a primary treatment BMP, should be located "off-line" from the primary conveyance/detention system in order to enhance effectiveness (they can also be made smaller when located "off-line"). If a biofiltration swale is used to protect a water quality infiltration BMP or a sand filtration BMP (see Chapter III-3), then it will be necessary to locate it "off-line."

In cases where a biofiltration swale is located "on-line" it must be sized as both a treatment facility and as a conveyance system to pass the peak hydraulic flows of the 10 and 100-year design storm. **To be effective, the depth of the stormwater during treatment must not exceed the height of the grass.**

Planning Considerations

1. *Local governments should maintain the necessary flexibility in ordinances and regulations to permit site-by-site assessment of biofiltration alternatives, and to allow for discretionary design, installation, operating, and maintenance requirements, as long as they do not conflict with the general intent of design and maintenance requirements stated below.*

2. *Biofiltration should be regarded as one possible element of an integrated stormwater management plan for any given site or class of sites. Selection and implementation of alternatives should be based on stated water quality objectives (see Chapter I-4).*

3. *With diverse opportunities existing to apply the variety of biofilter configurations, a creative approach is recommended to obtain the best match of system and conditions.*

4. *Since biofiltration is an on-site rather than a regional technique, localized commitments must be made to maximize its application and effectiveness.*

5. *Since flexibility exists in many design features, biofiltration success depends more on proper construction and maintenance than any other factors; effective inspection and enforcement programs should be emphasized to ensure that approved plans are implemented.*

General Technical Recommendations

1. Natural drainage courses should be regarded as significant local resources that are generally to be kept in use for stormwater management, including biofiltration.

2. Roadside ditches should be regarded as significant potential biofiltration sites; road design standards and ditch maintenance programs should be developed to maximize their usefulness in biofiltration.

3. Local governments should resist proposals to enclose open channels in pipes. In addition to offering the opportunity for biofiltration, open channels generally have more capacity than pipes and are easier to inspect and maintain.

4. Retention/detention pond design requirements should recognize and assess the alternative of installing low-flow biofiltration swales within ponds where sufficient land does not exist for both.

5. Opportunities to fit biofiltration retroactively to areas already developed should be exploited whenever possible.

6. Biofilters should generally not receive construction-stage runoff; if they do, presettling of sediments should be provided (see BMPs E3.35 and E3.40 in Chapter II-5). Such biofilters should be evaluated for the need to remove sediments and restore vegetation following construction.

7. Biofilters should be protected from siltation by a permanent presettling basin when the erosion potential is high (see BMP RD.10 in Chapter III-4); otherwise, presettling is not generally needed for normal operation. However, a series arrangement of a retention/detention pond and biofilter has the ability to offer extra protection to a sensitive receiving water, due to the complementary pollutant removal mechanisms that can operate in the two devices.

8. Biofilters must be vegetated in order to provide adequate treatment of runoff. By definition, biofilters require vegetation, and rock-lined or vegetated channels are not biofilters.

Design Criteria

Overview

The design, planning, and operation and maintenance details that follow have been adapted directly from Horner's "general recommendations" with minor modifications, and while this is judged to be the best available information, it must be considered as interim and subject to modification. Alternative criteria is being investigated which may be reflected in future editions of this manual.

Questions remain about the nutrient-removing abilities of biofilters in the Pacific Northwest and further work needs to be done to resolve optimal geometry and slopes of swales (2). As this and other information becomes available, especially monitoring data and consequent new ideas on design, they will be incorporated into later editions of this manual.

In summary, the interim criteria have been selected to ensure that the velocity of water does not exceed 1.5 feet per second along a swale of 200 feet in length during the water quality design storm (the 6-month, 24-hour storm). Although the 1990 and 1991 versions of this manual used the 2-year, 24-hour storm, we have chosen to change it to the 6-month, 24-hour storm to make all BMP designs consistent. We do not feel that the decrease in cross-sectional area and residence time are such that the larger size storm design is necessary. An additional requirement for swales designed to convey larger storms (up to the 100-year, 24-hour event) is that the peak velocity for the maximum design storm is kept below erosive levels. Complete details of the criteria are given below, and the appendices give step-by-step procedures for designing strips and swales including an example calculation.

General Criteria

1. For biofiltration, it is important to maximize water contact with vegetation and the soil surface. Gravelly and coarse sandy soils cannot be used for biofiltration unless the bottom of the swale is lined to prevent infiltration. (Note: Sites that have relatively coarse soils may be more appropriate for stormwater infiltration for streambank erosion control purposes after runoff treatment has been accomplished. In any case the General Limitations in Chapter III-3 will dictate the use of coarse soils for stormwater management purposes). Also, avoid very heavy clay soils that will not support good vegetative growth.

2. Select vegetation on the basis of pollution control objectives and according to what will best establish and survive in the site conditions. Also, consider whether wildlife habitat development can occur in concert with pollution control. If so, consider the needs of such development in vegetation selection. For general purposes, select fine, close-growing, water-resistant grasses. Alternatively, where some period of soil saturation is expected, where particular pollutant uptake characteristics are desired, or both, select emergent wetland plant species. Protect these plants from predation during establishment by netting. See Appendix III-6.1 for specific vegetation selection recommendations.

3. Establish grasses as follows (all weights are per 1,000 square feet):

If hydro-seeding -	5 lb. seed mix 7 lb. 10-20-20 (N-P-K) fertilizer* 50 lb. wood cellulose fiber mulch
If broadcast seeding -	5 lb. seed mix 7 lb. 10-20-20 (N-P-K) fertilizer* 70 lb. wood cellulose fiber mulch

*Note: this is just an estimate of the amount of fertilizer necessary. Make certain that the proper amount of fertilizer for the soil type is used.

4. Based on observations in this area, select a grass height of 6 inches or less and a flow depth of less than 5 inches. Grasses over that height tend to flatten down when water is flowing over them, which prevents sedimentation. To attain this height requires regular maintenance.

5. Where grasses are to be cultivated, if possible, select an area where moisture is sufficient to provide water requirements during the dry season, but where the water table is not so high as to cause long periods of soil saturation. Irrigate if moisture is inadequate during summer drought. If saturation will be extended and/or the slope is minimal but grasses are still desired, consider subdrains. Alternatively, consider designing a constructed wetland or wet pond that has a substantially longer water residence time than a swale or filter strip (see Chapter III-4). Also see BMPs E1.35 and E1.40 in Chapter II-5 for more information on seeding and sodding.

6. The channel slope should normally be between 2 and 4 percent. A slope of less than 2 percent can be used if underdrains are placed beneath the channel to prevent ponding (Figure III-6.3). A slope of greater than 4 percent can be used if check dams (Figure III-6.4) are placed in the channel to slow the flows accordingly. (see Provisions for Swales #4, below).

7. If possible, divert runoff (other than necessary irrigation) during the period of vegetation establishment. This requirement can normally be met in the Pacific Northwest by planting during July or August. Sodding is an

alternative when rapid establishment must occur. Where runoff diversion is not possible, cover graded and seeded areas with a suitable erosion control slope covering material (see Chapter II-5).

8. Prevent bare areas in biofilters by avoiding gravel, rocks, and hardpan near the surface; fertilizing, watering, and replanting as needed; and ensuring effective drainage. Note: Fertilizer must only be used at an application rate and formula which is compatible with plant uptake, and in relation to soil type. For example, high application rates of nitrogenous fertilizer in very permeable soils can result in leaching of nitrate into ground water.

