Catalog of Stormwater Best Management Practices for Idaho Cities and Counties

September 2005

Idaho Department of Environmental Quality
Water Quality Division
1410 N. Hilton
Boise, ID
(208) 373-0502
www.deq.idaho.gov

Volume 1: Introductory Materials

Section 1 - Introduction

The *Catalog of Stormwater Best Management Practices for Idaho Cities and Counties*, a series of five compact discs (CDs), provides technical guidance for construction site design and the selection of stormwater best management practices (BMPs). The catalog is a guidance document containing voluntary controls that could be formally adopted by a jurisdiction to establish standards, if desired. Measures, such as those described and other recognized equivalents, should be used to manage the quantity and quality of stormwater runoff from land development.

This information is primarily intended for design professionals (e.g., landscape architects, geologists, engineers, soil scientists, etc.) and their contractors. It is also applicable for local public officials or staff who are responsible for the review and approval of development applications.

There are several reasons why technical guidance regarding stormwater management is necessary:

- Idaho remains one of the fastest growing states in the nation. The increase in population leads to an increase in land development, a recognized source of nonpoint source pollution, more commonly termed “polluted runoff.” The catalog includes BMPs that help to prevent discharge of pollutants from developing areas, both during the construction phase and for the life of the development. The BMPs can also be used to reduce polluted runoff from existing land uses.
- Many water bodies throughout the state are not in compliance with state water quality standards. Beneficial uses such as domestic water supply, fishing, swimming, boating, and agricultural water supply can often be impaired due to excessive pollutants from stormwater runoff. The catalog provides guidance for controls to reduce “conventional” pollutants, with special consideration for phosphorus and sediment, both common pollutants in Idaho.
- Federal National Pollutant Discharge Elimination System (NPDES) stormwater regulations have mandated that some communities develop and implement stormwater management programs to ensure that pollutants in stormwater runoff are controlled to the maximum extent practicable. Because polluted runoff has the potential to contribute to the degradation of receiving water quality, improved stormwater management program implementation at the local level will play an ever-increasing role in attaining and maintaining water quality standards.

In general, there are two types of BMPs for stormwater pollution control:
1. Source control BMPs focus on minimizing or eliminating the source of the pollution so that pollutants are prevented from contacting runoff or entering the drainage system.
2. Treatment control BMPs which tend to be more expensive to implement than source control BMPs, are designed to remove pollutants after they have entered runoff. Examples of source control BMPs include spill controls and employee education, while treatment control BMPs include detention ponds and oil/water separators. Most source control BMPs tend to be non-structural, and most treatment control BMPs tend to be structural in nature, although there can be exceptions. For example, a roof over a materials storage area at an industrial site would be considered a structural source control.

The majority of the practices focus on controlling pollution at its source, before runoff enters a drainage conveyance such as a sewer system or river. However, some BMPs are also included that can be used to treat runoff and remove pollutants that have already entered the drainage conveyance. The structural measures will reduce pollutant loads in post-construction site runoff, provided that the facilities are properly designed, installed, and maintained on a periodic basis.

The catalog presents general technical guidelines. Specific conditions or local regulations may require modification of the recommended BMPs, and alternative practices that are approved by a local permitting authority may also require modification or replacement of recommended BMPs. The BMP selection matrices should be used as screening tools to assist the design professional, landowner, or reviewer in selecting the most appropriate or suitable measure based on site-specific conditions.

In order to illustrate the use and application of certain BMPs, manufacturer and product names may be used in the catalog. This does not represent an endorsement of a specific manufacturer or product.

1.1 Organization

The first volume of the CD series includes a brief discussion of stormwater runoff impacts; an overview of agencies responsible for stormwater permitting and authority in Idaho; and a step-by-step procedure for site design.

The second volume of the CD series contains construction BMPs including both erosion and sediment controls and source controls.

The third volume of the CD series introduces the concept of low-impact development and provides techniques that can minimize changes to the hydrologic functioning of a development site.

The fourth volume of the CD series contains post-construction/ permanent BMPs.

The fifth volume of the CD series provides BMPs for specific land use activities, including industrial, commercial, and residential activities.

The catalog is intended for use in conjunction with local governmental requirements, such as applicable planning and building codes. The catalog is not all-inclusive and should be used along with other reference books and manuals published by other agencies as necessary or appropriate based on local conditions and policies.

1.2 Updates

The practice of stormwater management is quickly evolving. Design information for various BMPs is expected to change as more people apply the practices and learn from their experience. New BMPs will also be added to the mix. To accommodate these changes, periodic updates and amendments will be made to the catalog. These will be posted on the Department of Environmental Quality (DEQ) Web site as they become available.

Section 2 - Stormwater Runoff Quantity and Quality Impacts

Traditionally, the objective of stormwater management has been to transport runoff efficiently through the drainage system in order to prevent flooding and protect lives and property. This is referred to as flood or quantity control. Although public health and safety are the most important goals, other objectives should be met as well. These include management of runoff quantities and flow to mimic predevelopment conditions and minimize damage to property and natural resources; management of development sites to minimize the amount of sediment and other contaminants in runoff; and management of development to preserve the stability and integrity of drainage ways and stream corridors.

Today it is necessary to balance quantity, quality, and habitat protection objectives. This balance can be achieved by pursuing regional solutions, such as effective land use planning, which minimizes impervious areas and preserves native vegetation, especially riparian areas along streams and lakes. Local ordinances and codes can also help to reduce impervious areas and increase vegetation by limiting the extent to which a site can be developed. Quantity and quality goals can also be met at the local level through proper site planning and appropriate design that carefully considers the various impacts of development and application of best management practices (BMPs) to minimize problems.

2.1 Stormwater Runoff Quantity

The quantity or volume of stormwater runoff from urban and suburban land uses depends on several factors: the intensity and duration of a given storm event; the basin slope; the amount and type of vegetation retained, and most importantly the amount of impervious area such as asphalt and concrete, building rooftops, and compacted soils. Urbanization increases the quantity of runoff, which has a serious impact on receiving waters. As shown in Figure 2-1, the natural water balance is disrupted when an area develops. Paved surfaces and buildings replace vegetation that once intercepted the rain, allowed it to soak into the ground, and returned water to the air through evapo-transpiration. Heavily compacted surfaces act much the same as pavement in preventing water from seeping into the ground. Snowmelt, especially when accelerated by rain, also increases the chance of flooding. As the volume and flow rate (speed) of the runoff increases, water reaches streams and lakes more quickly and typically there is less recharge to groundwater to contribute baseflow to streams.

The higher runoff volumes and rates lead to overland erosion, scouring or undercutting of streambanks, flooding, and loss of habitat.

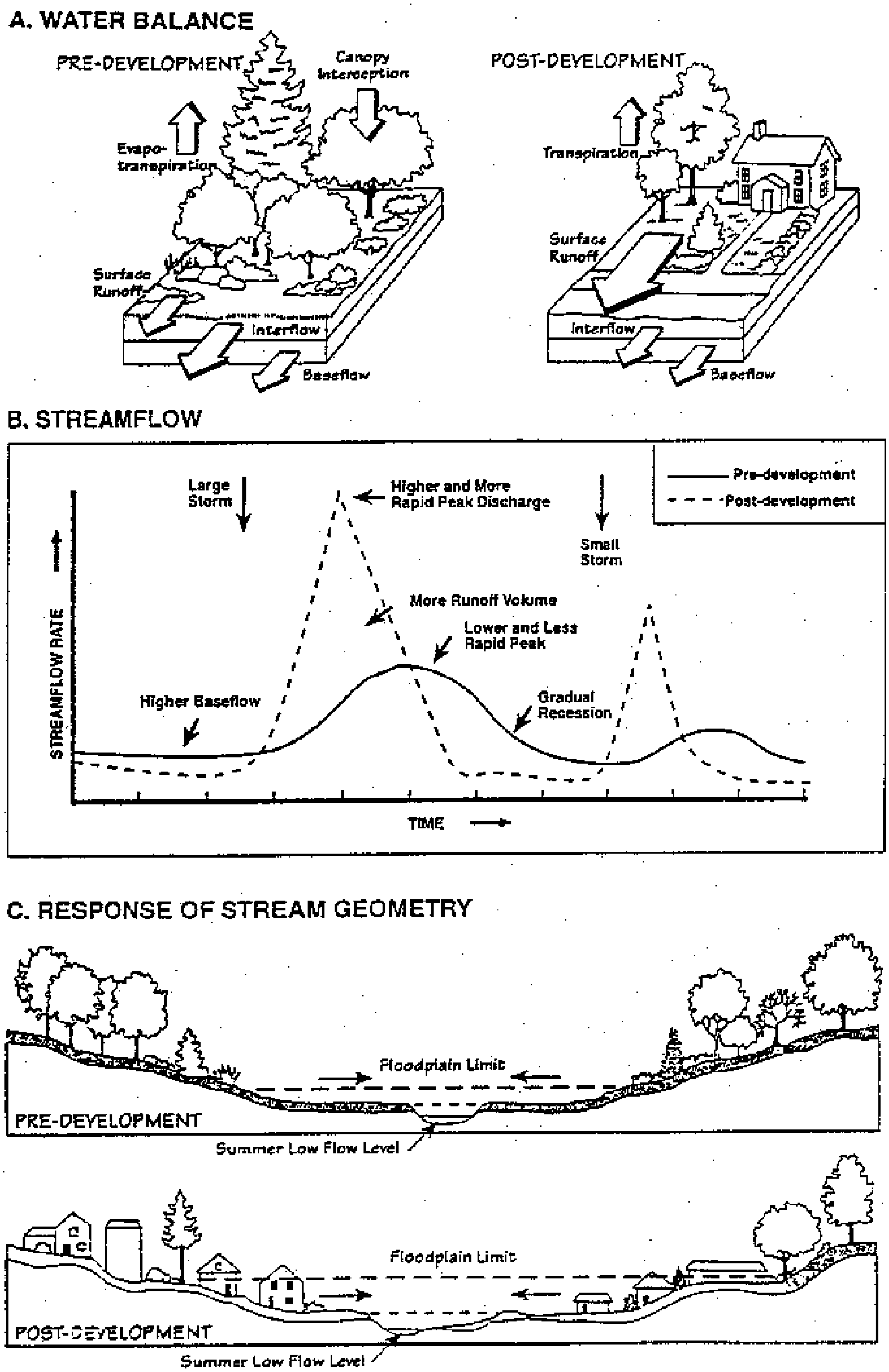


Figure 2-1. Impact of Urbanization on Watershed Hydrology

2.2 Stormwater Runoff Quality

Urbanization also adversely affects the temperature and quality of stormwater runoff, which in turn has a serious impact on receiving waters. Runoff collects and transports pollutants from impervious surfaces, including:

- Sediment, which can carry other pollutants and can smother fish eggs
- Organic debris and fertilizer containing nutrients such as phosphorus and nitrogen
- Bacteria and viruses from humans and animals
- Organic chemicals, such as pesticides, oil and antifreeze
- Heavy metals such as lead, copper, zinc and cadmium from roof runoff, worn tires and automobiles
- Oxygen-demanding substances
- Floatables, such as litter.

Sediment

The most common pollutant found in urban runoff is sediment. Sediment consists of tiny soil particles that are washed or blown into nearby waterways. Sediment can fill up river channels, lakes, wetlands, and reservoirs, creating potential flooding problems. In addition, sediment can smother aquatic life such as phytoplankton, fish, and invertebrates and make feeding or reproducing difficult for other aquatic life. Sediment can also carry other pollutants, such as nutrients, toxic chemicals, and heavy metals. These pollutants can affect water quality and potentially contaminate drinking water supplies. Sediment is associated with the following:

- Construction site runoff
- Streambank erosion
- Road maintenance
- Yard and garden landscaping

Nutrients

The most common nutrients found in urban runoff are nitrogen and phosphorus. Excessive levels of nutrients encourage undesirable algal blooms and aquatic weed growth in surface waters. When the nutrients are used up, this growth dies and uses oxygen as it decays. As a result, the lake, river, or other receiving waterway has less dissolved oxygen, creating an unfavorable environment for fish and other aquatic life. Nutrients are associated with the following:

- Automobile emissions
- Gasoline and oil additives

- Pesticides and fertilizers
- Lawn clippings and leaves

Bacteria and Viruses

Two of the most common bacteria and viruses found in urban runoff are fecal coliform and enterococcus. If high levels of bacteria and viruses in stormwater flow into a nearby waterway, human health could be jeopardized. Bacteria and viruses are associated with the following:

- Sanitary sewer infiltration into the storm drain system
- Failing septic tanks
- Pet and wildlife wastes

Petroleum-Derived Substances

The most common petroleum-derived substances found in urban runoff are oil and grease. Petroleum-derived substances contain hydrocarbons. Hydrocarbons are toxic to sensitive animal and aquatic life species. In addition, hydrocarbons degrade fish habitat and can accumulate in the food chain. Petroleum-derived substances are associated with the following:

- Parking lots and roads
- Automobile service stations
- Waste oil storage
- Illegal dumping or improper disposal of petroleum-derived substances

Toxic Chemicals

The most common toxic chemicals found in urban runoff are organic compounds. Organic compounds can be pesticides, paints, solvents, adhesives, or other similar products. Improper disposal or storage, illegal discharges, or unnecessary application of toxic chemicals can harm aquatic life. In addition toxic chemicals can accumulate in the food chain and can potentially contaminate drinking water supplies. Toxic chemicals are associated with the following:

- Automobile emissions
- Household cleaners
- Toxic chemicals storage
- Illegal dumping or improper disposal of toxic chemicals

Heavy Metals

The most common heavy metals found in urban runoff are lead, copper, cadmium, and zinc. Nickel and chromium are also frequently present in urban runoff. As these metals corrode, dissolve, or settle out, wind or water deposits them in surface water. Heavy metals can degrade water quality because they can be toxic to aquatic life, can accumulate in the food chain, and can contaminate drinking water supplies. Heavy metals are associated with the following:

- Automobile emissions
- Automobile brake and tire wear
- Galvanizing agents
- Batteries
- Paints and wood preservatives
- Metal roof tops and pipes

Oxygen-Demanding Substances

The most common substances found in urban runoff that reduce the available oxygen in water are organic matter. When microorganisms decompose organic matter, dissolved oxygen levels become depleted. If dissolved oxygen levels in water become too low, aquatic life can become stressed or die. Oxygen demanding substances are associated with the following:

- Leaves and lawn clippings
- Small wood products (sawdust, wood chips, bark)
- Animal wastes
- Food wastes from leaking garbage dumpsters
- Street litter

Floatable Materials

The most common floatable materials found in urban runoff are street litter and industrial yard waste. Floatable materials can contain significant amounts of pollutants such as heavy metals, toxic chemicals, and bacteria. Floatable materials can also cause waterways or permanent stormwater controls, such as detention basins, to become unsightly.

Section 3 - Responsibility for Stormwater Management and Permitting

This chapter introduces an overview of current federal, state, and local government agency stormwater plans, programs, and regulations. Design professionals may have to work closely with some government agencies more than others when planning a development project. As a result, those government agencies and their requirements have been included in more detail.

Table 3-1 on the following page summarizes the current regulations for stormwater pollution control. The table identifies the government agency or special purpose district that has stormwater authority with regard to a specific project activity.

Responsibility for stormwater management is often held collectively by landowners and several agencies and special districts. Persons wishing to discharge stormwater runoff into a drainage facility should contact the appropriate agency or special district about conditions or permitting requirements that may apply.

Landowners are principally responsible for stormwater runoff from their property. In subdivisions with a stormwater facility (e.g., detention pond) that collects runoff from the entire development, the developer or local homeowners' association may assume responsibility for maintenance. Alternately, the facility could have an easement to allow for maintenance by the city, county, or local highway jurisdiction. In this case, the local agency may charge the developer or homeowners' association for the cost of such maintenance.

Local highway jurisdictions are responsible for maintaining roads in the unincorporated areas of a county, including all drainage contained in the road right-of-way. Ada County Highway District is the exception, with responsibility for all urban streets, rural roadways and associated drainage facilities (excluding state and federal roads) in Ada County. For the most part, the drainage system associated with county roads consists of natural drainages (e.g., streams), irrigation canals, and roadside ditches.

County building and planning departments are responsible for reviewing and issuing building permits in the unincorporated county. However, they may not be responsible for building permits in the impact areas. Some building departments throughout the state may also require stormwater BMPs based on specific types of development.

District health departments, through their on-site septic system review process, work closely with county landowners outside the sewered areas. The seven District Health Departments across the state also monitor public health related water quality parameters, support the efforts of local sewer districts, and track performance of on-site systems. For centralized sewer systems, the Idaho Department of Environmental Quality (IDEQ) assumes the responsibility for review.

The Idaho Transportation Department (ITD) is responsible for building, operating, and maintaining all state roads and highways (e.g., Hwy 55, Interstate 84), including all of the approaches from county roads contained within the state highway right-of-way. Within some city limits, ITD and a given city or local highway jurisdiction may share maintenance responsibilities. ITD is responsible for maintaining the drainage systems (roadside ditches and stream, canal, and river crossings) associated with state roads. If a development project has the potential to affect a highway project in a given city limit, then design professionals should contact an ITD office. ITD incorporates erosion and sedimentation controls into its construction projects.

The IDEQ is the designated agency for implementation of the Federal Water Pollution Control Act (33 U.S.C.A. §§1251 to 1387) also known as the Clean Water Act. This responsibility involves the control and abatement of all sources of pollution to both surface and ground waters. IDEQ's delegated authority for nonpoint source control includes responsibility for both surface water and ground water pollution. The Nonpoint Source Management Program provides technical assistance and support to cities, counties, and watershed advisory groups throughout the state.

Idaho adopts water quality standards to protect public health and welfare, enhance the quality of water, and serve the purposes of the Clean Water Act. These standards are the benchmarks DEQ uses to know if it is doing its job to protect Idaho's surface water. Nonpoint source pollution management includes the use of Best Management Practices (BMPs) which should be designed, implemented and maintained to provide full protection or maintenance of beneficial uses (IDAPA 58.01.02, § 350.02).

Any project that requires a federal permit or license under the Clean Water Act, such as a National Pollutant Discharge Elimination System permit, or a Clean Water Act Section 404 dredge and fill permit, requires a Clean

Water Act Section 401 certification. The certification states that the project will not cause a violation of state water quality standards.

IDEQ is also responsible for protecting the quality of ground water in Idaho and relies on a combination of programs to protect ground water from pollution, clean up degraded ground water, and monitor and assess ground water quality. The IDEQ's authority for nonpoint source control of ground water pollution includes the Ground Water Quality Protection Act (Chapter 1, Title 39, Sections 120 through 127, Idaho Code), the Idaho Ground Water Quality Plan, and the Ground Water Quality Rule (IDAPA 16.01.11).

The Idaho Department of Water Resources (IDWR) has authority, in conjunction with the US Army Corps of Engineers, to regulate stream channel alterations under the Stream Channel Protection Act (Title 42, Chapter 38, Idaho Code) and to regulate the safety of most impoundment structures under the Dam Safety Act (Title 42, Chapter 17, Idaho Code). The Idaho Stream Channel Protection Act requires that the stream channels of the state and their environment be protected against alteration for the protection of fish and wildlife habitat, aquatic life, recreation, aesthetic beauty and water quality. This means IDWR must approve in advance any work being done within the beds and banks of a continuously flowing stream. Dams 10 feet or higher or which store more than 50 acre-feet of water are regulated by the IDWR. IDWR is also involved in the coordination of permits for lakeshore encroachments.

Wastewater disposal by injection wells is regulated through the State Underground Injection Control Program, under Title 42, Chapter 39, Idaho Code. An injection well is "(1) A bored, drilled or dug hole or is a driven mine shaft or a driven well point, and (2) deeper than its largest straight-line surface dimension; and (3) used for or intended to be used for injection," Design professionals considering using injection wells for stormwater runoff disposal should contact DWR for information on proper disposal methods.

U.S. Army Corps of Engineers permits are required under Section 404 of the Clean Water Act for discharges of dredged or fill material into waters of the United States, including wetlands. This includes excavation activities that result in the discharge of dredged material and destroy or degrade waters of the United States. The Corps administers the day-to-day program, including individual permit decisions and jurisdictional determinations; develops policy and guidance, and enforces Section 404 provisions.

The Environmental Protection Agency (EPA) develops and interprets environmental criteria used in evaluating permit applications; determines scope of geographic jurisdiction, approves and oversees State assumption, identifies activities that are exempt, reviews/comments on individual permit applications, has authority to veto the Corps' permit decisions (Section 404[c]), can elevate specific cases (Section 404[q]) , and enforces Section 404 provisions.

The EPA, Region 10 (Seattle) is also the National Pollutant Discharge Elimination System (NPDES) permitting authority for the State of Idaho. As such, the agency is responsible for permitting all point source discharges to waters of the United States, including stormwater discharges. The 1987 Amendments to the Clean Water Act (CWA) prohibit the discharge of any pollutant to waters of the U.S. from non-agricultural sources unless authorized by a NPDES permit. These requirements are being implemented in two phases through the EPA's Stormwater Program. The federal stormwater regulations require permits for entities that own and operate municipal separate storm sewer systems (MS4s) that meet certain criteria, certain classifications of industrial facilities, and construction sites larger than one acre.

Boise City, Garden City, the Ada County Highway District, Ada County Drainage District 3, District 3 of ITD, and Boise State University are the only entities in Idaho subject to Phase I municipal separate storm sewer system requirements. Owners or operators of MS4s in Idaho within "urbanized areas" (UAs), based on 2000 Census data, are regulated entities under Phase II requirements. Owners or operators of MS4s outside UAs could also be regulated as more information becomes available or through petition to EPA.

Operators of Phase II-designated small MS4s are required to apply for NPDES permit coverage and develop, implement and enforce a stormwater management program designed to reduce the discharge of pollutants to the "maximum extent practicable," to protect water quality, and to satisfy the requirements of the CWA. The stormwater management program must address six minimum control measures, including public education and outreach, public participation/involvement, illicit discharge detection and elimination, construction site runoff control, post-construction runoff control, and pollution prevention/good housekeeping for municipal operations. Additional information can be accessed at http://cfpub1.epa.gov/npdes/home.cfm?program_id=6.

Industrial facilities identified by EPA as needing an NPDES industrial stormwater permit must obtain an NPDES permit if they discharge stormwater either directly to surface waters or indirectly through separate municipal storm drains. Industrial facilities that must obtain coverage for their stormwater discharges can be found at
http://cfpub1.epa.gov/npdes/stormwater/swcats.cfm?program_id=6.

Construction activities that disturb an area of one acre or more or that are part of a larger common plan of development (such as lots in subdivisions created since 1987) are required to submit a Notice of Intent (NOI) and prepare and implement a Stormwater Pollution Prevention Plan (SWPPP). These permit requirements are in addition to local regulations.
More information can be found at
http://cfpub.epa.gov/npdes/stormwater/cgp.cfm.

The Bureau of Reclamation (BOR) operates dams and reservoirs and has jurisdiction over activities associated with reservoirs, such as camping and boating. Irrigation districts and ditch companies, and individual farmers operate irrigation systems primarily throughout the southern half of the state. Land development projects must seek approval from a ditch or canal company/district to discharge stormwater from pending development sites to such conveyances.

Table 3.1 Current Regulations for Stormwater Control

Land Use Activity	Agency or Local Function	Permit, Approval Process, or Authority	Type of Construction
Plan Review			
Stormwater Pollution Prevention Plan review	U.S. Environmental Protection Agency (EPA)	National Pollutant Discharge Elimination System (NPDES) discharge permits	Industrial, commercial, and residential over one acre or part of a larger common plan of development
Stormwater, erosion control or drainage plan review	Local public works, building, or planning department or local highway jurisdiction	Consult local authority	Commercial, industrial, residential, subdivision
Stor**mwater Discharges**			
To a right-of-way	Local highway jurisdictions	Consult local authority	Commercial, industrial, residential, subdivision
To a natural waterway	EPA, Army Corp of Engineers (ACE) and/or local watershed-based authority	NPDES discharge permit	Commercial, industrial, residential, subdivision
To a canal or drain	Local canal or drainage district EPA, COE	Permission from local canal company or drainage district, NPDES discharge permit	Commercial, industrial, residential, subdivision
To a Bureau of Reclamation (BOR) canal	BOR, EPA	Permission from BOR, NPDES discharge permit	Commercial, industrial, residential, subdivision
From selected industrial facilities	EPA	NPDES stormwater discharge permit	Industrial
Stormwater Disposal			
To subsurface through an injection well	Idaho Department of Water Resources regional office Some Health Districts	Underground Injection Control Program	Commercial, industrial, residential, subdivision
Site Preparation/Construction			
All new development and redevelopment	Local public works, building, or planning department or local highway jurisdiction	Local or county ordinance	Commercial, industrial, residential, subdivision
Construction over one acre and lots in subdivisions created after 1987	EPA	NPDES stormwater permit	Commercial, industrial, residential, subdivision
Development project potentially impacting an existing highway	Idaho Transportation Department, local highway jurisdictions	Idaho Code, Title, Chapter 39, Section 7-8	Commercial, industrial, residential, subdivision
Development project potentially impacting an existing drainage facility	Local public works, building, or planning department, canal company, drainage district or local highway jurisdiction	Local or county ordinance, State statute	Commercial, industrial, residential, subdivision

Land Use Activity	Agency or Local Function	Permit, Approval Process, or Authority	Type of Construction
Dewatering			
Discharges to a right-of way	Local highway jurisdictions	Consult local authority	Commercial, industrial, residential, subdivision
Discharge to a canal or drain	Local canal company, drainage district	Permission from canal company or drainage district	Commercial, industrial, residential, subdivision
Other Permits			
Filling of wetlands or other waterways of the U.S.	U.S. Army Corps of Engineers	404 (dredge and fill) permit	Commercial, industrial, residential, subdivision

Section 4 - Development Site Planning

To ensure cost-effective site design and to reduce pollutants entering our stormwater, design professionals should work with the site developer or property owner as early as possible in the project development process to create an integrated site plan. Even before a preliminary site plan is drawn, the design professional and the developer or property owner should consider stormwater Best Management Practices (BMPs) as part of the project plan. This type of planning will not only reduce the amount of pollutants entering our stormwater system, but will also avoid costly construction delays later on.

The following process is recommended when developing a project site plan. This process can be used on small infill projects as well as large development projects. It provides a general overview of site planning considerations and choosing BMPs that most effectively fit the conditions of the site and type of development project. For assistance in the selection of the most appropriate or suitable BMP, the user should refer to Table 4.1. It is essential to check with the local permitting authority for other guidance.

Step 1—Evaluate site conditions

Gather basic information for the project site before using this catalog to select BMPs. General guidance for gathering information such as soil type, depth to the high water table, and slope is provided in Appendix C. To obtain some types of information, contacting the local permitting authority is recommended. For example, local agency staff can help by identifying locations of environmentally sensitive areas on or near the site and by providing local planning and building code requirements.

Step 2—Identify performance goals and regulatory considerations for site

Stormwater management performance goals and objectives should be identified for the development site. These goals and objectives are based on applicable regulatory requirements for quantity (flood and drainage) control and peak flow reduction; and any special local area needs such as fisheries protection, water supply watershed protection, ground water protection and other issues of local importance. While the selection of the appropriate level of control is usually a local mandate, in some cases the downstream receiving waters will influence the regulatory requirements.

Examples include Total Maximum Daily Load (TMDL) requirements, protection of endangered species, and/or federal stormwater regulations and associated NPDES Stormwater Permits conditions.

The regulatory requirements of the local jurisdiction must be considered in the selection of BMPs. Many jurisdictions have requirements for control of the rate of discharge (or peak runoff rate) from new or redevelopment to control increased flooding, channel protection or water quality. This control is usually accomplished by detention of the flow, discharging at a controlled release rate through an orifice (small opening). Other performance goals and objectives may include specific pollutant guidelines, water quality control, multi-parameter controls, including groundwater recharge and channel protection; and habitat protection strategies.

Contact the local permitting authority and obtain the permit application forms and any other applicable requirements for the project site area. These could include planning and building codes, flood control and water quality design standards, and seasonal restrictions for earthmoving and grading.

Identify the storm drain system or waterway where site runoff will drain. Identifying where your site runoff will drain will determine which requirements you will need to follow.

Check with the agency managing the receiving drainage system for the site, to learn about any special restrictions or permitting that may be required, including the maximum carrying capacity of the receiving system. Local requirements may change periodically, so remember to check with the agencies for each new construction project.

Step 3—Develop Conceptual Site Design

At the early stages of site design, identify opportunities to reduce the quantity and improve the quality of site stormwater runoff. Design sites to preserve and minimize disturbance to existing soils, vegetation and water quality sensitive areas. Consider using the following techniques on your site:

- Design the site, using innovative architectural designs, to limit impervious areas
- Design on-site water re-use facilities.
- Reduce impervious areas by using cluster development and rooftop or basement parking.
- Disconnect impervious surfaces.

- Identify preliminary stormwater disposal space allocation requirements early.

Vegetation may be one of the most cost effective resources for improving water quality. Integrating stormwater controls within the landscape saves money and keeps pollutants such as sediments, and oil and grease out of stormwater runoff. Controls such as vegetated swales and irrigated grass buffer strips can be part of the landscape with minimal construction costs. Consider using the following techniques for your site:

- Preserve existing vegetation or plant native vegetation in disturbed areas.
- Maximize and preserve vegetative canopy, particularly shrubs and coniferous trees

Prepare a preliminary construction schedule early in the development of the project. Seasonal weather conditions impact many construction activities and strategic schedule and sequence planning can facilitate construction, as well as minimize impacts on stormwater. Timing can be especially important in areas at higher elevation because of the generally limited duration of a construction season. Careful planning is needed to minimize the potential impact of construction near streams and the shoreline, for stream and river crossings (pipelines and utilities), and for projects that require revegetation during the short growing season.

Present the conceptual plan and preliminary construction schedule to the local permitting agency staff for feedback before proceeding further with the design drawings. For larger projects, this would likely take the form of a pre-application meeting. This important check-in is recommended in order to save time and money later in the process.

Step 4—Characterize Stormwater Flows (Run-on and Runoff)

Evaluate the characteristics of the run-on that enters the site from adjacent and upstream properties, as well as the runoff that will be discharged from the site following development or redevelopment. Consider the following, which will potentially influence the quantity (volume), peak flow, and quality of run-on to and runoff from the site:

- Upstream activities currently affecting the site
- Planned upstream land use likely to affect the site in the future
- Type and capacity of the downstream receiving water or drainage system
- Amount of impervious area planned for the site

- Activities that will take place on the site (e.g., industrial and commercial activities may generate different pollutants and may require different BMPs than residential activities)

Perform hydrologic calculations for both the pre-developed and post-development stages, with upstream and downstream conditions in mind. Use local design standards for flood control and water quality control, or those suggested in Appendix D if no local standards exist. Calculate the required volume and peak flow of the discharge and determine the amount of runoff to be detained and/or treated on site. Appendix D contains guidance for calculating runoff.

Step 5- Evaluate BMPs

The selection of BMPs should be based on BMP performance goals, identified in Step 2, and the physical constraints of the development site. The treatment requirements of local jurisdictions vary, and must be considered in the selection of BMPs. Site suitability is a key factor to successful BMP performance, especially for structural BMPs. Physical site constraints may include soil suitability, depth to water table, depth to bedrock, slope and watershed size. In many instances, individual BMPs may be modified to account for site constraints, while in other cases, it may eliminate a BMP facility as an option altogether.

Table 4.1 shows site selection criteria and site selection restrictions for each BMP. Use the table to give a general sense of the BMPs that could be appropriate for your site. The table also shows which BMPs should be eliminated from further consideration due to restrictive site-specific conditions. The following describes the information presented in Table 4.1

- Targeted pollutants - an indication is given of the expected pollutant removal effectiveness for typical pollutants of concern in urban stormwater runoff: sediment, phosphorus, trace metals (e.g., lead, copper, cadmium), bacteria, and petroleum hydrocarbons (e.g., gasoline, oil and grease). Estimated values are provided for phosphorus and sediment removal for most of the permanent BMPs, based on available data from other areas. For the other pollutants, a more qualitative estimate is provided through full, half, and empty circles. A full circle on the table indicates that the BMP is very effective at controlling the pollutant (70 percent or greater of the pollutants may be removed). A half-filled circle represents moderate effectiveness (greater than or equal to 30 percent and less than 70 percent of the pollutants may be removed). Finally, an empty circle indicates little or no effectiveness (less than 30 percent of the pollutants may be removed).

- Drainage area - The maximum contributing drainage area for the BMP
- Maximum slope - The maximum allowable site slope for placement of the BMP
- Minimum depth to bedrock - The minimum allowable depth to bedrock for placement of a BMP on a site
- Depth to high water table - The minimum allowable depth to the high water table for locating a BMP on a site
- NRCS soil type - Soil type is classified as A, B, C or D. A has the best infiltration rate (e.g., sands), while D allows little or no infiltration (e.g., clays). The BMP is best suited for the soil types given on the table.
- Use with freeze/thaw cycle - BMP performance during the winter and spring freeze/thaw cycles are indicated as good, fair or poor.
- Drainage/flood control - A checkmark in this column of the table indicates that the BMP can be used to provide drainage and flood control as well as water quality control.

Pollutant removal has become one of the main objectives for using BMPs. The quantification of efficiency of BMPs has often centered on examinations and comparisons of "percent removal" defined in a variety of ways. There is no single value for percent pollutant removal for a particular BMP. Pollutant removal efficiency is site specific and highly variable between storm events even within the same area. Assuming routing and design volumes are properly designed, BMP performance will vary with influent loadings and characteristics.

BMPs do not typically function with a uniform percent removal across a wide range of influent water quality concentrations. For example, a BMP that demonstrates a large percent removal under heavily polluted influent conditions may demonstrate poor percent removal where low influent concentrations exist. Other factors that affect variability in BMP water quality performance include active pollutant removal mechanisms, BMP design characteristics, and conditions within the BMP.

The goal in watershed management should be to reduce the pollutant load either through source control (the most effective way to do it) or through multi-stage treatment (treatment trains). Although individual BMPs may be less effective on a percent basis, if they cumulatively still result in a lower effluent concentration (or load), they benefit the watershed.

Choose BMPs for the construction phase and select other BMPs for permanent control of stormwater pollution after the construction is complete. Some temporary BMPs, such as earth berms, can be converted to permanent facilities after construction is complete.

Some site situations, such as steep slopes, will severely limit options in selecting BMPs. Steep slopes will require more complex engineering and BMPs tend to be structural in nature, requiring less land space than facilities on flat sites. Plan to include slope protection and vegetative controls on the site to reduce the amount of erosion and sediments in site runoff. Also investigate upstream conditions and eliminate any off-site sources of sediment from neighboring properties. After applying these measures, if high sediment loads are still unavoidable, select a detention facility that will initially treat the stormwater through simple settling. Use stormwater filters and vegetated detention only after pretreatment settling has been applied to reduce the sediment load. Otherwise excessive sediment may clog the infiltration facilities and damage vegetation.

Where quantity control is an issue, consider an off-line water quality facility. In this situation, the water quality device is located off-line from the primary drainage facility. The water quality portion is designed only to treat a small volume of water, typically associated with smaller, more frequent storm events. The runoff from large storm events bypasses the facility to avoid flooding. In this type of combination system, stormwater runoff is directed to off-line facilities through flow-splitting and diversion structures.

Consider combining BMPs to improve effectiveness. Combination or "treatment train" facilities (i.e., several facilities in a row or series) can be designed so that upfront facilities pretreat the runoff, allowing the main device to function optimally. This concept also allows different mechanisms to clean different portions of the pollutant load. For example, sedimentation ponds are good at removing coarse particulates but are not effective with dissolved pollutants.

Incorporate source controls in your site design. Source controls are stormwater BMPs that prevent pollutants from ever entering a stormwater system. Compared to treatment controls, source controls are more cost effective for controlling stormwater pollution on a site. Some examples of source controls are as follows:

- Providing covered (roofed) structures for outdoor storage or outdoor work areas to prevent rain from washing pollutants off the site.

- Preventing run-on into storage areas by using properly designed berms or grading around storage areas.
- Using designated vehicle wash areas and disposing wash water into the sanitary sewer, where allowed.

Industrial sites can have more toxic pollutants on site compared to commercial or residential sites. Consequently, the BMPs used on an industrial site will be different from those used on a commercial or residential site. When planning for stormwater controls on an industrial site, use source controls that reduce or remove toxic pollutants before you use treatment controls. Treatment controls may still be needed, however, to treat pollutants that are not completely removed by source controls.

Treatment controls are more comprehensive and more costly than source controls. Treatment controls for industrial sites may require installing or constructing water quality controls, such as oil/water separators and water quality inlets, or hydraulic controls, such as retention ponds. Each industrial site must be evaluated to determine which BMPs (either singly or in combination) will be appropriate for a site. In addition, some controls are less costly to install during new construction than to retrofit afterwards. Therefore, design professionals should consider what potential pollutants may originate from the site throughout the life span of the facility, not just during construction.

When planning source control and treatment control BMPs for a site, consider how the controls can be used together (that is, multiple systems). Multiple systems can remove pollutants more effectively than individual source and treatment control BMPs. Also, multiple systems can provide additional secondary benefits such as controlling floods, enhancing fish and wildlife habitats, providing aesthetics and recreation, and complying with landscaping requirements.

Step 6—Prepare Preliminary Project Design (Stormwater Site Plan)

A stormwater site plan is recommended for all new developments, whether industrial, commercial or residential. A stormwater site plan should include the following elements:

- Project overview (brief description)
- Site plans (attach)
- Preliminary conditions summary, including soil types and depth to high groundwater (see Appendix C for directions on how to collect this information)

- Identification of adjacent land uses and environmentally sensitive areas (such as wetlands, natural streamside riparian areas which provide wildlife habitat, or other areas designated by the local permitting agency)
- Analysis of off-site upstream and downstream conditions, including capacity of the downstream system
- Hydrologic calculations
- Plan for design and placement of proposed construction BMPs, including erosion controls (construction BMP plan)
- Design and placement of proposed permanent stormwater BMPs (include preliminary sizing calculations)
- Operation and maintenance plan for the temporary and permanent stormwater BMPs
- Other permits for the site (either issued or planned)

An example stormwater site plan is included in Appendix E. If permanent BMPs are not planned for the site, provide a rationale for why this is not necessary (e.g., low risk) or not possible (e.g., space constraints). In such cases, the local agency staff may not agree with the rationale and may provide assistance to select and locate appropriate BMPs.

Step 7—Prepare the Preliminary Landscape Plan

When designing the site landscape plan and choosing plants for vegetated stormwater BMPs, consider using species of trees, shrubs, plants, and grasses that are native to the area. In this way, irrigation will only be required during the plant establishment period (typically one to two years, depending on the particular species). Using native plants reduces water, pesticide/herbicide, and fertilizer use. Additionally, use of native plants in stormwater BMPs will help ensure proper plant establishment and performance of the BMP.

Properly selecting the plants and preparing the site are crucial to successful plant establishment. Plants should be planted during favorable planting and seeding seasons. In addition, irrigating, mulching, and providing weed and pest control on the site may be necessary to encourage proper plant growth.

Step 8—Submit the Preliminary Project Design

Present the preliminary project design or stormwater site plan and preliminary landscape plan to the local permitting authority for approval before proceeding further. Use the opportunity to ask questions, if any, about the permit application forms or fee.

All submittals should include the preliminary design calculations to demonstrate that the facilities will meet the applicable standards. It is recommended that professionals licensed in the State of Idaho prepare the submittal or oversee its preparation.

Step 9—Complete the Design

Once the preliminary plans have been approved, complete the final plans for design and construction of the project. In addition to the plans normally required for development (e.g., grading and drainage, building), the final design package should include:

- Type and location of BMPs for use during construction (Stormwater Pollution Prevention Plan or Erosion and Sediment Control Plan)
- Size/design and location of permanent stormwater BMPs
- Landscape plan
- Maintenance plan for BMPs and vegetation during construction and after construction

Prepare a maintenance plan that outlines the scope of activities, schedule, and parties responsible for inspecting and maintaining the stormwater BMPs on the site. At a minimum, the maintenance plan should identify safety provisions, site access, sediment disposal, and vegetation maintenance.

In cases when the sediment is suspected to contain a high level of pollutants, include provisions in the maintenance plan for testing the sediment. For example, if the site is located in an area with a history of upstream industrial spills, then testing could include parameters such as oil and grease, metals, or nutrients. Store and dispose of sediments removed from stormwater BMPs in accordance with applicable local, state, and federal regulations.

Step 10—Submit Final Plan and Obtain Permits

Submit the final documents to the appropriate permitting agency for final approval and permitting. More than one permit may be required for the site and more than one agency may be involved. This will include, at a minimum, approvals from the local municipality and/or local highway jurisdictions and the filing of a Notice of Intent with the EPA and preparation of a Stormwater Pollution Prevention Plan, if the construction site is larger than one acre or part of a larger plan of development.

Step 11— Install and Maintain BMPs

Once the permits are obtained, the final construction schedule can be developed. The following points should be kept in mind when establishing the schedule:

- Comply with seasonal restrictions for earthmoving and exposed soil established by the local permitting authority.
- Schedule installation of BMPs. Some of the temporary BMPs should be installed before earthmoving activities begin.
- Implement housekeeping BMPs (e.g., covering stockpiles) as soon as possible after the project breaks ground.
- Schedule regular inspections of the site and the stormwater BMPs throughout the construction process and repair or replace BMPs as needed.
- Maintain the BMPs as specified in the maintenance plan.
- Schedule removal of the temporary BMPs (or retrofit them for permanent use) at the end of the construction project.

Table 4.1a. Selection Matrix for Construction Site BMPs	Targeted Pollutants					Physical Constraints							
	Sediment	Phosphorus	Trace Metals	Bacteria	Petroleum Hydrocarbons	Drainage area (acres)	Maximum slope (%)	Minimum depth to bedrock, ft	Minimum depth to high water table, ft	SCS soil type[1]	Use with freeze/thaw cycle	Drainage/flood control	Expected life[2]
General Construction Site Guidelines (Erosion Controls)													
Timing of construction	◖	○	○	○	○	unlimited	Unlimited	NA	NA	ABCD	Good		
Staging areas	◖	○	○	○	○	unlimited	15	NA	NA	ABCD	Good	Yes	
Preservation of existing vegetation	●	○	○	○	○	unlimited	Unlimited	NA	NA	ABCD	Good		
Clearing limits	●	○	○	○	○	unlimited	Unlimited	NA	NA	ABCD	Good		
Stabilization of construction entrance	●	◖	◖	○	◖	unlimited	15	3	NA	ABCD	Good		2+ yrs
Erosion prevention on temporary and private roads	●	◖	◖	○	◖	unlimited	15	3	NA	ABCD	Good		
Housekeeping (Source Controls)													
Dust control	●	○	◖	○	◖	NA	5	NA	NA	NA	NA		
Cover for materials and equipment	●	○	●	○	●	NA	NA	NA	NA	NA	NA		
Stockpile management	●	○	●	○	●	NA	NA	NA	NA	NA	NA		
Spill prevention and control	○	○	◖	○	◖	NA	NA	NA	NA	NA	NA		
Vehicle/equipment washing and maintenance	●	●	●	○	●	NA	5	NA	NA	BCD	NA		
Waste management	◖	○	◖	○	○	NA	NA	NA	NA	NA	NA		

Table 4.1a. Selection Matrix for Construction Site BMPs (cont.)	Targeted Pollutants					Physical Constraints							
	Sediment	Phosphorus	Trace Metals	Bacteria	Petroleum Hydrocarbons	Drainage area (acres)	Maximum slope (%)	Minimum depth to bedrock, ft	Minimum depth to high water table, ft	SCS soil type[1]	Use with freeze/thaw cycle	Drainage/flood control	Expected life[2]
Concrete waste management	◖	○	○	○	○	NA	NA	NA	NA	NA	NA		
Sanitary/septic waste management	◖	○	○	●	○	NA	NA	NA	NA	NA	NA		
Slope Protection (Erosion Controls)													
Mulching	●	◖	○	○	○	2	NA	NA	NA	ABCD	Fair		6-8 mths
Hydraulic mulching	●	◖	○	○	○	100	15	NA	NA	ABCD	Fair		6-8 mths
Geotextile	●	○	○	○	○	100	100	NA	NA	ABCD	Good		8-12 mths
Matting	●	○	○	○	○	Unlimited	100	2	NA	ABCD	Good		6 mths
Soil binders	●	◖	○	○	○	Unlimited	NA	NA	NA	ABCD	Fair		6-12 mths
Topsoiling	●	○	○	○	○	unlimited	50	3	2	NA	Fair		
Seeding	●	◖	◖	○	○	unlimited	5	2	2	ABCD	Fair		Permanent
Sodding	●	◖	◖	○	○	unlimited	14	2	2	ABCD	Fair		Permanent
Planting	●	◖	◖	○	○	unlimited	50	3	3	ABCD	Fair		Permanent
Pipe slope drain	●	○	○	○	◖		50	2	25	ABCD	Good	Yes	1 yr – permanent
Slope roughening	●	○	○	○	○	1	20	3	55	BCD	Good		
Gradient terracing	●	○	○	○	○	10	50	6	58	BCD	Good	Yes	
Retaining walls	●	○	○	○	○	Unlimited	67	NA	83	ABCD	Fair		

Table 4.1a. Selection Matrix for Construction Site BMPs (cont.)	Targeted Pollutants					Physical Constraints							
	Sediment	Phosphorus	Trace Metals	Bacteria	Petroleum Hydrocarbons	Drainage area (acres)	Maximum slope (%)	Minimum depth to bedrock, ft	Minimum depth to high water table, ft	SCS soil type[1]	Use with freeze/thaw cycle	Drainage/flood control	Expected life[2]
Channel and Stormdrain Protection													
Temporary channel liners	●	○	○	○	○	NA	NA	NA	NA	ABCD	Good		
Gabions	●	○	○	○	○	Unlimited	40	NA	2	ABCD	Good		
Riprap slope and outlet protection	●	○	○	○	○	5	40	NA	NA	ABCD	Good		Permanent
Inlet protection	●	○	○	○	○	1	5	2	2	ABCD	Good		1 yr
Check dams	●	○	○	○	○	10	50	2	NA	ABCD	Good	Yes	6 mths-1 yr
Temporary stream crossing	●	○	○	○	◖	NA	NA	2	NA	ABCD	Good	Yes	6 mths
Sediment Collection and Runoff Diversion (Sediment Controls)													
Biofilter bags	●	○	○	○	○	1ac/400 ft	2 (bales) 10 bags	2	2	ABCD	Fair		3 mths
Fiber rolls	●	○	○	○	○	Varies w/use	Varies w/use	2	2	ABCD	Good	Yes	6 mths
Silt fence	●	○	○	○	○	1ac/400 ft	33	2	2	ABCD	Good		6 mths
Vegetative buffer strip	●	○	○	○	○	Unlimited	20	5	3	ABCD	Fair		Permanent
Sediment trap (basin)	●	○	◖	○	○	5	10	3	2	ABCD	Good		8-18 mths
Portable sediment tank	●	○	◖	○	○	5	NA	NA	NA	NA	Good		Permanent
Temporary swale	●	○	◖	○	○	10	14	5	3	BCD	Fair	Yes	2 yrs
Earth dike	●	○	◖	○	○	10	10	5	5	ABC	Fair	Yes	2-25 yrs

Table 4.1a. Selection Matrix for Construction Site BMPs (cont.)	Targeted Pollutants					Physical Constraints							
	Sediment	Phosphorus	Trace Metals	Bacteria	Petroleum Hydrocarbons	Drainage area (acres)	Maximum slope (%)	Minimum depth to bedrock, ft	Minimum depth to high water table, ft	SCS soil type[1]	Use with freeze/thaw cycle	Drainage/flood control	Expected life[2]
Perimeter dike/swale	●	○	◐	○	○	2	10	5	5	ABC	Fair	Yes	2 yrs
Temporary berms	●	○	○	○	○	5	50	NA	NA	ABCD	Good	Yes	
Temporary storm drain diversion	●	○	○	○	○	5	50	NA	NA	ABCD	Good	Yes	
Instream sediment trapping devices	●	○	○	○	○	NA	NA	NA	NA	ABCD	Good		
Dewatering	●	○	○	○	○	NA	NA	NA	NA	ABCD	Good		

Table 4-1b. Selection Matrix for Post-Construction BMPs	Targeted Pollutants					Physical Constraints							
	Sediment	Phosphorus	Trace Metals	Bacteria	Petroleum Hydrocarbons	Drainage area (acres)	Maximum slope (%)	Minimum depth to bedrock, ft	Minimum depth to high water table, ft	SCS soil type[1]	Use with freeze/thaw cycle	Drainage/flood control	Expected life[2]
Stormwater Filters													
Vegetated swale	65%	15%	◖	○	◖	15	4	3	2	BCD	Fair	Yes	Permanent
Bioretention swale	75%	30%	●	◖	●	5	4	3	3	AB	Fair	Yes	Permanent
Vegetative filter strip	50%	40%	◖	◖	◖	5	6	5	3	BCD	Fair		Permanent
Sand filter	85%	55%	◖	◖	◖	5(inlets) 50 (basin)	6	3	3	NA	Fair	Yes	25 yrs
Compost filter	95%	40%	●	◖	●	1	6	NA	NA	NA	Fair		20+ yrs
Catchbasin insert	35%	5%	◖	○	◖	0.1	NA	NA	NA	NA	Fair		
Media filter	●	50%	●	◖	●	According to manufacturer's specifications				NA	Fair		20+ yrs
Infiltration Facilities													
Infiltration trench	75%	65%	●	●	●	10	15	3	3	AB	Fair		10 yrs
Bioretention basin	90%	75%	●	●	●	5	2	3	3	AB	Fair	Yes	25 yrs
Porous pavement	85%	64%	●	●	◖	0.25-10	2	2-5	2-5	AB	Fair	No	
Detention Facilities													
Wet pond (conventional pollutants)	80%	45%	●	◖	◖	15-20	10	3	2	CD	Good	Yes	Permanent
Wet pond (nutrient control)	80%	65%	●	◖	◖	5-20	5	3	2	CD	Fair	Yes	Permanent
Wet extended detention pond	80%	65%	●	◖	◖	10-50	10	3	2	CD	Good	Yes	Permanent
Dry extended detention pond	45%	25%	◖	○	◖	10-50	10	6	4	ABC	Good	Yes	Permanent

Table 4 –1b. Selection Matrix for Post-Construction BMPs (cont.)	Targeted Pollutants					Physical Constraints							
	Sediment	Phosphorus	Trace Metals	Bacteria	Petroleum Hydrocarbons	Drainage area (acres)	Maximum slope (%)	Minimum depth to bedrock, ft	Minimum depth to high water table, ft	SCS soil type[1]	Use with freeze/thaw cycle	Drainage/flood control	Expected life[2]
Biodetention basin	75%	45%	●	◖	●	25-50	5	3	2	CD	Fair	Yes	Permanent
Presettling/sedimentation basin	60%	30%	◖	○	○	10+	10	3	2	CD	Good		Permanent
Wet vault/tank	60%	30%	◖	○	○	5	15	12	12	ABC	Fair	Yes	Permanent
Other Structural Controls													
Oil/water separator	15%	5%	◖	○	●	1	15	8	8	ABC	Fair		20+ yrs
Swirl concentrator	35%	15-20%	◖	○	◖	According to manufacturer's specifications				NA	Fair		
Level spreader	NA	NA	○	○	○	5	1	NA	NA	ABCD	Fair	Yes	

● = very effective, removes > 70% of pollutant ◖ = moderately effective, removes 25-70% of pollutant ○ = least effective, removes < 25% of pollutant

N/A = Not applicable

[1] NRCS soil types (A,B,C,D) range from A = high infiltration to D = little or no infiltration

[2] Longevity data collected from various sources, including Panhandle Health District 1996, Boise City 1997, and EPA 1993. The numbers shown represent industry guidelines; the actual life expectancy is dependent on proper design, placement, and maintenance of BMPs.

The pollutant removal efficiencies given above are for planning purposes only. Actual removal rates are dependent on specific site characteristics, maintenance, and other factors. The following sources were used to determine the most likely average removal rate for conditions prevalent in Idaho: California 1993, Debo and Reese 1995, King County 1994, King County 1995, Maine 1995, Minnesota 1989, Panhandle Health District 1996, Portland 1991, and USEPA 1995.

Appendix A - References

California, 1993. Camp Dresser and McKee, Larry Walker Associates, Resources Planning Associates for Stormwater Quality Task Force. March 1993. "California Storm Water Best Management Practice Catalogs."

Debo, T. and A. Reese, 1995. "Municipal Storm Water Management." Ann Arbor: Lewis Publishers.

King County, 1994. King County Surface Water Management, Washington. Originally published in 1990 and updated regularly, including a major revision in 1994. "Surface Water Design Manual."

King County, 1995. King County, Snohomish County, Seattle Drainage and Wastewater Utility, and Port of Seattle. October 1995. "Evaluation of Commercially-Available Catchbasin Inserts for the Treatment of Stormwater Runoff from Developed Sites."

Maine, 1995. Maine Department of Environmental Protection. November 1995. "Stormwater Management for Maine: Best Management Practices."

Minnesota, 2000. Minnesota Pollution Control Agency. March 2000. "Protecting Water Quality in Urban Areas. Best Management Practices for Dealing with Storm Water Runoff from Urban, Suburban, and Developing Areas of Minnesota."

Panhandle Health District, 1996. Panhandle Health District, Coeur d'Alene, Idaho. August 1996. "Estimating and Mitigating Phosphorus from Residential and Commercial Areas in Northern Idaho."

Portland, 1991. City of Portland, City of Lake Oswego, Clackamas County, Unified Sewerage Agency. August 1991. "Surface Water Quality Facilities Technical Guidance Catalog." Prepared by Brown and Caldwell Consultants.

Portland, 1995. City of Portland. March 1995. "City of Portland Stormwater Facilities: A Design Guidance Manual." Prepared by Woodward-Clyde Consultants.

U.S. EPA, 1995. United States Environmental Protection Agency, Center for Environmental Research Information. April 1995. "National Conference on Urban Runoff Management: Enhancing Urban Watershed Management at the Local, County and State Levels." (EPA/625/R-95/003).

U.S. EPA, 1999. United States Environmental Protection Agency, Office of Water. August 1999. "Preliminary Data Summary of Urban Storm Water Best Management Practices." (EPA-821-R-99-012).

Appendix B – Glossary

BMP	Best Management Practice
BACTERIA	Single-celled microorganisms that lack chlorophyll; some cause disease; others are necessary to sustain life (see Fecal Coliform Bacteria).
BACTERIAL DECOMPOSITION OR MICROBIAL DECOMPOSITION	Microorganisms, or bacteria, have the ability to degrade organic compounds as food resources and to absorb nutrients and metals into their tissues to support growth.
BEST MANAGEMENT PRACTICE (BMP)	In this Catalog, the term refers to source or treatment controls designed to reduce pollution in stormwater runoff. Source controls are measures or devices designed to keep pollutants out of runoff. Examples include covers and roofs on outdoor storage processing areas and berms and sumps around outdoor source areas. Treatment controls are typically structural devices designed to temporarily store or treat urban stormwater runoff to reduce flooding, remove pollutants, and provide other amenities (e.g. enhance aesthetics and wildlife habitat).
BIOCHEMICAL OXYGEN DEMAND (BOD)	The quantity of dissolved oxygen used by microorganisms (e.g., bacteria) during the biochemical oxidation of matter (both organic and oxidizable inorganic matter) over a specified period of time.
BIOFILTRATION	The use of natural materials and vegetation to trap and remove pollutants from stormwater. Grass swales and constructed wetlands can be used for biofiltration.
CHANNEL	A natural or artificial waterway that periodically or continuously contains moving water. It has a definite bed and banks that confine the water.
CHANNEL EROSION	The widening, deepening, and headward cutting of small channels and waterways, due to erosion caused by moderate to larger floods.
CHEMICAL OXYGEN DEMAND (COD)	The quantity of maximum oxidizable matter in a sample.

COE	Army Corps of Engineers
CONTRIBUTING WATERSHED AREA	Portion of the watershed contributing its runoff to the site or BMP in question.
CONVEYANCE SYSTEM	The drainage facilities, both natural and human-made, which collect, contain, and provide for the flow of surface water and urban runoff from the highest points on the land down to a receiving water. The natural elements of the conveyance system include swales and small drainage courses, streams, rivers, lakes, and wetlands. The human-made elements of the conveyance system include gutters, ditches, pipes, channels, and most retention/detention facilities.
CWA	Clean Water Act
DEQ	Department of Environmental Quality, State of Idaho
DEBRIS	Any material, organic or inorganic, floating or submerged, moved by a flowing stream.
DESIGN STORM	A rainfall event of specified size and return frequency (e.g., a storm that occurs only once every 2 years) that is used to calculate the runoff volume and peak discharge rate to a BMP. Design storm information is presented in Appendix D of this Catalog.
DISCHARGE	Outflow; the flow of a stream, canal, or aquifer. One may also speak of the discharge of a canal or stream into a lake, river, or ocean. (Hydraulics) Rate of flow, specifically fluid flow; a volume of fluid passing a point per unit of time, commonly expressed as cubic feet per second, cubic meters per second, gallons per minute, gallons per day, or millions of gallons per day.
DISSOLVED OXYGEN (DO)	Oxygen which is present (dissolved) in water and available for use by fish and other aquatic animals. If the amount of dissolved oxygen in the water is too low, aquatic animals will suffocate.
DIVERSION	A channel, embankment, or other man-made structure constructed to divert water from one area to another (Soil Conservation Society of America, 1982).

DOWNSTREAM SCOUR	Downstream channel erosion usually associated with an upstream structure that has altered hydraulic conditions in the channel.
DRAINAGE BASIN OR SUBBASIN	See WATERSHED.
DRY-WEATHER FLOW	Flow occurring during the dry season (generally considered to be May through September) which may be associated with reservoir releases or releases of water from industrial or residential activities.
EPA	Environmental Protection Agency
EROSION	The wearing away of the land surface by running water, wind, ice, or other geological processes.
FLOODPLAIN	Any lowland that borders a stream and is inundated periodically by its waters.
FREQUENT FLOODING	A phenomenon in urban streams whereby the number of bankfull and sub-bankfull flood events increases sharply after the development. The frequency of these disruptive floods is a direct function of watershed imperviousness.
GRADING	The cutting and/or filling of the land surface to a desired slope or elevation.
GRAVEL	Sediment particles larger than sand and ranging from 2 to 64 mm (0.25 to 3 inches) in diameter.
GRAVITATIONAL SETTLING	The tendency of particulate matter to drop out of stormwater runoff as it flows downstream when runoff velocities are moderate and/or slopes are not too steep.
GROUNDWATER TABLE	The level below which the soil is saturated, that is, the pore spaces between the individual soil particles are filled with water. Above the groundwater table and below the ground surface, water in the soil does not fill all pore spaces.
HABITAT	A place where a biological organism lives. The organic and non-organic surroundings that provide life requirements such as food and shelter.
HEAVY METALS	Metals of relatively high atomic weight, including but not limited to chromium, copper, lead, mercury, nickel, and zinc. These metals are generally found in minimal quantities in stormwater, but can be highly toxic even at trace levels.

IDAPA	Idaho Administrative Procedures Act
IDWR	Idaho Department of Water Resources
IMPERVIOUS SURFACE	Material which resists or blocks the passage of water.
INFILTRATION	The penetration of water through the ground surface into subsurface soil or the penetration of water from the soil into sewer or other pipes through defective joints, connections, or manhole walls. The infiltration rate is expressed in terms of inches/hour. Infiltration rates will be slower when the soil is dense (e.g., clays) and faster when the soil is loosely compacted (e.g., sands). Can also refer to seepage of groundwater into sewer pipes through cracks and joints.
INLET	(1) A drainage passway. (2) A short, narrow waterway connecting a bay, lagoon, or similar body of water with a large parent body of water. (3) An arm of the sea (or other body of water) that is long compared to its width and may extend a considerable distance inland.
ITD	Idaho Transportation Department
NATURAL BUFFER	A low sloping area of maintained grassy or woody vegetation located between a pollutant source and a waterbody. A natural buffer is formed when a designated portion of a developed piece of land is left unaltered from its natural state during development. A natural vegetative buffer differs from a vegetated filter strip in that it is natural and in that they need not be used solely for water quality purposes. To be effective, such areas must be protected against concentrated flow.
NPDES	National Pollutant Discharge Elimination System
NUTRIENTS	Elements or substances, such as nitrogen or phosphorus, that are necessary for the growth and development of living things (e.g., plants). Large amounts of these substances reaching water bodies can lead to reduced water quality and eutrophication by promoting excessive aquatic algae growth. Some nutrients can be toxic at high concentrations.
OUTFALL	The point of discharge for a river, drain, pipe, etc.
PERMEABILITY	The quality of a soil horizon that enables water or air to move through it.

POLLUTANT	Generally, any substance introduced into the environment that adversely affects the usefulness of a resource.
POLLUTION	Impairment of water quality caused by man-made waste discharges or natural processes.
RIPARIAN	A relatively narrow strip of land that borders a stream or river, often coincides with the maximum water surface elevation of the one-hundred year storm.
RUNOFF	See "Stormwater Runoff."
RUNON	Off-site flow which flows onto a site.
SCOUR	Concentrated erosive action of flowing water in streams that removes material from the bed and banks.
SCS	Soil Conservation Service of the U.S. Department of Agriculture (USDA). Note: New name for this agency, as of 1996, is Natural Resources Conservation Service (NRCS).
SEDIMENT	The product of erosion processes; the solid material, both mineral and organic, that is in suspension, is being transported, or has been moved from its site of origin by air, water, gravity, or ice (USDA-SCS, 1991).
SEDIMENTATION	The process of sand and mud settling and building up on the bottom of a creek, river, lake, or wetland.
SEEPAGE	Water escaping through or emerging from the ground along an extensive line or surface as contrasted with a spring, where the water emerges from a localized spot (Soil Conservation Society of America, 1982).
SLOPE	The degree of deviation of a surface from horizontal, measured as a percentage, as a numerical ratio, or in degrees (Soil Conservation Society of America, 1982).
SOURCE CONTROL	A pollution control measure which operates by keeping pollutants from entering stormwater
STORM DRAIN (or STORM SEWER SYSTEM)	Above and below ground structures for transporting stormwater to streams or outfalls for flood control purposes.
STORMWATER RUNOFF	Excess precipitation that is not retained by vegetation, surface depressions, or infiltration, and thereby collects on the surface and drains into a surface water body.

STORMWATER SITE PLAN	A plan prepared during the project design phase to show the BMPs and techniques that will be used to control stormwater pollution during construction and after construction is complete. Appendix E provides a description of the recommended contents of a stormwater site plan.
STORMWATER TREATMENT	Detention, retention, filtering, or infiltration of a given volume of stormwater to remove urban pollutants and reduce frequent flooding.
STREAM BUFFER	A variable width strip of vegetated land adjacent to a stream that is preserved from development activity to protect water quality and aquatic and terrestrial habitats.
SUSPENDED SEDIMENT	The very fine soil particles that remain in suspension in water for a considerable period of time (Soil Conservation Society of America, 1982).
TOPOGRAPHY	The relative positions and elevations of the natural or man-made features of an area that describe the configuration of its surface (Soil Conservation Society of America, 1982).
TOTAL MAXIMUM DAILY LOAD (TMDL)	The sum of individual waste load allocations for point sources and load allocations for nonpoint sources and natural background. The Idaho Department of Environmental Quality has the authority to set TMDLs for water quality-limited bodies.
TOXIC	Related to or caused by a poison, hazardous waste, or toxin.
URBAN RUNOFF	Stormwater that passes through and out of developed areas to a stream or other body of water. (See Stormwater Runoff.)
USDA	United States Department of Agriculture.
VELOCITY	The distance that water travels in a given direction in a stream during an interval of time.
WATERSHED OR DRAINAGE BASIN	A geographic area within which all surface water drains into a particular body of water (e.g., a river or stream).
WET-WEATHER FLOW	Water derived primarily from rain, melting snow or irrigation during the wet season (generally considered to be October through April) that flows over the surface of the ground.

Appendix C – Data Needs Guidance

C.1 – Topography

Data Description

Topography is a crucial factor to consider in siting stormwater BMPs. Steep slopes in particular can eliminate the use of many BMPs and reduce the effectiveness of others. Some BMPs can only be utilized on essentially level terrain (e.g., sedimentation basins, detention and wet ponds, and constructed wetlands). In addition, steep slopes in combination with erosion-prone soils can contribute to high rates of erosion and sedimentation when soils are disturbed, as during new construction activities.

Sources of Information

Slope maps and contour maps (down to 2-foot intervals) can be produced from digital elevation models (DEMs) and/or 7.5 minute, U.S. Geologic Survey (USGS) topographic quadrangles. In cases where contour maps and slope maps have not yet been developed, they could be produced for the entire watershed in a fairly short time with GIS either through the IDEQ (208/373-0550) or Idaho Department of Lands (208/334-0277). If resources were not immediately available to produce these products, 7.5 minute, U.S. Geologic Survey (USGS) topographic quadrangles could be used. These maps have a contour interval of 20 feet, with 10 feet supplemental intervals in flatter areas.

USGS maps may not be accurate enough for sites with complicated drainage and/or steeper slopes. If slope and drainage are important, contours should be generated through a survey of the site, or aerial photography.

C.2 – SOIL TYPES

Description

Of primary concern are highly erodible soils, hydric (wetland) soils, soil depth, and the infiltrative capacity of soils. Highly erodible soils can create a wide range of problems for many types of development and construction. Problems include water quality degradation, fish and wildlife habitat impairment, instability for structures, and aesthetic impairment. Many restrictions exist limiting construction in wetland areas, and many stormwater BMPs are ineffective or impossible to implement in saturated soils. Soil infiltration capacity largely determines the effectiveness of stormwater BMPs (e.g., infiltration trenches and ponds). In glaciated terrain, soil depth can also be widely variable, and soils tend to be relatively underdeveloped and shallow.

Sources of Information

The USDA Natural Resource Conservation Service (NRCS) (formerly the Soil Conservation Service—SCS) has published soil surveys for many Idaho counties. These surveys are readily available from a local NRCS or Soil and Water Conservation District field office. The soil surveys contain general soil maps, soil descriptions, soil properties, and soil classifications. In addition, NRCS may publish a list of hydric soils in select, surveyed counties and include where hydric soils are most likely to occur, and whether all major components of a soil unit are hydric. Consult the local NRCS office for a list of highly erodible soils, including slope ratings.

NRCS also maintains a more-detailed soil database (SSURGO) than the generalized soil survey. "Soils erosion sensitivity" maps can be developed from this database if it has been digitized. In other cases, the U.S. Forest Service has developed "soil severity" ratings for soils in recently burned areas of a National Forest. For specific sites, soil borings and tests may be necessary to determine soil types and depth, especially in transitional landscape areas.

C.3 – Land Use and Land Ownership

Description

Land use information and zoning is essential to know before determining BMP placement. Often this information will already be known for a site where a stormwater BMP is being considered, since BMPs often accompany other development. Zoning requirements determine whether permits can be obtained to build structural BMPs. Land ownership is important to know when considering the implementation of BMPs to ensure all legal considerations are taken into account, access issues are resolved, and maintenance of BMPs is arranged. Availability of land for placement of large structural BMPs, e.g., detention facilities, must also be ascertained in some local situations. Consult the local permitting authority.

Sources of Information

Current and projected land use data and restrictions can be obtained from the municipality or county. To ensure proper compliance with current planning department regulations, the local planning departments should also be contacted. A county assessor's office generally has ownership records for specific sites, and the IDEQ (208/373-0115) has generalized ownership maps from various large-scale land owners (e.g., U.S. Forest Service, private timber, large agricultural operations, and others).

C.4 – CRITICAL AREAS AND VEGETATION

Description

Critical areas include wetlands, protected and endangered species habitat areas, and floodplains. Ground cover and vegetation can be an indication of critical areas, and can influence the ability to construct and implement stormwater BMPs.

Sources of Information

Wetlands have been mapped for the National Wetlands Inventory, and these maps are available at a local NRCS field office. The NRCS also has site-specific information or wetland delineations for some specific sites in particular counties, as do the local municipalities, and the Health District offices. Protected and endangered species information is available from the U.S. Fish and Wildlife Service or Idaho Fish and Game Department. Floodplain information can be obtained from the NRCS, cities, and counties. Ground cover and vegetation can be identified for large areas from aerial photos, or detailed vegetation surveys can be conducted for specific sites.

C.5 – Culturally Significant Sites

Description

Culturally significant sites include Native American tribal sites, archaeological digs, and historic buildings and areas designated in the National Historic Register built since the arrival of European descendants. Cultural sites must be identified and protected during construction, and if cultural relics are found during construction, construction must cease immediately until the relics can be protected, and the extent of the archaeological find and its significance can be determined.

Sources of Information

- The state archaeologist office (208/334-3847) is a good source of information regarding archaeological sites.
- The Historic Preservation Office (208/334-3861) is an excellent

source of information for historical structures and sites.

C.6 - UTILITIES AND INFRASTRUCTURE

Description

Utilities and infrastructure that can influence construction of BMPs include wastewater, water, gas, electricity, telephone, and transportation (roads, railroads, airports). At the least, utilities must be located before digging. Construction near infrastructure must be coordinated with future infrastructure development plans and easements.

Sources of Information

- Local building/public works/planning department
- Local sewer and water districts
- Domestic water suppliers
- Local transportation provider
- Idaho Transportation Department (208) 334-8000
- Utility company: Idaho Power (800) 672-4455
- Utility locator services
- Telephone Company

C.7 – Water Resources

Description

The following water resources greatly influence the ability to construct and implement BMPs: hydrography of tributaries and lakes/reservoirs, groundwater levels/water table depth, well locations, irrigation diversions and canals.

Sources of Information

- IDEQ or US Geological Survey 7.5 minute quadrangles for hydrography
- Idaho Department of Water Resources (208/327-7900) for groundwater/water table or location nearest monitoring wells or test holes, well locations; and irrigation diversions and canals.
- Irrigation Districts for irrigation diversions and canals

C.8 - BOUNDARIES

Description

Watershed boundaries should be ascertained to determine which immediate receiving water body will be affected by the BMPs under consideration, and to be aware of and work in coordination with other activities within the watershed. Political, irrigation district, water district, and sewer district boundaries should be known for legal reasons, and to coordinate BMP activities with the neighboring entities.

Sources of Information

All boundaries listed exist on IDEQ's Geographical Information System (208/373-0119), or contact the individual districts, sewer district, or water district.

C.9 – Other Flood Reduction and Water Quality Improvement Projects

Description

Other water quality related projects could be "leveraged" to obtain greater water quality benefits than stand-alone stormwater BMPs. Coordination of adjacent projects would likely yield greater water quality benefits.

Sources of Information

- Flood control districts
- Water quality: IDEQ (208/373-0502)

APPENDIX D
GENERAL GUIDANCE FOR HYDROLOGIC/HYDRAULIC DESIGN

APPENDIX D: General Guidance for Hydrologic/Hydraulic Design

Local issues and concerns will dictate the regulatory requirements for flood control, peak discharge and water quality management, which should be considered in the selection and design of Best Management Practices (BMPs). Many jurisdictions have requirements for control of the rate of discharge (or peak runoff rate) from new or redevelopment to control increased flooding, channel protection or water quality. This control is usually accomplished by detention of the flow, discharging at a controlled release rate. Other performance goals and objectives may include specific pollutant guidelines, water quality control, multi-parameter controls, including groundwater recharge and channel protection; and habitat protection strategies.

Stormwater runoff control requirements are expressed differently. Requirements for flood control address peak discharges to a predevelopment level in order to control increased flooding or channel protection and are usually expressed as a design storm event for one or more design storms. Nationally, the two most frequently used storms are the 2- and 10-yr storms (EPA, 2004).

One of two criteria is typically used for water quality control: 1) a specified runoff depth and/or 2) a percent removal rate. Typically the runoff depth required is either ½ or one inch. With respect to the percent removal requirement, the most frequently used requirement nationally is 80% removal of suspended solids (Ibid).

Selection of a return period for the design storm is generally the purview of the local regulatory authority and may correspond to controlling discharge or runoff volume. In general, the return periods selected are based on a perception that controlling the design storm will result in some intended benefit such as flood control, control of downstream damage to stream geomorphology and water quality. Examples are given in Table D-1.

Design for Flood Control Facilities

Local design standards for sizing stormwater facilities for flood control should be used if they exist. The most commonly used method for sizing facilities to control flooding is to compare pre-development runoff with projected post-development runoff. The developer is then responsible for the difference. For example, a new subdivision of single-family residential ½-acre lots is to be created from an existing ranch. Modeling shows that the estimated peak flow from the ranch during a 10-year storm is 40 cfs. After development, the projected flow will be 320 cfs. The developer is responsible for the additional 280 cfs. He may provide on-site detention of adequate volume to maintain the peak flow at the existing 40 cfs. He may contribute in-lieu of fees towards a regional detention facility, which would decrease flows from his development and adjacent ones. Or he may help pay for the increased culvert sizes and ditches necessary to carry the excess flow. If the latter is followed, he will also need to evaluate the impact of these flows downstream and get permission from the downstream property owners affected by the increased flows and the affected jurisdictions.

Table D-1. Design Storm Frequencies and Assumed Benefits (EPA, 2004)

Design Storm	Assumed Benefits	Comments
½ - 1 in. rainfall	Intended to capture 70-80% of annual runoff volume in an attempt to improve water quality.	Used by many municipalities. Some studies have shown that capturing the first ½ in. will control 70% of the annual runoff.
1-in. rainfall	Intended to capture 90% of annual runoff volume in an attempt to improve water quality.	Replacing ½ in. as basis for water quality control. Some studies have shown that capturing the first 1 in. of runoff will control 90% of the annual runoff.
1-yr	Intended to capture sufficient runoff volume to improve water quality and provide down stream channel protection.	Used by some municipalities for water quality management and is based on the supposition that the channel-forming event is the annual storm.
2-yr	Intended to provide protection from accelerated channel erosion and for habitat protection.	Used by many municipalities. Limited field monitoring indicates that the strategy is flawed, as increased volume in post-development runoff results in pond discharges at flow rates near the peak discharge for much longer times than in the predevelopment state. This results in more erosion over the storm duration which subsequently result in wider and deeper channels than in the predevelopment state, even though the peak flow rates for pre- and post-development are equal.
10-yr	Intended to provide flood protection from intermediate sized storm events by matching post-disturbed peaks to pre-disturbed peaks.	When used for on-site detention, flood control benefits are provided primarily to local areas with limited protection of larger downstream channels. In some cases there is increased potential for downstream flooding due to timing of runoff events.
100-yr	Used for flood control protection from major storms; also used to maintain 100-yr floodplain limits.	When used for on-site detention, flood control benefits are provided primarily to local areas with limited protection of larger downstream channels. In some cases there is increased potential for downstream flooding due to timing of runoff events.

Design for Water Quality Facilities

The tendency for solids and associated constituents to be washed off of paved areas during the initial portion of the storm event is referred to as the first flush. In general, the potential for first flush is determined by the storm characteristics, the size of the subwatershed and the partitioning characteristics of the pollutants of concern. Nationally, many jurisdictions specify a treatment volume that is designed to capture the first flush component of the stormwater runoff. In practice, this is achieved by specifying a rainfall amount (such as the first ½-inch, 1-inch or other rainfall depth over impervious areas) or the capture of a stormwater runoff volume that correlates to a design storm (such as the 6-month, 1-yr or 2-yr frequency storm. Ideally, several decades of storm volume and intensity information for a given county would be analyzed to determine rainfall volumes for the various design storms. The Idaho Transportation Department has done that analysis, but only for 2-year storms and larger.

The second water quality control approach is to require that a specified amount of the pollutant(s) of concern be removed from the stormwater runoff before it is discharged from the point of compliance. The reduction is commonly specified as a percentage reduction of the pollutant(s) of concern, and the compliance point will usually be the municipal separate storm sewer system (MS4) or final stormwater discharge location in the watershed. An example is the federal coastal zone guidance that specifies that urban runoff from a new and stabilized development site have 80% of the suspended solids removed before it is discharged from the site. Implementing the pollution reduction strategy requires knowledge of the pre-construction and post-development average mass of pollutant(s). The strategy is generally considered to be effective if the regulating municipality selects an achievable pollutant reduction, and ensures that the stormwater controls are properly selected, designed, constructed, operated and maintained.

Estimating Runoff During Snowmelt

Most stormwater facilities are designed for design storms that are usually assumed to consist of precipitation entirely in the form of rain. In most parts of the country the largest storms are intense summer thunderstorms. In the Pacific Northwest the largest rainfall volumes occur in less intense, but prolonged winter storms. A different type of event that often contributes to flooding is snowmelt, especially in conjunction with a rainstorm. One characteristic that makes snowmelt so damaging is that the heavy flows are not lessened by absorption into ground that is saturated and frozen. Due to the significant amount of water tied up in the snowpack, snowmelt can cause significant capacity and erosion problems. This problem is worsened if a significant rain event occurs during the melt when the ground is still frozen.

Three factors must be considered to arrive at an estimate of flows occurring during snowmelt. First, the storm should be derived from the Intensity/Duration/Frequency curves in the same manner as the regular design storm. Since the IDF curves represent the greatest intensity expected during a given time period and since this usually occurs during summer thunderstorms, assuming that this storm intensity occurs during snowmelt is being quite conservative.

Second, the CN number should be adjusted. The CN numbers given for the various land uses in the tables in this appendix is for an antecedent moisture condition of II. An AMC of II is defined as average conditions. The following table should be used to convert these AMC II numbers to those of AMC III. AMC III is defined as heavy rainfall, or light rainfall and low temperatures occurring within the last five days, leading to saturated soils.

Third, the water contributed from the snowmelt itself needs to be computed. The Degree-Day Method outlined in the HEC-1 model developed by the Army Corps of Engineers is recommended for making this estimate.

The Degree-Day Method is based on the following equation:

SNWMT = COEF (TMPR – FRZTP)

Where SNWMT is the melt in inches per day,
TMPR is the air temperature in degrees F,
FRZTP is the temperature in degrees F at which snow melts, and
COEF is the melt coefficient in inches per degree-day, usually about 0.07.

Assuming the worst conditions. a sudden thaw of 40 degrees, the snowmelt = 0.07 (40-32) or 0.56 inches/day. This should be added to the rainfall from the storm and used in conjunction with the increased CN read from the following table.

Calculating Peak Discharge Rates and Volumes

The following sections contain basic steps to be taken in order to calculate the peak discharge rates from pre- and post-development conditions and the volume of stormwater that must be retained onsite to control for peak discharge rates from specified storms. Two formulas are presented: The Natural Resources Conservation Service (NRCS) TR-55 Method and the Rational Method. Other hydrologic methods may be accepted for determination of runoff rate and volume. However the design professional should obtain approval from the approving jurisdiction prior to beginning hydrology studies for the project if an alternate hydrologic method is selected.

The Rational Method should only be used for projects that are less than 100 acres in size. The NRCS TR-55 can be used for projects greater than 100 acres in size. Consult the local permitting authority to determine whether there are additional requirements or preferred alternatives for sizing storm designs. Local design standards should be used if they exist.

Rational Method

The rational method is a method for computing peak runoff rates for flow based runoff treatment BMPs such as biofiltration swales and oil-water separators. It is also a common method for computing the peak runoff rate for design of infiltration trenches and conveyance systems. The greatest accuracy is obtained for areas smaller than 100 acres and for developed conditions with large areas of impervious surface (e.g., pavement, roof tops).

Procedure: Design peak runoff rates may be determined by the Rational formula:

$Q_p = CIA$

A = site area (acres)
C = dimensionless runoff coefficient
T_c = time of concentration
I = average rainfall intensity (in/hr) for a duration equal to the time of concentration and for the recurrence interval chosen for design
Q_p = peak discharge

1. Calculate the site area (A).

Use USGS topographic maps, site visits, and other available information.

2. Determine the runoff coefficient C.

This value is obtained from Tables 1 and 2 based on pre-development and post-development conditions. For mixed surfaces, determine a weighted coefficient using the following formula:
C = [(C1 * A1) + (C2 * A2) . . . + (Cn * An)]/A

3. Calculate the time of concentration in minutes (Tc).

The time of concentration, (in/hr), over a duration equal to the time of concentration for the contributing area can be estimated using the surface flow time curve (Figure 1).

4. Determine the average rainfall intensity (i).

This value is obtained from the intensity-duration-frequency curves included based on the time of concentration (Tc) from step 3.

5. Calculate the peak discharge (Qp).

Q_p = (C) * (i) * (A)
Calculate both pre-development and post-development Q_p.
Steps to Calculate Onsite Storage Volumes for Control of Peak Discharge Rates

V_r = volume of runoff
C = dimensionless runoff coefficient
I = average rainfall intensity
T = storm duration
A = contributing area to site (acres)

6. Calculate the contributing drainage area (A).

Use value from step 1 above.

7. Determine the average rainfall intensity (i).

For the 50-year event, use 1 inch/hour. For the 100-year event, I minimum is 1.1 inches/hour.

8. Determine the storm duration (T).

For this value, use one hour.

9. Determine the runoff coefficient (C).

Use value from step 2 above.

10. Calculate the volume of runoff (V).

$V_r = C * (i) * T * A$

Table 1. Recommended "C" coefficients (Modified for ASCE (1972) and the Southeastern Wisconsin Regional Planning Commission)

Description of Runoff Area	Runoff Coefficients "C"
Business	
Central business areas	0.70-0.95
District and local areas	0.50-0.70
Residential	
Single-family	0.35-0.45
Multi-family, detached	0.40-0.60
Multi-family, attached	0.60-0.75
Residential .5 acre lots or larger	0.25-0.40
Industrial and Commercial Light areas Heavy areas	0.50-0.80
Parks, cemeteries	0.10-0.25
Playgrounds	0.20-0.35
Unimproved areas	0.10-0.30
Landscaped areas	0.20
Streets (Asphalt, Concrete), Drives and Walks, Roofs	0.90-0.95

Table 2. Pervious Surface Coefficients

	Runoff Coefficient			
Slope	A soils	B soils	C soils	D soil
Flat 0-2%	0.04	0.07	0.11	0.15
Average 2-6%	0.09	0.12	0.15	0.20
Steep >6%	0.13	0.18	0.23	0.28

<u>NRCS TR-55 Method</u>

The TR-55 Method is a single event hydrograph method for designing flow control BMPs. It can also be used for computing peak runoff rates and runoff volumes for design of runoff treatment BMPs.

The following sections are taken from the TR55 Manual published by the SCS in 1986. The use of the excerpts is to assist and provide general guidance for sizing stormwater volumes and peak flows for stormwater BMP design.

Reference

U.S. Environmental Protection Agency, September 2004. Stormwater Best Management Practice Design Guide: Volume 1 General Considerations. Office of Research and Development, Washington DC, EPA/600/R-04/121.

Table for Converting AMC II to AMC III.

CN for condition II	CN for condition III	CN for condition II	CN for condition III
100	100	62	79
99	100	61	78
98	99	60	78
97	99	59	77
96	99	58	76
95	98	57	75
94	98	56	75
93	98	55	74
92	97	54	73
91	97	53	72
90	96	52	71
89	96	51	70
88	95	50	70
87	95	49	69
86	94	48	68
85	94	47	67
84	93	46	66
83	93	45	65
82	92	44	64
81	92	43	63
80	91	42	62
79	91	41	61
78	90	40	60
77	89	39	59
76	89	38	58
75	88	37	57
74	88	36	56
73	87	35	55
72	86	34	54
71	86	33	53
70	85	32	52
69	84	31	51
68	84	30	50
67	83	25	43
66	82	20	37
65	82	15	30
64	81	10	22
63	80	5	13

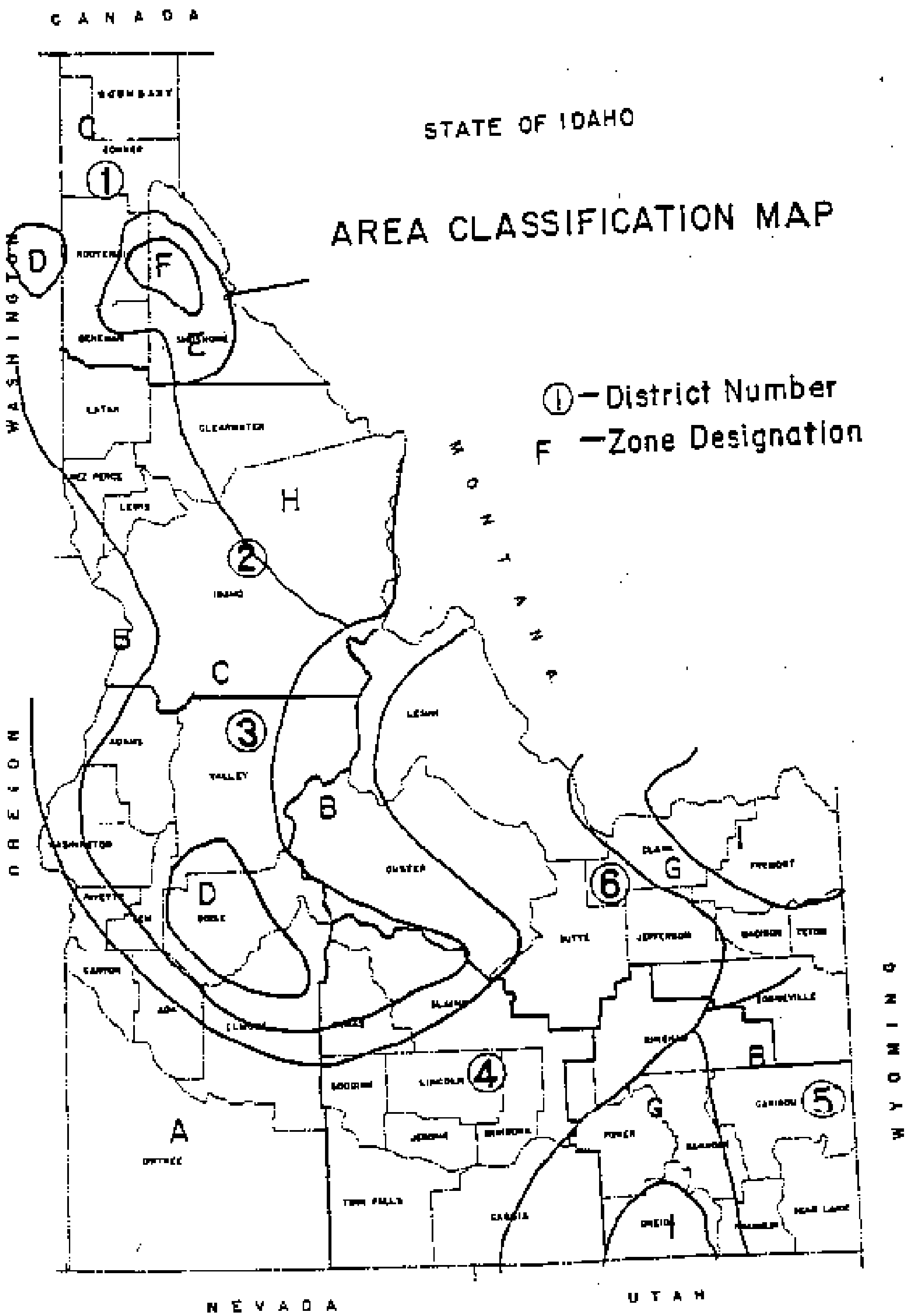
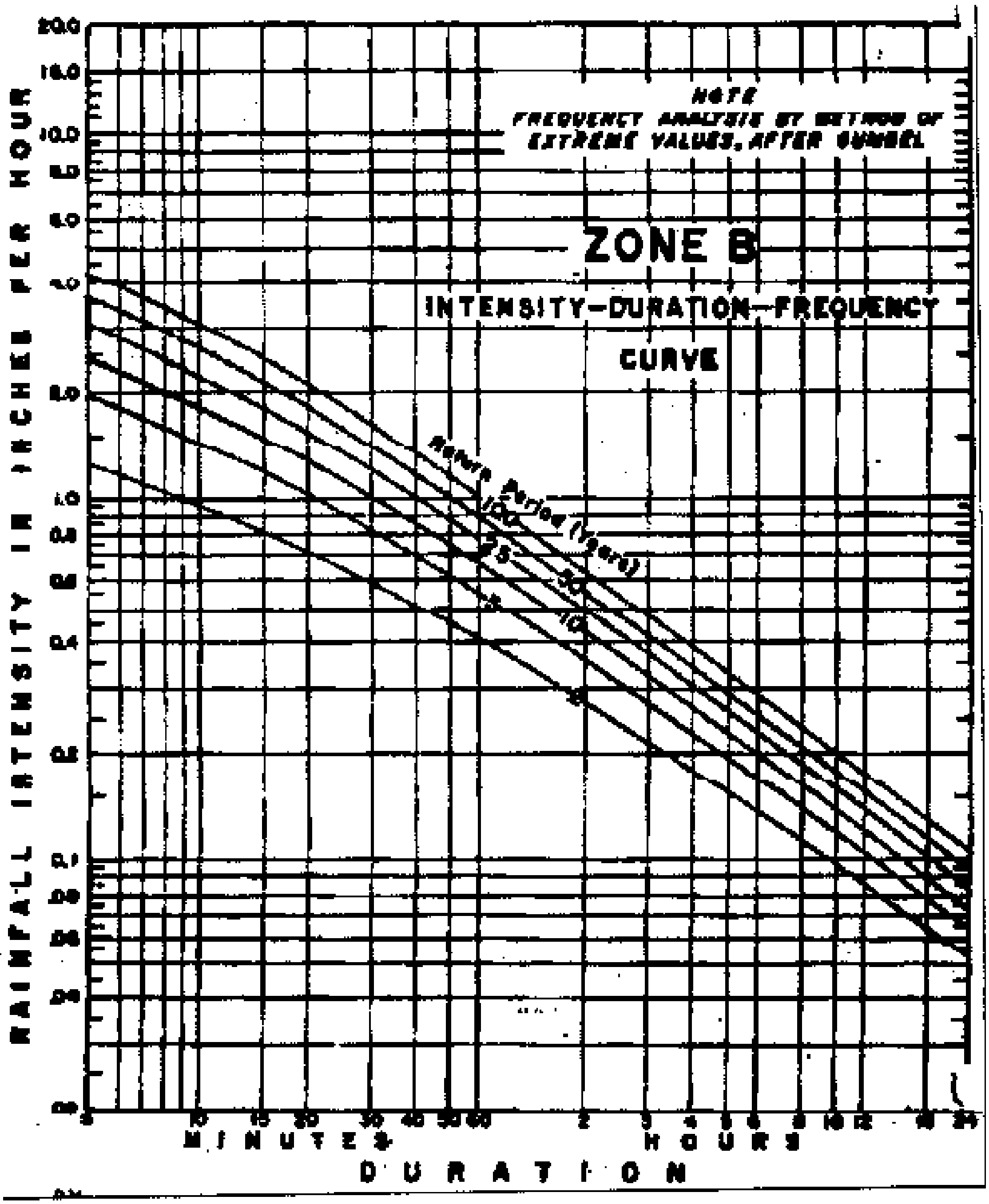
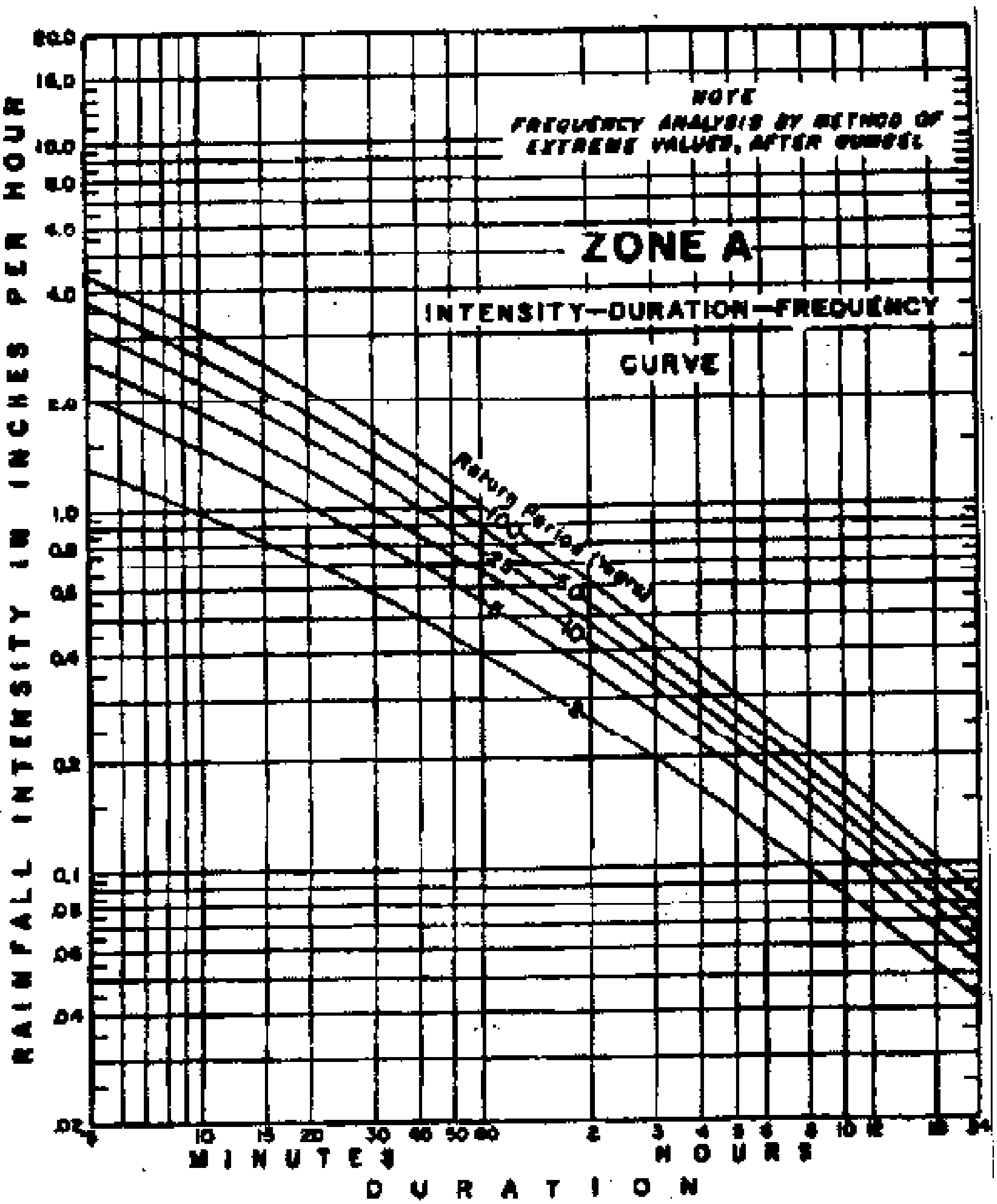


Figure D-1. State of Idaho Area Classification Map

FIGURES D-2

INTENSITY/DURATION/FREQUENCY CURVES FOR JTD ZONES


NOTE
FREQUENCY ANALYSIS BY METHOD OF EXTREME VALUES, AFTER GUMBEL
ZONE B
INTENSITY—DURATION—FREQUENCY
CURVE
Return Period (Years)
100
50
25
10
5
2
RAINFALL INTENSITY IN INCHES PER HOUR
20.0
10.0
8.0
6.0
4.0
2.0
1.0
0.8
0.6
0.4
0.2
0.1
.08
.06
.04
5
10
15
20
30
40
50
60
2
3
4
5
6
8
10
12
18
24
MINUTES
HOURS
DURATION



NOTE
FREQUENCY ANALYSIS BY METHOD OF EXTREME VALUES, AFTER GUMBEL
ZONE A
INTENSITY—DURATION—FREQUENCY
CURVE
Return Period (Years)
100
50
25
10
5
2
RAINFALL INTENSITY IN INCHES PER HOUR
20.0
16.0
10.0
8.0
6.0
4.0
2.0
1.0
0.8
0.6
0.4
0.2
0.1
.08
.06
.04
.02
5
10
15
20
30
40
50
60
2
3
4
5
6
8
10
12
18
24
MINUTES
HOURS
DURATION

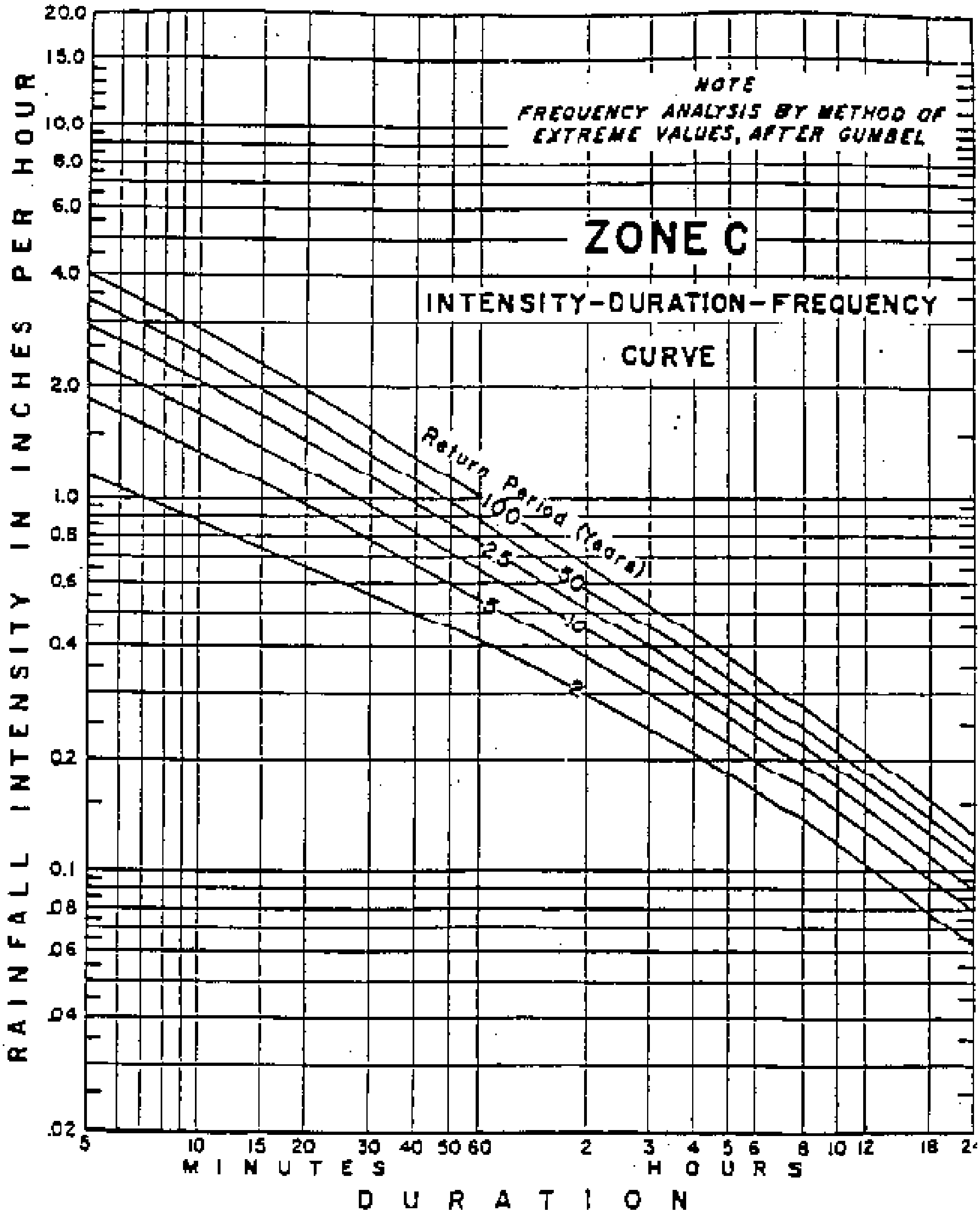
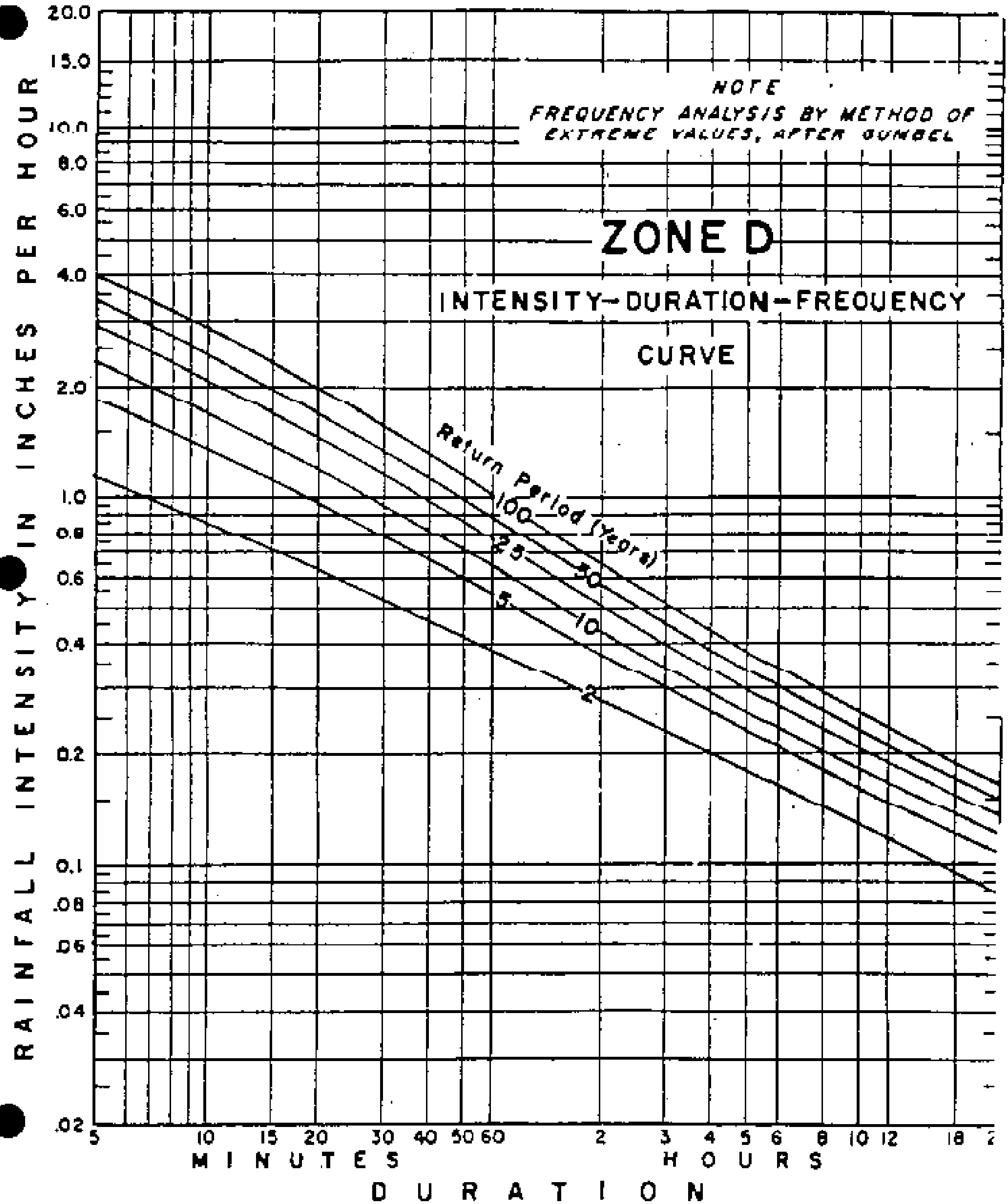
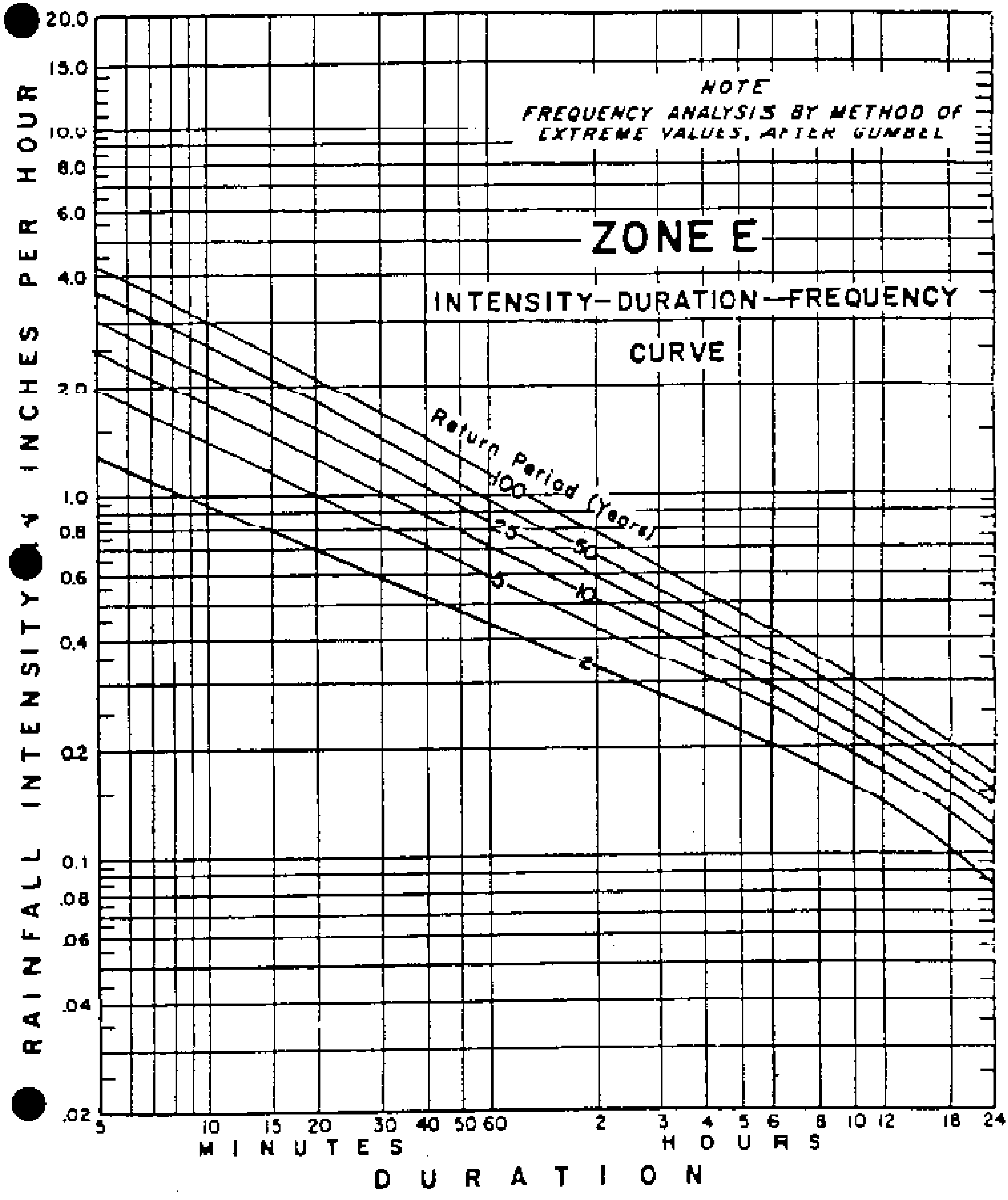


Figure D-2. Zone C Intensity-Duration-Frequency (IDF) Curve

ZONE D, INTENSITY-DURATION-FREQUENCY CURVE
(IDAHO TRANSPORTATION DEPARTMENT)

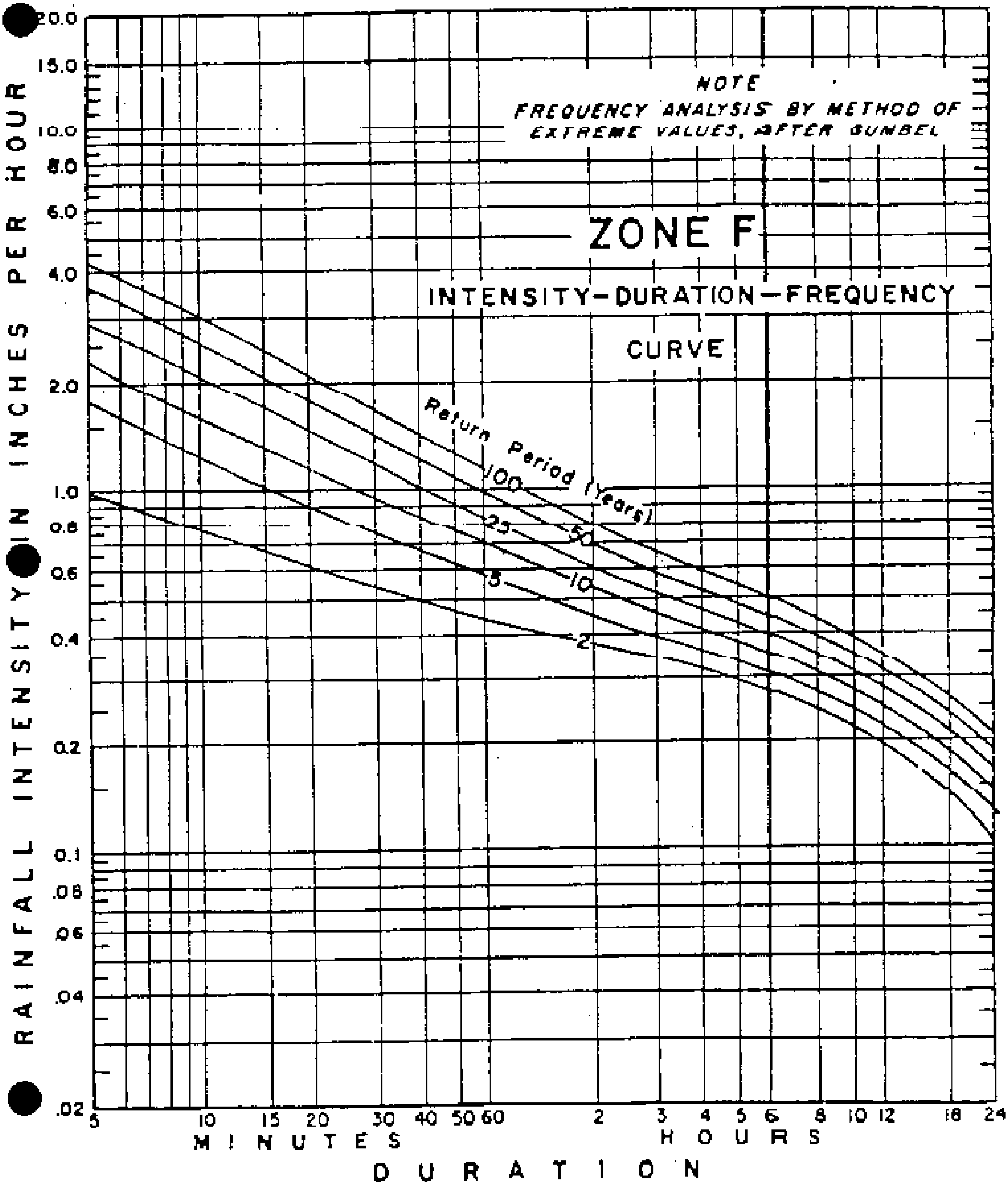


ZONE E, INTENSITY-DURATION-FREQUENCY CURVE
(IDAHO TRANSPORTATION DEPARTMENT)



ZONE F, INTENSITY-DURATION-FREQUENCY CURVE

(IDAHO TRANSPORTATION DEPARTMENT)



Calculating Storm Water Volumes and Peak Flows

The following is an excerpt from the TR55 manual published by the Soil Conservation Service (now called the Natural Resources Conservation Service) in 1986. The procedures can be used for calculating stormwater runoff volumes and peak flows for BMP design.