9. If flow is to be introduced via curb cuts, place pavement slightly above the biofilter elevation. Curb cuts should be at least 12 inches wide to prevent clogging.

10. Attempt to avoid compaction during construction. If compaction occurs, till before planting to restore lost soil infiltration capacity.

Specific Criteria for Biofiltration Swales

1. Design swales for hydraulic capacity and stability according to the method detailed in Appendix AIII-6.1. Base the capacity design for biofiltration on the vegetation height equal to the design flow depth and the 6-month frequency, 24-hour duration storm. Unless runoff from larger events will bypass the swale, base the capacity design for flood passage on the 100-year frequency, 24-hour duration storm, plus 1 foot freeboard (Figure III-6.5).

2. Base the design on a trapezoidal cross-section for ease of construction. A parabolic shape will evolve over time. Make side slopes no steeper than 3 horizontal:1 vertical.

3. Provide a minimum of 200 feet of swale, using a wide-radius curved path, where land is not adequate for a linear swale (avoid sharp bends to reduce erosion or provide for erosion protection). If a shorter length must be used, increase swale cross-sectional area by an amount proportional to the reduction in length below 200 feet, in order to obtain the same water residence time.

4. Install log or rock check dams approximately every 50 feet, if longitudinal slope exceeds 4 percent. Adjust check dam spacing in order not to exceed 4 percent slope within each channel segment between dams.

5. Below the design water depth, install an erosion control blanket, at least four inches of topsoil, and the selected biofiltration seed mix. Above the design water line, use an erosion control seed mix with straw mulch or sod (see BMP E1.15 in Chapter II-5).

Construction and Maintenance Criteria

Construction

See Appendix AIII-6.1.

Maintenance

- Groomed biofilters planted in grasses must be mowed regularly during the summer to promote growth and pollutant uptake. Be sure not to cut below the design flow (**maintenance personnel must be made aware of this requirement**). Remove cuttings promptly, and dispose in a way so that no pollutants can enter receiving waters.

- If the objective is prevention of nutrient transport, mow grasses or cut emergent wetland-type plants to a low height at the end of the growing season. For other pollution control objectives, let the plants stand at a height exceeding the design water depth by at least two inches at the end of the growing season.

- Remove sediments during summer months when they build up to 6 inches at any spot, cover biofilter vegetation, or otherwise interfere with biofilter operation. Use of equipment like a Ditch Master is strongly recommended over a backhoe or dragline. If the equipment leaves bare spots, re-seed them immediately.

- Inspect biofilters periodically, especially after periods of heavy runoff. Remove sediments, fertilize, and reseed as necessary. Be careful to avoid introducing fertilizer to receiving waters or ground water.

- Clean curb cuts when soil and vegetation buildup interferes with flow introduction.

- Perform special public education for residents near biofilters concerning their purpose and the importance of keeping them free of lawn debris.

- See that litter is removed in order to keep biofilters attractive in appearance.

- Base roadside ditch cleaning on an analysis of hydraulic necessity. Use a technique such as the Ditch Master to remove only the amount of sediment necessary to restore needed hydraulic capacity, leaving vegetative plant parts in place to the maximum extent possible.

III-6.4 BMP RB.10 VEGETATIVE FILTER STRIP

Purpose and Definition

A vegetative filter strip is designed to provide runoff treatment of conventional pollutants but not nutrients. This BMP is not designed to provide streambank erosion control. Also, unlike a biofiltration swale, a vegetative filter strip should not be used for conveyance of larger storms because of the need to maintain sheet flow conditions, plus the filter strip would likely be prohibitively large for this application.

Planning Considerations

See BMP RB.05, Biofiltration Swale. Additional planning considerations are provided below.

Application

Vegetative filter strips can be effective at pretreating runoff to protect infiltration and filtration BMPs from siltation. It may also be a viable treatment BMP for small, less intensely developed sites. The maximum recommended drainage area for a vegetative filter strip is 5 acres. Vegetative filter strips must not receive concentrated flow discharges as their effectiveness will be destroyed plus the potential for erosion could cause filter strips to become sources of pollution.

Slope

Vegetative filter strips should not be used on slopes greater than about 10 percent because of the difficulty in maintaining the necessary sheet flow conditions. Note: This does not mean that vegetated buffers are not suitable for slopes greater than

10 percent; it simply means that effective treatment of runoff is unlikely for slopes greater than 10 percent. Do not confuse a "buffer zone," which is used to protect streams and other environmental resources, with a "vegetative filter strip," which is a runoff treatment BMP.

Design Criteria

The design, planning, and operation and maintenance details that follow have been adapted directly from Horner's "general recommendations" with minor modifications, and while this is judged to be the best available information, it must be considered as interim and subject to modification. Alternative criteria is being investigated which may be reflected in future editions of this manual. Questions remain about the nutrient-removing abilities of biofiltration BMPs in the Pacific Northwest and further work needs to be done. As information becomes available, especially monitoring data and consequent new ideas on design, they will be incorporated into later editions of this manual.

In summary, an interim criteria have been selected to ensure that a residence time of 20 minutes for the water as it flows across (perpendicular to) the strip. Complete details of the criteria are given below, and the appendices give step-by-step procedures for designing strips and swales including an example calculation.

General Criteria

See BMP RB.05, Biofiltration Swale.

Specific Criteria for Vegetative Filter Strips

1. Design vegetative filter strips according to the same method detailed in Appendix AIII-6.1 for biofiltration swales. Calculate the necessary filter strip width (perpendicular to flow) on the basis of the 6-month frequency, 24-hour duration storm and a hydraulic radius (R) approximately equal to the design flow depth (y). *Note: The design flow depth (y) will normally be no more than 0.5" (0.04 ft) because of the need to maintain sheet flow over the strip)*

2. Calculate the necessary length (parallel to flow) to produce a water residence time of at least 20 minutes (the length should normally be in the range of 100-200 feet).

3. Install a shallow stone trench across the top of the strip to serve as a level spreader or make use of curb cuts in a parking lot. Make provisions to avoid flow bypassing the filter strip.

4. Vegetative filter strips should not be used for slopes in excess of 10 percent, and preferably less, because of the difficulty in maintaining the necessary sheet flow conditions.

Construction and Maintenance

See BMP RB.05, Biofiltration Swale.

III-6.5 REFERENCES

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APPENDIX AIII-6.1
DESIGN PROCEDURE FOR BIOFILTRATION SWALE AND VEGETATIVE FILTER STRIP DESIGN

Introduction

This section has been adapted with minor modifications from Appendix D - Application Guide of "Biofiltration Systems for Storm Runoff Water Quality Control" by Dr. Richard R. Horner (2).

This guide provides biofilter design procedures in full detail, along with examples. It can be removed from the manual for convenient use alone, if desired. Refer to Sections III-6.3 and III-6.4 for design criteria and operation and maintenance details.

Procedure

Note: The procedures for swale and filter strip design are basically the same. The steps are given in full for swales, and notes are included to allow the procedure to be applied to filter strips as well. Unless specifically indicated, steps apply to both filter strips and biofilters.

Preliminary Steps (P)

Step #

P-1. Estimate runoff flow rate (Q) for the 6-month frequency, 24-hour duration storm, according to methods outlined in Chapter III-1.

P-2. Biofilters should normally be placed on slopes of 2 to 4 percent. If it can be demonstrated that adequate drainage to avoid persistent pooling will occur (using underdrains, if necessary), a slope less than 2 percent can be used. If the site slope exceeds 4 percent, the local government should make a determination of the site's suitability for a biofilter, and, if suitable, what special design features should be included. If the slope exceeds 6 percent, it is recommended that the biofilter traverse the slope or that the site topography be modified to produce a slope under 6 percent. If stepped, each section should slope at less than 6 percent. In any swale application with slope greater than 4 percent, check dams should be placed approximately every 50 feet.

P-3. Select a vegetation cover suitable for the site.

Refer to Table III-6.1 to select grasses. If the site will be persistently wet, consider wetland genera such as Typha (cattails), Scirpus (bulrushes), and Lemna (duckweed), which have relatively high rates of pollutant uptake. Other wetland plants that have been observed to serve well in biofilters are Carex (sedges), and water cresses (A. Levesque, King County, personal communication). If development of wildlife habitat is an objective, consider habitat needs in selecting vegetation.

Table III-6.1.
Characteristics of Grasses Suitable for Lining Puget Sound Region Biofilters. (a)

Common Name	Persistence/ Growth Form	Description	Rating (b)
Annual ryegrass or Italian ryegrass	Annual/bunchgrass	Common erosion control grass; establishes rapidly on bare soils but does not reseed well.	3
Kentucky bluegrass	Perennial/sod-forming	Common turf grass; may require irrigation in dry season. May need regular reseeding.	3
Tall fescue	Perennial/ bunchgrass	Common turf grass; can be used alone; may require irrigation in dry season.	4
Western wheatgrass	Perennial/ sod-forming	Tolerates drought	3

a. Adapted from Goldman et al. (3). Other recommended grasses and legumes:

Meadow foxtail	Creeping red fescue	Annual ryegrasses
Tall fescue	Timothy	White clover
Redtop	Seaside colonial bentgrass	

Other water-resistant grasses that grow well in regional conditions are Poa trivialis (roughstalk bluegrass) and Lolium perenne (perennial ryegrass) (West. D., Seattle City Light, personal communication).

The seeding mix specified for the parking lot swales at the West Willows Technical Center in Redmond was as follows:

52% perennial rye
35% winter rye 13% clover

Shapiro and Associates recommends the following seeding mix for this application (Gorski A., Shapiro and Associates, personal communication):

40% redtop bentgrass 20% tall fescue 5% Russian wild rye
30% red fescue 5% perennial rye

b. Ratings are for erosion protection: 1 - fair; 2 - good; 3 - excellent; 4 - superior.

Design for Biofiltration Capacity

Note: There are a number of ways of applying the design procedure introduced by Chow (4). These variations depend on the order in which steps are performed, what variables are established at the beginning of the process and which ones are calculated, and what values are assigned to the variables selected initially. The procedure recommended here is an adaptation appropriate for biofiltration applications of the type being installed in the Puget Sound region. This procedure reverses Chow's order, designing first for capacity and then for stability. The capacity analysis emphasizes the promotion of biofiltration, rather than transporting flow with the greatest possible hydraulic efficiency. Therefore, it is based on criteria that promote sedimentation, filtration, and other pollutant removal mechanisms. Since these criteria include a lower maximum velocity than permitted for stability, the biofilter dimensions usually do not have to be modified after a stability check.

Design Steps (D)

Step #

D-1. Establish the height of vegetation during the winter and the design depth or flow. Maximizing height advances biofiltration and allows greater flow depth, which reduces the width necessary to obtain adequate capacity. However, if nutrient capture is the principal objective, vegetation should be mowed at the end of the growing season to minimize nutrient release. The design depth of flow should be at least two inches less than the winter vegetation height. **Note: Sheet flow (<1 inch deep) generally exists in vegetative filter strips (use 0.5 inch).**

D-2. Select a value of Manning's n. Use one of the following values for an initial analysis (after U.S. Department of Commerce, (5)), or refer to Table III-2.8 in Chapter III-2.

Dense grass up to 6 inches tall - 0.07
Vegetation with coarser stems (e.g., wetland plants, woody plants) - 0.07

D-3. Select the swale shape. (Skip this step in filter strip design.) Use a trapezoidal shape for biofilter swales, as is feasible.

Rectangular and V-shapes are the least desirable from the stability standpoint. If one of these shapes is required by the site configuration, specify reinforcement for the side walls in conformance with the standards of the local government.

D-4. Use Manning's equation and first approximations relating hydraulic radius and dimensions for the selected shape to obtain a working value of a biofilter width dimension:

$$Q = \frac{1.486}{n} AR^{0.667} s^{0.5} \qquad (6\text{-}1)$$

Where:
- Q = design runoff flow rate (ft^3/s, cfs)
- n = Manning's n (dimensionless)
- A = Cross-sectional area (ft^2)
- R = Hydraulic radius = A/wetted perimeter (ft)
- s = longitudinal slope as a ratio of vertical rise/horizontal run (dimensionless)

Refer to Figure III-6.5 to obtain equations for A and R for the selected shape. In addition to these equations, for a rectangular shape:

$$A = Ty \qquad (6\text{-}2)$$

$$R = \frac{Ty}{T+2y} \qquad (6\text{-}3)$$

where: T = width
y = depth of flow in feet, expressed as a decimal

If these expressions are substituted in Equation 6-1 and solved for T (for previously selected y), the results are complex equations that are difficult to solve manually. However, approximate solutions can be found by recognizing that $T>>y$ and $z^2>>1$, and that certain terms are nearly negligible. The approximations for the various shapes are:

Parabolic: $R \approx 0.67\ y$ (6-4)

Trapezoidal: $R \approx y$ (6-5)

V: $R \approx 0.5\ y$ (6-6)

Rectangular: $R \approx y$ (6-7)
(Also use for vegetative filter strips)

Making these substitutions and those for A from Figure III-6.5, and then solving for T gives:

Parabolic: $T \approx \frac{Qn}{0.76\ y^{1.667}\ s^{0.5}}$ (6-8)

Trapezoidal: $b \approx \frac{Qn}{1.486\ y^{1.667}\ s^{0.5}} - Zy$ (6-9)

V: $T \approx \frac{Qn}{0.47\ y^{0.667}\ s^{0.5}}$ (6-10)

Rectangular: $T \approx \frac{Qn}{1.486\ y^{1.667}\ s^{0.5}}$ (6-11)

(Also use for vegetative filter strips.)

For trapezoidal and V-shapes, select a side slope Z of at least 3.

Solve the appropriate equation for T or b. For a V-shape, check if $Z = T/2y$ is at least 3. For a trapezoid, compute b (Step D-4a) and then top width T, where $T = b + 2yZ$ (Step D-4b).

D-5. Compute A using the appropriate equation from Figure III-6.5 or Equation 6-2.

D-6. Compute the flow velocity at design flow rate:

$$V = \frac{Q}{A} \qquad (6\text{-}12)$$

This velocity should be less than 1.5 ft/s, a velocity that was found to permit the sedimentation of most particles in typical urban runoff (see (2)). However, the smallest particles (clay and much of the silt fraction) may not be removed. Also, it is not known what velocity will cause grasses to be knocked from a vertical position, thus reducing filtration. Therefore, the velocity should be as low as space allows.