Chapter 2: Estimating runoff

SCS Runoff Curve Number method

The SCS Runoff Curve Number (CN) method is described in detail in NEH-4 (SCS 1985). The SCS runoff equation is

$$Q = \frac{(P - I_a)^2}{(P - I_a) + S} \qquad \text{[Eq. 2-1]}$$

where

Q = runoff (in),
P = rainfall (in),
S = potential maximum retention after runoff begins (in), and
I_a = initial abstraction (in).

Initial abstraction (I_a) is all losses before runoff begins. It includes water retained in surface depressions, water intercepted by vegetation, evaporation, and infiltration. I_a is highly variable but generally is correlated with soil and cover parameters. Through studies of many small agricultural watersheds, I_a was found to be approximated by the following empirical equation:

$$I_a = 0.2S. \qquad \text{[Eq. 2-2]}$$

By removing I_a as an independent parameter, this approximation allows use of a combination of S and P to produce a unique runoff amount. Substituting equation 2-2 into equation 2-1 gives

$$Q = \frac{(P - 0.2S)^2}{(P + 0.8S)} \qquad \text{[Eq. 2-3]}$$

S is related to the soil and cover conditions of the watershed through the CN. CN has a range of 0 to 100, and S is related to CN by

$$S = \frac{1000}{CN} - 10. \qquad \text{[Eq. 2-4]}$$

Figure 2-1 and table 2-1 solve equations 2-3 and 2-4 for a range of CN's and rainfall.

Factors considered in determining runoff curve numbers

The major factors that determine CN are the hydrologic soil group (HSG), cover type, treatment, hydrologic condition, and antecedent runoff condition (ARC). Another factor considered is whether impervious areas outlet directly to the drainage system (connected) or whether the flow spreads over pervious areas before entering the drainage system (unconnected). Figure 2-2 is provided to aid in selecting the appropriate figure or table for determining curve numbers.

CN's in table 2-2 (*a* to *d*) represent average antecedent runoff condition for urban, cultivated agricultural, other agricultural, and arid and semiarid rangeland uses. Table 2-2 assumes impervious areas are directly connected. The following sections explain how to determine CN's and how to modify them for urban conditions.

Hydrologic soil groups

Infiltration rates of soils vary widely and are affected by subsurface permeability as well as surface intake rates. Soils are classified into four HSG's (A, B, C, and D) according to their minimum infiltration rate, which is obtained for bare soil after prolonged wetting. Appendix A defines the four groups and provides a list of most of the soils in the United States and their group classification. The soils in the area of interest may be identified from a soil survey report, which can be obtained from local SCS offices or soil and water conservation district offices.

Most urban areas are only partially covered by impervious surfaces: the soil remains an important factor in runoff estimates. Urbanization has a greater effect on runoff in watersheds with soils having high infiltration rates (sands and gravels) than in watersheds predominantly of silts and clays, which generally have low infiltration rates.

Any disturbance of a soil profile can significantly change its infiltration characteristics. With urbanization, native soil profiles may be mixed or removed or fill material from other areas may be introduced. Therefore, a method based on soil

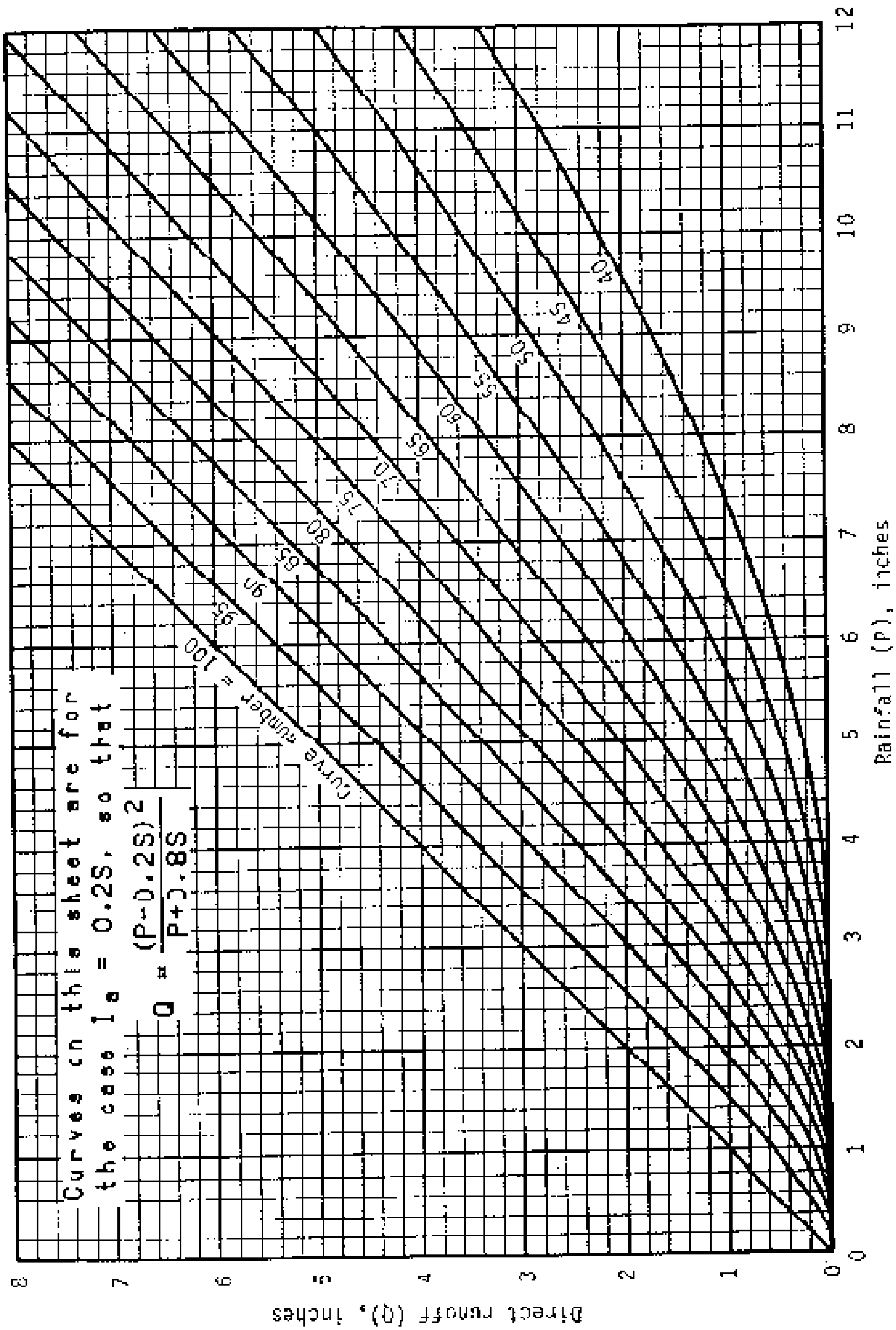


Figure 2-1.—Solution of runoff equation.

texture is given in appendix A for determining the HSG classification for disturbed soils.

Cover type

Table 2-2 addresses most cover types, such as vegetation, bare soil, and impervious surfaces. There are a number of methods for determining cover type. The most common are field reconnaissance, aerial photographs, and land use maps.

Treatment

Treatment is a cover type modifier (used only in table 2-2b) to describe the management of cultivated agricultural lands. It includes mechanical practices, such as contouring and terracing, and management practices, such as crop rotations and reduced or no tillage.

Hydrologic condition

Hydrologic condition indicates the effects of cover type and treatment on infiltration and runoff and is generally estimated from density of plant and residue cover on sample areas. *Good* hydrologic condition indicates that the soil usually has a low runoff potential for that specific hydrologic soil group, cover type, and treatment. Some factors to consider in estimating the effect of cover on infiltration and runoff are (a) canopy or density of lawns, crops, or other vegetative areas; (b) amount of year-round cover; (c) amount of grass or close-seeded legumes in rotations; (d) percent of residue cover; and (e) degree of surface roughness.

Table 2-1.—Runoff depth for selected CN's and rainfall amounts[1]

Rainfall	Runoff depth for curve number of—												
	40	45	50	55	60	65	70	75	80	85	90	95	98
	inches												
1.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.08	0.17	0.32	0.56	0.79
1.2	.00	.00	.00	.00	.00	.00	.03	.07	.15	.27	.46	.74	.99
1.4	.00	.00	.00	.00	.00	.02	.06	.13	.24	.39	.61	.92	1.18
1.6	.00	.00	.00	.00	.01	.05	.11	.20	.34	.52	.76	1.11	1.38
1.8	.00	.00	.00	.00	.03	.09	.17	.29	.44	.65	.93	1.29	1.58
2.0	.00	.00	.00	.02	.06	.14	.24	.38	.56	.80	1.09	1.48	1.77
2.5	.00	.00	.02	.08	.17	.30	.46	.65	.89	1.18	1.53	1.96	2.27
3.0	.00	.02	.09	.19	.33	.51	.71	.96	1.25	1.59	1.98	2.45	2.77
3.5	.02	.08	.20	.35	.53	.75	1.01	1.30	1.64	2.02	2.45	2.94	3.27
4.0	.06	.18	.33	.53	.76	1.03	1.33	1.67	2.04	2.46	2.92	3.43	3.77
4.5	.14	.30	.50	.74	1.02	1.33	1.67	2.05	2.46	2.91	3.40	3.92	4.26
5.0	.24	.44	.69	.98	1.30	1.65	2.04	2.45	2.89	3.37	3.88	4.42	4.76
6.0	.56	.90	1.14	1.52	1.92	2.35	2.81	3.28	3.78	4.30	4.85	5.41	5.76
7.0	.84	1.24	1.68	2.12	2.60	3.10	3.62	4.15	4.69	5.25	5.82	6.41	6.76
8.0	1.25	1.74	2.25	2.78	3.33	3.89	4.46	5.04	5.63	6.21	6.81	7.40	7.76
9.0	1.71	2.29	2.88	3.49	4.10	4.72	5.33	5.95	6.57	7.18	7.79	8.40	8.76
10.0	2.23	2.89	3.56	4.23	4.90	5.56	6.22	6.88	7.52	8.16	8.78	9.40	9.76
11.0	2.78	3.52	4.26	5.00	5.72	6.43	7.13	7.81	8.48	9.13	9.77	10.39	10.76
12.0	3.38	4.19	5.00	5.79	6.56	7.32	8.05	8.76	9.45	10.11	10.76	11.39	11.76
13.0	4.00	4.89	5.76	6.61	7.42	8.21	8.98	9.73	10.42	11.10	11.76	12.39	12.76
14.0	4.65	5.62	6.55	7.44	8.30	9.12	9.91	10.67	11.39	12.08	12.75	13.39	13.76
15.0	5.33	6.36	7.35	8.29	9.19	10.04	10.85	11.63	12.37	13.07	13.74	14.39	14.76

[1]Interpolate the values shown to obtain runoff depths for CN's or rainfall amounts not shown.

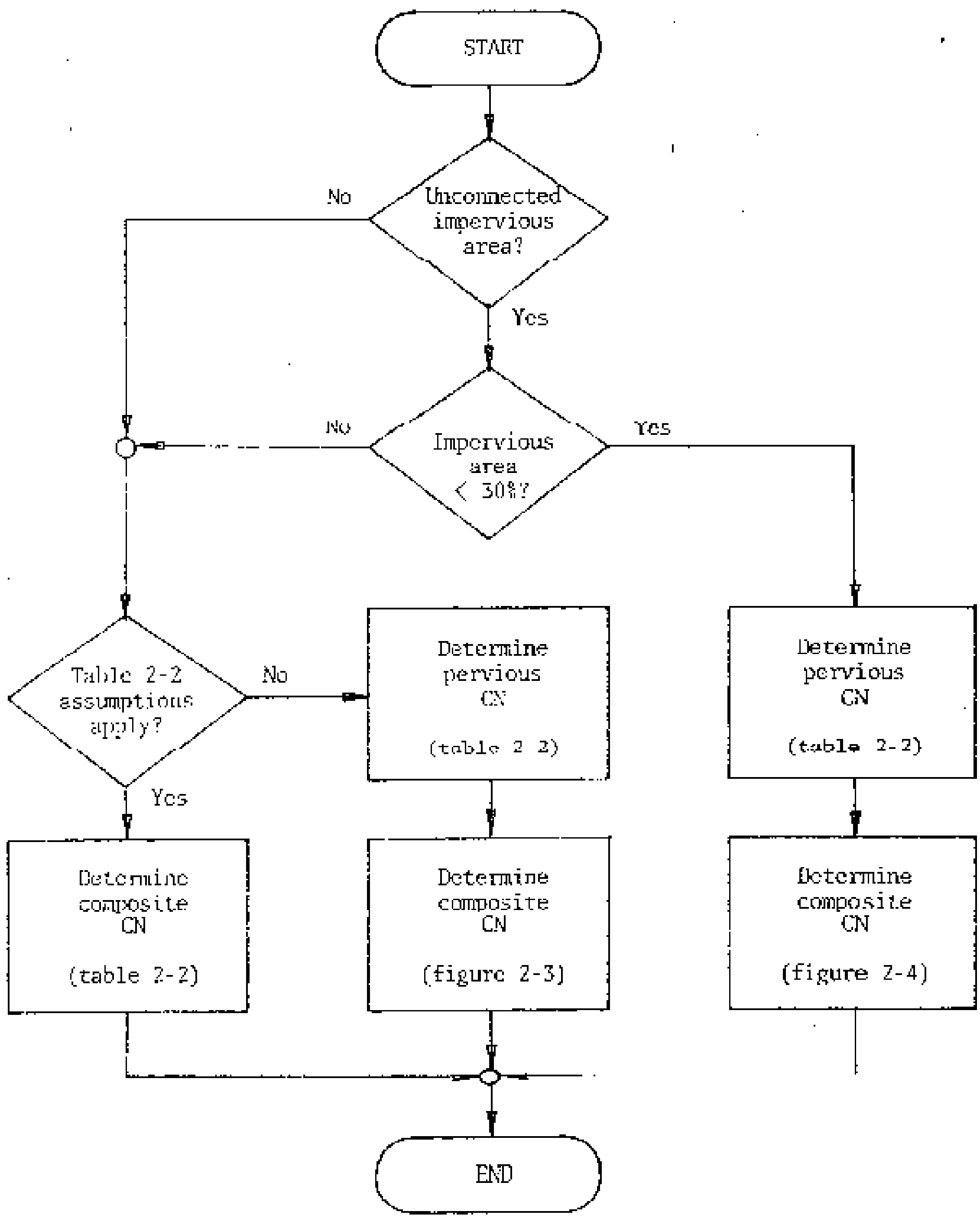


Figure 2-2.—Flow chart for selecting the appropriate figure or table for determining runoff curve numbers.

Table 2-2a.—Runoff curve numbers for urban areas[1]

Cover description		Curve numbers for hydrologic soil group—			
Cover type and hydrologic condition	Average percent impervious area[2]	A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.)[3]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right of way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only)[4]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation)[5]		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

[1]Average runoff condition, and $I_a = 0.2S$.
[2]The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using figure 2-3 or 2-4.
[3]CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.
[4]Composite CN's for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.
[5]Composite CN's to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4, based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

Table 2-2b.—Runoff curve numbers for cultivated agricultural lands[1]

Cover description			Curve numbers for hydrologic soil group—			
Cover type	Treatment[2]	Hydrologic condition[3]	A	B	C	D
Fallow	Bare soil	—	77	86	91	94
	Crop residue cover (CR)	Poor	76	85	90	93
		Good	74	83	88	90
Row crops	Straight row (SR)	Poor	72	81	88	91
		Good	67	78	85	89
	SR + CR	Poor	71	80	87	90
		Good	64	75	82	85
	Contoured (C)	Poor	70	79	84	88
		Good	65	75	82	86
	C + CR	Poor	69	78	83	87
		Good	64	74	81	85
	Contoured & terraced (C&T)	Poor	66	74	80	82
		Good	62	71	78	81
	C&T + CR	Poor	65	73	79	81
		Good	61	70	77	80
Small grain	SR	Poor	65	76	84	88
		Good	63	75	83	87
	SR + CR	Poor	64	75	83	86
		Good	60	72	80	84
	C	Poor	63	74	82	85
		Good	61	73	81	84
	C + CR	Poor	62	73	81	84
		Good	60	72	80	83
	C&T	Poor	61	72	79	82
		Good	59	70	78	81
	C&T + CR	Poor	60	71	78	81
		Good	58	69	77	80
Close-seeded or broadcast legumes or rotation meadow	SR	Poor	66	77	85	89
		Good	58	72	81	85
	C	Poor	64	75	83	85
		Good	55	69	78	83
	C&T	Poor	63	73	80	83
		Good	51	67	76	80

[1]Average runoff condition, and $I_a = 0.2S$.
[2]*Crop residue cover* applies only if residue is on at least 5% of the surface throughout the year.
[3]Hydrologic condition is based on combination of factors that affect infiltration and runoff, including (a) density and canopy of vegetative areas, (b) amount of year-round cover, (c) amount of grass or close-seeded legumes in rotations, (d) percent of residue cover on the land surface (good $\geq$ 20%), and (e) degree of surface roughness.
Poor: Factors impair infiltration and tend to increase runoff.
Good: Factors encourage average and better than average infiltration and tend to decrease runoff.

Table 2-2c.—Runoff curve numbers for other agricultural lands[1]

Cover description		Curve numbers for hydrologic soil group—			
Cover type	Hydrologic condition	A	B	C	D
Pasture, grassland, or range—continuous forage for grazing.[2]	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow—continuous grass, protected from grazing and generally mowed for hay.	—	30	58	71	78
Brush—brush-weed-grass mixture with brush the major element.[3]	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	[4]30	48	65	73
Woods—grass combination (orchard or tree farm).[5]	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods.[6]	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	[4]30	55	70	77
Farmsteads—buildings, lanes, driveways, and surrounding lots.	—	59	74	82	86

[1]Average runoff condition, and $I_a = 0.2S$.

[2]*Poor:* <50% ground cover or heavily grazed with no mulch.
Fair: 50 to 75% ground cover and not heavily grazed.
Good: >75% ground cover and lightly or only occasionally grazed.

[3]*Poor:* <50% ground cover.
Fair: 50 to 75% ground cover.
Good: >75% ground cover.

[4]Actual curve number is less than 30; use CN = 30 for runoff computations.

[5]CN's shown were computed for areas with 50% woods and 50% grass (pasture) cover. Other combinations of conditions may be computed from the CN's for woods and pasture.

[6]*Poor:* Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.
Fair: Woods are grazed but not burned, and some forest litter covers the soil.
Good: Woods are protected from grazing, and litter and brush adequately cover the soil.

Table 2-2d.—Runoff curve numbers for arid and semiarid rangelands[1]

Cover description		Curve numbers for hydrologic soil group—			
Cover type	Hydrologic condition[2]	A[3]	B	C	D
Herbaceous—mixture of grass, weeds, and low-growing brush, with brush the minor element.	Poor		80	87	93
	Fair		71	81	89
	Good		62	74	85
Oak-aspen—mountain brush mixture of oak brush, aspen, mountain mahogany, bitter brush, maple, and other brush.	Poor		66	74	79
	Fair		48	57	63
	Good		30	41	48
Pinyon-juniper—pinyon, juniper, or both; grass understory.	Poor		75	85	89
	Fair		58	73	80
	Good		41	61	71
Sagebrush with grass understory.	Poor		67	80	85
	Fair		51	63	70
	Good		35	47	55
Desert shrub—major plants include saltbush, greasewood, creosotebush, blackbrush, bursage, palo verde, mesquite, and cactus.	Poor	63	77	85	88
	Fair	55	72	81	86
	Good	49	68	79	84

[1]Average runoff condition, and $I_a = 0.2S$. For range in humid regions, use table 2-2c.

[2]*Poor:* <30% ground cover (litter, grass, and brush overstory).
Fair: 30 to 70% ground cover.
Good: >70% ground cover.

[3]Curve numbers for group A have been developed only for desert shrub.

Antecedent runoff condition

The index of runoff potential before a storm event is the antecedent runoff condition (ARC). ARC is an attempt to account for the variation in CN at a site from storm to storm. CN for the average ARC at a site is the median value as taken from sample rainfall and runoff data. The CN's in table 2-2 are for the average ARC, which is used primarily for design applications. See NEH-4 (SCS 1985) and Rallison and Miller (1981) for more detailed discussion of storm-to-storm variation and a demonstration of upper and lower enveloping curves.

Urban impervious area modifications

Several factors, such as the percentage of impervious area and the means of conveying runoff from impervious areas to the drainage system, should be considered in computing CN for urban areas (Rawls et al., 1981). For example, do the impervious areas connect directly to the drainage system, or do they outlet onto lawns or other pervious areas where infiltration can occur?

Connected impervious areas

An impervious area is considered connected if runoff from it flows directly into the drainage system. It is also considered connected if runoff from it occurs as concentrated shallow flow that runs over a pervious area and then into a drainage system.

Urban CN's (table 2-2a) were developed for typical land use relationships based on specific assumed percentages of impervious area. These CN values were developed on the assumptions that (a) pervious urban areas are equivalent to pasture in good hydrologic condition and (b) impervious areas have a CN of 98 and are directly connected to the drainage system. Some assumed percentages of impervious area are shown in table 2-2a.

If all of the impervious area is directly connected to the drainage system, but the impervious area percentages or the pervious land use assumptions in table 2-2a are not applicable, use figure 2-3 to compute a composite CN. For example, table 2-2a gives a CN of 70 for a ½-acre lot in HSG B, with an assumed impervious area of 25 percent. However, if the lot has 20 percent impervious area and a pervious area CN of 61, the composite CN obtained from figure 2-3 is 68. The CN difference between 70 and 68 reflects the difference in percent impervious area.

Unconnected impervious areas

Runoff from these areas is spread over a pervious area as sheet flow. To determine CN when all or part of the impervious area is not directly connected to the drainage system, (1) use figure 2-4 if total impervious area is less than 30 percent or (2) use figure 2-3 if the total impervious area is equal to or greater than 30 percent, because the absorptive capacity of the remaining pervious areas will not significantly affect runoff.

When impervious area is less than 30 percent, obtain the composite CN by entering the right half of figure 2-4 with the percentage of total impervious area and the ratio of total unconnected impervious area to total impervious area. Then move left to the appropriate pervious CN and read down to find the composite CN. For example, for a ½-acre lot with 20 percent total impervious area (75 percent of which is unconnected) and pervious CN of 61, the composite CN from figure 2-4 is 66. If all of the impervious area is connected, the resulting CN (from figure 2-3) would be 68.

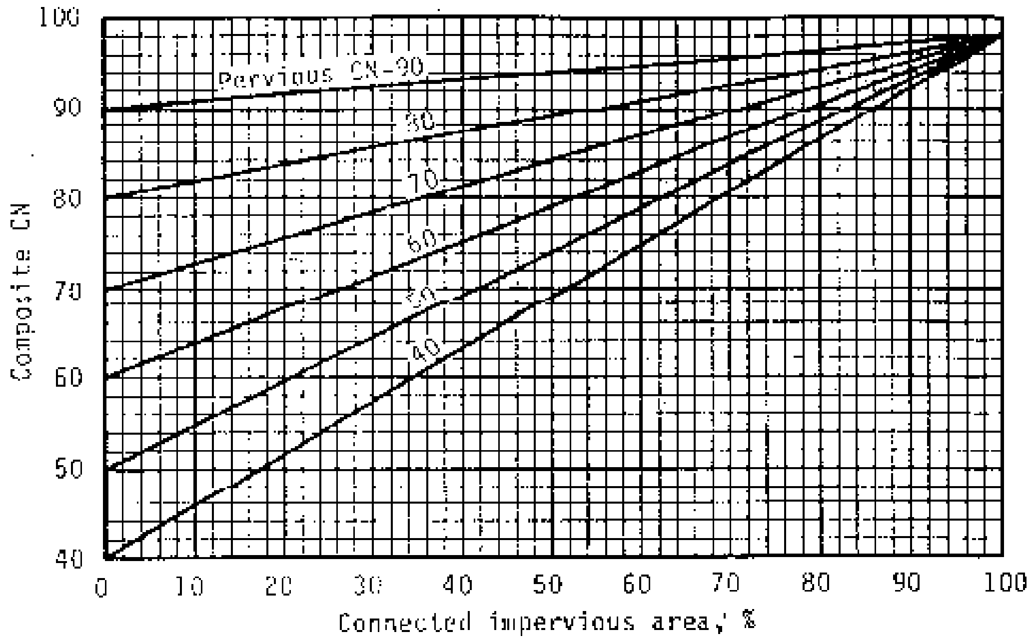


Figure 2-3.—Composite CN with connected impervious area.

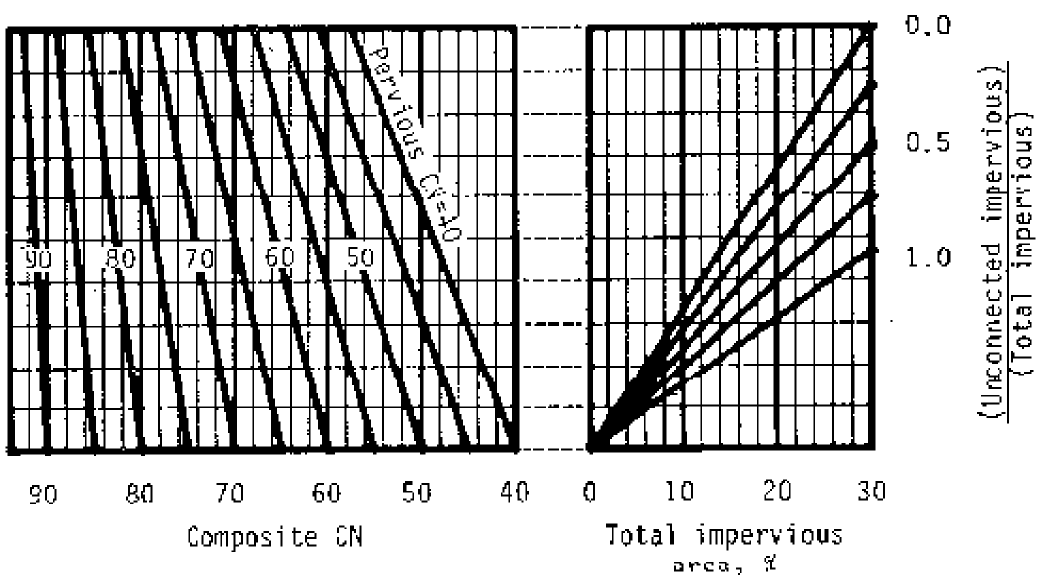


Figure 2-4.—Composite CN with unconnected impervious areas and total impervious area less than 30%.

Runoff

When CN and the amount of rainfall have been determined for the watershed, determine runoff by using figure 2-1, table 2-1, or equations 2-3 and 2-4. The runoff is usually rounded to the nearest hundredth of an inch.

Limitations

- Curve numbers describe average conditions that are useful for design purposes. If the rainfall event used is a historical storm, the modeling accuracy decreases.
- Use the runoff curve number equation with caution when recreating specific features of an actual storm. The equation does not contain an expression for time and, therefore, does not account for rainfall duration or intensity.
- The user should understand the assumption reflected in the initial abstraction term (I_a) and should ascertain that the assumption applies to the situation. I_a, which consists of interception, initial infiltration, surface depression storage, evapotranspiration, and other factors, was generalized as 0.2S based on data from agricultural watersheds (S is the potential maximum retention after runoff begins). This approximation can be especially important in an urban application because the combination of impervious areas with pervious areas can imply a significant initial loss that may not take place. The opposite effect, a greater initial loss, can occur if the impervious areas have surface depressions that store some runoff. To use a relationship other than I_a = 0.2S, one must redevelop equation 2-3, figure 2-1, table 2-1, and table 2-2 by using the original rainfall-runoff data to establish new S or CN relationships for each cover and hydrologic soil group.
- Runoff from snowmelt or rain on frozen ground cannot be estimated using these procedures.
- The CN procedure is less accurate when runoff is less than 0.5 inch. As a check, use another procedure to determine runoff.
- The SCS runoff procedures apply only to direct surface runoff: do not overlook large sources of subsurface flow or high ground water levels that contribute to runoff. These conditions are often related to HSG A soils and forest areas that have been assigned relatively low CN's in table 2-2. Good judgment and experience based on stream gage records are needed to adjust CN's as conditions warrant.
- When the weighted CN is less than 40, use another procedure to determine runoff.

Examples

Four examples illustrate the procedure for computing runoff curve number (CN) and runoff (Q) in inches. Worksheet 2 in appendix D is provided to assist TR-55 users. Figures 2-5 to 2-8 represent the use of worksheet 2 for each example. All four examples are based on the same watershed and the same storm event.

The watershed covers 250 acres in Dyer County, northwestern Tennessee. Seventy percent (175 acres) is a Loring soil, which is in hydrologic soil group C. Thirty percent (75 acres) is a Memphis soil, which is in group B. The event is a 25-year frequency, 24-hour storm with total rainfall of 6 inches.

Cover type and conditions in the watershed are different for each example. The examples, therefore, illustrate how to compute CN and Q for various situations of proposed, planned, or present development.

Example 2-1

The present cover type is pasture in good hydrologic condition. (See figure 2-5 for worksheet 2 information.)

Example 2-2

Seventy percent (175 acres) of the watershed, consisting of all the Memphis soil and 100 acres of the Loring soil, is ½-acre residential lots with lawns in good hydrologic condition. The rest of the watershed is scattered open space in good hydrologic condition. (See figure 2-6.)

Example 2-3

This example is the same as example 2-2, except that the ½-acre lots have a total impervious area of 35 percent. For these lots, the pervious area is lawns in good hydrologic condition. Since the impervious area percentage differs from the percentage assumed in table 2-2, use figure 2-3 to compute CN. (See figure 2-7.)

Example 2-4

This example is also based on example 2-2, except that 50 percent of the impervious area associated with the ½-acre lots on the Loring soil is "unconnected," that is, it is not directly connected to the drainage system. For these lots, the pervious area CN (lawn, good condition) is 74 and the impervious area is 25 percent. Use figure 2-4 to compute the CN for these lots. CN's for the ½-acre lots on Memphis soil and the open space on Loring soil are the same as those in example 2-2. (See figure 2-8.)

Worksheet 2: Runoff curve number and runoff

Project Heavenly Acres By WJR Date 10/1/85

Location Dyer County, Tennessee Checked NM Date 10/3/85

Circle one: (Present) Developed

1. Runoff curve number (CN)

Soil name and hydrologic group (appendix A)	Cover description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN [1/] Table 2-2	CN [1/] Fig. 2-3	CN [1/] Fig. 2-4	Area ☐ acres ☐ mi² ☒ %	Product of CN x area
Memphis, B	Pasture, good condition	61			30	1830
Loring, C	Pasture, good condition	74			70	5180
				Totals =	100	7010

1/ Use only one CN source per line.

CN (weighted) = total product / total area = 7010 / 100 = 70.1; Use CN = 70

2. Runoff

		Storm #1	Storm #2	Storm #3
Frequency	yr	25		
Rainfall, P (24-hour)	in	6.0		
Runoff, Q (Use P and CN with table 2-1, fig. 2-1, or eqs. 2-3 and 2-4.)	in	2.81		

Figure 2-5.—Worksheet 2 for example 2-1.

Worksheet 2: Runoff curve number and runoff

Project Heavenly Acres By WJR Date 10/1/85

Location Dyer County, Tennessee Checked [illegible] Date 10/3/85

Circle one: Present (Developed) 175 acres residential

1. Runoff curve number (CN)

Soil name and hydrologic group (appendix A)	Cover description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN 1/ Table 2-2	CN 1/ Fig. 2-3	CN 1/ Fig. 2-4	Area ☒ acres ☐ mi² ☐ %	Product of CN x area
Memphis, B	25% impervious 1/2 acre lots, good condition	70			75	5250
Loring, C	25% impervious 1/2 acre lots, good condition	80			100	8000
Loring, C	Open space, good condition	74			75	5550
				Totals =	250	18,800

1/ Use only one CN source per line.

CN (weighted) = $\frac{\text{total product}}{\text{total area}} = \frac{18,800}{250} = 75.2$; Use CN = 75

2. Runoff

		Storm #1	Storm #2	Storm #3
Frequency	yr	25		
Rainfall, P (24-hour)	in	6.0		
Runoff, Q .... (Use P and CN with table 2-1, fig. 2-1, or eqs. 2-3 and 2-4.)	in	3.28		

Figure 2-6.—Worksheet 2 for example 2-2.

Worksheet 2: Runoff curve number and runoff

Project Heavenly Acres By WJR Date 10/1/85

Location Dyer County, Tennessee Checked NM Date 10/3/85

Circle one: Present (Developed)

1. Runoff curve number (CN)

Soil name and hydrologic group (appendix A)	Cover description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN [1/] Table 2-2	CN [1/] Fig. 2-3	CN [1/] Fig. 2-4	Area ☒ acres ☐ mi^2 ☐ %	Product of CN x area
Memphis, B	35% impervious 1/2 acre lots, good condition		74		75	5550
Loring, C	35% impervious 1/2 acre lots, good condition		82		1000	8200
Loring, C	Open space, good condition	74			75	5550
				Totals =	250	19,300

[1/] Use only one CN source per line.

CN (weighted) = $\frac{\text{total product}}{\text{total area}} = \frac{19,300}{250} = 77.2$; Use CN = 77

2. Runoff

		Storm #1	Storm #2	Storm #3
Frequency	yr	25		
Rainfall, P (24-hour)	in	6.0		
Runoff, Q (Use P and CN with table 2-1, fig. 2-1, or eqs. 2-3 and 2-4.)	in	3.48		

Figure 2-7.—Worksheet 2 for example 2-3.

Worksheet 2: Runoff curve number and runoff

Project Heavenly Acres By WJR Date 10/1/85

Location Dyer County, Tennessee Checked NM Date 10/3/85

Circle one: Present (Developed)

1. Runoff curve number (CN)

Soil name and hydrologic group (appendix A)	Cover description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN [1/] Table 2-2	CN [1/] Fig. 2-3	CN [1/] Fig. 2-4	Area ☒acres ☐mi² ☐%	Product of CN x area
Memphis, B	25% connected impervious 1/2 acre lots, good condition	70			75	5250
Loring, C	25% impervious with 50% unconnected 1/2 acre lots, good condition			78	100	7800
Loring, C	Open space, good condition	74			75	5550
				Totals =	250	18,600

[1/] Use only one CN source per line.

CN (weighted) = $\frac{\text{total product}}{\text{total area}} = \frac{18{,}600}{250} = 74.4$; Use CN = 74

2. Runoff

		Storm #1	Storm #2	Storm #3
Frequency	yr	25		
Rainfall, P (24-hour)	in	6.0		
Runoff, Q .... (Use P and CN with table 2-1, fig. 2-1, or eqs. 2-3 and 2-4.)	in	3.19		

Figure 2-8. Worksheet 2 for example 2-4.

Chapter 3: Time of concentration and travel time

Travel time (T_t) is the time it takes water to travel from one location to another in a watershed. T_t is a component of time of concentration (T_c), which is the time for runoff to travel from the hydraulically most distant point of the watershed to a point of interest within the watershed. T_c is computed by summing all the travel times for consecutive components of the drainage conveyance system.

T_c influences the shape and peak of the runoff hydrograph. Urbanization usually decreases T_c, thereby increasing the peak discharge. But T_c can be increased as a result of (a) ponding behind small or inadequate drainage systems, including storm drain inlets and road culverts, or (b) reduction of land slope through grading.

Factors affecting time of concentration and travel time

Surface roughness

One of the most significant effects of urban development on flow velocity is less retardance to flow. That is, undeveloped areas with very slow and shallow overland flow through vegetation become modified by urban development: the flow is then delivered to streets, gutters, and storm sewers that transport runoff downstream more rapidly. Travel time through the watershed is generally decreased.

Channel shape and flow patterns

In small non-urban watersheds, much of the travel time results from overland flow in upstream areas. Typically, urbanization reduces overland flow lengths by conveying storm runoff into a channel as soon as possible. Since channel designs have efficient hydraulic characteristics, runoff flow velocity increases and travel time decreases.

Slope

Slopes may be increased or decreased by urbanization, depending on the extent of site grading or the extent to which storm sewers and street ditches are used in the design of the water management system. Slope will tend to increase when channels are straightened and decrease when overland flow is directed through storm sewers, street gutters, and diversions.

Computation of travel time and time of concentration

Water moves through a watershed as sheet flow, shallow concentrated flow, open channel flow, or some combination of these. The type that occurs is a function of the conveyance system and is best determined by field inspection.

Travel time (T_t) is the ratio of flow length to flow velocity:

$$T_t = \frac{L}{3600\ V} \qquad \text{[Eq. 3-1]}$$

where

T_t = travel time (hr),
L = flow length (ft),
V = average velocity (ft/s), and
3600 = conversion factor from seconds to hours.

Time of concentration (T_c) is the sum of T_t values for the various consecutive flow segments:

$$T_c = T_{t_1} + T_{t_2} + \ldots T_{t_m} \qquad \text{[Eq. 3-2]}$$

where

T_c = time of concentration (hr) and
m = number of flow segments.

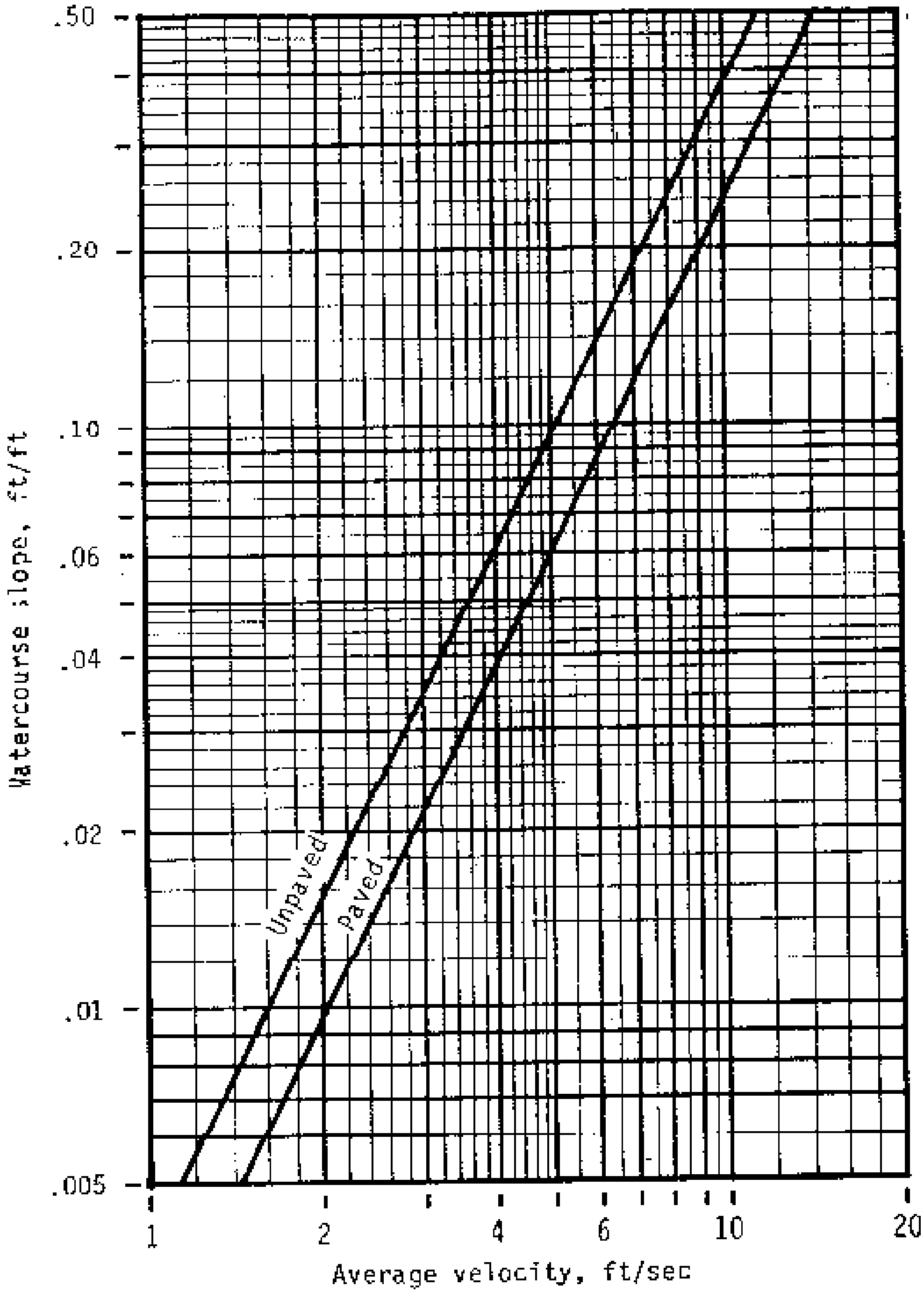


Figure 3-1.—Average velocities for estimating travel time for shallow concentrated flow.

Sheet flow

Sheet flow is flow over plane surfaces. It usually occurs in the headwater of streams. With sheet flow, the friction value (Manning's n) is an effective roughness coefficient that includes the effect of raindrop impact; drag over the plane surface; obstacles such as litter, crop ridges, and rocks; and erosion and transportation of sediment. These n values are for very shallow flow depths of about 0.1 foot or so. Table 3-1 gives Manning's n values for sheet flow for various surface conditions.

For sheet flow of less than 300 feet, use Manning's kinematic solution (Overton and Meadows 1976) to compute T_t:

$$T_t = \frac{0.007\,(nL)^{0.8}}{(P_2)^{0.5}\, s^{0.4}} \qquad \text{[Eq. 3-3]}$$

Table 3-1.—Roughness coefficients (Manning's n) for sheet flow

Surface description	n[1]
Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover ≤20%	0.06
Residue cover >20%	0.17
Grass:	
Short grass prairie	0.15
Dense grasses[2]	0.24
Bermudagrass	0.41
Range (natural)	0.13
Woods:[3]	
Light underbrush	0.40
Dense underbrush	0.80

[1]The n values are a composite of information compiled by Engman (1986).
[2]Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.
[3]When selecting n, consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

where

T_t = travel time (hr),
n = Manning's roughness coefficient (table 3-1),
L = flow length (ft),
P_2 = 2-year, 24-hour rainfall (in), and
s = slope of hydraulic grade line (land slope, ft/ft).

This simplified form of the Manning's kinematic solution is based on the following: (1) shallow steady uniform flow, (2) constant intensity of rainfall excess (that part of a rain available for runoff), (3) rainfall duration of 24 hours, and (4) minor effect of infiltration on travel time. Rainfall depth can be obtained from appendix B.

Shallow concentrated flow

After a maximum of 300 feet, sheet flow usually becomes shallow concentrated flow. The average velocity for this flow can be determined from figure 3-1, in which average velocity is a function of watercourse slope and type of channel. For slopes less than 0.005 ft/ft, use equations given in appendix F for figure 3-1. Tillage can affect the direction of shallow concentrated flow. Flow may not always be directly down the watershed slope if tillage runs across the slope.

After determining average velocity in figure 3-1, use equation 3-1 to estimate travel time for the shallow concentrated flow segment.

Open channels

Open channels are assumed to begin where surveyed cross section information has been obtained, where channels are visible on aerial photographs, or where blue lines (indicating streams) appear on United States Geological Survey (USGS) quadrangle sheets. Manning's equation or water surface profile information can be used to estimate average flow velocity. Average flow velocity is usually determined for bank-full elevation.

Manning's equation is

$$V = \frac{1.49\, r^{2/3}\, s^{1/2}}{n} \qquad \text{[Eq. 3-4]}$$

where

- V = average velocity (ft/s),
- r = hydraulic radius (ft) and is equal to a/p_w,
- a = cross sectional flow area (ft^2),
- p_w = wetted perimeter (ft),
- s = slope of the hydraulic grade line (channel slope, ft/ft), and
- n = Manning's roughness coefficient for open channel flow.

Manning's n values for open channel flow can be obtained from standard textbooks such as Chow (1959) or Linsley et al. (1982). After average velocity is computed using equation 3-4, T_t for the channel segment can be estimated using equation 3-1.

Reservoirs or lakes

Sometimes it is necessary to estimate the velocity of flow through a reservoir or lake at the outlet of a watershed. This travel time is normally very small and can be assumed as zero.

Limitations

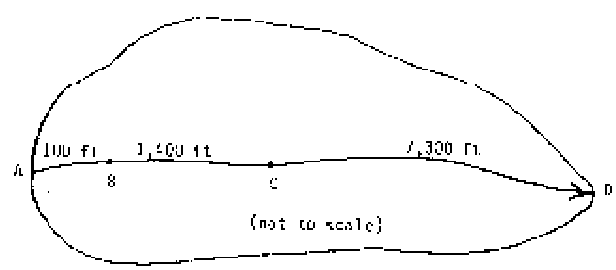
- Manning's kinematic solution should not be used for sheet flow longer than 300 feet. Equation 3-3 was developed for use with the four standard rainfall intensity-duration relationships.
- In watersheds with storm sewers, carefully identify the appropriate hydraulic flow path to estimate T_c. Storm sewers generally handle only a small portion of a large event. The rest of the peak flow travels by streets, lawns, and so on, to the outlet. Consult a standard hydraulics textbook to determine average velocity in pipes for either pressure or nonpressure flow.
- The minimum T_c used in TR-55 is 0.1 hour.
- A culvert or bridge can act as a reservoir outlet if there is significant storage behind it. The procedures in TR-55 can be used to determine the peak flow upstream of the culvert. Detailed storage routing procedures should be used to determine the outflow through the culvert.

Example 3-1

The sketch below shows a watershed in Dyer County, northwestern Tennessee. The problem is to compute T_c at the outlet of the watershed (point D). The 2-year 24-hour rainfall depth is 3.6 inches. All three types of flow occur from the hydraulically most distant point (A) to the point of interest (D). To compute T_c, first determine T_t for each segment from the following information:

Segment AB:	Sheet flow; dense grass; slope (s) = 0.01 ft/ft; and length (L) = 100 ft.
Segment BC:	Shallow concentrated flow; unpaved; s = 0.01 ft/ft; and L = 1400 ft.
Segment CD:	Channel flow; Manning's n = .05; flow area (a) = 27 ft^2; wetted perimeter (p_w) = 28.2 ft; s = 0.005 ft/ft; and L = 7300 ft.

See figure 3-2 for the computations made on worksheet 3.



Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project: Heavenly Acres   By: DW   Date: 10/6/85

Location: Dyer County, Tennessee   Checked: NM   Date: 10/8/85

Circle one: Present (Developed)

Circle one: (T_c) T_t through subarea

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only)

Segment ID		AB		
1. Surface description (table 3-1)		DENSE GRASS		
2. Manning's roughness coeff., n (table 3-1)		0.24		
3. Flow length, L (total L ≤ 300 ft)	ft	100		
4. Two-yr 24-hr rainfall, P_2	in	3.6		
5. Land slope, s	ft/ft	0.01		
6. $T_t = \frac{0.007\,(nL)^{0.8}}{P_2^{0.5}\,s^{0.4}}$ Compute T_t	hr	0.30	+	= 0.30

Shallow concentrated flow

Segment ID		BC		
7. Surface description (paved or unpaved)		Unpaved		
8. Flow length, L	ft	1400		
9. Watercourse slope, s	ft/ft	0.01		
10. Average velocity, V (figure 3-1)	ft/s	1.6		
11. $T_t = \frac{L}{3600\,V}$ Compute T_t	hr	0.24	+	= 0.24

Channel flow

Segment ID		CD		
12. Cross sectional flow area, a	ft^2	27		
13. Wetted perimeter, P_w	ft	28.2		
14. Hydraulic radius, $r = \frac{a}{P_w}$ Compute r	ft	0.957		
15. Channel slope, s	ft/ft	0.005		
16. Manning's roughness coeff., n		0.05		
17. $V = \frac{1.49\,r^{2/3}\,s^{1/2}}{n}$ Compute V	ft/s	2.05		
18. Flow length, L	ft	7300		
19. $T_t = \frac{L}{3600\,V}$ Compute T_t	hr	0.99	+	= 0.99
20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19)	hr			1.53

Figure 3-2.—Worksheet 3 for example 3-1.

Chapter 4: Graphical Peak Discharge method

This chapter presents the Graphical Peak Discharge method for computing peak discharge from rural and urban areas. The Graphical method was developed from hydrograph analyses using TR-20, "Computer Program for Project Formulation--Hydrology" (SCS 1983). The peak discharge equation used is

$$q_p = q_u A_m Q F_p \qquad \text{[Eq. 4-1]}$$

where

- q_p = peak discharge (cfs);
- q_u = unit peak discharge (csm/in);
- A_m = drainage area (mi^2);
- Q = runoff (in); and
- F_p = pond and swamp adjustment factor.

The input requirements for the Graphical method are as follows: (1) T_c (hr), (2) drainage area (mi^2), (3) appropriate rainfall distribution (I, IA, II, or III), (4) 24-hour rainfall (in), and (5) CN. If pond and swamp areas are spread throughout the watershed and are not considered in the T_c computation, an adjustment for pond and swamp areas is also needed.

Peak discharge computation

For a selected rainfall frequency, the 24-hour rainfall (P) is obtained from appendix B or more detailed local precipitation maps. CN and total runoff (Q) for the watershed are computed according to the methods outlined in chapter 2. The CN is used to determine the initial abstraction (I_a) from table 4-1. I_a/P is then computed.

If the computed I_a/P ratio is outside the range shown in exhibit 4 (4-I, 4-IA, 4-II, and 4-III) for the rainfall distribution of interest, then the limiting value should be used. If the ratio falls between the limiting values, use linear interpolation. Figure 4-1 illustrates the sensitivity of I_a/P to CN and P.

Peak discharge per square mile per inch of runoff (q_u) is obtained from exhibit 4-I, 4-IA, 4-II, or 4-III by using T_c (chapter 3), rainfall distribution type, and I_a/P ratio. The pond and swamp adjustment factor is obtained from table 4-2 (rounded to the nearest table value). Use worksheet 4 in appendix D to aid in computing the peak discharge using the Graphical method.

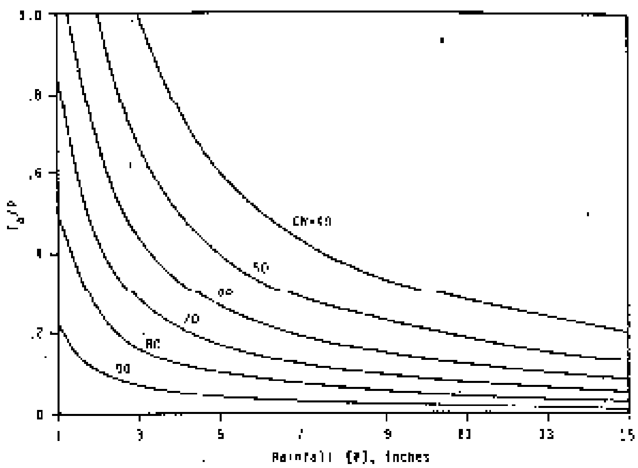


Figure 4-1.—Variation of I_a/P for P and CN.

Table 4-1.—I_a values for runoff curve numbers

Curve number	I_a (in)	Curve number	I_a (in)
40	3.000	70	0.857
41	2.878	71	0.817
42	2.762	72	0.778
43	2.651	73	0.740
44	2.545	74	0.703
45	2.444	75	0.667
46	2.348	76	0.632
47	2.255	77	0.597
48	2.167	78	0.564
49	2.082	79	0.532
50	2.000	80	0.500
51	1.922	81	0.469
52	1.846	82	0.439
53	1.774	83	0.410
54	1.704	84	0.381
55	1.636	85	0.353
56	1.571	86	0.326
57	1.509	87	0.299
58	1.448	88	0.273
59	1.390	89	0.247
60	1.333	90	0.222
61	1.279	91	0.198
62	1.226	92	0.174
63	1.175	93	0.151
64	1.125	94	0.128
65	1.077	95	0.105
66	1.030	96	0.083
67	0.985	97	0.062
68	0.941	98	0.041
69	0.899		

Table 4-2.—Adjustment factor (F_p) for pond and swamp areas that are spread throughout the watershed

Percentage of pond and swamp areas	F_p
0	1.00
0.2	0.97
1.0	0.87
3.0	0.75
5.0	0.72

Limitations

The Graphical method provides a determination of peak discharge only. If a hydrograph is needed or watershed subdivision is required, use the Tabular Hydrograph method (chapter 5). Use TR-20 if the watershed is very complex or a higher degree of accuracy is required.

- The watershed must be hydrologically homogeneous, that is, describable by one CN. Land use, soils, and cover are distributed uniformly throughout the watershed.
- The watershed may have only one main stream or, if more than one, the branches must have nearly equal T_c's.
- The method cannot perform valley or reservoir routing.
- The F_p factor can be applied only for ponds or swamps that are not in the T_c flow path.
- Accuracy of peak discharge estimated by this method will be reduced if I_a/P values are used that are outside the range given in exhibit 4. The limiting I_a/P values are recommended for use.
- This method should be used only if the weighted CN is greater than 40.
- When this method is used to develop estimates of peak discharge for both present and developed conditions of a watershed, use the same procedure for estimating T_c.
- T_c values with this method may range from 0.1 to 10 hours.

Example 4-1

Compute the 25-year peak discharge for the 250-acre watershed described in examples 2-2 and 3-1. Figure 4-2 shows how worksheet 4 is used to compute q_p as 345 cfs.

Worksheet 4: Graphical Peak Discharge method

Project Heavenly Acres By RHM Date 10/15/85

Location Dyer County, Tennessee Checked NM Date 10/17/85

Circle one: Present (Developed)

1. Data:

   Drainage area .... A_m = 0.39 mi^2 (acres/640)

   Runoff curve number .... CN = 75 (From worksheet 2), Figure 2-6

   Time of concentration .. T_c = 1.53 hr (From worksheet 3), Figure 3-2

   Rainfall distribution type = II (I, IA, II, III)

   Pond and swamp areas spread throughout watershed ...... = -- percent of A_m (-- acres or mi^2 covered)

		Storm #1	Storm #2	Storm #3
2. Frequency	yr	25		
3. Rainfall, P (24-hour)	in	6.0		
4. Initial abstraction, I_a .... (Use CN with table 4-1.)	in	0.667		
5. Compute I_a/P		0.11		
6. Unit peak discharge, q_u .... (Use T_c and I_a/P with exhibit 4-II)	csm/in	270		
7. Runoff, Q .... (From worksheet 2). Figure 2-6	in	3.28		
8. Pond and swamp adjustment factor, F_p .... (Use percent pond and swamp area with table 4-2. Factor is 1.0 for zero percent pond and swamp area.)		1.0		
9. Peak discharge, q_p .... (Where $q_p = q_u A_m Q F_p$)	cfs	345		

Figure 4-2.—Worksheet 4 for example 4-1.

Exhibit 4-I: Unit peak discharge (q_u) for SCS type I rainfall distribution

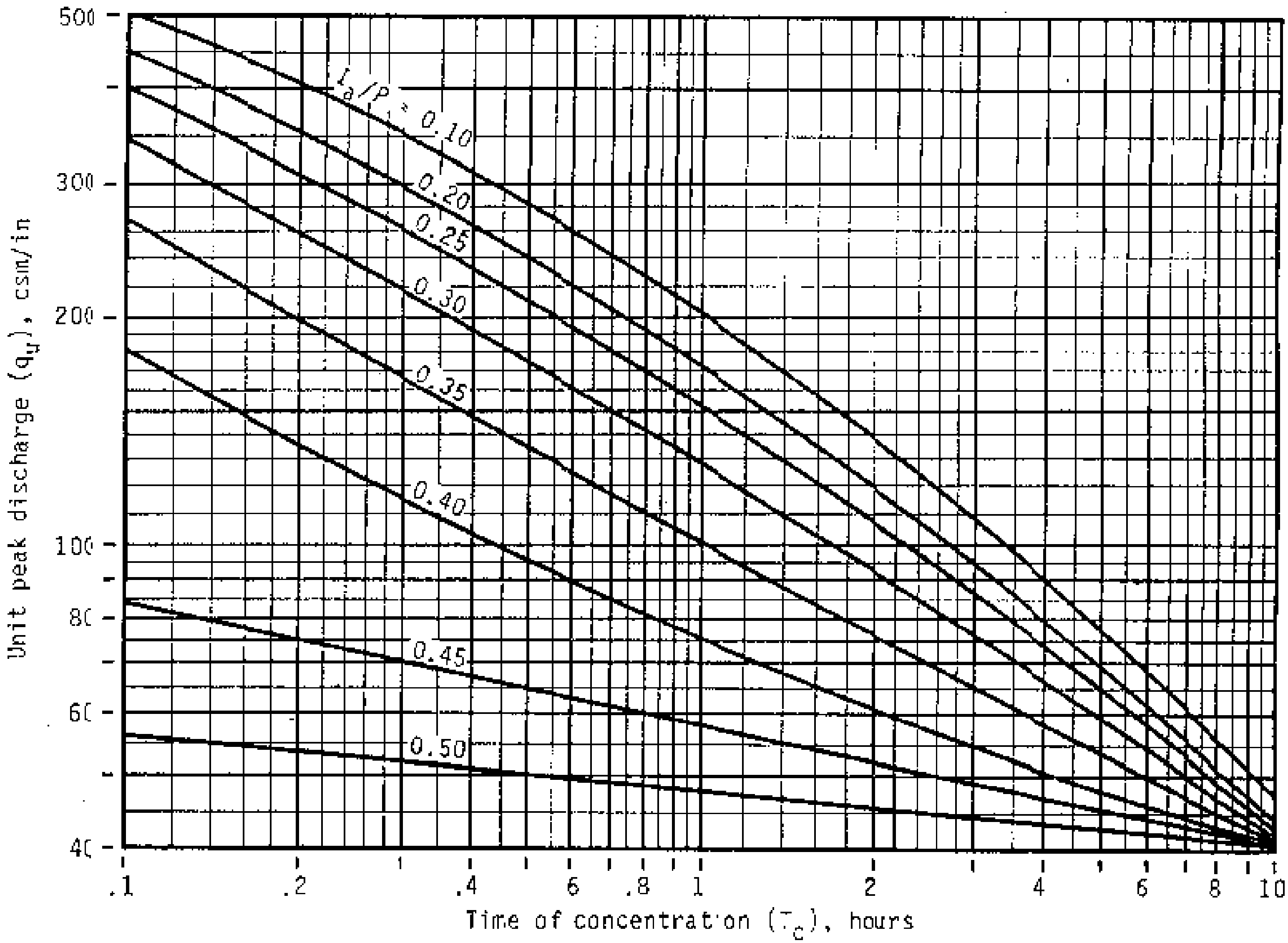


Exhibit 4-IA: Unit peak discharge (q_u) for SCS type IA rainfall distribution

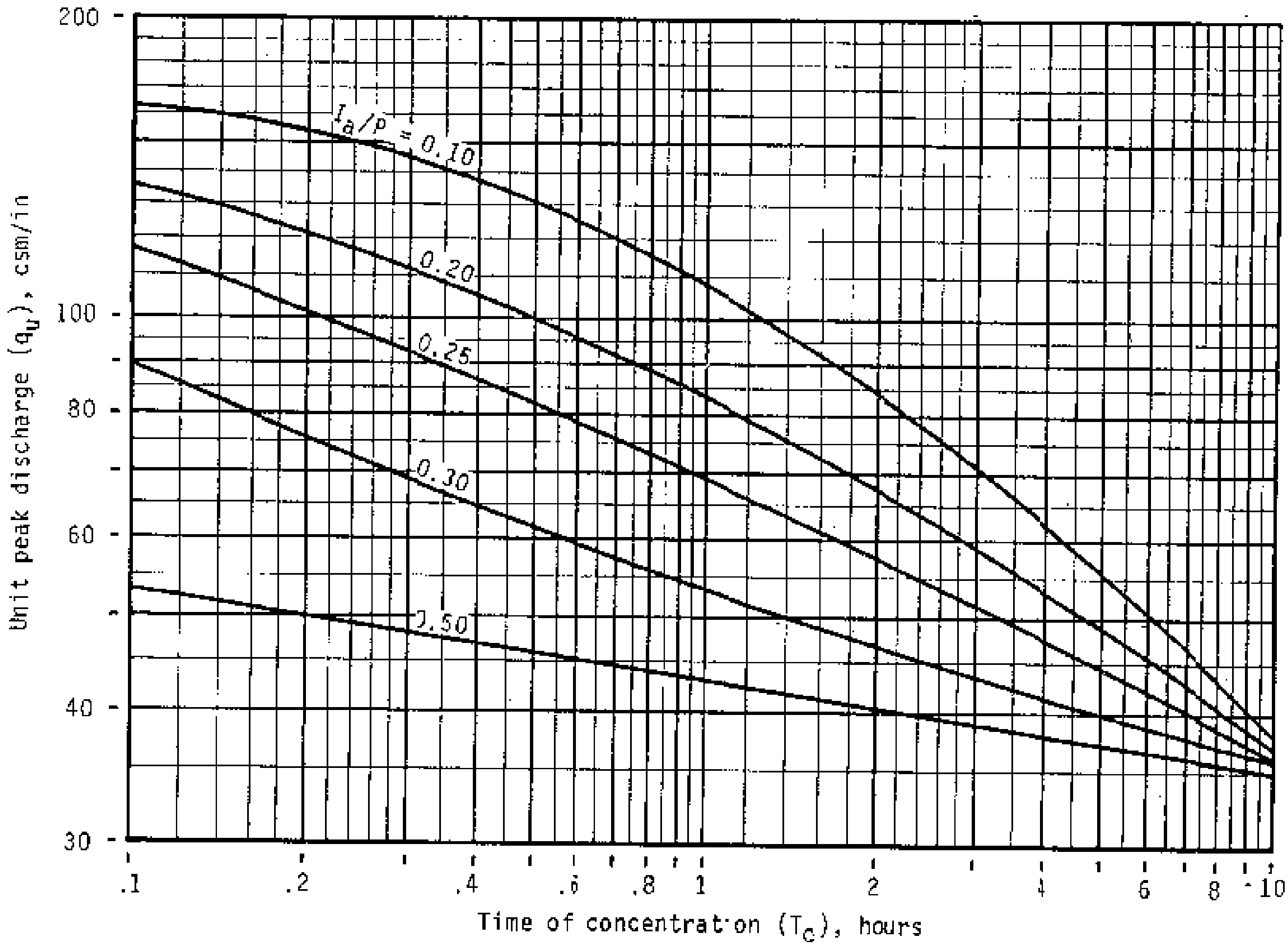


Exhibit 4-II: Unit peak discharge (q_u) for SCS type II rainfall distribution

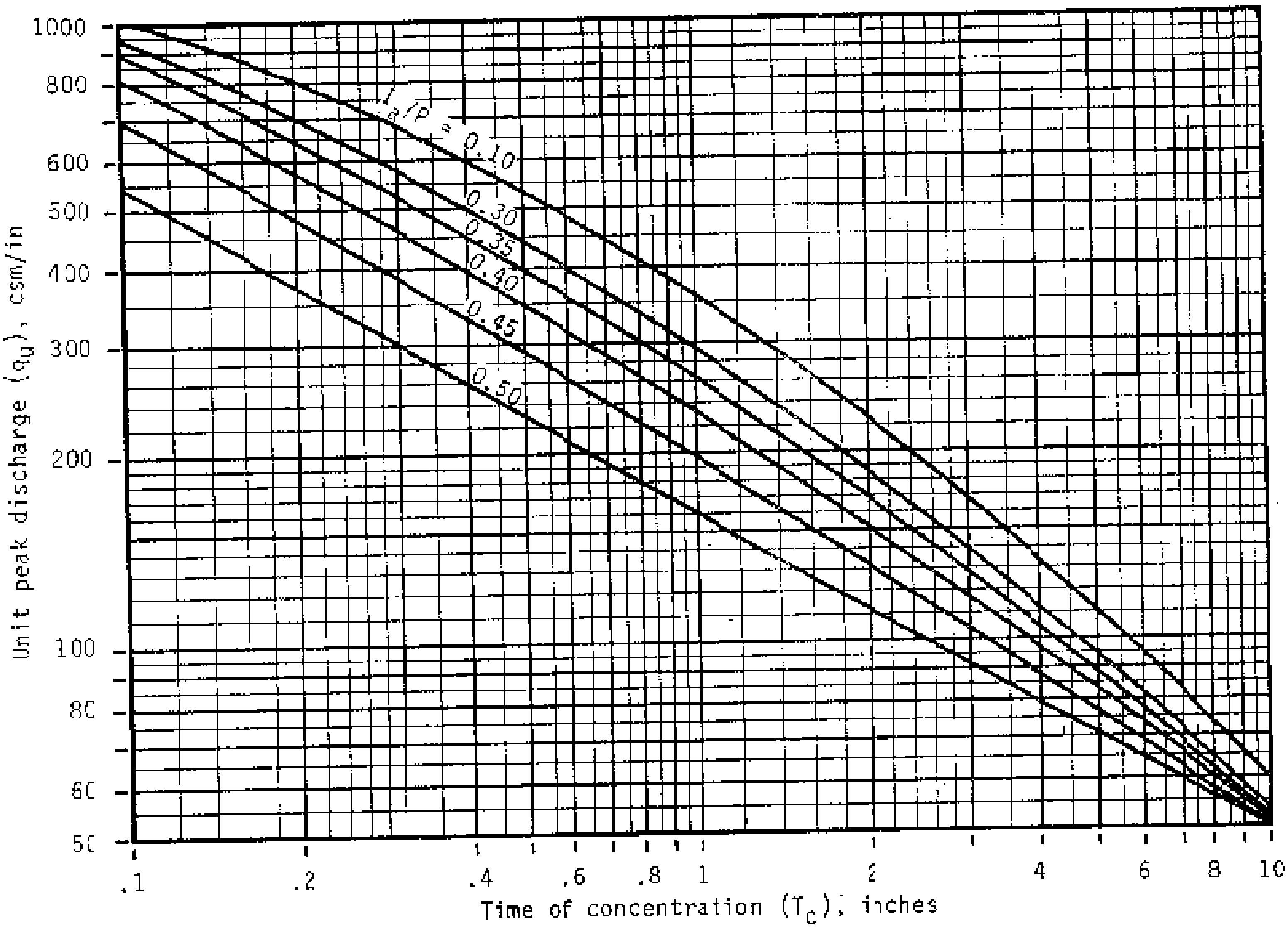
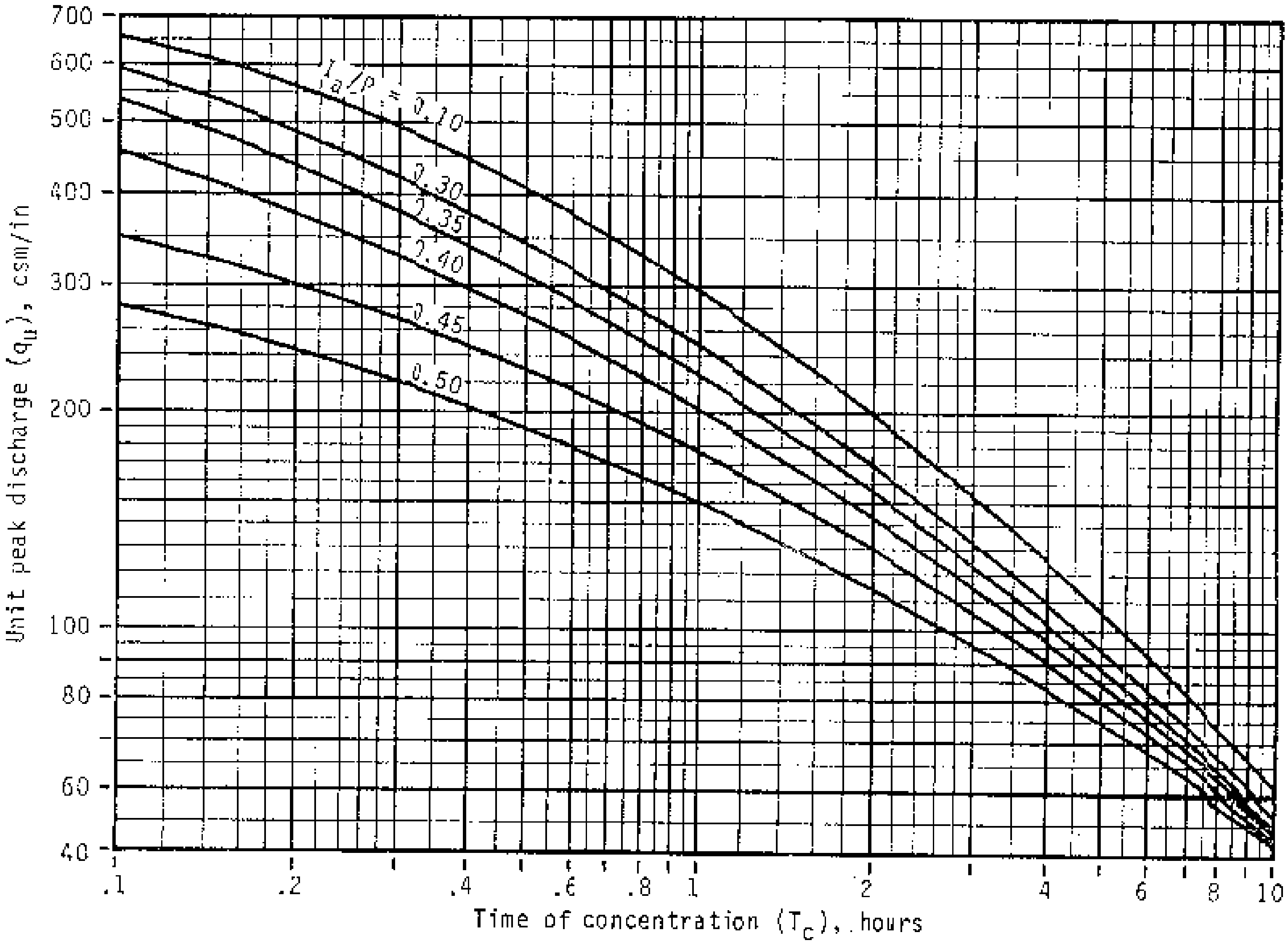


Exhibit 4-III: Unit peak discharge (q_u) for SCS type III rainfall distribution



Worksheet 2: Runoff curve number and runoff

Project ______________ By ______ Date ______

Location ______________ Checked ______ Date ______

Circle one: Present Developed ______________

1. Runoff curve number (CN)

Soil name and hydrologic group (appendix A)	Cover description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN [1/] Table 2-2	CN [1/] Fig. 2-3	CN [1/] Fig. 2-4	Area ☐ acres ☐ mi^2 ☐ %	Product of CN x area
				Totals =		

1/ Use only one CN source per line.

CN (weighted) = $\frac{\text{total product}}{\text{total area}}$ = ______ = ______; Use CN = ☐

2. Runoff

		Storm #1	Storm #2	Storm #3
Frequency	yr			
Rainfall, P (24-hour)	in			
Runoff, Q .... (Use P and CN with table 2-1, fig. 2-1, or eqs. 2-3 and 2-4.)	in			

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project ______________________ By ______ Date ________

Location ______________________ Checked ______ Date ________

Circle one: Present Developed ______________________

Circle one: T_c T_t through subarea ______________________

NOTES. Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only)	Segment ID			
1. Surface description (table 3-1)				
2. Manning's roughness coeff., n (table 3-1) ..				
3. Flow length, L (total L ≤ 300 ft)	ft			
4. Two-yr 24-hr rainfall, P_2	in			
5. Land slope, s	ft/ft			
6. $T_t = \frac{0.007\ (nL)^{0.8}}{P_2^{0.5}\ s^{0.4}}$ Compute T_t	hr		+	=

Shallow concentrated flow	Segment ID			
7. Surface description (paved or unpaved)				
8. Flow length, L	ft			
9. Watercourse slope, s	ft/ft			
10. Average velocity, V (figure 3-1)	ft/s			
11. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr		+	=

Channel flow	Segment ID			
12. Cross sectional flow area, a	ft^2			
13. Wetted perimeter, p_w	ft			
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r	ft			
15. Channel slope, s	ft/ft			
16. Manning's roughness coeff., n				
17. $V = \frac{1.49\ r^{2/3}\ s^{1/2}}{n}$ Compute V	ft/s			
18. Flow length, L	ft			
19. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr		+	=

20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19) .... hr

Worksheet 4: Graphical Peak Discharge method

Project ______________________ By _____ Date _______

Location ______________________ Checked _____ Date _______

Circle one: Present Developed ______________________

1. Data:

   Drainage area .... A_m = ________ mi^2 (acres/640)

   Runoff curve number .... CN = ________ (From worksheet 2)

   Time of concentration .. T_c = ________ hr (From worksheet 3)

   Rainfall distribution type = __II__ (I, IA, II, III)

   Pond and swamp areas spread throughout watershed ...... = ________ percent of A_m (____ acres or mi^2 covered)

			Storm #1	Storm #2	Storm #3
2.	Frequency	yr			
3.	Rainfall, P (24-hour)	in			
4.	Initial abstraction, I_a .... (Use CN with table 4-1.)	in			
5.	Compute I_a/P				
6.	Unit peak discharge, q_u .... (Use T_c and I_a/P with exhibit 4-__II__)	csm/in			
7	Runoff, Q .... (From worksheet 2). Figure 2-6	in			
8.	Pond and swamp adjustment factor, F_p .... (Use percent pond and swamp area with table 4-2. Factor is 1.0 for zero percent pond and swamp area.)				
9.	Peak discharge, q_p .... (Where $q_p = q_u A_m Q F_p$)	cfs			

Figure 4-2.—Worksheet 4 for example 4-1.

APPENDIX E

EXAMPLE STORMWATER RESIDENTIAL SITE PLAN

Appendix E
Outline for Example Stormwater Site Plan

In general, the following type of information should be included in a stormwater site plan. Consult the local permitting authority before preparing the plan to make sure it is necessary in the project site area, and also to determine which elements of the plan are required.

I. Project overview (brief description)

II. A conceptual site plan, including the following:

- Locations of structures, other impervious surfaces
- Lot layout
- Setback requirements
- Existing site features (topography, contours)
- Water quality sensitive areas
- Road rights-of-way and easements

III. Preliminary conditions summary, including soil types and depth to high groundwater.

IV. Off-site analysis - analysis of off-site upstream and downstream conditions, including capacity of the downstream system.

V. Identification of adjacent land uses and environmentally sensitive areas.

VI. Hydrologic calculations

VII. A site plan for design and placement of propose construction Best Management Practices (BMPs), including erosion and sediment controls, using standard map symbols

VIII. Design and placement of proposed permanent stormwater BMPs, including preliminary sizing calculations

IX. Operations and maintenance plan for the temporary and permanent stormwater BMPs

X. List/description of other permits for the site, either issued or planned

The Stormwater Site Plan should be stamped and dated by a professional civil engineer licensed in the State of Idaho and then submitted to the appropriate reviewing agency.

Example Stormwater Site Plan

I. Project overview

Construct a house of 1800 sq ft, attached garage of 400 sq ft, and a gravel driveway 250 long. The lot is 2.3 acres in size, located at 24040 Boot Hill Road in the Dodge Ranch Development. Since it is outside the sanitary service area, the house will be served by a septic system.

II. Site plan

Figure 1 shows the conceptual building plan including the lot layout, contour lines, building footprints, driveway alignment, property lines, county right of way, and location of nearby stream (sensitive waterway). The direction of surface water flow is also shown.

III. Preliminary conditions summary, including soil types and depth to high groundwater

The Soil Survey map from the Natural Resources Conservation Service shows that the soil type at the site is classified as Archibal Loam, a silty loam. Its hydrologic classification is Type B. A well log from an adjacent property showed a groundwater elevation of 5040 feet, so the depth to groundwater is assumed to range from 10 to 18 feet. For BMP selection, the minimum depth of 10 feet was used.

The developer of this subdivision surveyed the 2-foot contour intervals. The average slope is 2 feet vertical/70 feet horizontal or about 3%.

IV. Off-site analysis – analysis of off-site upstream and downstream conditions, including capacity of the downstream system

Approximately 2 acres of undeveloped land lie upslope and appear to drain into this property. Flows from this upstream property were assumed to be insignificant and were not included in the calculations. Runoff from the 24040 Boot Hill Road lot enters a drainage ditch that leads to a culver about 100 feet away. The culver is 12 inches in diameter with a 2% slope. The capacity of the culvert is 2.3 cfs. (Calculated using an inlet control nomograph supplied by the Idaho Transportation Department).

V. Identification of adjacent land uses and environmentally sensitive areas

The lot is situated in a development zoned for single family residential. About half of the lots are developed so far. The only environmentally sensitive area is a small stream that is located 200 feet downhill from the site.

VI. Hydrologic calculations

Hydrologic calculations are shown in the attached worksheets. The first set of worksheets show that the peak flow previous to development is 0.0072 cfs. The second set shows peak flows after development are projected to be 0.1 cfs, 114 times as great.

VII. Plan for design and placement of proposed construction BMPs

The Stormwater Site Plan, Figure 2, shows the placement of proposed construction BMPs. These include:

- Preserve existing trees by establishing clearing limits to be marked before starting construction
- Stabilize the slope with matting and seeding where it will be cut for the house
- Realign driveway to lessen slope
- Cover excavated topsoil until reuse
- Stabilize construction entrance with gravel

VIII. Design and placement of proposed permanent stormwater BMPs

The first three BMPs listed above will remain in place as permanent BMPs after construction is finished.

IX. Operation and maintenance plan for temporary and permanent stormwater BMPs

The only maintenance anticipated for the permanent BMPs is watering the seeded slope as necessary until the grass is re-established

X. List/description of other permits for the site

A local building permit
A septic permit from the local District Health Department

Figure E-1. Conceptual Site Plan

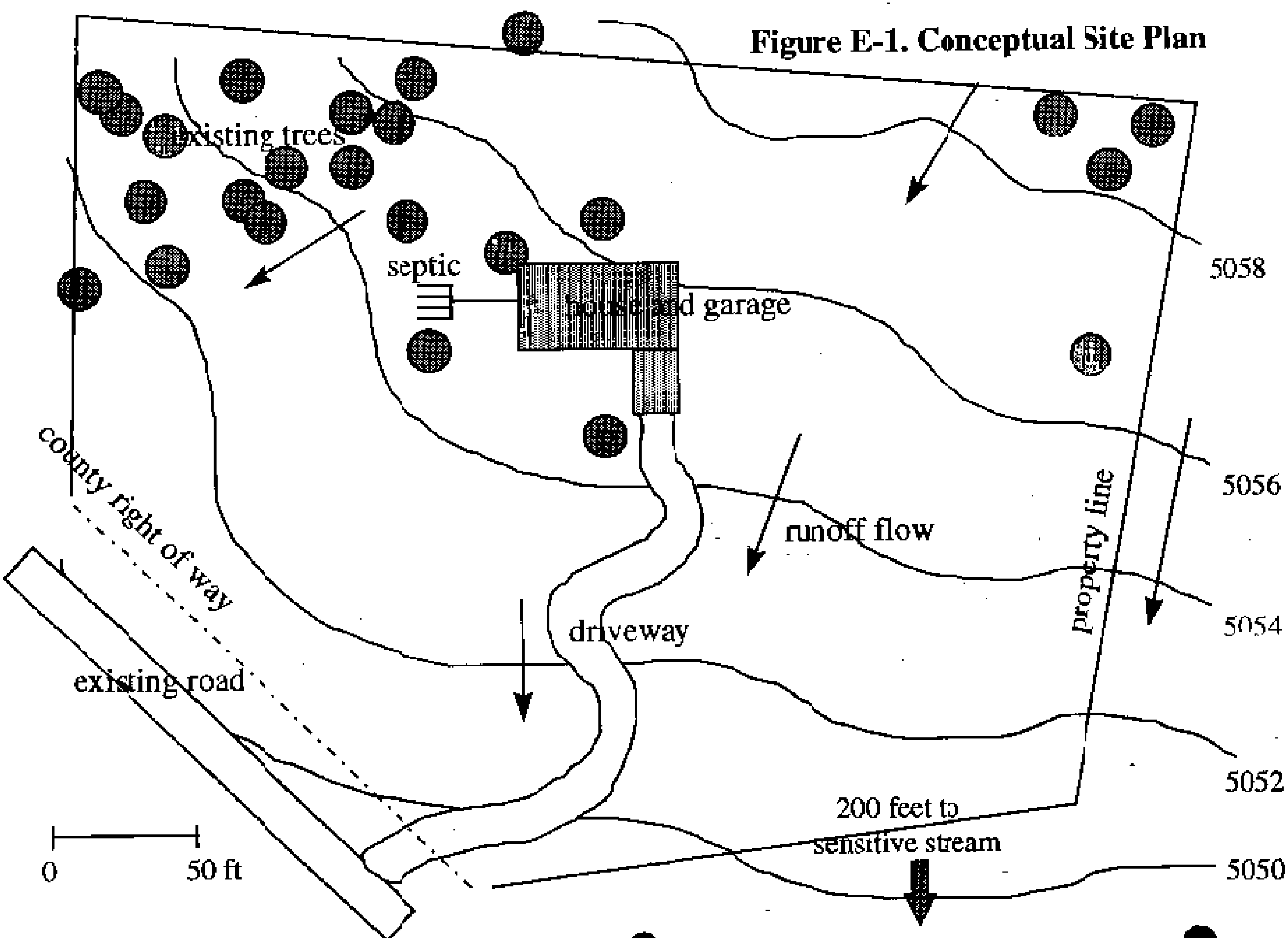
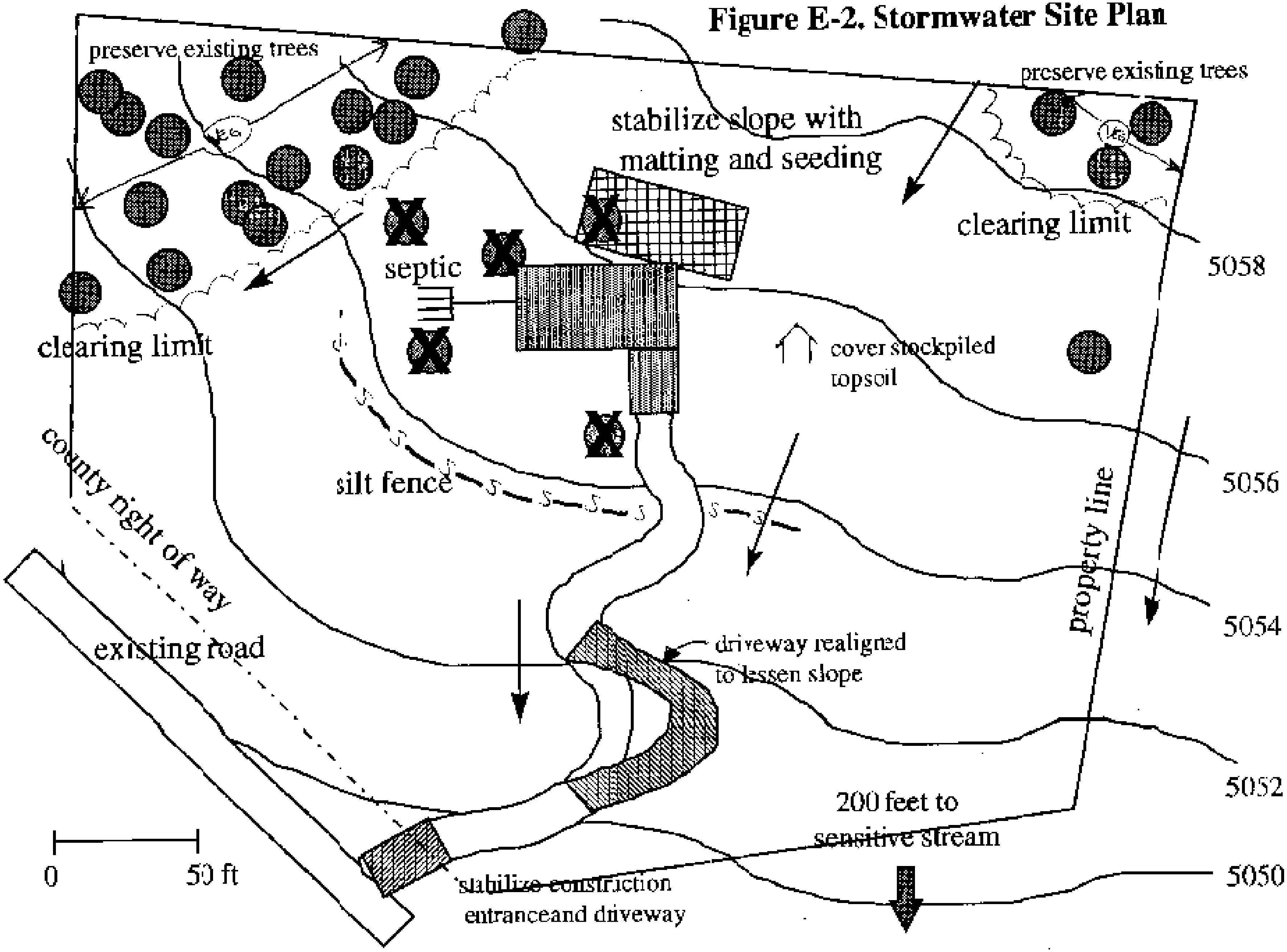


Figure E-2. Stormwater Site Plan



Worksheet 2: Runoff curve number and runoff

Project 24040 Boot Hill Road By DRF Date 1/30/97

Location Dodge Ranch Development Checked CKB Date 1/30/97

Circle one: (Present) Developed 2.3 acres

1. Runoff curve number (CN)

Soil name and hydrologic group (appendix A)	Cover description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN 1/ Table 2-2	CN 1/ Fig. 2-3	CN 1/ Fig. 2-4	Area ☐ acres ☐ mi² ☒ %	Product of CN x area
Archibald B	Wooded, good condition	55			100	5500
				Totals =	100	5500

1/ Use only one CN source per line.

CN (weighted) = $\frac{\text{total product}}{\text{total area}} = \frac{5500}{100} = 55$; Use CN = 55

2. Runoff

	Storm #1	Storm #2	Storm #3
Frequency .... yr	5		
Rainfall, P (24-hour) used Fig D-2 .... in	.08 x 24 = 1.92		
Runoff, Q .... in (Use P and CN with (table 2-1) fig. 2-1, or eqs. 2-3 and 2-4.)	.02		

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project 24040 Bert Hill Road By DRF Date 1/20/97
Location Dodge Ranch Development Checked GLG Date 1/30/97
Circle one: (Present) Developed
Circle one: T_c T_t through subarea

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only)

	Segment ID			
1. Surface description (table 3-1)		woods and brush		
2. Manning's roughness coeff., n (table 3-1) .. assume light underbrush		0.40		
3. Flow length, L (total L ≤ 300 ft)	ft	300		
4. Two-yr 24-hr rainfall, P_2	in	1.5		
5. Land slope, s	ft/ft	2/70 = 0.03		
6. $T_t = \frac{0.007\,(nL)^{0.8}}{P_2^{0.5}\,s^{0.4}}$ Compute T_t	hr	1.07	+	=

Shallow concentrated flow

	Segment ID			
7. Surface description (paved or unpaved)		none		
8. Flow length, L	ft			
9. Watercourse slope, s	ft/ft			
10. Average velocity, V (figure 3-1)	ft/s			
11. $T_t = \frac{L}{3600\,V}$ Compute T_t	hr		+	=

Channel flow

	Segment ID			
12. Cross sectional flow area, a	ft^2			
13. Wetted perimeter, p_w	ft			
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r	ft	none		
15. Channel slope, s	ft/ft			
16. Manning's roughness coeff., n				
17. $V = \frac{1.49\, r^{2/3}\, s^{1/2}}{n}$ Compute V	ft/s			
18. Flow length, L	ft			
19. $T_t = \frac{L}{3600\,V}$ Compute T_t	hr		+	=

20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19) .... hr 1.07

Worksheet 4: Graphical Peak Discharge method

Project 24040 Boot Hill Road By DRF Date 1/30/97

Location Dodge Ranch Development Checked CFS Date 1/2/97

Circle one: (Present) Developed

1. Data:

Drainage area .... A_m = 0.0036 mi² (acres/640)

Runoff curve number .... CN = 55 (From worksheet 2)

Time of concentration .. T_c = 1.07 hr (From worksheet 3)

Rainfall distribution type = II (I, IA, II, III)

Pond and swamp areas spread throughout watershed ...... = Ø percent of A_m (____ acres or mi² covered)

			Storm #1	Storm #2	Storm #3
2.	Frequency	yr	5		
3.	Rainfall, P (24-hour)	in	1.92		
4.	Initial abstraction, I_a (Use CN with table 4-1.)	in	1.636		
5.	Compute I_a/P		0.85		
6.	Unit peak discharge, q_u (Use T_c and I_a/P with exhibit 4-II)	csm/in	100		
7.	Runoff, Q (From worksheet 2). Figure 2-6	in	0.02		
8.	Pond and swamp adjustment factor, F_p (Use percent pond and swamp area with table 4-2. Factor is 1.0 for zero percent pond and swamp area.)		1.0		
9.	Peak discharge, q_p (Where $q_p = q_u A_m Q F_p$)	cfs	0.0072		

$q_p = 100 \times 0.0036 \times 0.02 \times 1.0$

Figure 4-2.—Worksheet 4 for example 4-1.

Worksheet 2: Runoff curve number and runoff

Project 24040 Boot Hill Road　　By DRF　　Date 1/30/97

Location Dodge Ranch Development　　Checked CKB　　Date 1/30/97

Circle one: Present (Developed)　　2.3 acres

1. Runoff curve number (CN)

Soil name and hydrologic group (appendix A)	Cover description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN [1/] Table 2-2	CN [1/] Fig. 2-3	CN [1/] Fig. 2-4	Area ☐ acres ☐ mi² ☒ %	Product of CN x area
Archibald B	2+ acre residential	65			100	6500
				Totals =	100	6500

1/ Use only one CN source per line.

CN (weighted) = $\frac{\text{total product}}{\text{total area}} = \frac{6500}{100} = 65$; Use CN = 65

2. Runoff

		Storm #1	Storm #2	Storm #3
Frequency	yr	5		
Rainfall, P (24-hour)	in	1.92		
Runoff, Q .... (Use P and CN with table 2-1, fig. 2-1, or eqs. 2-3 and 2-4.)	in	0.14		

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project 24040 Boot Hill Road By DRF Date 1/30/97

Location Dodge Ranch Development Checked CJB Date 1/30/97

Circle one: Present **(Developed)**

Circle one: T_c T_t through subarea

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

$T_t = \frac{0.007(0.15 \times 300)^{0.8}}{1.5^{0.5} \times 0.03^{0.4}}$

Sheet flow (Applicable to T_c only)

		Segment ID			
1. Surface description (table 3-1)		short grass prairie			
2. Manning's roughness coeff., n (table 3-1) (0.15 short grass prairie)		0.15			
3. Flow length, L (total L ≤ 300 ft)	ft	300			
4. Two-yr 24-hr rainfall, P_2	in	1.5			
5. Land slope, s	ft/ft	2/70 = .03			
6. $T_t = \frac{0.007\,(nL)^{0.8}}{P_2^{0.5}\, s^{0.4}}$ Compute T_t	hr	0.49	+	=	0.49

Shallow concentrated flow

		Segment ID			
7. Surface description (paved or unpaved)		none			
8. Flow length, L	ft				
9. Watercourse slope, s	ft/ft				
10. Average velocity, V (figure 3-1)	ft/s				
11. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr		+	=	

Channel flow

		Segment ID			
12. Cross sectional flow area, a	ft^2	none			
13. Wetted perimeter, p_w	ft				
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r	ft				
15. Channel slope, s	ft/ft				
16. Manning's roughness coeff., n					
17. $V = \frac{1.49\ r^{2/3}\ s^{1/2}}{n}$ Compute V	ft/s				
18. Flow length, L	ft				
19. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr		+	=	
20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19)	hr				0.49

Worksheet 4: Graphical Peak Discharge method

Project 24040 · Post Hill Road By DRF Date 1/29/97

Location Dodge Ranch Development Checked CH Date 1/30/97

Circle one: Present (Developed)

1. Data:

Drainage area .... A_m = 0.0036 mi^2 (acres/640)

Runoff curve number .... CN = 65 (From worksheet 2)

Time of concentration .. T_c = 0.5 hr (From worksheet 3)

Rainfall distribution type = II (I, IA, II, III)

Pond and swamp areas spread throughout watershed ...... = Ø percent of A_m (____ acres or mi^2 covered)

		Storm #1	Storm #2	Storm #3
2. Frequency	yr	5		
3. Rainfall, P (24-hour)	in	1.92		
4. Initial abstraction, I_a .... (Use CN with table 4-1.)	in	1.077		
5. Compute I_a/P		0.56		
6. Unit peak discharge, q_u .... (Use T_c and I_a/P with exhibit 4-II)	csm/in	200		
7. Runoff, Q .... (From worksheet 2). Figure 2-6	in	0.14		
8. Pond and swamp adjustment factor, F_p .... (Use percent pond and swamp area with table 4-2. Factor is 1.0 for zero percent pond and swamp area.)		1.0		
9. Peak discharge, q_p .... (Where $q_p = q_u A_m Q F_p$)	cfs	0.1		

$q_p = 200 \times 0.0036 \times 0.14 \times 1.0$

Figure 4-2.—Worksheet 4 for example 4-1.