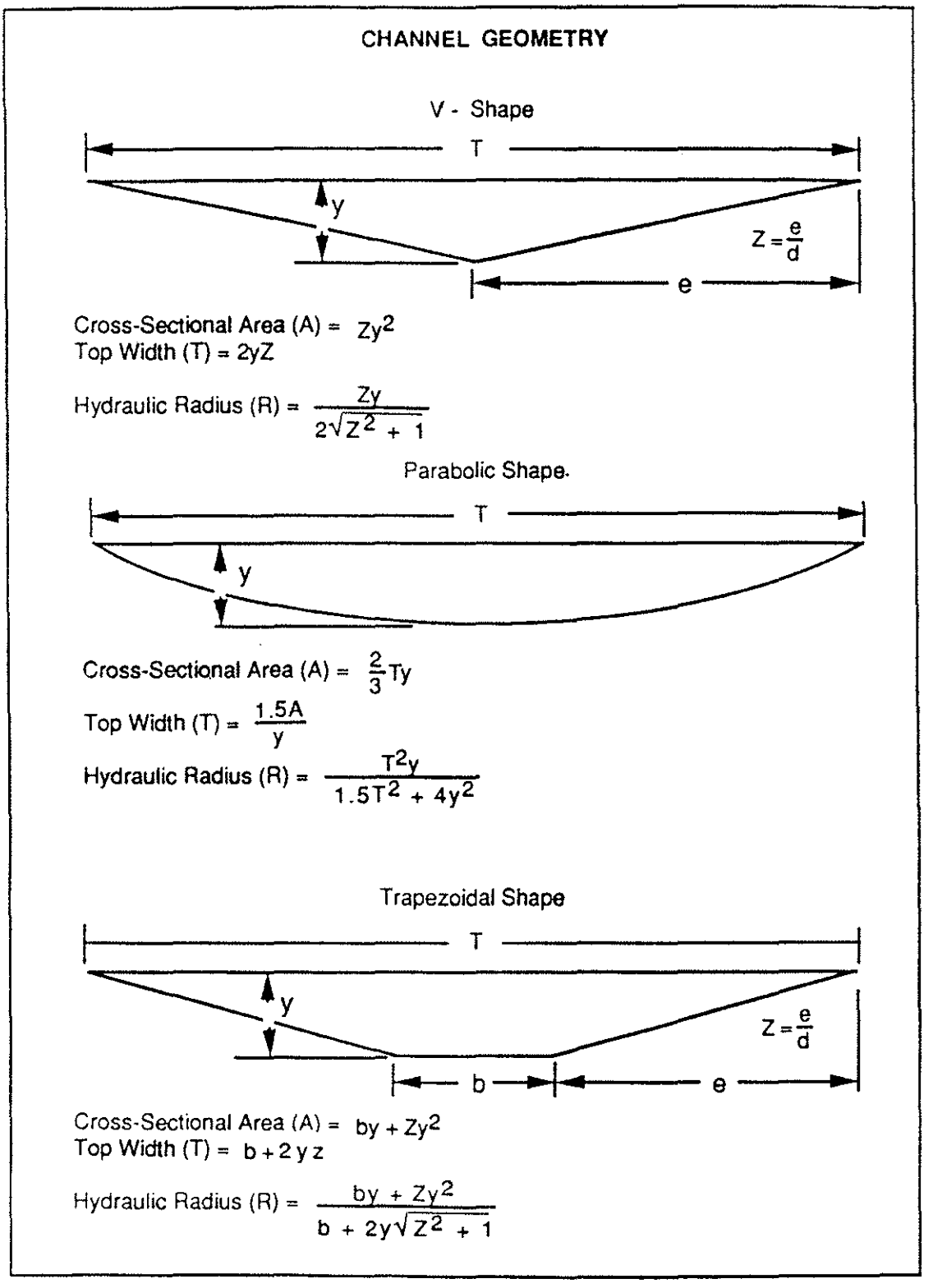


Figure III-6.5 Geometric Formula for Common Swale Shapes (from Livingston et al., 1984).

If V > 1.5, repeat steps D-1 to D-6 until the condition is met.

D-7. This approximate analysis tends to produce a design that results in V < 1.5, often by a substantial margin. This situation is preferred if sufficient space is available. If that is the case, proceed to the stability check. IF NOT, perform a more exact analysis according to steps D-8 to D-15, otherwise go to Step D-16.

D-8. Estimate the degree of retardance to flow created by the selected vegetation from Table III-6.2. When uncertain, be conservative by selecting a relatively high degree.

Table III-6-2. Guide for Selecting Degree of Retardance (a).

Coverage	Average Grass Height (inches)	Degree of Retardance
Good	2-6	D. Low
	<2	E. Very low
Fair	2-6	D. Low
	<2	E. Very low

a. After Chow (4). In addition, Chow recommended selection of retardance D for a grass-legume mixture 4-5 inches high. No retardance recommendations have appeared for emergent wetland species. Therefore, judgment must be used. Since these species generally grow less densely than grasses, using a "fair" coverage would be a reasonable approach.

D-9. Refer to Figure III-6.6 and use the selected degree of retardance and Manning's n from step D-2 to obtain a first approximation of VR, the product of velocity and hydraulic radius.

D-10. Compute hydraulic radius, using V_{max} = 1.5 ft/s:

$$R = \frac{VR}{V_{max}} \qquad (6\text{-}13)$$

D-11. Use Manning's equation to solve for the actual VR associated with this R and n:

$$VR = \frac{1.486}{n} R^{1.667} s^{0.5} \qquad (6\text{-}14)$$

where VR is in units of ft^2/sec

D-12. Compare the actual VR from step D-11 and the first approximation of VR from step D-9. If they do not agree within 5 percent, select a new n and repeat steps D-9 to D-12 until acceptable agreement is reached.

D-13. Compute the actual V for the final design conditions (using the actual VR calculated in Step D-11):

$$V = \frac{VR}{R} \qquad (6\text{-}15)$$

Check to be sure V <1.5 ft/s.

D-14. Use the continuity equation to calculate the flow cross-sectional area (A):

$$A = \frac{Q}{V} \qquad (6\text{-}16)$$

D-15. Use the appropriate equation in Figure III-6.5 or Equation 6-2 to compute T or b. For trapezoidal and V-shapes, use a Z of at least 3, and for trapezoids use T = b+2yZ.

D-16. If there is still not sufficient space for the biofilter, the local government and the project proponent should consider the following solutions (listed in order of preference):

a. Divide the site drainage to flow to multiple biofilters.

b. Use infiltration to provide lower discharge rates to the biofilter (only if the criteria and General Limitations in Chapter III-3 are met).

c. Increase vegetation height and design depth of flow (note: the design must ensure that vegetation remains standing during design flow).

d. Reduce the developed surface area to gain space for biofiltration.

e. Increase the longitudinal slope.

f. Increase the side slopes.

Proceed to the stability check.

Check for Stability (Minimizing Erosion)

Notes:

(1) The stability check must be performed for the combination of highest expected flow and least vegetation coverage and height.

(2) Maintain the same units as in the biofiltration capacity analysis.

Stability Check Steps (SC)

(Note: Not required for biofiltration BMPs which are located "off-line" from the primary conveyance/detention system, i.e., when flows in excess of the peak flow for the 6-month, 24-hour design storm bypass the biofilter. This is the desired configuration.)

Step #

SC-1. Unless runoff from events larger than the 6-month, 24-hour storm will bypass the biofilter, perform the stability check for the 100-year, 24-hour storm. Estimate Q for that event as recommended in Preliminary step P-1.

SC-2. Estimate the vegetation coverage ("good" or "fair") and height on the first occasion that the biofilter will receive flow, or whenever the coverage and height will be least. Attempt to avoid flow introduction during the vegetation establishment period by timing of planting or bypassing.

SC-3. Estimate the degree of retardance from Table III-6.2. When uncertain, be conservative by selecting a relatively low degree.

SC-4. Establish the maximum permissible velocity for erosion prevention (V_{max}) from Table III-6.3.

Table III-6.3
Guide for Selecting Maximum Permissible
Swale Velocities for Stability Check (a)

Cover	Slope (%)	Maximum Velocity (ft/sec)
Kentucky Bluegrass Tall Fescue	0 - 5	5
Kentucky Bluegrass Tall Fescue Western Wheatgrass	5 - 10	4
Grass-legume Mixture	0 - 5 5 - 10	4 3
Red Fescue Redtop	0 - 5 5 - 10	2.5 Not Recommended

(a) Adapted from references 3, 4, and 6.

SC-5. Select a trial Manning's n. The minimum value for poor vegetation cover and low height (possibly, knocked from the vertical by high flow) is 0.033. A good initial choice under these conditions is 0.04.

SC-6. Refer to Figure III-6.6 to obtain a first approximation for VR.

SC-7. Compute hydraulic radius, using the Vmax from step SC-4:

$$R = \frac{VR}{V_{max}} \qquad (6\text{-}13)$$

SC-8. Use Manning's equation to solve for the actual VR:

$$VR = \frac{1.486}{n} R^{1.667} s^{0.5} \qquad (6\text{-}14)$$

SC-9. Compare the actual VR from step SC-8 and first approximation from step SC-6. If they do not agree within 5 percent, repeat steps SC-5 to SC-9 until acceptable agreement is reached.

SC-10. Compute the actual V for the final design conditions:

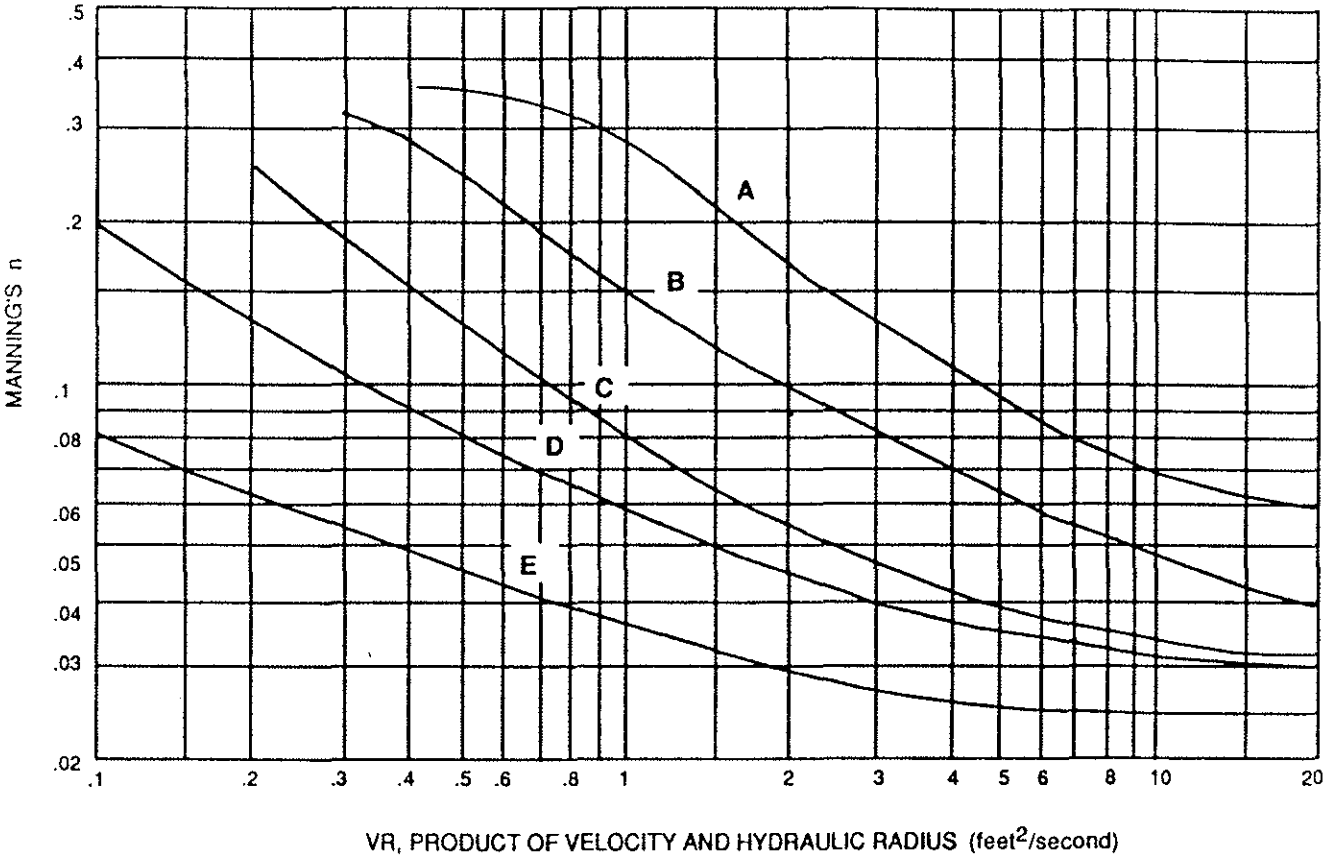
$$V = \frac{VR}{R} \qquad (6\text{-}15)$$

Check to be sure $V < V_{max}$ from step SC-4.

SC-11. Compute the required A for stability:

$$A = \frac{Q}{V} \qquad (6\text{-}16)$$

Figure III-6.6
The Relationship of Manning's n with VR for Various Degrees of Flow Retardance (from Livingston et al., 1984, after U.S. Soil Conservation Service, 1954)



SC-12. Compare the A computed in step SC-11 of the stability analysis with the A from the biofiltration capacity analysis (step D-5 or D-14).

If less area is required for stability than is provided for capacity, the capacity design is acceptable. If not, use A from step SC-11 of the stability analysis and recalculate channel dimensions (refer to Figure III-6.5 or Equation 6-2). Use y from Step D-1.

SC-13. Calculate the depth of flow at the stability check design flow rate condition for the final dimensions (refer to Figure III-6.5 or Equation 6-2). (For trapezoids use y = (T-b)/2Z)

SC-14. Compare the depth from step SC-13 to the depth used in the biofiltration capacity design (Step D-1). Use the larger of the two and add 1 foot freeboard to obtain the total depth (y_t) of the swale. Skip this step in filter strip design. (Editor's Note: If space is limited, calculate the depth needed for the 100-year, 24-hour storm then add this depth again for freeboard, up to a maximum freeboard of 1 foot.)

SC-15. Recalculate the hydraulic radius (trapezoidal channel - see Figure III-6.5):

$$R = \frac{by_t + zy_t^2}{b + 2y_t(Z^2 + 1)^{0.5}}$$

(use b from Step D-4 or D-15 calculated previously for biofiltration capacity, or Step SC-12, as appropriate, and y_t = total depth from Step SC-14)

SC-16. Make a final check for capacity based on the stability check design storm and maximum vegetation height and cover (this check will ensure that capacity is adequate if the largest expected event coincides with the greatest retardance). Use Equation 6-1, a Manning's n of 0.1, and the calculated channel dimensions, including freeboard, to compute the flow capacity of the channel under these conditions. Use R from step SC-15, above, and $A = by_t + Zy_t^2$ using b from Step D-4a, or D-15 or SC-12, as appropriate.