Volume 2: Erosion and Sediment Controls

Section 1 - Introduction

The *Catalog of Stormwater Best Management Practices for Idaho Cities and Counties*, a series of five compact discs (CDs), provides technical guidance for construction site design and the selection of stormwater best management practices (BMPs). The catalog is a guidance document containing voluntary controls that could be formally adopted by a jurisdiction to establish standards, if desired. Measures, such as those described and other recognized equivalents, should be used to manage the quantity and quality of stormwater runoff from land development.

This information is primarily intended for design professionals (e.g., landscape architects, geologists, engineers, soil scientists, etc.) and their contractors. It is also applicable for local public officials or staff who are responsible for the review and approval of development applications.

There are several reasons why technical guidance regarding stormwater management is necessary:

- Idaho remains one of the fastest growing states in the nation. The increase in population leads to an increase in land development, a recognized source of nonpoint source pollution, more commonly termed “polluted runoff.” The catalog includes BMPs that help to prevent discharge of pollutants from developing areas, both during the construction phase and for the life of the development. The BMPs can also be used to reduce polluted runoff from existing land uses.
- Many water bodies throughout the state are not in compliance with state water quality standards. Beneficial uses such as domestic water supply, fishing, swimming, boating, and agricultural water supply can often be impaired due to excessive pollutants from stormwater runoff. The catalog provides guidance for controls to reduce “conventional” pollutants, with special consideration for phosphorus and sediment, both common pollutants in Idaho.
- Federal National Pollutant Discharge Elimination System (NPDES) stormwater regulations have mandated that some communities develop and implement stormwater management programs to ensure that pollutants in stormwater runoff are controlled to the maximum extent practicable. Because polluted runoff has the potential to contribute to the degradation of receiving water quality, improved stormwater management program implementation at the local level will play an ever-increasing role in attaining and maintaining water quality standards.

In general, there are two types of BMPs for stormwater pollution control:
1. Source control BMPs focus on minimizing or eliminating the source of the pollution so that pollutants are prevented from contacting runoff or entering the drainage system.
2. Treatment control BMPs which tend to be more expensive to implement than source control BMPs, are designed to remove pollutants after they have entered runoff. Examples of source control BMPs include spill controls and employee education, while treatment control BMPs include detention ponds and oil/water separators. Most source control BMPs tend to be non-structural, and most treatment control BMPs tend to be structural in nature, although there can be exceptions. For example, a roof over a materials storage area at an industrial site would be considered a structural source control.

The majority of the practices focus on controlling pollution at its source, before runoff enters a drainage conveyance such as a sewer system or river. However, some BMPs are also included that can be used to treat runoff and remove pollutants that have already entered the drainage conveyance. The structural measures will reduce pollutant loads in post-construction site runoff, provided that the facilities are properly designed, installed, and maintained on a periodic basis.

The catalog presents general technical guidelines. Specific conditions or local regulations may require modification of the recommended BMPs, and alternative practices that are approved by a local permitting authority may also require modification or replacement of recommended BMPs. The BMP selection matrix should be used as a screening tool to assist the design professional, landowner, or reviewer in selecting the most appropriate or suitable measure based on site-specific conditions.

In order to illustrate the use and application of certain BMPs, manufacturer and product names may be used in the catalog. This does not represent an endorsement of a specific manufacturer or product.

1.1 Organization

The first volume of the CD series includes a brief discussion of stormwater runoff impacts; an overview of agencies responsible for stormwater permitting and authority in Idaho; and a step-by-step procedure for site design.

The second volume of the CD series contains construction BMPs including both erosion and sediment controls and source controls.

The third volume of the CD series introduces the concept of low-impact development and provides techniques that can minimize changes to the hydrologic functioning of a development site.

The fourth volume of the CD series contains post-construction/ permanent BMPs.

The fifth volume of the CD series provides BMPs for specific land use activities, including industrial, commercial, and residential activities.

The catalog is intended for use in conjunction with local governmental requirements, such as applicable planning and building codes. The catalog is not all-inclusive and should be used along with other reference books and manuals published by other agencies as necessary or appropriate based on local conditions and policies.

1.2 Updates

The practice of stormwater management is quickly evolving. Design information for various BMPs is expected to change as more people apply the practices and learn from their experience. New BMPs will also be added to the mix. To accommodate these changes, periodic updates and amendments will be made to the catalog. These will be posted on the Department of Environmental Quality (DEQ) Web site as they become available.

Section 2 - Construction Site Discharge Controls

This volume of the *Catalog of Stormwater Best Management Practices for Idaho Cities and Counties*, presents Best Management Practices (BMPs) that are designed to control stormwater pollution during the construction phase of a project. The categories of BMPs include contractor awareness and education, general construction site guidelines, housekeeping, slope protection, storm drain and channel protection, sediment collection, and permanent stabilization. Each BMP fact sheet presents application and limitations information, as well as design parameters, construction guidelines, and maintenance tips. Pollutant removal effectiveness is also included. Contact the local permitting authority for additional requirements or restrictions that may apply to any of the BMPs discussed in this volume.

2.1 Federal Stormwater Requirements

Federal stormwater regulations require that some communities develop and implement stormwater management programs to ensure that pollutants in stormwater runoff are controlled to the maximum extent practicable. Because polluted runoff has been shown to contribute significantly to the degradation of water quality, stormwater management at the local level will play an ever-increasing role in attaining and maintaining water quality standards.

Under the National Pollution Discharge Elimination System (NPDES) stormwater program, stormwater discharges from so-called large, medium, and regulated-small municipal separate storm sewer systems (MS4s) should be authorized under an NPDES permit. Congress instructed Environmental Protection Agency (EPA), through the Clean Water Act (CWA), to implement the stormwater program in two phases: Phase I and Phase II.

Public organizations responsible for operating and maintaining these separate storm sewer systems - entities such as cities, counties, states, and/or the federal government - may be required to obtain an NPDES permit to discharge stormwater to waters of the United States. EPA's Phase I stormwater rules were finalized in 1990. Under Phase I, medium and/or large MS4 operators (broadly defined as communities serving populations of 100,000 people or more, based on the 1990 Census) were required to submit comprehensive NPDES permit applications between 1992-1994; based on such applications, the state or EPA NPDES permitting authorities issued individual NPDES permits to those municipalities. Boise City, Garden City, the Ada County Highway District, District 3 of the Idaho Transportation Department, Ada County Drainage District 3, and Boise State University are the only entities in the state of Idaho to be regulated under Phase I.

The Stormwater Phase II final rule expands the existing Phase I program by requiring operators of small MS4s in urbanized areas to implement programs and practices to control polluted stormwater runoff. A regulated-small MS4 is defined in the Phase II stormwater rules as any small MS4 located in "urbanized areas" as defined by the Bureau of the Census, as well as those small MS4s located outside of an urbanized area that are designated to be included by NPDES permitting authorities.

The Phase II final rule requires an operator of a regulated small MS4 to develop, implement, and enforce a program to reduce pollutants in stormwater runoff to their MS4 from construction activities that result in a land disturbance of greater than or equal to 1 ac. The MS4 operator is required to implement a program that includes the following practices under Phase II (40CFR122.34(b)(4)(ii)):

- An ordinance or other regulatory mechanism to require erosion and sediment controls, as well as sanctions to ensure compliance, to the extent allowable under state, tribal, or local law
- Requirements for construction site operators to implement appropriate erosion and sediment control (ESC) best management practices
- Requirements for construction site operators to control waste, such as discarded building materials, concrete truck washout, chemicals, litter, and sanitary waste at the construction site that may cause adverse impacts to water quality
- Procedures for site plan review that incorporate consideration of potential water quality impacts
- Procedures for receipt and consideration of information submitted by the public
- Procedures for site inspection and enforcement of control measures

Construction activities (including other land-disturbing activities) that disturb 1 ac. or more are also regulated under the NPDES stormwater program. On March 10, 2003, new regulations came into effect that extended coverage to construction sites that disturb 1-5 acres in size, including smaller sites that are part of a larger common plan for development or sale. Sites disturbing 5 acres or more were regulated previously.

Operators of regulated construction sites are required to develop and implement stormwater pollution prevention plans and to obtain permit coverage from EPA under the Construction General Permit (CGP). The CGP outlines a set of provisions that construction operators should follow to comply with the requirements of the NPDES stormwater regulations and requires all owners of land where applicable construction activity occurs to take the following steps:

- Submit a Notice of Intent (NOI) to comply with the CGP
- Eliminate or minimize non-stormwater discharges from the construction site to storm drains and other water bodies(Non-stormwater discharges may result from a variety of sources, including dumping, leaking storage and maintenance areas, and spillage of chemicals and waste materials)
- Develop, implement, and update a Stormwater Pollution Prevention Plan (SWPPP) for the site
- Develop a site-monitoring program and perform inspections of the measures implemented as part of the SWPPP

In general, you need to apply for coverage under the CGP if your construction site will disturb 1 ac. or more (this also applies to smaller sites that are part of a larger, common plan of development or sale that is greater than 1 ac. in size), and you are responsible for either the construction plans and specifications, including the ability to make modifications to those plans and specifications (e.g., an owner, developer, general contractor) or the day-to-day activities at a project that are necessary to ensure compliance with a stormwater pollution prevention plan for the site (e.g., general contractor). The owner and the operator of the land where the construction takes place may be responsible for filing the NOI, complying with the terms of the CGP, and seeing that all contractors comply with the CGP as well. If an individual purchases a property with a project in-process and construction is to continue, a separate NOI should be filed by the new owner. Once construction and final site stabilization is complete or site ownership has been transferred, a Notice of Termination should be filed to verify that CGP coverage is no longer necessary.

A working copy of the SWPPP should be kept at the construction site or be available for review by EPA and local regulatory agencies. A copy of the Stormwater General Permit IDR 1000000 and the NOI for the project should be attached to this SWPPP.

The SWPPP should be amended whenever there is a change in design, construction, operation, or maintenance that has a significant effect on the potential for discharge of pollutants to surface waters or an MS4. The SWPPP should also be amended if it proves to be ineffective in significantly reducing pollutants. The SWPPP also should be amended to indicate any new contractor and/or subcontractor that will implement any measure of the SWPPP. All amendments should be signed, dated, and kept as attachments to the original SWPPP.

More information about the Construction General Permit requirements can be found at http://cfpub.epa.gov/npdes/stormwater/cgp.cfm.

2.2 Plan Preparation

The purpose of the Construction Site Discharge Control Plan (Plan), also referred to as the Erosion and Sediment Control Plan or Stormwater Pollution Prevention Plan, is to establish clearly which control measures are intended to prevent erosion, sediment transport, and the off-site discharge of pollutants. The Plan reviewer, the construction superintendent and other contractor personnel, and the construction site inspector will use the Plan. The Plan should be designed to show the contractor when, how, and where BMPs will be physically implemented. It should also demonstrate to the regulators what methods will be used to achieve compliance with water quality regulations.

The Plan should be completed before the project goes to bid so that all potential contractors know what will be expected. The Plan should provide specific, reasonable controls that allow a contractor to bid on and to build the project profitably. The approved Plan should be part of the general construction contract. The method of payment for implementing this Plan should be specifically stated in the contract, and erosion and sediment control should be considered an early pay item.

The following information provides a general overview of site planning considerations and choosing BMPs that most effectively fit the conditions of the site and type of development project. For the selection of the most appropriate or suitable BMP, the user should refer to the BMP Selection Matrix in Table 1. It is essential to check with the local permitting authority for other requirements.

2.21- Planning

Planning the operation to fit the existing site features - including soils, vegetation, precipitation, and topography - is essential. The initial step in plan preparation is to gather information on the site where construction is to take place.

2.22-Soils

Soil texture is determined by the proportion of sand, silt, and clay particles in the soil. Soil texture affects the erodibility of the soil, how quickly soil particles will settle out of runoff, and the amount of runoff that will occur at a site. Soil erodibility is greater in the case of silts and fine sands than clays or soils with substantial gravel content. Relatively high organic content also offers cohesiveness that resists erosion. Clays tend to produce a larger volume of runoff, however, because of their relatively poor permeability.

Soil texture influences runoff volumes and infiltration potential. Water percolates more rapidly into coarsely textured, highly porous soils. Finely textured silt and clay soils permit almost no infiltration, generating large runoff volumes. Finely textured soils also take longer to dry between storm events and may remain unworkable for long periods of time.

There are several ways to determine the potential for erosion and sediment transport problems associated with the soils. These include geotechnical reports, county soil surveys, jar testing, and hand texturing. Materials engineers prepare geotechnical reports, which include structural properties of soils for construction purposes. These reports include information on soil erodibility, infiltration rates, groundwater levels and often provide specific recommendations to prevent erosion, such as stating maximum allowable slope angles or stating when retaining walls are required.

The Natural Resource Conservation Service (NRCS) has performed soil surveys throughout the state of Idaho and has developed maps that show specific soil classifications for any given location. Soil maps are compiled by county and are available from the NRCS office.

2.23-Vegetation

Vegetation is the most important factor in terms of preventing erosion. Vegetative ground cover offers a number of important advantages, including reducing raindrop impact, slowing runoff velocity, helping to absorb water, and holding soil in place. Elimination of vegetation effectively decreases the soil's ability to hold and process water and may result in a decrease in groundwater recharge. Limiting and staging the removal of existing vegetation and decreasing the area and duration of soil exposure can significantly reduce soil erosion and sediment transport.

2.24-Precipitation

Precipitation characteristics, such as frequency, intensity and duration, directly influence the amount of runoff that occurs and the potential for erosion on a site, particularly when the precipitation is in the form of rainfall. As the frequency of rainfall increases, the soil may remain saturated for long periods of time, and the volume of runoff may be greater. Higher intensity storms produce rainfall with higher velocities, thereby generating more erosion. Longer storm events also increase the erosion potential simply due to their duration. Seasonal variation in precipitation affects erosion potential, as do seasonal temperature variations. Frozen soils are relatively erosion resistant but can result in high runoff if rainfall does occur.

Although weather cannot be controlled during a construction project, builders can minimize erosion through proper timing, phasing, and BMP selection if general weather patterns are known. Average monthly precipitation totals give a good starting point to determine how projects should be phased and at what times of year the site should be most heavily protected. Extreme events, not averages, are responsible for sever erosion problems. The probability of extreme events can be easily created to assess the probability of any rainfall amount over any given time period.

There is a wealth of readily available weather data on the Internet. The Western Regional Climate Center has statistical information on precipitation, temperature, and several other measurements on their Web site. Included on their site is tabular and graphical information as well as interactive probability graphing capabilities. The Web address for the Western Regional Climate Center is http://www.wrcc.dri.edu/summary/climsmid.html.

2.25-Topography

Topography - the size, gradient, and stability of slopes - in the project work area should be evaluated to assess the potential risks during construction. The potential for erosion increases exponentially with increasing slope length and gradient. With increased slope lengths and gradients, runoff travels faster with more erosive energy. Higher velocity runoff forms rills and gullies that concentrate erosive flows and energy even further.

Areas with little topographic relief pose the least threat of erosion due to terrain. Slopes can be grouped by slope gradient and degree of potential erosion hazard as in Table 1:

Table 1. Erosion Hazard Based on Slope Gradient and Length

Erosion Hazard	Slope Gradient	Maximum Length
Low	0-7%	300 ft.
Moderate	7-15%	150 ft.
High	>15%	75 ft.

However, a slope with a low erosion hazard may still require soil erosion control measures because of its length, the highly erosive nature of the soil, the size of the drainage area, or the lack of vegetative protection. The relative erodibility of the various soils can be determined from the soil map and the soil descriptions.

When evaluating site topography, try to identify areas that can be used to reduce the risk of turbid water discharges. Closed depressions, flat areas or gently-sloped/heavily-vegetated areas can often be used to treat runoff and eliminate the risk of discharges during construction.

Natural drainage patterns that exist on the site should be identified as critical areas where water will concentrate. Where possible, natural drainage ways should be used to convey runoff over and off the site to avoid the expense and problems of constructing an artificial drainage system. Man-made ditches, diversions, and waterways will become part of the erosion problem if they are not properly constructed and stabilized. Care should also be taken to be sure that increased runoff from the site will not erode or flood the existing natural drainage system.

If there are erosion-sensitive areas on or around the project site, special precautions should be taken to minimize erosion during construction. Stream and wetland boundaries should be delineated and shown with their buffer zones on the plan. Perimeter control BMPs, such as clearing limit fences, silt fences, vegetation buffer strips, etc., should always be placed between the site and downslope sensitive areas to identify erosion-sensitive areas.

2.3- Scheduling

Contractors should schedule grading and earthmoving operations to expose the smallest practical area of land for the shortest possible time. The clearing and grubbing of excessively large areas of land at one time is an unnecessary invitation to sediment problems. These initial earth-disturbing activities should be kept to a bare minimum. On the areas where disturbance takes place, consider staging of construction, temporary seeding, and/or temporary mulching as a technique to reduce erosion. Staging of construction involves stabilizing one part of the site before disturbing another. In this way, the entire site is not disturbed at once, and the time without ground cover is minimized. If possible, schedule land disturbance activities during dry seasons or periods.

2.4- Soil Erosion Control

Apply soil erosion prevention and control practices as a first line of defense against off-site damage. Selection of the appropriate BMP should be based on the type of erosion that could occur on a construction site, the physical features of the site, and the types of activities that will be performed on the site. The following are some of the different types of erosion that may be encountered.

Raindrop erosion is the first effect of a rainstorm on the soil. Raindrop impact dislodges soil particles and splashes them into the air. These detached particles are then vulnerable to sheet erosion.

Sheet erosion is the erosion caused by a shallow sheet of water as it runs over the land. These very shallow, moving sheets of water are seldom the detaching agent, but the flow transports soil particles that are already detached by raindrop erosion. The shallow surface flow rarely moves as a uniform sheet for more than a few feet on land surfaces before concentrating in surface irregularities. Preserving existing vegetation where possible and soil stabilization reduce raindrop erosion and sheet erosion. However, if allowed to start, sheet erosion can lead to Rill erosion.

Rill erosion is the erosion that develops as the shallow surface flow begins to concentrate in the low spots of the landscape surface. As the flow changes from shallow sheet flow to deeper flow in these low areas, the velocity and turbulence of flow increase. The energy of this concentrated flow is able to detach and transport soil particles. This action begins to cut tiny channels of its own. Rills are small but well-defined channels that are, at the most, only a few inches deep. They are easily obliterated by harrowing or other surface treatments and have no more than 1 square ft cross-section.

Gully erosion is when the flow in individual rills combine to create larger channels. The major difference between gully and rill erosion is size. Gullies are too large to be repaired with conventional tillage equipment and usually require heavy equipment and special techniques for stabilization.

Channel erosion is caused by the volume and velocity of flow causing movement of the streambed and bank materials.

Step Four - Sediment Control

Apply sediment control practices as a second line of defense against off-site damage. It provides a backup when all possible erosion control measures have been utilized. Whereas erosion control practices are designed to prevent soil particles from being detached, sediment control involves using practices that prevent the detached soil particles, or sediment, from leaving the disturbed area and reaching the receiving waterways. This goal is accomplished by reducing the capacity of surface runoff to transport sediment and by containing the sediment on site. Sediment control practices are designed to slow the flow of water by spreading, ponding, or filtering.

Step Five - Control Non-Stormwater Discharges

Construction sites can generate many other pollutants, in addition to sediment, through paving operations, handling and storage of various materials, spills, and waste handling. These pollutants include such things as petroleum products, solvents, paints, sanding dusts, pesticides, and fertilizers. There is also the potential for runoff contamination from sources that produce these pollutants and inspect the site accordingly. Solid waste can also be a problem at construction sites, and litter control should be used on every construction site as a BMP.

Step Six - Maintenance

It is important to implement a thorough maintenance program before, during, and after development is completed. Inspect all BMPs and additional safeguards to determine that they are working properly and to ensure that problems are corrected as soon as they develop. The maintenance schedule should be based on site conditions, design safeguards, construction sequence, and anticipated weather conditions.

Inspections should include materials storage areas, locations where vehicles enter and exit the site, the operational functionality of BMPs, and evidence of pollutants entering the drainage system in disturbed areas. An individual should be assigned the responsibility for routine checks of operating practices. All temporary and permanent erosion control BMPs should be maintained and repaired as needed to assure continued performance of their intended function.

2.3 Stormwater Pollution Prevention Plan

Plan Narrative

The Plan narrative should contain an introduction, analysis, and conclusion. The narrative should also include details of the stormwater pollution prevention concepts and techniques used before and during construction, up to final landscaping, to control soil erosion. Tracking on public roadways and sediment discharge should also be addressed. The Plan narrative should explain the sequence of events that will take place during construction and the rationale behind the design of the site. The following points should be covered by the narrative:

- Project description, including an approximate schedule for completion
- Description of existing and modified site conditions, including receiving waters
- Description of potential pollutants
- The location and schedule of soil disturbance
- Descriptions of BMPs, including their purpose and construction installation details. Include good housekeeping practices such as litter control, including general waste management and concrete waste management. Table 1 provides an overview of selected requirements and pollutant removal effectiveness for various types of construction/temporary BMPs and permanent BMPs. Use Table 1 to give a general sense of the range of nonstructural and structural BMPs that could be appropriate for the site. Table 1 also shows which BMPs should be eliminated from further consideration due to restrictive site-specific conditions
- Plans for permanent stabilization
- Calculations used for the design of stormwater management measures, if any
- An inspection and maintenance schedule
- Location of any signage on the site. Sign includes a copy of NOI and identifies the location of SWPPP
- The name, title, address, and telephone number of the landowner or owner's representative

The Plan should be typed on 8.5 x 11 in. paper and bound in a sturdy binder. Maps, diagrams, and figures should be clearly labeled and folded to fit within the binder. The Plan should contain the title on the outside of the binder and include a title sheet, table of contents, list of figures and tables, and the narrative or body, in that order.

The project description should include the schedule of operations. Present the construction activity schedule of the general contract as part of the Plan. The installation of erosion control BMPs should be tied to the order of land disturbing activities in the construction schedule. The following types of activities should be included in the schedule:

- Installation of perimeter control and detention BMPs prior to soil-disturbing activities
- Phasing and timing of clearing, grubbing, and grading
- Short-term BMP strategies
- Installation of permanent BMPs and a description of how temporary BMPs have been coordinated with the development of permanent measures
- Erosion control inspection and maintenance schedule

The schedule should discuss the timing of the installation or use of the BMPs in relationship to clearing, grading, and construction activities. The schedule should also include inspection and maintenance activities during construction.

Plan Sheets

The Plan sheets are the most important part of the erosion control plan. Site plans are maps and engineering plans illustrating and specifying the project's location, existing and modified site conditions, and BMPs. The following information should be included in the of site plan:

- The location of the proposed construction site in relation to the surrounding area
- Property boundaries and lot lines
- The north arrow, scale, and date
- The location of proposed structures and impervious features, including roadways and utilities
- The location of water conveyance systems and new or modified drainage systems (including system dimensions)
- Existing topography and drainage patterns
- Approximate slopes after grading (2-ft intervals)
- Existing vegetation and areas of clearing
- Areas of soil disturbance.
- The location of critical areas, such as water bodies and wetlands
- The location of major structural controls and areas where stabilization practices are to occur. (see Appendix D for map symbols)
- Geology or geotechnical engineering reports, if this information was used for design purposes. (An engineering geology or geotechnical report providing recommendations for erosion control may need to be submitted upon a determination that additional information is required.)

All temporary and permanent erosion control features should be shown on the plan sheets. See Appendix D for map symbols. In addition to the BMPs, plan sheets should show the clearing and grubbing limits, cut and fill slope lines, topography, impervious features, drainage features, environmentally sensitive areas and associated buffer zones, receiving water, and stormwater treatment areas.

The plan sheets will be used by the contractor to install the BMPs and by the regulators to evaluate the site for compliance. The Plan should include details and notes that correspond to erosion and sediment controls on each plan view. In addition to instructions on installation and maintenance, the Plan should indicate when to remove controls that are no longer needed.

2.4 Plan Implementation

The prevention of water pollution is a responsibility shared by everyone involved in the development/construction process. The Plan designer is responsible for determining the type of controls that will be needed to control erosion, sedimentation, and the discharge of pollutants from the construction site.

During site preparation, BMPs should be installed in accordance with the Plan. Successful erosion control depends on proper installation of BMPs, and proper installation of BMPs depends on effective communication between the designer and contractor. Contractors must understand why BMPs are needed and how to install them correctly. For most large projects, a pre-construction conference is recommended. At a pre-construction conference, the main contractor and subcontractors should review the approved plan and discuss any questions or potential problems..

The responsible person should see that the Plan is implemented correctly and provide support of pollution prevention practices for all construction activities. Once implemented, controls should be monitored and maintained to ensure their effectiveness. The controls should be monitored before and after each rainstorm to assess effectiveness. When inspections reveal problems, they should be addressed without delay, and any necessary modifications, repairs, cleaning, or other maintenance operations performed expeditiously.

Ensure that control measures are updated and that the Plan is amended as necessary and as dictated by changes in construction and the construction schedule. Significant changes should be resubmitted for approval to local jurisdictions before they are implemented. Approved changes and associated formal documentation should be noted on the Plan. Finally, ensure that site stabilization and landscape installation occurs, as specified in the Plan.

Contractor Awareness and Education

One of the best and most cost-effective measures for controlling stormwater pollution at new construction sites is for the general contractor to encourage pollution awareness among crew leaders, or, on smaller jobs, individual workers. The general contractor needs to be aware that he/she is responsible for educating and informing all subcontractors. Education may take many forms, including the following:

- Provide copies of the construction BMP plan and applicable BMP fact sheets to the crew leaders

- Point out and label sensitive areas that should not be disturbed during the project
- Clearly tag trees and other vegetation that should be removed and instruct crew leaders not to remove or disturb any other vegetation without prior approval
- Discuss techniques and answer questions about erosion and pollution control at regular site safety meetings
- Demonstrate proper housekeeping methods, including proper use and application of water for dust control
- Inform the crew leaders of actions to take in the event of a spill of toxic materials (e.g., used oil, hydraulic fluid, pesticides, or herbicides)
- Post signs throughout the site at key locations reminding crew leaders how to properly store construction materials, handle and dispose of toxic or solid wastes, dispose of wash water, and similar instructions
- Remind the crew leader of fines and penalties that may be levied against the project by the permitting agencies if pollution is not properly controlled

Section 3 – General Construction Site Guidelines

For the selection of the most appropriate or suitable BMP, the user should refer to the BMP Selection Matrix in Table 1. It is essential to check with the local permitting authority for other requirements. The following pages contain BMP fact sheets providing general guidelines for all construction site activities, including these topics:

Timing of Construction BMP 1

Description

Schedule and sequence construction work and erosion control applications so that they occur under optimal conditions--that is, during periods when the potential for erosion is lowest. Proper timing will minimize erosion and also maximize the effectiveness of control methods.

Applications

This measure applies to almost any ground-disturbing activity, but it is especially relevant to large construction projects and any areas where work activities can be planned to coincide with periods of low erosion potential, such as during dry weather. The period May 15 through November 1 is recommended as the best time for initiating construction activities and completing soil stabilization in most of Idaho. When construction during the wet season is unavoidable, use other BMPs described in this catalog to control erosion, such as any of the slope protection techniques.

Limitations

Drainage area - unlimited
Minimum bedrock depth - N/A
NRCS soil type - ABCD
Drainage/flood control – no
Maximum slope – unlimited
Minimum water table – N/A
Freeze/thaw – good

Targeted Pollutants

Sediment

Design Parameters

- Construction work involving soil disturbance or exposure should be scheduled during seasonal low-runoff periods under favorable soil moisture conditions whenever possible.
- Erosion controls should be installed in stages to protect completed work and minimize exposed soils.
- Sediment collection systems should be installed prior to activities expected to produce sediment.
- Slope stabilization measures should be initiated within 14 calendar days after construction activities in that portion of the site where earthmoving activities have temporarily or permanently ceased.
- Consider site characteristics and permit conditions when deciding what kind of erosion control devices to incorporate into a construction project. Select measures that can be installed without disrupting critical timing or sequencing of other construction or erosion control activities.
- Identify the locations and dimensions for all erosion control and stormwater management measures as clearly as possible on the site plans. This will help ensure effectiveness and proper timing of installation or implementation.

Construction Guidelines

- Develop a scheduling/sequencing plan that addresses the following timing considerations. If using a Critical Path Method (CPM) for scheduling, incorporate the erosion control and stormwater management practices into the CPM.

- Work activities that leave a site most susceptible to erosion should be scheduled for periods when the potential for erosion is lowest.
- Allow time to install sediment collection systems, drainage systems, and runoff diversion devices before beginning ground-disturbing work in a given area.
- Plan to install and maintain effective soil stabilization measures as work progresses, not just at the completion of all construction.
- Conduct work in units or stages so that some portions of the project site are final-graded and ready for seeding each time an approved season of seeding arrives. (See BMP 2-Staging Areas).

Maintenance Continually monitor site conditions and progress of work. Update the project work schedule to maintain appropriate timing and sequencing of construction and control applications.

Staging Areas BMP 2

Description

This BMP includes measures for collecting runoff from a staging area, materials storage site, or industrial activity area or for diverting water flow away from such areas so that pollutants do not mix with clean stormwater runoff. Various flow diversion structures, called stormwater conveyances, can be used to contain runoff on site, to channel it around the industrial area, or to carry pollutant-laden water directly to a treatment device or facility. Several options are available:

Stormwater Conveyances: This term includes many kinds of channels, gutters, drains, and sewers. Stormwater conveyances can be either temporary or permanent. They are constructed or lined with many different materials, including concrete, clay tiles, asphalt, plastics, metals, riprap, compacted soils, and vegetation. The type of material used depends on the use of the conveyance.

Dikes or Berms: Diversion dikes or berms are ridges built to block runoff from passing beyond a certain point. Temporary dikes are usually made with compacted soil or compost. More permanent ones are constructed out of concrete, asphalt, or other durable materials.

Diversion dikes are used to prevent the flow of stormwater runoff onto construction or staging/storage areas. Limiting the flow across these areas reduces the volume of stormwater that may carry pollutants from the area and may, therefore, require treatment. This method is suitable for sites where significant volumes of stormwater runoff tend to flow onto active materials handling or equipment staging sites and other construction areas.

Graded Areas and Pavement: Land surfaces can be graded, or graded and paved, so that stormwater runoff is directed away from construction activity areas. The slope of the grade allows the runoff to flow, but keeps it from washing over areas that may be contaminated with pollutants. Like conveyances and dikes, grading can prevent runoff from entering construction areas and becoming contaminated with pollutants from these areas. Grading can be a permanent or temporary control measure.

Applications

Stormwater Conveyances: Stormwater conveyances can be used for two different purposes. The first is to keep uncontaminated stormwater from getting into areas of a construction site where it may become contaminated. This can be accomplished by collecting the stormwater in a conveyance and directing the flow away from those areas. Secondly, conveyances can be used to collect stormwater downhill from construction areas and keep it separate from runoff that has not been in contact with those areas. When potentially contaminated stormwater is collected in a conveyance like this, it can be directed to a treatment device or another facility on the site if desired.

Other beneficial aspects of stormwater conveyances include:

- Prevention of temporary flooding at industrial sites.
- Low maintenance.
- Erosion-resistant conveyance of stormwater runoff.
- Long-term control of stormwater flows.

Dikes or Berms: Typically, dikes are built on slopes just uphill from an active construction area together with some sort of a conveyance, such as a swale. The conveyance is necessary to keep the water away from the dike so that the water will not pool and seep through the dike. See BMP 41-Earth Dike.

Some advantages of diversion dikes are that they:

- Effectively limit stormwater flows over industrial site areas.
- Can be installed at any time.
- Are economical, temporary structures when built from soil on site.
- Can be converted from temporary to permanent at any time.

Graded Areas and Pavement: Grading is appropriate for any construction site where outdoor activities may pollute stormwater runoff--parking lots or outdoor storage areas, for example. Grading is often used in conjunction with coverings, buffer zones, and other practices to reduce the runoff velocity, increase infiltration of uncontaminated runoff, or direct pollutant-laden runoff to stormwater treatment facilities. Grading and paving are relatively inexpensive and easy to implement.

Limitations

Drainage area - unlimited	Maximum slope – 15%
Minimum bedrock depth - N/A	Minimum water table – N/A
NRCS soil type - ABCD	Freeze/thaw – good
Drainage/flood control – yes	

Stormwater Conveyances:
Once the stormwater is concentrated in conveyances, it should be routed through stabilized structures all the way to its discharge to a receiving water or other stormwater BMP.

- May increase flow rates.
- May be impractical if there are space limitations.
- May be expensive to install, especially for small facilities or after a site has already been constructed.

Dikes and Berms

- Are not suitable for large drainage areas unless there is a gentle slope.
- May require maintenance after heavy rains.

Graded Areas and Pavement

- May be uneconomical to re-grade and resurface large areas.
- May not be effective during heavy precipitation.

Targeted Pollutants

Sediment

Design Parameters

Stormwater Conveyances: In planning for stormwater conveyances, consider the amount and speed of the typical stormwater runoff. Also, consider the stormwater drainage patterns, so that channels may be located to collect the most flow and can be built to handle the amount of water they will receive. When deciding on the type of material for the conveyance, consider the resistance of the material, its durability, and its compatibility with any pollutants it may carry.

Conveyance systems are most easily installed when a facility is first being constructed. Where possible, use existing grades to decrease costs. Grades should be positive to allow for the continued movement of the runoff through the conveyance system; however, grades should not create an increase in velocity that causes an increase in erosion. Consider the materials used for lining the conveyance and the types of outlet controls provided.

Dikes and Berms: In planning for the installation of dikes, consider the slope of the drainage area, the height of the dike, the amount of runoff it will need to divert, and the type of conveyance that will be used with the dike. Steeper slopes result in higher volumes of runoff and higher velocities, which the dike should be capable of handling. Remember that dikes are limited in their ability to manage large volumes of runoff. See BMPs 41-Earth Dike for additional parameters.

Graded Areas and Pavement: When designing graded and paved areas, be sure to consider both control and containment of runoff flows. The grading should control the uncontaminated flow by diverting it around areas that may have pollutants. The grading should also contain the contaminated flows or divert them to treatment facilities.

Construction Guidelines

Stormwater Conveyances: Specific construction methods apply to the type of conveyance being used.

Dikes and Berms: Ideally, dikes are installed before construction activity begins. However, dikes can be easily constructed at any time. Temporary dikes (usually made of dirt) generally only last for 18 months or less, but they can be made into permanent structures by stabilizing them with vegetation. Slope protection such as vegetation is crucial for preventing the erosion of the dike.

Graded Areas and Pavement: Staging/storage areas should be designated prior to the start of construction.

Maintenance

- It is best to inspect stormwater conveyances within 24 hours of a rainstorm and remove debris promptly. Make daily inspections during periods of prolonged rainfall, since heavy storms may clog or damage the conveyances. It is important to repair damage to these structures as soon as possible.

- Dikes should be inspected regularly for damage. This is especially important after storm events since a heavy rain may wash parts of a temporary dike away. Any necessary repairs should be made immediately to make sure the structure continues to function effectively.
- Inspect unpaved, graded areas to check for gullies and other signs of erosion. Inspect paving regularly for cracks that may allow contaminants to seep into the ground. Also, check to make sure that the drains receiving the discharge from the paved area remain free of clogged sediment or other debris so that the water does not back up into areas where pollutants may be.

Preservation of Existing Vegetation — BMP 3

Description

Protect existing vegetation (including trees, grasses, and other plants) by preventing disturbance or damage to specified areas of a construction site or right-of-way. Preserving natural vegetation provides buffer zones and stabilized areas, which help control erosion, protect water quality, and enhance aesthetic benefits. This practice minimizes the amount of bare soil exposed to erosive forces.

Applications

This technique is applicable to all types of sites. Areas where preserving vegetation can be particularly beneficial are floodplains, wetlands, stream banks, steep slopes, and other areas where other structural erosion controls would be difficult to establish, install, or maintain. Compared to newly planted or seeded areas, preserving natural vegetation has many advantages:

- It can handle higher quantities of stormwater runoff than newly seeded areas.
- It does not require time to establish (it is effective immediately).
- It has greater filtering capacity because the vegetation and root structure are usually denser in preserved natural vegetation than in newly seeded or base areas.
- It usually requires less maintenance, watering, and chemical application (e.g., fertilizer, pesticides) than planting new vegetation.

It also:

- Enhances aesthetics.
- Provides areas for infiltration, thus reducing the quantity and velocity of stormwater runoff.
- Allows areas where wildlife can remain undisturbed.
- Provides noise buffers and screens for on-site operations.

Limitations

Drainage area - unlimited	Maximum slope – unlimited
Minimum bedrock depth - N/A	Minimum water table - N/A
NRCS soil type - ABCD	Freeze/thaw – good
Drainage/flood control – no	

Preservation of natural vegetation may be impractical in some situations because:

- It may constrict the area available for construction activities.
- It may not be cost-effective in areas with high land values.

Targeted Pollutants

Sediment

Design Parameters

- Successful preservation of vegetation requires good planning and site management to minimize the impact of construction activities on existing vegetation. The areas to be preserved should be identified in the plans and clearly marked in the field before any site disturbance begins. Clearly mark all trees to be preserved, and protect against ground disturbance within the dripline of each marked tree.

The dripline marks the edge of the tree's foliage where drips from rainfall would drop. Most of the tree's roots lie within the dripline and are vulnerable to damage.

- Preserving natural vegetation may affect some aspects of staging, work sequencing, and construction cost. In addition, control measures may be needed around the perimeter of the preserved area to maintain adequate water flow and drainage and to prevent damage from excessive erosion or sedimentation. Be sure to consider these and related factors when preparing the project site plan and project cost estimates.
- Consider the use of design exceptions to enable preservation of natural vegetation in certain areas where it would typically be removed and where its preservation would not pose safety problems.

Construction Guidelines

- Check the project plans for areas designated for preservation of natural vegetation. Keep all construction equipment, materials, and waste out of the designated areas.
- Do not modify existing drainage patterns through or into any preservation area unless specifically directed by the plans or approved by the local permitting authority.
- Perform maintenance activities as needed to ensure that the vegetation remains healthy and able to aid in erosion control and sediment collection.

Maintenance

Inspect at regular intervals to make sure the preserved vegetated areas remain undisturbed and are not being overwhelmed by sediment. Implement maintenance or restorative actions as needed. Proper maintenance is important to ensure healthy vegetation that can control erosion. Different species, soil types, and climatic conditions will require different maintenance activities such as mowing. Maintenance should be performed regularly, especially during construction.

Clearing Limits BMP 4

Description

Minimize the total amount of bare soil exposed to erosive forces by (1) controlling the amount of ground that is cleared and grubbed at one time in preparation for construction, and (2) limiting the amount of time that bare ground may remain exposed before slope protection or stabilization measures are put into place. This measure, in conjunction with appropriate timing (avoiding the rainy season), can reduce erosion and sedimentation.

Applications

Any areas where vegetation should be removed to facilitate construction. This practice should be a design consideration of all projects. It may be necessary to carefully coordinate land clearing, grading, and erosion control measures--see BMP 1-Timing of Construction.

Limitations

Drainage area - unlimited
Minimum bedrock depth - N/A
NRCS soil type - ABCD
Drainage/flood control – no
Maximum slope – unlimited
Minimum water table - N/A
Freeze/thaw – good

Targeted Pollutants

Sediment

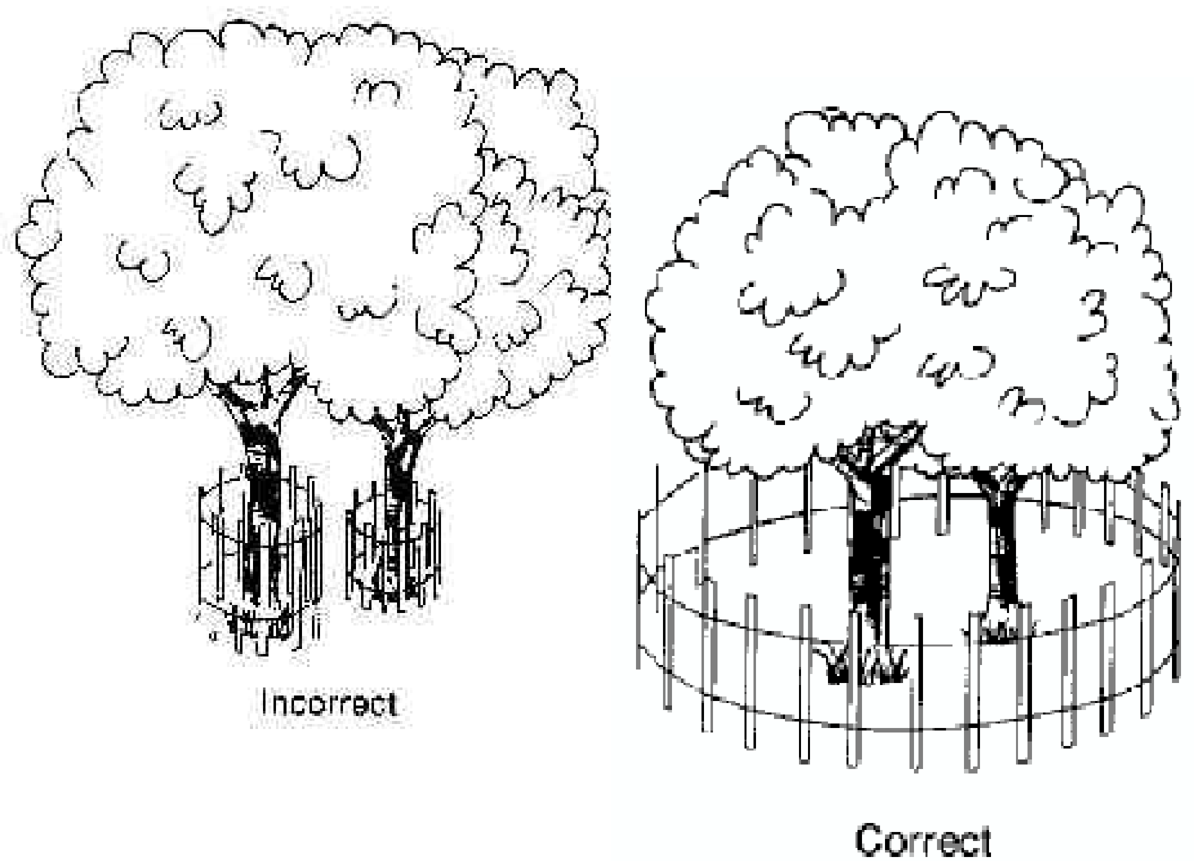
Design Parameters

- Evaluate the erosion potential of the project site (based on slope, soil type, intended season of work, use of heavy equipment).
- Based on the above analysis, establish the maximum allowable area that may be exposed at one time. The project site plan should clearly specify the maximum allowable exposure area.
- Initiate slope protection and reclamation as work progresses to help minimize the amount of disturbed soil.
- In all cases, stabilization measures should be initiated within 14 days after ceasing work in a given area or as soon as practicable during seasonally arid periods.

Construction Guidelines

- Do not disturb any areas that are not actually needed for the specified construction or related staging activities. See BMP 3-Preservation of Existing Vegetation.
- Conduct work in units or stages so that construction and stabilization take place promptly after clearing and grubbing and as much of the site as possible is ready for seeding each time the specified seeding season arrives.
- Implement soil stabilization measures concurrently with the progress of clearing and grading work to minimize the length of time that bare ground lies exposed to erosion.
- At the approach of a designated seeding season, be prepared to seed all portions of the project that are ready for seeding (as required).

Maintenance Conduct periodic inspections to check for unnecessary ground disturbance. Also check for clearing and grubbing beyond the contractor's capability and progress in keeping grading and pollution control measures current (in accordance with accepted work schedule).



Barrier should be installed at the drip line of tree branches.

Stabilization of Construction Entrance/Exit — BMP 5

Description

A temporary sediment removal device--normally a pad of crushed rock or stone--can be installed at the approach from a construction site to a public roadway to stabilize the road. This BMP is used to limit sediment tracking from vehicles and equipment leaving the construction site onto public rights-of-way and streets.

Applications

A stabilized construction entrance is appropriate in the following locations:

- Wherever vehicles are entering or leaving a construction site to or from a public right-of-way, street, alley, sidewalk or parking area.
- At any unpaved entrance/exit location where there is risk of transporting mud or sediment onto paved roads.

Limitations

Drainage area - unlimited
Minimum bedrock depth – 3 ft
NRCS soil type - ABCD
Drainage/flood control – no
Maximum slope – 15%
Minimum water table – N/A
Freeze/thaw – good

Targeted Pollutants

- Sediment
- Phosphorus
- Trace Metals
- Hydrocarbons

Design Parameters

Width: The width should be at least 10 ft but not less than the full width of points where ingress or egress occurs. At sites where traffic volume is high, the entrance should be wide enough for two vehicles to pass safely. Flare the entrance where it meets the existing road to provide a sufficient turning radius.

Length: The minimum length should be 50 ft except on a single-residence lot where a 30 ft minimum would apply.

Depth: Total depth of rock should be at least 6 in.

Aggregate: Fractured

stone 2 to 8 in. diameter (for the base layer) and crushed stone 2 in. diameter or reclaimed or recycled concrete equivalent (for the top layer).

Geotextile (filter fabric): Most installations will include geotextile (filter fabric) with the products placed over the entire area to be covered with aggregate. Work on single residential lots will generally not need geotextile unless there is potential for excessive erosion, a high water table, or other risk factor. The geotextile should be a woven or nonwoven fabric consisting only of continuous chain polymeric filaments or yarns of polyester. The geotextile should be inert to commonly encountered chemicals, hydrocarbons, mildew, and rot resistant.

Drainage: Runoff from a stabilized construction entrance should drain to a sediment trap or a sediment basin. Piping of surface water under the entrance should be provided as needed. If piping is impossible, install a mountable berm with 5:1 slopes.

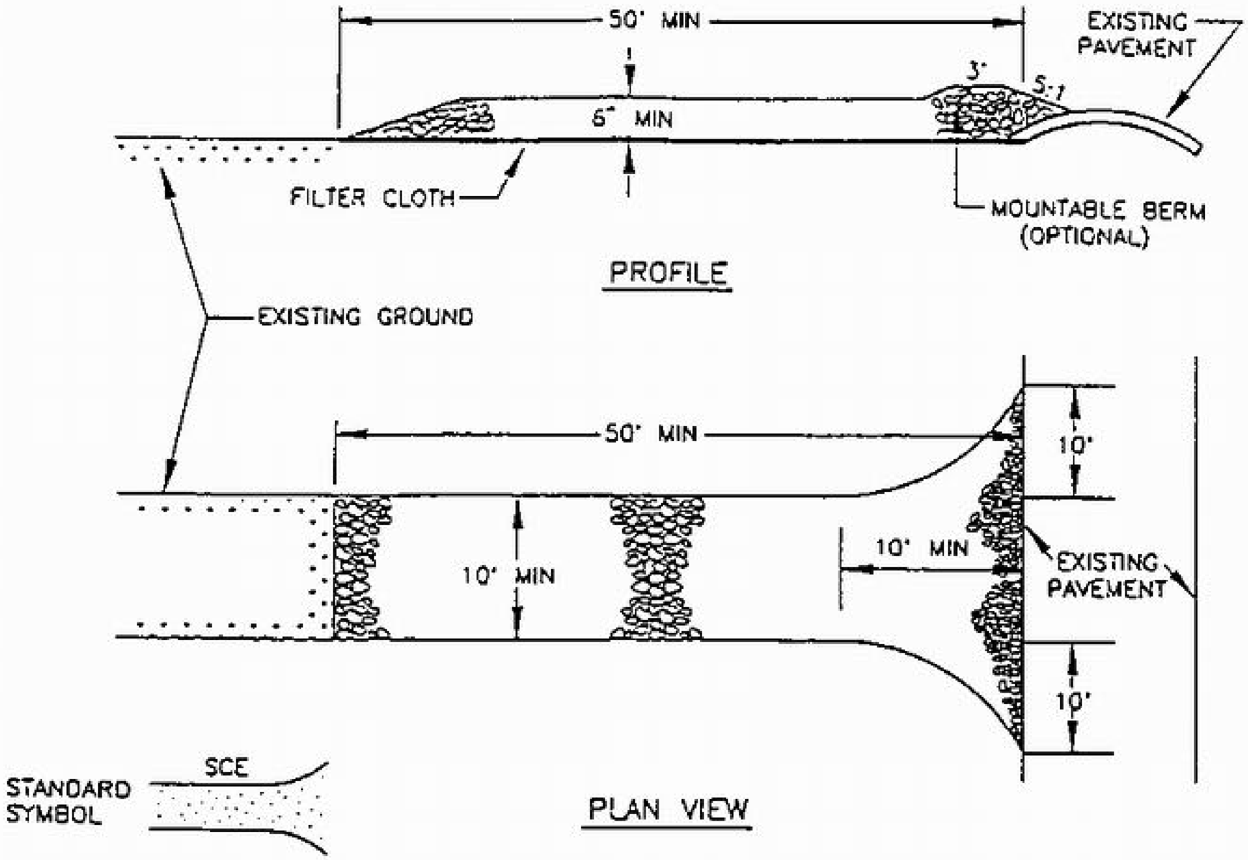
Dust Control: Dust control should be provided at all times (see BMP 7-Dust Control).

Construction Guidelines

- Clear all vegetation, roots, and all other obstructions in preparation for grading.
- Prior to placing geotextile (filter fabric), make sure that the entrance is properly graded and compacted.
- To reduce maintenance and loss of aggregate, place geotextile over the existing ground before placing the stone for the entrance.
- Place a 1 ft layer of fractured stone over the entire width and length of the entrance.
- Place a 4 in. layer of 2 in. crushed stone over the base layer.

Maintenance

- The entrance should be maintained in a condition that will prevent tracking or flow of mud onto public rights-of-way. This may require periodic top dressing with additional 2 in. stone (as conditions demand) and repair or cleaning of any structures used to trap sediment.
- All materials spilled, dropped, washed, or tracked from vehicles onto roadways or into storm drains should be removed immediately. When necessary, vehicle wheels should be cleaned to remove sediment prior to entrance onto public rights-of-way. When washing is required, it should be done on an area stabilized with aggregate that drains into an approved sediment trap.
- Trapped sediment should be removed from the site or stabilized on site and prevented from entering storm drains, ditches, or waterways. Disturbed soil areas resulting from removal should be permanently stabilized.
- The stabilized construction entrance may be removed after final site stabilization is achieved or after the temporary BMPs are no longer needed.



CONSTRUCTION SPECIFICATIONS

1 STONE SIZE-USE 2" STONE OR RECLAIMED OR RECYCLED CONCRETE EQUIVALENT.
2 LENGTH-AS REQUIRED, BUT NOT LESS THAN 50 FEET (EXCEPT ON A SINGLE RESIDENCE LOT WHERE A 30 FOOT MINIMUM LENGTH WOULD APPLY).
3 THICKNESS-NOT LESS THAN 6 INCHES.
4 WIDTH-10 FOOT MINIMUM, BUT NOT LESS THAN THE FULL WIDTH AT POINTS WHERE INGRESS OR EGRESS OCCURS.
5 FILTER CLOTH-WILL BE PLACED OVER THE ENTIRE AREA PRIOR TO PLACING OF STONE. FILTER WILL NOT BE REQUIRED ON A SINGLE FAMILY RESIDENCE LOT.
6 SURFACE WATER-ALL SURFACE WATER FLOWING OR DIVERTED TOWARD CONSTRUCTION ENTRANCES SHALL BE PIPED ACROSS THE ENTRANCE. IF PIPING IS IMPRACTICAL, A MOUNTABLE BERM WITH 5:1 SLOPES WILL BE PERMITTED.
7 MAINTENANCE-THE ENTRANCE SHALL BE MAINTAINED IN A CONDITION WHICH WILL PREVENT TRACKING OR FLOWING OF SEDIMENT ONTO PUBLIC RIGHT-OF-WAY. THIS MAY REQUIRE PERIODIC TOP DRESSING WITH ADDITIONAL STONE AS CONDITIONS DEMAND AND REPAIR AND/OR CLEANOUT OF ANY MEASURES USED TO TRAP SEDIMENT. ALL SEDIMENT SPILLED, DROPPED, WASHED OR TRACKED ONTO PUBLIC RIGHTS-OF-WAY MUST BE REMOVED IMMEDIATELY.
8 WASHING-WHEELS SHALL BE CLEANED TO REMOVE SEDIMENT PRIOR TO ENTRANCE ONTO PUBLIC RIGHTS-OF-WAY. WHEN WASHING IS REQUIRED, IT SHALL BE DONE ON AN AREA STABILIZED WITH STONE AND WHICH DRAINS INTO AN APPROVED SEDIMENT TRAPPING DEVICE.
9 PERIODIC INSPECTION AND NEEDED MAINTENANCE SHALL BE PROVIDED AFTER EACH RAIN.

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE	STABILIZED CONSTRUCTION ENTERANCE	STANDARD DRAWING
TOOTHMAN-ORTON ENGINEERING COMANY BOISE, IDAHO McCALL, IDAHO		SCE-1

Erosion Prevention on Temporary Roads BMP 6

Description

Any of several measures can be used to control erosion and sedimentation originating with haul roads, detours, access roads, and other unpaved or temporary roadbeds associated with a construction project. Possible measures include:

Road Placement: Place temporary roads as far as possible away from streams, surface waters or wetlands.

Open-Top Box Culvert: A wooden culvert installed across the road grade to convey surface runoff and roadside ditch flows to the downslope side. Open-top box culverts are useful for collecting surface runoff and ditch flows and channeling this water across the road without eroding the drainage system or road surface.

Waterbar (or Cross Ditch): A cut and berm built at a downward angle across the roadway, extending from the cutbank to the opposite fill shoulder. Waterbars reduce erosion by diverting stormwater runoff from the road surface and directing it to a safe discharge area.

Road Sloping: Constructing the road with an outward slope of 1 to 2% from the cut slope to the fill slope. Sloped roads are designed to divert surface water off the entire road surface so that water does not concentrate in any specific location.

Rolling Dip: Constructing the road with shallow, outward-sloping dips or undulations to collect surface runoff and con roads where erosion of the roadbed and fill slope is unlikely due to low runoff volume or intensity.

Rolling Dip: Used as a runoff diversion measure to prevent erosion of the road surface. Rolling dips are effective on long inclines to keep stormwater from flowing directly down the road, where it may cause gullying and other damage to the road surface and grade.

Level Spreader: Useful where concentrated runoff from bare ground or other unstabilized areas can be diverted onto stabilized areas under sheet flow conditions. Level spreaders are often placed at the outlets of diversion dikes or runoff interception trenches to control runoff, dissipate water velocity, and disperse the water over a broad surface area. Level spreaders are relatively inexpensive to install. They may be used on slopes of 3:1 or flatter.

Limitations

Drainage area - unlimited
Minimum bedrock depth – 3 ft
NRCS soil type - ABCD
Drainage/flood control – no
Maximum slope – 15%
Minimum water table - N/A
Freeze/thaw – good

Open-Top Box Culvert: Generally, box culverts are not required on grades of 6% or less and are ineffective under continuous or recurrent use where cleaning is sporadic.

Waterbar: Suitable only for light-use, low-maintenance, unpaved roads.

Road Sloping: Suitable only for low-traffic haul roads where runoff volume and intensity are low.

Rolling Dip: Not suitable on road grades steeper than 5% .

Level Spreader: Level spreaders are not recommended for use in most situations. They are not suitable on slopes steeper than 3:1 or where the soils are easily erodible. They should be constructed only on natural soils, not on fill material. Level spreaders cannot handle large quantities of sediment-laden stormwater. If altered by erosion or other disturbance, they may "short circuit" and actually concentrate flows into small streams instead of spreading the flows into sheet flow.

Targeted Pollutants

Sediment
Phosphorus
Trace Metal
Hydrocarbons

Design Parameters

Open-Top Box Culvert: Box culverts can be built from logs lumber discarded guardrail or corrugated steel. They are installed at a skewed angle downgrade across the roadway, with the discharge end extending 6 to 12 in beyond the surface of the roadbed.
Spacing between culverts should be in accordance with recommended cross

drainage spacing in Table 6-1. Where recommended spacing is less than 33 ft, the road should be paved with gravel or crushed rock.

Waterbar: Waterbars are generally constructed using a blade-equipped tractor or by hand. The size of the waterbar depends on the amount of precipitation in the area, the soil erodibility, and anticipated traffic.

- The waterbar should extend from the cutbank side of the road completely across to the fillslope side.
- Cut dimensions: Up to 16 in deep across road, 8 to 16 in deep at outlet, 3 to 4 ft wide.
- Berm dimensions and orientation: 1 to 2 ft high 5 in minimum height, skewed at angle of 30^o to 40^o across road.
- Spacing between bars: Use Table 6-1 for recommended cross drain spacing on low to moderately steep topography.
- Discharge: Runoff should not be directed onto fill material without proper energy dissipation and drainage away from the fill.

Geotextile (filter fabric): Most installations will include geotextile (filter fabric) with the properties listed in Table 6-2, placed over the entire area to be covered with aggregate. Work on single residential lots will generally not need geotextile unless there is potential for excessive erosion, a high water table or other risk factor. The geotextile should be a woven or nonwoven fabric consisting only of continuous chain polymeric filaments or yarns of polyester. The geotextile should be rot resistant and inert to commonly encountered chemicals, hydrocarbons, mildew.

Road Sloping: The slope should be approximately 1 to 2% from the cut slope outward to the fill slope. Berms on the outside of the road should be limited or removed to allow water to flow off the road surface. Provide sediment collection or erosion-control measures at the toe of the fill slope to prevent excessive erosion and sediment transport.

Rolling Dip: (applies to roads greater that 150 ft long only)The dip should be approximately 1 ft below the surface plane of the road. The upgrade approach to the bottom of the dip should be approximately 66 ft long. The downgrade approach to the bottom of the dip should be approximately 23 ft long. Align the dip across the road at nearly a 90^o angle, and slope it outward approximately 5% .

Construction Guidelines

Open-Top Box Culvert: Construct a box-like frame (three-sided, open-topped) of logs, lumber, discarded guardrail, or corrugated steel. Install it flush with the road surface, skewed at an angle downgrade across the roadway. Set the inflow end at the same grade as the side ditches on the road and extend it into the cut bank. The discharge end should extend 6 to 12 in. beyond the surface of the roadbed and should be directed onto vegetated ground or riprap or into another erosion-control structure such as a sediment trap or catch basin.

Waterbar: Cut each waterbar into solid soil to a minimum depth of 6 in. next to the cutbank and 8 in. at the road shoulder, with an adverse grade on the downroad or downgrade side of the waterbar. Build a continuous, firm berm of soil, at least 6 in. above normal grade, parallel to the waterbar cut on its downhill side. Include a bank tie-in point, cut 6 to 12 in. into the roadbed. For added stability, the bar may be compacted with a nonerosive fill material. The completed waterbar should extend across the full roadway width, aligned at an angle of 30^o to 40^o relative to the roadway. A dissipation or filter device (such as riprap or silt fence) may be needed below the waterbar to control erosion and trap sediment.

Road Sloping: Road sloping is built into the road during construction. Install erosion- and sediment-control measures downslope before completing the finish grade of the sloped road. Then construct the outward slope of 1 to 2% , as specified in the contract plans.

Rolling Dip: Rolling dips are built into the road, during construction, following the natural contours of the land. Install erosion and sediment measures at the low point of the dip (drainage outfall to fill slope) before final grading to direct stormwater discharge from the dip. Construct the dip according to the specifications shown in the contract plans. If not specified, make the dip 1 ft deep, with a 23 ft-long approach on the downgrade side and a 66 ft-long approach on the upgrade side.

Maintenance

Inspect all devices regularly according to provisions of the contract or project site plan. Make repairs promptly to avoid progressive damage. Remove accumulated sediments as necessary to ensure proper functioning.

Open-Top Box Culvert: Clean and repair the culverts on a regular basis. Remove sediments and other debris that may block drainage flow or decrease structural efficiency.

Waterbar: Properly constructed bars should require little or no maintenance. However, all waterbars need to be open at the lower end so water can easily flow away from the roadway. Hand shovel work may be necessary following high runoff periods or severe storms to ensure unrestricted flow.

Road Sloping: Minor regrading may be required to maintain slope angle.

Rolling Dip: Outflows should be kept free of debris to prevent ponding.

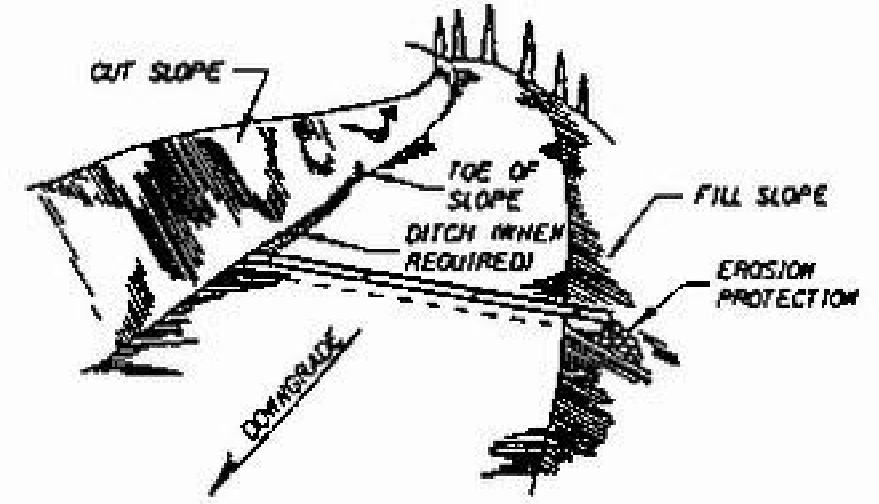
Table 6-1. Recommended Cross Drain Spacing (Source: ITD, 1994)

Road Grade (percent)	Spacing Between Open-Top Culverts, feet (meters)
2 to 5	300 to 500 (90 to 150)
6 to 10	200 to 300 (60 to 90)
11 to 15	100 to 200 (30 to 60)
16 to 20	<100 (<30)

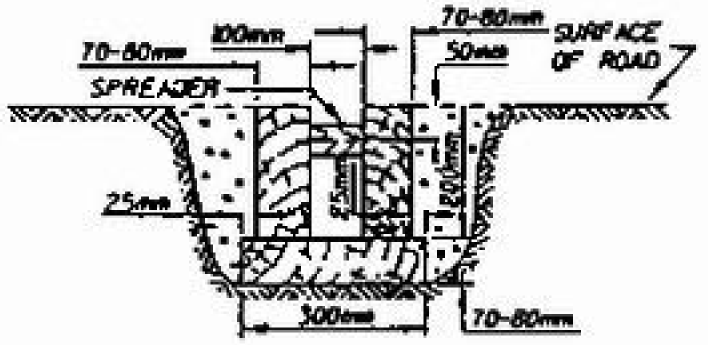
Table 6-2. Geotextile Properties by Road Type

Geotextile Properties	Light Duty[1] Roads Grade Subgrade	Heavy Duty[2] Haul Roads Rough Graded	Test Method
Grab Tensile Strength (lbs)	200	220	ASTM D1682
Elongation at Failure (%)	50	60	ASTM D1682
Mullen Brust Strength (lbs)	190	430	ASTM D3786
Puncture Strength (lbs)	40	125	ASTM D751 modified
Equivalent Opening Size	40-80	40-80	US Std Sieve CW-02215
Aggregate Depth (in.)	6	10	--

[1]Light Duty Road: Are sites that have been graded to subgrade and where most travel would be single axle vehicles and an occasional multi-axle truck. Trevira Spunbond 1115, Mirafi 100X, Typar 3401, or equivalent.
[2]Heavy Duty Road: Are sites with only rough grading, and where most ravel would be multi-axle vehicles. Trevira Spunbond 1135, Miraft 600X, or equivalent.
[3]Geotextiles not meeting these specifications may be used only when design procedure and supporting documentation are supplied to determine aggregate depth and fabric strength.

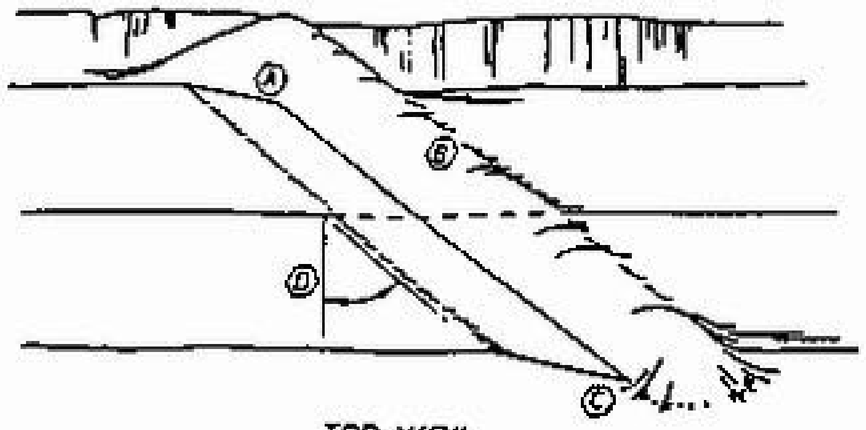


PERSECTIVE VIEW

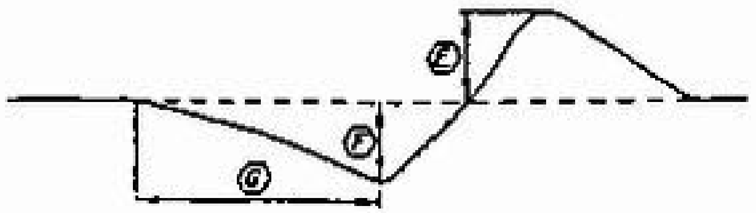


END VIEW

OPEN-TOP BOX CULVERT



TOP VIEW

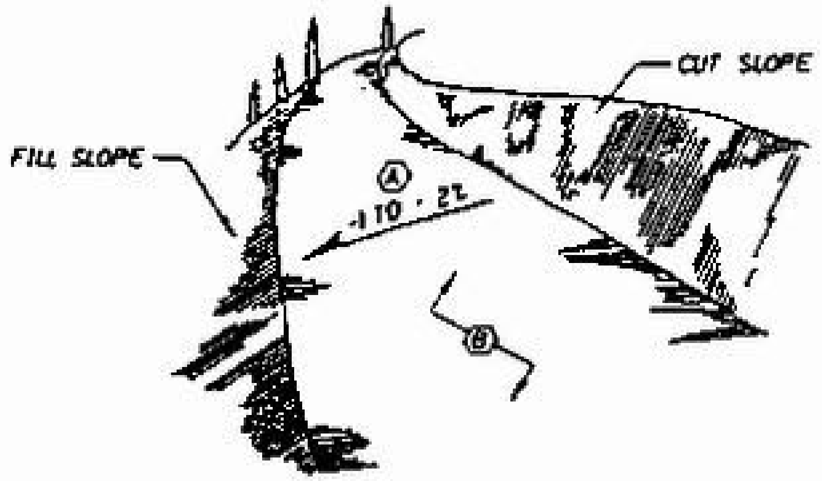


A. BANK TIE-IN POINT CUT 150 TO 300 mm INTO ROADBED.
B. CROSS DRAIN BERM HEIGHT ABOUT 0.5 m ABOVE ROAD BED.
C. DRAIN OUTLET CUT 200 TO 400 mm INTO ROAD.
D. ANGLE DRAIN 30° TO 40° DOWNGRADE WITH ROAD CENTERLINE.
E. HEIGHT UP TO 0.6 m.
F. DEPTH TO 0.5 m.
G. 1.0 TO 1.2 m.

CROSS SECTION AT CENTER LINE

WATERBAR (OR CROSS-DITCH)

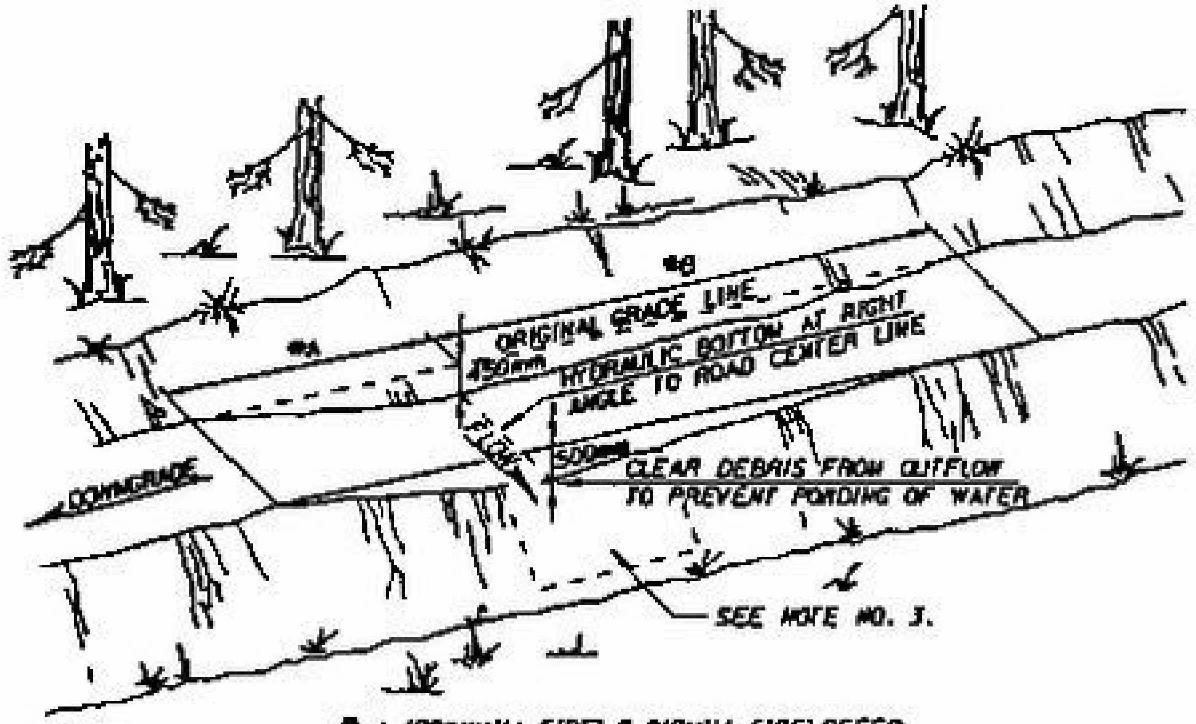
(SEE NOTE NO. 2)



A. DIVERT RUNOFF ACROSS ROAD SURFACE FROM TOE OF CUT SLOPE TO FILL SLOPE.

B. ROAD SURFACE MUST BE RELATIVELY EVEN TO PREVENT PUDDLING & EROSION.

ROAD SLOPING



* A (DOWNHILL SIDE), B (UPHILL SIDE) REFER TO THE ROLLING DIP DIMENSION TABLE.

ROLLING DIP DETAIL

ROLLING DIP DIMENSION TABLE		
% DOWNGRADE	A (DOWNHILL)	B (UPHILL)
0% TO 4%	10.5	20
4% TO 6%	7.5	23
6% TO 8%	4.5	26

NOTES

1. ALL OF THE INSTALLATIONS SHOWN ON THIS DRAWING SHALL BE USED IN CONJUNCTION WITH ITD CATALOG OF STORM WATER BEST MANAGMENT PRACTICES (BMPs) FOR HIGHWAY CONSTRUCTION AND MAINTENANCE.

2. CONSTRUCT WATERBARS OR CROSS DITCHES ONLY ON UNPAVED HAUL ROADS WITH LIMITED OR NO TRAFFIC. THE DEVICE CONFIGURATION SHOULD BE ADJUSTED TO FIELD CONDITIONS.

3. A SEDIMENT FILTERING DEVICE SHALL BE PLACED AT OUTFLOW OF A ROLLING DIP.

4. ALL DIMENSIONS AND DISTANCES ARE IN METERS UNLESS OTHERWISE NOTED AND ALL THE DETAILS SHOWN ARE NOT DRAWN TO ANY SCALE.

Section 4 – Housekeeping

For the selection of the most appropriate or suitable BMP, the user should refer to the BMP Selection Matrix in Table 1. It is essential to check with the local permitting authority for other requirements. The following pages contain BMP fact sheets for basic housekeeping that should be included in all construction projects, including the these topics:

Dust Control BMP 7

Description

This BMP describes products or measures used for reducing or preventing wind erosion by protecting the soil surface, roughening the surface, and reducing the surface wind velocity. Several dust control treatments are described below. Other methods are also available.

Vegetative Cover: For disturbed areas not subject to traffic, vegetation provides the most practical method of dust control (see BMP 21-Seeding and BMP 22-Sodding).

Mulch (including gravel mulch): When properly applied, mulch offers a fast, effective means of controlling dust (see BMP 15-Mulching).

Spray-On Adhesive: Asphalt emulsions, latex emulsions, or resin in water can be sprayed onto mineral soil to control dust (see BMP 16-Hydromulching).

Sprinkling: The site may be sprinkled with water until the surface is wet. Sprinkling is especially effective for dust control on haul roads and other traffic routes.

Stone: Stone or gravel used to stabilize construction roads and disturbed soils can also be effective for dust control and reduce soil losses from those areas by up to 80% .

Surface Roughening: Tilling or discing the surface of disturbed soils to produce a rough surface or ridges which when perpendicular to prevailing winds can reduce soil losses due to wind by 80% (see BMP 25-Slope Roughening).

Barriers: A board fence, wind fence, sediment fence, or similar barrier can control air currents and blowing soil. All of these fences are normally constructed of wood. Perennial grass and stands of existing trees may also serve as wind barriers. Barriers prevent erosion by obstructing the wind near the ground and preventing the soil from blowing off site.

Applications

The above measures for dust control should be used when open, dry areas of soil are anticipated on the site. Clearing and grading activities create the opportunity for large amounts of dust to become airborne. Therefore, one or several dust control measures should be considered prior to clearing and grading. In many cases, water erosion control measures incorporated into the project will indirectly prevent wind erosion. As a standard practice, any exposed area should be stabilized using vegetation to prevent both wind and water erosion. When rainfall is insufficient to establish vegetative cover, mulching is an effective way of conserving moisture, preventing surface crusting, reducing runoff and erosion, and helping to establish vegetation. It is a critical treatment on sites with erosive slopes.

Limitations

Drainage area – N/A	Maximum slope – 5%
Minimum bedrock depth – N/A	Minimum water table - N/A
NRCS soil type – N/A	Freeze/thaw – N/A
Drainage/flood control – no	

Vegetative measures may not be practical during dry periods unless a reliable supply of establishment water is available. Other methods should be stipulated in the project contract to ensure that dust control is not overlooked.
Barriers (such as walls or fences) can be part of the long-term dust control strategy in arid and semiarid areas, but they are not a substitute for permanent stabilization.

Targeted Pollutants

Sediment
Trace Metals
Hydrocarbons

Design Parameters

Dust Prevention: The best method of controlling dust is to prevent dust production. This can best be accomplished by limiting the amount of bare soil exposed at one time. In project design, identify all areas where ground disturbance will not be allowed. Design and locate haul roads, detours, and staging areas to avoid unnecessary exposure of bare ground and avoid using areas that are the most susceptible to wind erosion.

In the stormwater site plan, specify staging or work sequencing techniques that minimize the risk of wind erosion from bare soil. In most cases, this will require a change from traditional construction techniques that allow large areas to be disturbed at the outset of construction and to remain exposed for long periods of time.

Vegetative Cover: Follow recommended seeding and planting specifications. If site conditions are favorable, use an extended seeding season to ensure that seeding becomes established over as much of the project as possible before winter shutdown or substantial completion. Specify the use of establishment water to accelerate vegetative stabilization if other means of long-term slope protection are not feasible.

Mulch: Apply according to the design parameter for BMP 16-Hydromulching.

Sprinkling: Apply at a rate of 3 gallons per acre so that the soil is wet but not saturated or muddy and so that no dust is being generated.

Stone: At ingress/egress to public highways, apply as indicated in BMP 5-Stabilization of Construction Entrance. For detours, haul roads, or temporary traffic routes through the construction site, provide a layer of fractured stone 2 to 4 in. thick and 1 to 2 in. in diameter.

Surface Roughening: Tilling or discing should leave 6 in. (minimum) furrows, preferably perpendicular to the prevailing wind direction, to gain the greatest reduction in wind erosion. If the surface cannot be furrowed perpendicular to the prevailing wind direction, roughening the surface by using a ripper/scarifier (grader) or a ripper (cat) will produce the desired result of a 6 in. irregular surface.

Barriers: A wind barrier generally protects soil downwind for a distance of 10 times the height of the barrier. If additional protection is needed, use other methods in conjunction with the barrier.

Construction Guidelines

Site Assessment: Assess the potential problem of wind erosion and dust generation at the project site. Consider the soil type, prevailing wind direction, and the effect of other prescribed erosion control measures.

Use Preventive Strategies Wherever Possible:

- Minimize amount of bare ground exposed at one time.
- Minimize amount of ground disturbance occurring when wind erosion is highest.

Implement Dust Control Measures as Needed:

- Provide stabilized roadway to minimize amount of dust generated by construction vehicles and highway traffic (gravel, pave, or moisten the bare areas of the highway or detour route).
- Apply protective materials to exposed areas (e.g., stone, mulch, adhesive/ emulsions).
- Install barriers to prevent dust from blowing off site.
- Establish vegetation at the earliest possible opportunity (using establishment water if necessary to ensure viability).
- Keep haul roads, detours, and other bare areas moist by sprinkling them with water.
- Perform street sweeping, as needed.

Maintenance

- Dust control requires constant attention: it is not a one-time or once-in-awhile activity. Dust control sprinkling may have to be done several times a day during hot, dry weather.
- Areas protected by mulch, adhesive emulsions, or barriers need to be checked at regular intervals according to the inspection schedule set forth in the stormwater plan. Remove sediments that accumulate behind any sediment fence or barrier when the accumulation reaches one half the height of the barrier. Dispose of the sediments only in an approved location (not in wetlands or where they will contribute to pollution at the disposal site).

Apply chemical controls (emulsions and resins) at the manufacturer’s specified rates and in accordance with all federal, state, and local regulations governing their use. Chemical products should be stored, handled, and disposed of in accordance with all applicable regulations and department policies.

Cover for Materials and Equipment BMP 8

Description

This BMP includes partial or total physical enclosure of materials, equipment, process operations, or activities. Covering prevents stormwater from coming into contact with potential pollutants and reduces material loss from wind blowing. Tarpaulins, plastic sheeting, roofs, buildings, and other enclosures are examples of covering that are effective in preventing stormwater pollution. Covering can be temporary or permanent.

Applications

Covering is a simple, effective, and usually inexpensive way of reducing or preventing pollution. It is appropriate for outdoor material storage piles, such as stockpiles of dry materials, topsoil, spoils piles, gravel, sand, compost, sawdust, wood chips, and building materials. It is also effective where containers of liquids or solids are stored or transferred. Although it may be too expensive to cover or enclose all construction activities, the high-risk parts of a site can often be separated and covered. For example, chemical preparation areas, vehicle maintenance and washing areas, storage areas for chemically treated products and toxic wastes (e.g., used oils).

Limitations

Drainage area – N/A
Minimum bedrock depth – N/A
NRCS soil type – N/A
Drainage/flood control – no
Maximum slope – N/A
Minimum water table – N/A
Freeze/thaw – N/A

- Covering alone may not protect exposed materials from contact with stormwater runoff/run-on.
- Requires frequent inspections. Consider curbing or an elevated platform to prevent pollution from run-on water.

Targeted Pollutants

Sediment
Trace Metals
Hydrocarbons

Design Parameters

- In selecting an appropriate covering, evaluate the strength and longevity of the covering, as well as its compatibility with the materials or items being enclosed. Cost, aesthetics, weather conditions, drainage patterns, and size of the stockpiles or storage area are other factors affecting the choice of covering.
- In designing a covering for materials, remember to provide adequate access for loading, handling, and transfer. Cost considerations may justify a less-than-optimum access arrangement in some cases. For instance, tarpaulins and plastic sheeting have to be removed or rearranged to allow continued access as materials are depleted, but they are less expensive than a permanent structure such as a roof or shed.
- Climate or weather conditions also influence the choice or design of a covering. Tarpaulins and sheeting may be difficult to keep secured in

extremely windy areas.

- Where a permanent structure is indicated for a particular area or activity, consider building a roof instead of a complete enclosure. This will reduce costs and may also eliminate the need for ventilation and lighting systems that could be needed in a building.
- Consider the nature of the materials being enclosed, especially if they pose environmental or safety dangers. Materials that are biological, flammable, explosive, or chemically reactive require special ventilation and temperature control measures.
- Covering alone may not protect exposed materials from stormwater contact. Where stormwater run-on is a potential problem, place the material on an elevated, impermeable surface or build curbing around the outside of the materials to prevent pollution of stormwater from adjacent areas.

Construction Guidelines

Tarpaulins and Plastic Sheeting: Obtain enough fabric or sheeting to cover the indicated volume or area. Anchor the edges of the covering with stakes, tie-down ropes, large rocks, tires, or other readily available, heavy objects. Maintain an overlap of 3 ft along the borders and securely anchor the overlap area so that it does not separate (through wind or other causes).

Roofs, Sheds, and Buildings: Construct according to plans or drawings in accordance with existing building codes and departmental standards for such construction.

Maintenance

Frequently inspect coverings for damage and general wear. Repair or replace them immediately, as needed.

Stockpile Management BMP 9

Description

Stockpile management procedures and practices are designed to reduce or eliminate air and stormwater pollution from stockpiles of soil, paving materials such as Portland cement concrete (PCC) rubble, asphalt concrete (AC), asphalt concrete rubble, aggregate base, aggregate sub base or pre-mixed aggregate, asphalt minder (so called "cold mix" asphalt), and pressure-treated wood.

Applications

Implement in all projects that stockpile soil and other materials.

Limitations

Drainage area – N/A
Minimum bedrock depth - N/A
NRCS soil type – N/A
Drainage/flood control – no
Maximum slope – N/A
Minimum water table - N/A
Freeze/thaw – good

Targeted Pollutants

Sediment

Construction Guidelines

General

- Locate stockpiles a minimum of 50 ft away from concentrated flows of stormwater, drainage courses, and inlets.
- Protect all stockpiles from stormwater run-on using a temporary perimeter sediment barrier such as berms, dikes, fiber rolls, silt fences, sandbags, or gravel bags.
- Implement wind erosion control practices as appropriate on all stockpiled material.
- Place bagged materials on pallets and under cover.

Protection of Non-Active Stockpiles

- Soil stockpiles: During the rainy season, soil stockpiles should be covered or protected with soil stabilization measures and a temporary perimeter sediment barrier at all times. During the non-rainy season, soil stockpiles should be covered or protected with a temporary perimeter sediment barrier prior to the onset of precipitation.
- Stockpiles of PCC rubble, AC, asphalt concrete rubble, aggregate base, or aggregate sub base: During the rainy season, the stockpiles should be covered or protected with a temporary sediment perimeter barrier at all times. During the non-rainy season, the stockpiles should be covered or protected with a temporary perimeter sediment barrier prior to the onset of precipitation.
- Stockpiles of "cold mix": During the rainy season, cold mix stockpiles should be placed on and covered with plastic or comparable material at all times. During the non-rainy season, cold mix stockpiles should be placed on and covered with plastic or comparable materials prior to the onset of precipitation.
- Stockpiles/storage of pressure-treated wood: During the rainy season, pressure-treated wood should be covered with plastic or comparable

material at all times. During the non-rainy season, pressure-treated wood should be covered with plastic or comparable material at all times.

Protection of Active Stockpiles

- All stockpiles should be protected with a temporary linear sediment barrier prior to the onset of precipitation.
- Stockpiles of "cold mix" should be placed on and covered with plastic or comparable material prior to the onset of precipitation.

Maintenance

- Inspect and verify that BMPs are in place prior to the commencement of associated activities. While activities associated with the BMP are underway, inspect weekly during the rainy season and at 2-week intervals in the non-rainy season to verify continued BMP implementation.
- Repair and/or replace perimeter controls and covers as needed to keep them functioning properly.

Spill Prevention and Control BMP 10

Description

This BMP describes methods of minimizing exposure of pollutants to stormwater runoff by enclosing any drips, overflows, leaks, and other liquid material releases or by isolating pollutant spills from stormwater runoff. There are numerous spill containment methods, ranging from large structural barriers to simple, small drip pans. The benefits vary based on cost, maintenance requirements, and the size of spill control. Three possible options are discussed below:

Containment Diking: Temporary or permanent polyurethane or plastic berms, concrete berms, or retaining walls designed to hold spills. Diking is one of the best protective measures against stormwater pollution because it surrounds the area of concern and holds the spill, keeping spill materials separated from the stormwater outside of the diked area. Diking is one of the most common types of spill containment. Also see BMP 41-Earth Dike and BMP 43-Temporary Berms.

Curbing: Like containment diking, curbing is a barrier that surrounds an area of concern. It prevents spills or leaks from being released to the environment by routing runoff to treatment or control areas. The terms "curbing" and "diking" are sometimes used interchangeably, but curbing is usually small scale and cannot contain large spills like diking can. As with diking, common materials for curbing include earth, concrete, synthetic materials, metal, or other impenetrable materials. Asphalt is also a common material used in curbing.

Drip Pans: Pans used to contain very small volumes of leaks, drips, and spills. Drip pans can be depressions in concrete, asphalt, or other impenetrable materials, or they can be made of metals, plastic, or any material that does not react with the dripped chemicals. Empty or discarded containers may be used as drip pans. Catch drips so that the materials or chemicals can be cleaned up easily or recycled before they can contact stormwater. Drip pans can be a temporary or permanent measure.

Applications

Containment Diking: Diking can be used at any construction site, but it is most commonly used for controlling large spills or releases from liquid storage areas and liquid transfer areas. It is an effective containment method around tank truck loading and unloading areas. Proper diking contains spills, leaks, and other releases and prevents them from flowing into runoff conveyances, nearby streams, or infiltration into groundwater. It also allows for proper disposal and/or recycling of materials captured within the dike.

Curbing: Curbing is usually small scale; it cannot contain large spills like diking can. However, many facilities use curbing to contain small areas used for handling and transferring liquid materials.
Curbing is already a common practice. It is inexpensive, easy to install, and

provides excellent control of run-on. As with diking, materials spilled within a curbed area can be collected for proper disposal and/or recycling.

Drip Pans: Drip pans can be used at any site where valves and piping are present and the potential for small-volume leakage and dripping exist. Although leaks and drips should be repaired and eliminated as part of preventive maintenance programs, drip pans can provide a temporary solution where repair or replacement should be delayed. In addition, drip pans can be an added safeguard when they are positioned beneath areas where leaks and drips may occur.

Drip pans are inexpensive, easy to install, and simple to operate. They allow for reuse or recycling of the collected material.

Limitations

Drainage area - N/A
Minimum bedrock depth – N/A
NRCS soil type - N/A
Drainage/flood control – no
Maximum slope – N/A
Minimum water table – N/A
Freeze/thaw – N/A

Containment Diking:

- May be too expensive for some smaller facilities.
- Requires maintenance.
- Could collect polluted stormwater, with possible infiltration to ground water.

Curbing:

- Not effective for holding large spills.
- May require more maintenance than diking.

Drip Pans:

- Suitable only for small volumes.
- Should be inspected and cleaned frequently.
- Should be secured during poor weather conditions.
- Requires that personnel be trained in proper disposal methods so that contents are not disposed of improperly.

Targeted Pollutants

Trace Metals
Hydrocarbons

Design Parameters

Containment Diking:
Size: For tank truck loading and unloading operations, the diked area should be capable of holding an amount equal to any single tank truck compartment.

Materials: Materials used to construct the dike should be strong enough to safely hold spilled materials. The materials used usually depend on what is available on-site and the substance to be contained. Dikes may be made of earth (i.e., soil or clay), concrete, synthetic materials (liners), metal, or other impervious materials. Containment dikes may need to be designed with impervious materials to prevent leaking or pollution of stormwater, surface water, and ground water supplies.

In general, strong acids and bases may react with metal containers, concrete, and some plastics. So where spills may consist of these substances, other alternatives should be considered. Some of the more reactive organic chemicals may also need to be contained with special liners. If uncertain about the suitability of certain dike construction materials, refer to the *Material Safety Data Sheet* (MSDS) for the chemical being contained.

Curbing: When using curbing for runoff control, protect the berm by limiting traffic and installing reinforced berms in areas of concern. Materials spilled within a curbed area can be tracked outside of that area when personnel and equipment leave the area. This tracking can be minimized by grading within the curbing to direct the spilled materials to a downslope side of the curbed area. This will keep the materials away from personnel and equipment that pass through the area. It will also allow the materials to accumulate in one area, making cleanup much easier. Manual or mechanical methods, such as those provided by sump systems, can be used to remove accumulated material from a curbed area.

Drip Pans: When using drip pans, consider local weather conditions, the location of the drip pans, materials used for the drip pans, and how the pans will be cleaned. The location of the drip pan is important. Because drip pans should be inspected and cleaned frequently, they should be easy to reach and remove. Take special care to avoid placing drip pans in precarious positions such as next to walkways or on an uneven surface. Drip pans in these locations are easily overturned and may present a safety or environmental hazard. Weather is also an important factor. Heavy winds and rainfall can move or damage drip pans because the pans are small and lightweight. To prevent this, secure the pans by installing or anchoring them. Drip pans may be placed on platforms or behind wind blocks or may be tied down.

Maintenance

Cleaning guidelines should be included in the maintenance plan for all methods of spill prevention and control.

Containment Diking: Inspect containment dikes during or after significant storms or spills to check for washouts or overflows. In addition, regular testing to ensure that dikes are capable of holding spills is recommended. Soil dikes may need to be inspected on a more frequent basis.

Changes in vegetation, inability of the structure to retain stormwater, dike erosion, or soggy areas indicate problems with the dike's structure. Damaged areas should be patched and stabilized immediately, where necessary. Earthen dikes may require special maintenance of vegetation, such as mowing and irrigation.

When evaluating the performance of the containment system, pay special attention to the overflow system, since it is often the source of uncontrolled leaks. If overflow systems do not exist, accumulated stormwater should be released periodically. Polluted stormwater should be treated prior to release. Mechanical parts (such as pumps) or manual systems (slide gates, stopcock valves) may require regular cleaning and maintenance.

Curbing: Since curbing is sized to contain small spill volumes, frequent maintenance is needed to prevent overflow of any spilled materials. Inspect all curbed areas regularly and clean clogging debris. Repair the curb by patching or replacing it as needed to ensure effective functioning. Inspections should be conducted before forecasted rainfall events and immediately after storm events. If spilled or leaked materials are observed, cleanup should start immediately to allow space for future spills. In addition, prompt cleanup of spilled materials will prevent dilution by rainwater, which can adversely affect recycling opportunities.

Drip Pans: For drip pans to be effective, site operators should pay attention to the pans and empty them when they are nearly full. Because of their small holding capacities, drip pans will easily overflow if not emptied. Also, recycling efforts can be affected if stormwater accumulates in drip pans and dilutes the spilled material. It is important to have clearly specified and easily followed practices of reuse, recycle and/or disposal, especially the disposal of hazardous materials. Consider dumping the drip pan contents into a nearby larger-volume storage container and periodically recycling the contents of the storage container.

Frequent inspection of the drip pans is necessary due to the possibility of leaks in the pan itself. Also check for random leaking of piping or valves and for irregular, slow drips that may increase in volume. Conduct inspections before forecasted rainfall events to remove accumulated materials. Empty accumulations immediately after each storm event.

Vehicle/Equipment Washing & Maintenance BMP 11

Description

A typical vehicle/equipment washing and maintenance system is a lined, depressed area that collects the water used in washing off the trucks, cars, or other construction vehicles/equipment, and drains the wastewater into a collection or treatment system.

Applications

A wash-down area is used on projects where the soil is silty or heavy in clay, and has the likelihood of transporting dirt and mud off site. Projects that will take place over the course of the rainy season and areas where water is expected to be encountered (high ground water table) in the normal course of the project should be considered as candidates.

Limitations

Drainage area - N/A	Maximum slope – 5%
Minimum bedrock depth – N/A	Minimum water table - N/A
NRCS soil type - N/A	Freeze/thaw – N/A
Drainage/flood control – no	

Washing vehicles generates liquid, semi-solid, and solid wastes. These wastes should be contained on-site or treated to prevent pollution of surface and ground water.

Off-site: Treatment is required for all discharges to waters of the state since it could be contaminated with degreasers, hydrofluoric acid, hydrochloric acid, nitric acid, phosphoric acid, oil, hydraulic fluids, lubrication, and engine cleaning solvents. Waters of the state include all surface waters (canals, rivers, ponds, streams and lakes), and all ground water. Contact the local permitting authority to determine proper treatment and disposal methods.

On-site: If wash-water discharge to a sediment pond is the system of choice, sufficient acreage is required for the operation.

Targeted Pollutants

Sediment
Phosphorus
Trace Metals
Hydrocarbons

Design Parameters

- Detergents used on site in Idaho for vehicle washing should not contain phosphates. Phosphates are a plant nutrient that can cause excessive growth of aquatic plants when discharged into a stream or lake.
- A stabilized construction entrance (BMP 5), used to reduce off-site tracking of mud, dirt and rocks, should be installed at the vehicle wash/maintenance area. Washing and maintenance should be conducted in disturbed areas (staging areas) but should not be conducted in a cut or fill area until grading has been performed or where there will be a high volume of construction traffic. Highly erodible soils or frequently wet areas should be avoided.

Off-site discharge options:

- Lagoon: Pond-like structure that works on the principle of evaporation is easy to install and requires low maintenance. There is a need to be aware of safety issues (fencing the area from the public).
- Land application system: Large land area is required. This alternative is the lowest in out-of-pocket cost.
- Filtering and recycling of wash water: A good option for conservation measures. Initially, expense would be high. Monitoring of the operation would be more intensive.
- Municipal wastewater treatment plant: This option is available only in areas where a municipal wastewater treatment plant exists and the operation is capable of handling the load. This is the best option for limiting liability for larger construction projects.

Construction Guidelines

Designate an area that can be graded and bermed. The design should collect wastewater for evaporation or direct it to an off-site containment or treatment system. A lined pond should be used where pollutants such as oil, grease, fuels, etc., may reach the high-ground water table.

Maintenance

Check that the system controls are working as designed. Clean up sediments that have been tracked by vehicles onto nearby roadways.

Waste Management BMP 12

Description

This BMP entails meeting the regulatory requirements of hazardous waste management that includes hazardous waste determination; acquiring an EPA identification number; accumulation; record keeping reporting; and transportation manifesting. Good housekeeping will minimize the contribution of pollutants to stormwater discharges by handling and storing hazardous materials on site in a clean and orderly manner.

Applications

Compliance with applicable regulations will protect human health and the environment from hazardous waste generated by construction activities, reduce liability, and prevent unnecessary interruptions to schedules (i.e., project shut down due to environmental investigations/enforcement actions). The first step in preventing pollution of stormwater runoff is to maintain a clean and orderly work environment. This will reduce the possibility of accidental spills.

Common sense is the simplest and most inexpensive method to utilize. Improving the operation and maintenance of industrial machinery, material storage practices, material inventory controls, routine and regular clean-up, maintenance activities in work areas, and providing educational programs for employees regarding these practices will assist in reaching these goals.

Limitations

Drainage area - N/A	Maximum slope – N/A
Minimum bedrock depth - N/A	Minimum water table - N/A
NRCS soil type - N/A	Freeze/thaw – N/A
Drainage/flood control – no	

Carelessness and poor judgment often result in problems associated with the disposal of hazardous materials. Not being fully aware of all the hazards at the site could increase the potential for mishandling of such wastes, resulting in stormwater contamination.

Targeted Pollutants

Sediment
Trace Metals

Design Parameters

Select a designated waste collection area on site. Secure an adequate number of containers with lids or covers. If possible, provide a covered area or spill containment pallets. Arrange for waste collection before containers overflow (additional containers and more frequent pick-ups will be needed during the demolition phase). Provide immediate cleanup in case of a spill. Assure that waste is transported and disposed of at an approved facility. A liner, concrete pad, berm, etc., should be utilized to keep waste separated and to contain accidental spills so that stormwater runoff is not polluted. Provide labels and signs for the area to educate contractors about proper storage and handling and to comply with regulatory requirements.

Construction Guidelines

The best way to avoid polluting runoff from outside material storage areas is to prevent stormwater run-on or rain from coming in contact with the materials.

These are some of the methods that can be utilized to accomplish this:

- Identify, control, and enforce storage and disposal/stockpile areas
- Provide a barrier such as a liner, concrete pad or berm
- Protect the storage area by:
    - ✓ Storing the material indoors
    - ✓ Covering the area with a roof
    - ✓ Covering the material with a temporary covering
- Engineer safeguards such as:
    - ✓ Overflow protection devices
    - ✓ Protective guards around tanks, storage area, etc.

Maintenance

- Regularly pick up and dispose of all garbage and waste material.
- Make sure equipment is working properly.
- Routinely inspect for leaks or conditions that could lead to discharges of chemicals and contact with stormwater:
    - ✓ External corrosion and structural failure
    - ✓ Installation problems
    - ✓ Evidence of spills or overfills
- Locate storage areas away from direct traffic routes.
- Stack according to directions to avoid damage due to improper weight distribution.
- Store likes together, separate incompatible wastes.
- Assign hazardous material inventory to a limited number of people.
- Keep up-to-date inventory of all hazardous materials and wastes.
- Identify all chemical substances present at the work site.
- Label all containers with name, hazards, handling, and first-aid information.
- Mark those that require special instructions.
- Cleanup of liquid or dry material spills.
- Provide initial and annual training for employees on the hazards and the proper handling procedures.
- Do not mix products together unless specifically recommended.
- Use the entire product before disposing of container.
- Do not remove original product label from container.

Concrete Waste Management BMP 13

Description

Prevent or reduce the discharge of pollutants to stormwater from concrete waste by conducting off-site washout, performing on-site washout in a designated area, and training employees and subcontractors.

Applications

Concrete pours, such as foundation, footing or pile sites

Limitations

Drainage area – N/A
Minimum bedrock depth - N/A
NRCS soil type - BCD
Drainage/flood control – no
Maximum slope – N/A
Minimum water table - N/A
Freeze/thaw – good

Off-site washout of concrete wastes may not always be possible.

Targeted Pollutants

Concrete waste

Construction Guidelines

The following practices will help reduce stormwater pollution from concrete wastes:

- Avoid mixing excess amounts of fresh concrete or cement on site.
- Perform washout of concrete trucks off site or in designated areas only.
- Do not wash out concrete trucks into storm drains, open ditches, streets, or streams.
- Avoid dumping excess concrete in non-designated dumping areas.

For on-site washout:

- Locate washout area at least 50 ft from storm drains, open ditches, or water bodies. Construct a temporary pit or bermed area with a paved or gravel approach to capture liquid and solid waste.
- Wash out wastes into the temporary pit where the concrete can set, be broken up, and then disposed of properly.
- When washing concrete to remove fine particles and expose the aggregate, drain the water to a bermed or level area.
- Avoid washing sweepings from exposed aggregate concrete into the street or storm drain. Collect and return sweepings to aggregate base stockpile or dispose in the trash.
- Train employees and subcontractors in proper concrete waste management.

Maintenance

- Inspect subcontractors to ensure that concrete wastes are being properly managed.
- If using a temporary pit, dispose hardened concrete on a regular basis.

Sanitary/Septic Waste Management — BMP 14

Description

Prevent the discharge of pollutants to stormwater from sanitary/septic waste by providing convenient, well-maintained facilities, and arranging for regular service and disposal.

Applications

All construction sites where portable facilities are used.

Limitations

Drainage area – N/A
Minimum bedrock depth - N/A
NRCS soil type - N/A
Drainage/flood control – N/A
Maximum slope – N/A
Minimum water table - N/A
Freeze/thaw – N/A

No major limitations.

Targeted Pollutants

Nutrients
Bacteria

Approach

Sanitary and septic wastes should be disposed of in accordance with state and local requirements. Some of these requirements are listed below:

- Locate sanitary facilities in a convenient location.
- Avoid discharging or burying untreated raw wastewater.
- Ensure that temporary septic systems treat wastes to appropriate levels before discharging.
- If using an on-site disposal system (OSDS) such as a septic system, comply with local health agency requirements.
- Ensure that temporary sanitary facilities that discharge to the sanitary sewer system are properly connected. This practice will help eliminate illicit discharges.
- If discharging to the sanitary sewer, contact the local wastewater treatment plant for their requirements.
- Ensure that a licensed service maintains sanitary/septic facilities in good working order.
- Portable units may need to be staked or secured to a fixed object.

Maintenance

- Inspect facilities regularly.
- Arrange for regular waste collection.

Section 5 – Slope Protection and Stabilization

For the selection of the most appropriate or suitable BMP, the user should refer to the BMP Selection Matrix in Table 1. It is essential to check with the local permitting authority for other requirements.

Exposed soil surfaces should be minimized at all times. Whenever possible, natural vegetation on the site should be preserved. If exposed slopes are unavoidable, it is essential to apply erosion and sedimentation control BMPs to reduce discharge of sediment to nearby streams and the storm drainage system.

The following pages describe various slope protection and stabilization techniques. Any of the following BMPs can be implemented during the construction phase to control construction erosion and then kept in place for use after construction is complete:

BMP 15	Mulching
BMP 16	Hydraulic mulching
BMP 17	Geotextile
BMP 18	Matting
BMP 19	Soil binders
BMP 20	Topsoiling
BMP 21	Seeding
BMP 22	Sodding
BMP 23	Planting
BMP 24	Pipe slope drain
BMP 25	Slope roughening
BMP 26	Gradient terracing
BMP 27	Retaining walls

Mulching BMP 15

Description

Mulching is a temporary soil stabilization or erosion control practice where materials such as straw, grass, grass hay, compost, wood chips or wood fibers are placed on or incorporated into the soil surface. In addition to stabilizing soils, mulching can reduce the velocity of stormwater runoff over an area. When used together with seeding or planting, mulching can aid in plant growth by holding the seed, fertilizers, and topsoil in place, by helping to retain moisture, and by insulating against extreme temperatures.

Mulching protects the soil surface from splash erosion. It retards runoff, traps sediment, and creates more favorable conditions to assist germination and the early development of plants. The following natural and synthetic (stabilizers) mulches are suitable for use at construction sites:
Vegetative materials: wheat straw, rye straw, barley straw, grass hay
Wood products: wood cellulose fibers, wood chips, bark, sawdust
Other organic materials: leaves, peat, manure, compost
Rock products: gravel, slag, crushed stone
Fabricated mulch: jute, burlap, coconut (coir), excelsior, Kraft paper string
Synthetic mulch: asphalt, vinyl, plastics, latex, rubber, adhesives or "tackifiers."

Applications

- Mulch is an immediate, effective, and inexpensive means of controlling dust and erosion and aiding revegetation of construction sites. It provides immediate protection to soils that are exposed and that are subject to heavy erosion; it retains moisture (which may minimize the need for watering); and it requires no removal because of natural deterioration of most mulching materials.
- Mulch is often used alone in areas where temporary seeding cannot be used because of the season or climate. It may be used in conjunction with other treatments for increased effectiveness. Use of mulch may or may not require a binder, netting, or tacking agent to hold the mulch in place. On steep slopes and critical areas such as waterways, mulch matting is used with netting or anchoring to hold it in place.
- To aid in establishing vegetation, mulch seeded and planted areas where slopes are steeper then 2:1, where runoff is flowing across the area, or when seedlings need protection from bad weather. If the mulching effect is to be maintained longer than 3 months, the preferred mulch is vegetative material. Wheat straw is the most preferred vegetative material, followed by rye straw, barley straw, or grass hay.
- Wood chips are suitable for areas that will not be closely mowed and around ornamental plantings. Chips decompose slowly and do not require tacking, but they should be treated with nitrogen to prevent nutrient deficiency. Wood chips can be very inexpensive if they are obtained from trees cleared on the site. Chips should not be used on slopes greater than 6% because they tend to wash down slopes.

- Bark mulch is suitable for areas planted with grasses that will not be closely mowed. The bark may be applied mechanically or by hand.

- Crushed stone and gravel mulches are appropriate for dust control and soil protection on low-use dirt roads, driveways, and other areas of light vehicular activity within the construction site.

Limitations

Drainage area – 2 ac.	Maximum slope – 50%
Minimum bedrock depth – N/A	Minimum water table - N/A
NRCS soil type - ABCD	Freeze/thaw – fair
Drainage/flood control – no	

Disadvantages of mulch include the following:

- It may delay germination of some seeds because cover reduces the soil surface temperature.
- Mulch can be easily blown or washed away by runoff if not secured or incorporated. Lightweight mulch, such as straw, requires matting, crimping, or other methods to hold it in place.
- Some mulch materials, such as wood chips, may absorb nutrients necessary for plant growth.
- Straw mulch provides organic matter as it breaks down and is incorporated into the soil. If applications are too heavy, however, soil nutrient levels (especially nitrogen) may decline during the period of decomposition. Therefore, prescribed application rates of both the straw mulch and the specified fertilizer should be strictly followed. The use of a fertilizer low in phosphorus is recommended.
- Synthetic spray-on materials are not recommended except for temporary dust/erosion control or for steep, rocky slopes where other mulches and mechanical methods cannot be effectively applied. The synthetic mulches may create impervious surfaces and can have adverse effects on water quality.
- Avoid applying mulch as the only control on long slopes. Break up concentrated flows on these slopes using recommended methods in other BMPs.

Targeted Pollutants

Sediment
Phosphorus

Design Parameters

Stone and gravel:

- After the gravel or stone is applied, construction traffic may move over it. Areas that become compacted or depressed should be remulched to the same level as the remaining area to prevent flows from the site from becoming channelized into these depressions.
- Upon completion of activities on the site, the gravel or stone mulch may be left in place during revegetation operations.
- When used for driveways or dirt roads, a filter blanket should be placed under the gravel.

Straw:

- Straw mulch forms a loose layer when applied over a loose soil surface. To protect the mulch from wind drifting and water damage, it should be stabilized by covering it with netting, such as jute, or by spraying it with a tacking agent. Straw mulch should cover the entire seeded area or exposed slope. The mulch should extend into existing vegetation or stabilized areas on all sides to prevent wind or water damage which may start at the edges of the mulched area
- The straw fibers should be applied to form a uniform cover of loose straw through which 20% or less of the original ground surface can be seen. No large clumps of unscattered straw should exist after application.
- On small slopes, straw mulch should be applied by hand broadcasting to a uniform depth of 2 to 3.1 in. On larger slopes, straw can be blown onto the slope to achieve a uniform cover of 2 to 3.1 in.

Wood chips:
- Due to bacterial action during decomposition, nutrient concentrations in the soil may be depressed under a layer of wood chips. Because of this, applications should not exceed the specified thickness that would cause a marked decline in some soil nutrients for longer periods.
- When using wood chips to mulch revegetation projects, the specified application of fertilizer should be increased approximately 25% to replenish soil nutrients lost due to breakdown of wood chips.

Effectiveness of mulches:
- Crushed stone and gravel mulches retain their effectiveness indefinitely if properly applied and protected from compacting traffic. Sediment generation reduction is estimated at 70 to 90%, and nutrient generation reduction at 50 to 70%.
- Straw mulches react similarly to hydromulches, as they break down fairly rapidly. However, straw is twice as effective and at about half the cost of hydromulches. Sediment reduction by straw mulch without vegetation is 90 to 95% for a few months. It drops to 70 to 90% in 6 months, and further to 40 to 60% in 2 years, and 10 to 30% after that. Nutrient reductions are estimated at 60 to 80% for a few months, 50 to 70% in 6 months, 20 to 50% up to 2 years, and 0 to 10% beyond 2 years.
- Wood chips deteriorate more slowly than wood fiber and, therefore, retain their effectiveness longer. Sediment reductions of 90 to 95% can be expected for 1 year, 80 to 90% up to 2 years, and 50 to 60% beyond 2 years. Nutrient reductions of 60 to 80%, 50 to 70% , and 30 to 50% are estimated for the same period.

Construction Guidelines

- Seeding (temporary or permanent) can take place prior to or concurrent with mulching. Other surface runoff control measures should be installed prior to seeding and mulching. If seed is applied prior to mulch, mulch should be applied to seeded areas immediately after seeding.
- Mulches should not be applied when free surface water is present, but may be applied to damp ground.

- The choice of materials for mulching will be based on the type of soil to be protected, site conditions, season, and economics.

Straw mulch: The straw should be stabilized to prevent it from being damaged by water or wind (blown away). Use one of the following methods to apply straw mulch:

- Hand punching can be used on small sites, sites with rock and stone on the surface, sites with slopes that are steeper than 3:1, or sites that have been wattled. Take care not to damage wattling or planted vegetation. Use a spade or shovel to punch the straw into the slope until all areas have straw standing perpendicularly to the slope and embedded at least 4 in. into the slope. The bunches of straw should resemble the tufts of a toothbrush.
- Roller punching can be used on large, gently sloping sites without significant outcroppings of rock and stone. Roller punching should not be used on sites that have been wattled (unless there is adequate space between lines of wattling) or on planted sites. A roller equipped with straight studs not less than 6 in., from 4 to 6 in. wide, and approximately 3/4 in. thick, will best accomplish the desired effect. Studs should stand approximately 8 in. apart and should be staggered. All corners should be rounded to prevent withdrawing the straw from the soil. Vegetative planting may be conducted following roller punching.
- Crimper punching involves specially designed straw-crimping rollers. These are suitable for use wherever roller punching can be used. The crimpers consist of serrated disk blades, set 4 to 8 in. apart, that force straw mulch into the soil. Crimping should be done in two directions with the final pass conducted across the slope rather than up and down it.
- Tacking agents may be used on any type of site, but are best used only on very stony or rocky soils or small, steep slopes. Apply 28.5 ft^3/ac. of the tacking agent or its equivalent over the straw mulch. Agents that are neutral or nearly neutral in color and of demonstrated effectiveness for the soils and climate of the application area are acceptable.
- Matting may be used on large, steep areas that cannot be punched with a roller. Jute or wood excelsior on plastic netting should be applied over unpunched straw according BMP 18-Matting.

Maintenance

Inspect all mulched areas periodically (according to the inspection interval prescribed in the project site stormwater plan and after runoff-producing storm events. Repair damaged areas of the mulch immediately. Reseed or replant such areas, if necessary, before replacing the mulch cover. Straw mulch and other organic products do not have to be removed when the vegetation becomes established.

Table 15-1 shows the various mulches and their application rates.

Table 15-1. Guide to Mulch Materials, Rates and Uses				
Mulch Material	Quality Standards	Application Rate 1100 ft^2	Depth and Coverage	Remarks
Gravel, slag, or crushed stone	Washed, 3/4 to 11/2 in. diameter with at least 30% of it larger than 3/4 in. diameter	280 ft^3 (or more to ensure 90% coverage at 2.5 tons/1100 ft^2	2.75 to 3.1 in. uniform covering	Excellent mulch for short slopes around woody plants and ornamentals. Use where subject to foot traffic. Approximately 42.5 lb/ft
Hay or straw	Air dried, free of unwanted seeds and coarse material. Fibers should not be chopped or ground to reduce fiber length. Minimum fiber length - 8 in.	88 TO 110 lb (2 to 3 bales)	2 to 3.1 in. to form a uniform mat through which 20 to 40% of the original ground surface can be seen.	Use where the mulching effect is to be maintained for >3 months. Subject to blowing unless kept moist, punched, or tacked down. Most common and widely used mulching material. Can be used in critical erosion areas.
Wood fiber cellulose	Dyed material should not contain any growth inhibiting factors	22 to 33 lb		If used on critical areas, double the normal application rate. Apply with hydromulch. No tie-down required. Packaged in 110 lb bags
Wood chips	Do not use kiln-dried or air-dried material. Chip size 1/2 x 1 1/2 in. diameter and 1/10 to 1/2 in. thick		2.75 to 3.1 in. uniform depth	Applying at over the specified thickness may markedly reduce soil nutrients for a long time. Increase fertilizer 25% with wood chip mulch on revegetation sites.
Compost	Odorless or earthy smell	5.3 to 53 ft^3	2 to 3.1 in. uniform depth	Inexpensive, but may not be available in some areas.

Hydromulching — BMP 16

Description

Hydraulic mulching (hydromulching) is a process where wood fiber mulch, processed grass, hay, or straw mulch are applied with a tacking agent in a slurry with water to provide temporary stabilization of bare slopes or other bare areas. This mulching method provides uniform, economical slope protection. It may be combined with hydroseeding as a revegetation method (see BMP 21-Seeding).

Applications

Hydromulching is an effective way to increase water retention (thereby reducing erosion) for 6 months or up to 1 year. Beyond 1 year, the effectiveness drops off. Hydraulic mulching can be applied to areas that are within about 200 ft of a road or that can otherwise be reached by truck. Small roadside slopes and large, relatively flat areas are well adapted to this method. When adequate moisture exists, the slurry can be combined with seed and fertilizer to initiate stabilization and revegetation in a single application (see BMP 3-Preservation of Existing Vegetation). The mulch usually lasts about 1 year. The growing vegetation is needed to provide continued stabilization.

Limitations

Drainage area – 2 ac.	Maximum slope – 15%
Minimum bedrock depth - N/A	Minimum water table - N/A
NRCS soil type - ABCD	Freeze/thaw – fair
Drainage/flood control – no	

- Loses effectiveness after 1 year.
- Only suited for physically stable slopes (at natural angle of repose, or less).
- Avoid hydromulching on long uninterrupted slopes. Break up concentrated flows with other BMPs, such as BMP 26-Gradient Terracing or BMP 32-Check Dams.

Targeted Pollutants

Sediment
Phosphorus

Design Parameters

Effectiveness: Hydromulching initially reduces sediment generation by 70 to 80% as compared to sediment production off bare slopes. Within 2 years, the breakdown of wood fiber will have reduced its effectiveness to 40 to 60%. Beyond that time, only 10 to 30% effectiveness can be expected, and the mulch should be replaced. Nutrient generation is typically reduced 50 to 70% for 6 months, 20 to 50 percent up to 2 years, and 0 to 10% beyond 2 years.

Equipment: The hydraulic mulching machine should be equipped with a gear-driven pump and a paddle agitator. Agitation by recirculation from the pump is not acceptable. Agitation should be sufficient to produce homogeneous slurry of tacking agent and mulch (and seed fertilizer, if used).

Application rates: Apply the water at a minimum rate of 3000 gallons per acre. Tacking agent should be applied at 28.5 ft^3 of wet ingredients per acre. When seeding is combined with hydraulic mulching, be sure to include an appropriate specified formulation at the specified rate. Legume seeds should be pellet inoculated with the appropriate bacteria. Inoculation rates should be four times that required for dry seeding.

Construction Guidelines

- The time allowed between placement of seed in the hydraulic mulcher and the emptying of the hydraulic mulcher tank should not exceed 30 minutes.
- Wood fiber may be dyed to aid in uniform placement. Dyes should not stain concrete or painted surfaces nor injure plant or animal life when applied at the manufacturer's recommended rate.
- Application of the slurry should proceed until a uniform cover is achieved. The applicator should not be directed at one location for too long a period of time or the applied water will cause erosion.

Maintenance

Hydromulched slopes should be inspected periodically for damage due to wind, water, or human disturbance. Repair all damaged areas immediately using hydromulching at the original specifications or straw mulch.

Description

Geotextiles are porous fabrics known in the construction industry as filter fabrics, road rugs, synthetic fabrics, construction fabrics, or simply fabrics. Geotextiles are manufactured by weaving or bonding fibers made from synthetic materials such as polypropylene, polyester, polyethylene, nylon, polyvinyl chloride, glass, and various mixtures of these materials.

The material is applied from a roll and anchored into place to provide a continuous sheet over the exposed slope or surface. This sheeting reduces raindrop impact and surface erosion on disturbed soils. It can also protect new vegetation and aid in growth and establishment of vegetation by retarding evaporation of soil moisture. They can also be used on benched slopes.

Geotextiles are used for a variety of purposes as separators or reinforcement, for filtration and drainage, and for erosion control on slopes or stream banks. Matting or netting made of biodegradable materials (such as jute, wood fiber, straw, coconut, paper, or cotton) can be used for many of these same purposes, but it tends to be less durable. These products are discussed separately under BMP 18-Matting.

Applications

Geotextiles are an effective tool to prevent surface erosion and promote rapid establishment of a permanent (or temporary) vegetative cover. The two main applications are for slope protection and as a flexible channel lining. For slope protection applications, the fabrics are useful in preventing the loss of topsoil, thereby reducing surface erosion and promoting establishment of vegetative cover. They should be given serious consideration where slope, high flows, or other factors prevent use of organic matting.

Used alone, geotextiles can function as erosion control matting to stabilize channels and swales or to protect recently planted seedlings until they become established. They may be placed in ditches or along stream banks to protect new plantings if more elaborate measures, such as riprap or rock revetments, are not appropriate. The purpose of this application is to protect the integrity of the ditch or stream while permanent vegetative cover becomes established.

Geotextiles are also used as separators. An example of such a use is geotextile as a separator between riprap and soil. This "sandwiching" prevents the soil from being eroded from beneath the riprap. The following are some of the primary advantages of using geotextiles:

- Relatively low cost for many applications.
- Ease and convenience for many applications.
- Quick and effective protection against erosion problems.
- Design methodologies are available for many uses.
- A wide variety of geotextile products are available to match specific needs.
- Synthetic geotextiles may be removed and reused if economically

feasible.

- Better resistance to high-flow situations than organic matting.

Limitations

Drainage area – 100 ac.
Minimum bedrock depth - N/A
NRCS soil type - ABCD
Drainage/flood control – no
Maximum slope – 100%
Minimum water table - N/A
Freeze/thaw – good

- Effectiveness may be reduced drastically if the fabric is not properly selected, designed, or installed.
- Many synthetic geotextiles are sensitive to light and should be protected prior to installation.
- Geotextiles that are not biodegradable should not be used where their presence or appearance is aesthetically unacceptable.
- Should not be placed on 50% slopes if they are to be covered with overlying material.

Targeted Pollutants

Sediment

Design Parameters

Maximum slope steepness: Products are available for up to 50% slopes.

Durability/decomposition: Some synthetic geotextiles persist a very long time and should be considered a permanent measure. Others remain effective for less than 1 year. Those types designed to assist in establishment of vegetation will eventually photo-degrade or decompose. If a short-term, degradable product is needed, see BMP 18-Matting.

Materials: In determining how much fabric is needed, allow for an overlap of 4 in. on both sides of each roll and 3 ft at the ends of rolls. Also, the fabric should extend beyond the edge of the exposed area at least 1 ft at the sides and 3 ft at the top and bottom. Staples should be of 1/10 in. diameter (or heavier) steel wire. Allow for a spacing of approximately 5 ft apart along the sides and center of each roll and not more than 1 ft apart along upper end of a roll or at the overlap of two rolls.

Construction Guidelines

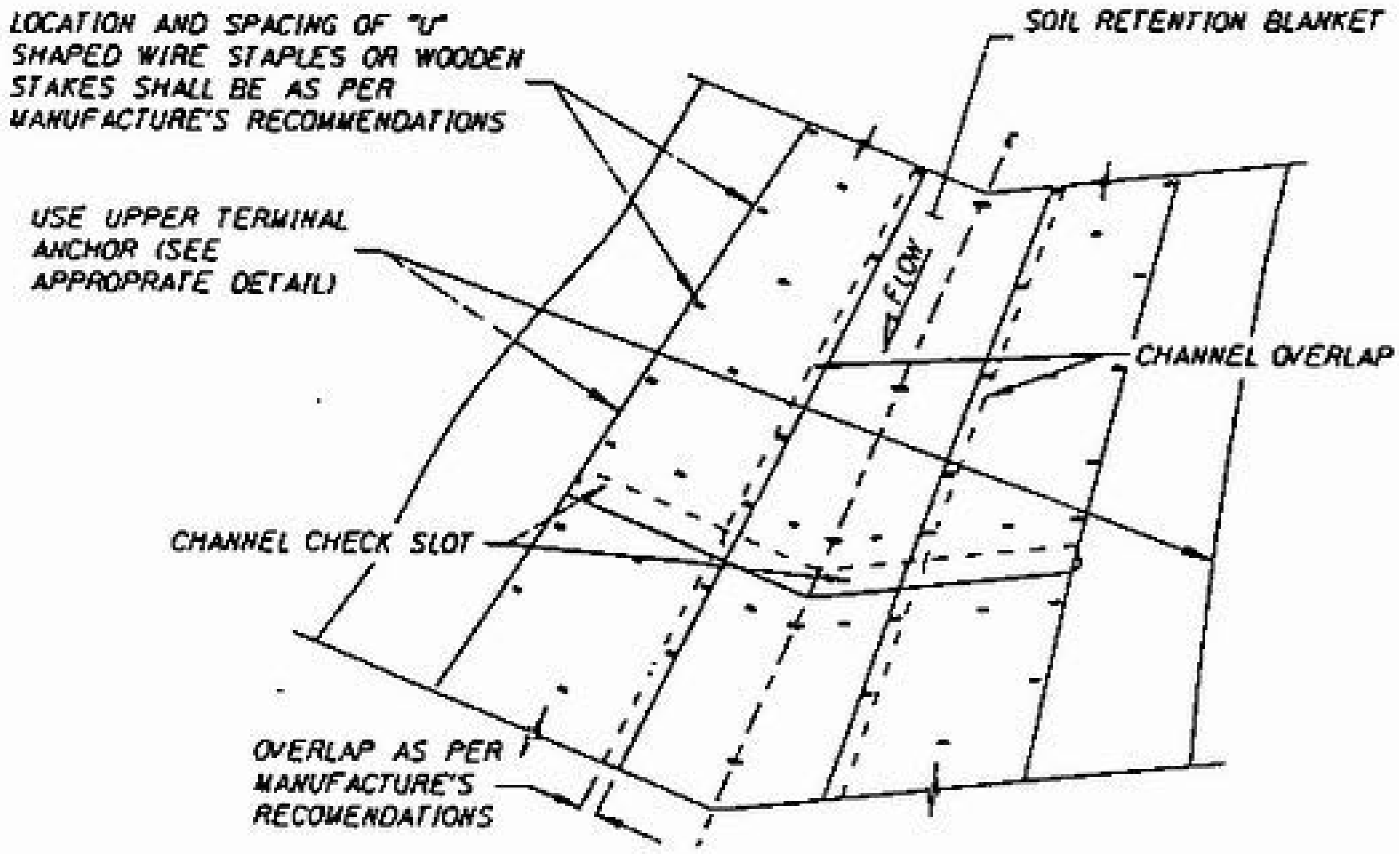
- The soil should be reasonably smooth. Fill and compact any rills and gullies. Remove protruding rocks and other obstructions.
- Apply the individual rolls up and down the slope, from the top to the bottom--never along the contour.
- Overlap the sides of rolls at least 4 in., and make sure there is at least a 3 ft overlap when an uphill roll joins to a downhill roll. The uphill roll should overlie the downhill roll.
- Extend the fabric beyond the edge of the mulched or seeded area at least 1 ft at the sides and 3 ft at the top and bottom of the area. If existing vegetation or structures mark the boundaries of the area, the fabric should continue into the stable vegetated area or to the edge of the structure.
- At the top of the area, bury the end of each roll in a trench at least 8 in. deep. The trench should then be backfilled and tamped.
- Staples should be driven perpendicularly into the slope face. Place them

approximately 5 ft apart down the sides and center of the roll, and not more than 1 ft apart at the upper end of a roll or at the end overlap of two rolls.

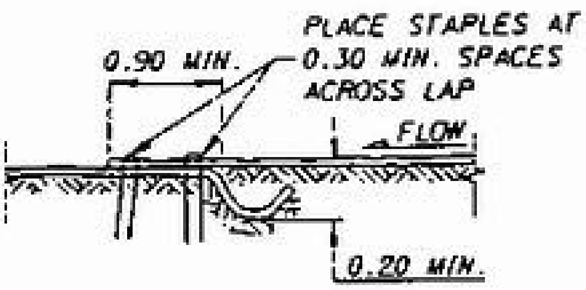
- Be sure the fabric makes uniform contact with the slope face underneath. No "bridging" of rills or gullies should be allowed.

Maintenance

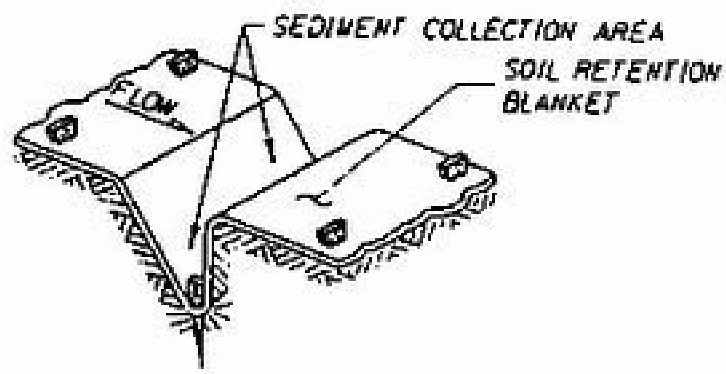
- Inspect weekly or monthly and within 24 hours after each runoff-producing storm. To assure proper functioning, complete one inspection during the first runoff-producing event after installation. If fabric sheeting is damaged or missing, replace it immediately to restore full protection. Also inspect to ensure that channelization and erosion is not occurring underneath fabric (sediment outwash is the most visible sign of this.)
- Products used for temporary control may be removed and reused, if this can be done without leaving the area susceptible to erosion.



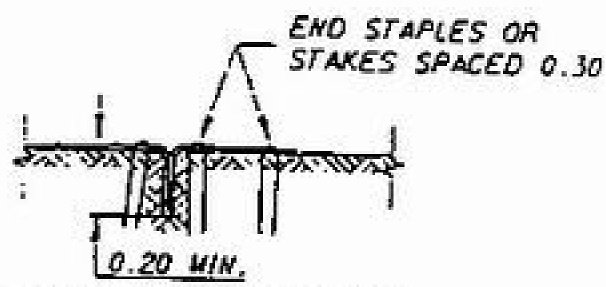
CHANNEL INSTALLATION



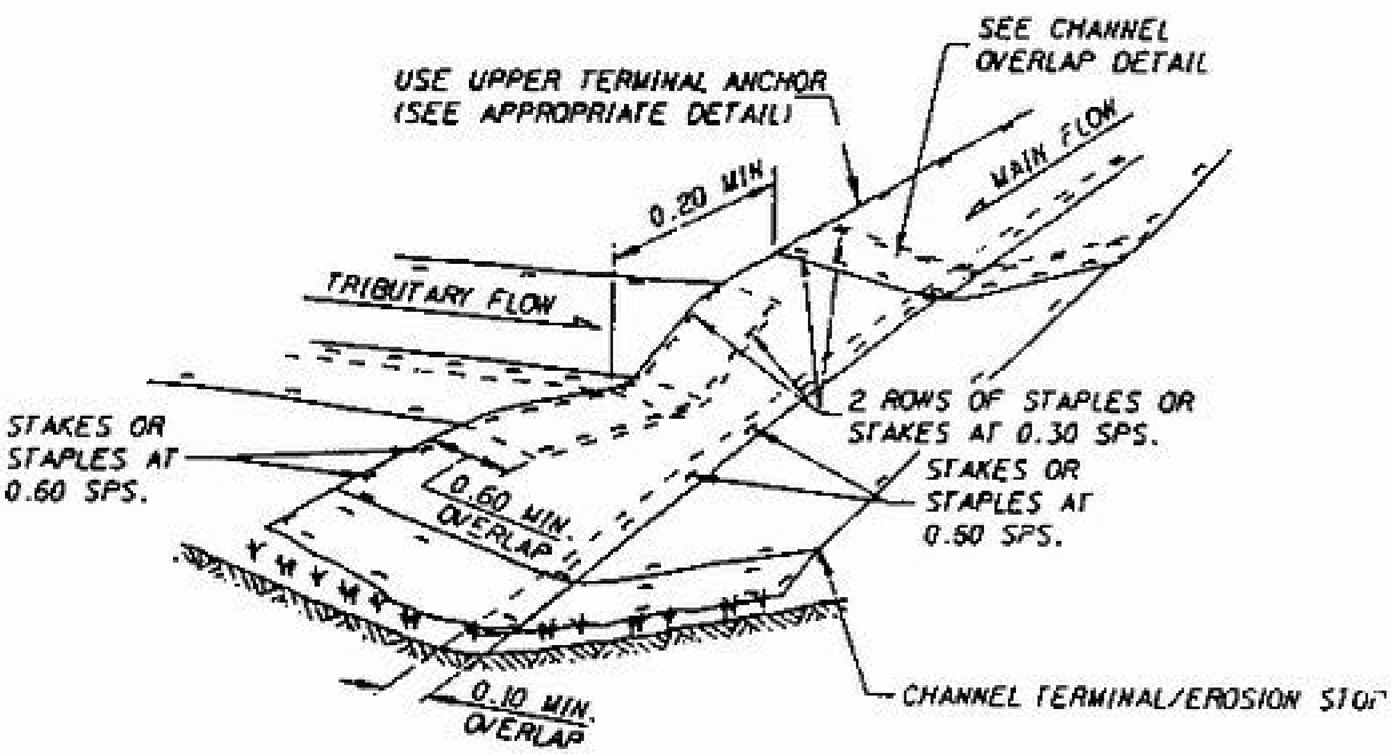
CHANNEL OVERLAP



CHANNEL CHECK SLOT



CHANNEL TERMINAL/EROSION STOP



CHANNEL INTERSECTION

Matting BMP 18

Description

Matting is a porous net or fibrous sheet that is laid over the ground surface for slope stabilization and erosion control or to hold mulch in place and protect it against wind or water damage. Matting and netting are sometimes classified as geotextiles (see BMP 17-Geotextile), but in this catalog, matting is considered to be materials made from biodegradable materials including straw, coconut (coir), jute, wood fiber (excelsior), paper, and cotton. Some of these organic materials may be held in place by plastic netting.

Applications

A wide variety of matting materials may be used for erosion control. Most are of two main types: woven, such as jute, and bonded to plastic, such as excelsior. Application examples for these two types are listed below.

Jute matting: Jute matting or netting is available as a heavy fiber net that is generally purchased in rolls and is stapled/anchored to slopes to provide a uniform covering. This covering protects mulches, provides additional water-holding capacity, and aids in moderating environmental fluctuations near the ground surface (as does a mulch).

Jute matting can be applied over straw, grass hay, wood fiber, or manure mulches when wind or water damage would occur without a protective net. Matting is the best single method for protecting the integrity of a mulched area. It may be applied alone as an alternative to straw or wood fiber mulches on flat sites for dust control and seed germination enhancement, but should not be applied alone where runoff quantities are significant.

Wood fiber (Excelsior) matting: Wood fiber matting is made by bonding wood excelsior fibers to a paper or plastic reinforcing net. The matting is generally purchased in rolls and stapled to slopes to provide a uniform covering which can protect mulches, provide enhanced water-holding capacity, and aid in moderating environmental fluctuations near the ground surface.

Plastic netting: Plastic netting (photo/biodegradable) is a monolithic plastic cloth-like material. It is used primarily to hold straw and other materials in place. Plastic netting is more durable than jute or wood fiber matting. It is much easier to handle and requires less labor, but it has no mulch capabilities itself. Plastic netting alone provides no soil stabilization or erosion control. It is best used to hold down mulches until vegetation becomes established.

Matting can be useful in the following circumstances:

- Construction sites becoming temporarily inactive (inactive period greater than 2 weeks and less than 1 year).
- Graded areas receiving permanent revegetation treatment by seeding.
- Bare areas receiving permanent revegetation treatment by seeding.

Limitations

Drainage area – 100 ac.
Minimum bedrock depth – 2 ft
NRCS soil type - ABCD
Drainage/flood control – no
Maximum slope – 100%
Minimum water table - N/A
Freeze/thaw – good

- Should not be used where overland water flow will exceed 6.5 ft/s. Because of the following characteristics of plastic netting and wood fiber matting, jute matting, straw or straw coconut matting are preferred.
- Plastic netting does not function as mulch (as does jute matting) since it does not absorb water. When plastic netting is used to anchor straw mulch, it increases the effectiveness of the mulch, but it does not provide direct control of erosion and sedimentation or nutrient generation. Straw mulch rates should be increased 25% when plastic netting is used instead of jute or straw.
- Wood fiber matting is more difficult to put in place than jute, and it is less predictable in controlling erosion. Properly applied, it can be as effective as jute matting at sediment and nutrient reduction. However, it is often 10 to 20% less effective.

Targeted Pollutants

Sediment

Design Parameters

- Jute matting should be fiber cloth of a uniform plain weave, undyed and unbleached single jute yarn, 3 to 4 ft wide and weighing an average 0.4 lb per linear foot of cloth with a tolerance of plus or minus 5%. It should have approximately 78 warp ends per width of cloth and 45 weft ends per linear meter of cloth. The yarn should be of a loosely twisted construction having an average twist of not less than 6.3 turns per 4 in. and should not vary in thickness by more than half of its normal diameter.
- Wood fiber matting should consist of machine-produced mats of curled wood excelsior, of which 80% have a 8 in. or longer fiber length. It should be of consistent thickness with the fiber evenly distributed over the entire area of the blanket (backing). The topside of each blanket should be covered with a 1 x 3 in. weave of twisted Kraft paper or biodegradable plastic mesh that has a high wet strength. Blankets should be fire and smolder resistant and contain no chemical additives. Blankets should be in rolls 3 to 4 ft wide and 130 to 200 ft long.
- Plastic netting with mesh opening from 1/10 x 1/10 in. to 1/5 x 1/5 in. should be applied over straw mulch similarly to the method specified below for jute matting.

Effectiveness: Jute matting acts similarly to straw mulch or hydromulch. Sediment reduction is typically 70 to 90% for up to 6 months, 40 to 60% for up to 2 years, and 10 to 30% beyond 2 years. Nutrient reduction is estimated at 50 to 70% for 6 months, 20 to 50% for up to 2 years, and 0 to 10% beyond 2 years.

Due to the difficulty of proper application, wood excelsior matting has a more variable effectiveness than straw, jute, or hydromulch. Properly applied, it can be as effective. Sediment reduction should range from 50 to 90%, 20 to 60%, and 0 to 30% in 6 months, 2 years, and beyond 2 years, respectively. Nutrient reductions for the same time periods are estimated to be 30 to 70%, 10 to 50%, and 0 to 10%.

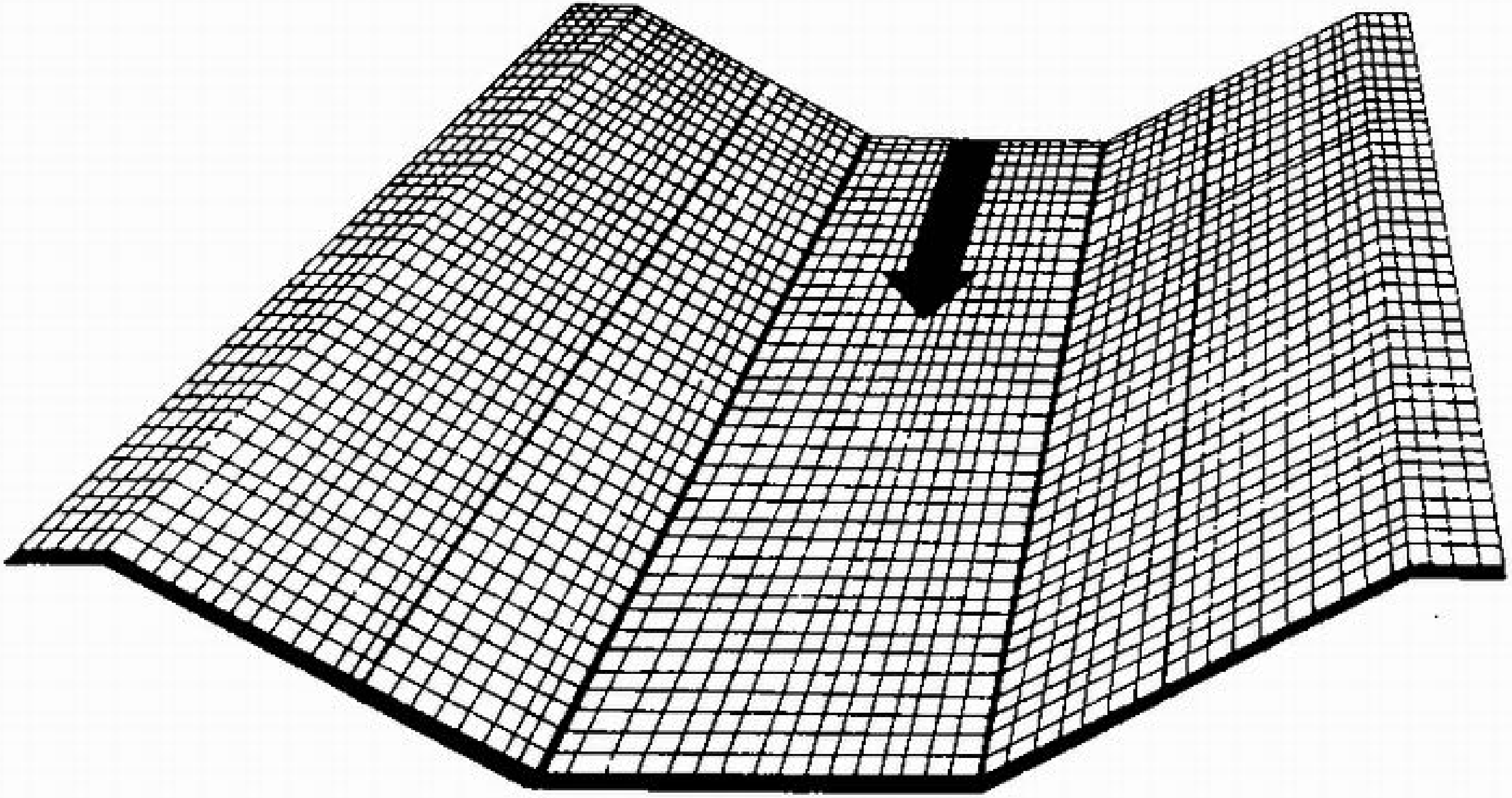
Construction Guidelines

The following guidelines apply to all matting and netting installations:

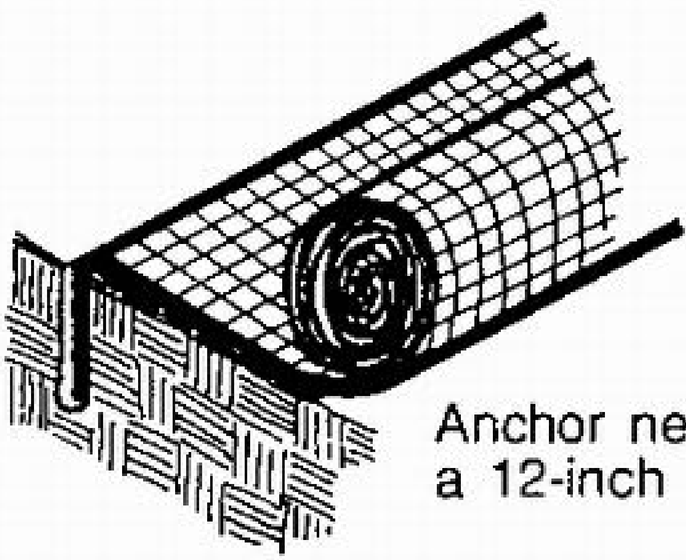
- The soil should be reasonably smooth. Fill and compact any gullies and rills. Rocks, vegetation or other obstructions that rise above the level of the soil should be removed.
- After site preparation and seeding (if any), the rolls of netting or matting should be rolled onto the surface from the top of the slope to the bottom of the slope. It is preferred that rolls are not constructed in a horizontal direction across the slope face. The rolling should follow water flow direction.
- At the top of the area, bury the end of each roll in a trench at least 8 in. deep. The trench should then be backfilled and tamped.
- Overlap the sides of rolls at least 4 in., and make sure that there is at least a 3 ft overlap when an uphill roll joins to a downhill roll. The uphill roll should overlie the downhill roll.
- Extend the matting beyond the edge of the mulched or seeded area at least 1 ft at the sides and 3 ft at the top and bottom of the area. If existing vegetation or structures mark the boundaries of the area, the matting should continue into the stable vegetated area or to the edge of the structure.
- Staples should be driven perpendicularly into the slope face. Place them approximately 3 ft apart down the sides and center of the roll, and not more than 1 ft apart at the upper end of a roll or at the end overlap of two rolls.
- Staples should be of heavy gauge wire (7/100 in. diameter or greater), bent into a "U" shape, with legs at least 6 in. long, and a 1 in. crown. Use longer staples and greater frequency in loose or sandy soil.
- Be sure the matting makes uniform contact with the slope face underneath. No “bridging” of rills or gullies should be allowed.
- If wood fiber matting is to be applied without other mulches, the minimum thickness of mat should be 1.5in. If the mat is to be applied over other mulches, the minimum mat thickness should be 0.5in.

Maintenance

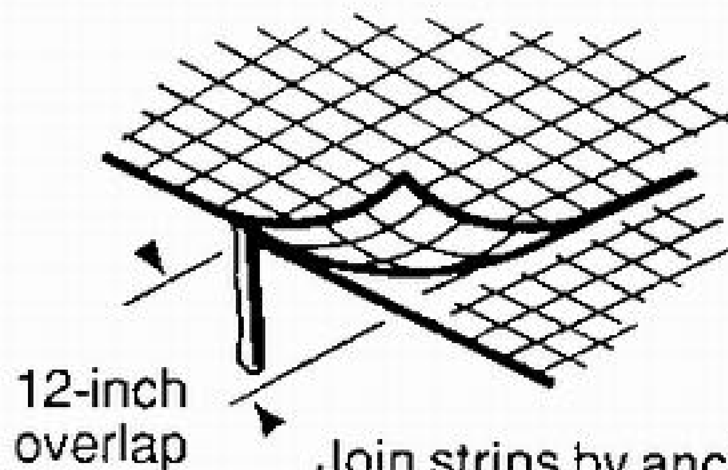
Inspect at regular intervals and after each runoff-producing storm event. Make repairs as necessary to restore complete coverage and full effectiveness of the matting or netting.



In channels, roll out strips of netting parallel to the direction of flow and over the protective mulch.



Anchor netting in a 12-inch trench



Join strips by anchoring and overlapping.

Soil Binders BMP 19

Description

Polyacrylamide (PAM) is a chemical that can be applied to disturbed soils at construction sites to reduce erosion and improve settling of suspended sediment.

PAM increases the soil's available pore volume, thus increasing infiltration and reducing the quantity of stormwater runoff that can cause erosion. Suspended sediment from PAM-treated soils exhibit increased flocculation over untreated soils. The increased flocculation aids in their deposition, thus reducing stormwater runoff turbidity and improving water quality.

Applications

PAM is suitable for use on disturbed soil areas that discharge to a sediment trap or sediment basin. PAM is typically used in conjunction with other BMPs to increase their performance. PAM can be applied to the following areas:

- Rough graded soils that will be inactive for a period of time
- Final graded soils before application of final stabilization (e.g., paving, planting, mulching)
- Temporary haul roads prior to placement of crushed rock surfacing
- Compacted soil road base
- Construction staging, materials storage, and layout areas
- Soil stockpiles
- Areas that will be mulched

Limitations

Drainage area – unlimited	Maximum slope – unlimited
Minimum bedrock depth - N/A	Minimum water table - N/A
NRCS soil type - ABCD	Freeze/thaw – fair
Drainage/flood control – no	

- PAM should not be directly applied to water or allowed to enter a water body.
- Do not use PAM on a slope that flows into a water body without passing through a sediment trap or sediment basin.
- PAM will work when applied to saturated soil but is not as effective as applications to dry or damp soil.
- PAM designated for erosion and sediment control should be "water soluble" or "linear" or "non-cross linked."

Targeted Pollutants

Sediment

Application Guidelines

- PAM should be used in conjunction with other BMPs and not in place of other BMPs, including both erosion and sediment controls.
- Stormwater runoff from PAM treated soils should pass through a sediment control BMP prior to discharging to surface waters.
  - ✓ When the total drainage area is greater than or equal to 5 acres, PAM treated areas should drain to a sediment basin.

- ✓ Areas less than 5 acres should drain to sediment control BMPs, such as a sediment trap, or a minimum of three check dams per acre. The total number of check dams used should be maximized to achieve the greatest amount of settlement of sediment prior to discharging from the site. Each check dam should be spaced evenly in the drainage channel.

- Do not add PAM to water discharging from the site.
- On PAM treated sites, the use of silt fence and fiber rolls should be maximized to limit the discharges of sediment to sediment traps and sediment basins.
- All areas no being actively worked on should be covered and protected from rainfall. PAM should not be the only cover BMP used.
- PAM can be applied to wet soil, but dry soil is preferred due to less sediment loss.
- Proper application and re-application plans are necessary to ensure total effectiveness of PAM usage.
- PAM, combined with water, is very slippery and can be a safety hazard. Care should be taken to prevent spills of PAM powder onto paved surfaces. During an application of PAM, prevent over spray from reaching pavement, as pavement will become slippery. If PAM powder gets on skin or clothing, wipe it off with a rough towel rather than washing with water; this only makes cleanup messier and longer.

Maintenance

- Inspect BMPs prior to forecast rain, daily during extended rain events, after rain events, weekly during the rainy season, and at 2-week intervals during the non-rainy season.
- Areas where erosion is evident should be repaired and BMPs re-applied as soon as possible. Care should be exercised to minimize the damage to protected areas while making repairs, as any area damaged will require re-application of BMPs.
- PAM should be reapplied on actively worked areas after a 48-hour period if PAM is to remain effective.
- Reapplication is not required unless PAM-treated soil is disturbed or unless turbidity levels show the need for an additional application.
- If PAM treated soil is left undisturbed a reapplication may be necessary after 2 months.
- More PAM applications may be required for steep slopes, silty and clayey soil (USDA Classification Type “C” and “D” soils), long grades, and high precipitation areas.
- When PAM is applied first to bare soil and them covered with straw, a reapplication may not be necessary for several months.

Topsoiling BMP 20

Description

Topsoiling is the placement of topsoil or other suitable plant growth material over disturbed lands to provide a suitable soil medium for vegetative growth and a supply of native or locally occurring seeds and propagules. Topsoiling may involve bringing in soils from off site or merely replacing fertile topsoil that was stripped and stockpiled during earlier site development activities.

Applications

Topsoiling is recommended on slopes 2:1 or flatter where the native soil is unsuitable for vegetative growth. It is an effective way of improving plant establishment on sites where moisture, nutrients, or pH levels are low, or where the remaining soil is too shallow to support root systems.

Limitations

Drainage area – unlimited
Minimum bedrock depth – 3 ft
NRCS soil type – N/A
Drainage/flood control – no
Maximum slope – 50%
Minimum water table – 2 ft
Freeze/thaw – fair

Be careful not to apply topsoil over a subsoil of contrasting texture. For instance, clay-like topsoil placed over a sandy soil may cause the topsoil to slough as water flows between the two soil layers of different permeability. Also, topsoil should not be applied when the subsoil is frozen or extremely wet.

Targeted Pollutants

Sediment

Design Parameters

Plan to maintain the existing or established grade of the subsoil. The topsoil should be uniformly distributed at a minimum compacted depth of 2 in. on slopes 3:1 or steeper, and 4 in. deep on flatter slopes. The soil should be a loam, sandy loam, clay loam, silt loam, sandy clay loam, or other mixture approved by an agronomist. It should be free of subsoil, refuse, sticks, noxious weed seeds, other extraneous materials, and stones larger than 1.5 in. diameter.

Topsoil can either be obtained commercially or stripped, stockpiled, and replaced on the construction site. Stockpiled topsoil should undergo a laboratory analysis to determine organic content, pH, and soluble salts. A pH of 6.0 to 7.5 and organic content of not less than 1.5% by weight is recommended. Where soil pH is less than 6.0, lime may be applied to adjust pH to 6.5 or higher. Any soils having soluble salt content greater than 500 parts per million should not be used.

If desired, it is possible to place a thin layer of topsoil 1.2 to 2 in. thick on benched slopes. In such applications, it is important not to apply so much topsoil that the value of the benches is destroyed. This method is especially valuable on rocky benches, especially on south- or west-facing slopes, however, proper placement of the soil is often a problem. In some cases, soil has been bucketed onto slopes. This produces an uneven spread and the quantity is hard to control. Soil can also be blown onto the slope using a snow blower. In that case, organic matter can be mixed with the soil, but the soil should be screened to remove any rocks larger than 2 in.. The advantage is that the amount of soil needed is much less and it can be spread very rapidly on the horizontal surfaces. The soil may need some form of stabilization before the next rain event. Consider whether mulch, matting, geotextiles or seeding is required and when.

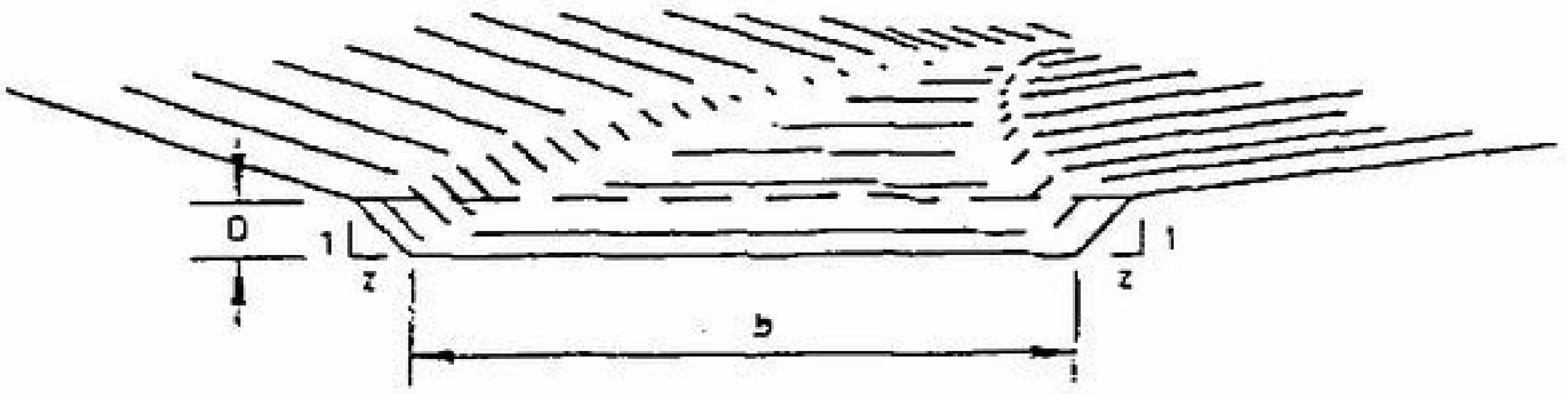
Construction Guidelines

The following guidelines apply to the placement of topsoil:

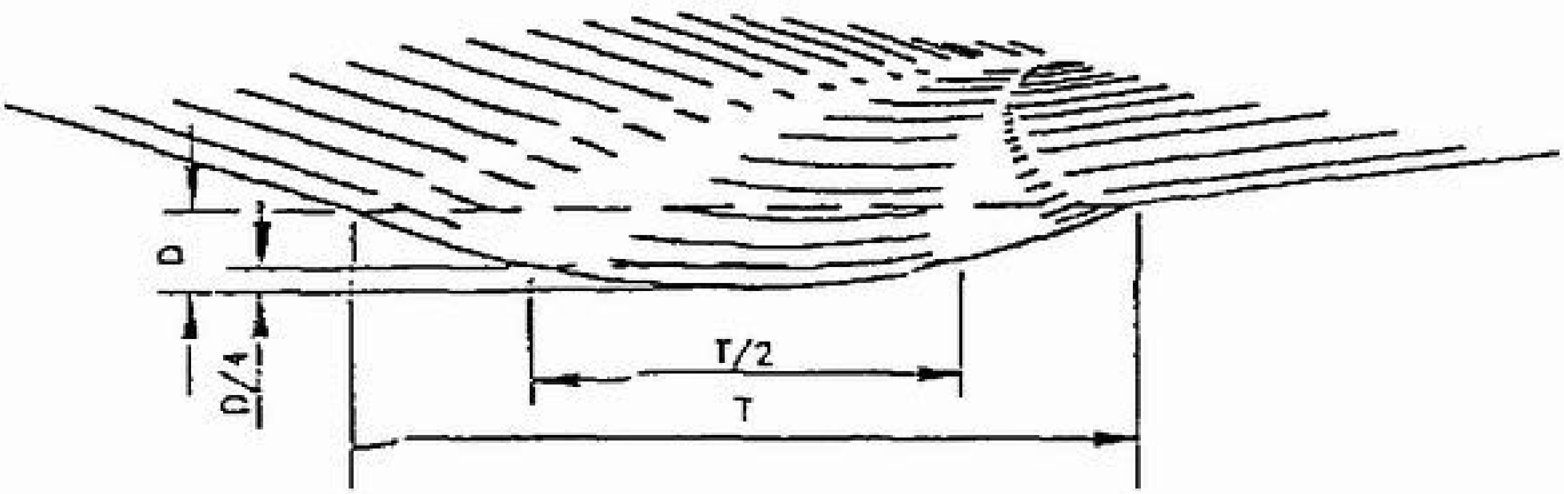
- The existing or established grade of subsoil should be maintained.
- Lime may be uniformly applied over designated areas where subsoil is highly acidic or heavy in clay content.
- Prior to spreading topsoil, loosen the subgrade by discing (or other method) to a depth of 2 in. to permit bonding of subsoil to topsoil. Tracking a bulldozer vertically over the slope will pack the soil and create horizontal erosion check slots to prevent topsoil from sliding down the slope.
- Spread the topsoil uniformly at a minimum compacted depth of 2 in. on 1:3 or steeper slopes and 4 in. on flatter slopes. A depth of 6 to 12 in. is preferred. Any surface irregularities should be corrected in an effort to prevent formation of water-holding depressions.
- Where quantities of stockpiled topsoil on site are limited, it is more desirable to cover all areas of exposed subsoil to a lesser depth than to cover partial areas to the suggested minimum depth of 3.1 in..
- Topsoil should not be placed when the subgrade is frozen, excessively wet, or in a condition that may otherwise be detrimental to proper grading or proposed sodding or vegetation establishment.

Maintenance

Periodically and after major storm events, inspect, repair, and reseed as necessary to control slope erosion and subsequent topsoil losses.



TRAPEZOIDAL CROSS-SECTION



PARABOLIC CROSS-SECTION

CONSTRUCTION SPECIFICATIONS

1 ALL TREES, BRUSH, STUMPS, OBSTRUCTIONS AND OTHER OBJECTIONABLE MATERIAL SHALL BE REMOVED AND DISPOSED OF SO AS NOT TO INTERFERE WITH THE PROPER FUNCTIONING OF THE WATERWAY.

2 THE WATERWAY SHALL BE EXCAVATED OR SHAPED TO LINE, GRADE AND CROSS SECTION AS REQUIRED TO MEET THE CRITERIA SPECIFIED HEREIN, AND BE FREE OF BANK PROJECTIONS OR OTHER IRREGULARITIES WHICH WILL IMPEDE NORMAL FLOW.

3 FILLS SHALL BE COMPACTED AS NEEDED TO PREVENT UNEQUAL SETTLEMENT THAT WOULD CAUSE DAMAGE IN THE COMPLETE WATERWAY.

4 ALL EARTH REMOVED AND NOT NEEDED IN CONSTRUCTION SHALL BE SPREAD OR DISPOSED OF SO THAT IT WILL NOT INTERFERE WITH THE FUNCTIONING OF THE WATERWAY.

5 STABILIZATION SHALL BE DONE ACCORDING TO THE APPROPRIATE "STANDARD AND SPECIFICATIONS FOR VEGETATIVE PRACTICES".

A FOR DESIGN VELOCITIES OF LESS THAN 3.5 ft. per sec., SEEDING AND MULCHING MAY BE USED FOR THE ESTABLISHMENT OF THE VEGETATION. IT IS RECOMMENDED THAT, WHEN CONDITIONS PERMIT, TEMPORARY DIVERSIONS OR OTHER MEANS SHOULD BE USED TO PREVENT WATER FROM ENTERING THE WATERWAY DURING THE ESTABLISHMENT OF THE VEGETATION.

B FOR DESIGN VELOCITIES OF MORE THAN 3.5 ft. per sec., THE WATERWAY SHALL BE STABILIZED WITH SOD, WITH SEEDING PROTECTED BY JUTE OR EXCELSIOR MATTING OR WITH SEEDING AND MULCHING INCLUDING TEMPORARY DIVERSION OF THE WATER UNTIL THE VEGETATION IS ESTABLISHED.

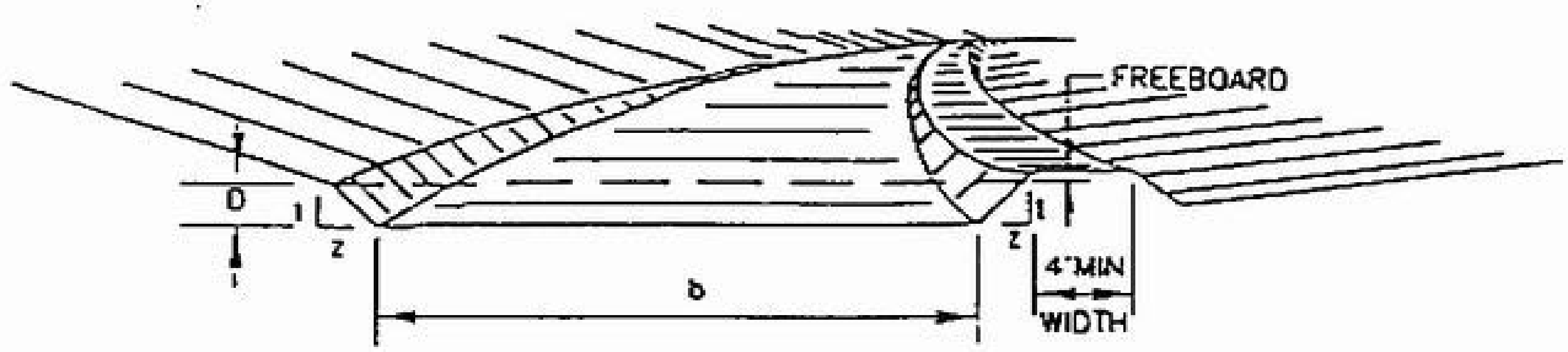
C STRUCTURAL – VEGETATIVE PROTECTION

(1) SUBSURFACE DRAIN FOR BASE FLOW SHALL BE CONSTRUCTED AS SHOWN ON THE STANDARD DRAWING AND AS SPECIFIED IN THE "STANDARD AND SPECIFICATIONS FOR SUBSURFACE DRAIN".

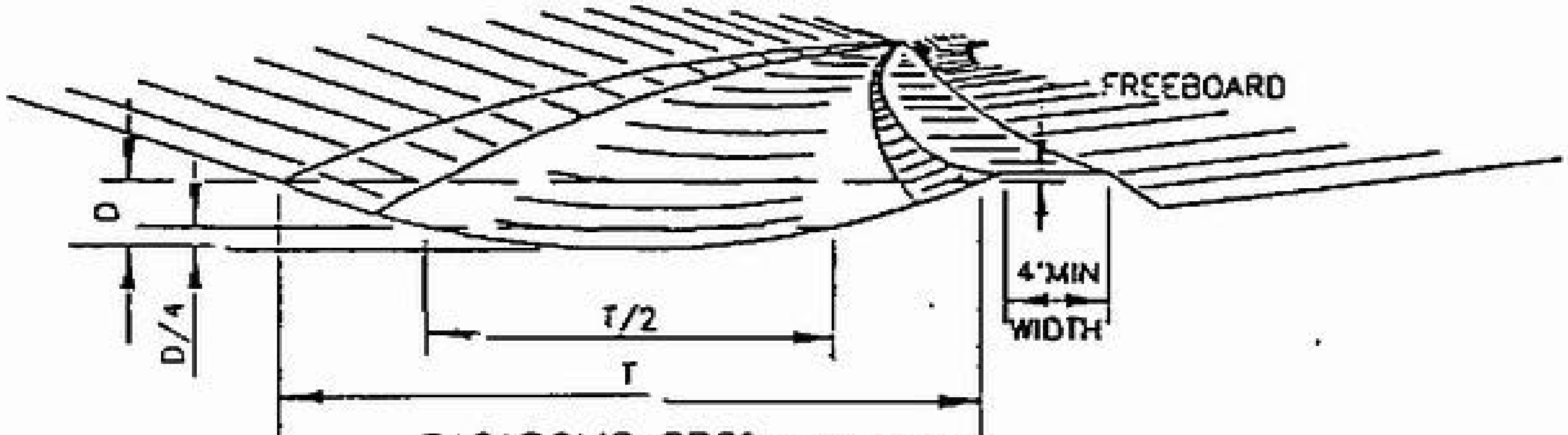
GW

STANDARD SYMBOL

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE TOOTHMAN-ORTON ENGINEERING COMANY BOISE, IDAHO McCALL, IDAHO	GRASSED WATERWAY	STANDARD DRAWING GW-1



TRAPEZOIDAL CROSS-SECTION



PARABOLIC CROSS-SECTION

CONSTRUCTION SPECIFICATIONS

1 ALL TREES, BRUSH, STUMPS, OBSTRUCTIONS AND OTHER OBJECTIONABLE MATERIAL SHALL BE REMOVED AND DISPOSED OF SO AS NOT TO INTERFERE WITH THE PROPER FUNCTIONING OF THE DIVERSION.

2 THE DIVERSION SHALL BE EXCAVATED OR SHAPED TO LINE, GRADE AND CROSS SECTION AS REQUIRED TO MEET THE CRITERIA SPECIFIED HEREIN, AND BE FREE OF BANK PROJECTIONS OR OTHER IRREGULARITIES WHICH WILL IMPEDE NORMAL FLOW.

3 FILLS SHALL BE COMPACTED AS NEEDED TO PREVENT UNEQUAL SETTLEMENT THAT WOULD CAUSE DAMAGE IN THE COMPLETED DIVERSION.

4 ALL EARTH REMOVED AND NOT NEEDED IN CONSTRUCTION SHALL BE SPREAD OR DISPOSED OF SO THAT IT WILL NOT INTERFERE WITH THE FUNCTIONING OF THE DIVERSION.

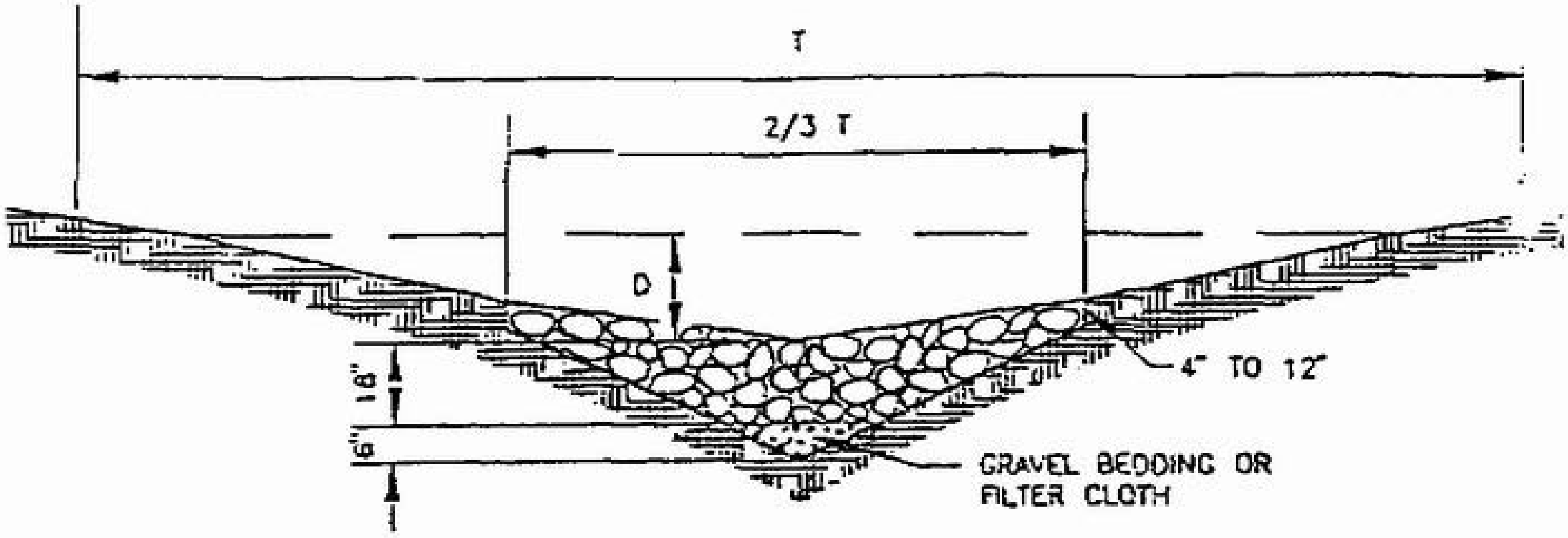
5 STABILIZATION SHALL BE DONE ACCORDING TO THE APPROPRIATE "STANDARD AND SPECIFICATIONS FOR VEGETATIVE PRACTICES".

A FOR DESIGN VELOCITIES OF LESS THAN 3.5 ft. per sec., SEEDING AND MULCHING MAY BE USED FOR THE ESTABLISHMENT OF THE VEGETATION. IT IS RECOMMENDED THAT, WHEN CONDITIONS PERMIT, TEMPORARY DIVERSIONS OR OTHER MEANS BE USED TO PREVENT WATER FROM ENTERING THE DIVERSION DURING THE ESTABLISHMENT OF THE VEGETATION.

B FOR DESIGN VELOCITIES OF MORE THAN 3.5 ft. per sec., THE DIVERSION SHALL BE STABILIZED WITH SOD, WITH SEEDING PROTECTED BY JUTE OR EXCELSIOR MATTING OR WITH SEEDING AND MULCHING INCLUDING TEMPORARY DIVERSION OF THE WATER UNTIL THE VEGETATION IS ESTABLISHED. SEE "THE STANDARD AND SPECIFICATIONS FOR PROTECTIVE MATERIALS".

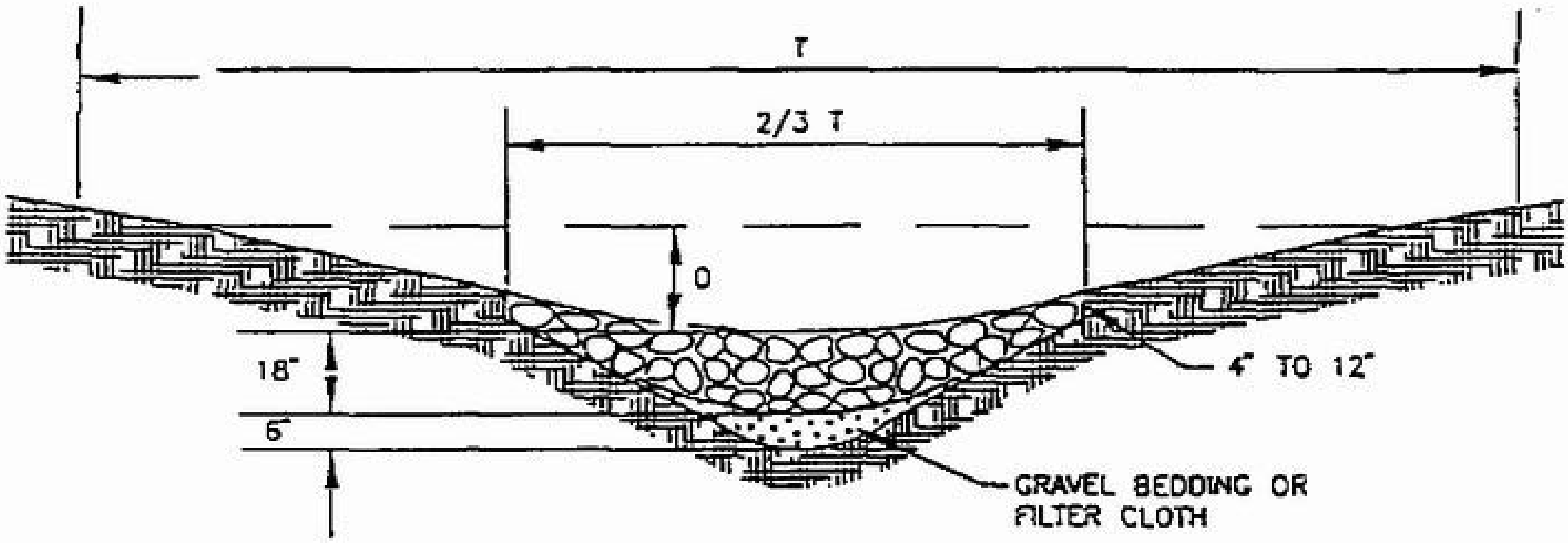
STANDARD SYMBOL

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE	DIVERSION	STANDARD DRAWING
TOOTHMAN-ORTON ENGINEERING COMANY BOISE, IDAHO McCALL, IDAHO		GW-3



WATERWAY WITH STONE CENTER DRAIN
"V" SECTION SHAPED BY MOTOR PATROL

"V" SECTION



WATERWAY WITH STONE CENTER DRAIN
ROUNDED SECTION SHAPED BY BULLDOZER

ROUNDED SECTION

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE	WATERWAY WITH STONE CENTER	STANDARD DRAWING
TOOTHMAN-ORTON ENGINEERING COMANY BOISE, IDAHO McCALL, IDAHO		RW-1

Seeding — BMP 21

Description

Permanent Seeding means growing a long-term or permanent vegetative cover (plants) on disturbed areas or areas that need assistance in revegetation. The purpose of permanent seeding is to reduce erosion and sedimentation and to establish desirable competitive ground cover for wildlife habitat and ease of roadside maintenance. This practice uses prescribed perennial grasses, legumes and native shrubs or wild flowers that will hold the soils, reduce stormwater runoff and act as a bio-filtering system on long-term basis.

The guidelines given in this fact sheet for design, construction and maintenance can also be used to install temporary seeding on construction sites.

Applications

Temporary seeding should be considered as slope protection and erosion control practice for construction sites. Permanent seeding should be considered for any disturbed area where all construction or maintenance activities have ceased or been finalized and is now ready for permanent vegetative cover. Typical areas subject to permanent vegetative cover are all areas disturbed by new construction, reconstruction and maintenance, and materials source site and areas in need of revegetation.

The primary advantages of seeding are:

- It establishes good soil stabilization.
- It prevents soil erosion and sedimentation.
- It contains and filters stormwater runoff.

Additional advantages specific to permanent seeding are:

- It provides wildlife ground cover and habitat.
- It competes with undesirable vegetation and noxious weeds.
- It provides aesthetic qualities.
- It reduces the cost of maintenance.

Limitations

Drainage area – unlimited
Minimum bedrock depth – 2 ft
NRCS soil type – N/A
Drainage/flood control – no
Maximum slope – 5%
Minimum water table – 2 ft
Freeze/thaw – fair

Permanent vegetative ground cover will take several years before sufficient establishment takes place. Establishment will occur quicker in high precipitation areas, usually over 20 in., as opposed to the arid or semi-arid regions of the state. Permanent seeding should be conducted in conjunction with various forms of mulching, matting, and annual grass (cereal grain) as a nurse crop.

Other factors that contribute to the success or failure of permanent seeding are:
- Seeding should be done at the proper time of year.
- Proper application of fertilizers as prescribed will contribute to the success of the seeding.
- Once seeded, the site should not be disturbed.
- Irrigation may have to be used in low precipitation area (arid/semi-arid) for establishment.

Targeted Pollutants

Sediment
Phosphorus
Trace metals

Design Parameters

Conduct all permanent seeding and fertilizing in accordance with local requirements. See Volume 4, Appendix C, Stormwater Plant Materials for additional guidelines.

Construction Guidelines

Permanent seeding is the last phase of reclaiming any disturbed soils.

Maintenance

- Inspect all seeded areas on a regular basis and after each major storm event to check for areas where corrective measures may have to be made.
- Indicate which areas need to be reseeded or where other remedial actions are necessary to assure establishment of permanent seeding.
- Continue monitoring of the site/area until permanent vegetation is established.

Sodding BMP 22

Description

Sodding entails the placement of rolls or strips of sod as a landscape planting or erosion control measure. Sod is a layer of soil bound by grass and plant roots into a thick mat. It is commercially available in rolled strips that are laid over an area of exposed soil. Sod stabilizes the area by immediately covering the surface with vegetation and enabling stormwater to infiltrate into the ground.

Applications

Sodding is appropriate for any graded or cleared area that might erode and where a permanent, long-lived plant cover is needed immediately. It can be a temporary or permanent BMP. Possible uses for sod include buffer zones, stream banks, dikes, swales, slopes, outlets, level spreaders, and filter strips. Primary advantages of sod are:

- Provides immediate dense vegetative cover and erosion control.
- Provides more stabilizing protection than initial seeding.
- Generates less weed growth than seeded vegetation does.
- Can be available for site activities (open to foot traffic) within a shorter time than can seeded vegetation.
- Can be placed at any time of the year as long as water is available and moisture conditions in the soil are favorable.

Limitations

Drainage area – unlimited
Minimum bedrock depth – 2 ft
NRCS soil type – ABCD
Drainage/flood control – no
Maximum slope – 14%
Minimum water table – 2 ft
Freeze/thaw – fair

- Purchase and installation costs are higher than for seeding.
- Continued irrigation may be required if the sod is placed during dry seasons or on sandy soils. Watering may be necessary after planting and during periods of drought or intense heat.
- Sod should not be installed during very hot or wet weather

Targeted Pollutants

Sediment
Phosphorus
Trace metals

Design Parameters

Materials: Use grasses that require little or no maintenance (watering or fertilizing). This may require advance planning to obtain grasses that are desirable for the location.

Site preparation: The soil surface should be find graded before laying down the sod. Topsoil may be needed in areas where soil textures or conditions are inadequate (such as dense or impermeable soils). Add lime and fertilizers as needed to promote good plant growth conditions.

Slope: Do not place sod on slopes greater than 3:1 if slopes are to be mowed. If placed on steep slopes, the sod should be laid with staggered joints or be pegged down (or both).

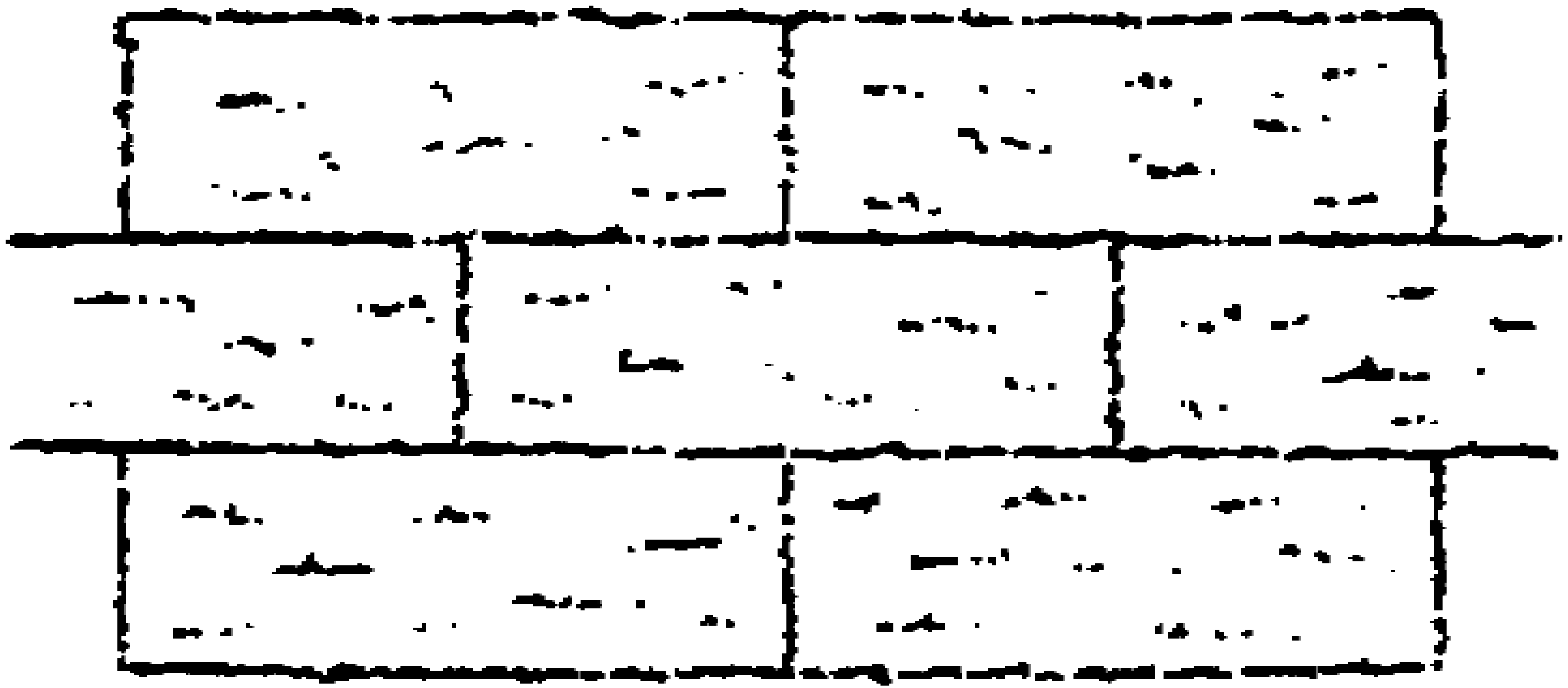
Installation methods: Sod can be applied in strips or other patterns, or alternate areas can be seeded to reduce expense. If placed on steep slopes or next to running waterways, consider placing chicken wire, jute, or other matting over the sod for extra protection against lifting.

Construction Guidelines

- Spread and grade the topsoil (if used). Sod may be placed directly on the ground (without topsoil) only if it has been specifically grown for sites with no topsoil.
- Prepare the soil surface by fine-grading the surface before laying sod. Sodding should then take place immediately after the soil bed is established.
- Lay the sod in a staggered pattern. Sod in waterways should be laid parallel to the flow.
- Sod can be laid in strips on the contour to reduce effective slope length.
- Roll or compact the sod immediately after installation to ensure firm contact with the underlying soil.
- Water to a depth of 4 in., as needed.

Maintenance

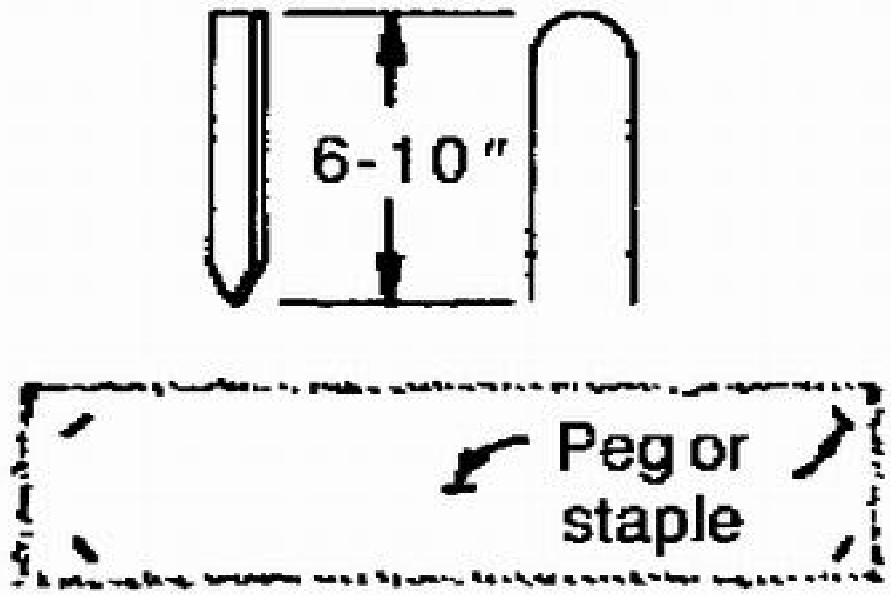
- Inspect the sod frequently after it is first installed, especially after large storm events, until it is established as permanent cover. Remove and replace any dead sod.
- Once the sod is established, mow the area as needed.
- Water as often as necessary during periods of intense heat or lack of rain.
- Sodding usually serves as both a temporary and permanent measure and, therefore, does not require removal.



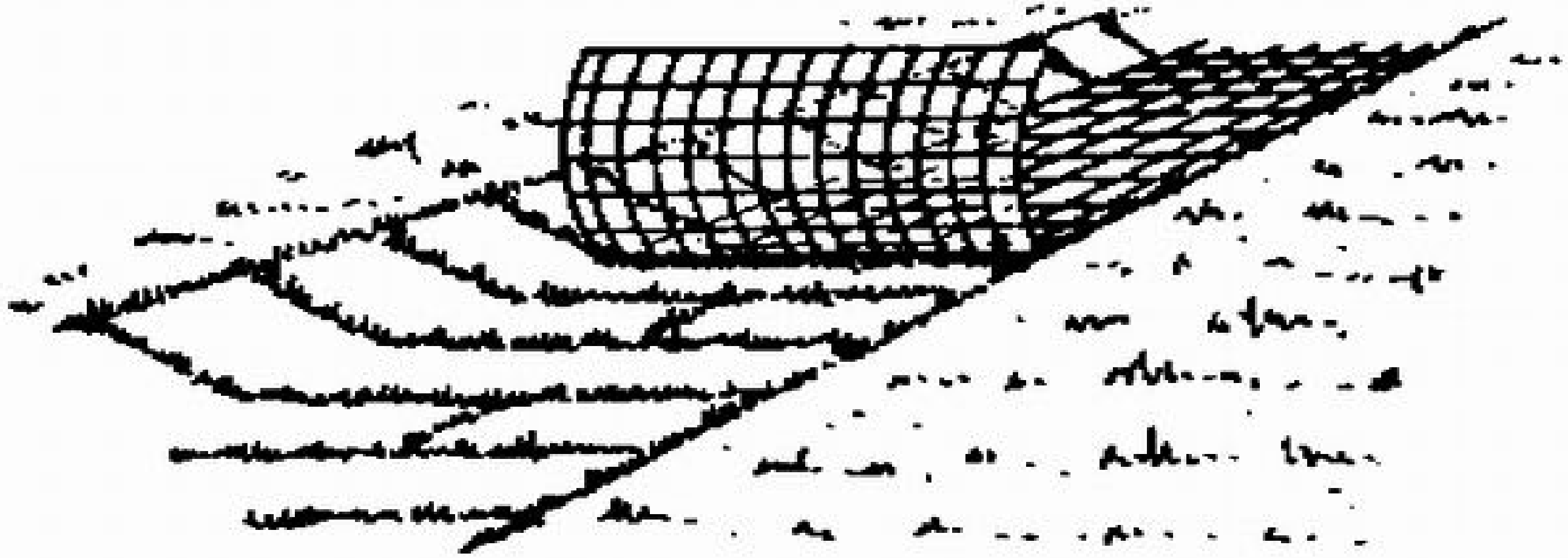
Lay sod in a staggered pattern with strips butted tightly against each other. A sharpened mason's trowel can be used to tuck down the ends and trim pieces.

Butting—angled ends caused by the automatic sod cutting must be matched correctly.

Lay sod across the direction of flow.



Use pegs or stables to fasten sod firmly at the ends of strips and in the center, or every 3-4' if the strips are long. When ready to mow, drive pegs or staples flush with the ground.



In critical areas, secure sod with netting and staples.

Planting

BMP 23

Description

Planting is the process of establishing vegetation by setting out plants that have been grown to a specified size or age. The plants may be potted in plastic tubes or in containers of various sizes, root wrapped, or may be bare rootstock.

Plantings are often specified for aesthetic purposes (landscaping) but can serve various erosion control functions as well. The living trees and shrubs in a planted area will grow large enough to provide soil stabilization and erosion control benefits sooner than the seeds of woody species can germinate and grow to effective size.

The use of trees and shrubs also provides greater aesthetic and biological diversity and, in many areas, is more compatible with vegetation on lands adjoining the planted site.

Also refer to Volume 4, Appendix C: Stormwater Plant Materials, for additional design guidance regarding using landscaping to maximize water quality benefits.

Applications

- Planting is the preferred method of revegetation in many situations where seeding and other slope treatments are either not effective or not appropriate as permanent measures. Such areas may include the following:
- Any finished slope that will remain undisturbed for at least 10 years, especially if the area is bordered by forests, wetlands or other naturally occurring woody vegetation. On such sites, trees and shrubs may be the desirable vegetation from a long-term perspective, but they may be very difficult or unreliable to establish from seed.
- Extremely rocky slopes or sites: If natural vegetation is present in significant amounts, such areas are difficult to seed and mulch effectively. Plantings can be used to provide additional stabilization.
- Streets or materials source sites that have been abandoned permanently.
- All types of landscaping, including urban thoroughfares, interchanges, and residential streets where landscape aesthetics are a concern.
- Wetlands and wildlife habitat areas: in such areas, it may be critical to plant the desired species initially so that the site is not overrun by weeds or undesirable plant species that detract from the intended use of the site.
- Areas where the higher rate of transpiration for trees and shrubs (compared to grasses and forbs) helps remove excess moisture from the soil.

Limitations

Drainage area – unlimited	Maximum slope – 50%
Minimum bedrock depth – 3 ft	Minimum water table – 3 ft
NRCS soil type – ABCD	Freeze/thaw – fair
Drainage/flood control – no	

- Purchase and installation costs are higher than for seeding.
- Continued or periodic irrigation may be required if planting occurs during dry season or on sandy soils. Watering may also be necessary up to 2 years after planting and during periods of drought or intense heat.
- Specific seasons of work apply for planting. Planting outside the designated season should not be allowed unless provisions for special care and maintenance of the plants are enforceable.

Targeted Pollutants

Sediment
Phosphorus
Trace metals

Design Parameters

Advantages of Planting: Many shrubs and trees are difficult to establish from seed in natural environments and natural seed crops vary widely from year to year. Rapid invasion from native vegetation and rapid establishment of sown seed of woody species is therefore unreliable. Vegetative plantings are used to provide living shrubs and trees that will grow to adequate size to provide soil stabilization and erosion control faster than seeds of woody species can germinate and grow to these dimensions.

Materials: Planted material may be grown from either cuttings or seed. At delivery to a job site, the plants may be potted (in containers), root wrapped, or bare root stock. Some species are successfully planted as sprigs or tubelings.

Use of Native Species: If possible, use species that are native to the area. Native species provide long-term soil stabilization which is aesthetically harmonious with natural vegetation and which requires little long-term maintenance. Short-term maintenance is necessary to ensure the establishment of the vegetation.

Maximizing Effectiveness: Successful planting projects depend on selecting suitable plant species, using healthy planting stock, and planting when the season and weather conditions are favorable. The site should be properly prepared for planting and should be properly maintained after planting to ensure long-term survival of the plants. Make sure the contract and plans include adequate provisions for all aspects of the planting process.

Since vegetative planting places living plants on a site, thus decreasing the length of time necessary to establish a complete revegetation project, it is more effective than seeding methods for revegetation. Adequate maintenance is absolutely necessary to achieve this effectiveness since vegetative planting require irrigation for at least the first year and will benefit from irrigation for 2 or more years.

Vegetative planting may be combined with seeded grasses and legumes that provide immediate surface coverage.

Construction Guidelines

- Make sure that planting sites are adequately graded and that tree locations and planting areas (for shrubs, vines, and ground covers) are marked and approved before planting begins.

- Plant materials should be examined before use to ensure that species, container sizes, and root and soil condition are acceptable. If possible, the growth medium for containerized plants should be similar to the soil type on the revegetation site. Container size guidelines are as follows:
- Tree species may be of bare rootstock or of potted stock. Pots should be one gallon size or larger.
- Shrub species may be of bare rootstock or of potted stock. The preferred planting pot is a tube of woven plastic that is planted with the plant contained in it. The pot deteriorates over time. The pots should be 2 in. long, with both ends open.
- Paper pots should be 2 to 3.1 in. square and 8.5 to 12 in. long. The paper around the rim should be removed to ground level at planting.
- Peat pots are not recommended since research has shown greater mortality of plantings in peat pots due to drying. If peat pots are used, any exposed peat pot material showing after planting should be removed.
- In general, no container should be less than 2 in. wide and 6 in. deep.

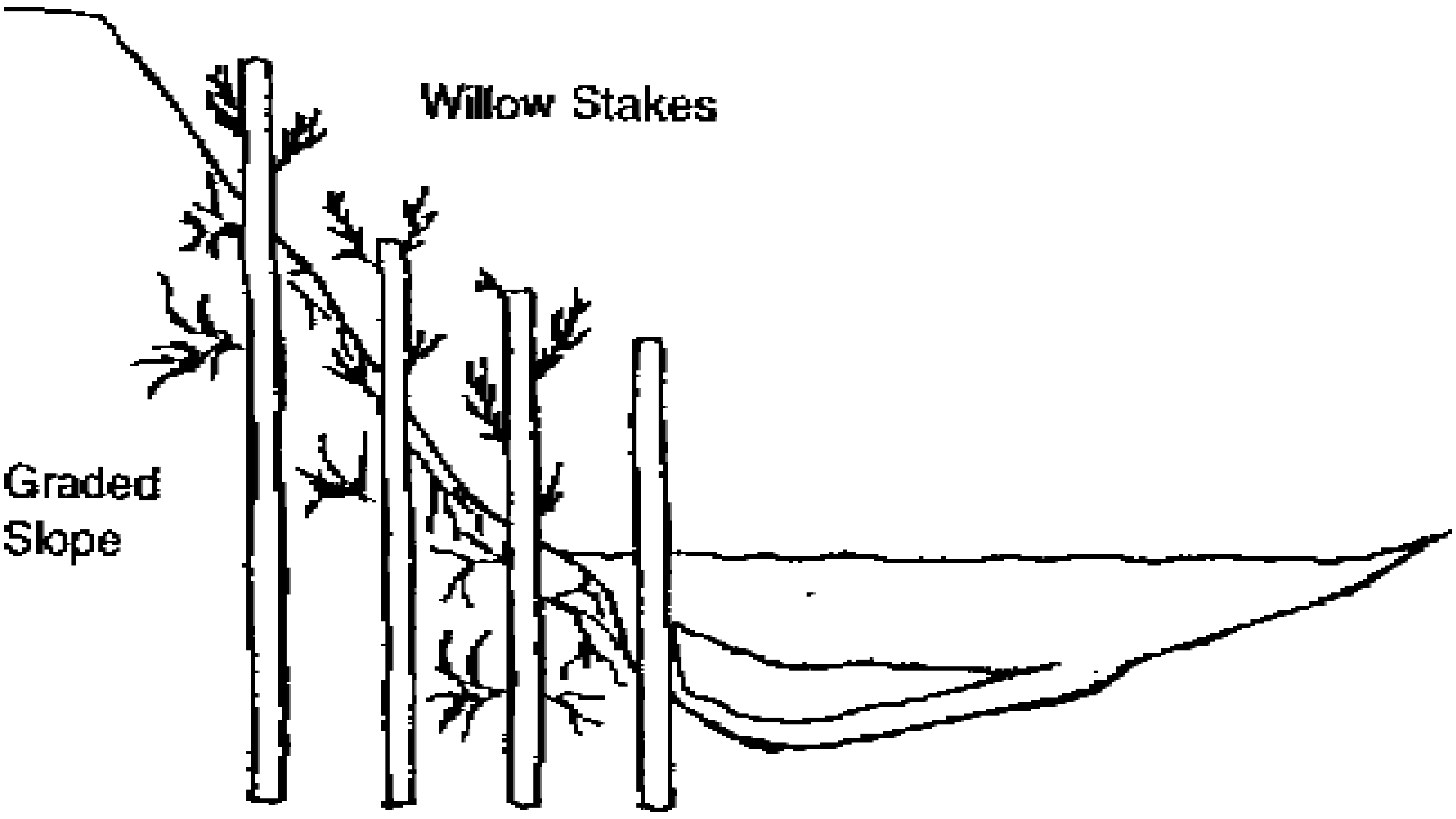
Plant storage: Store bundled bare root planting stock, whether tree or shrub species, in a cool, moist place from time of receipt until time of planting. This time should not exceed 10 days. Store potted planting stock in shade, out-of-doors, and kept lightly sprinkled with water to maintain a moist soil from the time of receipt to the time of planting. This time should not exceed 30 days.

Planting procedures:

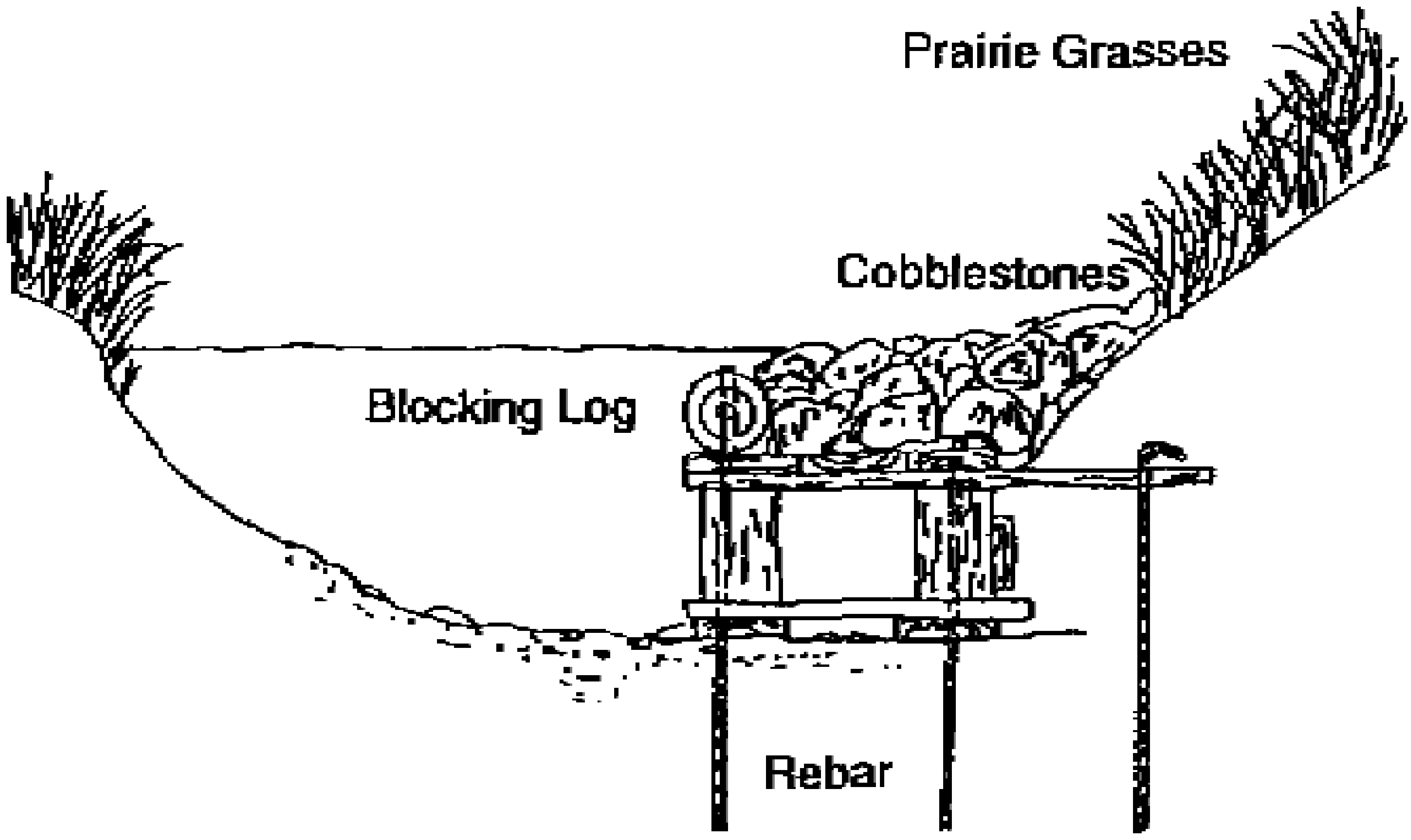
- Plant the mixture of trees and shrubs that has been prescribed. In no case should this be less than 690 plants per acre. If bare root stocks are used, planting rates should be increased by 1.25 times the stated rate.
- Voluntary or unskilled labor may be used in planting. However, a supervisor who is skilled in the techniques being used should direct the labor.
- Construct a basin 12 in. in diameter and depressed no more than 2 in. from the elevation of the downslope lip.
- Open the planting hole with a planting bar or shovel. Then place the plant near the downslope lip of the basin. This allows sloughing from the slope to fall in to the basin without burying the young plant.
- Carefully remove plants from their containers, if any, and place them in the planting holes so that the crown of the plant is at the surface of the soil. No air space should be allowed around the roots, nor should the roots be folded under. Plants in individual containers made of decomposable material are planted without removing them from the container.
- Apply fertilizer at the rate specified, and place wood chip or wood fiber mulch to a depth of 2 in. around each plant.
- The soil should be wetted to field capacity to a depth of 3.1 to 4 in. at the time of planting and each time the soil moisture level drops below the permanent wilting percentage.

Maintenance

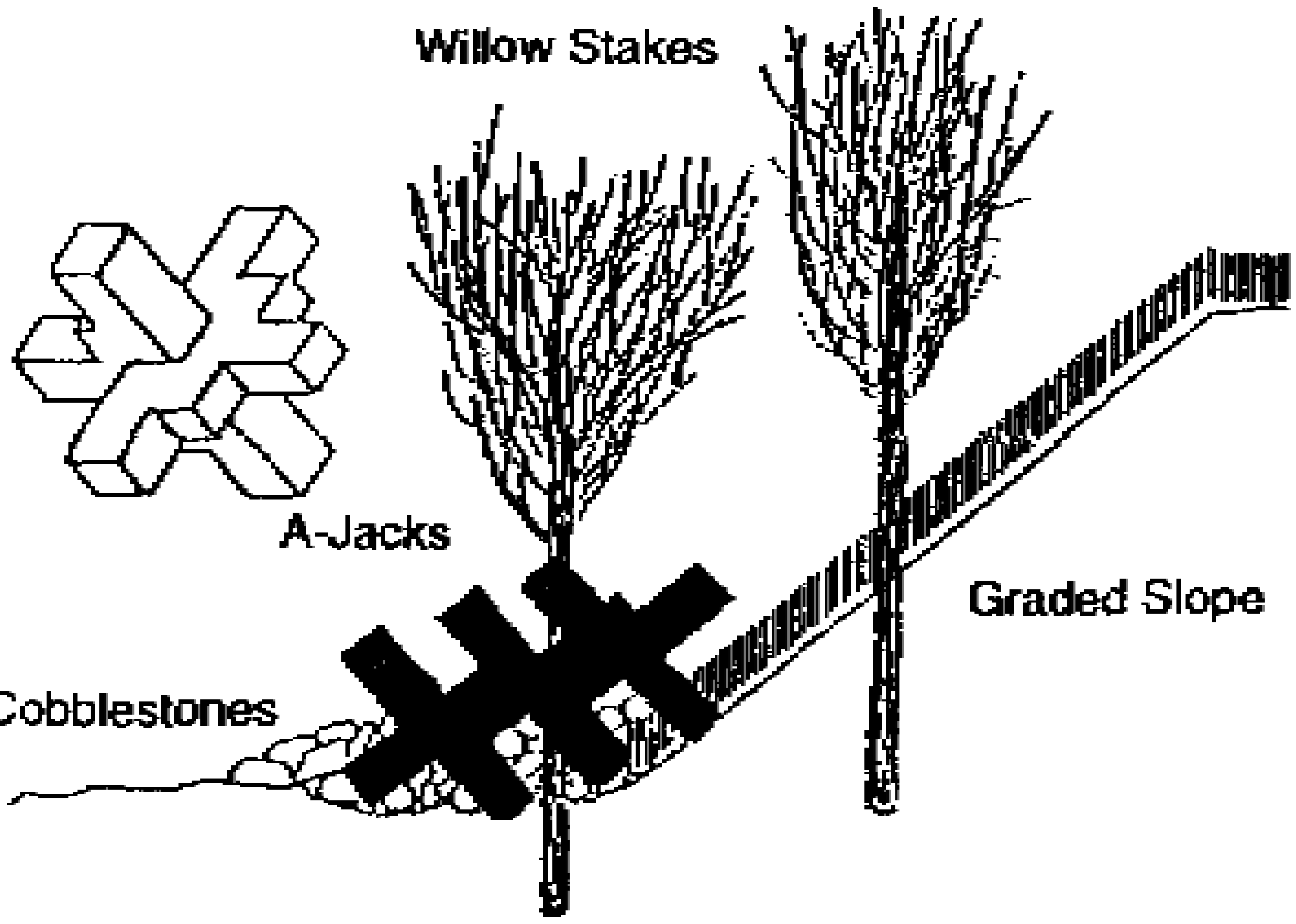
- Irrigation of vegetative plantings during the first 2 years following planting is required to increase the survival rate. Water as often as necessary during periods of intense heat or lack of rain.
- Inspect plantings frequently after first installed to see if plants are thriving. Remove and replace dead plants to restore the prescribed number of living plants per hectare.
- After storm events, examine the planting basins and mulch cover and make any needed repairs.