If the flow capacity is less than the stability check design storm flow rate, increase the channel cross-sectional area as needed for this conveyance. Specify the new channel dimensions.

Completion Steps (CO)

Step #

CO-1. If the biofilter is a swale, lay out the swale to obtain the maximum possible length. This length should be at least 200 feet. In limited spaces, attempt to attain that length by using a curved path. Use the widest radius bends possible to reduce the potential for erosion of the outside of curved sections. If a length shorter than 200 ft. must be used, increase A by an amount proportional to the reduction in length below 200 ft., in order to obtain the same water residence time. Recalculate channel dimensions from Figure III-6.5 or Equation 6-2.

If the swale is a vegetative filter strip, select a length for the calculated width that produces at least 20 minutes water residence time (normally 100-200 feet).

CO-2. If the swale longitudinal slope is greater than 4 percent, design log or rock check dams approximately every 50 feet.

APPENDIX AIII-6.2
EXAMPLE PROBLEM SHOWING APPLICATION OF DESIGN PROCEDURE FOR BIOFILTRATION SWALES AND VEGETATIVE FILTER STRIPS

Preliminary Steps

P-1. Assume that Q for the 6-month, 24-hour storm was established by one of the recommended procedures to be 3 cfs.

P-2. Assume the slope (s) is 2 percent.

P-3. Assume the vegetation will be a grass-legume mixture, with the dominant grass being red fescue.

Design for Swale Biofiltration Capacity

D-1. Set the winter grass height at 6 inches and design flow depth (y) at 4 inches (i.e. 0.33 feet) (Eq. 6-9). Recall that the design flow must be at least two inches less than the winter grass height.

D-2. Use n = 0.07

D-3. Base the design on a trapezoidal shape, with side slope (Z) equal to 3.

D-4a. Calculate the bottom width (b)

Where: n = 0.07

Q = 3 cfs
y = 0.33'
s = 0.02
Z = 3

$$b = Qn/(1.486y^{1.667}s^{0.5}) - Zy \qquad (6\text{-}9)$$

or

b = 5.24 feet

D-4b. Calculate the top width (T)

$$T = b + 2yZ = 5.24 + [2(0.33)(3)] = 7.24 \text{ feet}$$

D-5. Calculate the cross-sectional area (A)

$$A = by + Zy^2 = (5.24)(0.33) + (3)(0.33^2) = 2.06 \text{ ft}^2$$

(from Fig. III-6.5)

D-6. Calculate the flow velocity (V)

$$V = Q/A = \frac{3}{2.06} = 1.46 \text{ ft/s} < 1.5, \text{ so OK} \qquad (6\text{-}12)$$

Proceed directly to stability check.

A top width of 6 to 10 feet is typical of many swales surveyed in the area, and should fit within most sites. For the example, assume that it does so. The calculation procedure of steps SC-8 through 15 will be demonstrated in the stability check.

Check for Channel Stability

SC-1. Base the check on passing the 100-year, 24-hour storm runoff flow through the swale. Assume that Q for that storm was established by one of the recommended procedures to be 16 cfs.

SC-2. Base the check on a grass height of 3 inches with "fair" coverage (lowest mowed height and least cover, assuming flow bypasses or does not occur during grass establishment).

SC-3. Table III-6.2: Degree of retardance = D (low)

SC-4. From Table III-6.3, set V_{max} = 3 ft/sec since the vegetation is a combination of red fescue (V_{max} = 2.5 ft/sec) and legumes (V_{max} = 4 ft/sec).

SC-5. Select trial Manning's n = 0.04

SC-6. Figure III-6.6 VR = 3 ft^2/s

SC-7. Eq. 6-13 $R = \frac{VR}{V_{max}}$

$R = 1.0$ ft

SC-8. Eq. 6-14 $VR = \frac{1.486}{n} R^{1.667} s^{0.5}$

$VR = 5.25$ ft^2/sec

SC-9. VR from step SC-8 <VR from step SC-6 by > 5%.

Select new trial n = 0.047

from Figure III-6.6 VR = 1.7 ft^2/s

Eq. 6-13 R = 0.57 ft.

Eq. 6-14 VR = 1.75 ft^2/s (within 5% of VR = 1.7)

SC-10. Eq. 6-15 $V = VR/R = 1.75/0.57$

$V = 3.07$ ft/s <5 ft/s (OK)

SC-11. Eq. 6-16 $A = Q/V = 16/3.07 = 5.21$ ft^2

SC-12. For stability check, A = 5.21 ft^2 from Step SC-11, which is greater than the capacity from Step D-5 (2.06 ft^2). Therefore, recalculate channel dimensions using A from Step SC-11 and referring to Figure III-6.5.

$A = by + Zy^2$

where: A = 5.21 ft^2
Z = 3
y = ?
b = ?

(Note: both depth and width dimensions can be varied to obtain needed value of A, which is 5.21 ft^2 in this example.)

For this example, choose y = 0.67 ft. (note that y was originally set at 0.33 ft. in Step D-1) then calculate value for b.

For y = 0.67 ft., b = 5.81 ft.
T = b + 2yZ = 9.81 ft.

SC-13. Calculate depth of flow at the stability design flow rate condition.

For trapezoids use y = (T-b)/2Z from Figure III-6.5, and b = 5.81 ft and T = 9.8 ft from Step SC-12.

$y = (9.81 - 5.81)/6 = 0.67$ ft.

SC-14. The value for y calculated in SC-13 (0.67 ft.) is greater than that used in Step D-1. Use the greater value, and add 1 foot freeboard to give a total depth (y_t) of 1.67 feet.

SC-15. Recalculate hydraulic radius (R) where

b = 5.81 ft (from Step SC-12)
y_t = 1.67 ft (from Step SC-14)
Z = 3 (from Step D-3)

$$R = \frac{by_t + Zy_t^2}{b + 2y_t (Z^2 + 1)^{0.5}} = 1.1 \text{ feet}$$

SC-16. Recalculate Q where:

$$Q = \frac{1.486}{n} AR^{0.667} s^{0.5} \qquad \text{(Eq. 6-1)}$$

where: n = 0.07
A = $by_t + Zy_t^2$, using b from Step SC-12
R = 1.1 feet (from Step SC-15)
s = 0.02 (from Step P-2)

$A = (5.81)(1.67) + (3)(1.67^2) = 18.1$ ft^2

$$Q = \frac{1.486}{0.07} (18.1) (1.1)^{0.667} (0.02)^{0.5} = 57.9 \text{ cfs}$$

This is > 16 cfs for 100-year, 24-hour storm if it coincides with maximum flow retardance. Therefore, channel dimensions are okay.

Completion Steps

CO-1 Assume 200 feet of swale length is available. The final channel dimensions are:

Bottom width = 5.81 feet
Depth = 1.67 feet
Top width = b + 2yZ = 15.8 feet

CO-2 No check dams are needed for a 2% slope.