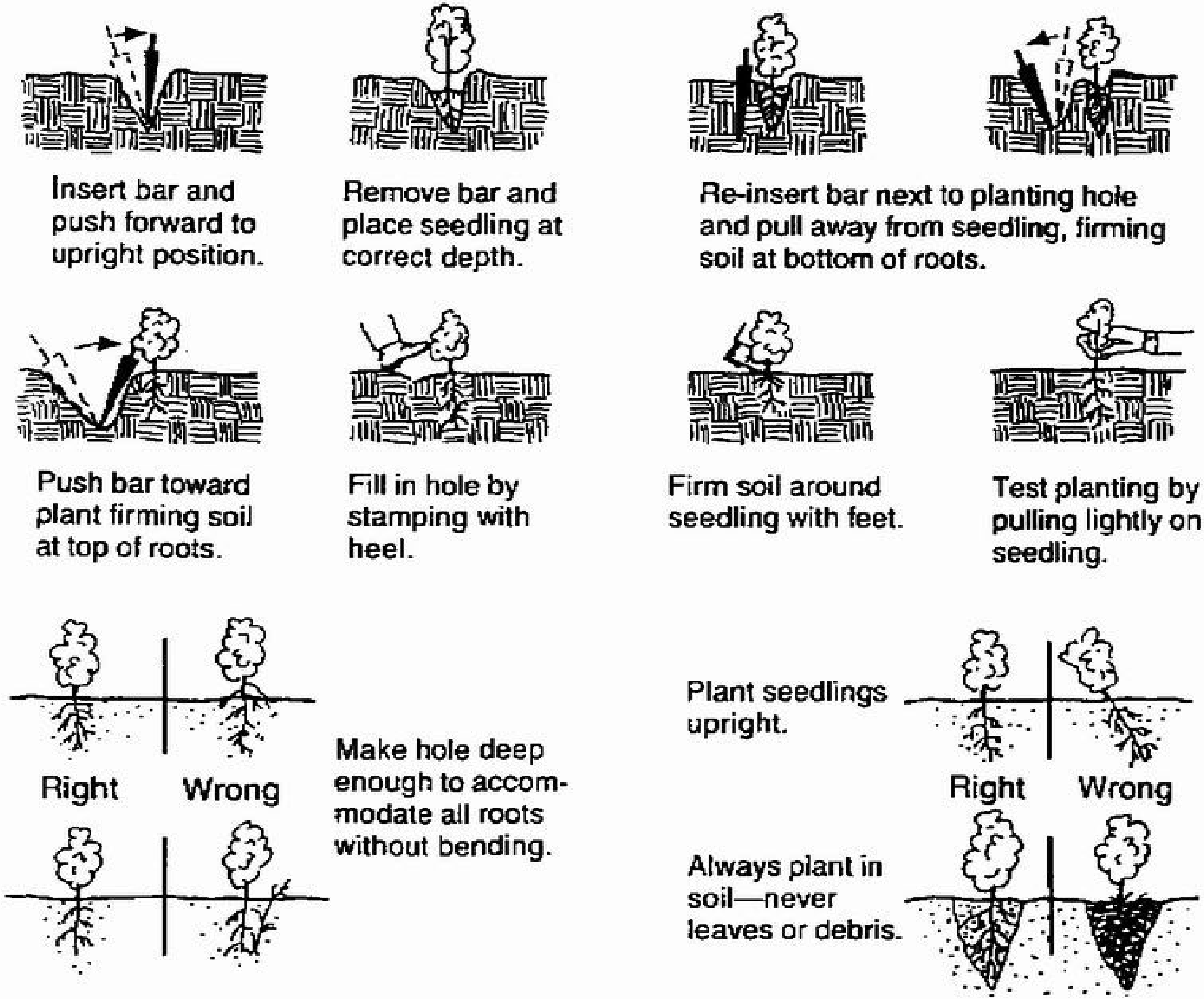
Willow posts installed below depth of streambed scour.



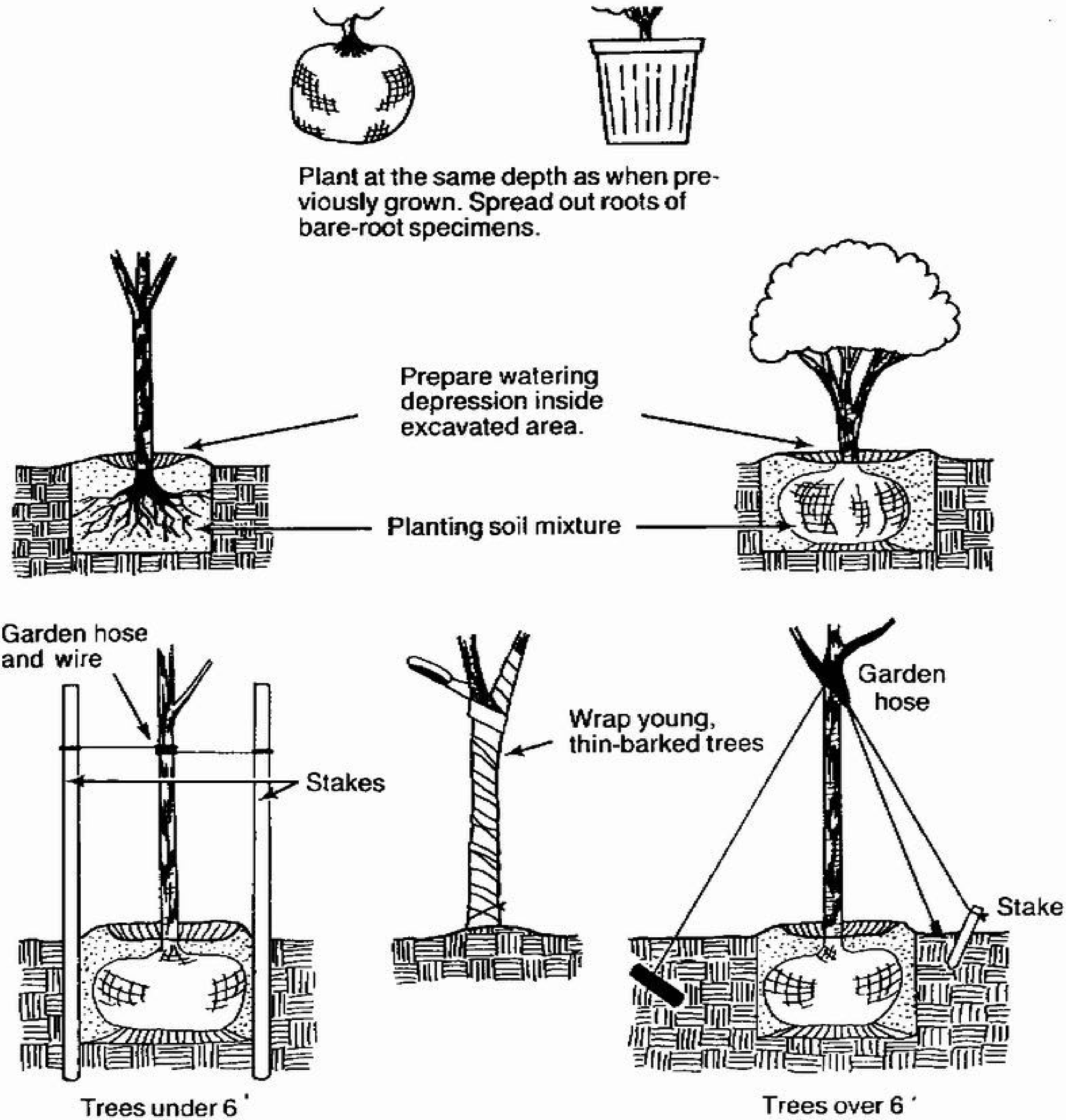
Lunker with riprap below baseflow stage. Rebar is driven below bed scour depth.



A-jack bank structures.



Planting bare-root seedlings (modified from Va. Div. of Forestry).


Plant at the same depth as when previously grown. Spread out roots of bare-root specimens.
Prepare watering depression inside excavated area.
Planting soil mixture
Garden hose and wire
Stakes
Wrap young, thin-barked trees
Garden hose
Stake
Trees under 6 '
Trees over 6 '

Pipe Slope Drain — BMP 24

Description

A pipe slope drain is a device used to carry concentrated runoff from the top to the bottom of a slope that has already been damaged by erosion or is at high risk for erosion. It may be used to convey runoff from off-site around a disturbed portion of the site. It may also be used to drain saturated slopes that have the potential for soil slides. Pipe slope drains can be either temporary or permanent, depending on the method of installation and the material used.

Pipe slope drains are made of flexible tubing or rigid pipe with a prefabricated entrance section. Other temporary slope drains may use plastic sheeting, stone gutters, fiber mats, riprap, concrete or asphalt ditches, or half-round pipe. Outlet protection such as riprap should be provided for velocity dissipation at the drain outlet.

Applications

Pipe slope drains are used whenever it is necessary to convey water down a slope without causing erosion. They are especially effective before a slope has been stabilized or before permanent drainage structures are ready for use. Pipe slope drains may be used with other devices, including sediment traps (BMP 38), and vegetative buffer strips (BMP 37).

Temporary pipe slope drains, usually flexible tubing or conduit, may be installed prior to the construction of permanent drainage structures. Permanent slope drains may be placed on or beneath the ground surface; pipes, sectional downdrains, paved chutes, or clay tiles may be used.

Pipe slope drains are appropriate in the following general locations:

- On cut or fill slopes before permanent stormwater drainage structures have been installed.
- Where earth dikes or other diversion measures have been used to concentrate flows.
- On any slope where concentrated runoff crossing the face of the slope may cause gullies, channel erosion, or saturation of slide-prone soils.
- As an outlet for a natural drainageway.
- The drainage area may be up to 10 acres.

Limitations

Drainage area – 5 ac.	Maximum slope – 50%
Minimum bedrock depth – 5 ft	Minimum water table – 2 ft
NRCS soil type - ABCD	Freeze/thaw – good
Drainage/flood control – yes	

Not suitable for drainage areas greater than 10 acres.

Targeted Pollutants

Sediment
Hydrocarbons

Design Parameters

Pipe sizing: Typical relationships between area and pipe diameter are shown in Table 24-1 below.

Spacing: For a two-lane highway construction project, experience has shown that temporary slope drains should be spaced at a longitudinal interval of 500 ft on a 2% grade, 200 ft on a 4% grade, and as may be dictated by field conditions on a grade of 5% or greater.

Materials: Pipe may be any heavy-duty, flexible tubing designed for this purpose, including nonperforated, corrugated plastic pipe; corrugated metal pipe; bituminous fiber pipe; or specially designed flexible tubing.
A standard flared end section secured with a watertight fitting should be used for the inlet. A standard T-section fitting may also be used. Extension collars should be 1 ft long segments of corrugated pipe. All fittings should be watertight.

Slope of drain: Try for a 3% minimum.

Construction Guidelines

- it in 6 in. on all sides to prevent erosion. A 6 in. metal toe plate may Temporary slope drains should be installed with inlets at points where water is discharged from ditches, berms, or other points of concentrated flow. All drains should be anchored to the slope to prevent disruption by water or other forces. The inlet section of the drain should be properly installed to funnel the flow into the drain. It is often necessary to construct cross berms to direct flow into the inlet.
- Place the pipe slope drain on undisturbed or well-compacted soil.
- Soil around and under the entrance section should be hand tamped in 4 to 8 in. lifts to the top of the dike to prevent piping failure around the inlet.
- Place filter cloth under the inlet, extend it 3 to 5 ft in front of the inlet, and key also be used for this purpose.
- Securely stake the pipe slope drain to the slope at intervals of 10 ft or less, using grommets provided for this purpose.
- Make sure that all slope drain sections are securely fastened together and have watertight fittings.
- Extend the pipe beyond the toe of the slope and discharge at a nonerosive velocity into a stabilized area or to a sedimentation trap or pond. Use rock outlet protection if necessary.
- The pipe slope drain should have a slope of 3% or steeper.
- The height at the centerline of the earth dike should range from a minimum of 1 ft over the pipe to twice the diameter of the pipe measured from the invert of the pipe. It should also be at least 6 in. higher than the adjoining ridge on either side.
- At no point along the dike will the elevation of the top of the dike be less than 6 in. higher than the top of the pipe.
- Immediately stabilize all areas disturbed by installation or removal of the pipe slope drain.

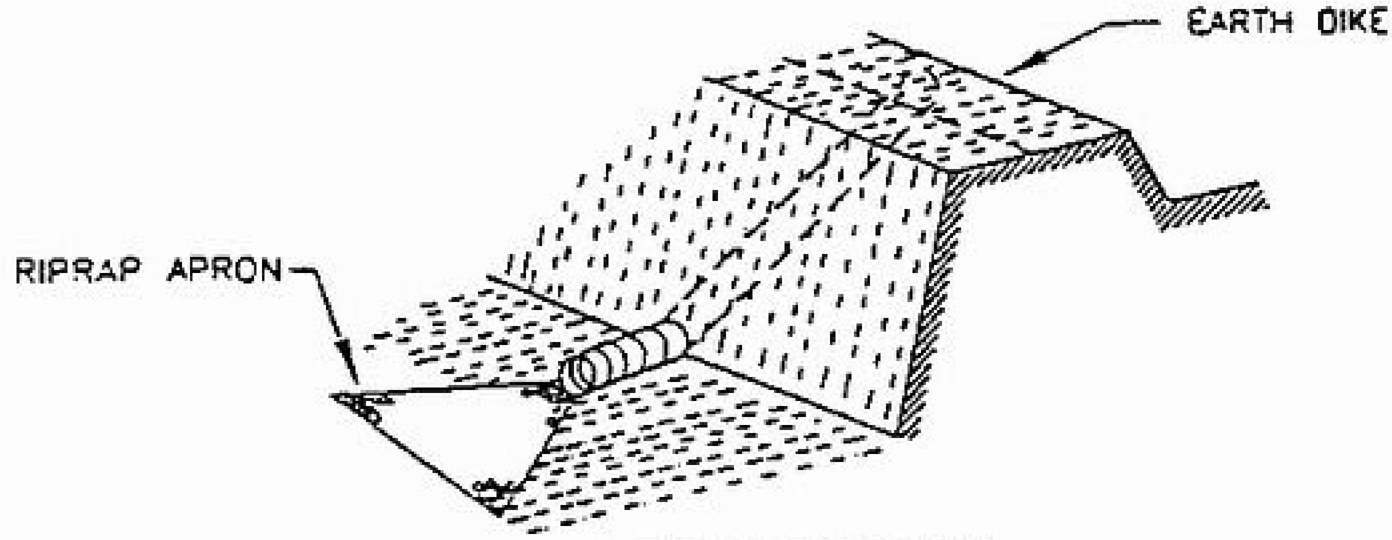
Maintenance

- Inspect the slope drain regularly and after every storm. Make any necessary repairs within 7 days or before the next storm (whichever comes first).
- Check to see that water is not bypassing the inlet or undercutting the inlet or pipe. If necessary, install headwalls or sandbags to prevent bypass flow.
- Check for erosion at the outlet point and check the pipe for breaks or clogs. Install additional outlet protection if needed and immediately repair the breaks and clean any clogs.
- Do not allow construction traffic to cross the pipe slope drain and do not place any material on it.
- If a sediment trap has been provided, clean it out when the sediment level reaches one-third to one-half the design volume.
- A temporary slope drain should remain in place up to 30 days after slopes have been completely stabilized.

Table 24-1. Relationship Between Area and Pipe Diameter

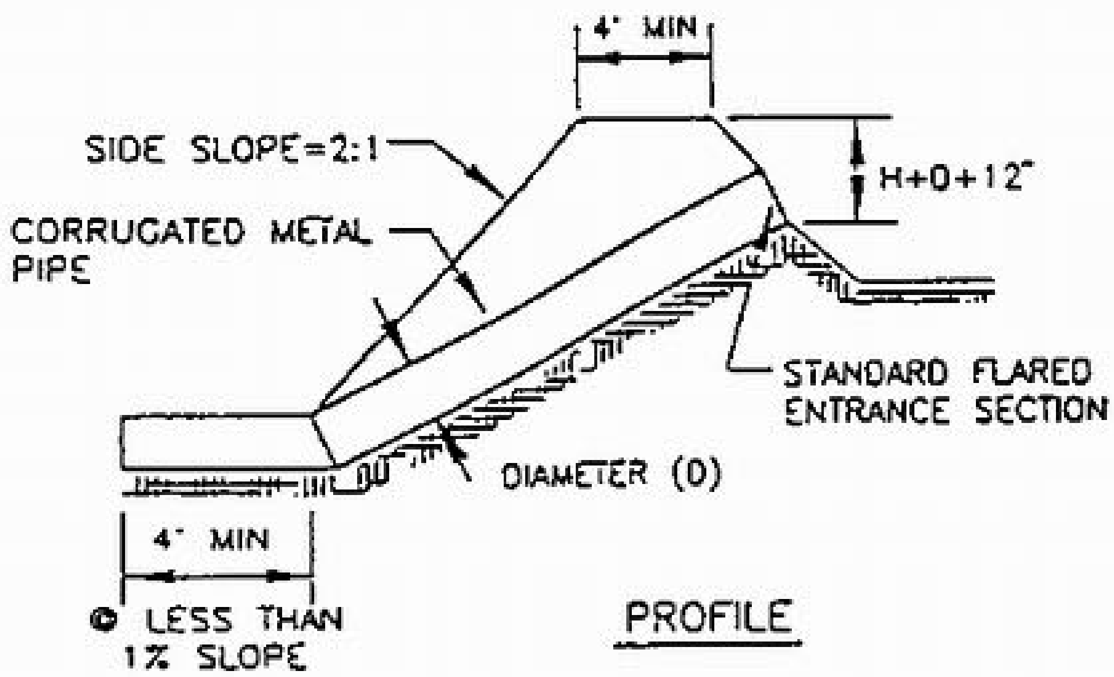
Maximum Drainage Area (Acres)	Pipe Diameter (in.)
0.5	12
1.5	18
2.5	21
3.5	24
5.0	30

PIPE SLOPE DRAIN (RIGID)

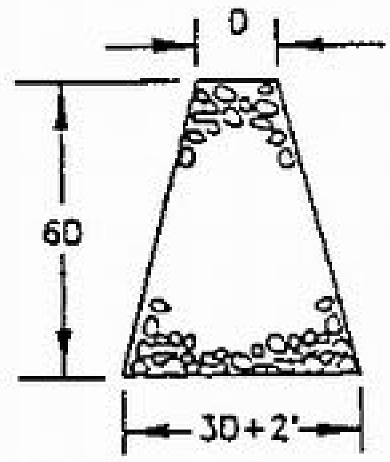


PERSPECTIVE VIEW

GSS-2
PSD-DIAM
STANDARD SYMBOL



PROFILE



RIPRAP SHALL CONSIST OF 6" DIAMETER STONE PLACED AS SHOWN AND SHALL BE A MINIMUM OF 12" IN THICKNESS.

RIPRAP APRON PLAN

NOTE. SIZE DESIGNATION IS: PSD-PIPE DIAMETER
(ie. PSD-12 = PIPE SLOPE DRAIN WITH 12" DIAMETER PIPE)

CONSTRUCTION SPECIFICATIONS

1 THE PIPE SLOPE DRAIN SHALL HAVE A SLOPE OF 3% OR STEEPER.

2 TOP OF THE EARTH DIKE OVER THE INLET PIPE AND ALL DIKES CARRYING WATER TO THE PIPE SHALL BE AT LEAST ONE FOOT HIGHER THAN THE TOP OF THE PIPE.

3 ADD 0.3 FOOT TO DIKE HEIGHT FOR SETTLEMENT.

4 SOIL AROUND AND UNDER THE SLOPE PIPE SHALL BE HAND TAMPED IN 4 INCH LIFTS.

5 THE PIPE SHALL BE CORRUGATED METAL PIPE WITH WATERTIGHT 12 INCH CONNECTING BANDS OR FLANGE CONNECTIONS.

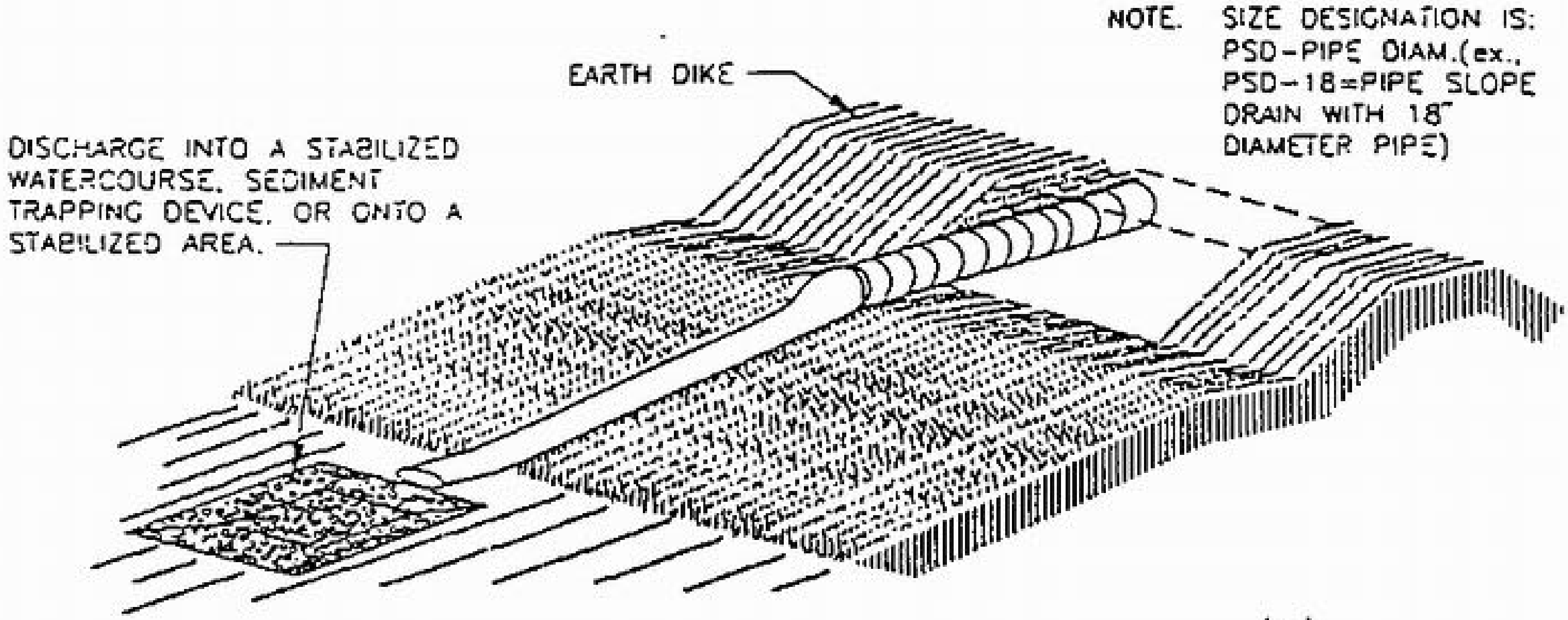
6 RIPRAP TO BE 4-8 INCHES IN A LAYER AT LEAST 8 INCHES IN THICKNESS AND PRESSED INTO THE SOIL.

7 PERIODIC INSPECTION AND REQUIRED MAINTENANCE MUST BE PROVIDED AFTER EACH RAIN EVENT.

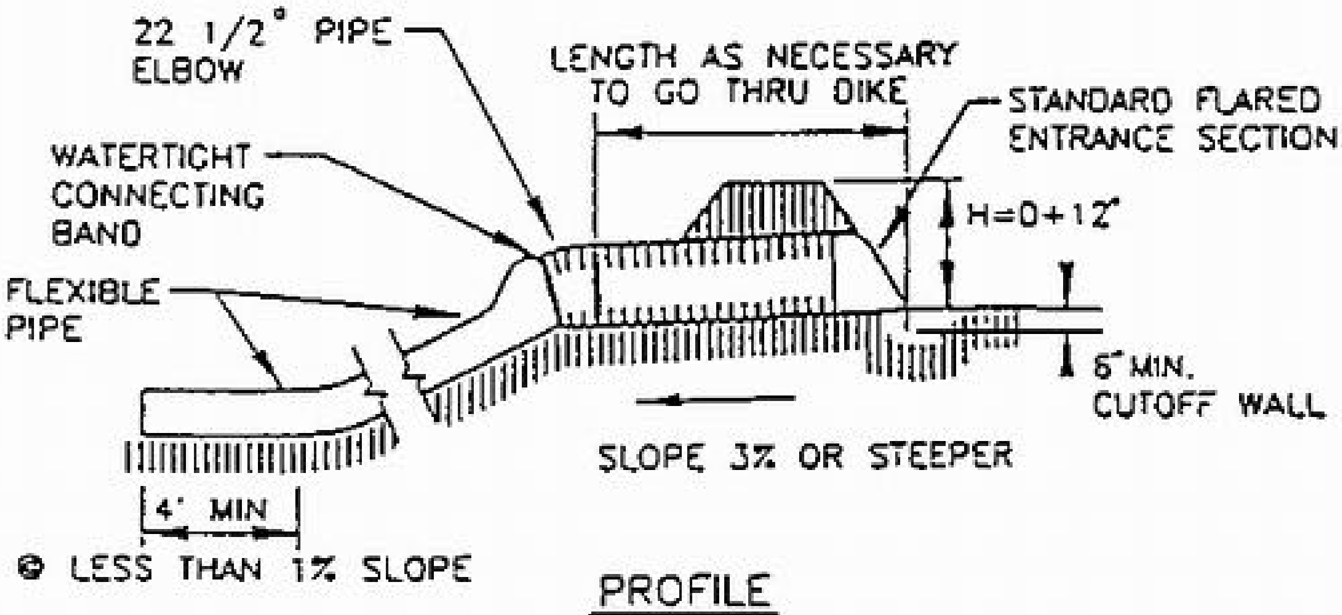
MAXIMUM DRAINAGE AREA: 5 ACRES

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE	GRADE STABILIZATION STRUCTURE	STANDARD DRAWING
TOOTHMAN-ORTON ENGINEERING COMANY BOISE, IDAHO McCALL, IDAHO		GSS-2

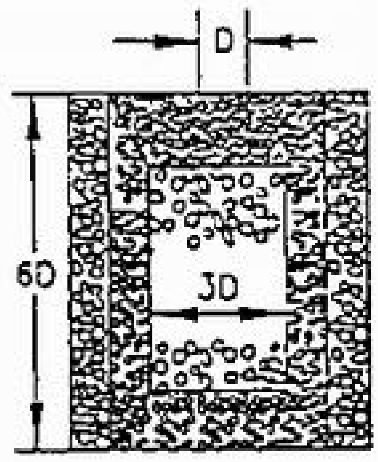
PIPE SLOPE DRAIN (FLEXIBLE)*



PERSPECTIVE VIEW



PROFILE



RIPRAP SHALL CONSIST OF 6" DIAMETER STONE PLACED AS SHOWN. DEPTH OF APRON SHALL EQUAL THE PIPE DIAMETER AND RIPRAP SHALL BE A MINIMUM OF 12" IN THICKNESS.

RIPRAP APRON PLAN

CONSTRUCTION SPECIFICATIONS

1 THE INLET PIPE SHALL HAVE A SLOPE OF 3% OR STEEPER.
2 THE TOP OF THE EARTH DIKE OVER THE INLET PIPE AND THOSE DIKES CARRYING WATER TO THE PIPE SHALL BE AT LEAST 1' HIGHER AT ALL POINTS THAN THE TOP OF THE INLET PIPE.
3 THE INLET PIPE SHALL BE CORRUGATED METAL PIPE WITH WATERTIGHT CONNECTING BANDS.
4 THE FLEXIBLE TUBING SHALL BE THE SAME DIAMETER AS THE INLET PIPE AND SHALL BE CONSTRUCTED OF A DURABLE MATERIAL WITH HOLD-DOWN GROMMETS SPACED 10' ON CENTERS.
5 THE FLEXIBLE TUBING SHALL BE SECURELY FASTENED TO THE CORRUGATED METAL PIPE WITH METAL STRAPPING OR WATERTIGHT CONNECTING COLLARS.
6 THE FLEXIBLE TUBING SHALL BE SECURELY ANCHORED TO THE SLOPE BY STAKING AT THE GROMMETS PROVIDED.
7 A RIPRAP APRON SHALL BE PROVIDED AT THE OUTLET. THIS SHALL CONSIST OF 6" DIAMETER STONE PLACED AS SHOWN ON THE ABOVE DRAWING.
8 THE SOIL AROUND AND UNDER THE INLET PIPE AND ENTRANCE SECTION SHALL BE HAND TAMPED IN 4" LIFTS TO THE TOP OF THE EARTH DIKE.
9 FOLLOW-UP INSPECTION AND ANY NEEDED MAINTENANCE SHALL BE PERFORMED AFTER EACH RAIN EVENT.

* DRAINAGE AREA MUST NOT EXCEED 5 ACRES.

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE	GRADE STABILIZATION STRUCTURE	STANDARD DRAWING
TOOTHMAN-ORTON ENGINEERING COMANY BOISE, IDAHO McCALL, IDAHO		GSS-3

Slope Roughening BMP 25

Description

Slope roughening entails establishing a rough soil surface by creating horizontal grooves, furrows, depressions, or steps running parallel to the slope contour over the entire face of a slope. This reduces the speed of runoff, increases infiltration, and traps sediment. It also helps establish vegetative cover by reducing runoff velocity and providing stable, level areas where seedlings can take hold and grow. This measure may be used prior to seeding/planting and should be applied using appropriate machinery.

Alternately, in some cases, leaving the slope in a roughened condition will control erosion and provide suitable rooting areas for plant seedlings better than a finely graded slope. Other measures, such as flow diversion should be used to keep erosion from occurring while vegetation is being established.

Applications

Slope and surface roughening provide simple, inexpensive, and immediate short-term erosion control for bare soil where vegetative cover is not yet established. The practice is appropriate for all slopes, although different methods are used depending on the steepness of the slope, the type of slope (cut or fill), soil and rock characteristics, future mowing and maintenance requirements, and type of equipment available. All slopes steeper than 3:1 and greater than 5 ft vertical height require roughening and may also require terracing, grooving, or furrowing prior to seeding.

Limitations

Drainage area – 1 ac.	Maximum slope – 20%
Minimum bedrock depth – 3 ft	Minimum water table – 5 ft
NRCS soil type - BCD	Freeze/thaw – good
Drainage/flood control – no	

This BMP is limited to slopes in medium to highly cohesive soils or in soft rock that can be excavated without ripping. Slope angle should be gentle enough to permit access to heavy equipment. The method is not applicable for use in moraines and other depositional soils. In addition, serration is of limited effectiveness in anything more than a gentle rain, and it is only a temporary measure. If the roughening is washed away in a heavy storm, the surface will have to be reroughened and reseeded. This BMP is not a stand-alone measure; it should be implemented in conjunction with other BMPs.

Targeted Pollutants

Sediment

Design Parameters

Slope roughening can be used with seeding, planting, and temporary mulching to stabilize an area. For steeper slopes and slopes that will be left roughened for longer period of time, try a combination of surface roughening and vegetative stabilization. Surface roughening should be applied immediately after grading activities have ceased (temporarily or permanently) in an area. Different methods can be used to roughen the slope surface. They include stair-step grading, grooving (using disks, spring harrows, or teeth on a front-end loader), and tracking (driving a crawler tractor up and down a slope, leaving the cleat imprints perpendicular to the slope). The selection of an appropriate method depends on the grade of the slope, mowing requirements after vegetative cover is established, whether the slope was formed by cutting or filling, and type of equipment available.

Slopes steeper than 2:1: Any slope steeper than 2:1 should be terraced or stair-step graded, with benches wide enough to retain sediment eroded from the slope above (see BMP 26-Gradient Terracing).

Slopes between 3:1 and 2:1: Cut slopes with a gradient steeper than 3:1 but less than 2:1 should be stair-step graded or groove cut. Stair-step grading works well with soils containing large amounts of small rock. Each step catches material discarded from above and provides a level site where vegetation can grow. Stairs should be wide enough to work with standard earth-moving equipment. Any implement that can be safely operated on the slope, including those described above, can do grooving. Grooves should not be less than 3 in. deep or more than 16 in. apart.

Fill slopes with a gradient steeper than 3:1 but less than 2:1 should be compacted every 12 in. of depth. The face of the slope should consist of loose, uncompacted fill 4 to 6 in. deep that can be left rough or can be grooved as described above, if necessary.

It is important to avoid excessive compacting of the soil surface, especially when tracking because soil compaction inhibits vegetation growth and causes higher runoff speed. Therefore, it is best to limit roughening with tracked machinery to sandy soils that do not compact easily and to avoid tracking on clay soils.

Slopes flatter than 3:1: Any cut or filled slope that will be mowed should have a gradient less than 3:1. Such a slope can be roughened with shallow grooves parallel to the slope contour by using normal tilling. Grooves should be close together (less than 10 in. and not less than 1 in. deep).

Construction Guidelines

Timing of work: To slow erosion, slope or surface roughening should be done as soon as possible after the vegetation has been removed from the slope. The roughened areas should be seeded as quickly as possible, preferably within 7 days after serration/roughening if weather conditions or water availability permits. In material that ravels or sloughs readily, delay the revegetation effort until at least 30 days after slope serration.

On slopes composed of material that weathers rapidly, slope roughening should be completed early in the summer. This will allow material to slough off the step face prior to fall seeding or planting so it does not smother the seeds or seedlings.

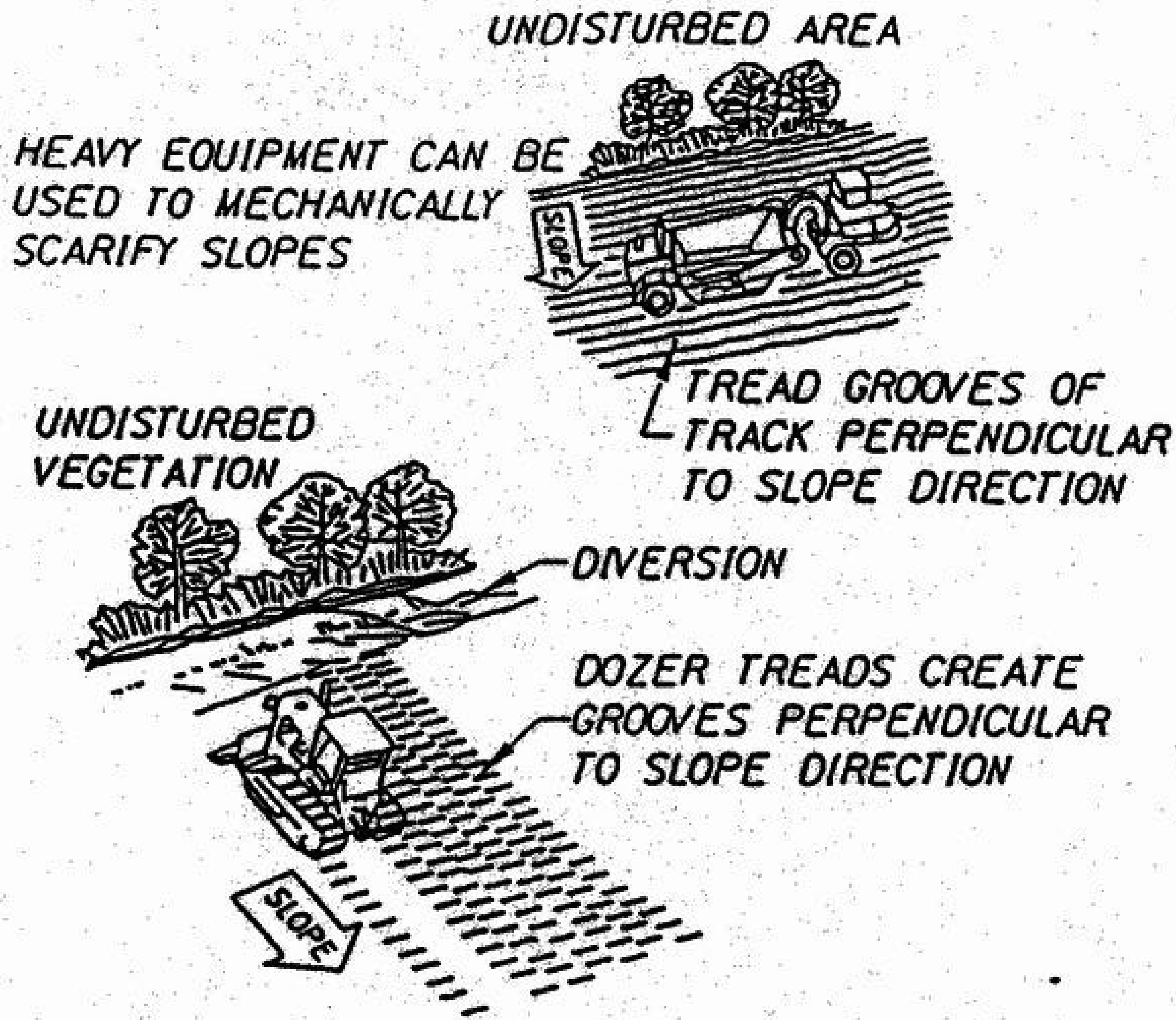
Equipment: Various types of heavy equipment of various kinds can be successfully used for slope roughening:

- A front-end loader equipped with disks, harrows, or teeth can make grooves across the slope.
- Driving a crawler tractor up and down the slope will make cleat imprints perpendicular to the slope.
- A dozer, equipped with a special blade containing a series of square grooves and positioned at the same angle as the cut, can serrate the slope along the contours.

Methods:
- Fill slopes constructed with highly erodible soils or soils containing high-clay contents should be minimally compacted prior to establishing a roughened surface. However, excessive compaction of the surface soil is undesirable because of reduction in infiltration and suppression of vegetation rooting.
- Make the grooves or depressions approximately horizontal (or parallel the roadway grade if its profile grade is less than 2%).
- Excavate each series of grooves in the opposite direction from the preceding series to minimize buildup of loose material at the ends of the steps or cuts.
- Loose material collected at the ends of steps should be removed and the ends blended into the natural ground surface.
- If encountering rock that is too hard to rip, try to blend the grooves into the rock.
- Remove materials which fall into the ditchline or roadway and any rock fragments larger than one-third the shelf width.
- Construct a slope bench at the bottom of the slope face.

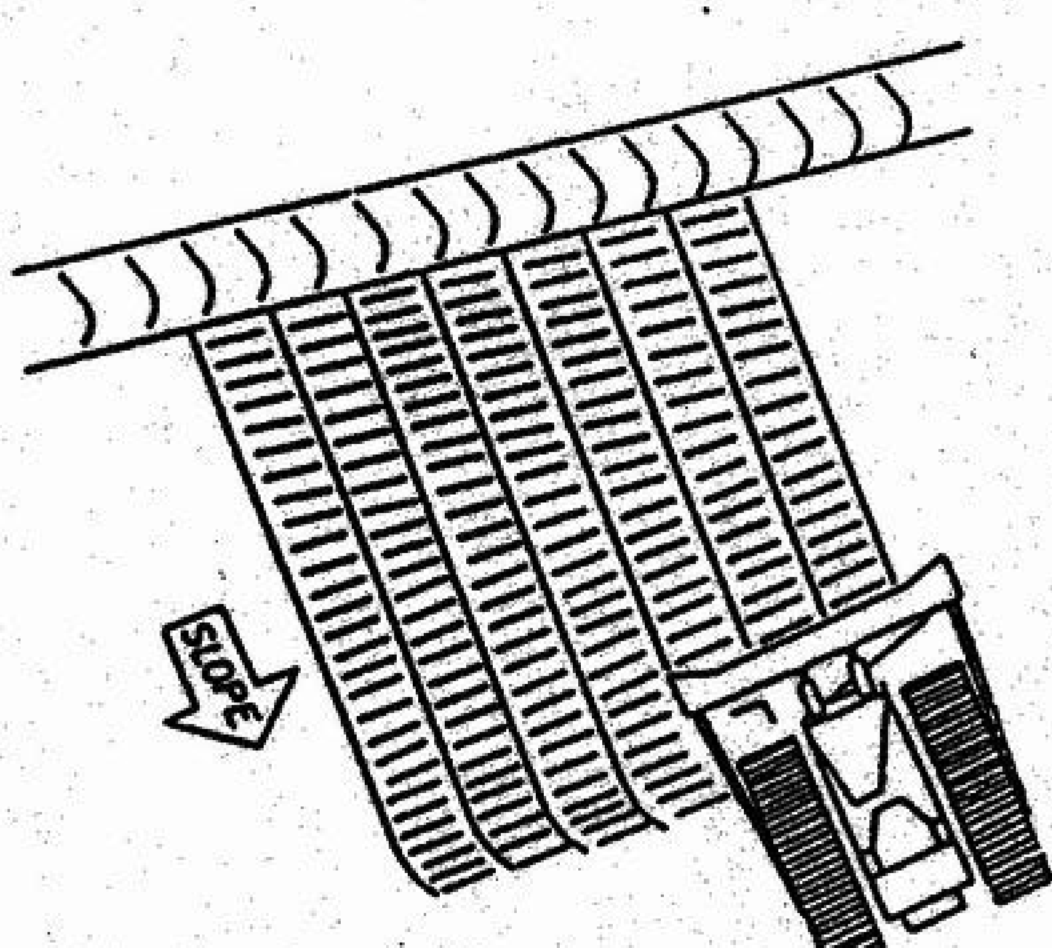
Maintenance

Inspect the slopes periodically for damage from surface runoff and seepage and inspect after each runoff-producing storm. Damage caused by construction-related activities should be repaired as soon as possible. If rills appear (small watercourses that have steep sides and are usually less than 4 in. deep), they should be immediately filled, and the slope should be promptly regraded and adequately protected.



UNVEGETATED SLOPES SHOULD BE TEMPORARILY SCARIFIED TO MINIMIZE RUNOFF VELOCITIES

SURFACE ROUGHENING



SCARIFIED FILL SLOPE

Gradient Terracing — BMP 26

Description

Gradient terracing is a term used to describe an earth embankment or ridge-and-channel arrangement constructed along the face of a slope at regular intervals. Gradient terraces are constructed at a positive grade. They reduce erosion damage by capturing surface runoff and directing it to a stable outlet at a speed that minimizes erosion.

Applications

Gradient terraces are usually limited to use on long, steep slopes that have a water erosion problem or where it is anticipated that water erosion will be a problem. They are used for reducing runoff velocity and increasing the distance of overland runoff flow. They hold moisture better than do smooth slopes, and they minimize sediment loading of surface runoff.

Limitations

Drainage area – 10 ac.	Maximum slope – 50%
Minimum bedrock depth – 6 ft	Minimum water table – 8 ft
NRCS soil type - BCD	Freeze/thaw – good
Drainage/flood control – yes	

Gradient terraces should not be constructed on excessively steep slopes or in areas with sandy or rocky soils. They will be effective only where suitable runoff outlets will be available. Gradient terraces may significantly increase cut and fill costs and cause sloughing if too much water infiltrates the soil.

Targeted Pollutants

Sediment

Design Parameters

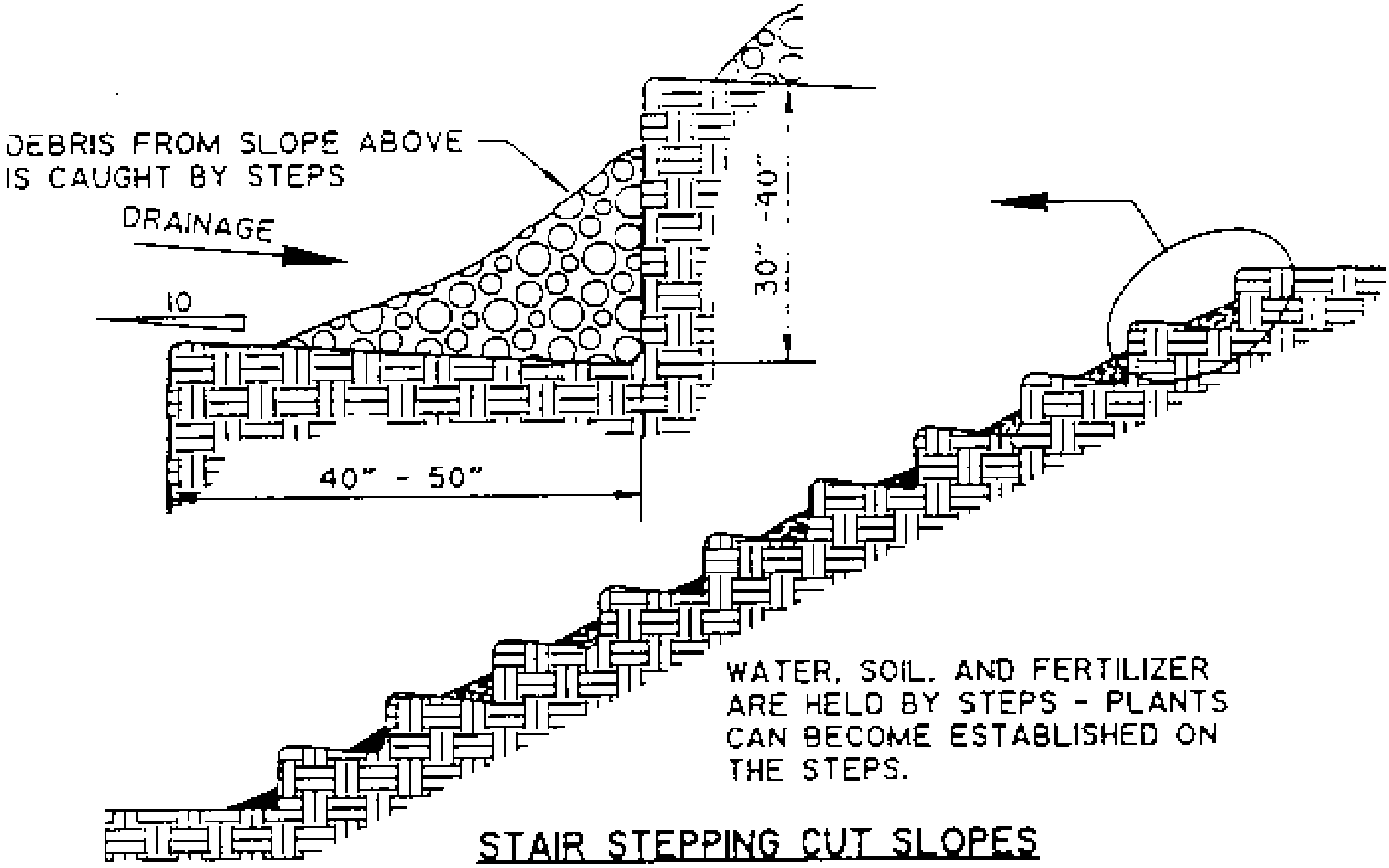
Gradient terraces should be designed and installed according to a plan determined by an engineering survey and layout. It is important that gradient terraces are designed with adequate outlets, such as a grassed waterway, vegetated area, or tile outlet. In all cases, the outlet should direct the runoff from the terrace system to a point where the outflow will not cause erosion or other damage. Vegetative cover should be used in the outlet where possible. The design elevation of the water surface of the terrace should not be lower than that at the junction of the outlet area when both are operating at design flow. Terraces can be constructed with linings to carry water to the outlet and can be used with a dike or similar measure above the terrace to divert runon from reaching the terraced slope.

Construction Guidelines

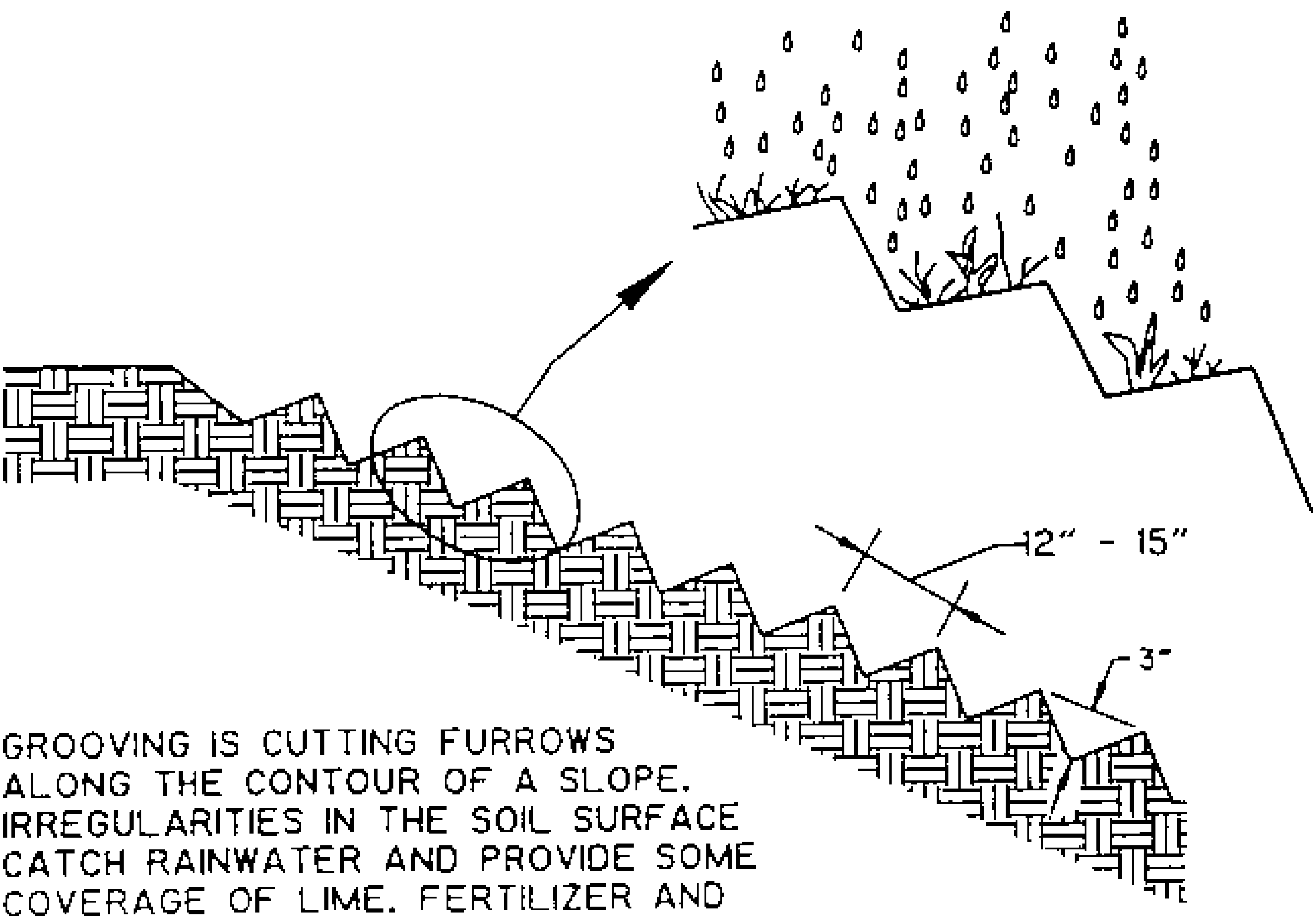
Construction of gradient terraces should be completed using equipment that is capable of meeting the specification established in the construction plans.

Maintenance

Inspect the gradient terraces regularly during project construction and inspect them after any major storm. If used as a permanent BMP, inspect at least once a year after project completion and after major storms. Evaluate whether the terrace is functioning effectively as a runoff collection and diversion device and note whether other stabilization measures (including vegetation) are performing effectively. Take prompt action as needed to ensure proper drainage and slope stability.



STAIR STEPPING CUT SLOPES



GROOVING SLOPES

Retaining Walls BMP 27

Description

Retaining walls are constructed against a slope or stream bank to prevent slope erosion, slope failure, or undercutting of the bank. Examples of retaining wall materials include: concrete, concrete masonry, rock, wood planking or railroad ties, and metal bins. Also see BMP 29-Gabions.

Applications

For slope protection or stabilization under extreme conditions or to protect erodible, unstable stream banks.

Concrete retaining wall: An engineered concrete wall that is designed to stabilize a slope and retain the rock or soil behind it. In addition to a solid concrete wall, precast, interlocking concrete blocks could be used.

Masonry retaining wall: An engineered structure similar to a concrete retaining wall but using masonry blocks, usually of specific design for aesthetic appeal.

Native rock retaining wall: A low-gravity wall constructed of rock materials native to the construction site. It provides an aesthetically attractive method of stabilizing a slope. Native rock is suitable for walls up to about 6.5 ft in vertical height where the slope is steeper than 2:1 behind the wall. They can be higher on slopes of 2:1 (or flatter) gradient with proper engineering design.

Redwood (wood planking) retaining wall: A retaining wall constructed of redwood planking and posts. Redwood retaining walls are useful for relatively small slopes of loose material that are underlain by a rigid rock base material or firm, non-plastic subsoil with high shear strength. The firm foundation is necessary to securely anchor the wall. Can construct in poorer foundation soils by using longer posts and closer spacing, 3 ft maximum. Redwood will generally last longer than other woods.

Railroad tie retaining wall: A retaining wall constructed of railroad ties. These are useful for relatively small slopes of loose material that are underlain by a rigid base of rock or firm, non-plastic subsoil. The wall should be securely anchored to the rock base or firm subsoil.

Mechanically stabilized earth (MSE) retaining walls: The following are considered MSE walls: reinforced earth, retained earth, Hilfiker, Genesis (Keystone/Tensar), and T-wall. All of those designs use some type of anchored structure to retain earthen materials behind a wall.

Limitations

Drainage area - unlimited	Maximum slope – 67%
Minimum bedrock depth - N/A	Minimum water table – 3 ft
NRCS soil type - ABCD	Freeze/thaw – fair

Drainage/flood control – no

- Retaining walls should be considered a permanent measure only. Cost and site-specific design requirements limit their use to situations where other stabilization measures would be ineffective or aesthetically unacceptable.
- Native rock retaining walls have a maximum height of about 6.5 ft.
- Redwood retaining walls require a firm foundation to anchor the wall.
- Wood treated with creosote or other chemicals to retard decay may leach out and cause toxic effects. Treated railroad ties should not be used along sensitive streams for instance.

Targeted Pollutants

Sediment

Design Parameters

Retaining walls require a site-specific design. Wall heights, requirements for drainage, and suitable materials should be determined through on-site inspections. Listed in this fact sheet are some suggestions of appropriate applications of retaining walls for erosion control. All types of retaining walls should conform to local building codes and ordinances. Plans and specifications should be prepared by professional engineers for most installations, including all that fall outside the parameters listed under the physical limits.

Construction Guidelines

Concrete retaining walls: Construct as designed by a professional engineer or as shown on the plans.

Masonry retaining walls: Construct as designed by a professional engineer or as shown on the plans.

Native rock retaining walls:

- Remove all large rocks from the eroding slope face and stockpile on site.
- Excavate a footing trench along the toe of the slope.
- Place the largest rocks in the footing trench with their longitudinal axis normal to the embankment face. Arrange subsequent rock layers so that each rock above the foundation course has a three-point bearing on the underlying rocks.
- The slope of the wall should be between 0.5:1 and vertical, depending upon the height of the wall, the height of the slope, the width of the right-of-way, or other limitations on space.
- Obtain fill material from the slope and place it behind the rock wall. Slope above the wall should be maintained at 2:1 or less with a slope bench at the toe. Backfill the footing trench with excavated material.
- If a roadway is located at the toe of the wall, pave the roadway up to the base of the rock wall and provide roadway curb for water transport. If a roadway is not located at the toe of the retaining wall, slope the backfilled material away from the wall at 2% and stabilize it.
- Revegetate the stabilized slope immediately with a method applicable to the particular site.

Redwood (wood planking) retaining wall:

- Prepare the site by rough grading the slope surface, then work from the bottom of the slope towards the top.
- Set the bottom course of redwood posts into rigid base foundation material and secure with a concrete collar.
- Install planking on the upslope side of the posts. Provide sufficient vertical spacing to allow drainage at the base of the wall and between planks.
- Backfill behind the wall with material from the slope above. Slope the backfill material between redwood walls at 2% toward the top of the lower wall.
- Proceed in a similar fashion up the slope to the desired height.
- Revegetate the backfilled benches behind the walls according to procedures applicable to the specific site.

Railroad tie retaining wall:

- Prepare the site by rough grading the slope surface, then work from the bottom of the slope toward the top.
- Set the bottom course of railroad ties onto a rigid base foundation material and secure with pinning or metal collars.
- Backfill behind the wall with material from the slope above. Slope the backfill material between the tiers of railroad ties at 2% toward the top of the lower wall. If the engineered wall requires deadmen, install in accordance with the design drawing.
- Proceed in a similar fashion up the slope to the desired height. If the total height exceeds 6 ft, the wall should be designed and approved by a registered engineer.
- Revegetate the backfilled benches behind the walls according to procedures applicable to the specific site.

MSE retaining wall: Prepare the site and construct as shown on the plans.

Maintenance

Retaining walls should be inspected periodically on regular intervals to detect signs of structural failure and to check for damage caused by subsurface drainage or material sloughing. In stream bank installations, inspect for signs of undercutting and other instability. Make all repairs promptly, as needed.

Section 6 – Storm Drain and Channel Protection

For the selection of the most appropriate or suitable BMP, the user should refer to the BMP Selection Matrix in Table 1. It is essential to check with the local permitting authority for other requirements.

It is important to protect storm drains during construction activities so that sediment and debris are not allowed to enter the system. Protection of natural channels and earth ditches is also critical to prevent scouring and undercutting. The following pages present fact sheets for these storm drain and channel protection BMPs:

BMP 28	Temporary channel liners
BMP 29	Gabions
BMP 30	Riprap slope and outlet protection
BMP 31	Inlet protection
BMP 32	Check dams
BMP 33	Temporary stream crossing

Temporary Channel Liners — BMP 28

Description

Channel liners are geosynthetic materials or jute matting used to line the bottom or banks of ditches or channels to prevent or reduce erosion, and, to some degree, to capture sediment.

Applications

Channel liners can be left in place until a more permanent BMP is put in place, (i.e., riprap) or can assist in holding the soil until permanent seeding is established. Complete contact of the channel liner with the surface of the soil is necessary to keeping water flowing over, not under, the liner.

Limitations

Drainage area – Dependent on product used
Minimum bedrock depth - N/A
NRCS soil type – N/A
Drainage/flood control – no
Maximum slope – Dependent on product used
Minimum water table - N/A
Freeze/thaw – good

- Channel liners should never be used in live streams unless approved by the appropriate state and federal authorities.
- Channel liners are not suitable when used in ditches or channels with steep sides or where the soils are gravelly or not compacted, because the soil may not hold the liner in place.

Targeted Pollutants

Sediment

Design Parameters

- Stable inlets and outlets should be designed and constructed prior to construction of channel liners.
- Channel liners should be installed on side slopes of 3H/1V or flatter and in channels with a low-flow velocity. The material (geosynthetic or jute matting) should be porous, long lasting (longer than 1 year) and flexible.

Construction Guidelines

Follow manufacturer's installation recommendations and the following general guidelines:

- Site preparation: Shape, grade, and compact the bottom and banks as required for a smooth fit. Remove rocks, clods, sticks, and other materials that prevent positive contact with the soil surface. Complete contact of channel liner with the soil surface is critical for satisfactory performance.
- Side ditches or channels: Treat in the same manner as the main ditch or channel.
- Channel liner applications: Start at the upstream end of the channel and continue down grade.
- Channel liner overlap: At least 3 ft with the end of the upstream liner overlapping the top of the next lower liner. The top end of the lower liner should be buried at least 6 in.. Both the top and bottom liner should be securely anchored in the area of the overlap. The outer edges of the channel liner should be buried in a trench at least 1 ft and properly anchored.

- Make field adjustments as necessary to ensure proper performance.

Maintenance

- Make corrections based on weekly erosion control inspections.
- After channel lining is installed, make sure all liner is in contact with the soil in all places, and that critical areas are securely anchored. Inspect channel liners periodically and following each storm event or snowmelt. Repair as necessary.

Gabions BMP 29

Description

Gabions are rectangular wire-mesh cages that are filled with rock and wired together to form a protective but permeable structure for slope stabilization and erosion control.

Applications

Gabions can be used as retaining walls to mechanically stabilize steep slopes or for revetments, weirs, channel linings, culvert headwalls, and culvert outlet aprons. They are particularly useful where seepage is anticipated. For related information, refer to BMP 27-Retaining Walls.

Limitations

Drainage area - unlimited
Minimum bedrock depth - N/A
NRCS soil type - ABCD
Drainage/flood control – no
Maximum slope – 40%
Minimum water table – 2 ft
Freeze/thaw – good

Materials costs and professional design requirements may make use of gabions impractical. Gabions may alter stream dynamics or adversely affect wildlife habitat. When used in channels with high-sediment loads, the galvanizing wire on the cages quickly wears off, causing rusting and the premature failure of the cages.

Targeted Pollutants

Sediment

Design Parameters

- Gabions to be installed in stream banks should be designed and installed according to Rule #9.3 of the *Stream Channel Alterations, Rules and Regulations and Minimum Standards*, Idaho Department of Water Resources, 1978.
- Professionals familiar with the use of gabions should prepare construction plans and specifications. The structure should be able to handle expected storm and flood conditions.
- On stream bank applications, the foundation is an important design feature of the structure. Consider the potential for the stream to erode the sides and bottom of the channel and make sure the gabions will be supported properly.
- The gabion structure should be securely "keyed" into the foundation and abutment surfaces. The rock filling holds the gabions in place by gravity, but tiebacks may be used if conditions warrant additional structural strength.
- Gabions are usually placed on a filter blanket, gravel layer, or both.

Materials

- Gabions should be fabricated in such a manner that the sides, ends, lids, and diaphragms can be assembled at the construction site into a rectangular basket of required sizes. Gabions should be of single unit construction. The base, ends, and sides should either be woven into a single unit or one edge of these members connected to the base section of the gabion in such a manner that strength and flexibility at the point of connection is at least equal to that of the mesh.

- Where the length of the gabion exceeds its horizontal width, the gabion should be equally divided by diaphragms, of the same mesh and gage as the body of the gabions, into cells whose length does not exceed the horizontal width. The gabion should be furnished with the necessary diaphragms secured in proper position on the base section in such a manner that no additional tying at this juncture will be necessary.
- All perimeter edges should be securely selvedged or bound so that the joints formed by tying the selvedges have the same strength as the body of the mesh.
- The fill material for the wire gabions should be rock ranging in size from a minimum of 4 in to a maximum of 8 in, both measured in the greatest dimension. Rock should be sound, durable, well graded, and should be obtained from a source approved by the Project Engineer.

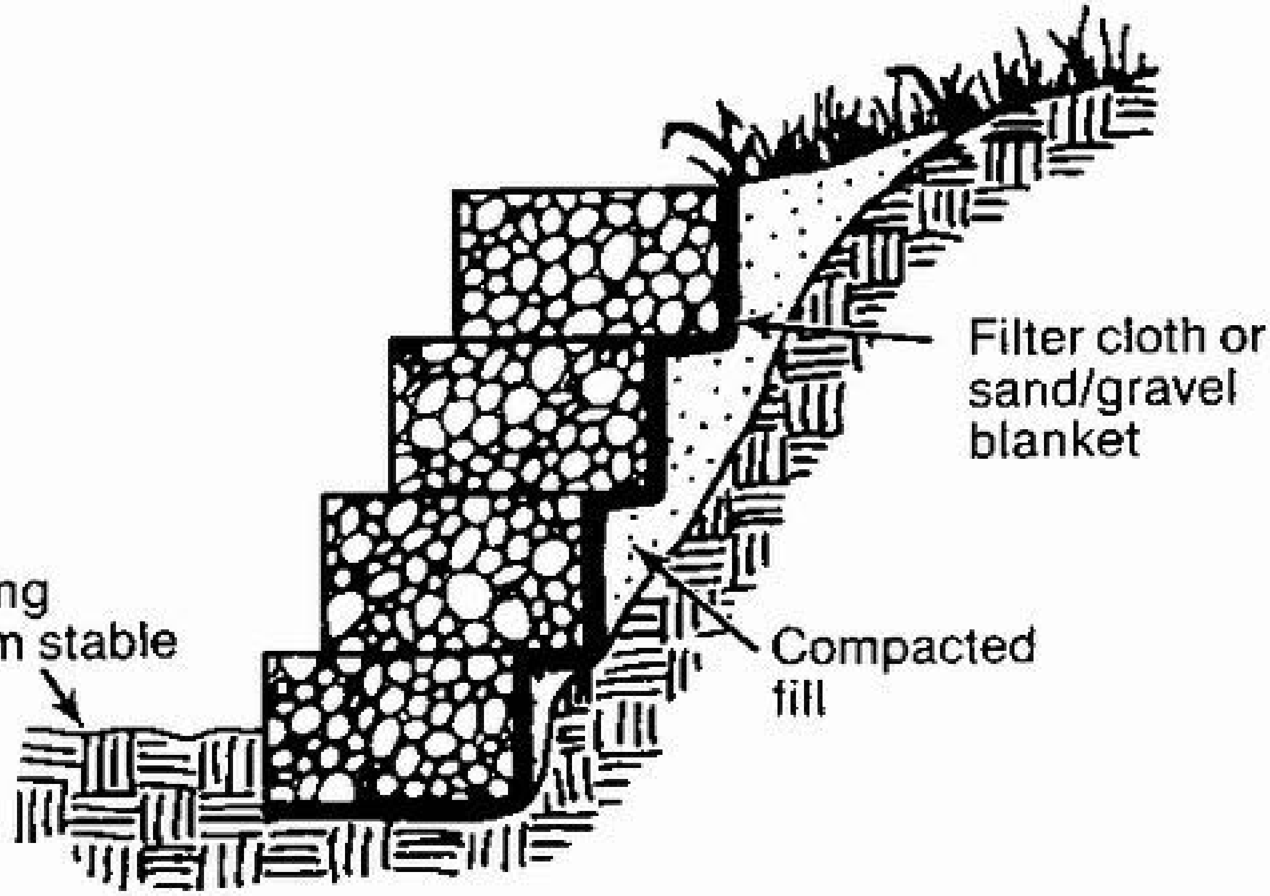
Construction Guidelines

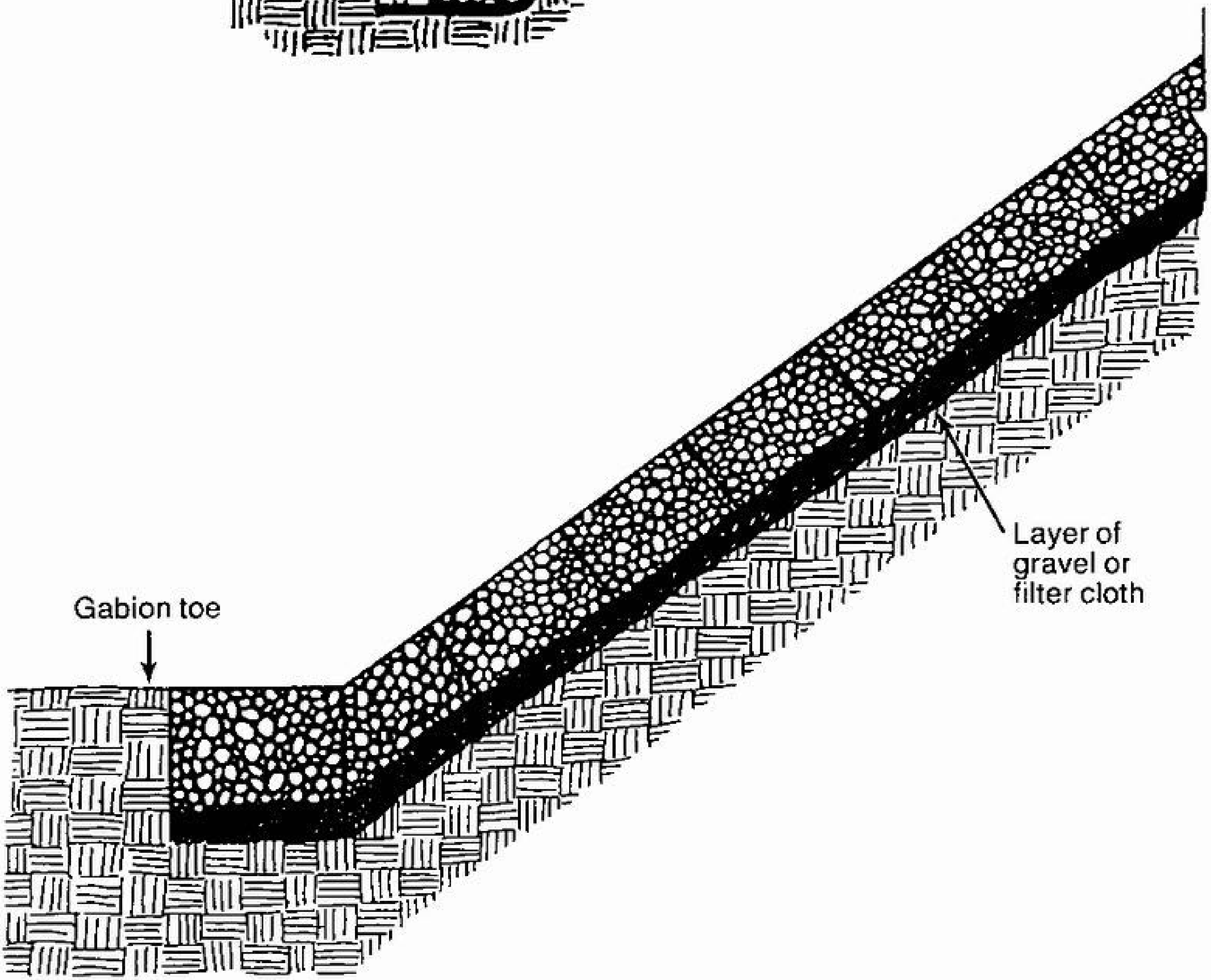
- Empty gabion baskets should be placed on a smooth, firm foundation excavated as directed by the plans. Each row, tier, or layer of baskets should be reasonably straight and should conform to the line and grade shown on the plans or established by the Project Engineer. The empty gabion baskets should be fastened to the adjacent baskets along the top and vertical edges. Each layer should be fastened to the underlying layer along the front, back and ends. Fastening should be performed in the same manner as provided for assembling the gabion units.
- Unless otherwise indicated on the plans, the vertical joints between basket units of adjacent tiers or layers, along the length of the structure, should be staggered by at least one cell.
- Before filling each gabion with rock, all kinks and folds in the wire mesh should be removed and all baskets should be properly aligned. A standard fence stretcher, chain fall or steel rod, may be used to stretch the wire baskets and hold alignment.
- The gabion cells should be carefully filled with rock placed by hand/machine in such a manner that the alignment of the structure will be maintained and so as to avoid bulges and to minimize voids. All exposed rock surface should have a reasonably smooth and neat appearance. No sharp rock edges should project through the wire mesh.
- The gabion cells in any row or layer should be filled in stages so that local deformations may be avoided. At no time should any cell be filled to a depth exceeding 12 in. more than any adjacent cell.
- The layer of rock should completely fill the gabion basket so that the lid will bear on the rock when it is secured. The lid should be joined to the sides, ends, and diaphragms in the same manner as specified for joining the vertical edges. The gabion basket lid should be secured so that no more than 1in. gap remains at any connection.
- Gabion rows or layers not completed at the end of each shift should have the last gabion filled with rock tied internally as an end gabion.
- The area behind the gabion structure should be backfilled with granular material. Geotextile, if required, should be spread uniformly over the back of the gabion structure as shown on the plans. Joining edges of the

geotextile should be overlapped a minimum of 12 in. and should be anchored in position with approved anchoring devices. The contractor should place the backfill material in a manner that will not tear, puncture, or shift the geotextile.

Maintenance

- Inspect regularly and after each major storm. Check for signs of undercutting or other instability.
- Repair damaged areas immediately to restore designed effectiveness and to prevent damage or erosion of the slope or stream bank.
- Check wire of cages for rusting and wear. Repair where possible or replace.


Filter cloth or
sand/gravel
blanket
Existing
bottom stable
Compacted
fill


Layer of
gravel or
filter cloth
Gabion toe

Riprap Slope and Outlet Protection BMP 30

Description

Riprap slope and outlet protection is created by an arranged layer or pile of rock placed over the soil surface on slopes and at or below storm drain outfalls or temporary dikes. Riprap used as slope protection protects against erosion and dissipates the energy of runoff or surface water flow. Outlet protection reduces the speed of concentrated stormwater flows, thereby reducing erosion or scouring at stormwater outlets. In addition, outlet protection lowers the potential for downstream erosion. This type of protection can be achieved through a variety of techniques, including stone or riprap outlet structures and armored scour holes installed below the storm drain outlet.

Applications

For slope protection, use riprap or blanketed slopes. Outlet protection should be installed at the outlets of all pipes, culverts, catch basins, sediment basins, ponds, interceptor dikes, and swales or channel sections where the velocity of flow may cause erosion in the receiving channel. Outlet protection should also be used at outlets where the velocity of flow at the design capacity may result in plunge pools (small, permanent pools located at an inlet or outfall). Outlet protection should be installed early during construction activities, but may be added at any time, as necessary.

Limitations

Drainage area – 5 ac.
Minimum bedrock depth - N/A
NRCS soil type - ABCD
Drainage/flood control – no

Maximum slope – 40%
Minimum water table - N/A
Freeze/thaw – good

The minimum particle size of the rock should be sized for the maximum expected velocity of flow out of the outlet and the soil conditions where the outlet will be located.

Targeted Pollutants

Sediment

Design Parameters

The design of rock outlet protection depends entirely on the location. Pipe outlets at the top of cuts or on slopes steeper than 10%, cannot be protected by rock aprons or riprap sections due to reconcentration of flows and high velocities encountered after the flow leaves the apron.

Tailwater depth: Tailwater depth immediately below the pipe outlet should be determined for the design capacity of the pipe. If the tailwater depth is less than half the diameter of the outlet pipe and the receiving stream is wide enough to accept divergence of the flow, it should be classified as a minimum tailwater condition. If the tailwater depth is greater than half the pipe diameter and the receiving stream will continue to confine the flow, it should be classified as a maximum tailwater condition. Pipes which outlet onto flat areas with no defined channel may be assumed to have a minimum tailwater condition.

Apron Size: The apron length and width should be determined according to the tailwater condition. If the pipe discharges directly into a well-defined channel, the apron should extend across the channel bottom and up the channel banks to an elevation 1 ft above the maximum tailwater depth or to the top of the bank, whichever is less. The upstream end of the apron, adjacent to the pipe should have a width two (2) times the diameter of the outlet pipe, or conform to pipe end section if used.

Bottom Grade: The outlet protection apron should be constructed with no slope along its length. There should be no overfall at the end of the apron. The elevation of the downstream end of the apron should be equal to the elevation of the receiving channel or adjacent ground.

Alignment: The outlet protection apron should be located so that there are no bends in the horizontal alignment.

Materials: The outlet protection may be done using rock riprap, grouted riprap or gabions (BMP 29-Gabions). Riprap size should be based on calculated shear stress. It should be composed of a well-graded mixture of stone size so that 50% of the pieces, by weight, should be larger than the d50 size determined by using the charts. A well-graded mixture as used herein is defined as a mixture composed primarily of larger stone sizes but with a sufficient mixture of other sizes to fill the smaller voids between the stones. The diameter of the largest stone size in such a mixture should be 1.5 times the d50 size. Gabions to be installed in stream banks should be designed and installed according to Rule #9.3 of the *Stream Channel Alterations, Rules and Regulations and Minimum Standards*, Idaho Department of Water Resources, 1978.

Thickness: The minimum thickness of the riprap layer should be 1.5 times the maximum tone diameter for d50 of 15 in. or less; and 1.2 times the maximum tone size for d50 greater than 15 in. Table 30 lists some examples.

Stone Quality: Stone for riprap should consist of field stone or rough unhewn quarry stone. The stone should be hard and angular and of a quality that will not disintegrate on exposure to water or weathering. The specific gravity of the individual stones should be at least 2.5.

Recycled concrete equivalent may be used provided it has a density of at least 150 pounds per cubic ft and does not have any exposed steel or reinforcing bars.

Filter: A filter is a layer of material placed between the riprap and the underlying soil surface to prevent soil movement into and through the riprap. Riprap should have a filter placed under it in all cases.

A filter can be of two general forms: A gravel layer or a plastic filter cloth. The plastic filter cloth can be woven or non-woven monofilament yarns and should meet these base requirements: thickness 10-60 mils, grab strength 90-120 lbs; and should conform to ASTM D-1777 and ASTM D-1682.

Gravel filter blanket, when used, should be designed by comparing particle sizes of the overlying material and the base material. Design criteria are available in any soils or civil engineering reference or from the National Resources Conservation Service.

Construction Guidelines

- The subgrade for the filter, riprap, or gabion should be prepared to the required lines and grades. Any fill required in the subgrade should be compacted to a density of approximately that of the surrounding undisturbed material.
- The rock or gravel should conform to the specified grading limits when installed respectively in the riprap or filter.
- Filter cloth should be protected from punching, cutting, or tearing. Any damage other than an occasional small hole should be repaired by placing another piece of cloth over the damaged part or by completely replacing the cloth. All overlaps whether for repairs or for joining two pieces of cloth should be a minimum of 1 ft.
- Stone for the riprap or gabion outlets may be placed by equipment. Both should be constructed to the full course thickness in one operation and in such a manner as to avoid displacement of underlying materials. The stone for riprap or gabion outlets should be delivered and placed in a manner that will insure that it is reasonably homogenous with the smaller stones and spalls filling the voids between the larger stones. Riprap should be placed in a manner to prevent damage to the filter blanket or filter cloth. Hand placement will be required to the extent necessary to prevent damage to the permanent works.
- Complete construction of the outlet protection before allowing erosive flows to pass through the outlet.

Maintenance

Once a riprap outlet has been installed, the maintenance needs are relatively low. Inspect after heavy storms and high flows for scouring under the outlet and dislodged stones, and repair damage promptly. For dikes, maintain the area upstream of the outlet structure so that accumulated sediments can be removed when they reach a depth of one-third the height of the dike, or 12 in., whichever is less.

Table 30-1. Rock Riprap Sizes and Thickness

Unit shear stress (lb/ft^2)	D_{50} (in.)	d_{max} (in.)	Minimum blanket thickness (in.)
0.67	2	4	6
2.00	6	9	14
3.00	9	14	20
4.00	12	18	27
5.00	15	22	32
6.00	18	27	32
7.80	21	32	38
8.00	24	36	43

Unit shear stress calculated as T = yds
where:
T = shear stress in lb/ft^2
y = unit weight of water, 62.4 lb/ft^3
d = flow depth in ft
s = channel gradient in ft/ft

Design Procedure and Examples

- Investigate the downstream channel to assure that non-erosive velocities can be maintained.
- Determine the tailwater condition at the outlet to establish which curve to use.
- Enter the appropriate chart with the depth of flow and discharge velocity to determine the riprap size and apron length required. It is noted that references to pipe diameter in the charts are based on full flow. For other than full pipe flow, the parameters of depth of flow and velocity should be used.
- Calculate apron width at the downstream end if a flared section is to be employed.

Example 1: *Pipe Flow (full) with discharge to unconfined section*
A circular conduit is flowing full:
Q = 280 cfs, diam. = 66 in., tailwater (surface) is 2 ft above pipe invert, (minimum tailwater condition)
Read d_{50} = 1.2 ft, and apron length 38 ft
Apron width = diam. + L_a = 5.5 + 38 = 43.5 ft

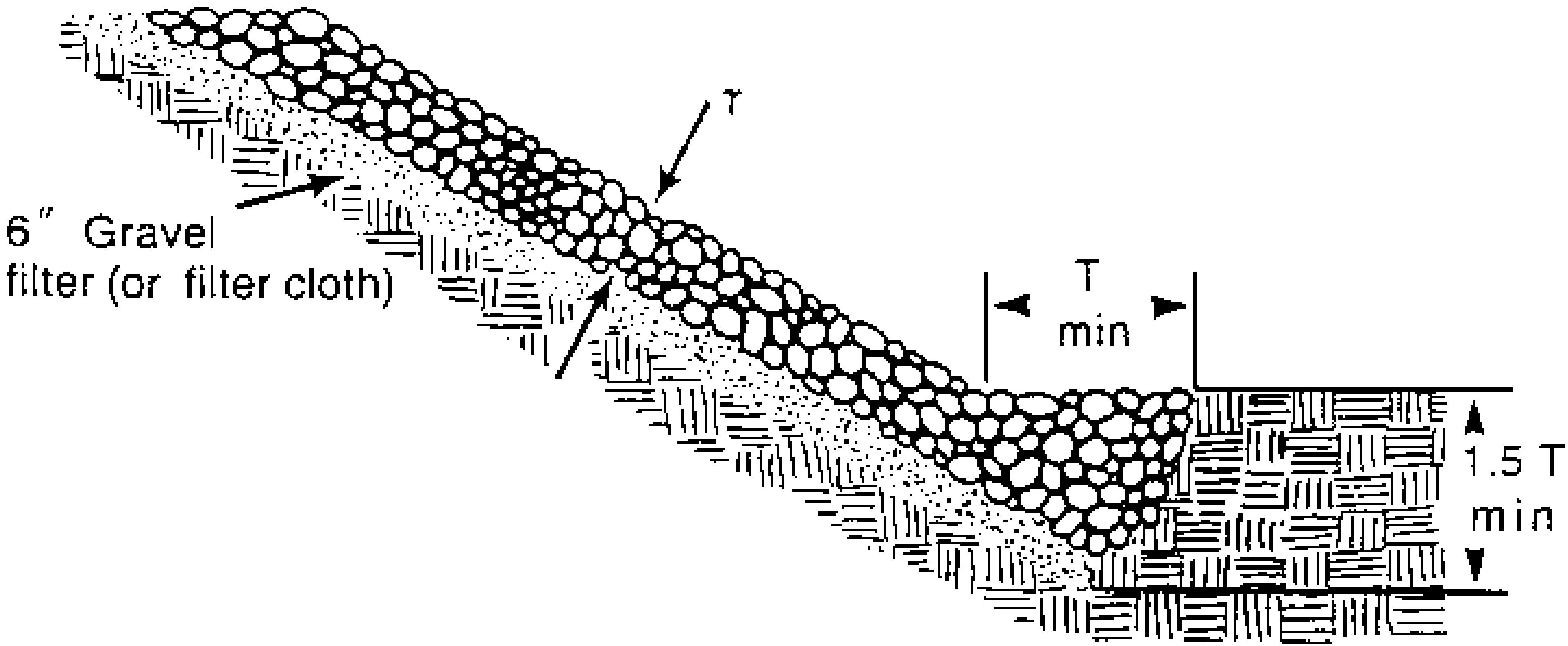
Example 2: *Box Flow (partial) with high tailwater*
A box conduit discharging under partial flow conditions. A concrete box 5.5 x 10 ft is flowing 5.0 ft deep, Q = 600 cfs and tailwater surface is 5 ft above invert (Max. tailwater condition).

$V = \frac{Q}{A} = \frac{600}{5x10} = 12$ fps

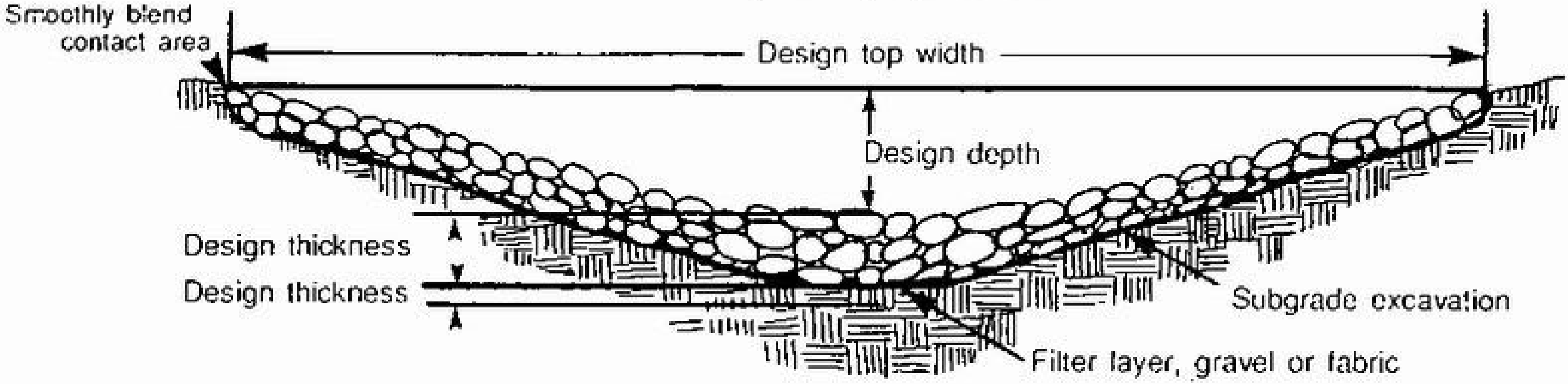
At the intersection of the curve d = 60 in. and V = 12 fps, read d_{50} = 0.4 ft
Then reading to the d = 60 in. curve, read apron length = 40 ft
Apron width, W = conduit width + 0.04 L_a = 10+(0.4) (40) = 26 ft

Example 3: *Open Channel Flow with Discharge to Unconfined Section*
A trapezoidal concrete channel 5 ft wide with 2:1 side slopes is flowing 2 ft deep, Q = 180 cfs (velocity = 10 fps) and the tailwater surface downstream is 0.8 ft (minimum tailwater condition).
At intersection of the curve d-24 ft and V = 10 fps, read d_{50} = 0.7 ft
Then reading up to the d = 24 in. curve, read apron length = 22 ft
Apron width, W = bottom of width of channel + L_a = 5 + 22 = 27 ft

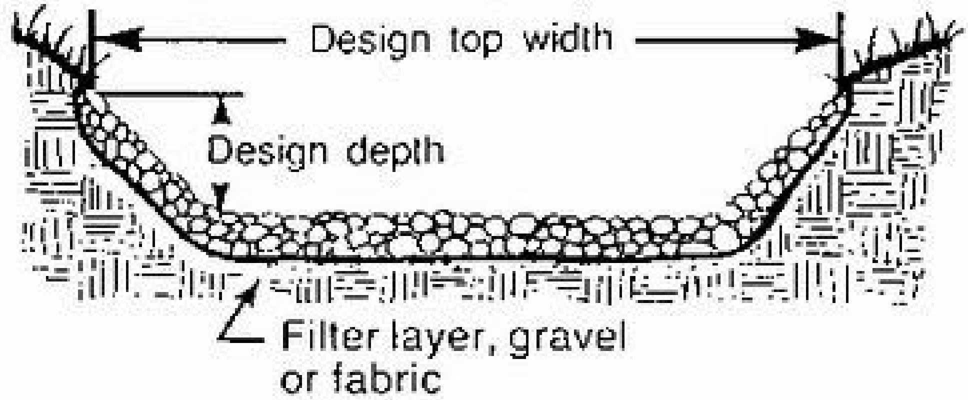
Example 4: *Pipe flow (partial) with discharge to a confined section*
A 48 in. pipe is discharging with a depth of 3 ft, Q = 100 cfs, and discharge velocity of 10 fps (established from partial flow analysis) to a confined trapezoidal channel with a 2 ft bottom, 2:1 side slopes, n = .04, and grade of 0.6%.
Calculation of the downstream channel (by Manning's Equation) indicates a normal depth of 3.1 ft and normal velocity of 3.9 fps.
Since the receiving channel is confined, the maximum tailwater condition controls.
At the intersection of d = 36 in. and v = 10 fps, Read d_{50} = 0.3 ft
Reading up to the d = 36 in. curve, read apron length = 30 ft
Since the maximum flow depth in this reach is 3.1 ft that is the minimum depth of riprap to be maintained for the entire length.


T
6" Gravel
filter (or filter cloth)
T
min
1.5 T
min

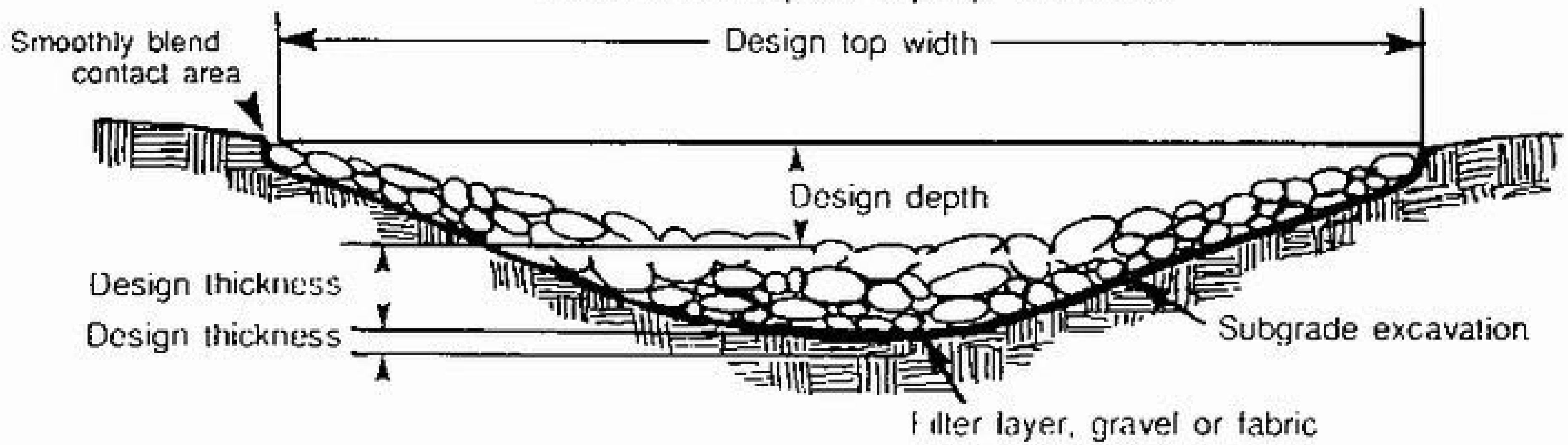
V-shaped Riprap Channel

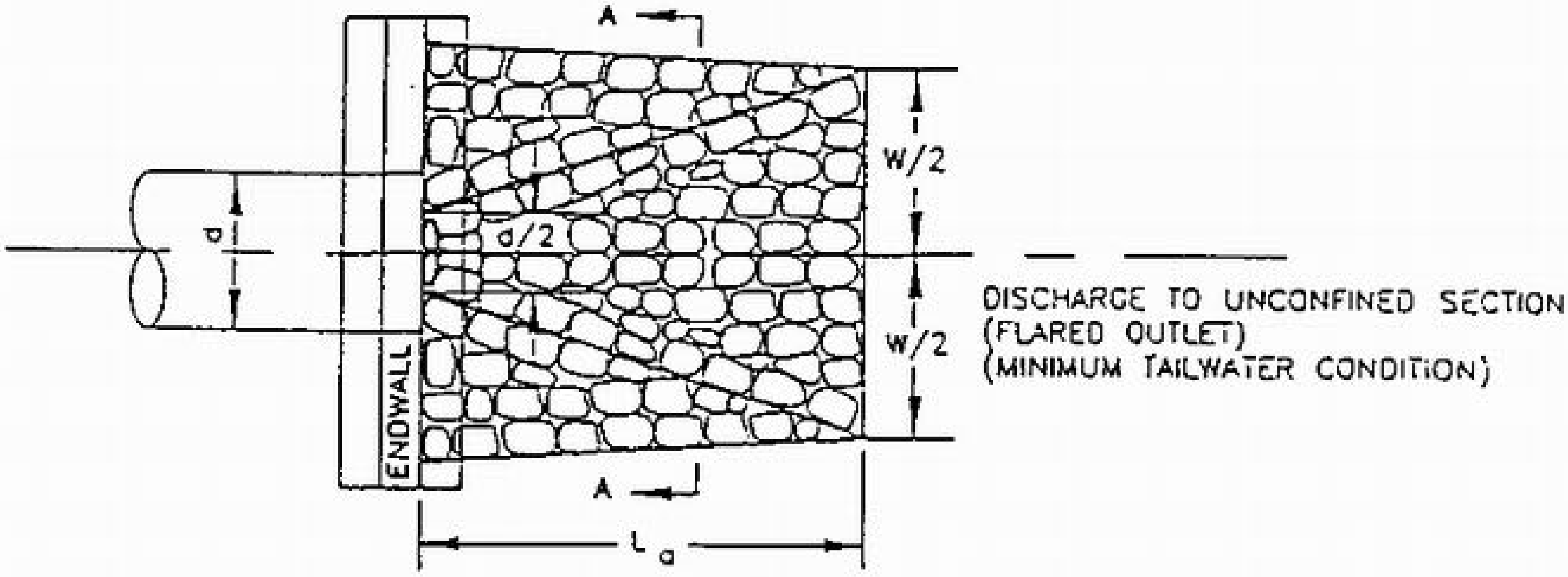


Trapezoidal Riprap Channel

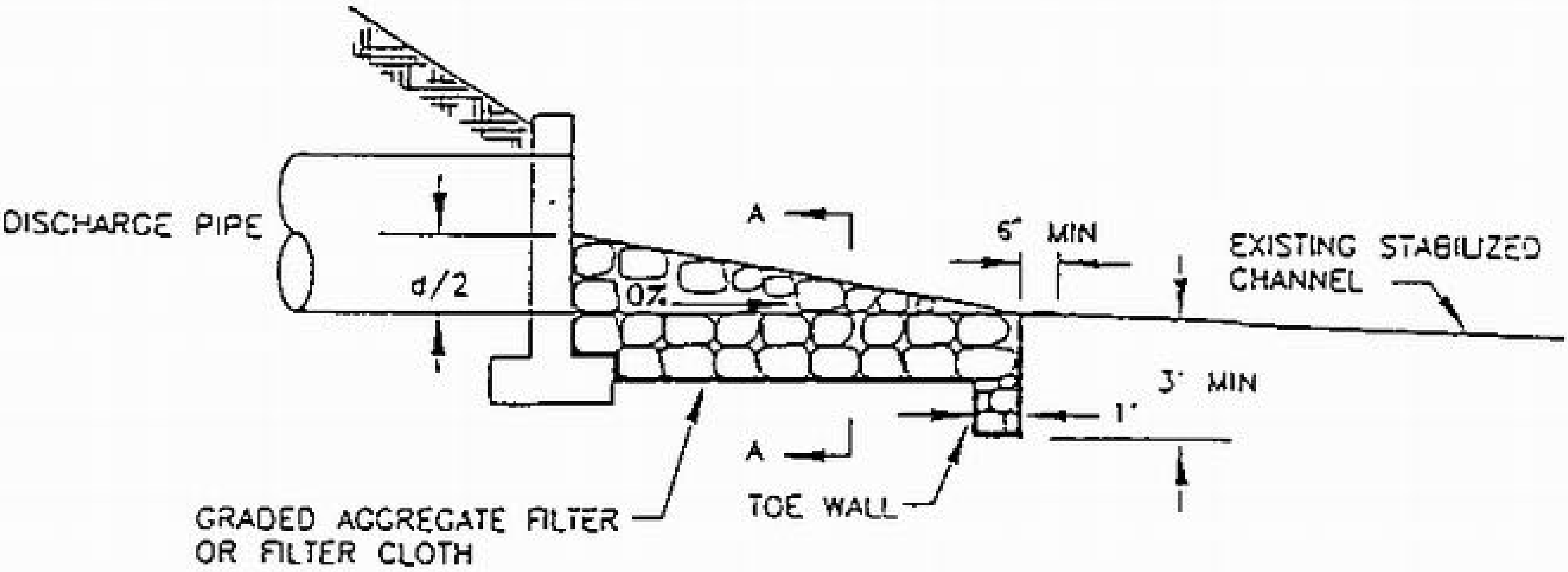


Parabolic-shaped Riprap Channel

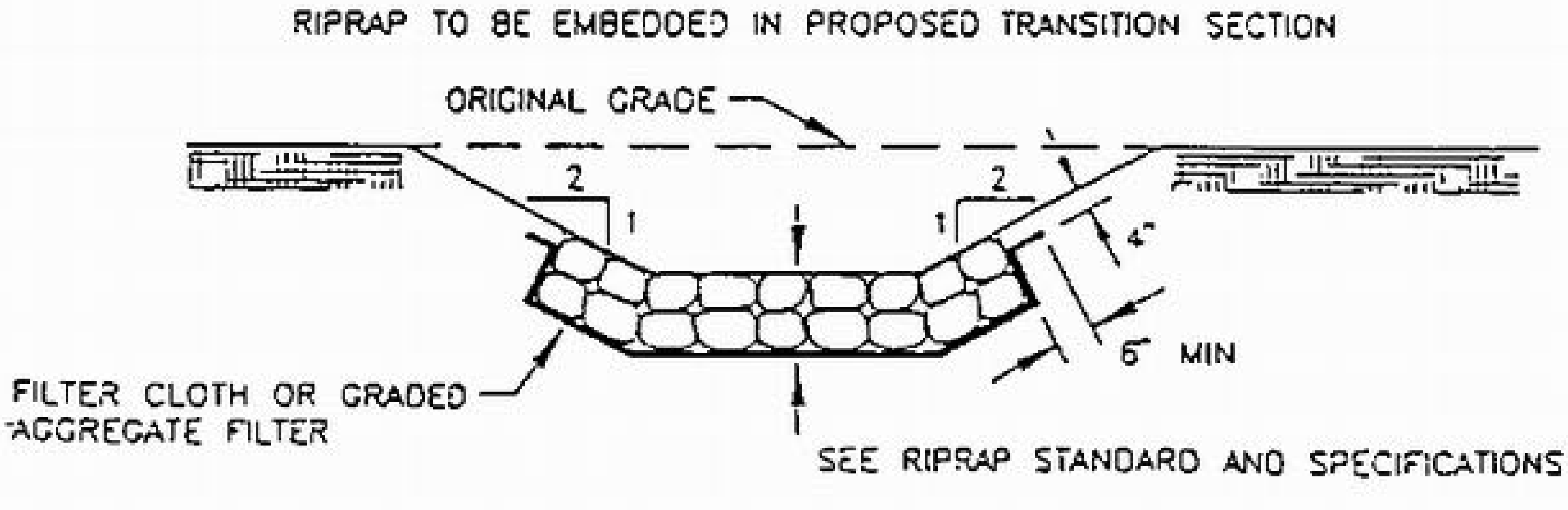




PLAN VIEW

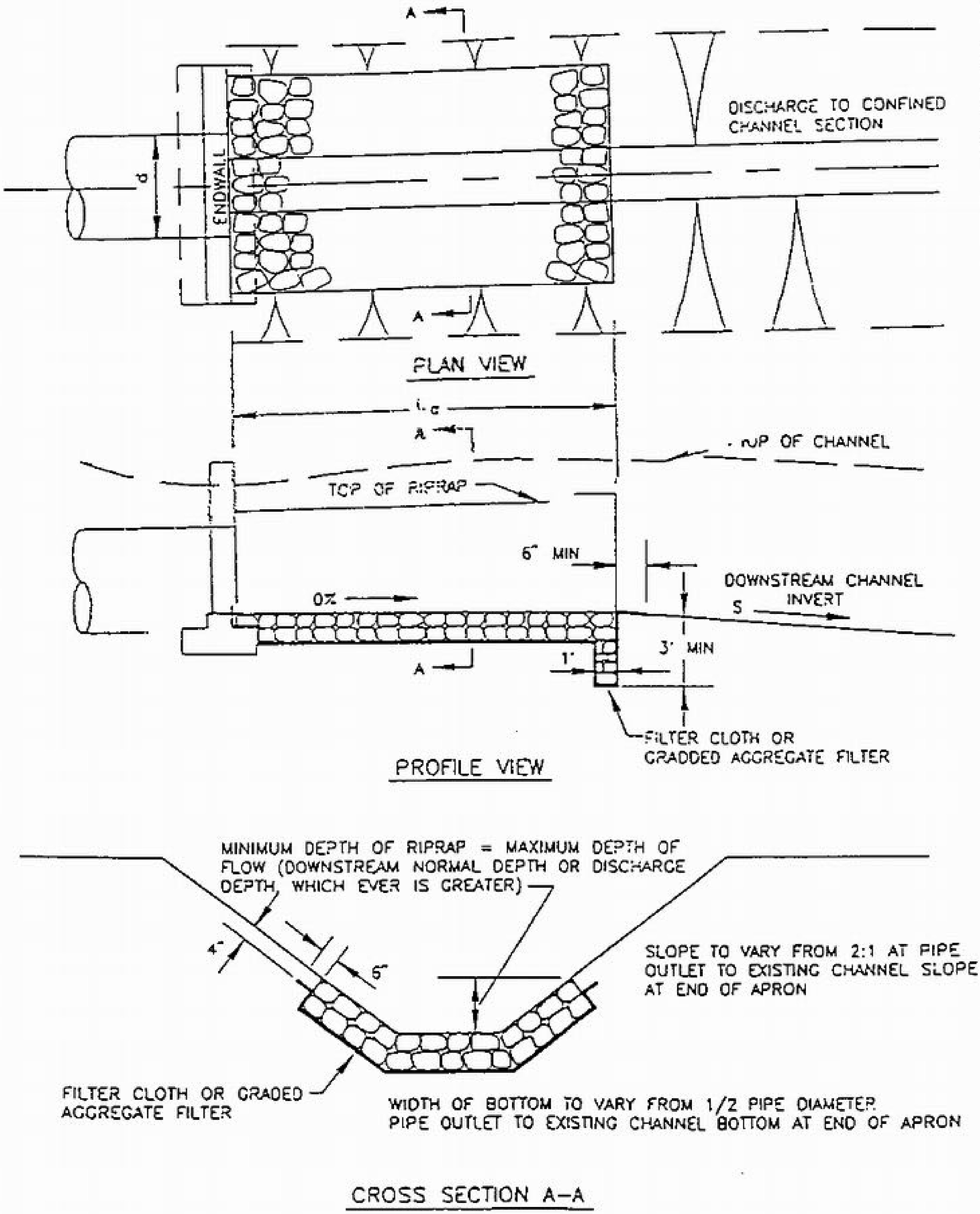


PROFILE VIEW

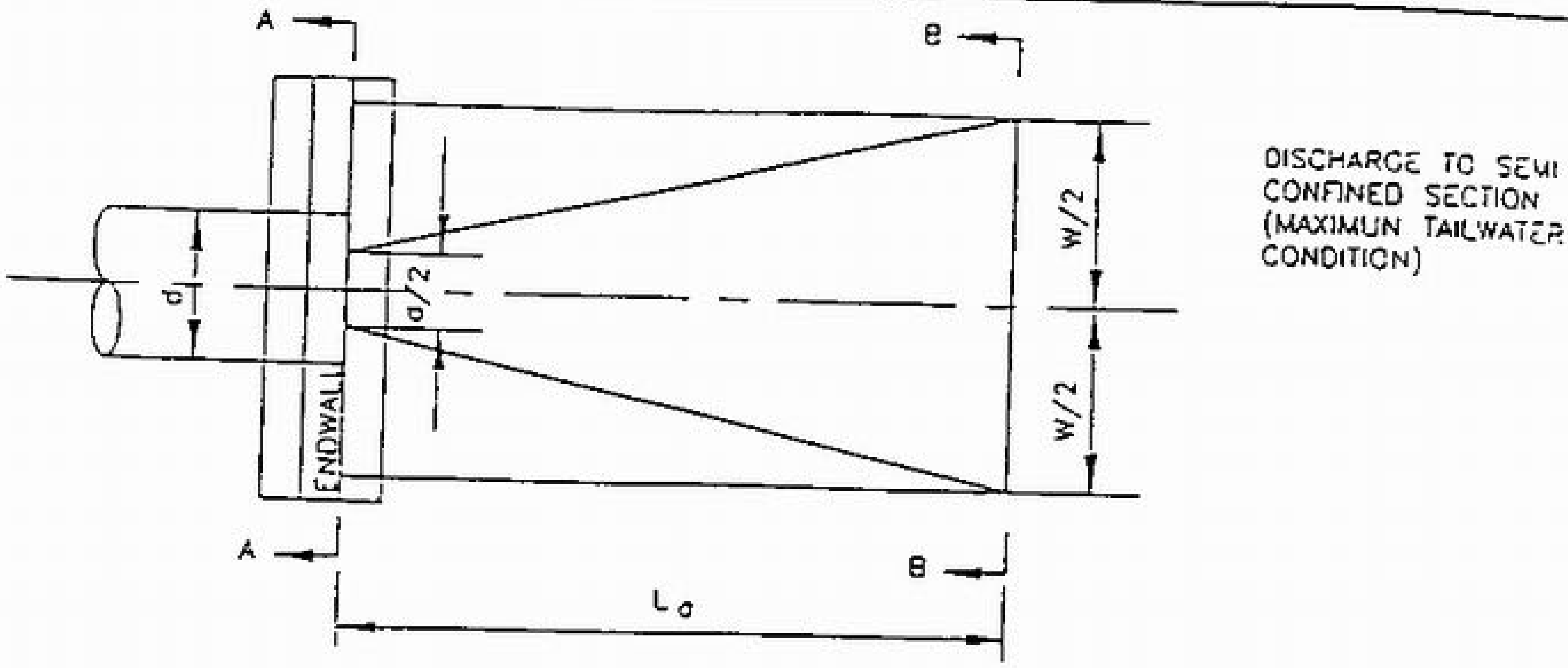


CROSS SECTION A–A

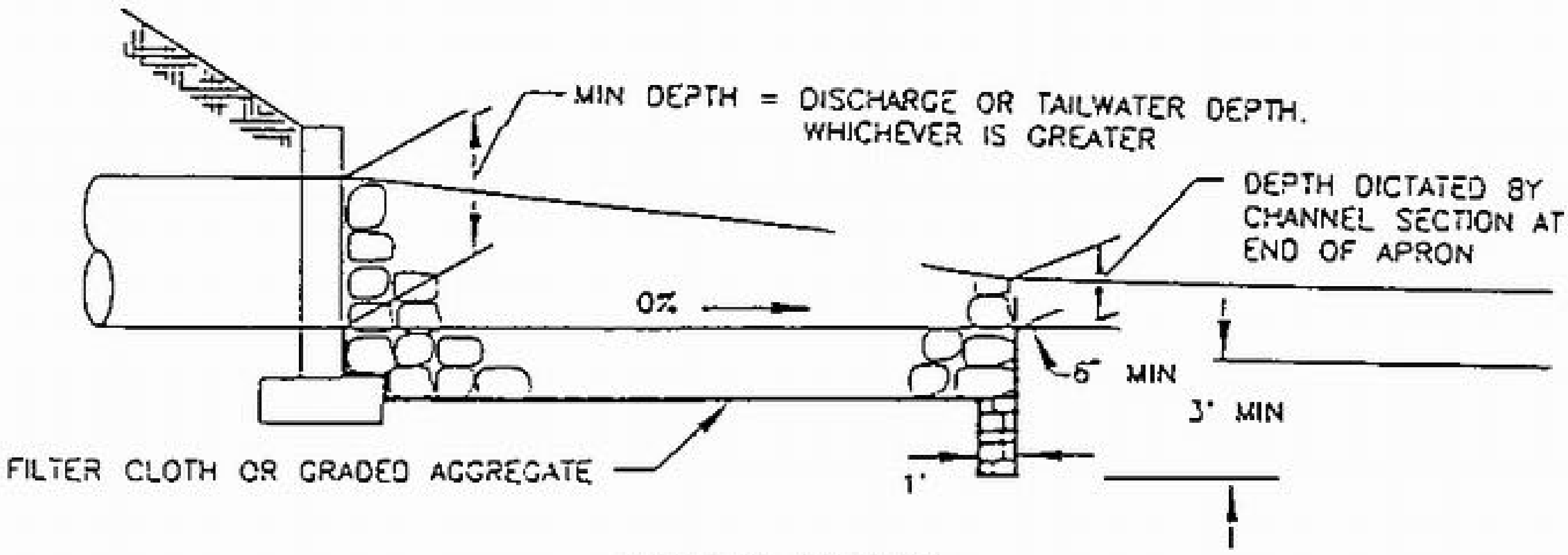
U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE	RIPRAP OUTLET PROTECTION – I	STANDARD DRAWING
TOOTHMAN–ORTON ENGINEERING COMANY BOISE, IDAHO McCALL, IDAHO		ROP–I



U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE	RIPRAP OUTLET PROTECTION – II	STANDARD DRAWING
TOOTHMAN–ORTON ENGINEERING COMANY BOISE, IDAHO McCALL, IDAHO		ROP–II

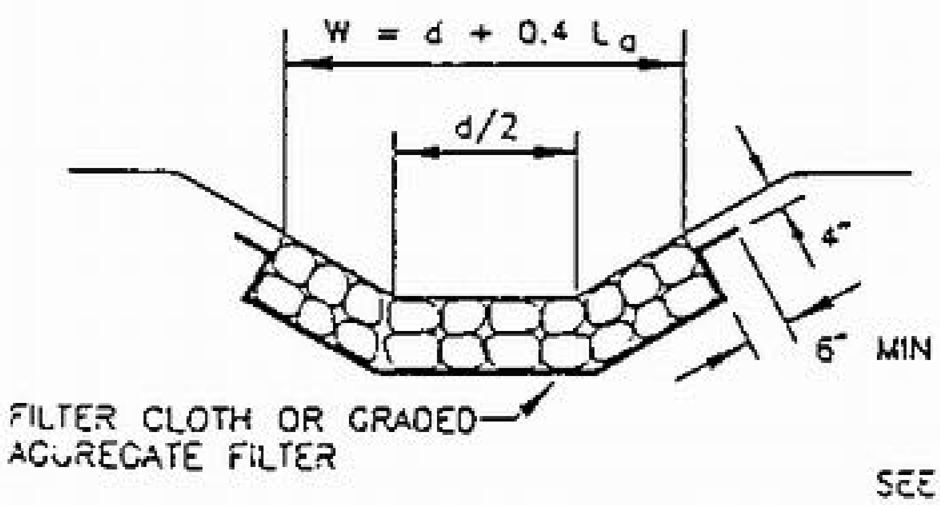


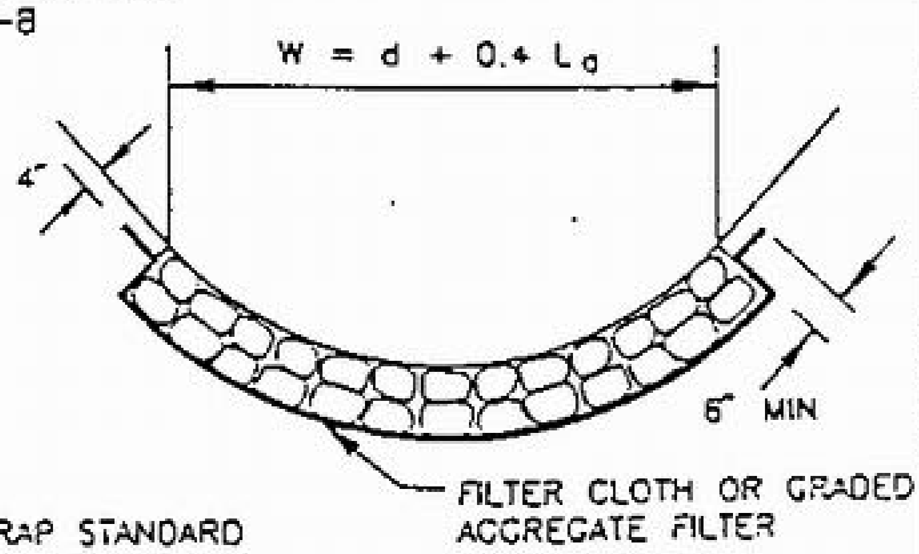
PLAN VIEW



PROFILE SECTION

CHANNEL SECTION TO VARY FROM A-A TO B-B





SEE RIPRAP STANDARD AND SPECIFICATION

CROSS SECTION A-A

CROSS SECTION B-B

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE	RIPRAP OUTLET PROTECTION – III	STANDARD DRAWING
TOOTHMAN-ORTON ENGINEERING COMANY BOISE, IDAHO McCALL, IDAHO		ROP-III

Inlet Protection BMP 31

Description

Inlet protection consists of a filtering measure placed around an inlet or drain to trap sediment and prevent the sediment from entering the storm drain system. Additionally, it serves to prevent the silting-in of inlets, storm drainage systems, or receiving channels. Inlet protection may be composed of gravel and stone with a wire mesh filter, block and gravel, or sod. Manufactured products are also available that are designed to trap silt and sediment at the point of entry to a storm drain. Inserts can include bags, racks, baskets and other materials that hang down into a catch basin or inlet. Inserts are made from filter fabric, wire mesh, metal plates, various types of plastic products and combinations of these and other materials. Care should be taken not to cause flooding with diverted flow.

Applications

- Inlet protection is appropriate for small drainage areas (less than 1 ac.) where storm drains will be ready for use before the drainage area reaches final stabilization. Storm drain inlet protection is also used where:
  - ✓ A permanent storm drain structure is being constructed on site and there is danger of sediment silting it in before permanent site stabilization.
  - ✓ There is a threat of sediment silting in an inlet that is in place prior to permanent stabilization.
  - ✓ Ponding around the inlet structure could be a problem to traffic on site.
- Block and gravel filters can be used where velocities are higher. They may be used with most types of inlets where overflow capability is needed and in areas of heavy flows (238 gal/min or greater).
- Gravel and mesh filters can be used where flows are higher and in locations subject to disturbance by site traffic. This type of protection may be used with most inlets where overflow capability is needed and in areas of heavy flows (238 gal/min or greater).
- Sod inlet filters are usually used where sediments in the stormwater runoff are low.
- Gravel and mesh filters and block and gravel filters should not be used in the right of way unless there is sufficient space to avoid a traffic hazard.

Limitations

Drainage area – 1 ac.	Maximum slope – 5%
Minimum bedrock depth – 2 ft	Minimum water table – 2 ft
NRCS soil type - ABCD	Freeze/thaw – good
Drainage/flood control – no	

- Consider sandbags (BMP 43-Temporary Berms) in situations where anchoring is not possible (e.g., paved road surfaces).
- Inlet protection is a high maintenance item compared with other more permanent measures.
- These devices require additional upslope BMPs to be effective.

Targeted Pollutants

Sediment

Design Parameters

Several different designs are in use and the configurations vary. The following design considerations apply to most of inlet protection. Some additional concerns apply to only one or two of the types.

Drainage area: Not to exceed 1 ac. Overland flow to the inlet should be no greater than 240 gal/min.

Slope gradient: The drainage area should be fairly flat, with slopes of 5% or less. With filter fabric designs, the area immediately surrounding the inlet should not exceed a slope of 1%.

Sump: Where possible, a block-and-gravel protection device should be provided with a sediment-trapping sump 12 to 20 in. deep as measured from the crest of the inlet. Side slopes should be 2:1. The recommended volume of excavation is 860 ft^3/ac. of ground disturbed.

Orientation: To achieve maximum trapping efficiency in gravel-and-mesh or block-and-gravel traps; the longest dimension of the basin should be oriented toward the longest inflow area.

Materials for excavated gravel inlet protection:

- Hardware cloth or wire mesh with 2/5 to 3/5 in. openings
- Washed gravel 0.8 to 4 in. diameter

Materials for block and gravel inlet protection:

- Hardware cloth or wire mesh with 2/5 to 3/5 in. openings
- Filter fabric (see the fabric specifications for silt fence, BMP 36-Silt Fence)
- Concrete blocks 4 to 12 in. wide
- Washed gravel 0.8 to 4 in. diameter

Inlet Inserts:

Devices should be installed as per the manufacturer's instruction meeting the following criteria:

- Devices should be installed as a point protection or in series as a perimeter sediment control BMP prior to any site grading activity.
- Installation should not block flows from filtering into the inlet or catch basin.
- Fabrics or other materials should be sized to handle projected site runoff and sediment load flows. Filter fabric should not be used alone as inlet protection.
- Devices should be installed without protruding parts that could be a traffic, worker, or pedestrian hazard.
- Retrieval edges, cords, bars, chains or other mechanisms should be flagged or marked for retrieval under submerged conditions.

Construction

Gravel and mesh:

Guidelines

- Remove any obstructions to excavating and grading. Excavate sump area, grade slopes, and properly dispose of soil.
- Secure the inlet grate to prevent seepage of sediment-laden water.
- Place wire mesh over the drop inlet so the wire extends a minimum of 1ft beyond each side of the inlet structure. Overlap the strips of mesh if more than one is necessary.
- Place filter fabric over the mesh, extending it at least 1 ft beyond the inlet opening on all sides. Ensure that weep holes in the inlet structure are protected by filter fabric and gravel.
- Place stone or gravel over the fabric/wire mesh to a depth of at least 20 in.

Block and gravel:

- open ends of the block should face outward, not upward, and the ends of adjacent blocks should abut. Lay one block on each side of the structure on its side to allow for dewatering of the pool.
- The block barrier should be at least 12 in. high and may be up to a Secure the inlet grate to prevent seepage of sediment-laden water.
- Place wire mesh over the drop inlet so the wire extends a minimum of 12 to 20 in. beyond each side of the inlet structure. Overlap the strips of mesh if more than one is necessary.
- Place filter fabric (optional) over the mesh and extend it at least 20 in. beyond the inlet structure.
- Place concrete blocks over the filter fabric in a single row lengthwise on their sides along the sides of the inlet. Excavate the foundation a minimum of 2 in. below the crest of the inlet. The bottom row of blocks should be against the edge of the structure for lateral support.
- The maximum of 24 in. high. It may be from 4 to 12 in. deep, depending on the size of block used.
- Prior to backfilling, place wire mesh over the outside vertical end of the blocks so that stone does not wash down the inlet.
- Place gravel against the wire mesh to the top of the blocks.

Swale, ditch line or yard inlet protection:

- Excavate completely around inlet to a depth of 18 in. below notch elevation.
- Drive 2 x 4 post 1 ft into ground at four corners of inlet. Place nail strips between posts on ends of inlet. Assemble top portion of 2 x 4 frame using overlap joint shown. Top of frame (weir) should be 6 in. below edge of roadway adjacent to inlet.
- Stretch wire mesh tightly around frame and fasten securely. Ends should meet at post.
- Stretch filter cloth tightly over wire mesh, the cloth should extend from top of frame to 18 in. below inlet notch elevation. Fasten securely to frame. Ends should meet at post, be overlapped and folded, then fastened down.
- Backfill around inlet in compacted 6 in. layers until layer of earth is even with notch elevation on ends and top elevation on sides.
- If the inlet is not in a low point, construct a compacted earth dike in the ditch line below it. The top of the dike is to be at least 6 in. higher than

the top of frame (weir).

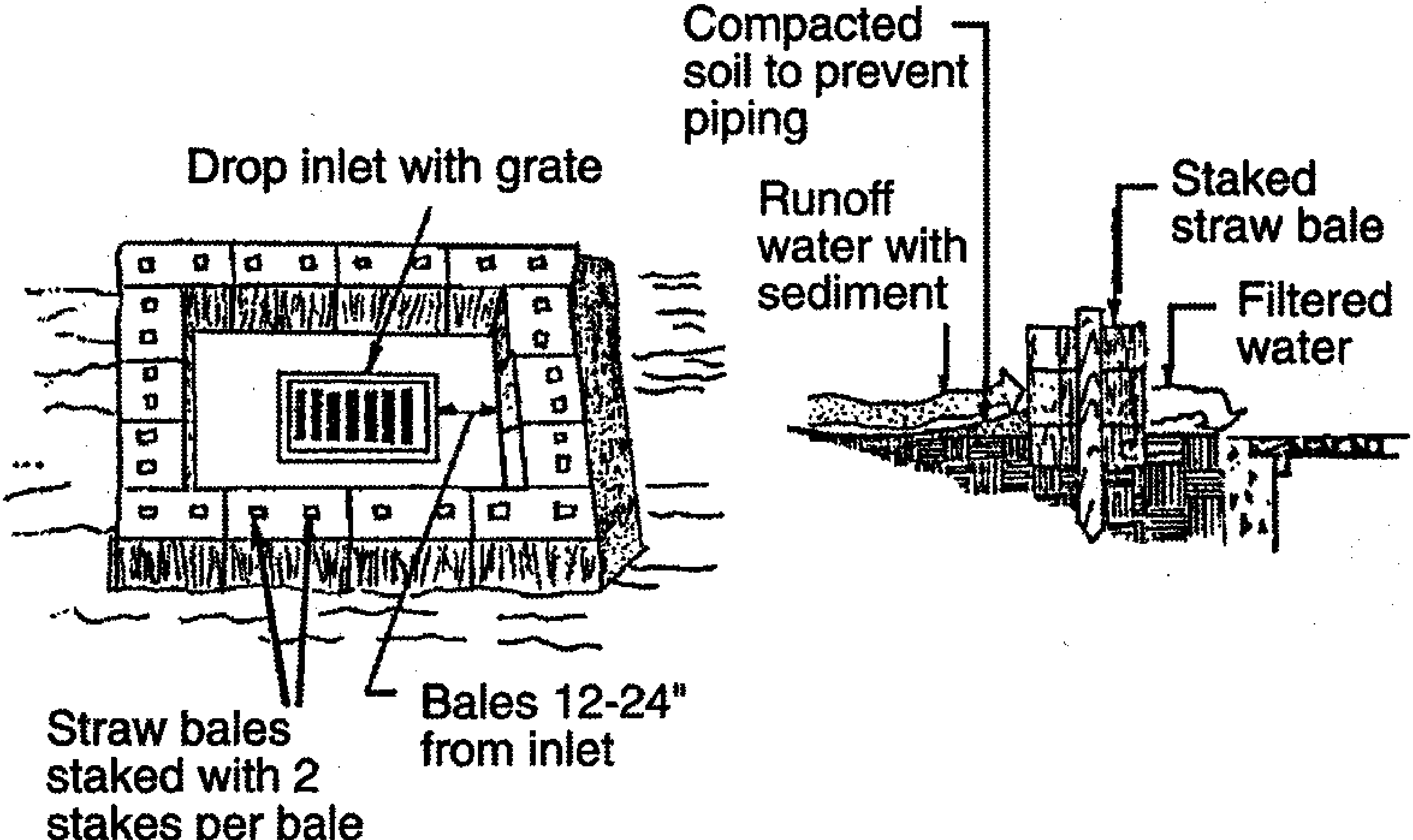
- This structure should be inspected frequently and the filter fabric replaced when clogged.

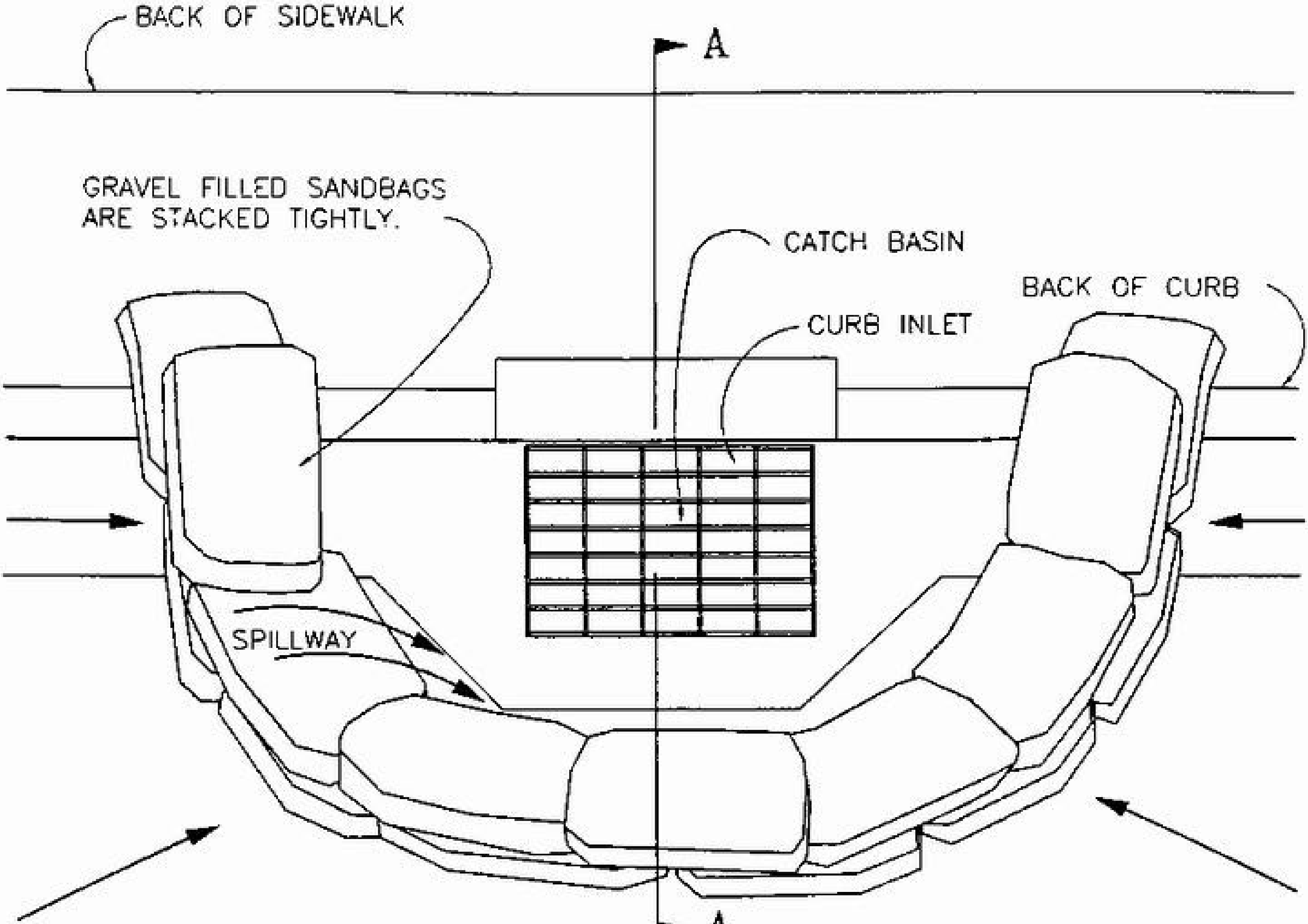
Curb Inlet Protection:

- Attach a continuous piece of wire mesh (30 in. minimum width by throat length plus 4 ft) to the 2 x 4 in. weir (measuring throat length plus 2 ft) as shown on the standard drawing.
- Place a piece of approved filter cloth (40-85 sieve) of the same dimensions as the wire mesh over the wire mesh and securely attach to the 2 in. of 4 in. weir.
- Securely nail the 2 x 4 in. weir to 9 in. long vertical spacers to be located between the weir and inlet face (maximum 6 ft apart).
- Place the assembly against the inlet throat and nail (minimum 2 ft) lengths of 2 x 4 in. to the top of the weir at spacer locations. These 2 x 4 in. anchors should extend across the inlet top and be held in place by gravel-filled bags or alternate weight.
- The assembly should be placed so that the end spacers are a minimum 1 ft beyond both ends of the throat opening.
- Form the wire mesh and filter cloth to the concrete gutter and against the face of curb on both sides of the inlet. Place clean 2 in. stone over the wire mesh and filter fabric in such a manner as to prevent water from entering the inlet under or around the filter cloth.
- This type of protection should be inspected frequently and the filter cloth and stone replaced when clogged with sediment.
- Assure that storm flow does not bypass inlet by installing temporary earth or asphalt dikes directing flow into inlet.

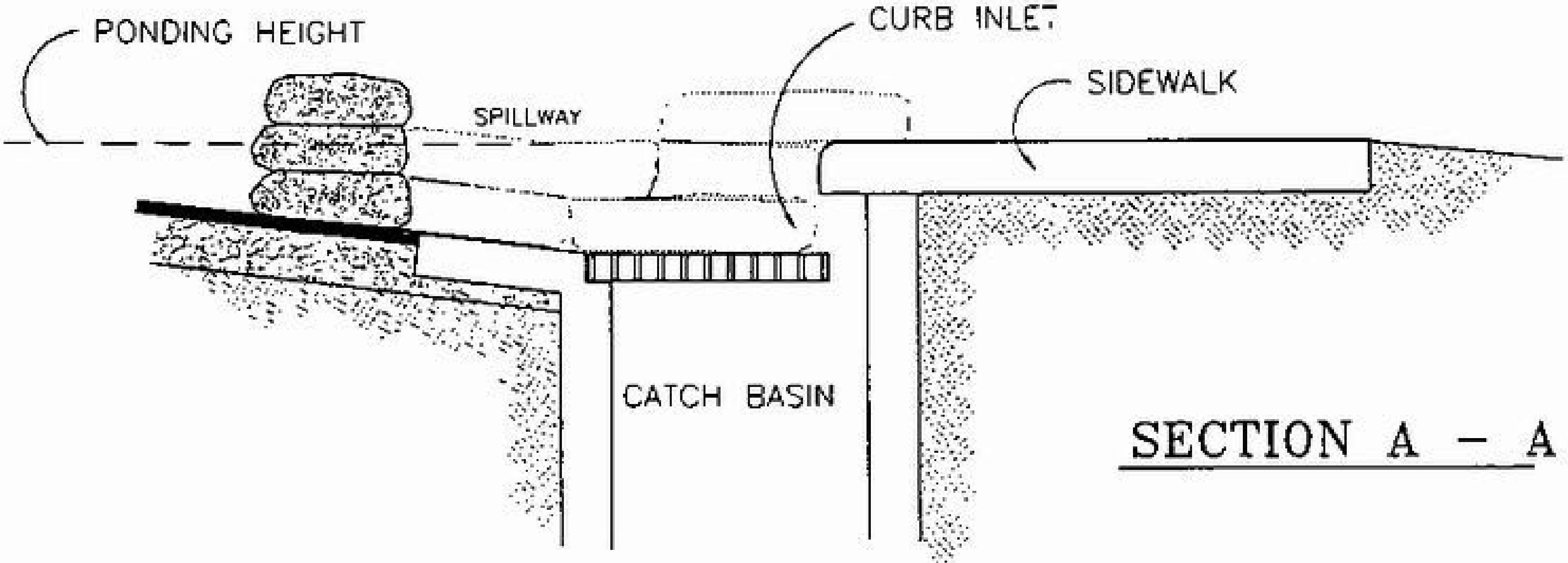
Maintenance

- Inspect regularly and after every storm. Make any repairs necessary to ensure the measure is in good working order.
- Remove accumulated sediment and restore the trap to its original dimensions when sediment has accumulated to half the design depth of the trap. All sediments removed should be disposed of properly.
- On gravel-and-mesh devices, clean (or remove and replace) the stone filter if it becomes clogged.
- Replacement of inlet inserts should be per manufacturer’s instructions or when device no longer drains. At no time should devices be punctured or otherwise modified to bypass.
- Unless cleaned for reuse as a permanent site control or cleaned and left to biodegrade, all inlet inserts should be removed after construction is completed (or after permanent vegetation is established).
- Inlet protection should remain in place and operational up to 30 days after the drainage area is completely stabilized.


Drop inlet with grate
Straw bales staked with 2 stakes per bale
Bales 12-24" from inlet
Compacted soil to prevent piping
Runoff water with sediment
Staked straw bale
Filtered water



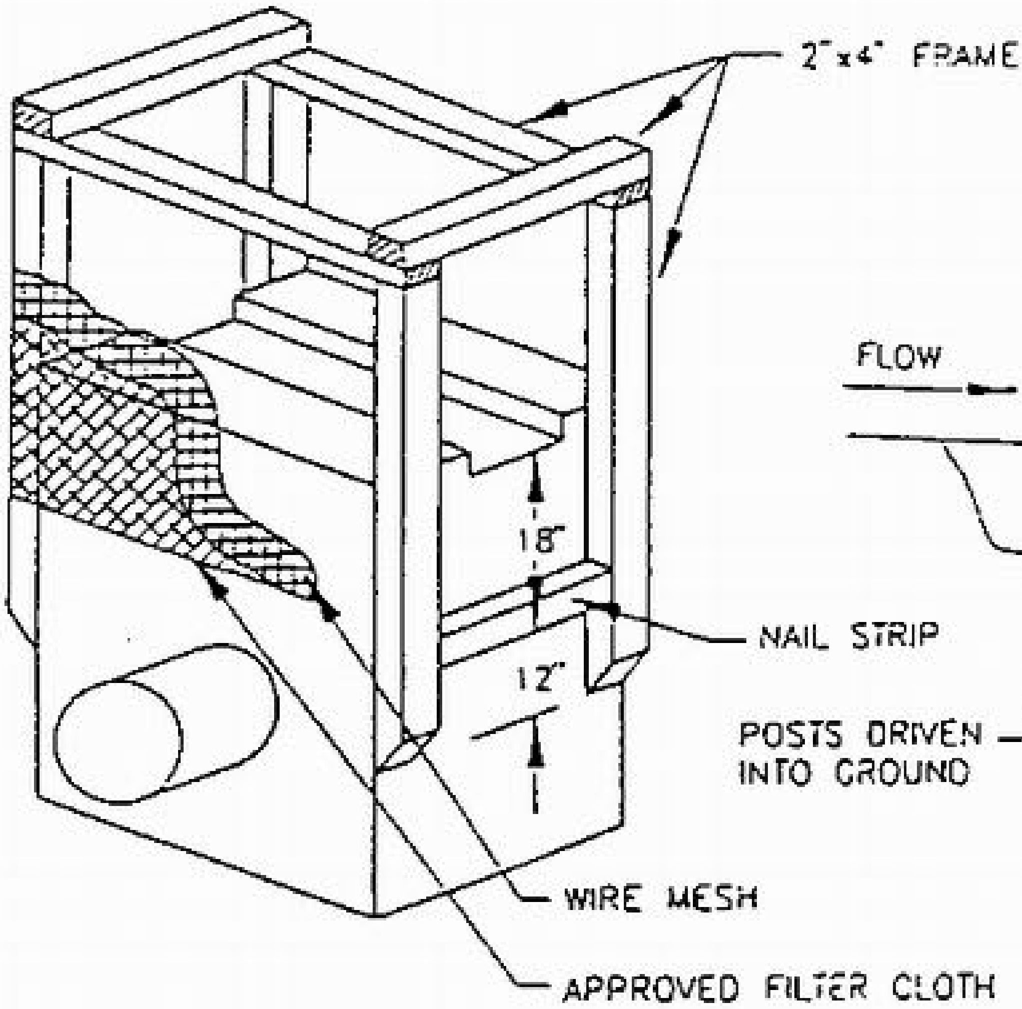
PLAN VIEW

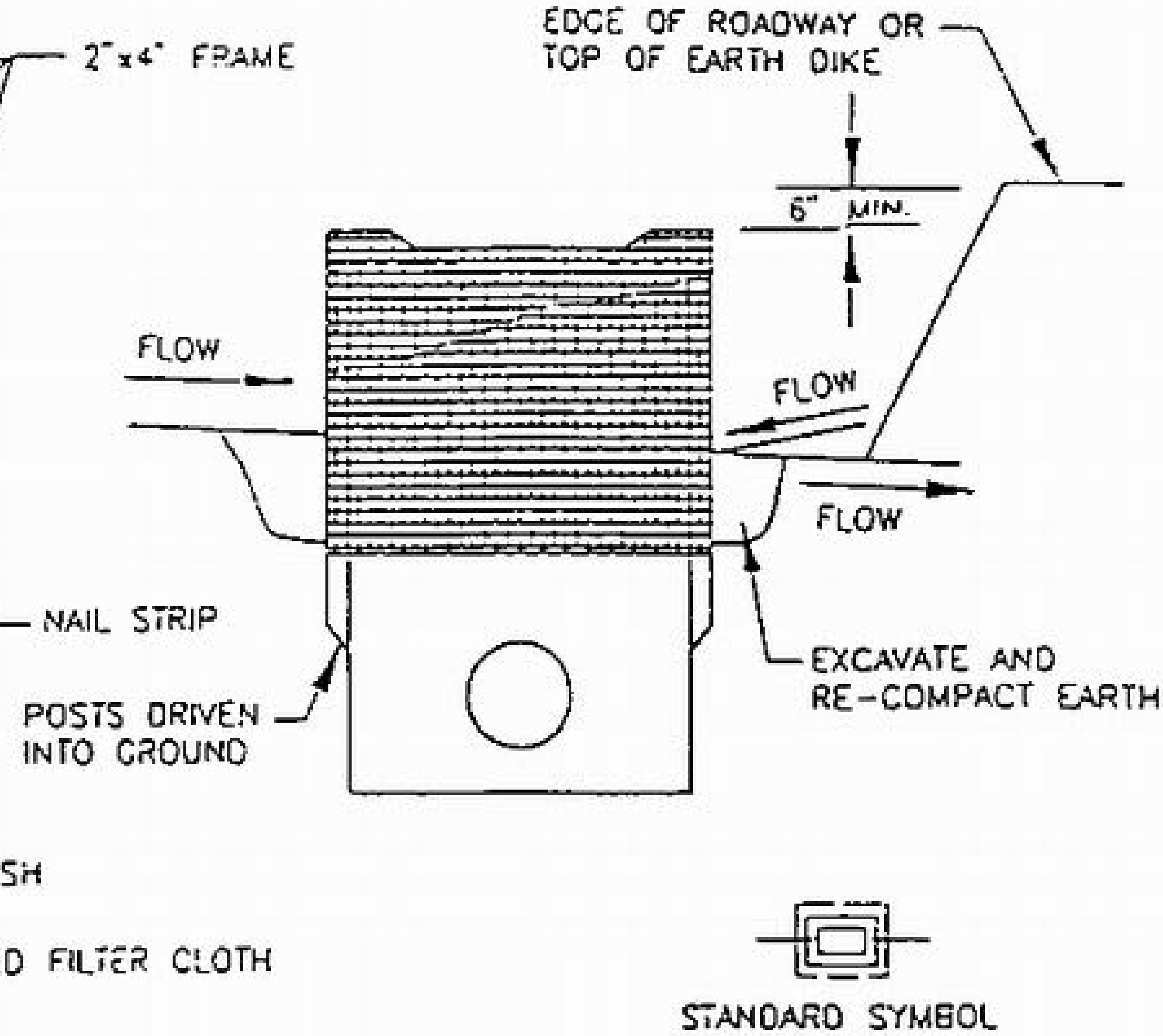


SECTION A – A

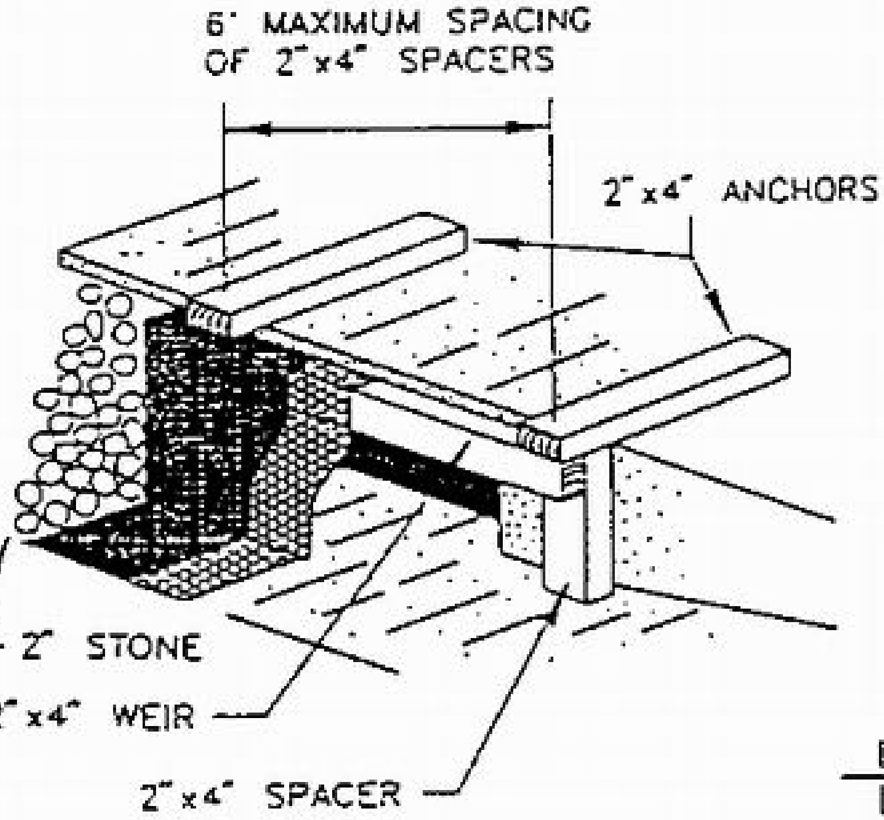
NOTES:

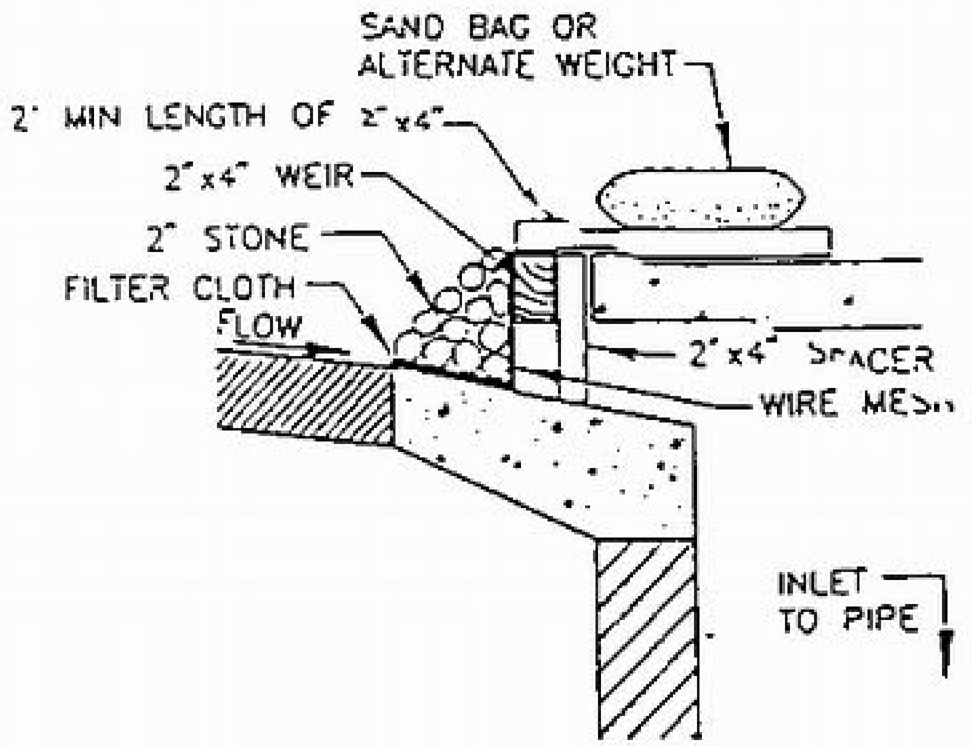
1. PLACE CURB TYPE SEDIMENT BARRIERS ON GENTLY SLOPING STREET SEGMENTS, WHERE WATER CAN POND AND ALLOW SEDIMENT TO SEPARATE FROM RUNOFF.
2. SANDBAGS, OF EITHER BURLAP OR WOVEN GEOTEXTILE FABRIC, ARE FILLED WITH GRAVEL, LAYERED AND PACKED TIGHTLY.
3. LEAVE ONE SANDBAG GAP IN THE TOP ROW TO PROVIDE A SPILLWAY FOR OVERFLOW.
4. INSPECT BARRIERS AND REMOVE SEDIMENT AFTER EACH STORM EVENT. SEDIMENT AND GRAVEL MUST BE REMOVED FROM THE TRAVELED WAY IMMEDIATELY.





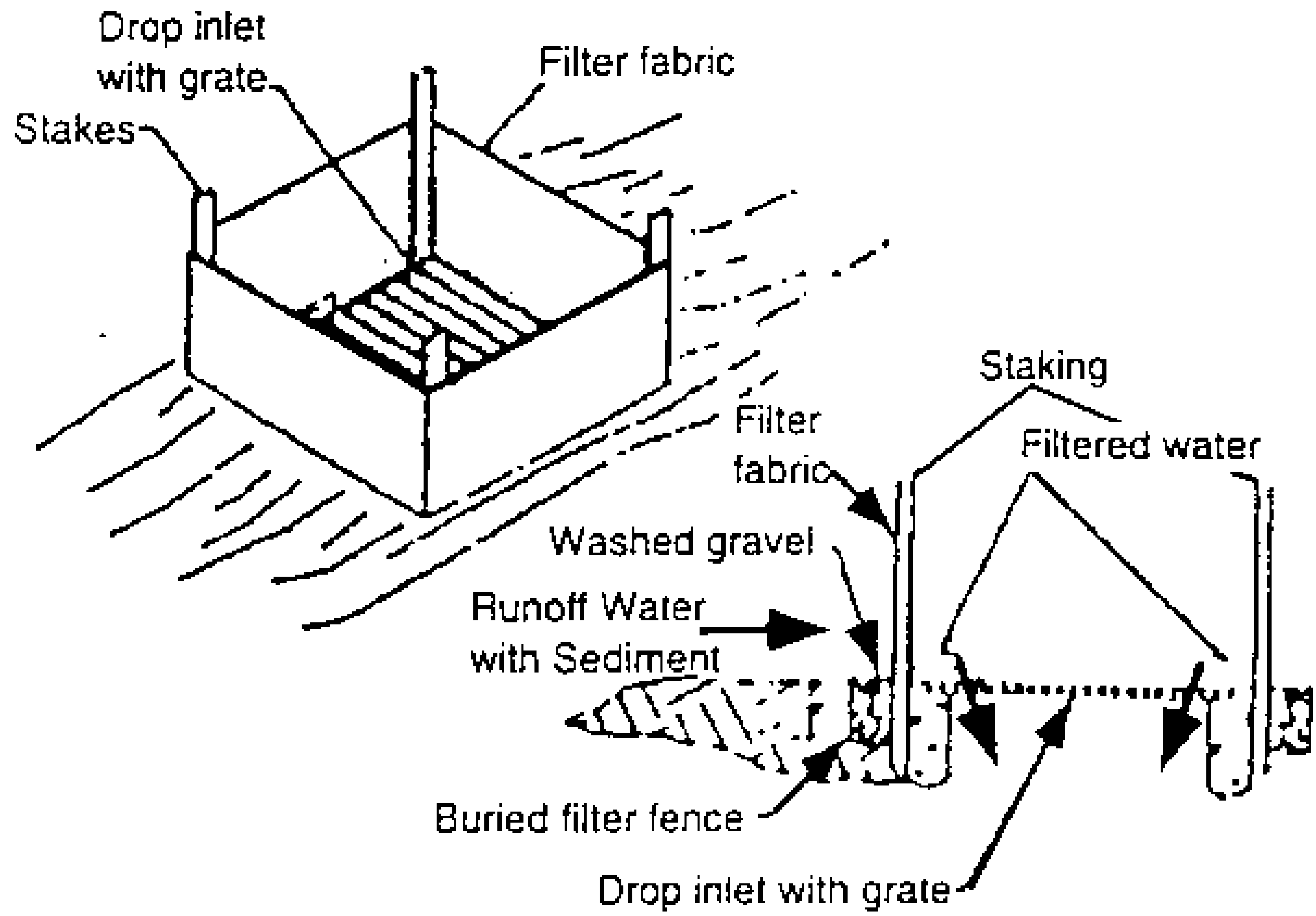
SWALE INLET PROTECTION DETAIL



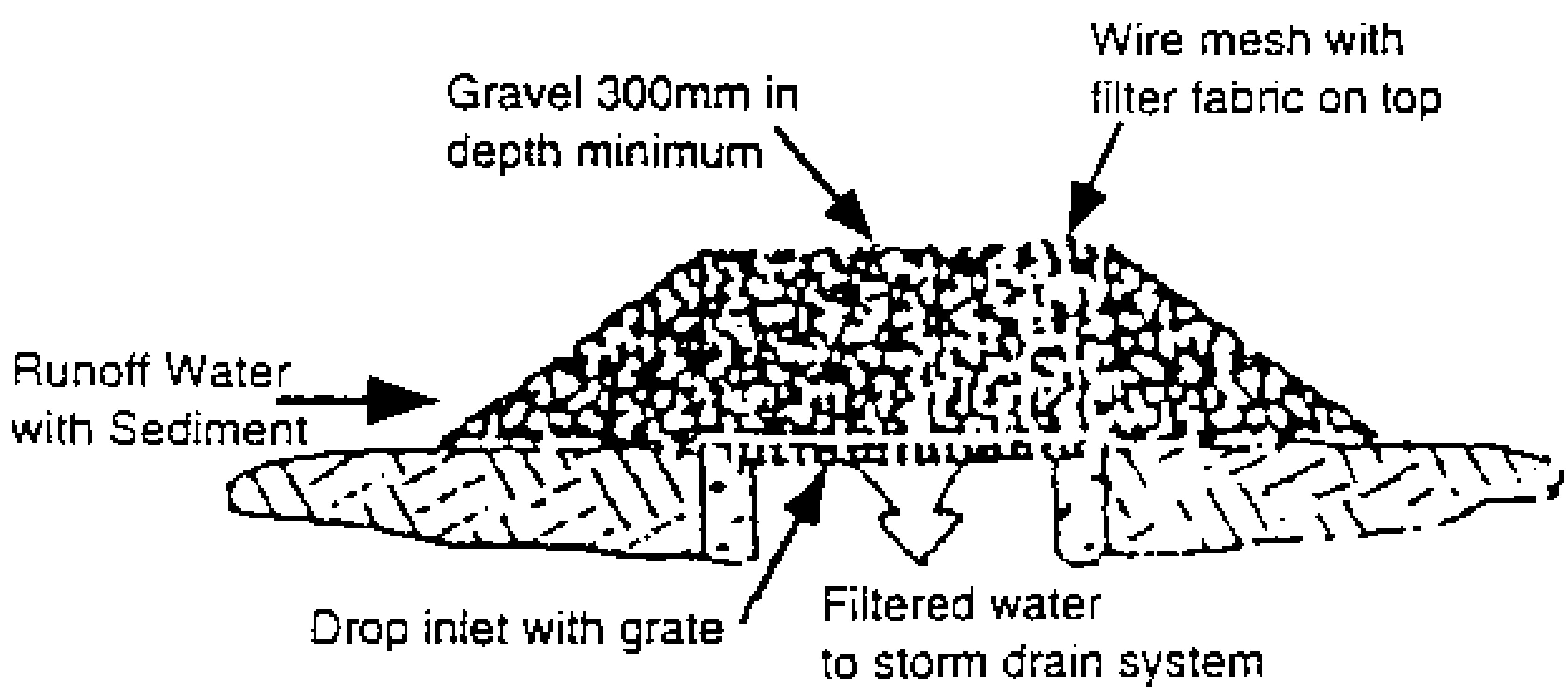


CURB INLET PROTECTION DETAIL

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE	INLET PROTECTION DETAIL	STANDARD DRAWING
TOOTHMAN-ORTON ENGINEERING COMANY BOISE, IDAHO McCALL, IDAHO		IPD-1



FILTER FABRIC FENCE INLET FILTER



GRAVEL AND WIRE MESH FILTER SECTION

Check Dams BMP 32

Description

Check dams are small dams constructed in open channels, swales, or drainageways. Check dams may be temporary or permanent barriers made of logs and brush, straw bales, stone, or other materials. A triangular silt dike is a geotextile-encased check dam that consists of a urethane foam core encased in geotextile material. Check dams are used to reduce or prevent excessive bank and bottom erosion by reducing the gradient or runoff velocity.

Applications

Check dams are often used in natural or constructed channels or swales where adequate vegetation cannot be established promptly. They are used below small drainage structures (smaller than 36 in. pipe culverts) but may be used below large structures if a diversion ditch cannot be used. Log and brush check dams should be placed where they will not cause flooding and where they can be left in place.

An array of three-dimensional manufactured barriers is also available: triangular and burrito-shaped, prefilled and fillable on-site, reusable and disposable, and temporary and more-or-less permanent. Triangular silt dikes are temporary, reusable barriers consisting of a triangular urethane foam core covered by permeable, woven geotextile fabric. From 16 to 20 in. wide at the base and usually 8 to 10 in. high, the silt dike is typically used at the toe of a slope to contain sediment from runoff or perpendicular to the flow of water in a drainage ditch.

Limitations

Drainage area – 10 ac.	Maximum slope – 50%
Minimum bedrock depth – 2 ft	Minimum water table - N/A
NRCS soil type - ABCD	Freeze/thaw – good
Drainage/flood control – yes	

Check dams should never be placed in live streams unless approved by appropriate local, state and/or federal authorities.

Targeted Pollutants

Sediment

Design Parameters

- The drainage area above the check dam should be between 1 and 4 acres.
- The dams should be spaced so that the toe of the upstream dam is never any higher than the top of the downstream dam. Excavating a sump immediately upstream from the check dam improves its effectiveness.
- Maximum height should be 2 ft. The center of the dam should be 16 to 10 in. lower than either edge, to form a weir for the outfall.
- The check dam should be as much as 20 in. wider than the banks of the

channel to prevent undercutting as overflow water re-enters the channel.

- Provide outlet stabilization below the lowest check dam (where the risk of erosion is greatest) and consider the use of channel linings or protection such as plastic sheeting or riprap where there may be significant erosion or prolonged submergence.
- Materials:
  - ✓ Stone 2 to 16 in. in diameter
  - ✓ Logs 6 to 8 in. in diameter
  - ✓ Sandbags filled with pea gravel
  - ✓ Filter fabric meeting the standard specifications (see BMP 36-Silt Fence)
- The logs should be driven into the ground a minimum of 28 in..

Construction Guidelines

Rock check dams: Place the stones on filter fabric either by hand or using appropriate machinery; do not simply dump them in place. Keep the side slopes 1:2 or flatter. Lining the upstream side of the dam with a layer of 0.8 to 1.1 in. gravel and 12 in. deep is a suggested option for additional channel protection.

Log check dams: Logs should be firmly embedded in the ground. Intermingled brush and logs or filter cloth may be attached to the upstream side of the dam to retard the flow and trap additional sediment. If a filter cloth is used, it should be securely stapled to the top of the dam and adequately anchored in the streambed.

Sandbag check dams: Be sure that all bags are securely sealed. Place the bags by hand or use appropriate machinery to place them in an interlocking pattern.

Gravel-filled burlap bags: Gravel-filled burlap bags may be used for temporary check dams in areas of concentrated flow. Fold the burlap bag flaps under the bags in a direction away from the water flow. Construct gravel bag check dams such that the crest of the downstream check dam is approximately level with the toe of the upstream check dam. Install check dams so the side end points are higher than the centerline crest. Erosion caused by high flows around the edges should be corrected immediately.

Triangular silt dike: The flexibility of the materials in triangular silt dikes allows them to conform to all channel configurations.

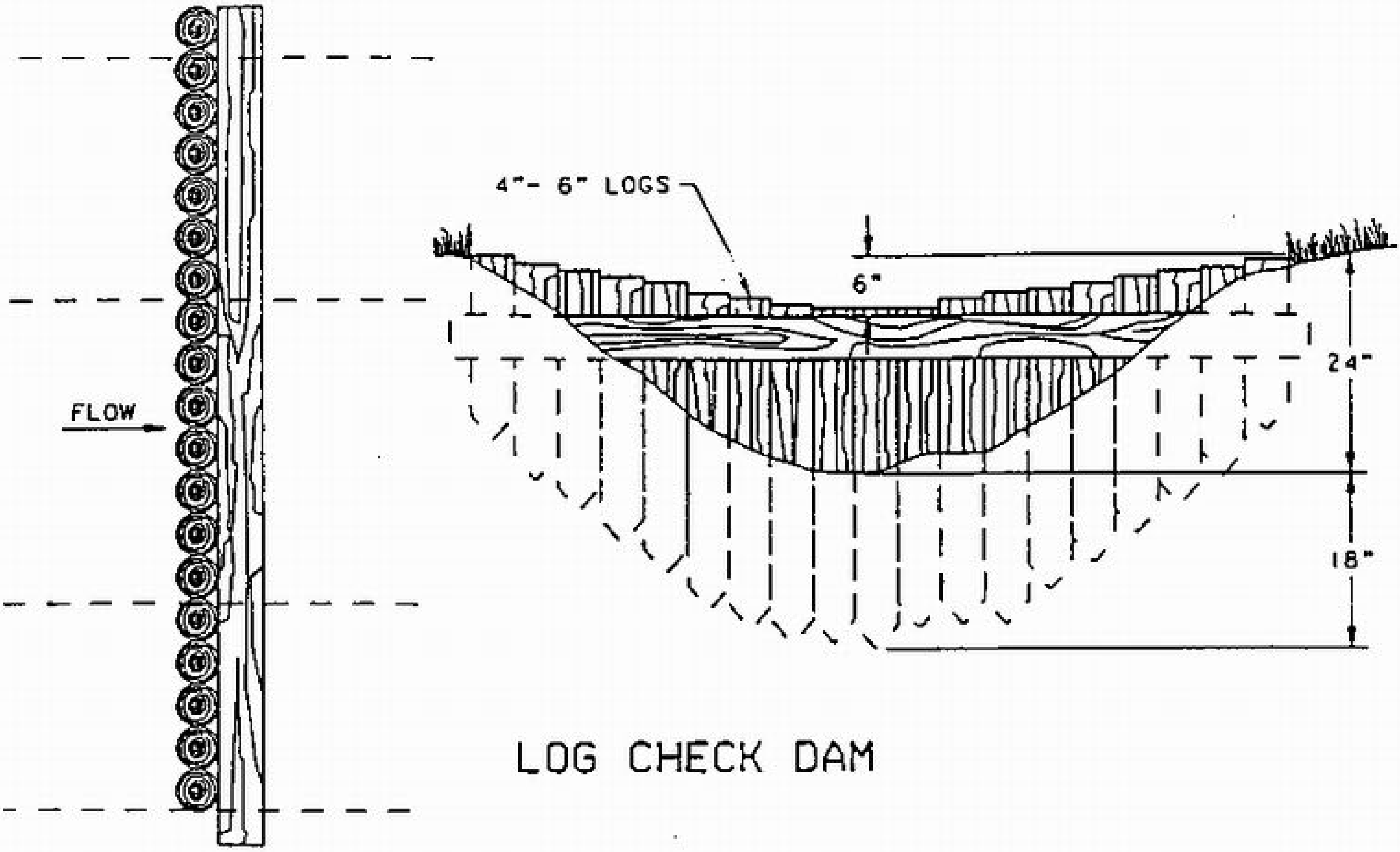
- They can be fastened to soil with staples or rock and pavement with adhesives.
- They have been used to build temporary sediment ponds, diversion ditches, concrete wash out facilities, curbing, water bars, level spreaders, and berms.

Riprap may be necessary on the downstream side of the dam to protect the streambed from scour.

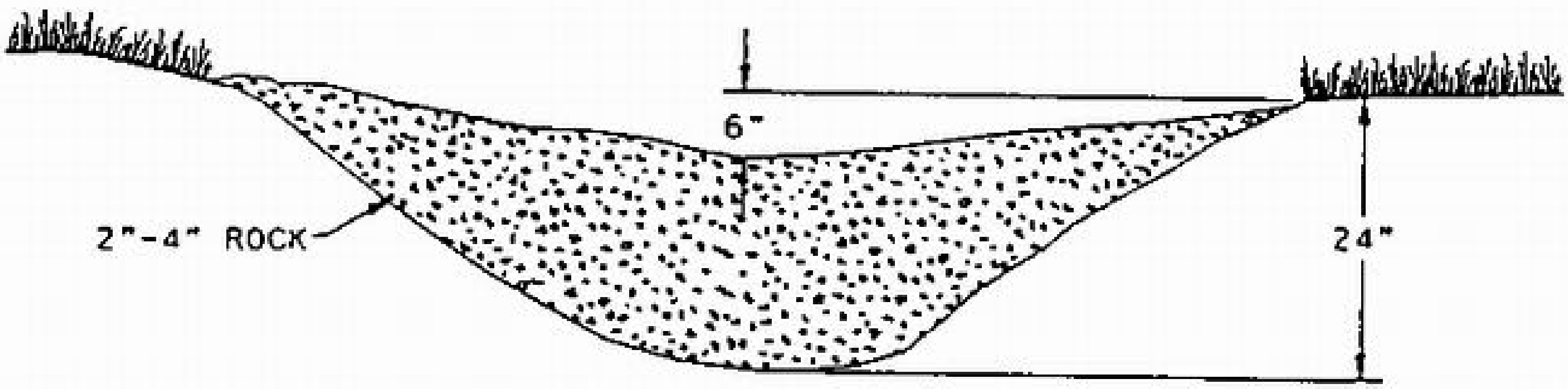
Maintenance

- Inspect the check dams regularly and after every runoff-producing storm. Make any repairs necessary to ensure the measure is in good working order.

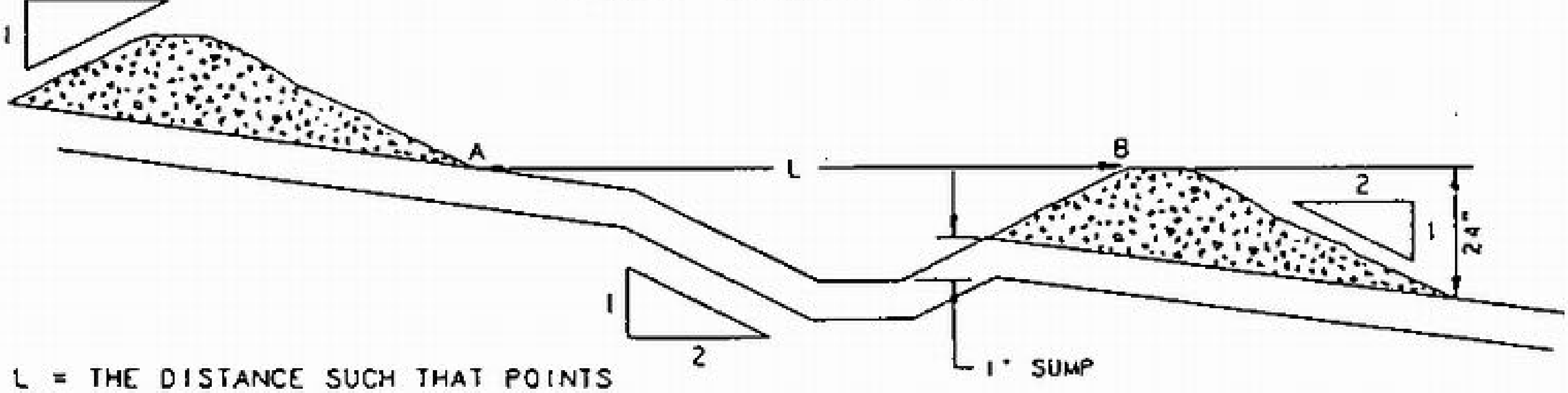
- Remove accumulated leaves and sediments from behind the dam when they reach a depth of one-half the original height of the dam. Dispose of all materials properly so they do not contribute to pollution problems at the disposal site.
- Restore stone as necessary for the dams to maintain their correct height.
- On sandbag dams, inspect the sandbag fabric for signs of deterioration.



LOG CHECK DAM

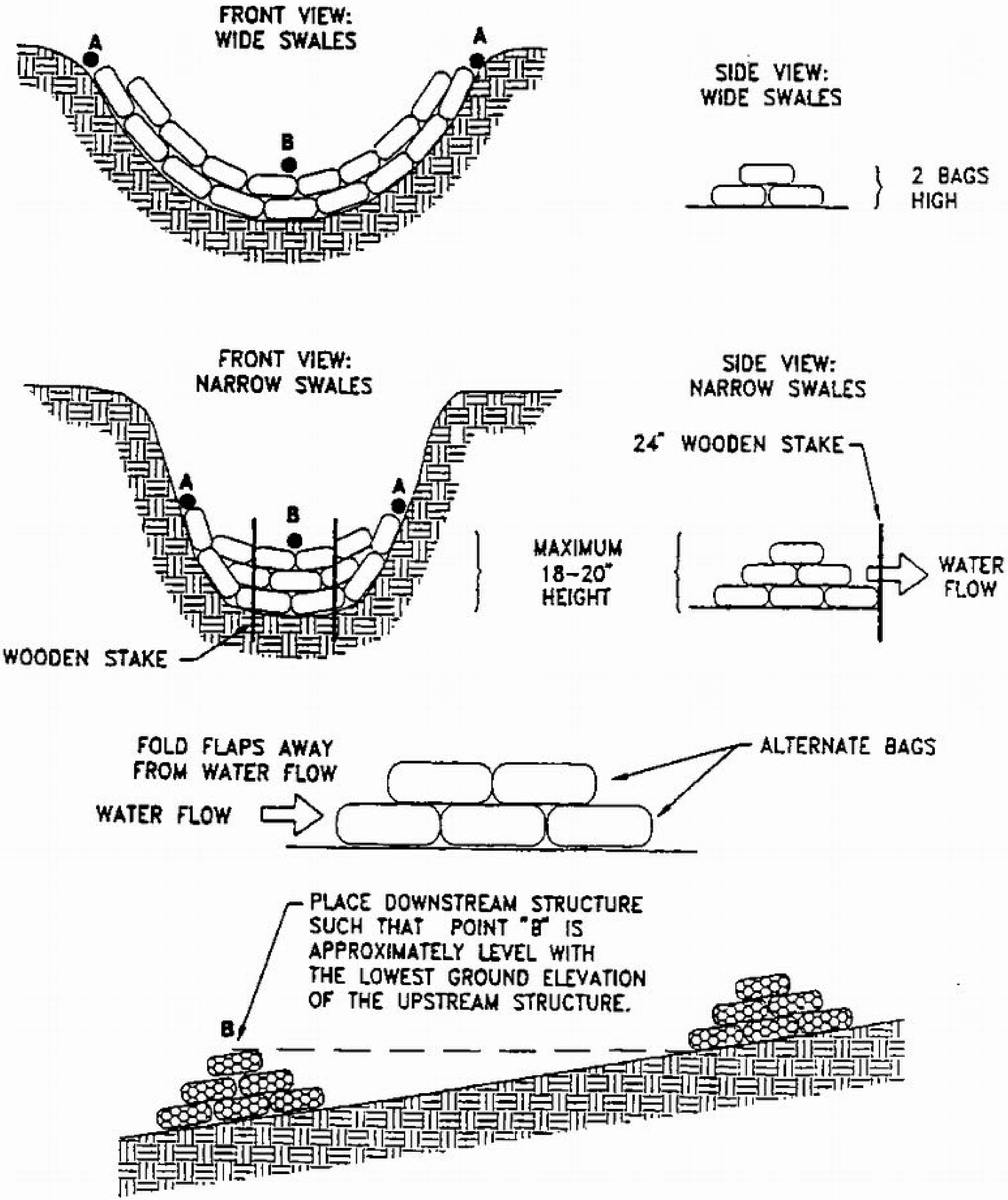


ROCK CHECK DAM



L = THE DISTANCE SUCH THAT POINTS A AND B ARE OF EQUAL ELEVATION

SPACING BETWEEN CHECK DAMS


FRONT VIEW:
WIDE SWALES
A
A
B
SIDE VIEW:
WIDE SWALES
2 BAGS
HIGH
FRONT VIEW:
NARROW SWALES
A
A
B
MAXIMUM
18-20"
HEIGHT
WOODEN STAKE
SIDE VIEW:
NARROW SWALES
24" WOODEN STAKE
WATER
FLOW
FOLD FLAPS AWAY
FROM WATER FLOW
WATER FLOW
ALTERNATE BAGS
PLACE DOWNSTREAM STRUCTURE
SUCH THAT POINT "B" IS
APPROXIMATELY LEVEL WITH
THE LOWEST GROUND ELEVATION
OF THE UPSTREAM STRUCTURE.
B

Temporary Stream Crossing BMP 33

Description

A temporary stream crossing is a bridge or culvert across a stream or watercourse for short-term use by construction vehicles or heavy equipment. Vehicles moving over unprotected stream banks will damage the bank, thereby releasing sediments and degrading the stream bank. A stream crossing provides a means for construction vehicles to cross streams or watercourses without moving sediment to streams, without damaging the streambed or channel, and without causing flooding.

Applications

- A temporary stream crossing is used when heavy equipment should be moved from one side of a stream channel to another, or where light-duty construction vehicles have to cross the stream channel frequently for a short period of time. Temporary stream crossings should be installed only when it is necessary to cross a stream and a permanent crossing is not feasible or not yet constructed.
- The specific loads and the stream conditions will dictate what type of stream crossing to employ.
- Where available materials and designs are adequate to bear the expected loadings, bridges are the preferred method to cross a stream as they provide the least obstruction to flows and fish migration.
- Culverts are the most common type of stream crossings and are relatively easy to construct. A pipe (to carry the stream flow) is laid into the channel and covered by gravel

Limitations

Drainage area – N/A	Maximum slope – N/A
Minimum bedrock depth – 2 ft	Minimum water table - N/A
NRCS soil type - ABCD	Freeze/thaw – good
Drainage/flood control – yes	

- Bridges are expensive to design and install. These costs may make it difficult to justify using a bridge as a temporary crossing in some situations.
- Culverts cause greater disturbance during installation and removal. In sensitive stream systems, these impacts may not be justifiable.
- Always attempt to minimize or eliminate the need to cross streams. Temporary stream crossings are a direct source of pollution; therefore, every effort should be made to use an alternate method such as a longer detour. When it is absolutely necessary to cross a stream, a well-planned approach will minimize damage to the stream bank and reduce erosion.
- Use of the following stream crossing measures below the high-water mark of a stream or other water body (waters of the U.S.) should be carefully evaluated due to Section 404 permit requirements. If the project will remain a Categorically Excluded (Cat-Ex) project, you may proceed if the situation is discussed in the Cat-Ex. Otherwise, Section 404 permitting (401 Certification) may be required. The design of temporary stream crossings involves extensive knowledge of hydrologic processes and, therefore, should be designed by a Professional Engineer.

Targeted Pollutants

Sediment
Hydrocarbons

Design Parameters

General:
In-stream excavation should be limited to only that necessary to allow installation of the temporary bridge or culvert as described below:

- Temporary bridges pose the least potential for creating barriers to aquatic migration. The construction of a temporary bridge or culvert should not cause a significant water level difference between the upstream and downstream water surface elevations.
- The temporary waterway crossing should be at right angles to the stream. Where approach conditions dictate, the crossing may vary 15 degrees from a line drawn perpendicular to the centerline of the stream at the intended crossing location.
- The centerline of both roadway approaches should coincide with the crossing alignment centerline for a minimum distance of 50 ft from each bank of the waterway being crossed. If physical or right-of-way restraints preclude the 50 ft minimum, a shorter distance may be provided. All fill materials associated with the roadway approach should be limited to a maximum height of 2 ft above the existing flood plain elevation.
- A water diverting structure such as a swale should be constructed (across the roadway on both roadway approaches) 50 ft (maximum) on either side of the waterway crossing. This will prevent roadway surface runoff from directly entering the waterway. The 50 ft is measured from the top of the waterway bank. Design criteria for this diverting structure should be in accordance with the BMP fact sheet in this catalog for the individual design standard of choice. If the roadway approach is constructed with a reverse grade away from the waterway, a separate diverting structure is not required.
- All crossings should have one traffic lane. The minimum width should be

12 ft with a maximum width of 20 ft.

- All temporary crossings should be removed within 14 calendar days after the structure is no longer needed.

Materials:

- No earth or soil materials should be used for construction within the waterway channel. (3/4 in. to 4 in.), also referenced as AASHTO designation No. 1, the minimum acceptable aggregate size for temporary crossings. Larger aggregates will be allowed.
- Filter cloth is a fabric consisting of either woven or nonwoven plastic, polypropylene, or nylon and is used to distribute the load, retain fines, allow increased drainage of the aggregate and reduce mixing of the aggregate with the subgrade soil. Filter cloths, such as Mirafi, Typar, Adva Filter, Polyfilter X, or an approved equivalent, should be used as required by the specific method.

Considerations for Choosing a Specific Method (Bridge or Culvert):
The following criteria for erosion and sediment control should be considered when selecting a specific temporary access waterway crossing standard method:

- Select standard design methods that will least disrupt the existing terrain of the stream reach. Consider the effort that will be required to restore the area after the temporary crossing is removed.
- Locate the temporary crossing where there will be the least disturbance to the soils of the existing waterway banks. When possible locate the crossing at the point receiving minimal surface runoff.
- The physical constraints of a site may preclude the selection of one or more of the standard methods.
- The time of year may preclude the selection of one or more of the standard methods due to fish spawning or migration restrictions.
- Vehicular loads, traffic patterns, and frequency of crossings should be considered in choosing a specific method.
- The standard methods will require various amounts of maintenance. The bridge method should require the least maintenance, whereas the ford method will probably require more intensive maintenance.
- Ease of removal and subsequent damage to the waterway should be primary factors in considering the choice of a standard method.

Temporary Bridge

- This is the preferred method for temporary access waterway crossings. Normally, bridge construction causes the least disturbance to the waterway bed and banks when compared to culverts.
- Most bridges can be quickly removed and reused.
- Temporary access bridges pose the least chance for interference with fish migration when compared to the other temporary access waterway crossings.

Temporary Culvert

- A temporary access culvert is a structure consisting of a section(s) of circular pipe, pipe arches, or oval pipes of reinforced concrete, corrugated
- metal, or structural plate, which is used to convey flowing water through the crossing.
- Temporary culverts are used where (1) the channel is too wide for normal bridge construction, or (2) anticipated loading may prove unsafe for single span bridges.
- Temporary culverts can be salvaged and reused.

Construction Guidelines

Temporary Bridge

- Construction, use, or removal of a temporary access bridge will not normally have any time-of-year restrictions since construction, use, or removal should not affect the stream or its banks.
- A temporary bridge structure should be constructed at or above bank elevation to prevent the entrapment of floating materials and debris.
- Abutments should be placed parallel to and on stable banks.
- Bridges should be constructed to span the entire channel. If the channel width exceeds 8 ft (as measured from top-of-bank to top-of-bank) then a footing, pier or bridge support may be constructed within the waterway. One additional footing, pier or bridge support will be permitted for each additional 8-ft width of the channel. However, no footing, pier or bridge support will be permitted within the channel for waterways less than 8 ft wide.
- Stringers should either be logs, sawn timber, prestressed concrete beams, metal beams, or other approved materials.
- Decking materials should be of sufficient strength to support the anticipated load. All decking members should be placed perpendicular to the stringers, butted tightly, and securely fastened to the stringers. Decking materials should be butted tightly to prevent any soil material tracked onto the bridge from falling into the waterway below.
- Run planking (optional) should be securely fastened to the length of the span. One run plank should be provided for each track of the equipment wheels. Although run planks are optional, they may be necessary to properly distribute loads.
- Curbs or fenders may be installed along the outer sides of the deck. Curbs or fenders are an option that will provide additional safety.
- Bridges should be securely anchored at only one end using steel cable or chain. Anchoring at only one end will prevent channel obstruction in the event that floodwaters float the bridge. Acceptable anchors are large trees, large boulders, or driven steel anchors. Anchoring should be sufficient to prevent the bridge from floating downstream and possibly causing an obstruction to the flow.
- All areas disturbed during installation should be stabilized within 14 calendar days of that disturbance.

Temporary Culvert

- All culverts should be strong enough to support their cross sectional area under maximum expected loads.
- The size of the culvert pipe should be the largest pipe diameter that will

fit into the existing channel without major excavation of the waterway channel or without major approach fills. If a channel width exceeds 3 ft, additional pipes may be used until the cross sectional area of the pipes is greater than 60% of the cross sectional area of the existing channel. The minimum size culvert that may be used is a 12-in. diameter pipe.

- The culvert(s) should extend a minimum of 1 ft beyond the upstream and downstream toe of the aggregate placed around the culvert. In no case should the culvert exceed 40 ft in length.
- Filter cloth should be placed on the streambed and stream banks prior to placement of the pipe culvert(s) and aggregate. The filter cloth should cover the streambed and extend a minimum 6 in. and a maximum 1 ft beyond the end of the culvert and bedding material. Filter cloth reduces settlement and improves crossing stability.
- The invert elevation of the culvert should be installed on the natural streambed grade to minimize interference with fish migration (free passage of fish).
- The culvert(s) should be covered with a minimum of 1 ft of aggregate. If multiple culverts are used they should be separated by at least 12 in. of compacted aggregate fill.
- All areas disturbed during culvert installation should be stabilized within 14 calendar days of the disturbance.

Maintenance

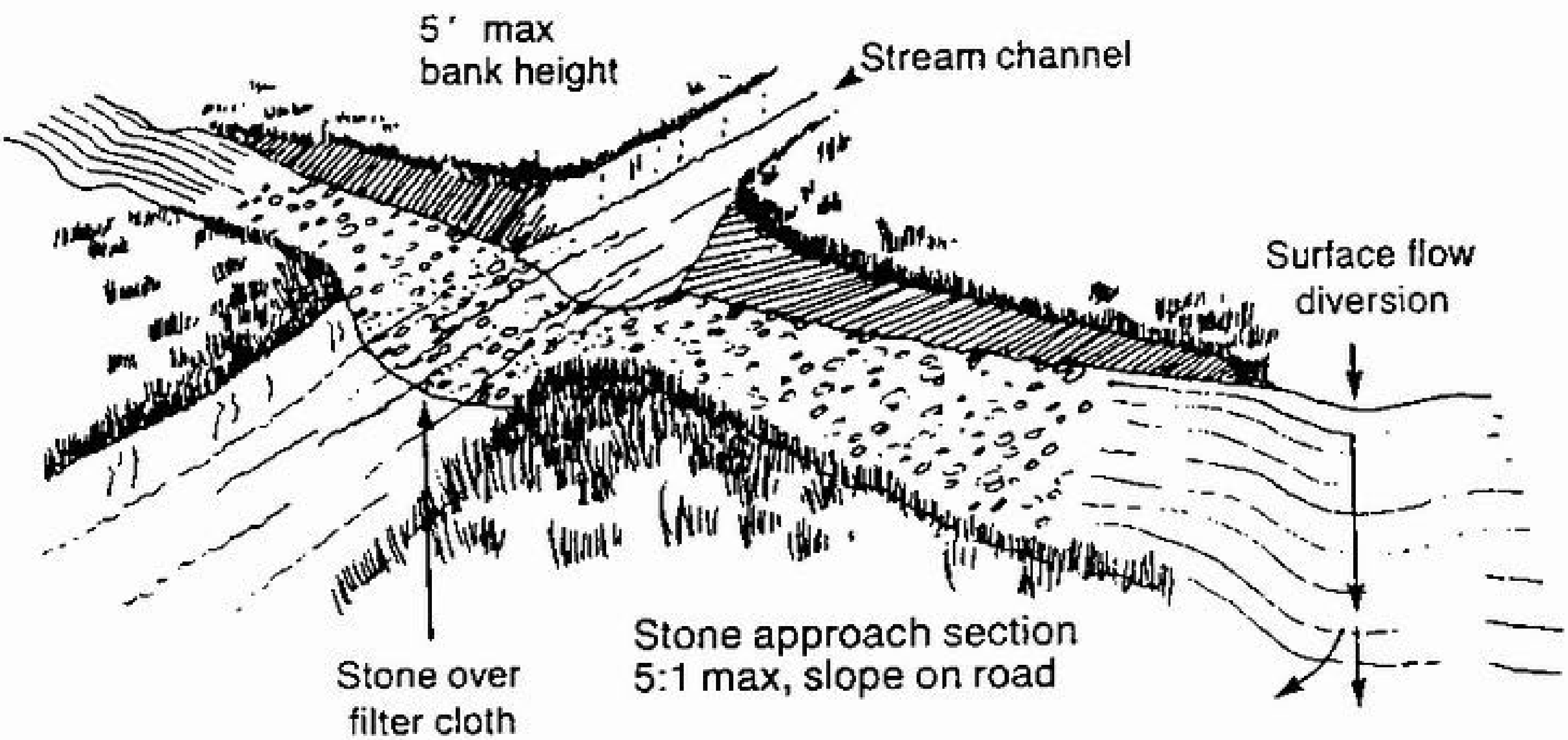
Temporary Bridge

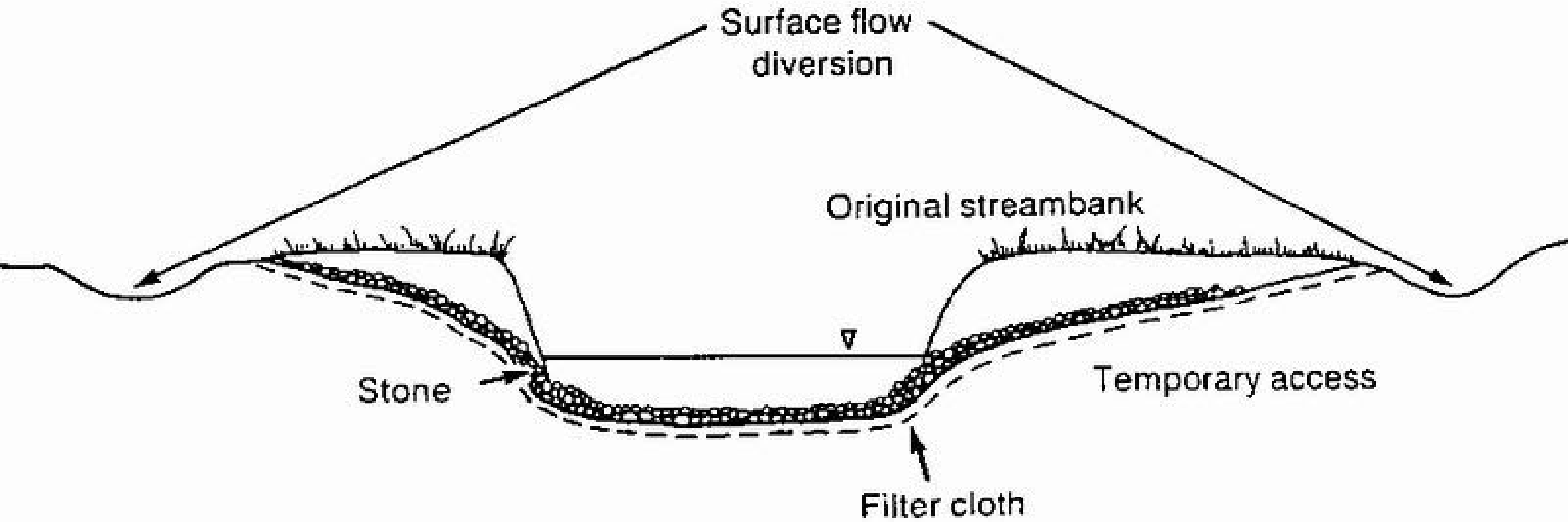
- Periodic inspections should be performed by the user to ensure that the bridge, streambed, and stream banks are maintained and not damaged.
- Maintenance should be performed, as needed, to ensure that the structure complies with the standard and specifications. This should include removal and disposal of any trapped sediment or debris. Sediment should be disposed of outside of the flood plain and stabilized.
- When the temporary bridge is no longer needed, all structures, including abutments and other bridging materials, should be removed within 14 calendar days. In all cases, the bridge materials should be removed within 1 year of installation.
- Final clean-up should consist of removal of the temporary bridge from the waterway, protection of banks from erosion, and removal of all construction materials. All removed materials should be stored outside the waterway flood plain.
- Removal of the bridge and clean up of the area should be accomplished without construction equipment working in the waterway channel.
- All areas disturbed during removal should be stabilized within 14 calendar days of that disturbance.

Temporary Culvert

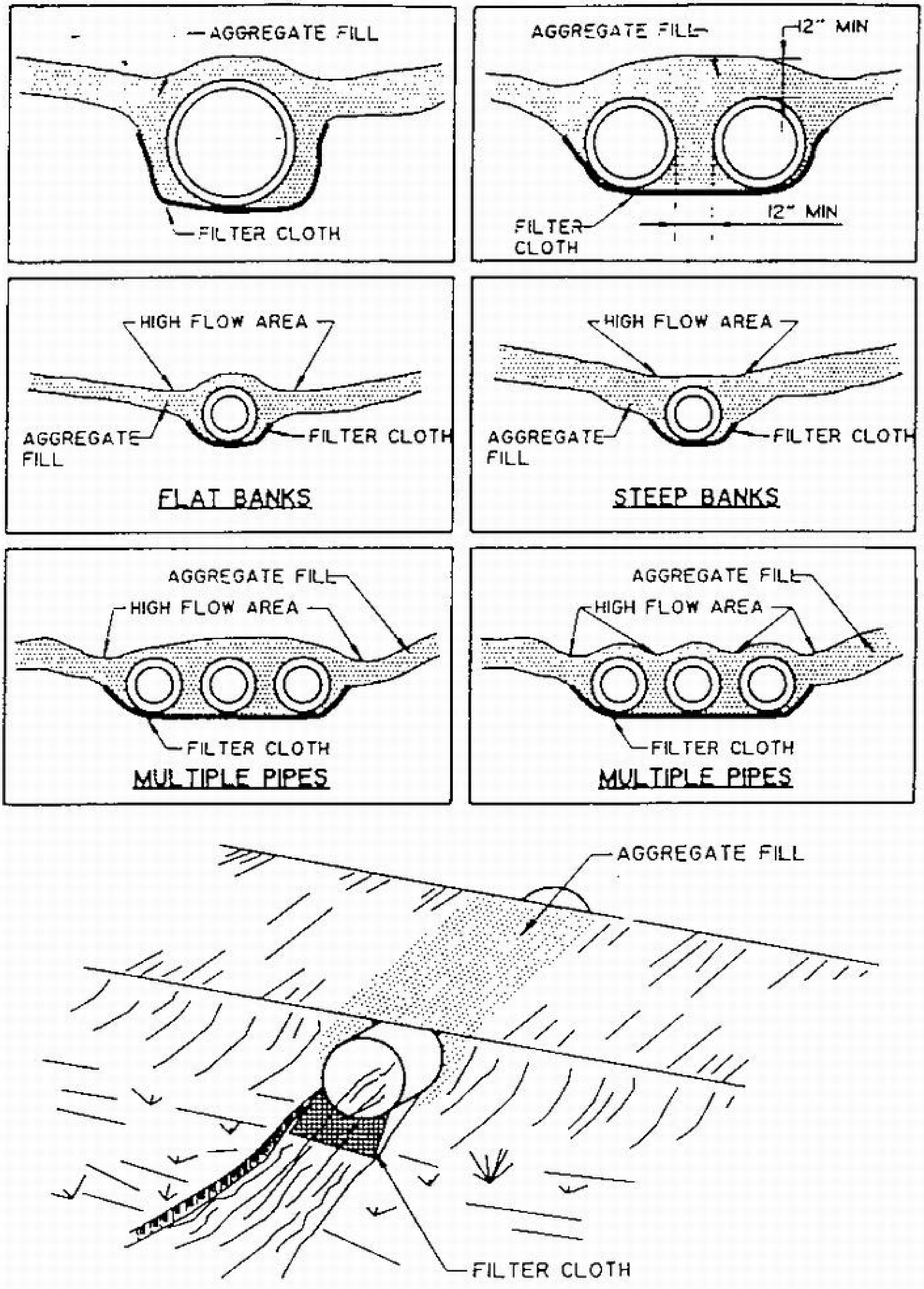
- Periodic inspection should be performed to ensure that the culverts, streambed, and stream banks are not damaged, and that sediment is not entering the stream or blocking fish passage or migration.
- Maintenance should be performed, as needed in a timely manner to ensure that structures are in compliance with this standard and specification. This includes removal and disposal of any trapped sediment or debris.

- Sediment should be disposed of and stabilized outside the waterway flood plain.
- When the crossing has served its purpose, all structures, including culverts, bedding and filter cloth materials, should be removed within 14 calendar days. In all cases, the culvert materials should be removed within 1 year of installation.
- Final clean-up should consist of removal of the temporary structure from the waterway, removal of all construction materials, restoration of original stream channel cross section, and protection of the steam banks from erosion. Removed material should be stored outside of the waterway flood plain.
- Removal of the structure and clean up of the area should be accomplished without construction equipment working in the waterway channel.
- All areas disturbed during culvert removal should be stabilized within 14 calendar days of the disturbance.



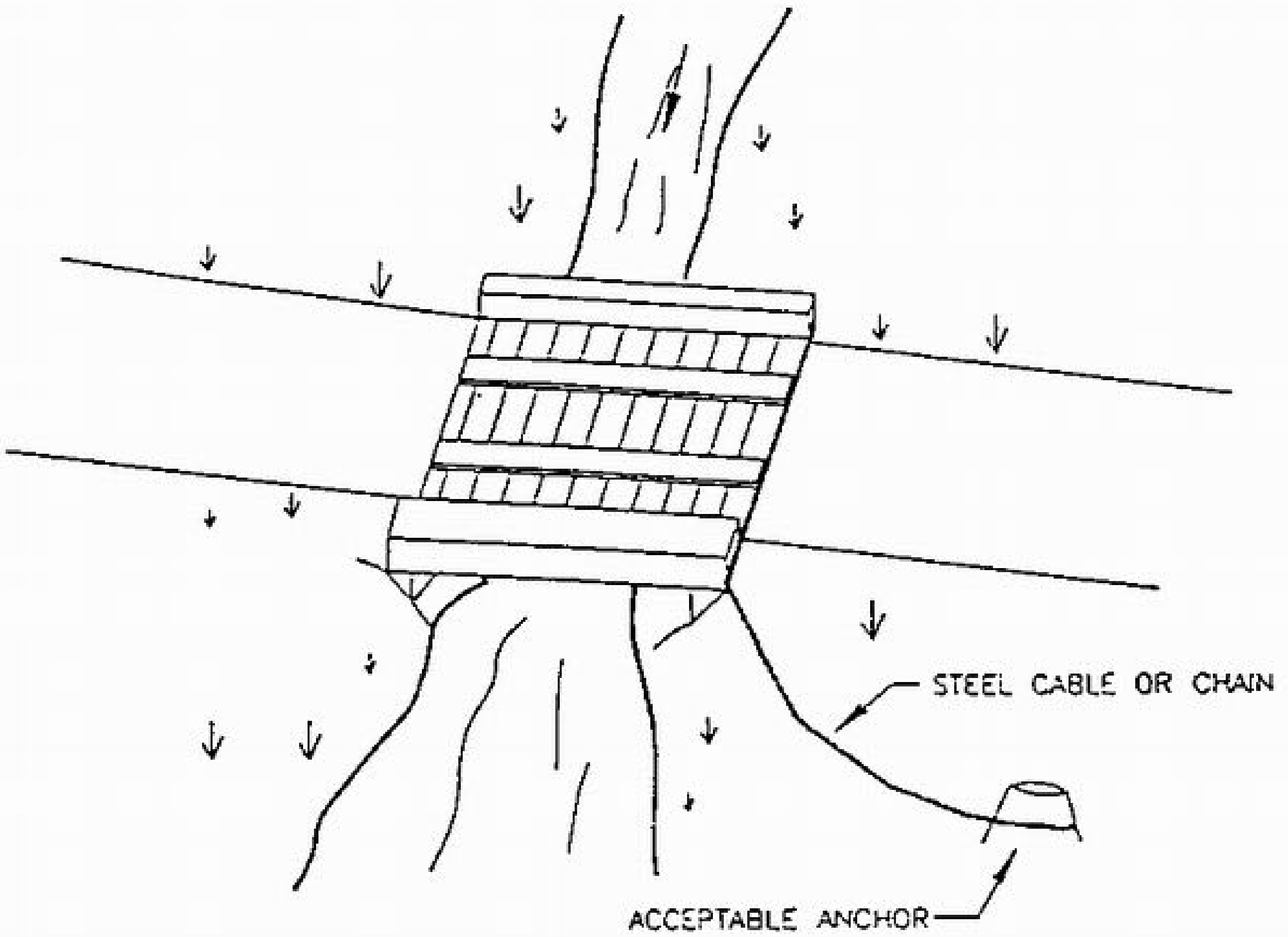


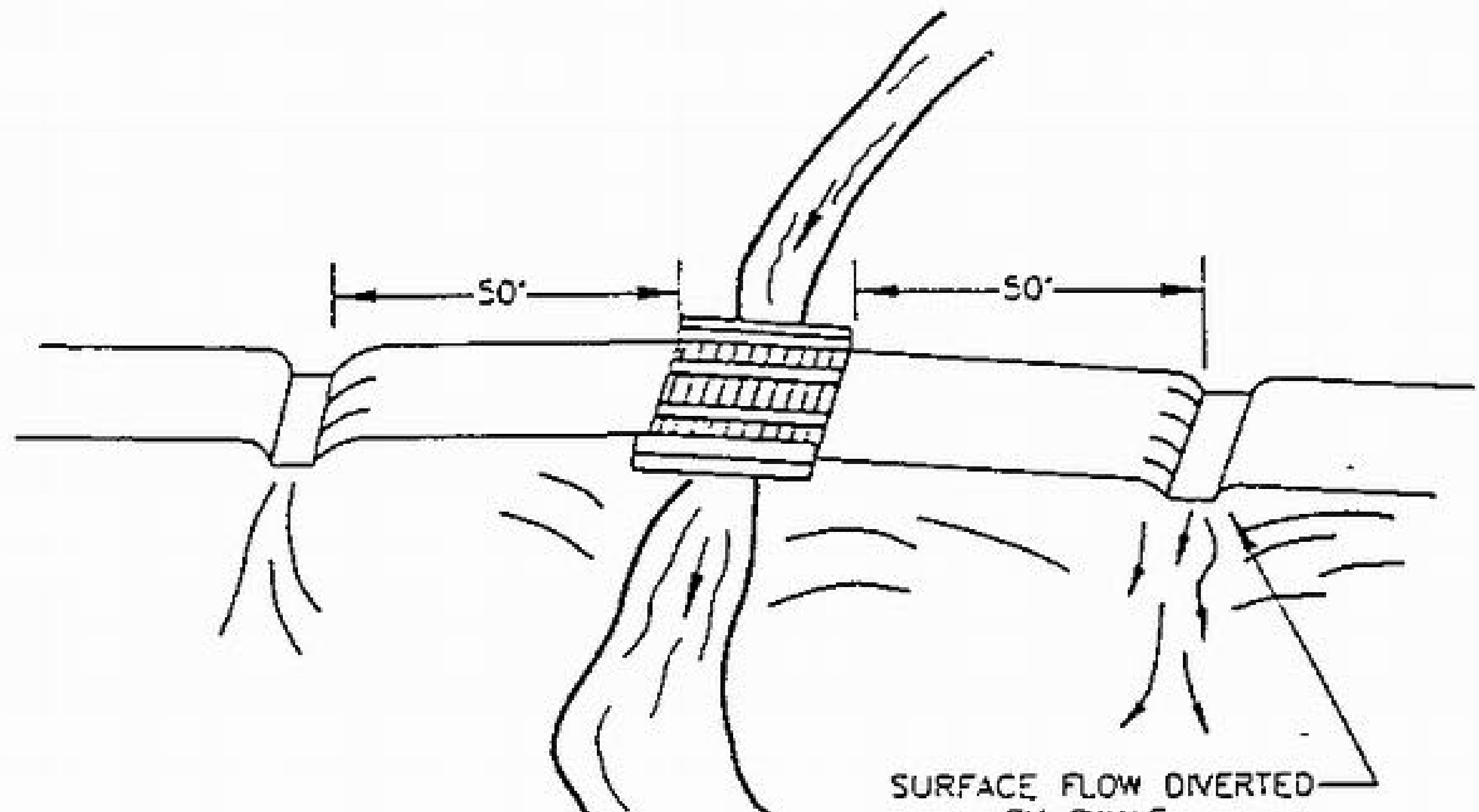
A well constructed ford offers little obstruction to flow while safely handling heavy loadings.



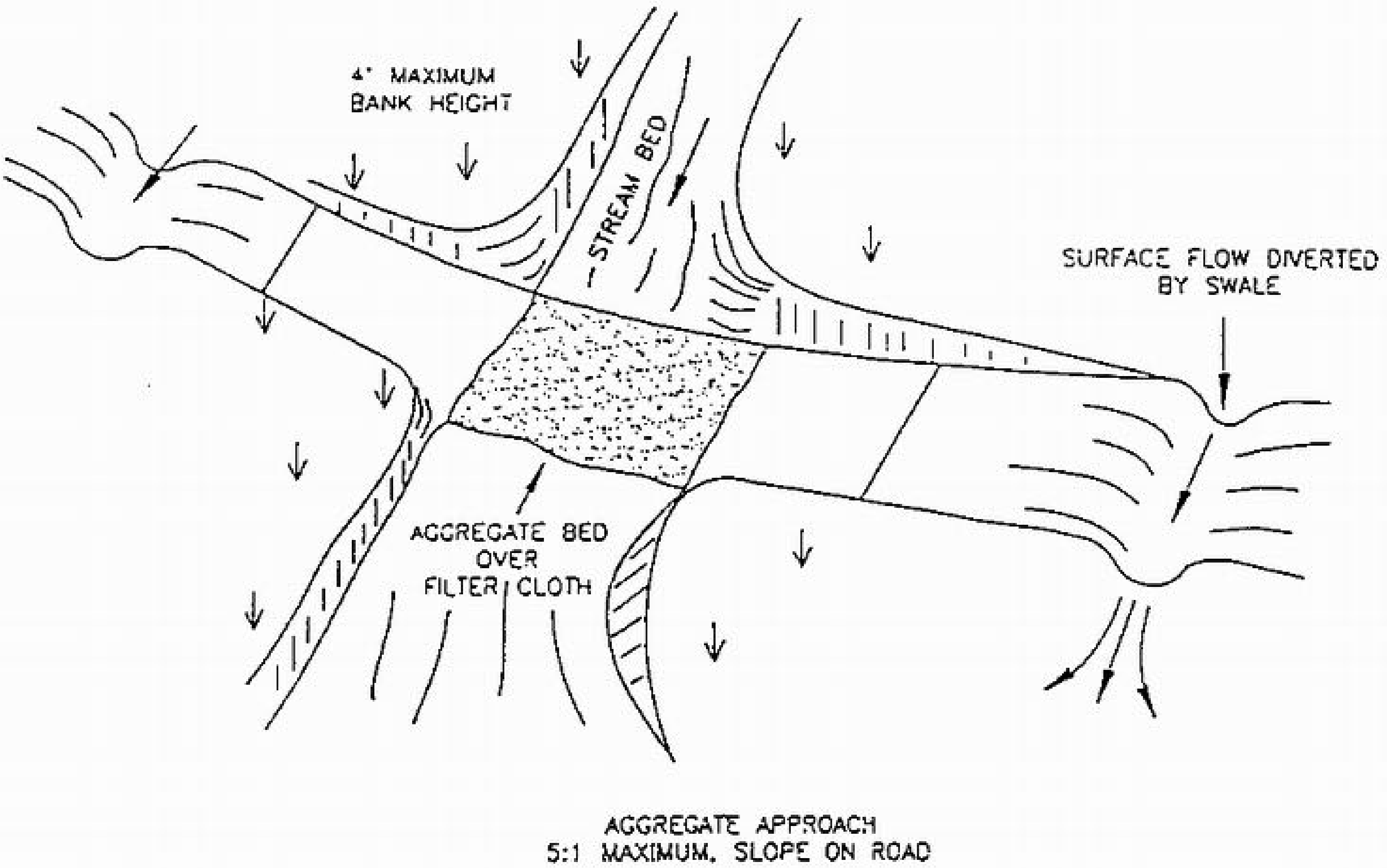
TEMPORARY ACCESS CULVERT

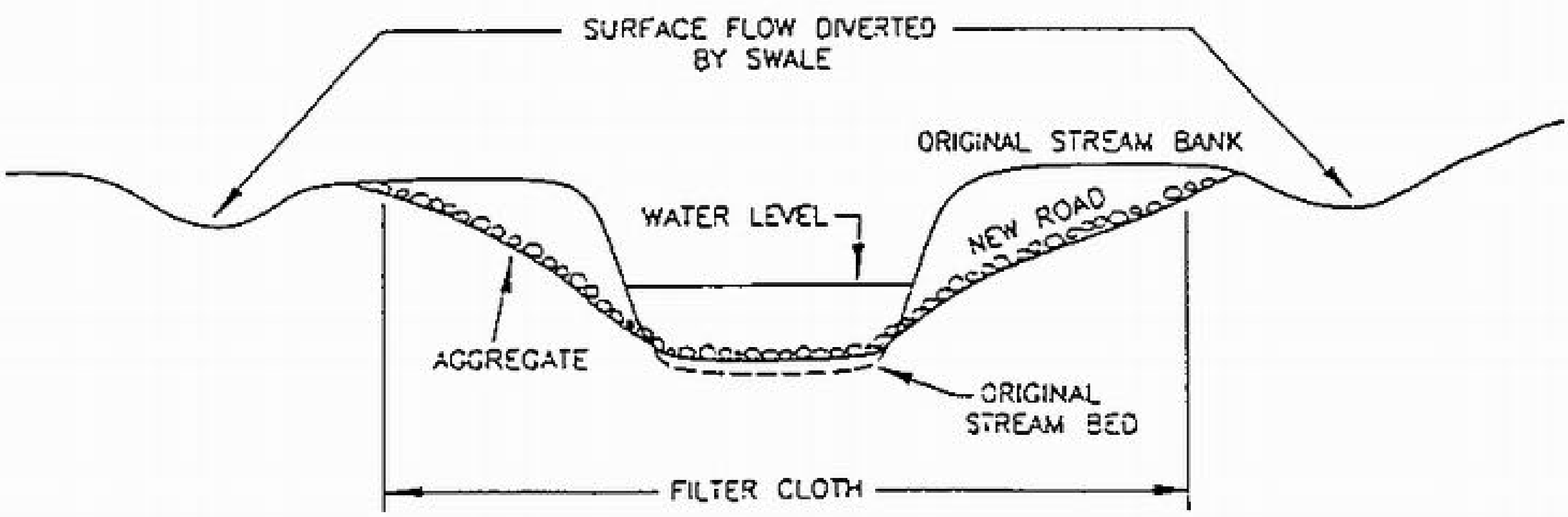
TEMPORARY ACCESS BRIDGE





U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE	TEMPORARY ACCESS BRIDGE	STANDARD DRAWING
TOOTHMAN-ORTON ENGINEERING COMANY BOISE, IDAHO McCALL, IDAHO		TAB-1





U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE	TEMPORARY ACCESS CULVERT	STANDARD DRAWING
TOOTHMAN-ORTON ENGINEERING COMANY BOISE, IDAHO McCALL, IDAHO		TAF-1

Section 7 – Sediment Collection and Runoff Diversion

For the selection of the most appropriate or suitable BMP, the user should refer to the BMP Selection Matrix in Table 1. It is essential to check with the local permitting authority for other requirements.

The following BMP fact sheets describe measures for use on a construction site to collect sediment, divert run-on from entering the site, keep runoff from leaving the site, or divert runoff away from sensitive areas or certain site activities:

Biofilter Bags BMP 34

Description

Temporary sediment barriers, consisting of biofilter bags, reduce the transport of sediment from a construction site by providing a temporary physical barrier to sediment and reducing runoff velocities. The barriers can be placed in various combinations to construct the required structure. They may also be used as a barrier to divert or direct small amounts of runoff around active work areas or to a slope drain, sediment trap or other filtration/sedimentation BMP. Biofilter bags (plastic mesh bags filled with wood chips) are temporary measures. They have a limited life span and should be regularly inspected and replaced when damaged.

Applications

The barriers are effective at storm drain inlets, across minor swales and ditches, as diversion dikes and berms, along property lines, and for other applications where the need for a barrier is temporary and structural strength is not required. These are several example applications:

- At the toe of embankment slopes
- At the outlet of slope drains
- As filter cores for log check dams
- In front of silt fences
- To protect inlets along paved streets

Limitations

Drainage area – N/A
Minimum bedrock depth - N/A
NRCS soil type - ABCD
Drainage/flood control – no
Maximum slope – 10%
Minimum water table – N/A
Freeze/thaw – fair

- These types of barriers are only suitable where flow rates are low (475 gal/min or less). They require regular inspections and repair, and periodic replacement (about 3 months maximum usefulness).
- Even when properly installed, temporary barriers are not usually as effective as silt fences (BMP 36) or gravel berms (BMP 43).

Targeted Pollutants

Sediment

Design Parameters

- Where slope gradient changes through the drainage area, steepness refers to the steepest slope section contributing to the barrier.
- The practice may also be used for a single-family lot if the slope is less than 15%. The contributing drainage area in this instance should be less than 1 ac. and the length of slope above the dike should be less than 200 ft.
- Concentrated flows no greater than 475 gal/min per second.
- The useful life is 3 months maximum, depending on site conditions.
- An undisturbed buffer zone of 3 to 6.5 ft is necessary between the barriers and surface waters to allow safe removal of the barrier and of accumulated sediments.
- The barrier should be embedded to a minimum depth of 6 in. and

backfilled for the entire length of the barrier. Each bag should be securely anchored with two stakes 2 in. x 2 in. x 3 ft or steel drift pins driven at least 20 in. into the ground.