CHAPTER III-7

OIL/WATER SEPARATORS

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CHAPTER III-7

OIL/WATER SEPARATORS

III-7.1 OVERVIEW

Oil/Water Separators have limited application in stormwater treatment because their treatment mechanisms are not well-suited to the "wastewater" characteristics of stormwater runoff (i.e., highly variable flow with high discharge rates, turbulent flow regime, low oil concentration, high suspended solids concentration). In addition, separators can require intensive maintenance, further restricting their desirability as a stormwater treatment BMP. The primary use of oil/water separators will be in cases where oil spills are a concern, in which case a spill control (SC-type) separator may be specified. There will be but a few other cases where an oil/water separator would be required, as other BMPs are more appropriate for controlling oil. Source control in particular should be the first option and may negate the need for special treatment. Other than to capture spills, the use of oil/water separators will be restricted to development sites that have high oil and grease loadings, such as petroleum storage yards and vehicle storage and/or maintenance facilities (see Chapters I-4 and IV-2 for land uses which require oil/water separators). There may be some cases that warrant the use of oil/water separators due to high vehicular traffic. These will have to be assessed on a case-by-case basis by the local government.

Sand filtration and oil absorbent materials are being investigated as alternatives to oil/water separators . While there is very limited data on the effectiveness of sand filtration for treating oil, this practice does have an established record of treatment of other pollutants and effective treatment of oil may also be accomplished. Sand filtration is to be considered an alternative to oil/water separators on an interim basis until further data is collected. See Chapter III-3 for details on sand filtration BMPs.

Absorbent materials are another alternative whose use has been pioneered by METRO in King County. Widely used for controlling spills, these "pillows" have been installed in storm drain inlets as a mechanism to absorb free oil from surface water runoff. Limited data is available to assess their effectiveness and some operational problems have occurred. The disposal of these pillows once they are exhausted can be a problem as well.

Three types of oil/water separators are discussed in this chapter:

BMP RO.05 Spill Control (SC-type) Separator
BMP RO.10 API Separator
BMP RO.15 Coalescing Plate Separator (CPS)

See Figures III-7.1, III-7.2, and III-7.3 for illustrations of these BMPs.

Because separators are usually manufactured units rather than constructed units, only limited details will be provided in this chapter. If oil/water separators are to be used, then an appropriate manufacturer or supplier should be contacted.

For a useful discussion of oil treatment of stormwater runoff the reader is referred to the publication "Oil and Water Don't Mix: The Application of Oil-Water Separation Technologies in Stormwater Quality Management" (METRO, October, 1990).

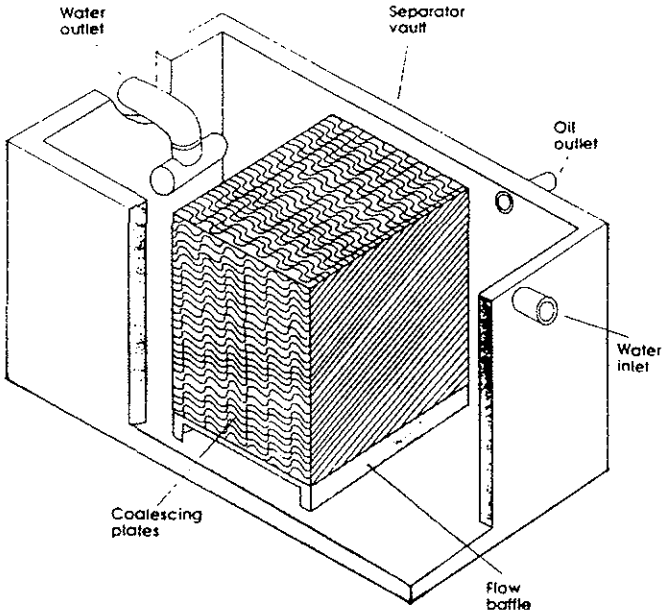


Figure III-7.3
CPS Separator

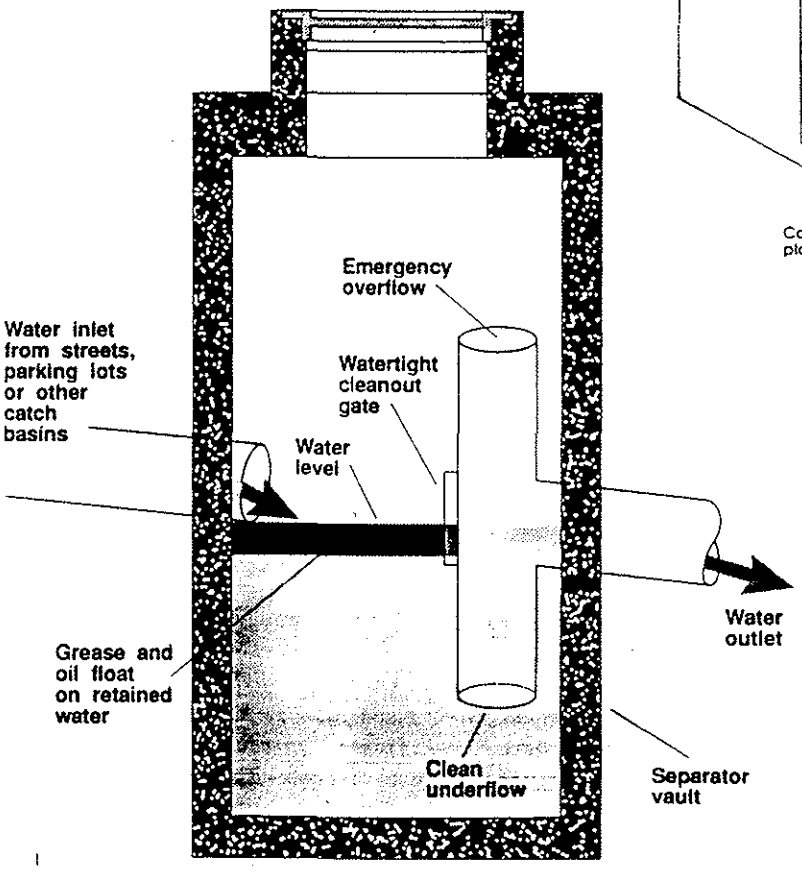
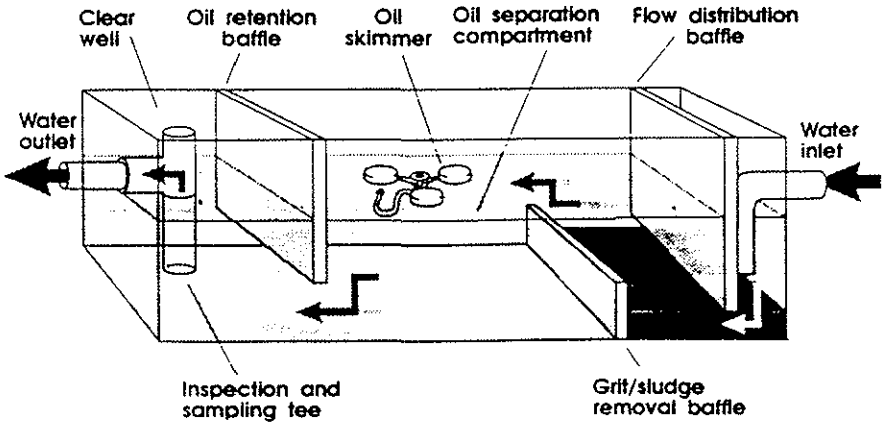


Figure III-7.1
SC-Type Separator

Figure III-7.2
API Separator



III-7.2 PLANNING CONSIDERATIONS AND GENERAL DESIGN CRITERIA

If an oil/water separator is used primarily for treatment (and not spill control), it should be located off-line from the primary conveyance/detention system. The contributing drainage area should be completely impervious and as small as necessary to contain the sources of oil. Non-source contributing areas only increase the size (and cost) of the separator and do not improve effectiveness. Under no circumstances should any portion of the contributing drainage area contain disturbed pervious areas which can be sources of sediment.

Description There are three general types of separators. The first type is the spill control separator (SC). It is a simple underground vault or manhole with a "T" outlet (Figure III-7.1). The SC-separator is effective at retaining only small spills. The SC-separator will not remove diluted oil droplets spread through the stormwater from oil-contaminated pavement.

The other two types of separators can remove dispersed oil: the American Petroleum Institute (API) separator (Figure III-7.2) and coalescing plate separator (CPS - Figure III-7.3).

The API-separator is a long vault or basin with baffles to improve the hydraulic conditions for treatment. Large API-separators may have sophisticated mechanical equipment for removing oil from the surface and settled solids from the bottom. However, most applications will use the simple system as illustrated.

The CPS-separator contains a bundle of plates made of fiberglass or polypropylene. The plates are closely spaced. Depending on the manufacturer and/or application, the plates may be positioned in the bundle at an angle of 45 to 60° from the horizontal.

The closely spaced plates improve the hydraulic conditions in the CPS-separator promoting oil removal. The primary advantage of the CPS-separator is its ability to theoretically achieve equal removal efficiencies with one-fifth to one-half the space needed by the API separator, when designed to remove the same size droplets.

Type of Separator Required

Land uses that must use an API or CPS-separator are identified in Chapter I-4 and in Chapter IV-2. The owner may choose between the API or CPS-separator using the design criteria outlined below. Other land uses or businesses should use the SC-separator for spill control as needed.

Effluent Guideline

Ecology requires that stormwater have no visible sheen, average less than 10 mg/l daily and at no time exceed a daily maximum of 15 mg/l.

Design Criteria

Requirements regardless of separator type

1. Separators should precede all other treatment and streambank erosion control BMPs.

2. Appropriate removal covers must be provided that allow access for observation and maintenance.

3. Stormwater from building rooftops and other impervious surfaces not likely to be contaminated by oil shall not discharge to the separator.

4. Any pump mechanism shall be installed downstream of the separator to prevent oil emulsification.

Additional requirements for API and CPS-separators

1. Separators are to be sized for the 6-month, 24-hour design storm. Larger storms shall not be allowed to enter the separator; the use of an isolation/diversion structure is recommended (see Chapter III-3 for details).

2. Separators shall have a forebay to collect floatables and the larger settleable solids. Its surface area shall not be less than 20 square feet (ft^2) per 10,000 ft^2 of the area draining to the separator.

Additional requirements for CPS-separators

1. Plates shall not be less than 3/4 inch apart.

2. The angle of the plates shall be from 45° to 60° from the horizontal.

Absorbent pillows may be used in separators. For API and CPS-type separators they should be placed in an afterbay. With the SC-separator, absorbent materials should be placed in the manhole/vault. Used absorbent pillows will need to be properly disposed of.

Sizing Procedure

Oil droplets exist in water in a wide distribution of sizes. The separator therefore is sized to remove all droplets of particular size and greater which will ensure that sufficient oil is removed to achieve the effluent standard.

API-separators are usually sized to remove oil droplets 150 micron in size and larger. Smaller droplets rise so slowly as to require a relatively large vault. CPS-separators are commonly sized to remove 60 or 90 micron and larger oil droplets.

There are no data on the size distribution of dispersed oil in stormwater from commercial or industrial land uses with the exception of petroleum products storage terminals. These data indicate that by volume, about 80 percent of the droplets are greater than 90 micron. Less than 30 percent are greater than 150 microns. For this manual both the API and CPS-separator are sized to remove 60 microns and larger droplets at a temperature of 10°C giving a rise rate of 0.033 feet per minute. The requirement for treatment of 60 micron and larger sized droplets may preclude the use of API separators.

API-Separator Sizing

API-separators are sized using these general guidelines.

- Horizontal velocity: 3 fpm or 15 times the rise rate whichever is smaller (rise rate of 0.033 ft/min is recommended)
- Depth of 3 to 8 feet
- Depth to width ratio of 0.3 to 0.5
- Width of 6 to 16 feet

- Baffle height to depth ratios of 0.85 for top baffles and 0.15 for bottom baffles

The separator is first sized for depth using the equation:

$$\text{Depth} = (Q/2V_h)^{1/2}$$

where: Q = design flow (cfm)

V_h = design horizontal velocity (fpm) = 0.50 (15 times 0.033)

Calculate the width using the above ratios (i.e., 0.3 to 0.5 depth-to-width ratio).

Then calculate length using the equation:

$$\text{Length} = \frac{\text{Depth}}{\text{Rise Rate}} * V_h = \frac{(Q/2V_h)^{1/2}}{0.033} * 0.50 = \frac{(Q/2V_h)^{1/2}}{0.066}$$

CPS-Separator Sizing

Calculate the projected (horizontal) surface area of plates required using the following equation:

$$A_p = \frac{Q}{\text{Rise Rate}}$$

Where A_p = projected surface area of the plate ($ft.^2$); note that the actual surface area, $A_a = A_p$ * cosine H

H = angle of the plates with the horizontal in degrees, usually varies from 45-60 degrees.

Q = design flow (cfm).

Rise rate - recommend using 0.033 ft/min.

Manufacturers of plate packs provide standard size packages which are rated at a particular flow (usually in gpm). However, as the manufacturer's flow rating is for conditions different than used above, the engineer must compare the plate surface area with the above calculation. Do not confuse the projected plate area with actual plate area (see Figure III-7.4).

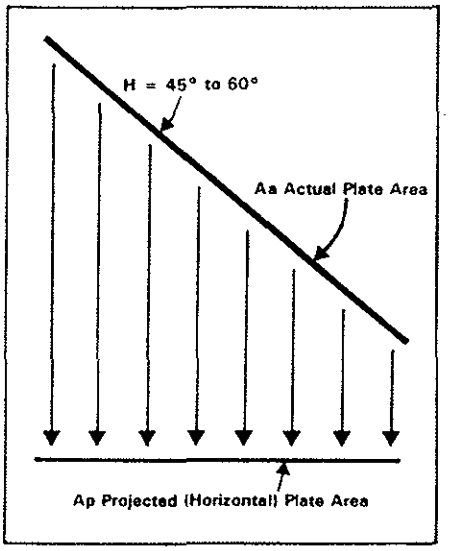
The width, depth, and length of the plate pack and the chamber in which the plate pack is placed is completely flexible and is a function of the plate sizes provided by the particular pack manufacturer and standard size vaults that are available for small sites.

III-7.3 CONSTRUCTION AND MAINTENANCE

Construction Specifications

There are no special construction considerations.

Figure III-7.4 Cross-Section of CPS Oil/Water Separator



Maintenance

Oil/water separators must be cleaned frequently to keep accumulated oil from escaping during storms. They must always be cleaned by October 15 to remove material that has accumulated during the dry season, and again after a significant storm. In addition:

1. The facility shall be inspected weekly by the owner.

2. Oil absorbent pads are to be replaced as needed but shall always be replaced in the fall prior to the wet season and in the spring.

3. The effluent shutoff valve is to be closed during cleaning operations.

4. Waste oil and residuals shall be disposed in accordance with current local government Health Department requirements.

5. Any standing water removed during the maintenance operation must be disposed to a sanitary sewer at a discharge location approved by the local government.

6. Any standing water removed shall be replaced with clean water to prevent oil carry-over through the outlet weir or orifice.