Construction Guidelines

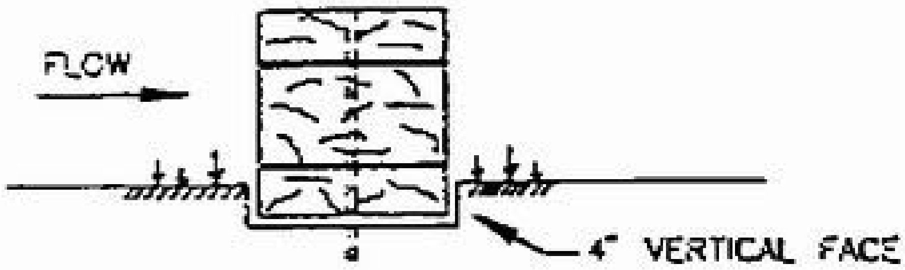
- Barriers used for sediment control at the toe of slopes should be in place prior to disturbing the slope. Install a short distance away from the toe of the slope to increase the effective area but outside of any ditch channel.
- Place the barriers in a single row lengthwise on the contour for sheet flow applications, or perpendicular to the contour in concentrated flow applications. When flows are expected to be high enough to surpass the infiltration capacity of the devices, the center (low point) bales should be wrapped in filter fabric with a 3 ft tail stapled securely and extending from the down gradient side of the barrier to prevent scouring. The ends of the adjacent barriers should tightly abut one another.
- Any gaps between barriers should be filled with tightly wedged straw. For concentrated flow applications, extend the end of the barrier so that the bottoms of the end units are at a higher elevation than the top of the lowest middle unit to assure that sediment-laden water flows through or over the barrier instead of around the ends.

Maintenance

- Perform one inspection during the first runoff-producing event after the installation of the barriers to assure proper functioning. No more than 1 ft depth of sediment should be allowed to accumulate. Damaged barriers, undercutting, or end runs should be repaired immediately.
- If approved, biofilter bags may be used after project completion as mulch.
- Temporary sediment barriers should be removed within 30 days of final stabilization of the site. If rebar is used it should be removed.

Table 34-1. Design Parameters

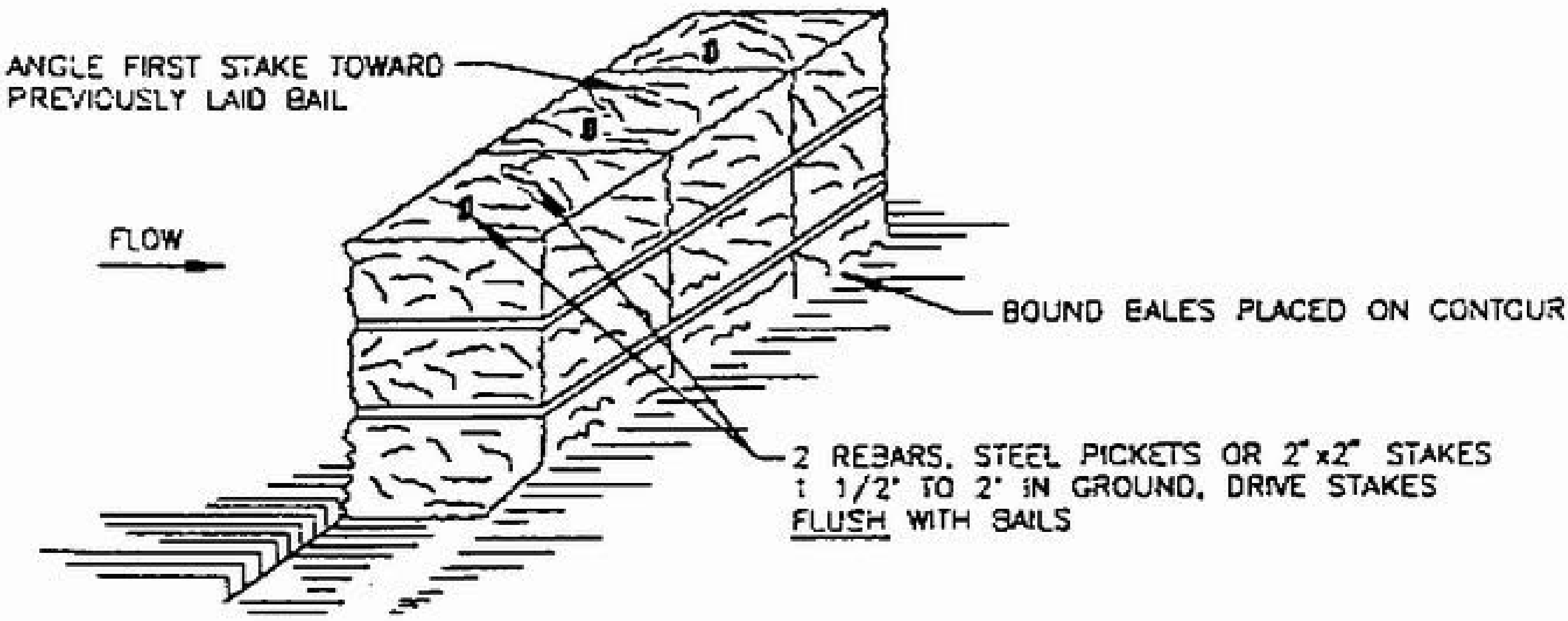
Constructed Slope	Percent Slope	Slope Length Feet
2:1	50	25
2.5:1	40	50
3:1	33	75
3.5:1	30	100
4:1	25	125



BEDDING DETAIL

SBD

STANDARD SYMBOL



ANCHORING DETAIL

CONSTRUCTION SPECIFICATIONS

1 BALES SHALL BE PLACED AT THE TOE OF A SLOPE OR ON THE CONTOUR AND IN A ROW WITH ENDS TIGHTLY ABUTTING THE ADJACENT BALES.

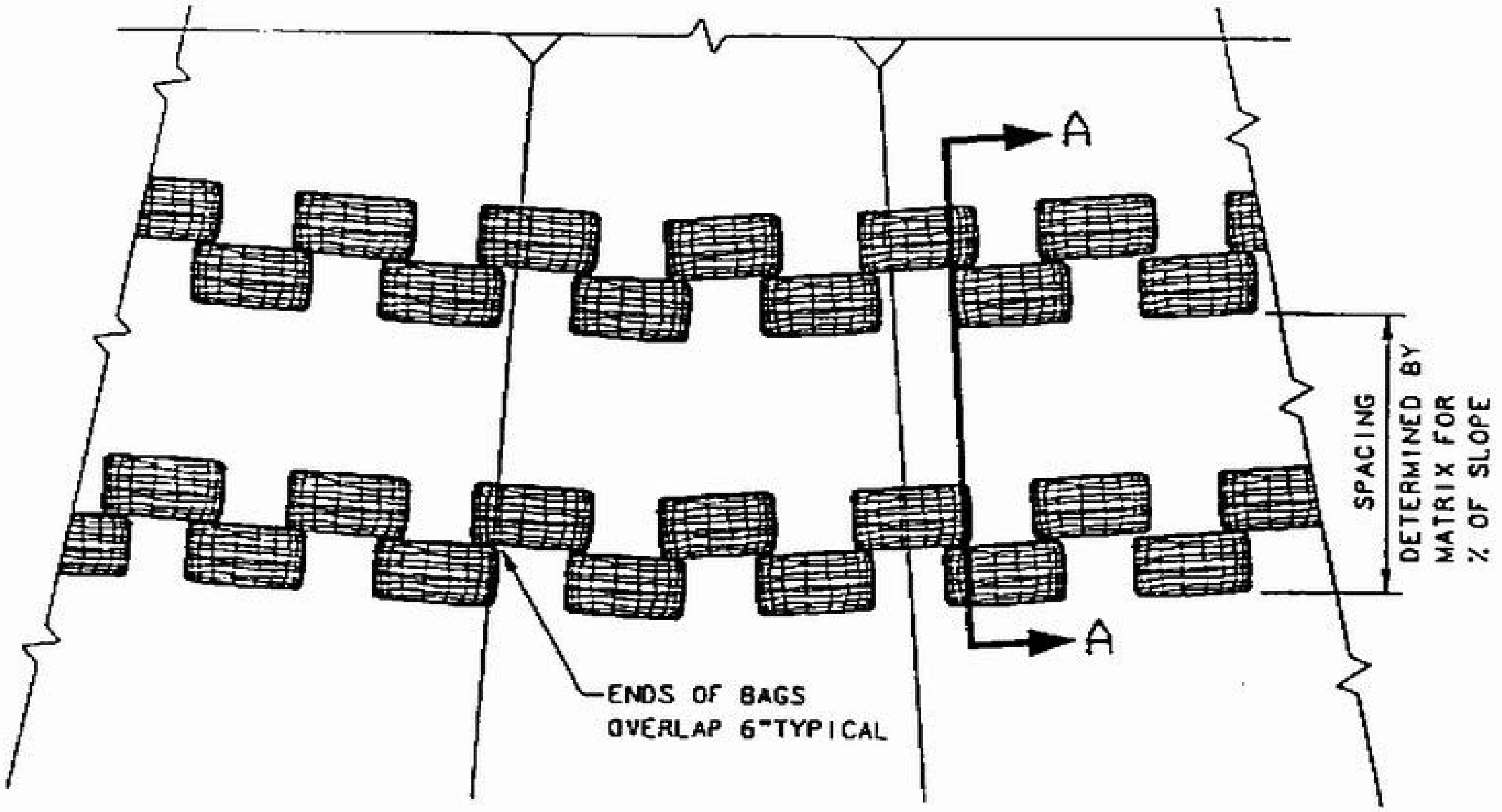
2 EACH BALE SHALL BE EMBEDDED IN THE SOIL A MINIMUM OF 4 INCHES AND PLACED SO THE BINDINGS ARE HORIZONTAL.

3 BALES SHALL BE SECURELY ANCHORED IN PLACE BY EITHER TWO STAKES OR RE-BARS DRIVEN THROUGH THE BALE. THE FIRST STAKE IN EACH BALE SHALL BE DRIVEN TOWARD THE PREVIOUSLY LAID BALE AT AN ANGLE TO FORCE THE BALES TOGETHER. STAKES SHALL BE DRIVEN FLUSH WITH THE BALE.

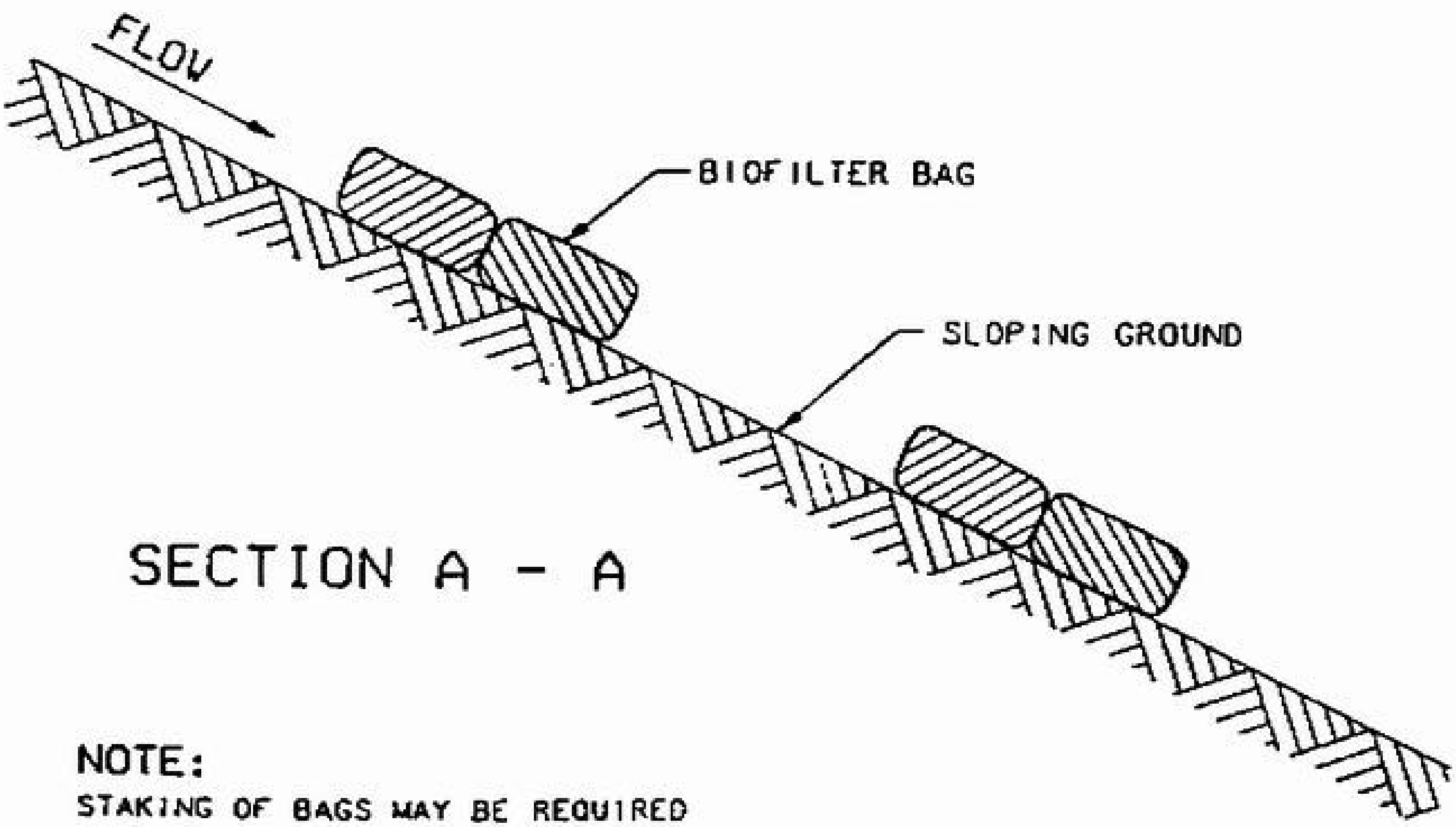
4 INSPECTION SHALL BE FREQUENT AND REPAIR REPLACEMENT SHALL BE MADE PROMPTLY AS NEEDED.

5 BALES SHALL BE REMOVED WHEN THEY HAVE SERVED THEIR USEFULLNESS SO AS NOT TO BLOCK OR IMPEDE STORM FLOW OR DRAINAGE.

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE TOOTHMAN-ORTON ENGINEERING COMANY BOISE, IDAHO McCALL, IDAHO	STRAW BALE DIKE	STANDARD DRAWING SBD-1



PLAN VIEW

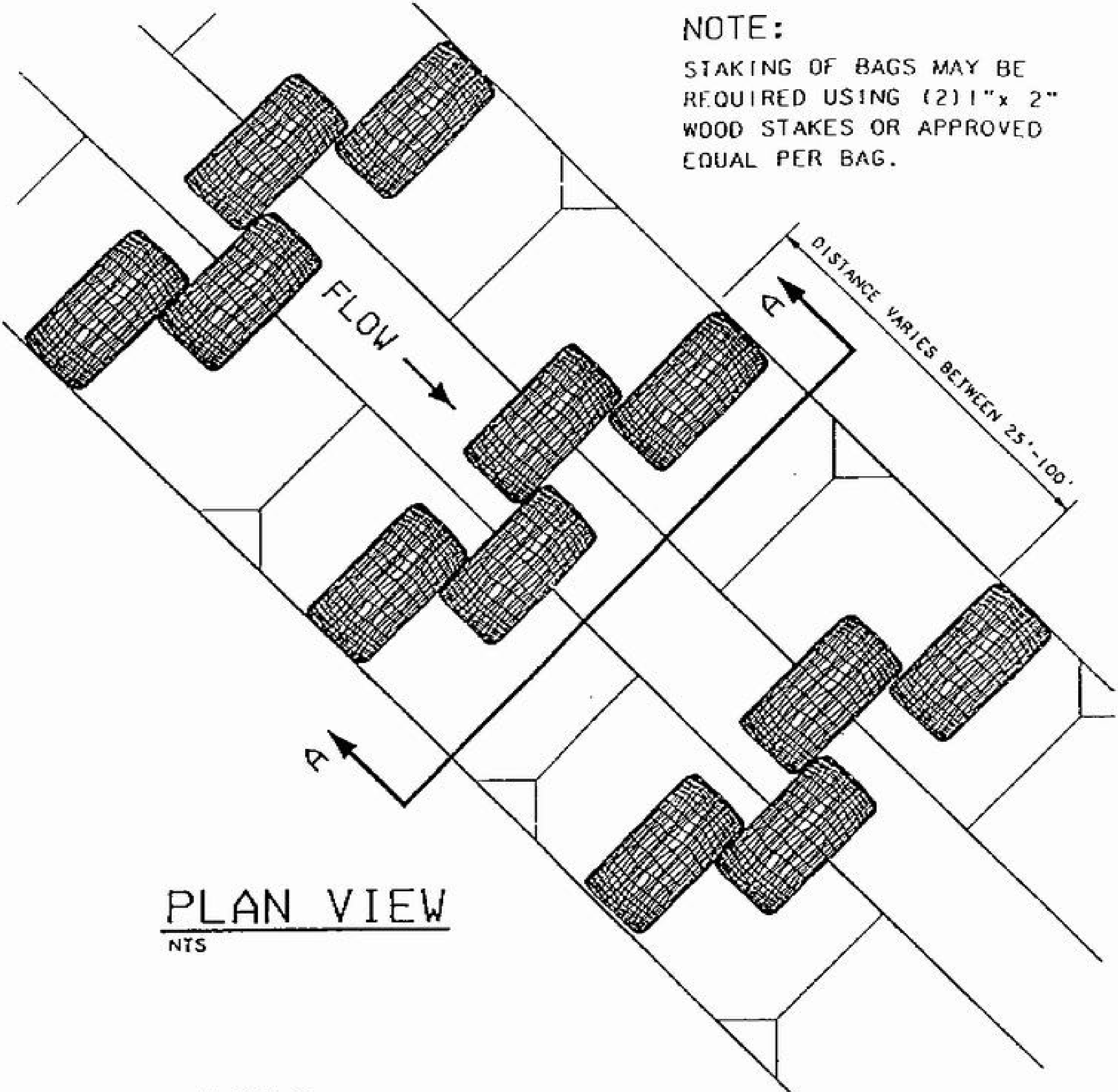


SECTION A - A

NOTE:
STAKING OF BAGS MAY BE REQUIRED WITH EITHER METHOD, USING (2) 1"x 2" WOOD STAKES OR APPROVED EQUAL PER BAG.

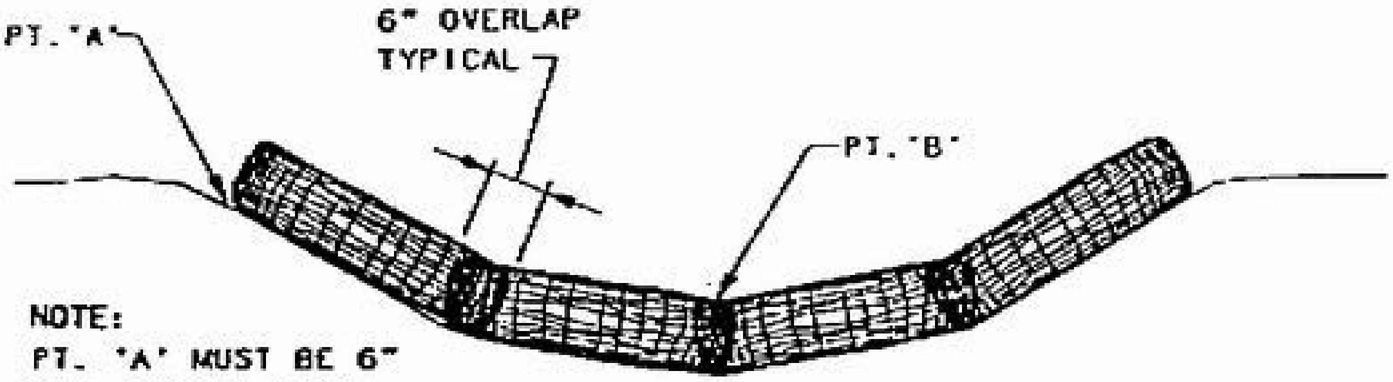
NOTE:

STAKING OF BAGS MAY BE REQUIRED USING (2) 1"x 2" WOOD STAKES OR APPROVED EQUAL PER BAG.



PLAN VIEW

NTS



NOTE:
PT. "A" MUST BE 6" MIN. HIGHER THAN PT. "B"

SECTION A-A

NTS

Fiber Rolls BMP 35

Description

A fiber roll (wattle/compost-filled socks) consists of straw, flax, or other similar materials bound into a biodegradable tubular plastic or similar encasing material. When fiber rolls are placed at the toe and on the face of slopes, they intercept runoff, reduce its flow velocity, release the runoff as sheet flow, and provide removal of sediment from the runoff. By interrupting the length of a slope, fiber rolls can also reduce erosion.

Applications

- Along the toe, top, face, and at grade breaks of exposed and erodible slopes to shorten slope length and spread runoff as sheet flow
- At the end of a downward slope where it transitions to a steeper slope
- Along the perimeter of a project
- As check dams in unlined ditches
- Down-slope of exposed soil areas
- Around temporary stockpiles
- As temporary curbs for conveying water to catch basins and pipe slope drains
- For catch basin protection

Limitations

Drainage area – N/A	Maximum slope – See Design Parameters
Minimum bedrock depth – N/A	Minimum water table - N/A
NRCS soil type - ABCD	Freeze/thaw – good
Drainage/flood control – yes	

- Fiber rolls are not effective unless trenched.
- Fiber rolls at the toe of slopes greater than 5:1 (H:V) should be a minimum of 20 in. diameter or installations achieving the same protection (i.e., stacked smaller diameter fiber rolls, etc.).
- Difficult to move once saturated.
- If not properly staked and trenched in, fiber rolls can be transported by high flows.
- Fiber rolls have a very limited sediment capture zone.
- Fiber rolls should not be used on slopes subject to creep, slumping, or landslide.

Targeted Pollutants

Sediment

Design Parameters

Locate fiber rolls on level contours spaced as follows:

- Slope inclination of 4:1 or flatter: Fiber rolls should be placed at a maximum interval of 20 ft.
- Slope inclination between 4:1 and 2:1: Fiber rolls should be placed at a maximum interval of 15 ft (A closer spacing is more effective.).
- Slope inclination 2:1 or greater: Fiber rolls should be placed at a maximum interval of 10 ft (A closer spacing is more effective.).

Construction Guidelines

- Fiber rolls should be either prefabricated rolls or rolled tubes of erosion control blanket. Field rolled fiber roll is assembled by rolling the length of erosion control blanket into a tube of minimum 8 in. diameter and binding the roll at each end and every 4 ft along the length of the roll with jute-type twine.
- Turn the ends of the fiber roll up slope to prevent runoff from going around the roll.
- Stake fiber rolls into a 2 to 4 in.-deep trench with a width equal to the diameter of the fiber roll. Drive stakes at the end of each fiber roll and spaced 4 ft maximum on center. Use wood stakes with a nominal classification of 0.75 x 0.75 in. and minimum length of 24 in.
- If more than one fiber roll is placed in a row, the rolls should be overlapped, not abutted.

Maintenance

- Inspect prior to forecast rain, daily during extended rain events, after rain events, weekly during the rainy season, and at 2-week intervals during the non-rainy season.
- Repair or replace split, torn, unraveling, or slumping fiber rolls.
- If the fiber roll is used as a sediment capture device, or as an erosion control device to maintain sheet flows, sediment that accumulates in the BMP should be periodically removed in order to maintain BMP effectiveness. Sediment should be removed when sediment accumulation reaches one-half the designated sediment storage depth, usually one-half the distance between the top of the fiber roll and the adjacent ground surface.
- Sediment removed during maintenance may be incorporated into earthwork on the site or disposed at an appropriate location.
- If fiber rolls are used for erosion control, such as in a mini-check dam, sediment removal should not be required as long as the system continues to control the grade. Sediment control BMPs will likely be required in conjunction with this type of application.

Silt Fence BMP 36

Description

A silt fence is a temporary sediment barrier consisting of a filter fabric stretched and attached to supporting posts. Wire fence backing is necessary with several types of filter fabric commonly used. Silt fences assist in sediment control by retaining some of the eroded soil particles and slowing the runoff velocity to allow particle settling.

Applications

- Silt fences can be used near the perimeter of a disturbed area to intercept sediment while allowing water to percolate through. The fences should remain in place until the disturbed area is permanently stabilized.
- Silt fences can also be used along the toe of fills, on the downhill side of large through-cut areas, along streams, and at natural drainage areas to reduce the quantity of sediment and to dissipate flow velocities to downstream areas.
- Also use at grade breaks on cut/fill slopes and above interceptor dikes.
- The silt fence should be constructed after the cutting and slashing of trees and before excavating haul roads, fill benches, or any soil disturbing construction activity in the drainage areas.

Limitations

Drainage area – 1 ac./100 ft	Maximum slope – 33%
Minimum bedrock depth – 2 ft	Minimum water table – 2 ft
NRCS soil type - ABCD	Freeze/thaw – good
Drainage/flood control – no	

Silt fences should not be used where there is a concentration of water in a channel or drainageway or where soil conditions prevent the minimum fabric toe-in depth or minimum depth for installation of support posts. If concentrated flow occurs after installation, take corrective action by placing rock berms or other corrective measures in the areas of concentrated flow.

Targeted Pollutants

Sediment

Design Parameters

- Maximum allowable slope lengths contributing runoff to a silt fence are listed in Table 36-1 below.
- Maximum drainage area for overland flow to a silt fence should not exceed 0.5 ac. per 100 ft of fence.
- Design computations are not required. All silt fences should be placed as close to the contour as possible, and the area below the fence should be undisturbed or stabilized.
- A detail of the silt fence should be shown on the plan, and contain the following minimum requirements:
  - ✓ The type, size, and spacing of fence posts
  - ✓ The size of woven wire support fences
  - ✓ The type of filter cloth used
  - ✓ The method of anchoring the filter cloth

- ✓ The method of fastening the filter cloth to the fencing support
- ▪ Where ends of filter fabric come together, they should be overlapped, folded and stapled to prevent sediment bypass.
- ▪ Materials:
  - ✓ Silt Fence Fabric: The fabric should meet the specifications in Table 36-2 below, unless otherwise approved by the appropriate erosion and sediment control plan approval authority. Such approval does not constitute statewide acceptance. Statewide acceptability depends on in-field and/or laboratory observations and evaluations.
  - ✓ Fence Posts (for fabricated units): The length should be a minimum of 36 in. long. Wood posts will be of sound quality hardwood with a minimum cross sectional area of 3.0 square in.. Steel posts will be standard "T" and "U" section weighing not less than 1 pound per linear ft.
  - ✓ Wire Fence (for fabricated units): Wire fencing should be a minimum 14.25 gage with a maximum 6 in. mesh opening, or as approved.
  - ✓ Prefabricated Units: Envirofence or approved equal may be used in lieu of the above method providing the unit is installed per manufacturer's instructions.

Construction Guidelines

- ▪ Posts should be spaced 10 ft apart when a wire mesh support fence is used and no more than 6.5 ft apart when using extra-strength filter fabric (without a wire fence). The posts should extend at least 16 in. into the ground.
- ▪ If standard strength filter fabric is to be used, fasten the optional wire mesh support fence to the upslope side of the posts using heavy duty wire staples, tie wires, or hog rings. Extend the wire mesh support to the bottom of the trench. The filter fabric should then be stapled or wired to the fence.
- ▪ Extra strength filter fabric does not require a wire mesh support fence. Staple or wire the filter fabric directly to the posts.
- ▪ Do not attach filter fabric to trees.
- ▪ Where joints in the fabric are required, splice it together only at a support post, with a minimum 6 in. overlap, and securely seal the joint.
- ▪ Embedded filter fabric should extend in a flap that is anchored by backfill, to prevent fabric from pulling out of ground.

Maintenance

Silt fences should be inspected periodically for damage (such as tearing by wind, animals, or equipment) and for the amount of sediment that has accumulated. Remove the sediment when it reaches one-half the height of the silt fence. In situations where access is available, machinery can be used.

Otherwise, the silt should be removed manually. The following are key elements to remember:

- ▪ The sediment deposits should be removed when heavy rain or high water is anticipated.
- ▪ The sediment deposits should be placed in an area where there is little danger of erosion.

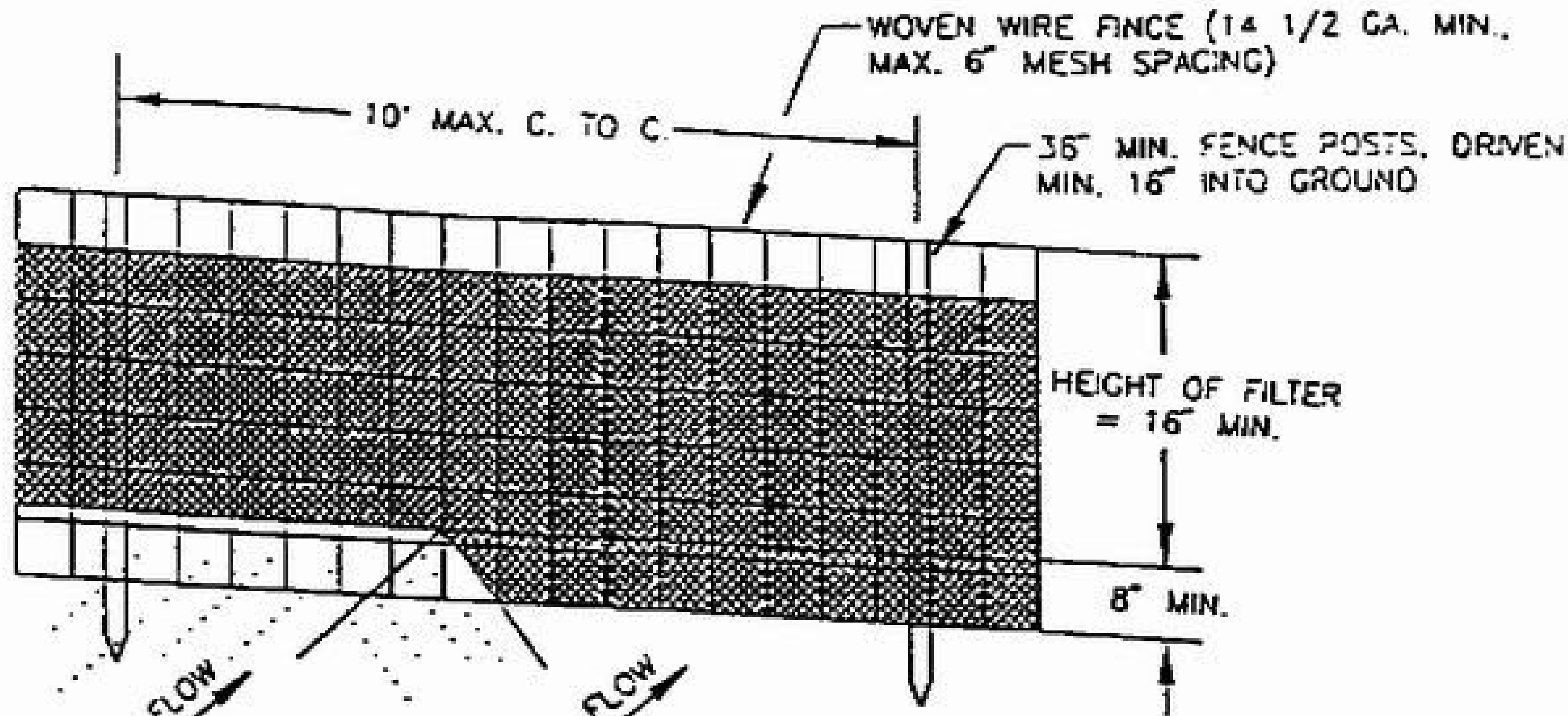
- The silt fence should not be removed until adequate vegetative growth ensures no further erosion of the slopes. Generally, the fabric is cut at ground level, the wire and posts are removed, then the sediment is spread, seeded, and protected (mulched) immediately.

Table 36–1. Maximum Allowable Slope Lengths

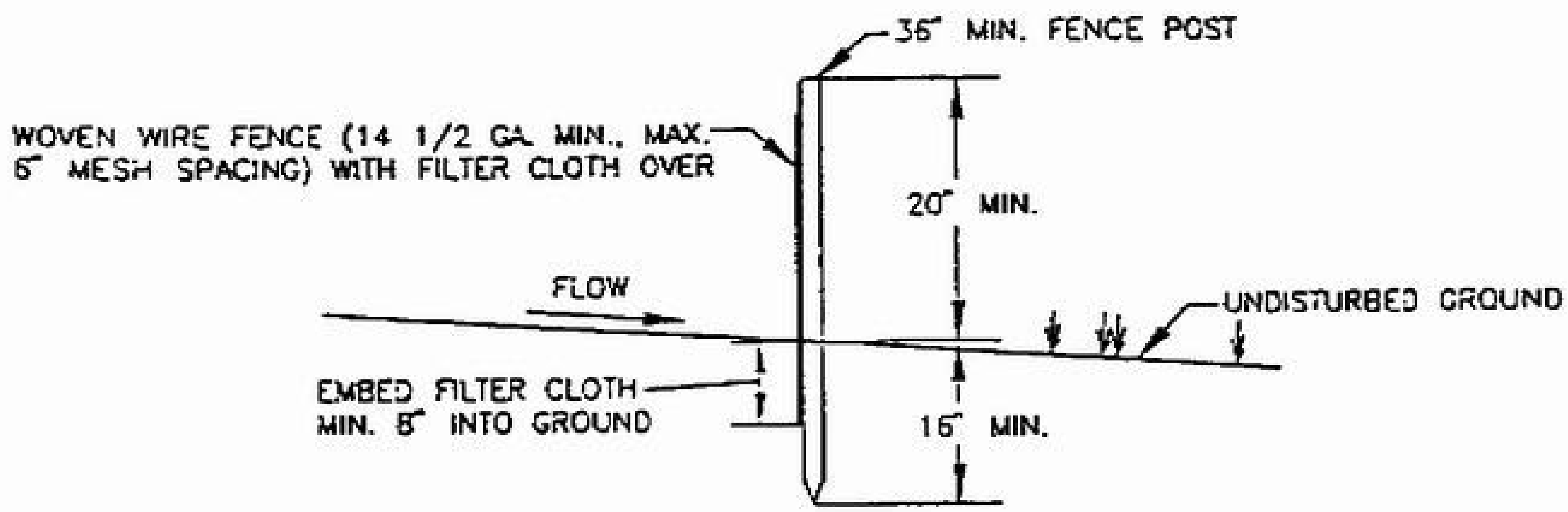
Slope Steepness	Maximum Slope Length (Feet)
2:1	50
3:1	75
4:1	125
5:1	175
Flatter than 5:1	200

Table 36-2. Filter Fabric Specifications

Fabric Properties	Value	Minimum Acceptable Test Method
Grab Tensile Strength (lbs)	90	ASTM D1682
Elongation at Failure (%)	50	ASTM D1682
Mullen Burst Strength (PSI)	190	ASTM D3786
Puncture Strength (lbs)	40	ASTM D751 (modified)
Equivalent Opening Size	40-80	US Std Sieve CW-02215
Ultraviolet Radiation Stability %	90	ASTM-G-26



PERSPECTIVE VIEW



SECTION

STANDARD SYMBOL

CONSTRUCTION NOTES FOR FABRICATED SILT FENCE

1. WOVEN WIRE FENCE TO BE FASTENED SECURELY TO FENCE POSTS WITH WIRE TIES OR STAPLES.
2. FILTER CLOTH TO BE FASTENED SECURELY TO WOVEN WIRE FENCE WITH TIES SPACED EVERY 24 INCHES AT TOP AND MID-SECTION.
3. WHEN TWO SECTIONS OF FILTER CLOTH ADJOIN EACH OTHER THEY SHALL BE OVERLAPPED BY 6 INCHES AND FOLDED.
4. MAINTENANCE SHALL BE PREFORMED AS NEEDED AND MATERIAL REMOVED WHEN "BULGES" DEVELOP IN THE SILT FENCE.

POSTS: STEEL, EITHER "T" OR "U" TYPE OR 2" HARDWOOD.

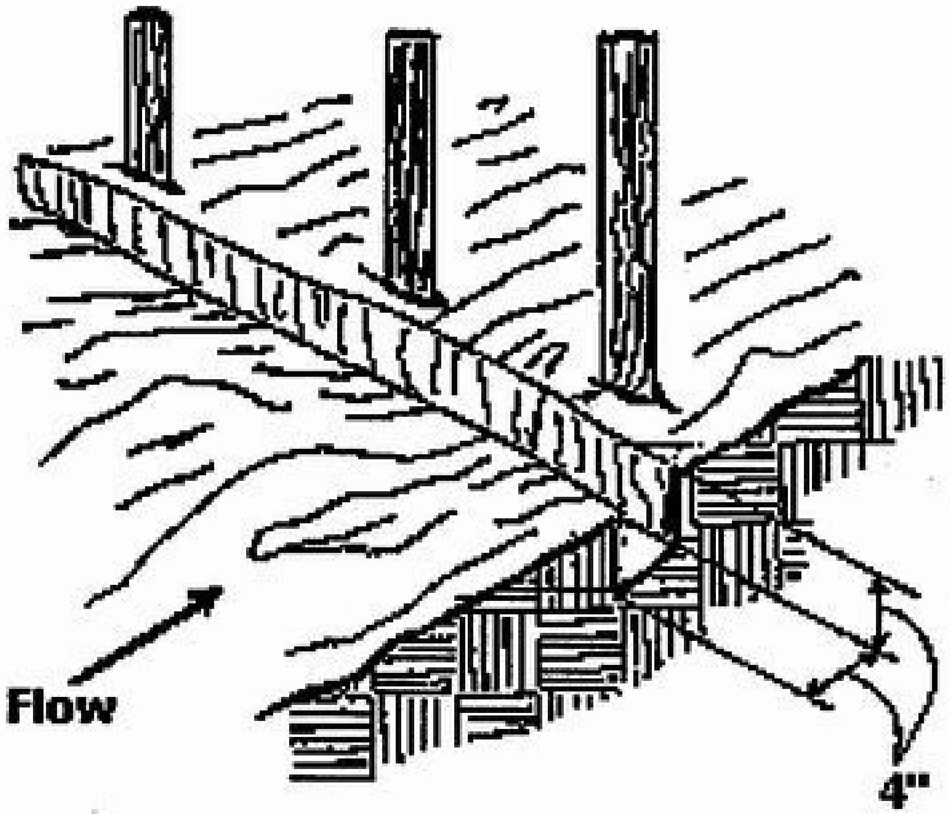
FENCE: WOVEN WIRE, 14 GAGE, 6" MAX. MESH OPENING.

FILTER CLOTH: FILTER X, MIRAFI 100X, STABILINKA T140N OR APPROVED EQUAL.

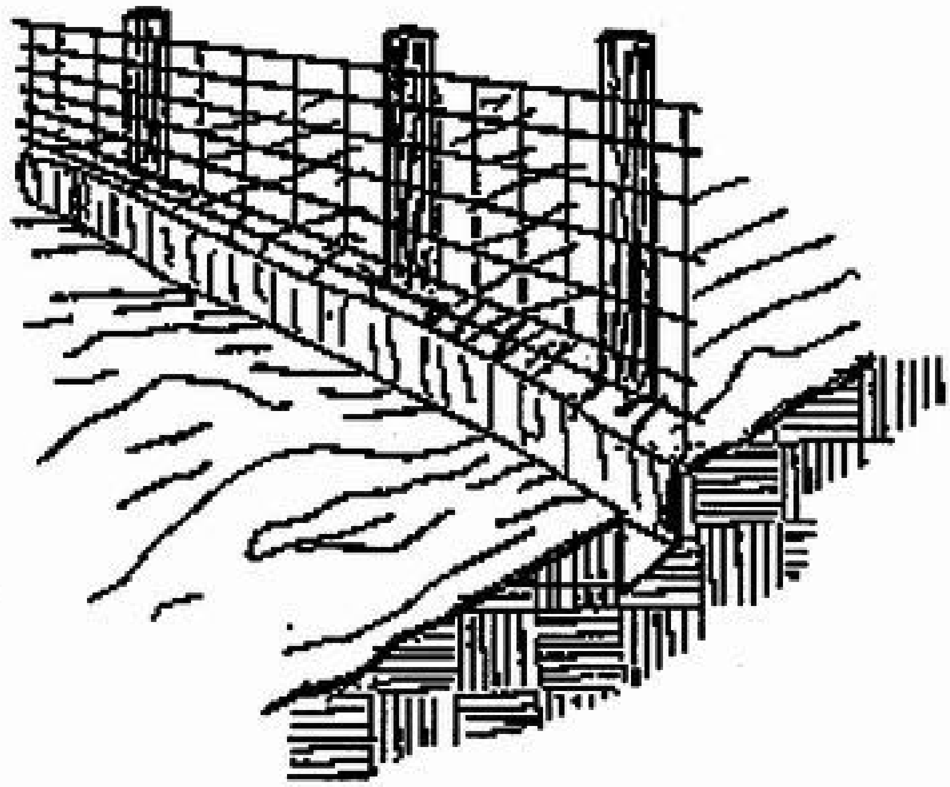
PREFABRICATED UNIT: GEOFAB, ENVIROFENCE OR APPROVED EQUAL.

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE	SILT FENCE	STANDARD DRAWING
TOOTHMAN-ORTON ENGINEERING COMANY BOISE, IDAHO McCALL, IDAHO		SF-1

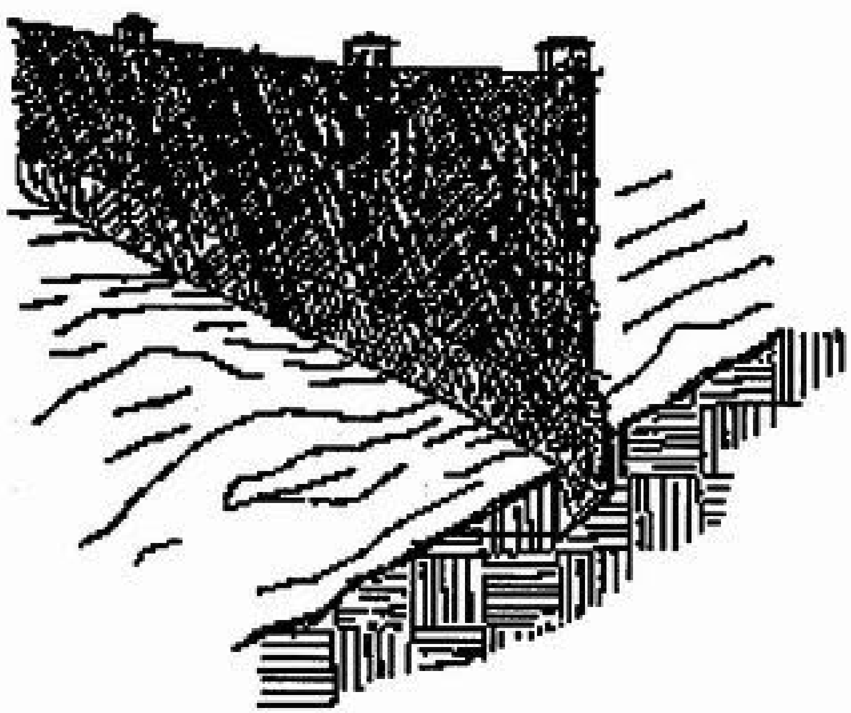
1. Set Posts and Excavate a 4" x 4" Trench upslope along the line of the posts.



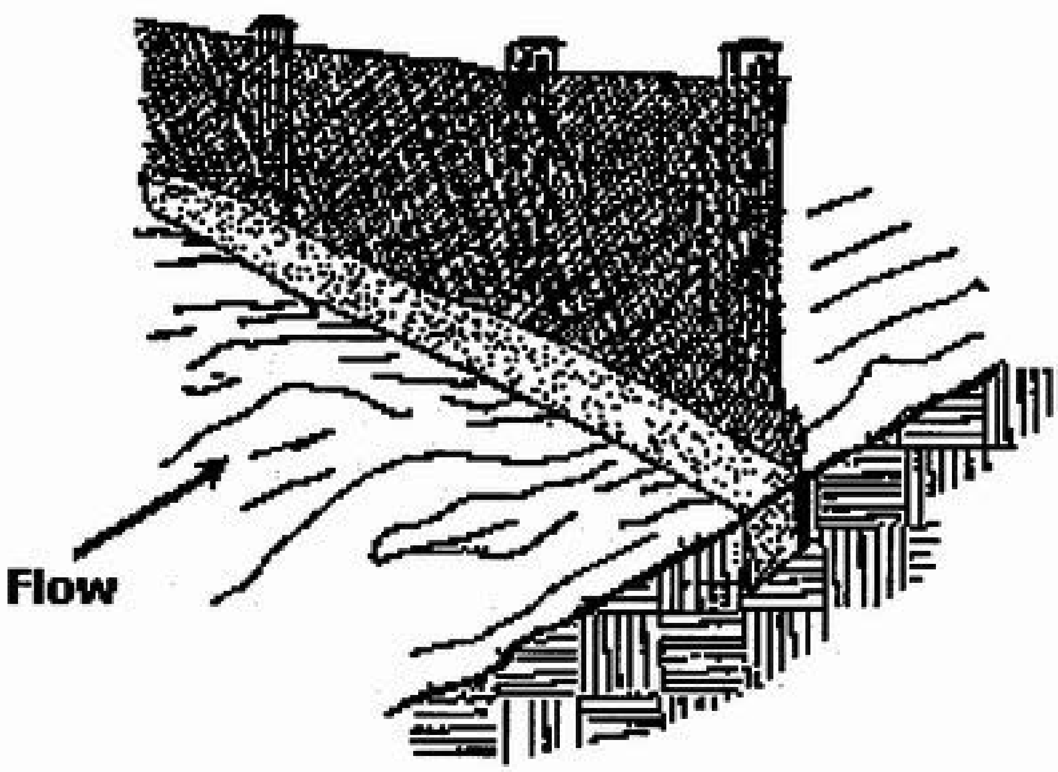
2. Staple Wire Fencing to the Posts.



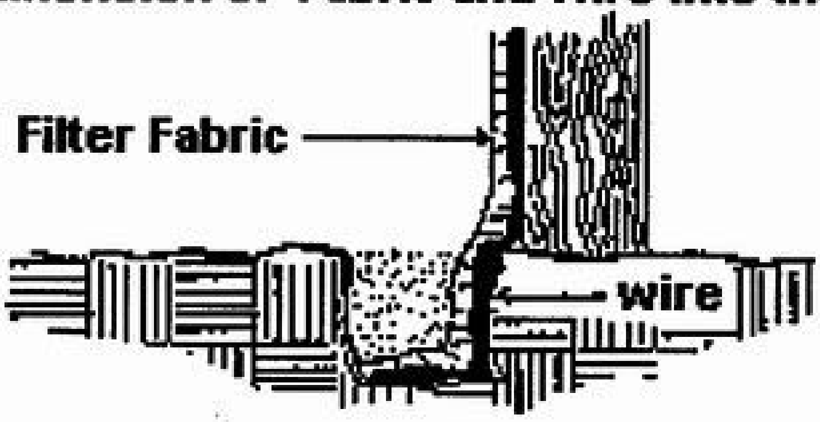
3. Attach the Filter Fabric to the Wire Fence and Extend it into the Trench.



4. Backfill and Compact the Excavated Soil



Extension of Fabric and Wire into the Trench



Vegetative Buffer Strip — BMP 37

Description

A vegetative buffer strip is a gently sloping area of vegetative cover that runoff water flows through before entering a stream, storm sewer, or other conveyance. The buffer strip may be an undisturbed strip of natural vegetation or it can be a graded and planted area.

Vegetative buffer strips act as living sediment filters that intercept and detain stormwater runoff. They reduce the flow and velocity of surface runoff, promote infiltration, and reduce pollutant discharge by capturing and holding sediments and other pollutants carried in the runoff water. Vegetative buffer strips function much like vegetated or grassed swales. Buffer strips, however, are fairly level and treat sheet flow across them, whereas grassed swales are indentations that treat concentrated flows running along them (see BMP 40-Temporary Swale).

Applications

- Used for temporary or permanent control, usually in conjunction with other sediment collection and slope protection practices. Consider use with level spreaders or diversion measures such as earth dikes (BMP 41) and slope drains (BMP 24). Also, silt fences (BMP 36) installed upgradient can prevent overloading of the buffer strip.
- May be placed at many locations between the source of sediment (road surface, side slopes) and a natural or constructed waterway. They are inexpensive and easily constructed, and can be put into place at any time if climatic conditions allow for planting.
- May be used at almost any site that can support vegetation, but is best suited for areas where the soils are well drained or moderately well drained and where the bedrock and the water table are well below the surface.
- Provides low to moderate treatment of pollutants in stormwater while providing a natural look to a site.
- Can provide habitat for wildlife.
- Can screen noise and views if trees or high shrubs are planted on the filter strips.

Limitations

Drainage area - unlimited	Maximum slope – 20%
Minimum bedrock depth – 5 ft	Minimum water table – 3 ft
NRCS soil type – ABCD	Freeze/thaw – fair
Drainage/flood control – no	

- Not effective for filtering high velocity flows from large paved areas, steep slopes, or hilly areas. Consider other measures if slopes exceed 15%.
- Requires significant land space.
- May have a short useful life due to clogging by sediments and oil and grease.
- Do not use planted or seeded ground as a buffer strip for sediment trapping until the vegetation is well established.

Targeted Pollutants

Sediment

Design Parameters

- A buffer strip should be at least 20 ft wide to function well. Along live streams or above wetlands, the minimum width should be 100 ft. The length of the strip should be approximately 50 to 82 ft. Where slopes become steeper, increase the length of the strip.
- Tall, dense stands of grass form good sediment traps, as do willows and alder. The willows and alder can be native or planted. A combination of grasses with willows or alder is also effective. Any planted species should be deep rooted and able to adjust to low oxygen levels. Vegetative cover should be at least 75% to assure adequate removal of sediments. Forested strips are always preferred to vegetated strips, and existing vegetation is preferred to planted vegetation. In planning for vegetated strips, consider climatic conditions, since vegetation may not take hold in especially dry and/or cold regions.
- In many cases, a vegetative buffer strip will not effectively control runoff and retain sediments unless employed in conjunction with other control measures. Where heavy runoff or large volumes of sediment are expected, provide diversion measures or other filtering measures above or below the buffer strip.

Construction Guidelines

- Try to direct sediment-laden water onto naturally vegetated or stabilized planted ground.
- Fertilizing seeded or planted ground may enhance growth (and improve its effectiveness as a buffer strip).
- Do not place any equipment, construction debris, or extra soil in the buffer strip (or the strip will be damaged).

Maintenance

- Inspect the buffer strip at regular intervals to ensure proper functioning. Check for damage by equipment and vehicles. In newly planted areas, check the progress of germination and plant growth, and arrange for fertilizing, if needed, to enhance growth and establishment. (Planted ground should not be used for a sediment trap until the vegetation is well established.) Make sure that water flowing through the buffer strip is not causing additional erosion nearby and not forming ponds due to erosion within the buffer strip.
- Buffer strips in natural vegetation do not generally require maintenance; however, on some sites it may be necessary to remove sediments and replant on a regular basis. Promptly repair any damage from equipment, vehicles, or erosion.

Sedimentation Trap (Basin) BMP 38

Description

A sedimentation trap is a temporary or permanent dam or basin used to collect, trap, and store sediment produced by construction activities, or as a flow detention facility for reducing peak runoff rates. Sediment basins can be designed to maintain a permanent pool or to drain completely dry. Either way, the basin detains sediment-laden runoff long enough to allow most of the sediment to settle out.

A sediment basin can be constructed by excavation or by placing an earthen embankment across a low area or drainage swale. The pond has a riser and pipe outlet with a gravel outlet or spillway to slow the release of runoff and provide some sediment filtration.

Applications

Sediment traps are appropriate where physical site conditions or land ownership restrictions preclude the effective use of barrier-type erosion control measures. It may be used below construction operations which expose critical areas to soil erosion.

A temporary sediment basin used in combination with other control measures, such as seeding or mulching, is especially effective for removing sediments. Note that the use of sedimentation basins on construction sites greater than or equal to 1 ac., with an NPDES stormwater permit has special requirements. Refer to Part IV.D.2.a. (2)(a) of the NPDES stormwater general permit for on-site activities.

Limitations

Drainage area – 5 ac.
Minimum bedrock depth – 3 ft
NRCS soil type - BCD
Drainage/flood control – no
Maximum slope – 10%
Minimum water table – 2 ft
Freeze/thaw – good

- May not be feasible downstream of narrow right-of-way due to lack of space.
- May not be practical in highly erodible soil types (0.01in. and smaller, very fine sand, silt and clay) due to extremely large basin size requirements.
- May not remove enough of the fine silts. Additional control measures such as filter cloth around riser should be used to minimize release of fine silts. If filter cloth is used, regular inspection and replacement is required to deal with clogging.
- Should not be located in any active stream channel.

Targeted Pollutants

Sediment

Design Parameters

- Design of the basin should be based upon the total drainage area lying upstream and (if permanent) on the future use of such lands. A professional engineer should approve the design.

- The volume of the sediment basin should be at least 1800 ft^3 /ac. of total drainage area (about 0.5 in. over the watershed). Disturbed areas greater than 10 acres within the same drainage basin should be provided a basin with a capacity of 3600 ft^3 of total drainage area (1 in. over the watershed) to meet the NPDES regulations.
- The basin should be designed with baffles or other deflectors to spread the flow throughout the basin. It should also include an emergency spillway and riser pipe(s). These structures should be designed on a site-specific basis using standard engineering practices. Calculating the settling zone volume and adding the necessary sediment storage volume should size the basin pond.
- The settling zone volume is determined by the pond surface area calculated using the following equation:

  SA = 1.2Qx / Vsed

  Where:

  ✓ SA = the pond surface area in square meters

  ✓ Qx = the design inflow (in cubic meters per second) based on the runoff from the design storm event for the drainage area.

  ✓ Vsed = the settling velocity for the design soil particle in meters per second. Table 38 lists theoretical settling velocities for different particle sizes (#200 sieve).

- For particle sizes of 0.01in. and smaller, the Vseds are so low that the SA becomes extremely large, often making the overall basin size requirement too large to be practical. In this case, extra protection measures should be taken to negate the need for the basin.
- The settling volume requirement is then calculated by multiplying the surface area by the settling depth. The settling depth should be a minimum of 1 ft and a maximum of 4 ft and is governed by a relationship with the basin length (distance from the inlet to the outlet). The ratio of length to settling depth should be greater than 200. For example, if the length was 394 ft, the settling depth should be less than 2 ft to achieve the ratio of greater than 200.
- Typically, a sediment storage depth of 3 ft is appropriate unless large volumes of soil are expected from highly erodible site conditions. In this case, use the universal soil loss equation or other applicable estimating methods to design the storage depth on a site-specific basis.

Determine the final pond dimensions and volume as follows:

- Determine the pond geometry for the sediment settling volume calculated above by adding a sediment storage depth of 3 ft and 3:1 side slopes from the bottom of the basin. The bottom should be level.
- Extend the side slopes (at 3:1) as necessary to obtain the settling zone volume at the settling zone depth determined above.
- Adjust the geometry of the basin to effectively combine the settling zone volume and sediment storage volume while preserving the depth and side slope criteria listed above.

Sediment basins covered by this standard should be limited to the following category:

- The water surface at the crest elevation of the pipe spillway should not exceed 10 ft measured upward from the original streambed to the crest elevation of the pipe spillway; and the drainage area should not exceed 150 acres.
- Because finer silts may not settle out completely, additional erosion control measures should be used to minimize release of the fine silt. Runoff should enter the basin as far from the outlet as possible to provide maximum retention time.

Construction Guidelines

- The temporary sediment basin should be installed before clearing and grading is undertaken. It should not be built within an active stream channel. Putting a dam in such a site could destroy aquatic habitat, and failure of the dam could result in flooding. A temporary sediment basin should be constructed only if there is sufficient space and appropriate topography. The basin should be made large enough to handle the maximum expected amount of site drainage. Fencing around the basin may be necessary for safety reasons or to discourage vandalism.
- The following general construction criteria are critical to successful installation and operation of sediment basins.
  - ✓ Locate the dam to provide maximum volume capacity for silt behind the structure.
  - ✓ Prepare the dam site by clearing vegetation and removing topsoil before beginning dam construction. Areas under the embankment and any structural works should be cleared and grubbed, and the topsoil stripped to remove all trees, vegetation, roots and other objectionable material. To facilitate cleanout and restoration, the pool area (measured at the top of the pipe spillway) should be cleaned of all brush, trees or other debris.
  - ✓ Level the bed for the pipe spillway to provide uniform support through its entire length under the dam.
  - ✓ Construct an emergency spillway (as per design) on undisturbed soil--not on fill. The design width and entrance/exit channel slopes are critical to the spillway's ability to successfully protect the dam with a minimum of erosion hazard in the spillway channel. The spillway should be lined with 4 in. of concrete, reinforced with 6 x 6 in. 10/10 wire mesh extending to a minimum of 36 in. down each face of the embankment. The spillway should be at least 20 in. deep with 1:1.5 slide slopes.
  - ✓ All pipe joints should be securely fastened and watertight. The riser should be rigidly and securely fastened to the barrel and the bottom of the riser should be sealed (watertight). The barrel should be placed on a firm foundation according to the lines and grades shown on the plans.
  - ✓ Place at least 1 ft of hand-compacted backfill (maximum 6 in. lifts) over the pipe spillway before crossing it with construction equipment. The movement of the hauling and spreading equipment over the fill should be controlled so that the entire surface of each lift will be traversed by not less than one tread tract of the

equipment.

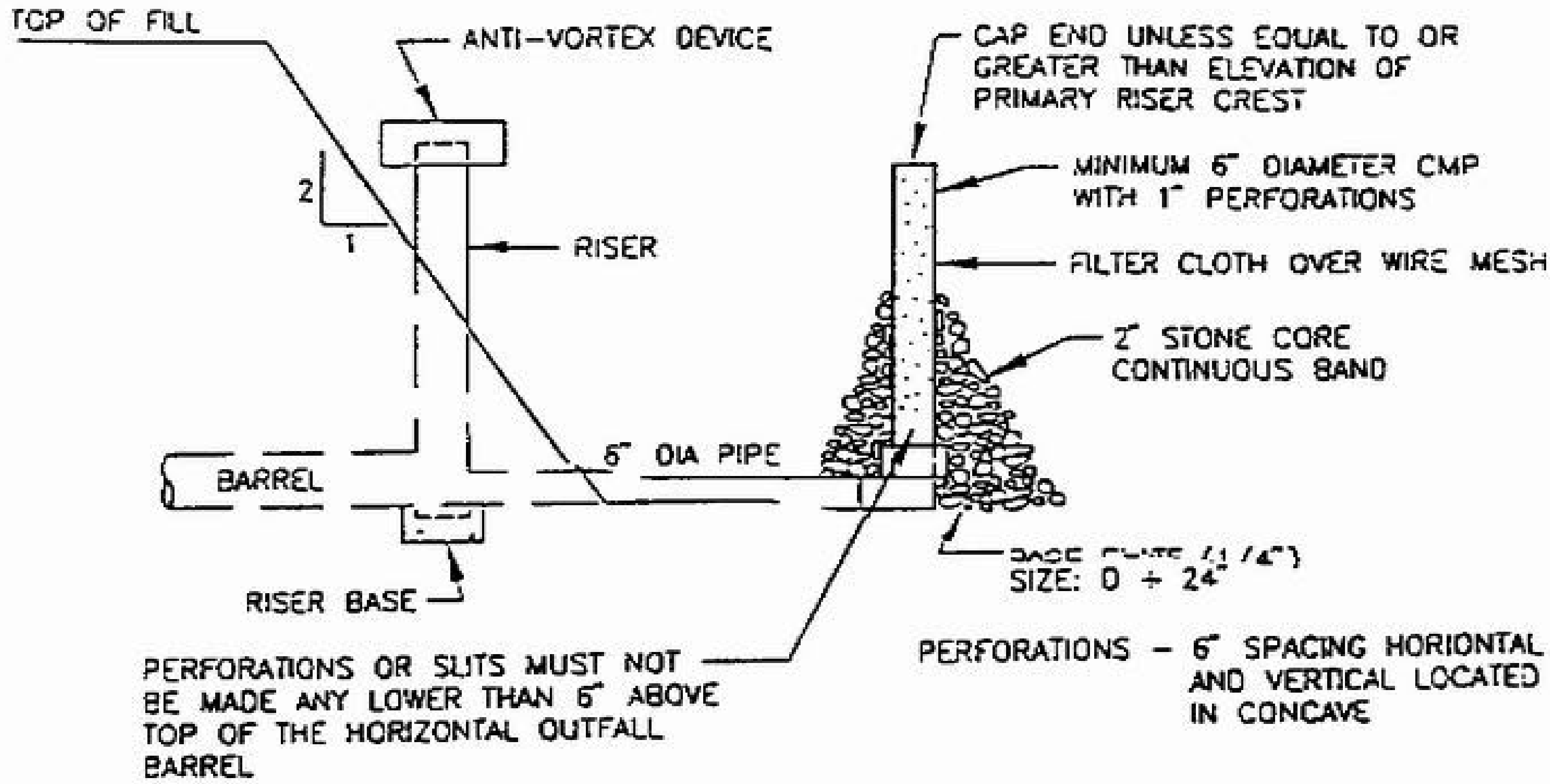
- ✓ The pipe spillway should discharge at ground elevation below the dam, and not more than 12 in. above any streambed.
- ✓ Fill material should be taken from approved designated borrow areas, and should be of the type and quality conforming to that specified for the adjoining fill material. It should be free of roots, woody vegetation, oversize stones, rocks exceeding 6 in. diameter, or other objectionable materials. Do not use frozen material.
- ✓ Areas on which fill is to be placed should be scarified prior to placement of fill. Fill materials should be placed in 6 in. maximum lifts, compacted by construction equipment. The embankment should be raised and compacted to an elevation that provides for anticipated settlement to design elevation (allow at least 10% for settlement). Lifts should be continuous over the entire length of the fill and approximately horizontal.
- ✓ Stabilize the embankment and emergency spillway with revegetation or other stabilization measures.

Maintenance

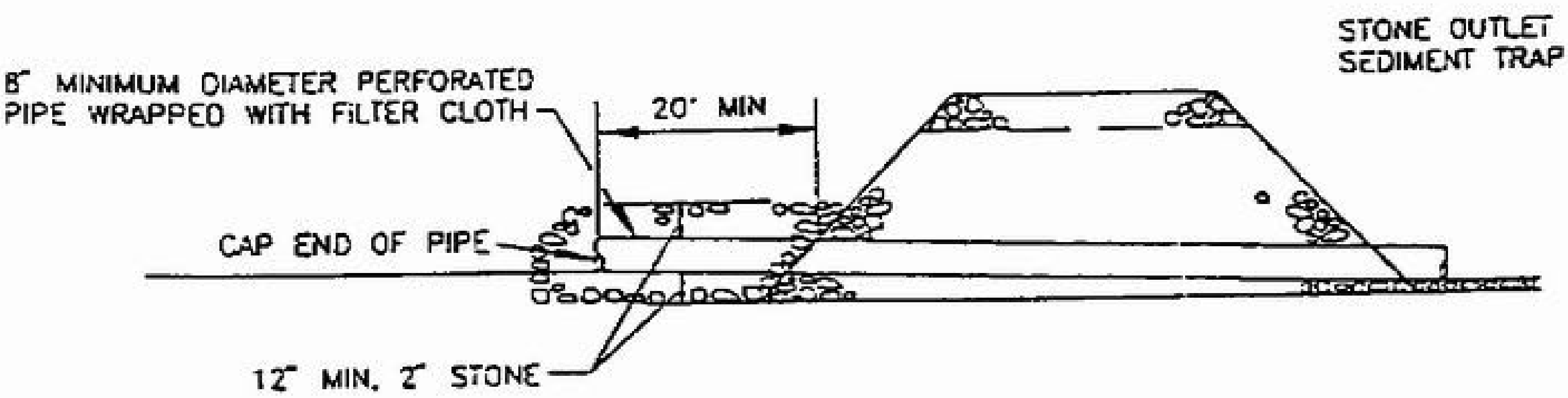
- Sediment basins should be readily accessible for maintenance and sediment removal. The sediment maintenance volume should be determined and marked before the basin is used. They should be inspected after each rainfall and be cleaned out when about half the volume has been filled with sediment. Poorly draining basins require maintenance to clean clogged riser or filter cloth. Removed sediment should be disposed of and stabilized in an approved location such that spoils do not re-enter waters of the state. Sediment may not be dumped into any water of the U.S. without appropriate permitting.
- The sediment basin should remain in operation and be properly maintained until vegetation or other measures permanently stabilize the drainage area. A well-built temporary sediment basin that is large enough to handle the post-construction runoff volume may later be converted to use as a permanent stormwater management structure.
- If the pond is located near a residential area, it is recommended for safety reasons that a sign be posted and that the area be secured by a fence.

Table 38-1. Theoretical settling velocities for different particle sizes (#200 sieve).

Size (in.)	V_{sed} (in./sec)
0.02	0.0023
0.008	0.00079
0.004	0.00028
0.002	0.000079
0.0008	0.000012
0.0004	0.0000028
0.0002	0.00000079

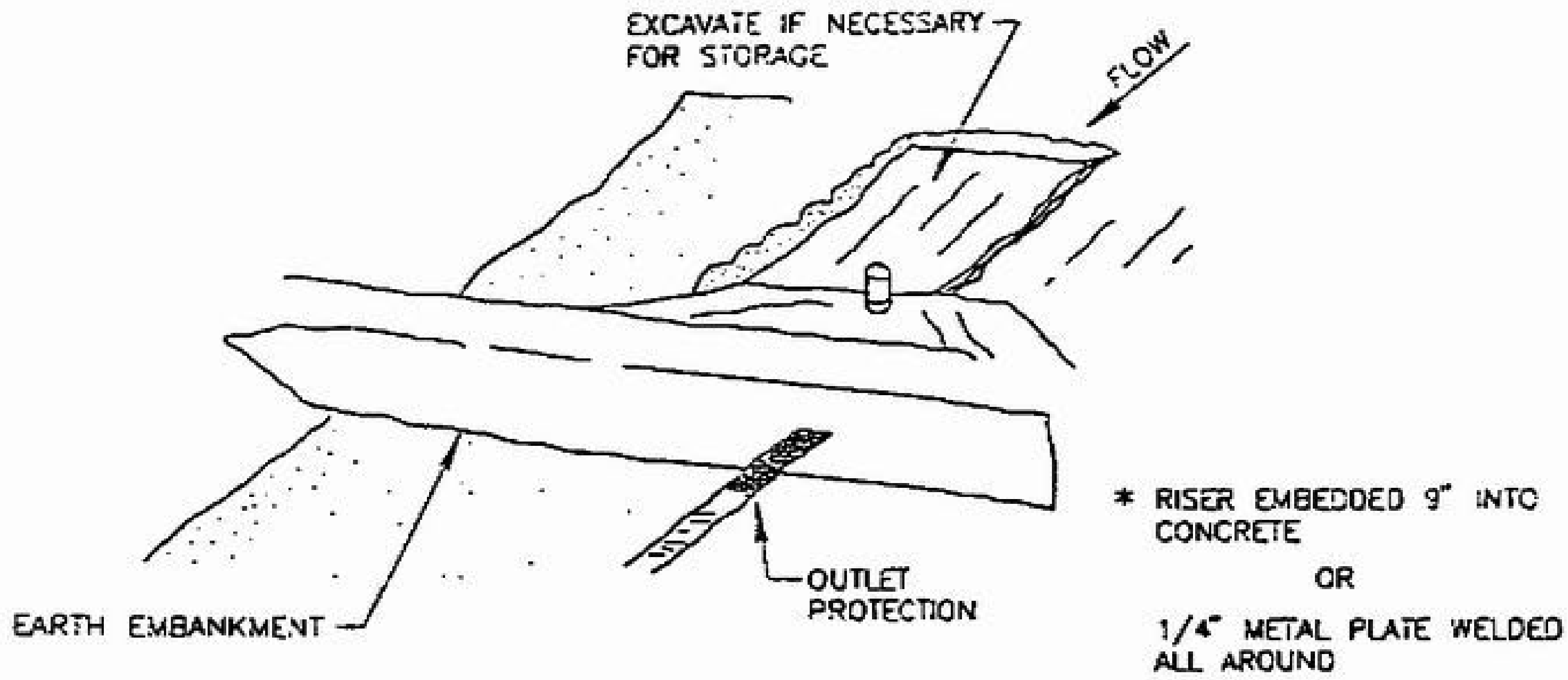


OPTIONAL SEDIMENT TRAP DEWATERING DEVICE-I
WITH 6" PERFORATED RISER

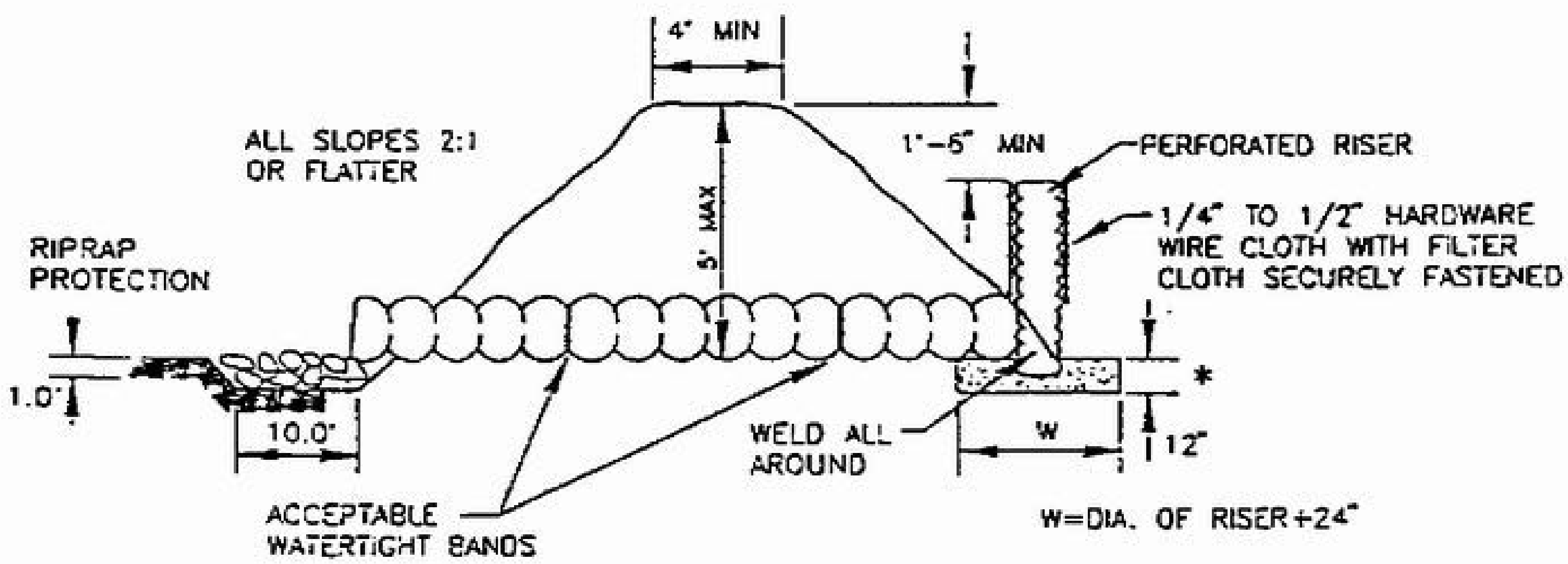


OPTIONAL SEDIMENT TRAP DEWATERING DEVICE-II

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE	OPTIONAL SEDIMENT TRAP DEWATERING DEVICES	STANDARD DRAWING
TOOTHMAN-ORTON ENGINEERING COMANY BOISE, IDAHO McCALL, IDAHO		ST



PERSPECTIVE VIEW



EMBANKMENT SECTION THRU RISER

SIZES OF PIPE NEEDED

BARREL DIAMETER ______________

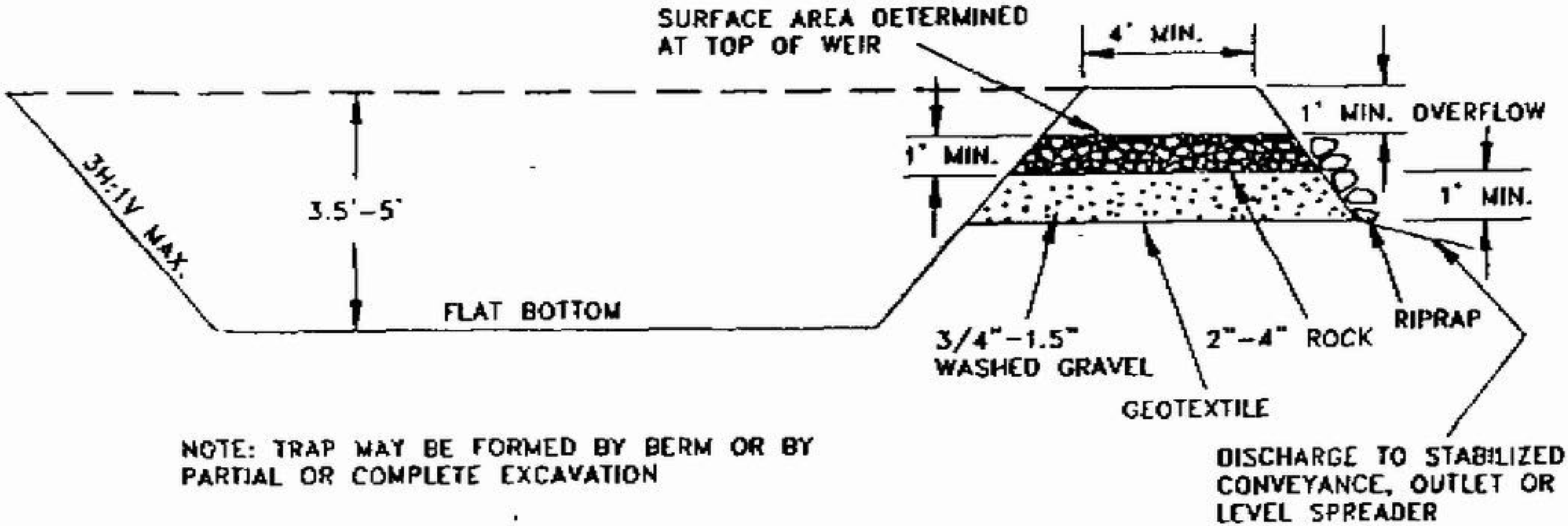
RISER DIAMETER ______________

NOTE:

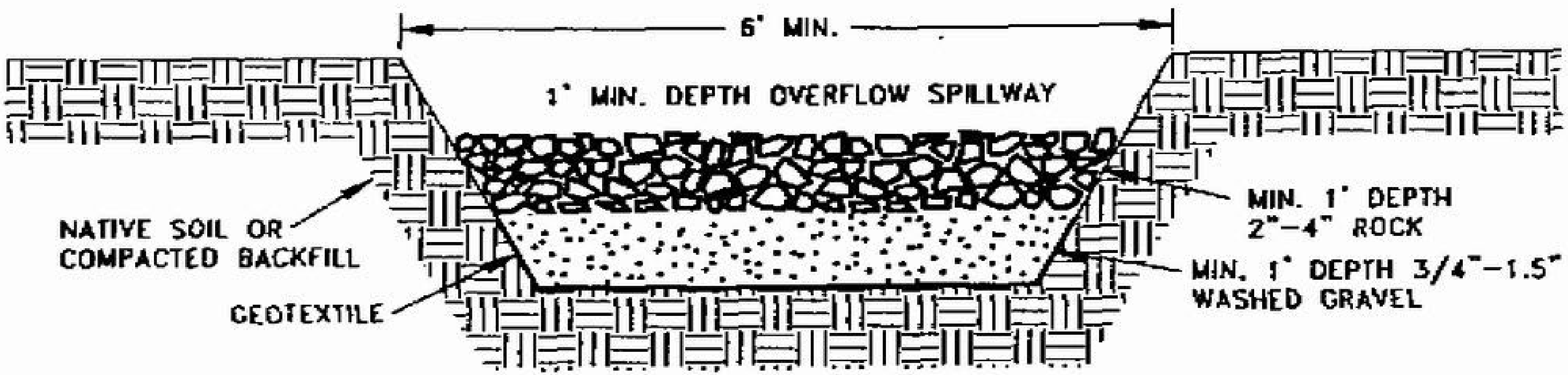
FOR CONSTRUCTION SPECIFICATION SEE SHEET __________

MAXIMUM DRAINAGE AREA: 5 ACRES

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE	PIPE OUTLET SEDIMENT TRAP	STANDARD DRAWING
TOOTHMAN-ORTON ENGINEERING COMANY BOISE, IDAHO McCALL, IDAHO		ST-1



CROSS-SECTION



TRAP OUTLET

Portable Sediment Tank BMP 39

Description

A sediment tank is a compartmented tank container through which sediment-laden water is pumped to trap and retain the sediment prior to pumping the water to drainageways, adjoining properties, and rights-of-way below the sediment-tank site.

Applications

A sediment tank should be used on sites where excavations are deep, and space is limited, such as urban construction, where direct discharge of sediment-laden water to stream and storm drainage systems is to be avoided.

Limitations

Drainage area - unlimited
Minimum bedrock depth - N/A
NRCS soil type – N/A
Drainage/flood control – no
Maximum slope – N/A
Minimum water table - N/A
Freeze/thaw – good

Targeted Pollutants

Sediment
Trace metals

Design Parameters

- The sediment tank should be located for ease of clean-out and disposal of the trapped sediment and to minimize the interference with construction activities and pedestrian traffic.
- The following formula should be used in determining the storage volume of the sediment tank: Pump Discharge (G.P.M.) x 16 = Cubic Foot Storage.
- Other container designs can be used if the storage volume is adequate and approval is obtained from the local approving agency.
- The pollution removal efficiency of the sediment tank can be considerably increased by using flocculation chemicals, such as aluminum sulfate, in the tank. Flocculation will allow some very small suspended solids to settle that otherwise would never be removed. The time it takes to settle out larger particulates will also decrease. However, a flocculation tank setup is considerably more complicated as the rate of flocculent addition should be carefully monitored.

Installation Guidelines

Follow manufacturer's specifications.

Temporary Swale BMP 40

Description

A temporary swale is an excavated drainage way designed to prevent runoff from entering disturbed areas by intercepting and diverting it to a stabilized outlet. Another purpose of a temporary swale is to intercept sediment laden-water and divert it to a sediment-trapping device.

Applications

Temporary swales are constructed for the following reasons:

- To divert flows from a disturbed area
- Intermediately across disturbed areas to shorten overland flow distance.
- To direct sediment laden water along the base of slopes to a trapping device.
- To transport off-site flows across disturbed areas such as rights-of-way.
- Swales collecting runoff from disturbed areas should remain in place until the disturbed areas are permanently stabilized.

Limitations

Drainage area – 10 ac.
Minimum bedrock depth – 5 ft
NRCS soil type - BCD
Drainage/flood control – yes
Maximum slope – 14%
Minimum water table – 3 ft
Freeze/thaw – fair

Targeted Pollutants

Sediment
Trace metals

Design Parameters

The following design criteria should be met, depending on the drainage area served by the swale:

	Swale A	Swale B
Drainage Area	5 ac. or less	5-10 ac.
Bottom Width of Flow Channel	4 ft	6 ft
Depth of Flow Channel	1 ft	1 ft
Side Slopes	2:1 or flatter	2:1 or flatter
Grade	0.5% min 20% max	0.5% min, 20% max

- The temporary swale should be designed with an outlet that functions with a minimum of erosion, and dissipates runoff velocity prior to discharge off the site.
- Runoff should be conveyed to a sediment-trapping device such as a sediment trap or sediment basin until the drainage area above the swale is adequately stabilized.
- The on-site location may need to be adjusted to meet field conditions in order to utilize the most suitable outlet condition.
- If a swale is used to divert flows from entering a disturbed area, a sediment-trapping device may not be needed.

Construction Guidelines

- Stabilization of the swale should be completed within 10 days of installation with proper seeding or mulching techniques (see BMP 21-

Seeding or BMP 15-Mulching). The flow channel should be stabilized according to the criteria in Table 40-1 below.

- In highly erodible soils, as defined by the Soil Survey (NRCS) of the project's county, refer to the next higher slope grade for type of stabilization.

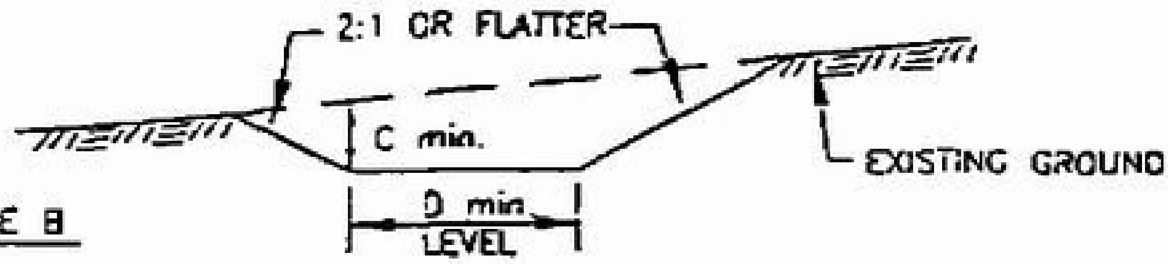
Maintenance

- Remove sediment and debris regularly.
- Mow vegetation regularly to encourage thicker, healthier growth.
- Do not overfertilize; it may compound water quality problems.

Table 40-1. Flow Channel Stabilization Criteria

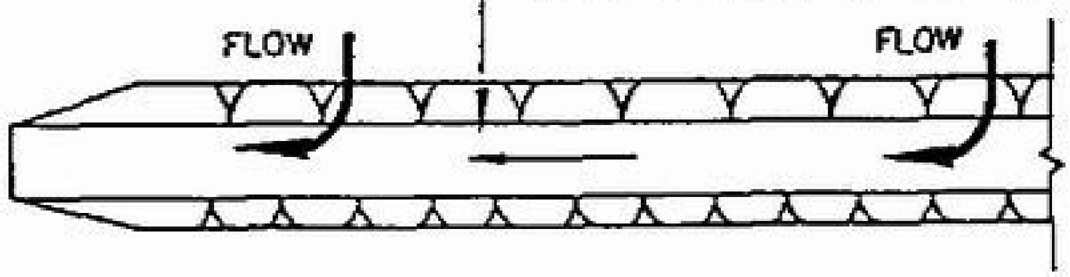
Type of treatment	Channel grade (percent)	Flow Channel A (less than 5 acres)	Flow Channel B (5-10 acres)
1	0.5-3.0	Seed and Straw Mulch	Seed and Straw Mulch
2	3.1-5.0	Seed and Straw Mulch	Seed and cover with Jute or Excelsior; Sod, or line with 2 in. stone
3	5.1-8.0	Seed and cover with Jute or Excelsior; Sod, or line with 2 in. stone	Line with 4-8 in. stone or Recycled Concrete Equivalent[a]
4	9.1-20	Line with 4-8 in. stone or Recycled Concrete Equivalent[a]	Engineering Design

[a] Recycled Concrete Equivalent should be concrete broken into the required size, and should contain no steel reinforcement.

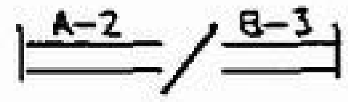


	SWALE A	SWALE B
C	1'	1'
D	4'	6'

CROSS SECTION



STANDARD SYMBOL



OUTLET AS REQUIRED
SEE ITEM NO. 8 BELOW

PLAN VIEW

CONSTRUCTION SPECIFICATIONS

1 ALL TEMPORARY SWALES SHALL HAVE UNINTERRUPTED POSITIVE GRADE TO AN OUTLET.

2 DIVERTED RUNOFF FROM A DISTURBED AREA SHALL BE CONVEYED TO A SEDIMENT TRAPPING DEVICE.

3 DIVERTED RUNOFF FROM AN UNDISTURBED AREA SHALL OUTLET DIRECTLY INTO AN UNDISTURBED STABILIZED AREA AT NON-EROSIVE VELOCITY.

4 ALL TREES, BRUSH, STUMPS, OBSTRUCTIONS AND OTHER OBJECTIONABLE MATERIAL SHALL BE REMOVED AND DISPOSED OF SO AS NOT TO INTERFERE WITH THE PROPER FUNCTIONING OF THE SWALE.

5 THE SWALE SHALL BE EXCAVATED OR SHAPED TO LINE, GRADE AND CROSS SECTION AS REQUIRED TO MEET THE CRITERIA SPECIFIED HEREIN AND BE FREE OF BANK PROJECTIONS OR OTHER IRREGULARITIES WHICH WILL IMPEDE NORMAL FLOW.

6 FILLS SHALL BE COMPACTED BY EARTH MOVING EQUIPMENT.

7 ALL EARTH REMOVED AND NOT NEEDED ON CONSTRUCTION SHALL BE PLACED SO THAT IT WILL NOT INTERFERE WITH THE FUNCTIONING OF THE SWALE.

8 STABILIZATION SHALL BE AS PER THE CHART BELOW.

FLOW CHANNEL STABILIZATION

TYPE OF TREATMENT	CHANNEL GRADE	A (5 AC OR LESS)	B (5 AC-10 AC)
1	0.5-3.0%	SEED AND STRAW MULCH	SEED AND STRAW MULCH
2	3.1-5.0%	SEED AND STRAW MULCH	SEED USING JUTE OR EXCELSIOR
3	5.1-8.0%	SEED WITH JUTE OR EXCELSIOR; SOD	LINED RIP-RAP 4"-8" RECYCLED CONCRETE EQUIVALENT
4	8.1-20%	LINED 4"-8" RIP-RAP	ENGINEERED DESIGNED

9 PERIODIC INSPECTION AND REQUIRED MAINTENANCE MUST BE PROVIDED AFTER EACH RAIN EVENT.

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE	TEMPORARY SWALE	STANDARD DRAWING
TOOTHMAN-ORTON ENGINEERING COMANY BOISE, IDAHO McCALL, IDAHO		TS-1

Earth Dike — BMP 41

Description

An earth dike is a temporary berm or ridge (or ridge-and-channel combination) of compacted soil located in a manner to channel water to a desired location. Earth dikes are used to protect work areas from upslope runoff and to divert sediment-laden water to appropriate traps or stable outlets. The channel portion (if used) generally has a lining of stone, riprap, or vegetation for stabilization.

Applications

Earth dikes are used in construction areas to control erosion, sedimentation, or flood damage. Earth dikes can be used in the following situations:

- Across unprotected slopes, as slope breaks, to reduce length.
- Below slopes to divert excess runoff to stabilized outlets.
- At or near the perimeter of the construction area to keep sediment-laden runoff from leaving the site.
- To protect cut or fill slopes by diverting upslope flows away from disturbed areas to a stabilized outlet.
- To direct any sediment-laden runoff to a sediment-trapping device.
- To direct clean water away from disturbed areas

Limitations

Drainage area – 10 ac.	Maximum slope – 10%
Minimum bedrock depth – 5 ft	Minimum water table – 5 ft
NRCS soil type - ABC	Freeze/thaw – fair
Drainage/flood control – yes	

- Despite an earth dike's simplicity, improper design can limit its effectiveness.
- Frequent inspection and maintenance are essential to the proper performance of this BMP.
- When the drainage area above the earth dike is greater than 10 ac., consult the NRCS standards and specifications for diversions.

Targeted Pollutants

Sediment
Trace metals

Design Parameters

The earth dike should be constructed of compacted soil or coarse aggregate according to the criteria in Table 41-1 below. The channel formed behind the dike should have a positive grade to a stabilized outlet. The channel should be stabilized with vegetation or other stabilization measures. Grades over 10% may require site-specific design developed or approved by a registered engineer.

Construction Guidelines

- Some general considerations include proper compaction of the earth dike, appropriate location to divert the intercepted runoff, and proper ridge height and thickness. Earth dikes should be constructed along a positive grade. Other than the discharge point, there should be no dips or low points where stormwater will collect.

- Runoff intercepted from disturbed areas should be diverted to a sediment-trapping device. Runoff from undisturbed areas can be channeled to an existing swale or to a level spreader. Stabilization for the dike and flow channel (or drainage swale) should be stabilized as soon as possible. Stabilization materials can include vegetation, stone, or riprap.
- Construct the dike where it will not interfere with major areas of construction traffic so that vehicle damage to the dike will be kept to the minimum.
- Install the dike prior to the majority of soil disturbing activity. The dike may be removed when stabilization of the drainage area and outlet are complete.
- Clear the area of all trees, brush, stumps, or other obstructions.
- Construct the dike to the designed cross-section, line and grade making sure that there are no irregularities or bank projections to impede the flow. Construct the connecting portion to any stream channel last.
- The dike should be compacted using earth-moving equipment (to prevent failure of the dike).
- The dike should be stabilized at least 10 days after installation. The flow channel should be stabilized according to the criteria in Table 41-2 below. In highly erodible soils, as defined by NRCS Soil Survey of the project's county, refer to the next higher slope grade for type of stabilization.
- Earth dikes should have an outlet that function with a minimum of erosion. Runoff should be conveyed to a sediment-trapping device until the drainage area above the dike is adequately stabilized. The on-site location may need to be adjusted to meet field conditions in order to utilize the most suitable outlet.

Maintenance

- Inspect diversion dikes regularly and after every storm. Make any repairs necessary to ensure they are in good working order.
- Inspect the dike, flow channel and outlet for deficiencies or signs of erosion.
- If material should be added to the dike, be sure it is properly compacted.
- Reseed/stabilize the dike as needed to maintain its stability regardless if there has been a storm event or not.

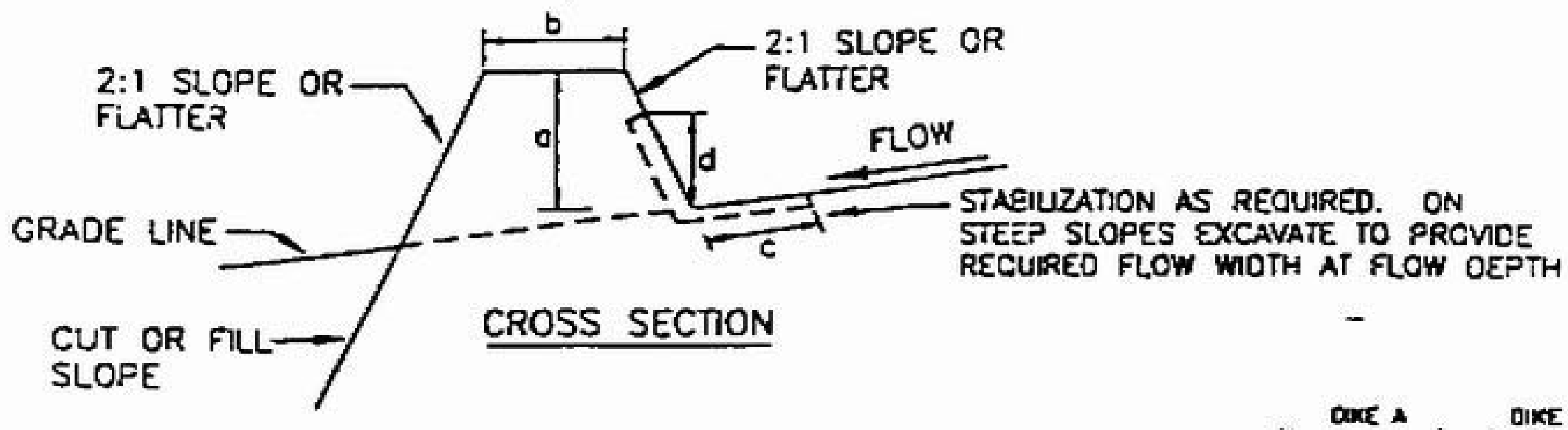
Table 41-1. Suggested Dike Design Criteria

Criteria	Drainage area < 5 acres	Drainage area between 5 to 10 acres
Dike Height	18 in.	3 ft
Dike Width	2 ft	3 ft
Flow Width	4 ft	6 ft
Flow Depth in channel	8 in.	15 in.
Side Slopes	2:1 or flatter	2:1 or flatter
Grade	0.5% - 20%	0.5% - 20%

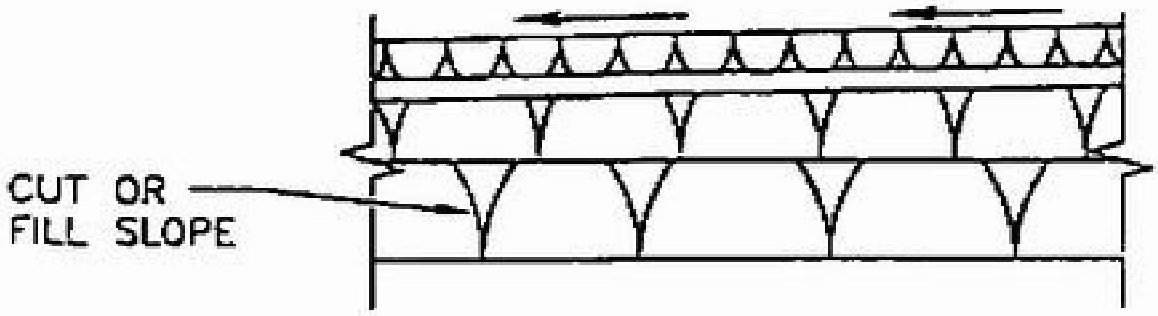
Table 41-2. Criteria for Earth Dike Construction

Type of treatment	Channel grade (percent)	Flow channel A (less than 5 acres)	Flow channel B (5-10 acres)
1	0.5-3.0	Seed and Straw Mulch	Seed and Straw Mulch
2	3.1-5.0	Seed and Straw Mulch	Seed and cover with Jute or Excelsior; Sod, or line with 2 in. stone
3	5.1-8.0	Seed and cover with Jute or Excelsior; Sod, or line with 2 in. stone	Line with 4-8 in. stone or Recycled Concrete Equivalent
4	8.1-20	Line with 4-8 in. stone or Recycled Concrete Equivalent	Engineering Design

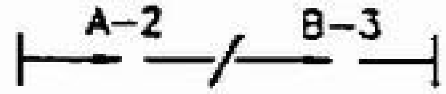
[a] Recycled Concrete Equivalent should be concrete broken into the required size, and should contain no steel reinforcement.



	DIKE A (5 ac. or less)	DIKE B (5–10 ac.)
a–DIKE HEIGHT	18"	36"
b–DIKE WIDTH	24"	36"
c–FLOW WIDTH	4'	6'
d–FLOW DEPTH	8"	15"



STANDARD SYMBOL



CONSTRUCTION SPECIFICATIONS

1 ALL DIKES SHALL BE COMPACTED BY EARTH–MOVING EQUIPMENT.
2 ALL DIKES SHALL HAVE POSITIVE DRAINAGE TO AN OUTLET.
3 TOP WIDTH MAY BE WIDER AND SIDE SLOPES MAY BE FLATTER IF DESIRED TO FACILITATE CROSSING BY CONSTRUCTION TRAFFIC.
4 FIELD LOCATION SHOULD BE ADJUSTED AS NEEDED TO UTILIZE A STABILIZED SAFE OUTLET.
5 EARTH DIKES SHALL HAVE AN OUTLET THAT FUNCTIONS WITH A MINIMUM OF EROSION. RUNOFF SHALL BE CONVEYED TO A SEDIMENT TRAPPING DEVICE SUCH AS A SEDIMENT TRAP OR SEDIMENT BASIN WHERE EITHER THE DIKE CHANNEL OR THE DRAINAGE AREA ABOVE THE DIKE ARE NOT ADEQUATELY STABILIZED.
6 STABILIZATION SHALL BE: (A) IN ACCORDANCE WITH STANDARD SPECIFICATIONS FOR SEED AND STRAW MULCH OR STRAW MULCH IF NOT IN SEEDING SEASON. (B) FLOW CHANNEL AS PER THE CHART BELOW.

FLOW CHANNEL STABILIZATION

TYPE OF TREATMENT	CHANNEL GRADE	DIKE A	DIKE B
1	0.5–3.0%	SEED AND STRAW MULCH	SEED AND STRAW MULCH
2	3.1–5.0%	SEED AND STRAW MULCH	SEED USING JUTE OR EXCELSIOR; SOD; 2" STONE
3	5.1–8.0%	SEED WITH JUTE OR SOD; 2" STONE.	LINED RIP–RAP 4"–8"
4	8.1–20%	LINED RIP–RAP 4"–8"	ENGINEERING DESIGN

A. STONE TO BE 2 INCH STONE, OR RECYCLED CONCRETE EQUIVALENT, IN A LAYER AT LEAST 3 INCHES IN THICKNESS AND BE PRESSED INTO THE SOIL WITH CONSTRUCTION EQUIPMENT.
B. RIP–RAP TO BE 4–8 INCHES IN A LAYER AT LEAST 8 INCHES IN THICKNESS AND PRESSED INTO THE SOIL.
C. APPROVED EQUIVALANTS CAN BE SUBSTITUTED FOR ANY OF THE ABOVE MATERIALS.

7 PERIODIC INSPECTION AND REQUIRED MAINTENANCE MUST BE PROVIDED AFTER EACH RAIN EVENT.

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE	EARTH DIKE	STANDARD DRAWING
TOOTHMAN–ORTON ENGINEERING COMANY BOISE, IDAHO McCALL, IDAHO		ED–1

Perimeter Dike/Swale BMP 42

Description

A perimeter dike/swale is a temporary ridge of soil excavated from an adjoining swale located along the perimeter of the site or disturbed area. The purpose of a perimeter dike/swale is to prevent off-site storm runoff from entering a disturbed area and to prevent sediment laden storm runoff from leaving the construction site or disturbed area.

Applications

- A perimeter dike/swale is constructed to divert flows from entering a disturbed area, along top of slopes to prevent flows from eroding the slope, or along base of slopes to direct sediment laden flows to a trapping device.
- The perimeter dike/swale should remain in place until the disturbed areas are permanently stabilized.

Limitations

Drainage area – 2 ac.
Minimum bedrock depth – 5 ft
NRCS soil type – ABC
Drainage/flood control – yes
Maximum slope – 10%
Minimum water table – 5 ft
Freeze/thaw – fair

Targeted Pollutants

Sediment
Trace metals

Design Parameters

The perimeter dike/swale should not be constructed outside the property lines without obtaining legal easements from effected adjacent property owners.
A detailed design is not required for the perimeter dike/swale. However, the following criteria should be used:

- Drainage area: Less than 2 acres (for drainage areas larger than 2 acres, but less than 10 acres, see BMP 41-Earth Dike; for drainage areas larger than 10 acres, see BMP 44-Storm Drain Diversion)
- Height: 18 in. minimum from bottom of swale to top of dike evenly divided between dike height and swale depth
- Bottom width of dike: 2 ft minimum
- Width of swale: 2 ft minimum
- Grade: Dependent upon topography, but should have positive drainage (sufficient grade to drain) to an adequate outlet. Maximum allowable grade not to exceed 20%.

Outlet

- The perimeter dike/swale should have an outlet that function with a minimum of erosion.
- Diverted runoff from a protected or stabilized upland area should outlet directly onto an undisturbed stabilized area.
- Diverted runoff from a disturbed or exposed upland area should be conveyed to a sediment-trapping device such as a sediment trap (BMP 38), or to an area protected by any of these practices.
- The on-site location may need to be adjusted to meet field conditions in

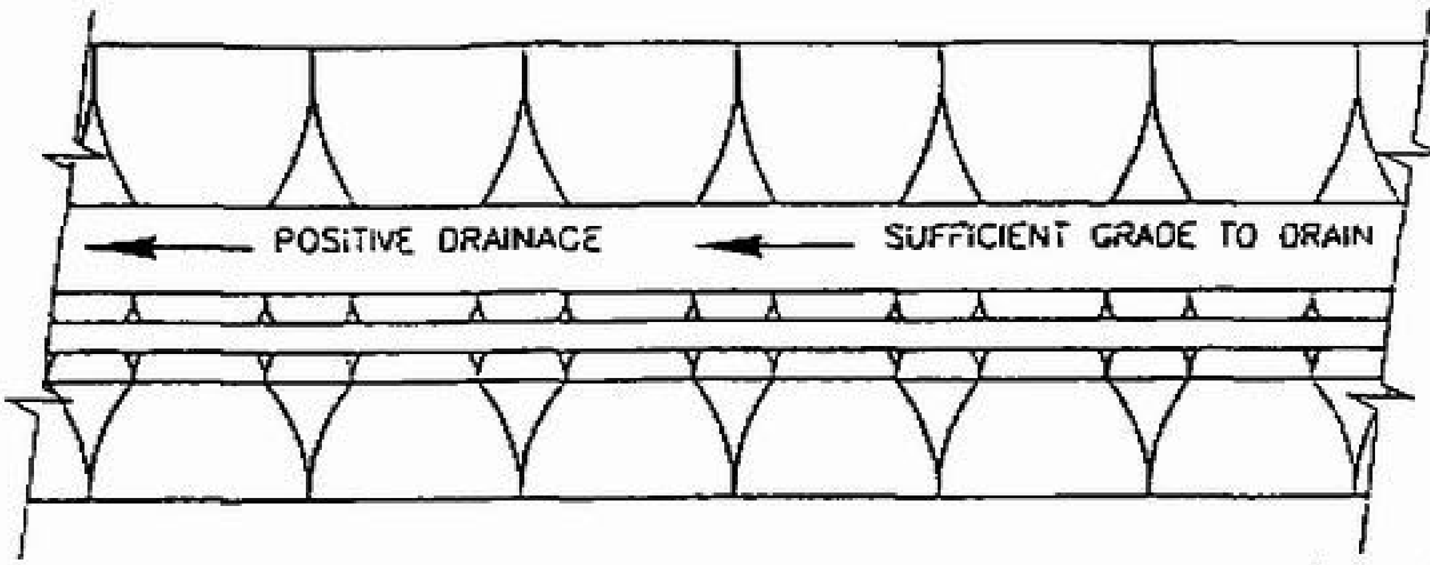
order to utilize the most suitable outlet.

Construction Guidelines

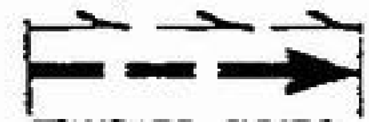
The disturbed area of the dike and swale should be stabilized within 10 days of installation, in accordance with the guidelines seed and straw mulch or straw mulch only if not in the seeding season.

Maintenance

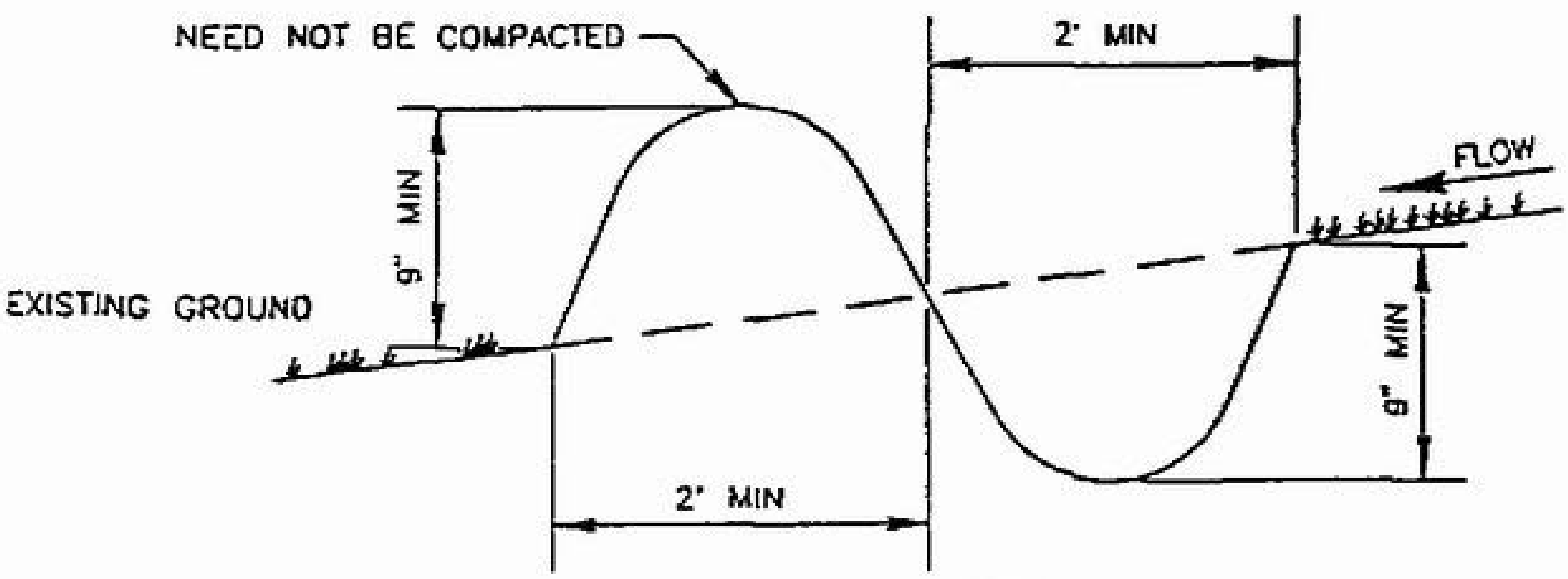
See BMP 41 - Earth Dike



PLAN VIEW



STANDARD SYMBOL



CROSS SECTION

CONSTRUCTION SPECIFICATIONS

1 ALL PERIMETER DIKE/SWALE SHALL HAVE UNINTERRUPTED POSITIVE GRADE TO AN OUTLET.

2 DIVERTED RUNOFF FROM A DISTRUBED AREA SHALL BE CONVEYED TO A SEDIMENT TRAPPING DEVICE.

3 DIVERTED RUNOFF FROM AN UNDISTURBED AREA SHALL OUTLET INTO AN UNDISTURBED STABILIZED AREA AT NON-EROSION VELOCITY.

4 THE SWALE SHALL BE EXCAVATED OR SHAPED TO LINE, GRADE AND CROSS SECTION AS REQUIRED TO MEET THE CRITERIA SPECIFIED IN THE STANDARD.

5 STABILIZATION OF THE AREA DISTURBED BY THE DIKE AND SWALE SHALL BE DONE IN ACCORDANCE WITH THE STANDARD AND SPECIFICATION FOR SEED AND STRAW MULCH, AND SHALL BE DONE WITHIN 10 DAYS.

6 PERIODIC INSPECTION AND REQUIRED MAINTENANCE MUST BE PROVIDED AFTER EACH RAIN EVENT

MAXIMUM DRAINAGE AREA LIMIT: 2 ACRES

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE	PERIMETER DIKE/SWALE	STANDARD DRAWING
TOOTHMAN-ORTON ENGINEERING COMANY BOISE, IDAHO McCALL, IDAHO		PDS-1

Temporary Berms BMP 43

Description

A temporary berm is a ridge of compacted soil, compost, or sandbags which intercepts and diverts runoff from small construction areas. Temporary berms are often constructed along the top edge of fill slopes but may also be constructed across the roadway (as a transverse berm) at a slight angle with the centerline.

Berms are used to prevent runoff onto newly constructed slopes until vegetation is established or until permanent measures are in place. They intercept flow from the construction area and direct it to temporary slope drains or to outlets where it can be safely discharged.

Applications

Temporary berms are used to direct or divert runoff flows, or as barriers to collect and store runoff. They are used at storm drain inlets, across minor swales and ditches, and for other applications where the structure is of a temporary nature.

Limitations

Drainage area – 5 ac.	Maximum slope – 50%
Minimum bedrock depth - N/A	Minimum water table - N/A
NRCS soil type – ABCD	Freeze/thaw – good
Drainage/flood control – yes	

Temporary berms do not provide filtration. Therefore, they can only be used for minor flows.

Targeted Pollutants

Sediment

Design Parameters

Soil berm: A berm of soil with an approximate height of 12 to 20 in. with a minimum top width of 2 to 3 ft and side slopes of 2:1 or flatter. Berms should be high enough to prevent flow from overtopping. Berms are normally constructed from embankment materials.

Compost berm: Compost filter berms will perform most effectively when constructed 1 ft high by 2 ft wide and 1.5 ft high by 3 ft wide.

Sandbag berm: The following dimensions are suitable for sandbag berms.

- Height - 20 in. minimum
- Top width - 20 in. minimum
- Bottom width - approximately 4.25 to 5 ft
- Sandbag size - length 2 to 2.6 ft, width 16 to 20 in., depth or thickness 6 to 8 in., and weight 88 to 132 lb

Construction Guidelines

Soil berm:

- All berms should be graded to drain to a slope drain inlet. When practical, embankments should be constructed with a gradual slope to one side of the embankment. This will permit the placement of all temporary berms and slope drains on one side of the embankment. When fills are constructed on sidehill slopes, the top surface should slope toward the inside so that surface runoff will be away from the fill slope.

- Compact the entire width of the berm. This can be accomplished with the track of a bulldozer or, preferably, with a grader wheel (rubber).

Compost berm: The American Association of State Highway and Transportation Officials (AASHTO) recently adopted test and particle size parameters for compost berms for controlling erosion. See Table 43-1 for recommendations on selecting the best compost for use in filter berms.

Sandbag berm:

- Install so that flow under or between bags is prevented.
- Stack the sandbags in an interlocking fashion to provide additional strength for resisting the force of the flowing water. However, do not stack them more than three high without broadening the foundation using additional sandbags or providing additional stability.
- Sandbag sediment barriers should store the runoff from design storm as specified.

Maintenance

- Temporary berms should be inspected and repaired periodically as well as after each significant rainfall.
- Sandbags should be reshaped or replaced as needed during inspection. Additional inspections should be made daily during wet weather. When silt reaches 6 in., the accumulated silt should be removed and disposed of at an approved site in a manner that will not contribute to additional siltation. The sandbag berm should be left in place until all upstream areas are stabilized and accumulated silt has been removed. Removal of bags should be done by hand.

Table 43-1. Compost filter berm parameters

Parameters	Filter Berm to be Vegetated	Filter Berm to be left Un-vegetated
pH	5.0-8.5	N/A
Soluble Salt Concentration (electrical conductivity in dS/m)	Maximum 5	N/A
Moisture Content (%, wet weight basis)	30-60	30-60
Organic Matter Content (%, dry weight basis)	25-65	25-100
Particle Size (% passing a selected mesh size, dry weight basis)	3 in., 100% passing 1 in., 90% to 100% passing ¾ in., 70% to 100% passing ¼ in., 30% to 75% passing Maximum: Particle size length of 6 in. (no more than 60% passing ¼	3 in., 100% passing 1 in., 90% to 100% passing ¾ in., 70% to 100% passing ¼ in, 30% to 75% passing Maximum: Particle size length of 6 in. (no more than 50% passing ¼

	in. in high rainfall/flow rate situations)	in. in high rainfall/flow rate situations)

Temporary Storm Drain Diversion BMP 44

Description

The re-direction of a storm drain line or outfall channel so that it may temporarily discharge into a sediment-trapping device. The purpose is to prevent sediment-laden water from entering a watercourse, public or private property through a storm drain system, or to temporarily provide underground conveyance of sediment-laden water to a sediment trapping device.

Applications

One of the following practices or procedures should be used whenever the off-site drainage area is less than 50% of the on-site drainage area to that system. A special exception may be given, at the discretion of the local permitting authority, where site conditions make this procedure impossible.

Limitations

Drainage area – 5 acres	Maximum slope – 50%
Minimum bedrock depth - N/A	Minimum water table - N/A
NRCS soil type - ABCD	Freeze/thaw – good
Drainage/flood control – yes	

Targeted Pollutants

Sediment

Design Methods

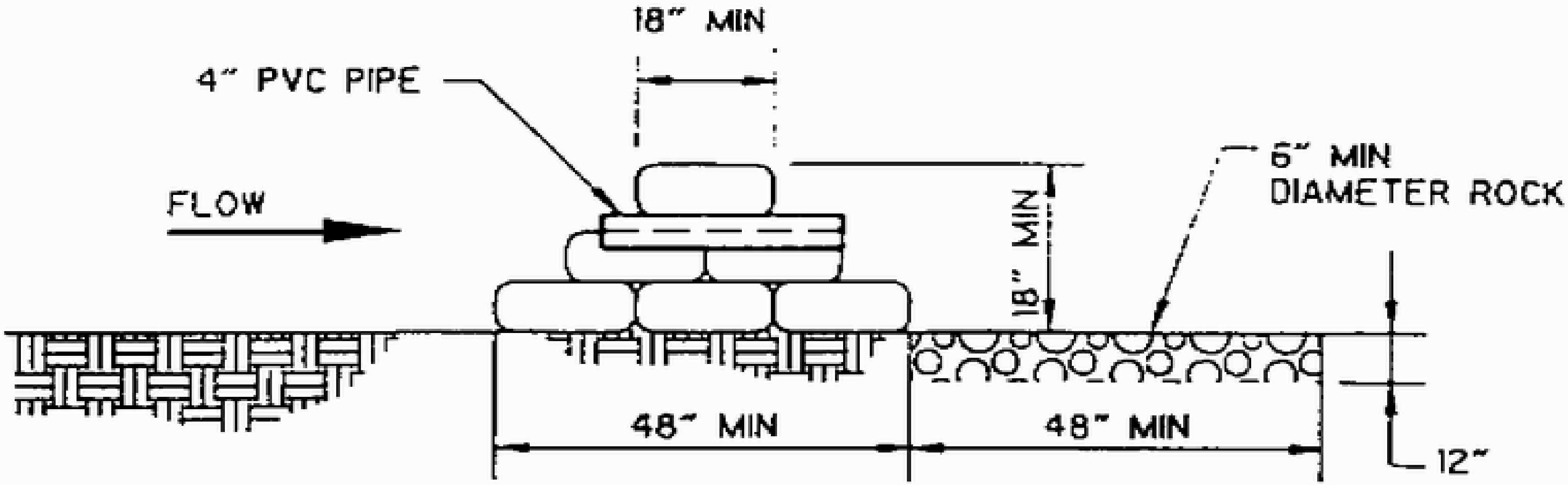
- Construction of a sediment trap (see BMP 38) below a permanent storm drain outfall: Temporarily divert storm flow into the basin or trap constructed below permanent outfall channel.
- In-line diversion of storm drain at an inlet or manhole: Achieved by installing a pipe stub in the side of a manhole or inlet and temporarily blocking the permanent outfall pipe from that structure. A temporary outfall ditch or pipe may be used to convey storm flow from the stub to a sediment trap or basin. This method may be used just above a permanent outfall or prior to connecting into an existing storm drain system.
- Delay completion of the permanent storm drain outfall and temporarily divert storm flow into a sediment trap: Earth dike (BMP 41), swale (BMP 40), or designed diversion is used, depending on the drainage area, to direct flow into a sediment trap. The trap should be constructed to one side of the proposed permanent storm drain location whenever possible.
- Installation of a stormwater management basin early in the construction sequence: Install temporary measures to allow use as a sediment basin. Since these structures are designed to receive storm drain outfalls, diversion should not be necessary.

Completion and Disposition

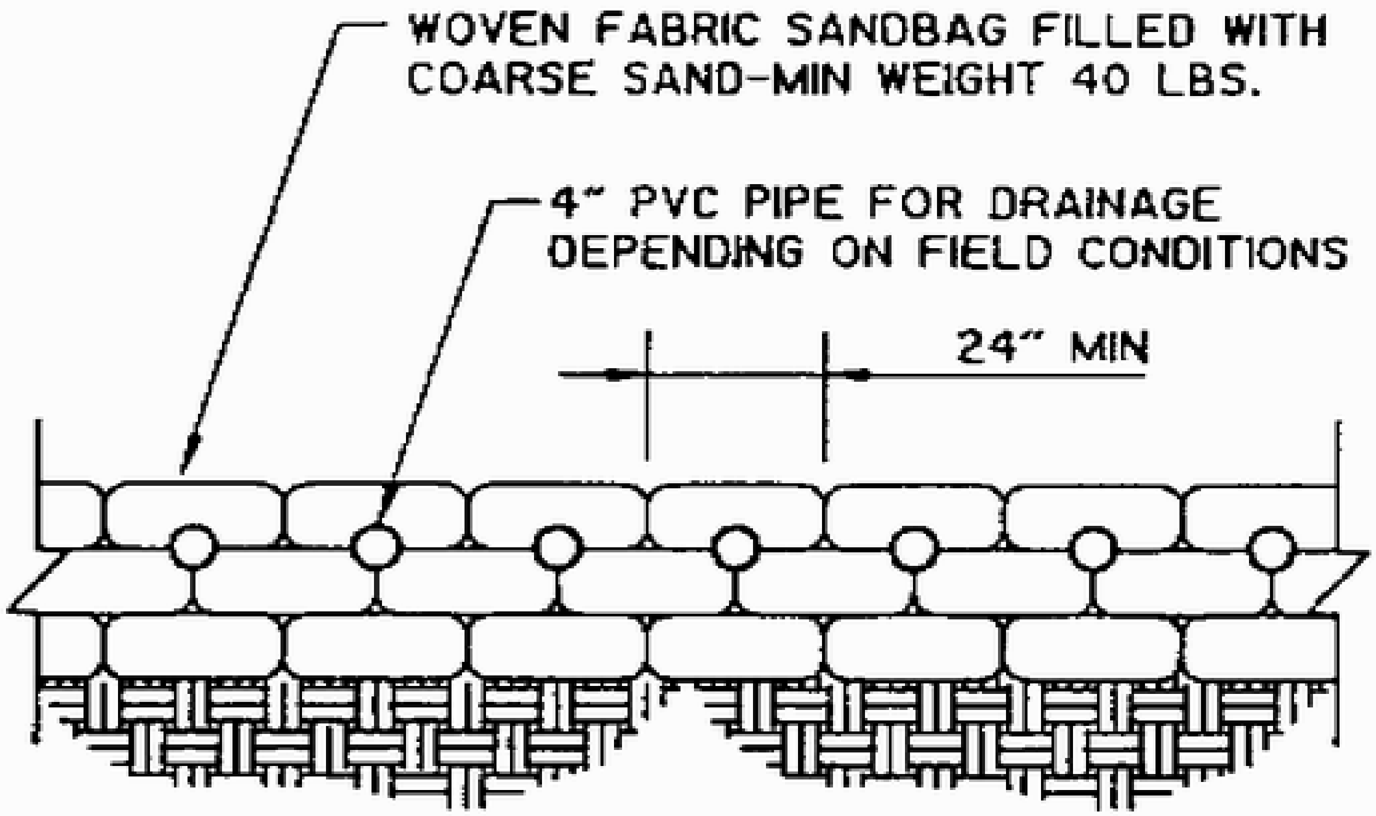
When the areas contributing sediment to the system have been stabilized procedures can be taken to restore the system to its planned use.
The following removal and restoration procedure is recommended:

- Flush the storm drain system to remove any accumulated sediment.
- Remove the sediment control devices, such as traps, basins, dikes, swales, etc.
- For sites where an inlet was modified, brick shut the temporary pipe stub and open the permanent outfall pipe.

- Establish permanent stabilized outfall channel as noted on the plans.
- Restore the area to grades shown on the plan and stabilize with vegetative measures.
- For basins that will be converted to stormwater management, remove the accumulated sediment, open the low flow orifice, and seed all disturbed areas to permanent vegetation.



CROSS-SECTION



FRONT VIEW

SAND BAG BERM

Instream Sediment Trapping Devices BMP 45

Description

Instream sediment trapping devices include both floating materials (turbidity curtains) anchored to the watercourse bottom and instream sediment collection mats that run along the watercourse bottom (Sedimat™). These materials are specifically designed to limit sediment transport impacts within a body of water. Turbidity curtains are floating silt fences that allow water to pass through but retain soil particles and other debris. Depending on the curtain's permeability, they can also slow the flow of water enough to give sediment time to settle.

Applications

To provide sedimentation protection for in-stream, bank, or upslope ground disturbance or from dredging or filling within a waterway. Practice applies within a flowing watercourse, lake, or other area of water impoundment or flow that has aquatic resources needing protection. Also applies when runoff occurs close to rivers, streams, lakes, reservoirs, or when construction projects take place on or under water.

Limitations

Drainage area – N/A
Minimum bedrock depth - N/A
NRCS soil type – N/A
Drainage/flood control – N/A
Maximum slope – N/A
Minimum water table - N/A
Freeze/thaw – N/A

Turbidity curtains should not be installed across streams unless they are specifically engineered to stop sand bar creation and are approved by appropriate local, state and/or federal authorities.

Targeted Pollutants

Sediment

Design Parameters

These BMPs are designed and selected for specific flow conditions. For sites with flow velocities or currents greater than 5 ft per second, a qualified engineer and product manufacturer should approve of the use.

- Materials should be of strong, heavy-weight materials that have ultraviolet light (UV) inhibitors. The tensile strength should be sufficient to withstand predicted flows. All material seams and line attachments should be sewn or vulcanized welded into place. Materials should be of bright colors, when applicable, to attract attention of boaters or swimmers using areas near the work site. Flotation devices for turbidity curtains should be flexible, buoyant units contained in an individual flotation sleeve or collar attached to the curtain.
- Shoreline turbidity curtain anchors and instream sediment mat anchors should be 2 x 4 or 1.33 pounds/lineal ft metal stakes. Bottom anchors for turbidity curtains should hold the curtain in position and may be any of the following anchor types: plow, fluke, mushroom, or a grappling hook. All instream anchors should have a floating anchor buoy or other identifying mark.

This is a partial listing of some of the proprietary products available:

- Brockton Equipment markets and customizes the Siltdam in a number of ways. Vinyl-cased polyethylene flotation logs are attached to a skirt of woven polypropylene, and the skirts are available in different permeabilities and lengths. A sealed pocket at the bottom of the skirt holds a galvanized steel chain for ballast.
- Indian Valley Industries produces turbidity curtains to specification, depending on water-flow rate, depth of channel, desired filtering properties and, if necessary, tide action. The 50-ft standard curtains have grommets along the bottom skirt edge so they can be anchored to the channel bottom.
- The SiltMaster, a floating turbidity curtain manufactured by Parker Systems Inc. of Chesapeake, VA, comes with various skirt lengths. Similar to the Siltdam, it has a chain ballast at the bottom of the skirt. The skirt is of either a permeable geotextile fabric to allow water but not silt to pass through or, if specified, an impermeable vinyl or urethane-coated fabric.

Construction Guidelines

For manufactured products, install as per manufacturer's instructions.

- Turbidity curtains should be installed parallel to flow of the watercourse allowing for 10 to 20% variance in the straight-line measurements. Allow for at least 50 ft between joints in the curtain and no more than 100 ft between anchor or stake locations.
- Instream sediment mats can be aligned either direction along the watercourse bottom, as long as upstream mat overlaps the downstream mat (like a drainage ditch erosion control blanket installation). Ensure the upstream edge is firmly trenched in to prevent flows from going under the mat. Mats should cross the entire stream and be staked or use stones to keep the mat in place. Follow the manufacturer's specifications for length of mat needed for the site's flow rate.
- Turbidity curtains should extend the entire depth of the watercourse. In significant wind or wave action areas a 10- to 12-ft depth is the most practical due to fabric and mooring anchor strain from the heavy-water and sediment loads.
- Soils should be allowed to settle for a minimum of 6 to 12 hours prior to BMP removal and cleaning. All cleaning operations should also use good sediment control practices. Consider sizing materials adequately to allow for maintenance only prior to removal, and not throughout project.
- In areas heavily impacted by wind generated wave action; turbidity curtains should have slack to follow the rise and fall of the water level without submerging. Curtains should also maintain adequate flow through, usually by using heavier woven fabric from the bottom sections of the curtain.
- Setting the upstream anchor points first, then unfurling the fabric and letting the flow carry the fabric downstream or to vertical position achieves best installation.

Maintenance Removal

Follow manufacturer instructions for fabric and material repair.

- All materials should be removed at low flows and in such a fashion as to scoop and trap sediments within the fabric. The removal area should be clear of any obstructions that could tear the fabric. For mats, consider rolling up from the downstream end to trap silts in the mat roll. For curtains, consider pulling the bottom line and top lines in together like a parachute to pull soils ashore.
- Spoils should be dewatered and reused on a nearby bank or upland area needing additional fill. Controls should be in place to ensure that the sediment does not re-enter the waterway.

Dewatering BMP 46

Description

To assess and appropriately dispose of rising groundwater or rainwater from excavations and other collection areas.

Applications

Public or private properties with the following:

- Foundation work excavations
- Utilities and infrastructure installation and repair projects, including installation, repair and maintenance of:
  - ✓ Electrical conduits
  - ✓ Vaults/tanks
  - ✓ Sewer and storm drain systems
  - ✓ Phone and cable lines
  - ✓ Gas or other fuel lines
- Other excavations or graded areas requiring dewatering

Limitations

Drainage area – N/A	Maximum slope – N/A
Minimum bedrock depth - N/A	Minimum water table - N/A
NRCS soil type – N/A	Freeze/thaw – N/A
Drainage/flood control – yes	

Targeted Pollutants

Sediment

Design Parameters

Depending on season, flow rate, volume, or residual contamination, the discharge will be allowed to flow to:

- The ground in a manner that ensures no runoff leaving the site. This may require a permit or other authorization from the local drainage authority.
- The storm drain system. A permit or letter of authorization with discharge restrictions may be required.
- The sanitary sewer. A permit or letter of authorization with discharge restrictions may be required.

The site should be assessed for the issues listed below to assist the local drainage authority in determining which discharge option to approve:

- Water clarity. If the water is cloudy or turbid, there are dissolved and/or settable solids in the water that should be filtered or settled out prior to discharge. Determine if contaminants are present in impounded water. Check for odors, discoloration, or oily sheen. Check any soils and/or groundwater testing results.
- If contamination may be or is present, a certified laboratory should test the proposed discharge waters with results submitted to the local drainage authority. Sampling and testing requirements will be determined on a case-by case basis depending on site history or suspected pollutants. Contact DEQ or the local authority responsible for receiving system before testing to get assistance in identifying the required parameters of concern and any specific sampling requirements. After review, the local drainage authority will specify if any pretreatment is required prior to discharge.

Construction Guidelines

Sediment should be settled prior to discharge. All settling systems should be engineered and adequately sized for site conditions. In general settling and filtering options include the following:

- Containment in a pond structure for a minimum of 4 hours or until water is clear. Place pump in a gravel bed at bottom of pond.
- Pumping to a settling tank with sampling ports
- Filtering through a sieve or other filter media (swimming pool filter). Simple on-site filter systems can be constructed including: wrapping the ends of the suction and discharge pipes with filter fabric; discharging through a series of drums filled with successively finer gravel and sand; and other filtering techniques like those described in the inlet protection section.
- Manufactured bags, polymers, or other systems. These systems do not always work on fine clay soils, and will only be allowed for use where approved. Chemical treatments should have state approval before they are used.

- The flow path should be lined or protected in some way to prevent mobilization of additional sediment.

Filtered material should be either dried and reused on site in a mixture with other site soils or should be appropriately disposed of based on nature and levels of any contaminants present.

Maintenance

- Remember to check filtering devices frequently to make sure they are unclogged and operating correctly. Adjustments may be needed depending on the amount of sediment in the water being pumping.
- Systems should be filled in or otherwise removed when permanent dewatering controls are in place and connected to an approved treatment and receiving system.

Table 1. Selection Matrix for Best Management Practices	Targeted Pollutants					Physical Constraints							
	Sediment	Phosphorus	Trace Metals	Bacteria	Petroleum Hydrocarbons	Drainage area (acres)	Maximum slope (%)	Minimum depth to bedrock, ft	Depth to high water table, ft	SCS soil type[1]	Use with freeze/thaw cycle	Drainage/flood control	Expected life[2]
General Construction Site Guidelines (Erosion Controls)													
Timing of construction	◖	○	○	○	○	unlimited	Unlimited	NA	NA	ABCD	Good		
Staging areas	◖	○	○	○	○	unlimited	15	NA	NA	ABCD	Good	Yes	
Preservation of existing vegetation	●	○	○	○	○	unlimited	Unlimited	NA	NA	ABCD	Good		
Clearing limits	●	○	○	○	○	unlimited	Unlimited	NA	NA	ABCD	Good		
Stabilization of construction entrance	●	◖	◖	○	◖	unlimited	15	3	NA	ABCD	Good		2+ yrs
Erosion prevention on temporary and private roads	●	◖	◖	○	◖	unlimited	15	3	NA	ABCD	Good		
Housekeeping (Source Controls)													
Dust control	●	○	◖	○	◖	NA	5	NA	NA	NA	NA		
Cover for materials and equipment	●	○	●	○	●	NA	NA	NA	NA	NA	NA		
Stockpile management	●	○	●	○	●	NA	NA	NA	NA	NA	NA		
Spill prevention and control	○	○	◖	○	◖	NA	NA	NA	NA	NA	NA		
Vehicle/equipment washing and maintenance	●	●	●	○	●	NA	5	NA	NA	BCD	NA		
Waste management	◖	○	◖	○	○	NA	NA	NA	NA	NA	NA		

Table 1. Selection Matrix for Best Management Practices (cont.)	Targeted Pollutants					Physical Constraints							
	Sediment	Phosphorus	Trace Metals	Bacteria	Petroleum Hydrocarbons	Drainage area (acres)	Maximum slope (%)	Minimum depth to bedrock, ft	Depth to high water table, ft	SCS soil type[1]	Use with freeze/thaw cycle	Drainage/flood control	Expected life[2]
Concrete waste management	◖	○	○	○	○	NA	NA	NA	NA	NA	NA		
Sanitary/septic waste management	◖	○	○	●	○	NA	NA	NA	NA	NA	NA		
Slope Protection (Erosion Controls)													
Mulching	●	◖	○	○	○	2	NA	NA	NA	ABCD	Fair		6-8 mths
Hydraulic mulching	●	◖	○	○	○	100	15	NA	NA	ABCD	Fair		6-8 mths
Geotextile	●	○	○	○	○	100	100	NA	NA	ABCD	Good		8-12 mths
Matting	●	○	○	○	○	Unlimited	100	2	NA	ABCD	Good		6 mths
Soil binders	●	◖	○	○	○	Unlimited	NA	NA	NA	ABCD	Fair		6-12 mths
Topsoiling	●	○	○	○	○	unlimited	50	3	2	NA	Fair		
Seeding	●	◖	◖	○	○	unlimited	5	2	2	ABCD	Fair		Permanent
Sodding	●	◖	◖	○	○	unlimited	14	2	2	ABCD	Fair		Permanent
Planting	●	◖	◖	○	○	unlimited	50	3	3	ABCD	Fair		Permanent
Pipe slope drain	●	○	○	○	◖		50	2	25	ABCD	Good	Yes	1 yr – permanent
Slope roughening	●	○	○	○	○	1	20	3	55	BCD	Good		
Gradient terracing	●	○	○	○	○	10	50	6	58	BCD	Good	Yes	
Retaining walls	●	○	○	○	○	Unlimited	67	NA	83	ABCD	Fair		

Table 1. Selection Matrix for Best Management Practices (cont.)	Targeted Pollutants					Physical Constraints							
	Sediment	Phosphorus	Trace Metals	Bacteria	Petroleum Hydrocarbons	Drainage area (acres)	Maximum slope (%)	Minimum depth to bedrock, ft	Depth to high water table, ft	SCS soil type[1]	Use with freeze/thaw cycle	Drainage/flood control	Expected life[2]
Channel and Stormdrain Protection													
Temporary channel liners	●	○	○	○	○	NA	NA	NA	NA	ABCD	Good		
Gabions	●	○	○	○	○	Unlimited	40	NA	2	ABCD	Good		
Riprap slope and outlet protection	●	○	○	○	○	5	40	NA	NA	ABCD	Good		Permanent
Inlet protection	●	○	○	○	○	1	5	2	2	ABCD	Good		1 yr
Check dams	●	○	○	○	○	10	50	2	NA	ABCD	Good	Yes	6 mths-1 yr
Temporary stream crossing	●	○	○	○	◖	NA	NA	2	NA	ABCD	Good	Yes	6 mths
Sediment Collection and Runoff Diversion (Sediment Controls)													
Biofilter bags	●	○	○	○	○	1ac/400 ft	2 (bales) 10 bags	2	2	ABCD	Fair		3 mths
Fiber rolls	●	○	○	○	○	Varies w/use	Varies w/use	2	2	ABCD	Good	Yes	6 mths
Silt fence	●	○	○	○	○	1ac/400 ft	33	2	2	ABCD	Good		6 mths
Vegetative buffer strip	●	○	○	○	○	Unlimited	20	5	3	ABCD	Fair		Permanent
Sediment trap (basin)	●	○	◖	○	○	5	10	3	2	BCD	Good		8-18 mths
Portable sediment tank	●	○	◖	○	○	5	NA	NA	NA	NA	Good		Permanent
Temporary swale	●	○	◖	○	○	10	14	5	3	BCD	Fair	Yes	2 yrs
Earth dike	●	○	◖	○	○	10	10	5	5	ABC	Fair	Yes	2-25 yrs

Table 1. Selection Matrix for Best Management Practices (cont.)	Targeted Pollutants					Physical Constraints							
	Sediment	Phosphorus	Trace Metals	Bacteria	Petroleum Hydrocarbons	Drainage area (acres)	Maximum slope (%)	Minimum depth to bedrock, ft	Depth to high water table, ft	SCS soil type[1]	Use with freeze/thaw cycle	Drainage/flood control	Expected life[2]
Perimeter dike/swale	●	○	◖	○	○	2	10	5	5	ABC	Fair	Yes	2 yrs
Temporary berms	●	○	○	○	○	5	50	NA	NA	ABCD	Good	Yes	
Temporary storm drain diversion	●	○	○	○	○	5	50	NA	NA	ABCD	Good	Yes	
Instream sediment trapping devices	●	○	○	○	○	NA	NA	NA	NA	ABCD	Good		
Dewatering	●	○	○	○	○	NA	NA	NA	NA	ABCD	Good		

● = very effective, removes > 70% of pollutant ◖ = moderately effective, removes 25-70% of pollutant ○ = least effective, removes < 25% of pollutant

N/A = Not applicable

[1] NRCS soil types (A,B,C,D) range from A = high infiltration to D = little or no infiltration

[2] Longevity data collected from various sources, including Panhandle Health District 1996, Boise City 1997, and EPA 1993. The numbers shown represent industry guidelines; the actual life expectancy is dependent on proper design, placement, and maintenance of BMPs.

The pollutant removal efficiencies given above are for planning purposes only. Actual removal rates are dependent on specific site characteristics, maintenance, and other factors. The following sources were used to determine the most likely average removal rate for conditions prevalent in Idaho: California 1993, Debo and Reese 1995, King County 1994, King County 1995, Maine 1995, Minnesota 1989, Panhandle Health District 1996, Portland 1991, and USEPA 1995.

Appendix A - References

California, 1993. Camp Dresser and McKee, Larry Walker Associates, Resources Planning Associates for Stormwater Quality Task Force. March 1993. "California Storm Water Best Management Practice Catalogs."

Fifield, J.S., 1997. "Field Manual for Effective Sediment and Erosion Control Methods." Parker, Colorado: Hydrodynamics Incorporated.

Maine, 1995. Maine Department of Environmental Protection. November 1995. "Stormwater Management for Maine: Best Management Practices."

Minnesota, 2000. Minnesota Pollution Control Agency. March 2000. "Protecting Water Quality in Urban Areas. Best Management Practices for Dealing with Storm Water Runoff from Urban, Suburban, and Developing Areas of Minnesota.

North Carolina, 1993. State of North Carolina. Originally published in 1988 and updated regularly. "North Carolina Erosion and Sediment Control Planning and Design Manual."

USA, 1994. Unified Sewerage Agency of Washington County, Oregon. February 1994. "Erosion Prevention and Sediment Control Plans."

U.S. EPA, 1999. United States Environmental Protection Agency, Office of Water. August 1999. "Preliminary Data Summary of Urban Storm Water Best Management Practices." (EPA-821-R-99-012).

Appendix B – Glossary

AASHTO	American Association of State Highway and Transportation Officials
ADSORPTION	Adhesion of the molecules of a gas, liquid or dissolved substance to a surface. Adsorption differs from absorption in that adsorption is the assimilation or incorporation of a gas, liquid, or dissolved substance into another substance.
AREAL	Of an expanse of land or region.
ASTM	American Society for Testing and Materials
BMP	Best Management Practice
BACTERIA	Single-celled microorganisms that lack chlorophyll; some cause disease, others are necessary to sustain life (see Fecal Coliform Bacteria).
BACTERIAL DECOMPOSITION OR MICROBIAL DECOMPOSITION	Microorganisms, or bacteria, have the ability to degrade organic compounds as food resources and to absorb nutrients and metals into their tissues to support growth.
BANK RUN	Gravelly deposits consisting of smooth round stones, generally indicative of the existence of a prehistoric sea. Such deposits are normally found in coastal plain regions.
BANK STABILIZATION	Methods of securing the structural integrity of earthen stream channel banks with structural supports for prevention of bank slumping and undercutting of riparian trees, and overall erosion prevention. To maintain the ecological integrity of the system, recommended techniques include the use of willow stakes, imbricated riprap, or brush bundles.
BERM, EARTHEN	An earthen mound used to direct the flow of runoff around or through a BMP.
BEST MANAGEMENT PRACTICE (BMP)	In this Catalog, the term refers to source or treatment controls designed to reduce pollution in stormwater runoff. Source controls are measures or devices designed to keep pollutants out of runoff. Examples include covers and roofs on outdoor storage processing areas and berms and sumps around outdoor source areas. Treatment controls are typically structural devices designed to temporarily store or treat urban stormwater runoff to reduce flooding, remove pollutants, and provide other amenities (e.g. enhance aesthetics and wildlife habitat).

BIOCHEMICAL OXYGEN DEMAND (BOD)	The quantity of dissolved oxygen used by microorganisms (e.g., bacteria) during the biochemical oxidation of matter (both organic and oxidizable inorganic matter) over a specified period of time.
CATCHBASIN	A structure at the point where a street gutter empties into a sewer, built to catch debris that would not easily pass through the sewer.
CATCHMENT AREA	See CONTRIBUTING WATERSHED AREA. Also known as drainage catchment area.
CBR	California Bearing Ratio
CEC	Cation Exchange Capacity
CHANNEL	A natural or artificial waterway that periodically or continuously contains moving water. It has a definite bed and banks that confine the water.
CHANNEL EROSION	The widening, deepening, and headward cutting of small channels and waterways, due to erosion caused by moderate to larger floods.
CHECK DAM	A small dam (a) placed perpendicular to a stream to enhance aquatic habitat, or (b) placed perpendicular in biofiltration swales to reduce water velocities, promote sediment deposition, and enhance infiltration.
CHEMICAL OXYGEN DEMAND (COD)	The quantity of maximum oxidizable matter in a sample.
COE	Army Corps of Engineers
CONTRIBUTING WATERSHED AREA	Portion of the watershed contributing its runoff to the site or BMP in question.
CONVEYANCE SYSTEM	The drainage facilities, both natural and human-made, which collect, contain, and provide for the flow of surface water and urban runoff from the highest points on the land down to a receiving water. The natural elements of the conveyance system include swales and small drainage courses, streams, rivers, lakes, and wetlands. The human-made elements of the conveyance system include gutters, ditches, pipes, channels, and most retention/detention facilities.
CPEP	Corrugated High Density Polyethylene Pipe
CULVERT	A covered channel or a large-diameter pipe that directs flow below the ground level.
CWA	Clean Water Act
DEQ	Department of Environmental Quality, State of Idaho
DEBRIS	Any material, organic or inorganic, floating or submerged, moved by a flowing stream.

DECIDUOUS	Trees that shed leaves in the fall/winter.
DISCHARGE	Outflow; the flow of a stream, canal, or aquifer. One may also speak of the discharge of a canal or stream into a lake, river, or ocean. (Hydraulics) Rate of flow, specifically fluid flow; a volume of fluid passing a point per unit of time, commonly expressed as cubic feet per second, cubic meters per second, gallons per minute, gallons per day, or millions of gallons per day.
DISSOLVED OXYGEN (DO)	Oxygen that is present (dissolved) in water and available for use by fish and other aquatic animals. If the amount of dissolved oxygen in the water is too low, aquatic animals will suffocate.
DIVERSION	A channel, embankment, or other man-made structure constructed to divert water from one area to another (Soil Conservation Society of America, 1982).
DOWNSTREAM SCOUR	Downstream channel erosion usually associated with an upstream structure that has altered hydraulic conditions in the channel.
DRAINAGE BASIN OR SUBBASIN	See WATERSHED.
DRIPLINE	An imaginary line around a tree or shrub at a distance from the trunk equivalent to the canopy spread.
EMBANKMENT	A bank (of earth or riprap) used to keep back water.
EMERGENT PLANT	An aquatic plant that is rooted in the sediment but whose leaves are at or above the water surface. Such wetland plants provide habitat for wildlife and waterfowl in addition to removing stormwater pollutants.
ENERGY DISSIPATION	The loss of kinetic energy of moving water due to internal turbulence, boundary friction, change in flow direction, contraction, or expansion.
EPA	Environmental Protection Agency
EROSION	The wearing away of the land surface by running water, wind, ice, or other geological processes.
EXFILTRATION	The downward movement of runoff through the bottom of an infiltration BMP into the subsoil.
FHWA	Federal Highway Administration
FILTER FABRIC	See Geotextile Fabric

FLOODPLAIN	Any lowland that borders a stream and is inundated periodically by its waters.
FRAGIPAN	A loamy, brittle subsurface horizon low in porosity and content of organic matter and low or moderate in clay but high in silt or very fine sand.
GABION	A large rectangular box of heavy gauge wire mesh which holds large cobbles or boulders. Used in streams and ponds to change flow patterns, stabilize banks, or prevent erosion.
GEOMEMBRANE	Lining of filter fabric on the bottom and sides of porous pavement to prevent lateral or upward movement of soil into the stone reservoir.
GEOTEXTILE FABRIC	Textile of relatively small mesh or pore size that is used to (a) wallow water to pass through while keeping sediment out (permeable), or (b) prevent both runoff and sediment from passing through (impermeable). Also known as filter fabric.
GRADING	The cutting and/or filling of the land surface to a desired slope or elevation.
GRAVEL	Sediment particles larger than sand and ranging from 2 to 64 mm (0.25 to 3 inches) in diameter.
GRAVITATIONAL SETTLING	The tendency of particulate matter to drop out of stormwater runoff as it flows downstream when runoff velocities are moderate and/or slopes are not too steep.
GROUNDWATER TABLE	The level below which the soil is saturated, that is, the pore spaces between the individual soil particles are filled with water. Above the groundwater table and below the ground surface, water in the soil does not fill all pore spaces.
HEAVY METALS	Metals of relatively high atomic weight, including but not limited to chromium, copper, lead, mercury, nickel, and zinc. These metals are generally found in minimal quantities in stormwater, but can be highly toxic even at trace levels.
HOT SPOTS	Hot spots are land use categories that are considered to be potential significant sources of pollutants and may generate higher pollutant concentrations than other land uses. Examples include vehicle service, maintenance and equipment cleaning areas; and outdoor storage and loading/unloading areas of hazardous materials.
IDAPA	Idaho Administrative Procedures Act
IDWR	Idaho Department of Water Resources
IMPERMEABLE	Properties that prevent the movement of water through the material.

IMPERVIOUS SURFACE	Material which resists or blocks the passage of water.
INFILTRATION	The penetration of water through the ground surface into subsurface soil or the penetration of water from the soil into sewer or other pipes through defective joints, connections, or manhole walls. The infiltration rate is expressed in terms of inches/hour. Infiltration rates will be slower when the soil is dense (e.g., clays) and faster when the soil is loosely compacted (e.g., sands). Can also refer to seepage of groundwater into sewer pipes through cracks and joints.
ITD	Idaho Transportation Department
NATURAL BUFFER	A low sloping area of maintained grassy or woody vegetation located between a pollutant source and a waterbody. A natural buffer is formed when a designated portion of a developed piece of land is left unaltered from its natural state during development. A natural vegetative buffer differs from a vegetated filter strip in that it is natural and in that they need not be used solely for water quality purposes. To be effective, such areas must be protected against concentrated flow.
NPDES	National Pollutant Discharge Elimination System
NUTRIENTS	Elements or substances, such as nitrogen or phosphorus, that are necessary for the growth and development of living things (e.g., plants). Large amounts of these substances reaching water bodies can lead to reduced water quality and eutrophication by promoting excessive aquatic algae growth. Some nutrients can be toxic at high concentrations.
OUTFALL	The point of discharge for a river, drain, pipe, etc.
PERCOLATION	The downward movement of water through the soil.
PERMEABILITY	The quality of a soil horizon that enables water or air to move through it.
PHYSICAL INFILTRATION	The separation of particulates from runoff by grass, leaves and other organic matter on the surface, as the runoff passes across or through the ground.
POLLUTANT	Generally, any substance introduced into the environment that adversely affects the usefulness of a resource.
POLLUTION	Impairment of water quality caused by man-made waste discharges or natural processes.
RIPRAP	A combination of large stone, cobbles, and boulders used to line channels, stabilize banks, reduce runoff velocities, or filter out sediment.

ROOT ZONE	The part of the soil that is, or can be, penetrated by plant roots (Soil Conservation Society of America, 1982).
ROTOTILLING	Mechanical means of tilling, or rotating, the soil.
RUNOFF	See "Stormwater Runoff."
RUNOFF CONVEYANCE	Methods for safely conveying stormwater to a BMP to minimize disruption of the stream network, and promote infiltration or filtering of the runoff.
RUNON	Off-site flows which flows onto a site.
SCOUR	Concentrated erosive action of flowing water in streams that removes material from the bed and banks.
SCS	Soil Conservation Service of USDA. Note: New name for this agency, as of 1996, is Natural Resources Conservation Service (NRCS).
SEDIMENT	The product of erosion processes; the solid material, both mineral and organic, that is in suspension, is being transported, or has been moved from its site of origin by air, water, gravity, or ice (USDA-SCS, 1991).
SEDIMENTATION	The process of sand and mud settling and building up on the bottom of a creek, river, lake, or wetland.
SEEDBANKS	Refers to the large number and diversity of dormant seeds of plant species that exist within the soil. The seeds may exist within the soil for years before they germinate under the proper moisture, temperature, or light conditions. Within marsh soils, this seedbank helps to maintain above-ground plant diversity and can also be used to rapidly establish marsh plants within a newly constructed stormwater marsh.
SEEPAGE	Water escaping through or emerging from the ground along an extensive line or surface as contrasted with a spring, where the water emerges from a localized spot (Soil Conservation Society of America, 1982).
SHEET FLOW	Water, usually storm runoff, flowing in a thin layer over the ground surface (Soil Conservation Society of America, 1982).
SLOPE	The degree of deviation of a surface from horizontal, measured as a percentage, as a numerical ratio, or in degrees (Soil Conservation Society of America, 1982).
SOURCE CONTROL	A pollution control measure which operates by keeping pollutants from entering stormwater
STORM DRAIN (or STORM SEWER SYSTEM)	Above and below ground structures for transporting stormwater to streams or outfalls for flood control purposes.

STORMWATER RUNOFF	Excess precipitation that is not retained by vegetation, surface depressions, or infiltration, and thereby collects on the surface and drains into a surface water body.
STREAM BUFFER	A variable width strip of vegetated land adjacent to a stream that is preserved from development activity to protect water quality and aquatic and terrestrial habitats.
SUBSOIL	The bed or stratum of earth lying below the surface soil.
SUBSTRATE AMENDMENTS	A technique to improve the texture, and organic content of soils in a newly excavated pond system. The addition of organic rich soils is often required to ensure the survival of aquatic and terrestrial landscaping around ponds.
SUSPENDED SEDIMENT	The very fine soil particles that remain in suspension in water for a considerable period of time (Soil Conservation Society of America, 1982).
SWALE	A natural depression or wide shallow ditch used to temporarily store, route, or filter runoff.
TOPOGRAPHY	The relative positions and elevations of the natural or man-made features of an area that describe the configuration of its surface (Soil Conservation Society of America, 1982).
TOTAL MAXIMUM DAILY LOAD (TMDL)	The sum of individual waste load allocations for point sources and load allocations for nonpoint sources and natural background. The Idaho Division of Environmental Quality has the authority to set TMDLs for water quality-limited bodies.
URBAN RUNOFF	Stormwater that passes through and out of developed areas to a stream or other body of water. (See Stormwater Runoff.)
VACUUM SWEEPING	Method of removing quantities of coarse-grained sediments from porous pavements in order to prevent clogging. Not effective in removing fine- grained pollutants.
VEGETATED FILTER STRIP	A vegetated section of land designed to accept runoff as overload sheet flow from upstream development. It may adopt any natural vegetated form, from grass meadow to small forest. The dense vegetative cover facilitates pollutant removal. A filter strip cannot treat high velocity flows; therefore, they have generally been recommended for use in agriculture and low density development. A vegetated filter strip differs from a natural buffer in that the strip is not natural ; rather, it is designed and constructed specifically for the purpose of pollutant removal. A filter strip can also be an enhanced natural buffer, however, whereby the removal capability of the natural buffer is improved through engineering and

	maintenance activities such as land grading or the installation of a level spreader. A filter strip also differs from a grassed swale in that a swale is a concave vegetated conveyance system, whereas a filter strip has a fairly level surface.
VELOCITY	The distance that water travels in a given direction in a stream during an interval of time.
WEIR	A structure that extends across the width of a channel and is intended to impound, delay or in some way alter the flow of water through the channel. A CHECK DAM is a type of weir as is any kind of dam.

Appendix C - Disposal Alternatives Table

General Construction, Painting and Maintenance

Discharge/Activity	Disposal Techniques
Excess oil-based paint	▪ Recycle/reuse; donate to nonprofit organization ▪ Dispose of as hazardous waste
Excess water-based paint	▪ Recycle/reuse; donate to nonprofit organization ▪ For small quantities, let the paint residue dry in the can; remove lid; dispose in trash ▪ For large quantities, solidify with cat litter, air dry, then dispose in trash
Clean-up of oil-based paint	Wipe paint out of brushes, then: ▪ Filter and reuse thinners and solvents ▪ Donate to nonprofit organization or dispose of as hazardous waste
Clean-up of water based paint	Wipe paint out of brushes, then: ▪ Rinse to sanitary sewer ▪ Dispose in trash
Empty paint cans (dry)	Remove lids, dispose lids and cans in trash
Paint stripping substances (with solvent)	Dispose of as hazardous waste
Exterior cleaning of buildings (high pressure water)	▪ Prevent entry into storm drain and remove offsite ▪ Wash onto soil-covered area, spade in ▪ Mop up washwater and discharge to sanitary sewer
Exterior cleaning of buildings (mercury, chromium, or other hazardous materials in paints)	▪ Use dry cleaning methods (e.g. sand blasting) ▪ Mop up wash water, reduce volume by evaporating liquid mixture ▪ Dispose of as hazardous waste
Exterior cleaning of buildings (paint contains lead)	▪ Dispose of as hazardous waste ▪ For assistance, contact EPA 1-800-LEAD-FYI
Paint scraping/sand blasting (no hazardous materials in paints)	▪ Dry sweep, dispose in trash

General Construction, Painting, and Maintenance (cont.)

Construction & demolition debris (no hazardous materials in debris)	▪ Reduce/reuse concrete, wood, or other construction materials ▪ Transport to landfill as construction and demolition waste
Construction & demolition debris (hazardous materials such as asbestos in debris)	▪ Follow landfill packaging requirements; transport to landfill as asbestos waste or other hazardous waste

Building & Property Management/Maintenance

Leaking garbage dumpsters	▪ Collect and contain leaking material ▪ Repair leak, return dumpster for repair.
Washwater from cleaning garbage dumpsters	Filter wash water through grease interceptor; contact wastewater treatment plant staff before discharging to sanitary sewer
Cleaning driveways, paved areas	Sweep & dispose in trash. For vehicle leaks: ▪ Clean up leaks with rags or absorbents ▪ Sweep using granular absorbent material (e.g., cat litter) ▪ Mop & dispose of mop water in sanitary sewer
Cleaning sidewalks, paved areas	▪ Clean up leaks with rags or absorbents ▪ Sweep using granular absorbent material (e.g., cat litter) ▪ Either mop & dispose of mop water in sanitary sewer or collect all water from cleaning and pump to sanitary sewer.

Vehicle Maintenance

Discharge/Activity	**Disposal Techniques**
Used motor oil	Use secondary containment while storing; send to recycler
Antifreeze	Use secondary containment while storing; send to recycler
Other vehicle fluids and solvents	Dispose of as hazardous waste
Automobile batteries	Send to auto battery recycler

Vehicle Maintenance

Vehicle washing	▪ Recycle wash water ▪ Contact local wastewater treatment plant before discharging to oil/water separator connected to sanitary sewer
Mobile vehicle washing	▪ Recycle wash water ▪ Contact local wastewater treatment plant before discharging to oil/water separator connected to sanitary sewer
Rinse (new car fleets)	▪ Contact local wastewater treatment plant before discharging to oil/water separator connected to sanitary sewer ▪ Contact operator of storm drain system regarding approval to discharge, if rinse water is free of detergents or other cleaners.
Vehicle leaks (auto repair shops)	▪ Sweep up leaks using granular, absorbent material (e.g., cat litter) ▪ Mop and dispose of mop water to oil/water separator connected to sanitary sewer

Other Wastes

Discharge/Activity	**Disposal Techniques**
Contaminated pumped ground water, infiltration/foundation drainage	Treat as necessary; with prior approval from wastewater treatment plant, discharge to sanitary sewer

Table D-1. Map Symbols

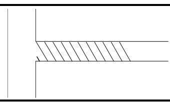
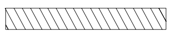
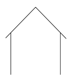
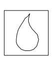
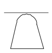
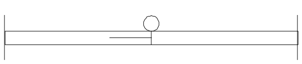
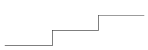
SYMBOL	FILE NAME	DESCRIPTION
	BMP3	Preservation of existing vegetation
	BMP4	Clearing limits
	BMP5	Stabilization of construction entrance/roads/driveways
	BMP6	Erosion prevention on temporary and private roads
	BMP7	Dust control
	BMP8	Cover for materials and equipment
	BMP9	Spill prevention and control
	BMP10	Vehicle/equipment washing and maintenance
	BMP15	Mulching
	BMP16	Hydromulching
	BMP17	Geotextile
	BMP18	Matting
	BMP24	Pipe slope drain
	BMP25	Slope roughening
	BMP26	Gradient terracing
	BMP27	Retaining wall

Table D-1. Map Symbols

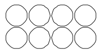
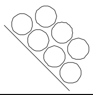
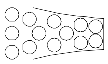
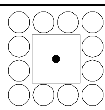
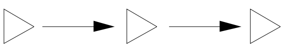
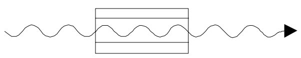
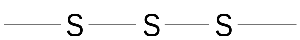
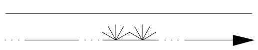
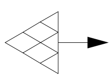
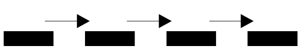
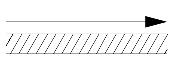
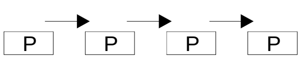
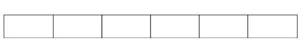
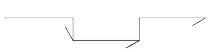
SYMBOL	FILE NAME	DESCRIPTION
	BMP29	Gabions
	BMP30	Riprap slope protection
	BMP30	Riprap outlet protection
	BMP31	Inlet protection
	BMP32	Check dams
	BMP33	Temporary stream crossing
	BMP34	Biofilter bags
	BMP36	Silt fence
	BMP37	Vegetative buffer strip
	BMP38	Sediment trap (basin)
	BMP39	Portable sediment tank
	BMP40	Temporary swale
	BMP41	Earth dike
	BMP42	Perimeter dike/swale
	BMP43	Temporary berms (sandbags)
	BMP44	Temporary storm drain diversion

Table D-1. Map Symbols

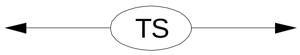
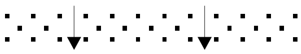
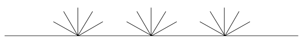
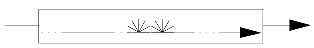
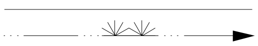
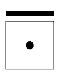
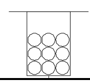
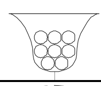
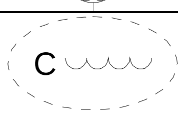
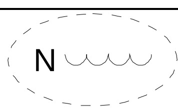
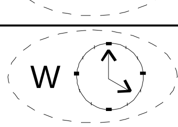
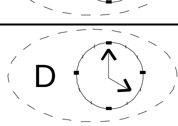
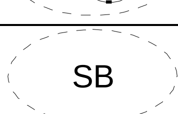
SYMBOL	FILE NAME	DESCRIPTION
	BMP20	Topsoiling
	BMP21	Seeding
	BMP22	Sodding
	BMP23	Planting
	Volume 4; BMP1	Vegetated swale
	Volume 4; BMP3	Vegetative filter strip
	Volume 4; BMP4	Sand filter
	Volume 4; BMP5	Compost stormwater filter
	Volume 4; BMP6	Catch basin insert
	Volume 4; BMP9	Infiltration trench
	Volume 4; BMP10	Bioretention basin
	Volume 4; BMP13	Wet pond (conventional control)
	Volume 4; BMP14	Wet pond (nutrient control)
	Volume 4; BMP15	Wet extended detention pond
	Volume 4; BMP16	Dry extended detention pond
	Volume 4; BMP18	Presettling/sedimentation basin

Table D-1. Map Symbols

SYMBOL	FILE NAME	DESCRIPTION
V/T	Volume 4; BMP19	Wet vault/tank
OWS	Volume 4; BMP21	Oil/water separator

Volume 3: Low-Impact Development Techniques

Section 1 - Introduction

The *Catalog of Stormwater Best Management Practices for Idaho Cities and Counties*, a series of five compact discs (CDs), provides technical guidance for construction site design and the selection of stormwater best management practices (BMPs). The catalog is a guidance document containing voluntary controls that could be formally adopted by a jurisdiction to establish standards, if desired. Measures, such as those described and other recognized equivalents, should be used to manage the quantity and quality of stormwater runoff from land development.

This information is primarily intended for design professionals (e.g., landscape architects, geologists, engineers, soil scientists, etc.) and their contractors. It is also applicable for local public officials or staff who are responsible for the review and approval of development applications.

There are several reasons why technical guidance regarding stormwater management is necessary:

- Idaho remains one of the fastest growing states in the nation. The increase in population leads to an increase in land development, a recognized source of nonpoint source pollution, more commonly termed "polluted runoff." The catalog includes BMPs that help to prevent discharge of pollutants from developing areas, both during the construction phase and for the life of the development. The BMPs can also be used to reduce polluted runoff from existing land uses.
- Many water bodies throughout the state are not in compliance with state water quality standards. Beneficial uses such as domestic water supply, fishing, swimming, boating, and agricultural water supply can often be impaired due to excessive pollutants from stormwater runoff. The catalog provides guidance for controls to reduce "conventional" pollutants, with special consideration for phosphorus and sediment, both common pollutants in Idaho.
- Federal National Pollutant Discharge Elimination System (NPDES) stormwater regulations have mandated that some communities develop and implement stormwater management programs to ensure that pollutants in stormwater runoff are controlled to the maximum extent practicable. Because polluted runoff has the potential to contribute to the degradation of receiving water quality, improved stormwater management program implementation at the local level will play an ever-increasing role in attaining and maintaining water quality standards.

In general, there are two types of BMPs for stormwater pollution control:
1. Source control BMPs focus on minimizing or eliminating the source of the pollution so that pollutants are prevented from contacting runoff or entering the drainage system.
2. Treatment control BMPs which tend to be more expensive to implement than source control BMPs, are designed to remove pollutants after they have entered runoff. Examples of source control BMPs include spill controls and employee education, while treatment control BMPs include detention ponds and oil/water separators. Most source control BMPs tend to be non-structural, and most treatment control BMPs tend to be structural in nature, although there can be exceptions. For example, a roof over a materials storage area at an industrial site would be considered a structural source control.

The majority of the practices focus on controlling pollution at its source, before runoff enters a drainage conveyance such as a sewer system or river. However, some BMPs are also included that can be used to treat runoff and remove pollutants that have already entered the drainage conveyance. The structural measures will reduce pollutant loads in post-construction site runoff, provided that the facilities are properly designed, installed, and maintained on a periodic basis.

The catalog presents general technical guidelines. Specific conditions or local regulations may require modification of the recommended BMPs, and alternative practices that are approved by a local permitting authority may also require modification or replacement of recommended BMPs. The BMP selection matrix should be used as a screening tool to assist the design professional, landowner, or reviewer in selecting the most appropriate or suitable measure based on site-specific conditions.

In order to illustrate the use and application of certain BMPs, manufacturer and product names may be used in the catalog. This does not represent an endorsement of a specific manufacturer or product.

1.1 Organization

The first volume of the CD series includes a brief discussion of stormwater runoff impacts; an overview of agencies responsible for stormwater permitting and authority in Idaho; and a step-by-step procedure for site design.

The second volume of the CD series contains construction BMPs including both erosion and sediment controls and source controls.

The third volume of the CD series introduces the concept of low-impact development and provides techniques that can minimize changes to the hydrologic functioning of a development site.

The fourth volume of the CD series contains post-construction/ permanent BMPs.

The fifth volume of the CD series provides BMPs for specific land use activities, including industrial, commercial, and residential activities.

The catalog is intended for use in conjunction with local governmental requirements, such as applicable planning and building codes. The catalog is not all-inclusive and should be used along with other reference books and manuals published by other agencies as necessary or appropriate based on local conditions and policies.

1.2 Updates

The practice of stormwater management is quickly evolving. Design information for various BMPs is expected to change as more people apply the practices and learn from their experience. New BMPs will also be added to the mix. To accommodate these changes, periodic updates and amendments will be made to the catalog. These will be posted on the Department of Environmental Quality (DEQ) Web site as they become available.

Section 2 - Natural Drainage Systems Design

Land use changes associated with development continue to impact water resources because of the failure to fully consider how these changes affect natural systems on and off-site. Focus on the symptoms of the problem by applying practices that control flow or provide treatment, has not addressed the cause of the problem, which is natural functioning of the site being impaired by development activities.

The traditional engineering approach compensates for the loss of natural functions by constructing a network of runoff collection, conveyance, and disposal infrastructure with the objective of concentrating flow and carrying water away from the place where it falls as quickly as possible. Conventional stormwater management relies heavily on curbs, pipes, inlets, dams, riprap, detention basins, and other "hard" engineering solutions. Cities install storm sewer systems that quickly channel runoff from roads and other impervious surfaces. Traditional runoff collection and conveyance systems substitute for the natural dips and swales, depressions, streams, and wetlands of a watershed, generally eliminating most soil infiltration.

The design process presents opportunities for both environmental quality protection and economic benefits concurrently by considering convergent objectives. Further, land development and the built environment in general afford opportunities for a convergence of objectives by avoiding the perpetuation of single-purpose structures and infrastructure. The identification and application of solutions that augment the built environment, mimic natural systems, and provide multiple functions is the key.

A natural drainage systems approach creates opportunities early in the land development process to shape natural resources, land use, and ultimately landscapes in ways that encourage communities to function in sustainable ways. The built environment can be designed to mimic natural system functions by using practices that infiltrate and evapotranspirate, achieving a greater economy by returning stormwater to the natural water cycle.

A natural drainage systems approach manages stormwater on-site by design to the greatest extent possible. This approach distributes hydrologic functions throughout a site and connects it to adjacent sites and public infrastructure. These connections treat stormwater as close as possible to the source of runoff generation using simple, non-structural practices that mimic natural functions afforded by soil, vegetation, and landforms. A distributed, at-the-source control strategy, if it incorporates an informed understanding of the site, reduces drainage system costs by eliminating the need for pipe and inlet conveyances and highly engineered mitigation or proprietary treatment structures.

A natural drainage systems approach seeks to prevent erosion and encourage contributions of base flow to rivers, streams, and lakes. When stormwater discharge enters streams, rivers, and lakes without any form of treatment it may cause channel instability, which in turn results in streambank erosion and sedimentation. In this case, the opportunity to slowly pass surface water as treated subsurface ground water flow to these same water systems is lost. Retaining, filtering, and distributing water on-site results in slowing and reducing the release of precipitation as downstream runoff on a cumulative basis.

Landscape and infrastructure should be viewed as multi-functional and compatible. Every urban landscape or infrastructure feature (roof, streets, parking, sidewalks, and green space) offers the opportunity to store, convey, filter, retain, and reuse runoff allowing buildings and landscaping to function in concert with each other.

2.1 Low Impact Development

Low Impact Development (LID) is an alternative stormwater management approach that is gaining rapid acceptance in the United States as a tool to meet regulatory compliance and resource protection goals and is practiced extensively in Europe. The LID approach is an innovative stormwater management approach with a basic principle that is modeled after nature: manage rainfall at the source using uniformly distributed decentralized micro-scale controls. Its goal is the creation of built environments that mimic natural systems.

The Maryland Prince Georges County Department of Environmental Resources pioneered LID in the 1990s. The LID effort began with the development and use of bioretention cells. In 1998, Prince Georges County produced the first municipal LID manual. This was later expanded into a nationally distributed LID manual that was published in 2000. Many municipalities across the nation have embraced LID due to its holistic approach to design. Fundamentals of LID include:

- Using hydrology as the integrating framework
- Thinking micromanagement
- Controlling stormwater at the source
- Using simple, nonstructural methods

- Creating a multifunctional landscape.

The goal of LID is to mimic a site's predevelopment hydrology by using design solutions that infiltrate, filter, store, evaporate, and detain runoff close to its source. Solutions are based on the premise that stormwater management should not be seen as stormwater disposal. Instead of conveying and managing / treating stormwater in large, costly end-of-pipe facilities located at the bottom of drainage areas, LID addresses stormwater through small, cost-effective landscape features located at the lot level.

These landscape features and the built environment are the building blocks of an LID approach. Almost all components of the urban environment have the potential to serve as a component of LID through design integration. This includes open space, but also rooftops, streetscapes, parking lots, sidewalks, and medians. LID is a versatile approach that can be applied equally well to new development, urban retrofits, and redevelopment / revitalization projects.

The LID approach does not eliminate the use of stormwater BMPs but rather selectively integrates BMPs into a development site where they can function optimally. The difference between LID and conventional BMP applications is that LID design is tailored to a specific context and a specific problem. The goal is to identify a development strategy that maintains the hydrological integrity of a site or restores natural functions when and where they are displaced by urbanization.

Water is a defining characteristic of the western landscape and should inform the overall site design. The land should be viewed in terms of topographical contours and the consequent flow of water. Low impact development achieves stormwater management by creating a functional landscape that mimics natural watershed hydrologic functions (discharge, frequency, recharge, and volume). This is accomplished in several ways.

First, impacts are minimized to the extent practicable by conserving natural resources/ecosystems, maintaining natural drainage courses, minimizing clearing and grading, reducing imperviousness, and reducing use of pipes. Benefits are achieved through conservation and minimization by reducing impervious surfaces using narrower residential streets, less impervious sidewalk area, additions of porous pavement or replacement of existing pavement with pervious structures, and creation of concave medians and landscaped traffic-calming features. Techniques that conserve existing site resources and functions include preservation of vegetation and trees, site finger printing (minimal disturbance), preservation of soils that have high infiltration rates, location of BMPs on high-infiltration soils and construction of impervious features on soils with low infiltration rates (Coffman et al, 1998).

Second, dispersed detention and retention storage are created throughout a site with the use of open swales, flatter slopes, rain gardens (bioretention), rainwater capture and reuse (cisterns and rain barrels), pedestal sidewalks and yard, curb, or subsurface storage. Other storage techniques are available that can be integrated into the site planning and design process for an LID site. These techniques include swales with check dams, restricted drainage pipes, and inlet / entrance controls; wide low gradient swales; rooftop storage; retention ponds; and shallow parking lot storage. These detention practices can easily be integrated into the site design features. Conveyance is accomplished through grassed channels and bioretention channels, and disconnection of impervious areas to redirect runoff to vegetated areas.

Third, the predevelopment time of concentration (Tc) is maintained by strategically routing flows to maintain travel time. The following site techniques can be used for this purpose. Maintain the predevelopment flow path length by dispersing and redirecting flows using open swales and natural or vegetated drainage patterns. Increase surface roughness through techniques that preserve existing vegetation or created vegetated swales. Detain flows through open swales and rain gardens, minimize disturbances by minimizing compaction and changes to existing vegetation, and flatten grades in impacted areas. Disconnect impervious areas by eliminating curb/gutter and redirecting down spouts, and connect pervious and vegetated areas.

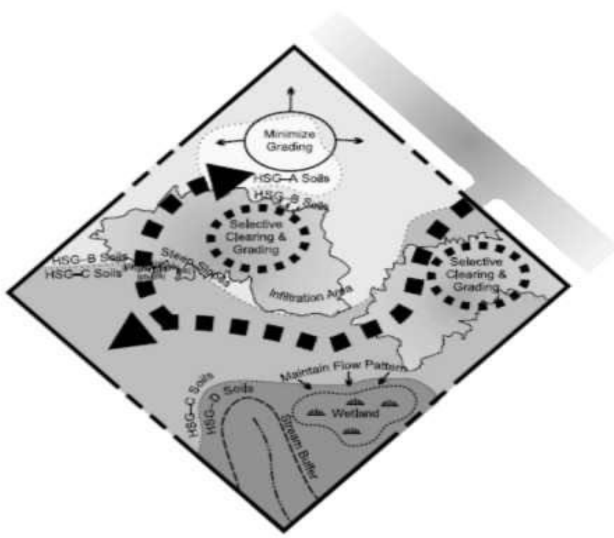


Figure 1. Hydrologically functional landscape (from U.S. EPA, Low-Impact Development Design Strategies, Figure 2-1, http://www.epa.gov/owow/nps/lidnatl.pdf).

2.2 Expanding the Solutions Palette

There are a number of tools that are available for use in the land development arena to prevent degradation of streams, lakes, and other water bodies. These solutions differ from conventional BMPs in that they are used in a comprehensive sense, tailored to a specific context and a specific set of problems. They can preserve or restore natural functions to maintain groundwater recharge, use soil and vegetation to infiltrate, retain, and filter runoff; and use landforms to direct and redefine flow paths that follow natural gradients by gravity. All design solutions that promote a natural drainage systems approach in conjunction with land development have been grouped into the following categories:

- Programming and Pre-design
- Runoff Minimization
- Rainwater Capture
- Infiltration and Landscaping
- Conveyance

2.2.1 Programming and Pre-design

Surface forms, soils, and plants are critical functional components of a landscape. Each plays a role in the flow and processing of water through a site by providing pathways, retention, detention, treatment, and disposal. These site elements can be protected during the design and construction process.

Areas that are conserved in their natural state retain their natural hydrology and are not exposed to erosion during construction. Using techniques from the BMPs listed below, site disturbance is minimized by reducing clearing and grading, relying on functional grading, minimizing the fingerprint of the development, and protecting natural site functions and adjacent water bodies.

Minimizing site disturbance
- Reduced clearing and grading
- Functional grading
- Site fingerprinting

Protecting natural site functions
- Protect natural site functions
- Preserve natural corridors

Protecting adjacent water bodies
- Aquatic buffers

2.2.2 Runoff Minimization

Impervious areas directly connected to the storm drain system are the greatest contributor to nonpoint source pollution in stormwater runoff. Streets and other transport-related structures typically can comprise between 60 and 70% of the total impervious area, and unlike rooftops, streets are almost always directly connected to a stormwater system. Much of the recent literature on development impacts has focused on the level of imperviousness (or directly connected imperviousness) of a watershed as the factor that indicates the structural integrity of a stream or the health of its aquatic species.

One aspect of a strategy for minimizing runoff is to address impervious surfaces by fitting development to natural gradient, locating impervious surfaces to drain to natural systems, minimizing directly connected impervious areas, and breaking up flow directions. When a stabilized surface is needed, alternative surfaces that are more permeable are used to minimize their impact.

Another aspect of this strategy locates and configures development based on characteristics of the site such as soil types, vegetation, and landform. It involves site-planning techniques that concentrate development on one or more portions of a site, and conversely maintains more of the site in open space. The strategy has been called open space design, conservation development, and cluster development. Reconfigured development forms offer an attractive alternative to conventional subdivision design and are applicable to most forms of residential development, with special opportunities in rapidly growing rural settings and within suburban fringes of growing communities. BMPs involving these strategy aspects are listed below.

Imperviousness disconnection

- Fit development to natural gradient
- Locate impervious surfaces to drain to natural systems
- Minimize directly connected impervious areas
- Break up flow directions

Permeable pavement

- Use alternative surfaces
- Trail and path network

Vertical and clustering construction

- Alternative development configuration
- Trail and path network

Define development envelope
Identify sensitive areas
Alternative lot configurations

2.2.3 Rainwater Capture

Rain and snow fall as naturally distilled water that could be used as a resource to provide many beneficial uses such as irrigation, recreational lakes, groundwater recharge, industrial cooling and process water, and other non-potable domestic uses when collected on site. The collection, capture and storage of rainwater from roofs, paved surfaces and the landscape is called water harvesting.

The strategy of this technique is to fit tanks, cisterns, or sealed wells to take house roof water. The effect of using roof-generated runoff for domestic water supply is to eliminate roof impervious surfaces from contributing stormwater runoff, thus reducing the total volume of runoff from the site.

Another strategy uses green roofs, which help manage stormwater by mimicking a variety of hydrologic processes normally associated with open space. Plants capture rainwater on their foliage and absorb it in their root zone, encouraging evapotranspiration and preventing much stormwater from ever entering the runoff stream.

Stormwater runoff can also be captured and infiltrated into subsurface storage associated with green space available when techniques for creating narrow roadways, reconfigured driveways, alternative turnarounds, and reduced sidewalks are used.

Water harvesting BMPs are listed below.

Rainfall harvesting
Green roofs

Subsurface storage
Narrow roadways
Reconfigure driveways
Alternative turnarounds
Reduced sidewalk application

2.2.4 Infiltration and Landscaping

While the foremost objective should be to minimize the total disturbance of the site, there are instances where grading can be used to create forms that provide hydrologic functions. If carefully fitted to topography and soil, subtle and inexpensive landform alterations such as swales, berms, and depressions can serve to guide or slow the flow of water. Other techniques for new developments that perform hydrologic functions are constructed wetlands on larger sites, bioretention areas, and stormwater planters. Functionality can also be provided in the built environment through the use of green parking lots.

If grading or excavation has removed soil from the site, healthy soil may need to be recreated. Methods that rebuild the soil on-site are more sustainable than importing topsoil. Only on rare occasions should soil materials be imported in quantity, and never at the expense of another site.

Revegetation of a site should emphasize creation of sustainable landscapes. This means using regionally appropriate vegetation, controlling invasive species, and planting based on patterns of plant growth that occur naturally in the region. At a larger scale, urban forestry programs can restore natural functions.

Below is a list of BMPs that retain or improve water infiltration and reduce runoff.

Bioretention basins and depressions
- Bioretention
- Soil amendments
- Soil restoration

Created wetlands
Stormwater planters
Green parking lots

Lawn replacement
- Vegetation restoration
- Urban forestry

2.2.5 Conveyance

There are also conveyance techniques, which provide hydrologic functions by dispersing and redirecting flows. Open Swales and shallow channels slow runoff, filter it, and promote infiltration into the ground. As a result, runoff volumes are smaller, peak discharge rates are lower, and runoff is cleaner. Vegetated swales can replace curb and gutter systems as well as storm sewers that convey runoff. Swales can function as conveyances in association with alternative street layouts and when traditional curb and gutter is eliminated. They can also be used to provide parking lot and street storage.

Other conveyance practices such as furrows and trenches mimic natural drainage patterns and work to disperse runoff.

These techniques are included in the BMPs listed below.

Created wetlands

Swales
- Alternative street layouts
- Parking lot and street storage
- Biofiltration
- Eliminate curb and gutter

Furrows
Dispersal trench
Pop-up emitter

Reduced Clearing and Grading BMP 1

Description

Clearing and grading at a site should be limited to the minimum amount needed to build lots, allow access, and provide fire protection. Reducing clearing and grading is important in protecting the quality of existing site resources and functions and preventing future impacts to water features while maintaining healthy functioning of existing native soils.

General Information

A development site should be designed to reduce the amount of clearing and grading that is necessary. Some areas of the development site should never be cleared and graded, or clearing in these areas should at least be sharply restricted. These areas include the following:

- Stream buffers
- Forest conservation areas
- Wetlands, springs and seeps
- Highly erodible soils
- Steep slopes
- Environmental features
- Stormwater infiltration areas

A site designer can go even further and analyze the entire site to find other open spaces where clearing and/or grading can be avoided. Ideally, only those areas actually needed to build structures and provide access should be cleared. All protected areas should be delineated on construction drawings and shown as the "limits of disturbance." These limits should be clearly visible in the field, and posted by signage, staking, flagging or most preferable, fences (i.e., silt fence or temporary safety/snow fence). The limits and the purpose of the limits should be clearly conveyed to site personnel and the construction foreman at a preconstruction meeting.

When clearing and grading is necessary, phased clearing and grading should be used whenever feasible. All disturbed areas should be revegetated as soon as possible. Emphasis should be placed on reforestation of disturbed areas. In some instances, soils in disturbed areas may need to be restored before successful reforestation or revegetation can be implemented.

Additional Resources

Brown and Caraco 2000. *Muddy Water In – Muddy Water Out?* Available on Center for Watershed Protection website.

Coffman, L., 2000. *Low-Impact Development Design Strategies, An Integrated Design Approach*. Available on EPA website.

Corish, K.A., 1995. *Clearing and Grading Strategies for Urban Watersheds,* Metropolitan Washington council of Governments.

Natural Resources Defense Council. 1997. *Stormwater Strategies.* Available on website.

Functional Grading BMP 2

Description

Subtle and inexpensive landform alterations such as swales, berms, and depressions are carefully fitted to the topography and site soils and guide or slow the flow of runoff. Specific concepts range in scale and application from micro site-by-site terraformed saucers to use of subtle earthen berms placed in zones of existing vegetation.

General Information

When grading is unavoidable it should follow regional landforms, a technique called landform grading. The concept of landform grading is construction of landforms based on natural patterns. Landform grading mimics stable natural slopes. Landformed slopes offer a diversity of concave and convex, shaded and sunny, exposed and sheltered habitats. The resulting slopes are carefully engineered but look natural. Landform grading (Schor 1992; Schor and Gray, 1995) entails modifying surface topography and drainage so that slopes are stable against erosion and mass wasting. Landform grading has been shown to decrease erosion and respects geomorphologic processes of natural slopes (Thompson and Sorvig, 2000).

Vegetation is selected and planted in such a way that it is compatible with hillside hydrogeology. Grasses and groundcovers are planted in drier, convex-shaped slopes or interfluves, while trees and shrubs are planted in wetter, concave-shaped valleys, swales, and depressions. Careful attention is applied to drainage, which follows natural drop lines on a slope in a manner that minimizes gradients.

There are other instances where grading can be used to create forms that provide hydrologic functions. Terraforming is a term for a careful grading process that is suited to the scale of the site and the development. It can result in subtle, sometimes nearly imperceptible depressions or saucers to receive residential rooftop runoff or stormwater from the driveway and turnaround. It can be replicated lot by lot, possibly relying on several signature concepts in a particular development to facilitate both installation and ongoing maintenance or integrated into a large site, such as an office park (Delaware, 1997). Examples are the use of rear yard depressions or the use of the driveway or elevated roadway to create subtle upslope dams.

Berming is another grading technique used to block the passage of runoff, retain it, and allow it to infiltrate naturally into vegetated areas upslope. Berms can be incorporated with individual driveways, lot by lot, in order to capture and infiltrate runoff from roads and driveways. Such berm systems may intersect the vegetated swale, with the berms extending along the contours into the respective lot and providing volume control as necessary. Berming can be carefully integrated into total site development by taking advantage of zones of existing vegetation.

Another effective approach that avoids some problems of conventional grading is terracing. Terracing is used to grade long slopes in steps or small horizontal benches. This "stepped slope" method is a modern version of the terraced slopes used for centuries by traditional societies that practice agriculture on hillsides. Stepped slopes are small horizontal benches that are constructed as the slope is being graded. Each step dissipates the energy of water from above, allowing more time for infiltration to occur. While some erosion does occur, this eroded material can provide a rooting medium for seeds. The terraces should be level or slope back into the hillside, or erosion may occur faster than the step can be stabilized by revegetation.

Sensitive site resources should be protected when functional grading is used and erosion and sediment control practices should be used until disturbed areas are stabilized.

Additional Resources

Schor, H. 1980. "Landform Grading: Building Nature's Slopes." *Pacific Coast Builder*, pp. 80-83.

Schor, H., March 1992. "Hills Like Nature Makes Them." *Urban Land*, pp. 40-43.

Schor, H. and D.H. Gray. "Landform Grading and Slope Evolution." *ASCE Journal of Geotechnical and Geoenvironmental Engineering*,

Thompson, J.W. and K. Sorvig, 2000. Sustainable Landscape Construction: A Guide to Green Building Outdoors, Island Press.

Description

Site fingerprinting involves delineating the smallest possible areas and restricting ground disturbance to these areas where structures, roads, and rights of way will exist after construction is completed.

General Information

Site fingerprinting can be used to reduce the limits of clearing and grading, thereby minimizing the hydrologic impacts. The smallest site disturbance area possible is delineated and flagged to minimize soil compaction. Clearing of vegetation and disturbance of soil is carefully limited to a prescribed distance from proposed structures and improvements. The maximum distances reflect construction techniques and equipment needs, together with the physical situation such as slopes. The temporary storage of construction equipment in these areas is also restricted.

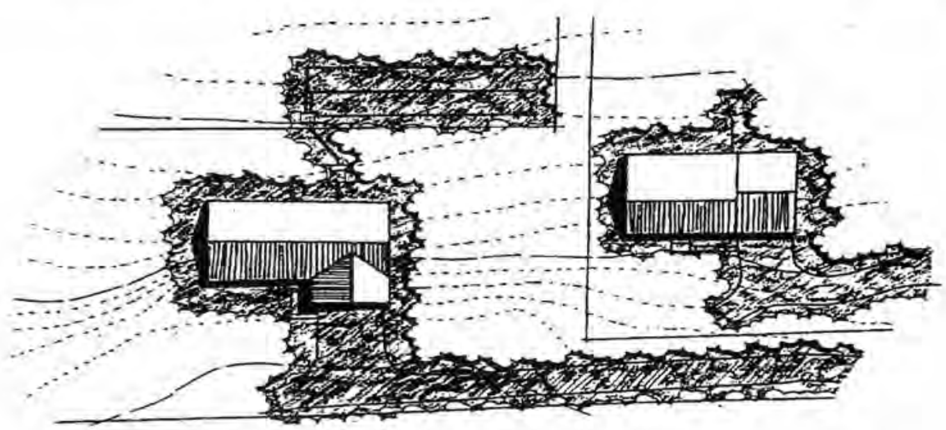
Additional Resources

Corish, K.A., 1995. *Clearing and Grading Strategies for Urban Watersheds,* Metropolitan Washington Council of Governments.

Delaware Department of Natural Resources and Brandywine Conservancy, 1999. *Conservation Design for Stormwater Management.* Available on website.

Figure 3-1.

Traditional site fingerprinting depicting areas that were cleared and graded in shading (Corish, 1995)



Protect Natural Site Functions BMP 4

Description

Landforms, soils, and vegetation are protected from development impacts so that they continue to provide hydrologic functions for the site. Limiting the amount of disturbed area, minimizing soil compaction especially of high-permeability soils and preserving existing native vegetation protect the natural functions of a site.

General Information

The urbanization process significantly modifies land surfaces and generally reduces a watershed's depression storage. The combination of site compaction, site imperviousness, and reduced depression storage can cause significant downstream problems. Limiting development impacts is the most effective way to preserve natural site functions.

Maintaining a site's existing topography helps protect the natural drainage channels and depressions which are much more effective in regulating water quality and quantity than any structural storm water facility. Protecting and using the hydrology of a site to generate the development form can save on development costs by minimizing earthwork and expensive drainage structures by working with natural landforms. The drainage system can also suggest pathway alignment, optimum locations for park and play areas, and potential building sites (Coffman, 2000).

Preserve the natural hydrologic functions of the site including streams and their buffers, floodplains, wetlands, steep slopes, and high-permeability soils; create landform alterations that perform a hydrologic function. Leave critical areas with desirable trees in their natural condition or only partially cleared.

Prior to construction, topsoil should be removed from all parts of the site that will be built on, as well as access paths and staging areas to be used later in restoring other portions of the site. Topsoil should not be relocated to critical areas such as preserved trees zones, vegetative stream buffers, or wetlands. To prevent erosion, small stockpiles can be covered with plastic; large stockpiles may require stabilization by seeding or mulching.

During construction, soil compaction should be minimized. This includes compaction by heavy equipment and small repeated forces such as persistent foot traffic. Limiting on-site stockpiling of materials and parking also reduces soil compaction. Staging areas should be chosen carefully, located preferably in an area that is already designed to be a hard surface such as a driveway, patio, or plaza, and well away from important trees or sensitive areas. In some cases, it is possible to use existing roads or parking areas adjacent to the site for materials storage.

Where possible, existing vegetation should be protected. Existing trees are among the most valuable features a site can have, from both ecological and real-estate perspectives. Trees stabilize the soil and prevent erosion, decrease stormwater runoff, moderate temperature, provide buffers and screens, filter pollutants from the air, supply oxygen, provide habitat for wildlife, and increase property values. Although trees are the most prominent vegetation on most sites, the health of other vegetation may be equally important in some regions. Shrubs, meadows, hedgerows, windbreaks, and groves strongly affect both the character and the ecological functioning of the site (Thompson and Sorvig, 2000).

During site evaluation, note where valuable trees and other natural landscape features should be preserved. Locate roadways, buildings, storage areas, and parking pads away from valuable vegetation. Designate groups of trees, individual trees, and other vegetation to be saved on the erosion and sedimentation control plan.

Although direct contact by equipment is an obvious means of damaging trees and other vegetation, the most serious damage is caused by root zone stress from compacting, filling, or excavating too close to the tree. Fence protected areas, build with great care under trees, and avoid grade changes near trees to protect vegetation. Clearly mark boundaries to maintain sufficient undisturbed areas around the trees. Minimize trenching in areas with trees. Follow natural contours, where feasible, to minimize cutting and filling in the vicinity of trees. Do not excavate, traverse, or fill closer than the drip line, or perimeter of the canopy, of trees to be saved.

Areas to be protected should be marked prior to any clearing and grading. Fluorescent marker paint or flagging should be used around protected features to guide preliminary clearing, followed immediately by fencing. All fenced areas should be completely off-limits to vehicle and foot traffic, and to materials storage. Protection fencing should remain until all work and cleanup are complete. At the very least, fencing should remain in place until all heavy machines (including delivery vehicles) have left the site.

Additional Resources

Arendt, R.G., 1996. *Conservation Design for Subdivisions: A Practical Guide to Creating Open Space Networks,* Island Press.

Center for Sustainable Design, *Tree Preservation and Protection,* Mississippi State University. Available on website.

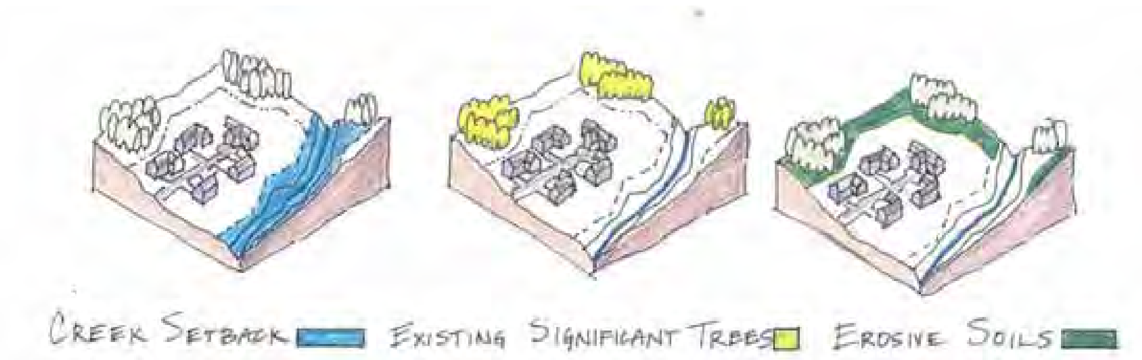
Dramstad, Wenche E., James D. Olson, and Richard T. Forman, 1997. *Landscape Ecology Principles in Landscape Architecture and Land-Use Planning,* Harvard University Graduate School of Design, Island Press and the American Society of Landscape Architects.

Forman, R. T., 1995. *Land Mosaics: The Ecology of Landscapes and Regions,* Cambridge University Press.

Johnson, B. R. and K. Hill, eds., 2001. *Ecology and Design: Frameworks for Learning,* Island Press.

Puget Sound Action Team, March 2003. *Natural Approaches to Stormwater Management*, Washington. Available on website.

Figure 4-1. Protect natural site functions



Preserve Natural Corridors BMP 5

Description

Preserve corridors that provide landscape connectivity. Protecting corridors provides higher quality linkages between habitat patches for wildlife and allows for informal walking trails for human movement.

General Information

Corridors, both natural and human-created, permeate the land. Rivers, roads, power lines, and hedgerows are familiar examples. Greenway corridors (linear open spaces or conservation areas) contribute to many ecological and societal goals. They help maintain biological diversity, protect water resources, conserve soil, support recreation, enhance community and cultural cohesion, and provide species dispersal routes. Greenways provide a crucial connectivity among parks and natural areas and can additionally protect waterways.

Corridors help to maintain functional habitats – which include travel corridors for native wildlife as they move from nests or burrows to areas where they hunt, feed, or breed. The resulting greenways frequently offer an additional benefit through the creation of informal walking trails through woodlands, or alongside meadows, creeks, or other natural features.

Most greenways are created with multiple goals in mind. Two of the foremost are conserving nature and providing recreational opportunities. Designers are challenged to maximize the synergism that exists between these goals while minimizing the conflict. Every greenway project should start with biological conservation and water resource protection as goals, regardless of how developed or pristine the affected area.

When corridor protection is implemented as part of a development, the designer should consider significant unprotected biological, water, recreational, or other features that could be maintained or enhanced by a greenway or network of greenways. This will help determine greenway alignment, width and design. Greenway design can be used to connect and therefore multiply open spaces. Greenways can also be located and designed to serve as protective buffers for stream channels or other sensitive areas.

Greenways are one way to connect neighborhoods without building streets for automobiles. A network of streams, ridges or other natural features provides excellent opportunities to connect neighborhoods with non-vehicular greenways. Preserving greenways is important particularly in places where land development has isolated - or threatens to isolate – remaining fragments of nature in floodways, in steep-sided ravines, along rocky ridgetops, or in remnant patches of upland vegetation. Greenways should be designed that maintain or enhance these natural features and associated processes.

Additional Resources

Dramstad, Wenche E., James D. Olson, and Richard T. Forman, 1997. *Landscape Ecology Principles in Landscape Architecture and Land-Use*

Planning, Harvard University Graduate School of Design, Island Press and the American Society of Landscape Architects.

Forman, R. T. et al, 2002.*Road Ecology: Science and Solutions,* Island Press, Washington, D.C.

Little, C.E., 1995. *Greenways for America,* Johns Hopkins University Press.

Smith, D.S. and P.C. Helmund, eds., 1993. *Ecology of Greenways,* University of Minnesota Press, Minneapolis, NM.

Aquatic Buffers BMP 6

Description

An aquatic buffer is an area along a shoreline, wetland, or stream where development is restricted or prohibited. The primary function of aquatic buffers is to physically protect and separate a stream, lake or wetland from future disturbance or encroachment.

General Information

Properly designed, buffers can provide stormwater management and act as a right-of-way during floods, sustaining the integrity of stream ecosystems and habitats. Technically, aquatic buffers are one type of conservation area, function as an integral part of the aquatic ecosystem, and can also function as part of an urban forest.

The three types of buffers are:

- Water pollution hazard setbacks, areas that may create a potential pollution hazard to the waterway. By providing setbacks from these areas in the form of a buffer, potential pollution can be avoided.
- Vegetated buffers that are any number of natural areas that exist to divide land uses or provide landscape relief.
- Engineered buffers, areas specifically designed to treat stormwater before it enters into a stream, shore or wetland.

There are ten key criteria to consider when establishing a stream buffer:

- Minimum total buffer width
- Three-zone buffer system
- Mature forest as a vegetative target
- Conditions for buffer expansion or contraction
- Physical delineation requirements
- Conditions where buffer can be crossed
- Integrating storm water and storm water management within the buffer
- Buffer limit review
- Buffer education, inspection, and enforcement
- Buffer flexibility.

In general, a minimum base width of at least 100 feet is recommended to provide adequate stream protection. The three-zone buffer system, consisting of inner, middle, and outer zones, is an effective technique for establishing a buffer. The zones are distinguished by function, width, vegetative target, and allowable uses. The inner zone protects physical and ecological integrity and is a minimum of 25 feet plus wetland and critical habitats. The vegetative target consists of mature forest, and allowable uses are very restricted (flood controls, utility right-of-ways, footpaths, etc.).

The middle zone provides distance between upland development and the inner zone and is typically 50 to 100 feet, depending on stream order, slope, and 100-year floodplain. The vegetative target for this zone is managed forest, and usage is restricted to some recreational uses, some storm water BMPs, and bike paths.

The outer zone functions to prevent encroachment and filter backyard runoff. The width is at least 25 feet and, while forest is encouraged, turf grass can be a vegetative target. Uses for the outer zone are unrestricted and can include lawn, garden, compost, yard wastes, and most storm water BMPs.

Additional Resources

Herson-Jones, 1995. *Riparian Buffer Strategies for Urban Watersheds,* Environmental Land Planning Series, Metropolitan Washington Council of Governments.

Maguire, T.D., 1997. *Environmental Planning Tools and Techniques.* Idaho Department of Environmental Quality, Boise, ID.

Schueler, 1995. "The Architecture of Urban Stream Buffers". Available on Stormwater Center website.

Schueler, 1995. *Site Planning for Urban Stream Protection.* Available on Center for Watershed Protection website.

USEPA, *Buffer Zone Fact Sheet.* Available on EPA website.

Fit Development to Natural Gradient   BMP 7

Description

Site disturbance can be minimized by locating buildings and roads along existing contours, orienting the major axes of buildings parallel to existing contours, staggering floor levels to adjust to grade changes, and designing structures including garages to fit into the terrain, lot by lot.

General Information

Steep topography poses a problem in the development of building sites and roads. Most conventional grading is based on straight lines, in plan or section or both. Such grading patterns produce level or near-level surfaces for human use and unvarying slopes on the "in-between" areas such as road cuts or embankments. However, these slopes are subject to erosion and mass wasting.

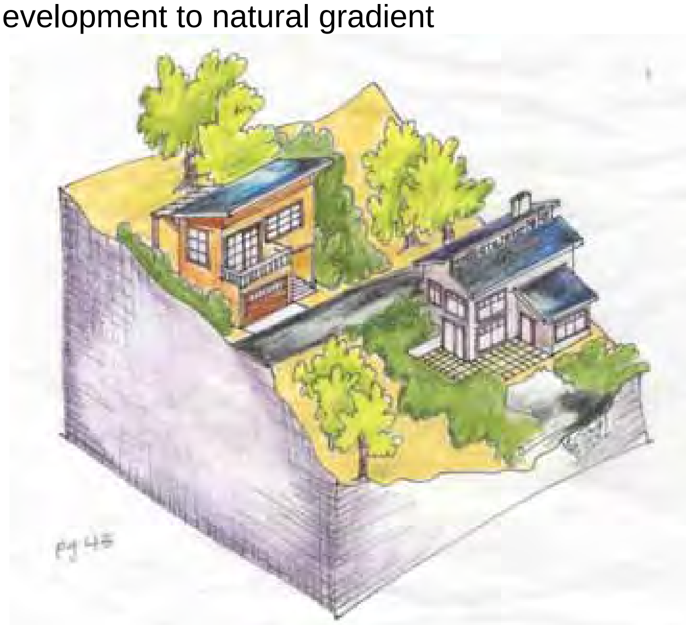
One technique to slow, if not completely prevent this problem is to fit the development to the existing contours. Steep slopes should be avoided and buildings aligned with topography to minimize grading. The major axes of buildings should be oriented parallel to existing contours and floor levels should be staggered to adjust to grade changes.

Avoid placing roads on steep slopes by designing roads to follow grades and run along ridgelines. Roads that follow contour lines increase cut and fill and make driveways difficult. Roads that go straight uphill reduce cut and fill, but may become excessively steep.

Additional Resources

Thompson, J.W. and K. Sorvig, 2000. *Sustainable Landscape Construction: A Guide to Green Building Outdoors,* Island Press, Washington, D.C.

Figure 7-1. Fit development to natural gradient



Locate Impervious Surfaces to Drain to Natural Systems BMP 8

Description

Existing zones of vegetation, from forested zones to scrub vegetation are used for management of stormwater runoff, often with some sort of landforming to achieve volume control. The scale of this technique can vary from micro-control by redirecting sidewalk and driveway runoff to adjacent vegetation to conveyance of runoff from larger impervious surfaces to natural areas on the development site.

General Information

Disconnecting as much impervious area as possible to increase opportunities for infiltration and reduce water runoff flow can optimize this technique. Carefully locate impervious areas so that they drain to natural systems, vegetated buffers, natural resource areas, or infiltratable zones/soils. When this is not possible, direct flows from impervious areas (roofs and paved surfaces) to bioretention areas, infiltration devices, drainage swales, retention areas, natural systems, or vegetated buffers.

The site design should be designed to maximize the overland sheet flow distance and to minimize disturbance of vegetation along flow paths. Flow velocity in areas that utilize natural drainage patterns should be kept as low as possible to avoid soil erosion. Flows can be slowed by installing a level spreader along the upland ledge of the natural drainage way buffer, or creating a flat grassy area on the upland side of the buffer where runoff can spread out.

Additional Resources

Delaware Department of Natural Resources and Brandywine Conservancy, 1997. *Conservation Design for Stormwater Management.* Available on website.

Minimize Directly Connected Impervious Areas BMP 9

Description

The impact of impervious surfaces is reduced by minimizing directly connected impervious areas, directing runoff from the impervious areas to pervious areas and/or small depressions, and in the process disconnecting hydrologic flow paths.

General Information

Impervious areas directly connected to the storm drain system are the greatest contributor to nonpoint source pollution. Any impervious surface, which drains into a catch basin, area drain, or other conveyance structure, is a "directly connected impervious area" (DCIA). A basic site planning principle for stormwater management is to minimize these directly connected impervious areas. This can be done by limiting overall impervious land coverage and directing runoff from these impervious areas to pervious areas or small depressions. Locate impervious areas to drain to natural systems and when this is not possible, direct flows from impervious areas (roofs and paved surfaces) to bioretention areas, infiltration devices, drainage swales, retention areas, natural systems, or vegetated buffers.

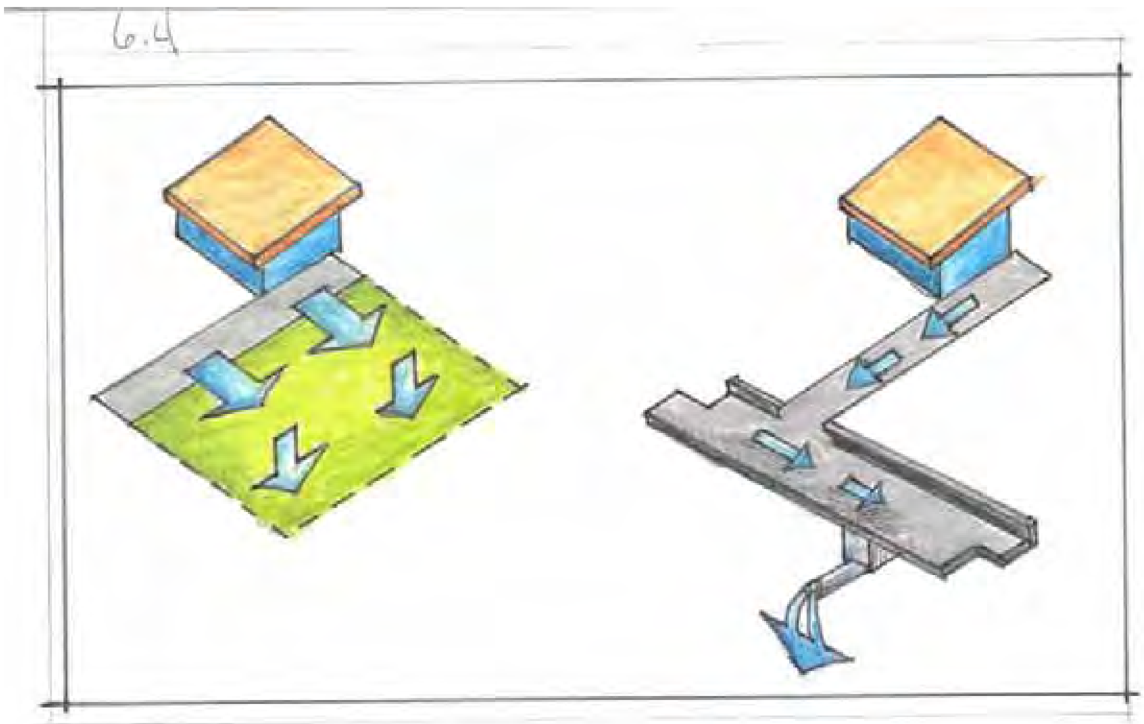
Strategies include:

- Disconnecting roof drains and directing flow to vegetated areas
- Directing flows from paved areas such as driveways to stabilized vegetated areas
- Breaking up flow directions from large paved surfaces
- Encouraging sheet flow through vegetated areas
- Carefully locating impervious areas so that they drain to natural systems, vegetated buffers, natural resource areas, or infiltratable zones/soils
- When applying this technique to roads, use slotted curbing along with stabilized grass shoulders and swales. The connection between impervious areas can be addressed in varying degrees.
- The runoff generated by impervious surfaces can be directed over grass-covered areas before runoff leaves the site, enters a curb and gutter system, or enters another storm water collection system.
- The runoff can be directed over a grass-covered area and then into low-velocity grass-lined swales and pervious street shoulders that have replaced street curb and gutter systems.
- The runoff can be directed over a grass-covered area and then into oversized swales with driveway and street crossing culverts arranged to direct flow into grass-lined swales. The swales are used as elongated detention areas.

Additional Resources

Bay Area Stormwater Management Agencies Association (BASMAA), 1999. Start at the Source: Design Guidance Manual for Stormwater Quality Protection.

Figure 9-1. Minimize directly connected impervious areas.



Break Up Flow Directions From Paved Surfaces BMP 10

Description

Impervious surfaces are designed to allow storm water to runoff in a dispersed manner in several directions. The drainage of impervious surfaces is pitched onto adjacent vegetated soil and not onto other pavements or into storm sewers.

General Information

Impervious areas can be designed so that precipitation is not collected and conveyed to one discharge point but rather is dispersed in several directions and discharged to adjacent vegetated areas. The drainage of driveways and sidewalks is directed onto adjacent vegetated soil and not onto other pavements or into storm sewers. Large parking areas are broken up with "infiltration islands" or served by underground storage or recharge beds. Stormwater bioretention areas, vegetated swales and filter strips can be integrated into landscape areas and traffic islands.

Retention grading can create slightly sunken and bermed lawn areas to hold rainwater from roofs, driveways, and sidewalks until it can percolate into the ground. A driveway drywell can be used to recharge groundwater if automobile fluids are contained or treated first. A grassed or mulched swale can provide further filtration and keep surface water on-site.

Street drainage can be detached from drainage inlets and diverted into vegetated swales on both sides of the right of way. Break up flow directions by locating roads on ridgelines, allowing water to drain naturally downhill. Curbless road design encourages infiltration via roadside swales, bioretention areas and buffers.

Use Alternative Surfaces — BMP 11

Description

Various forms of porous materials (poured in-place pervious concrete and porous asphalt, unit pavers-on-sand, and granular materials) are used instead of concrete or asphalt when surface stability is needed.

General Information

No ground surface should be any harder than absolutely necessary for its function. Many conventional paved areas are much harder than required by their function. Paving, for instance, should not be used where crushed stone will do, nor crushed stone where a path of bark chips is sufficient.

Various forms of porous materials (poured in-place pervious concrete and porous asphalt, unit pavers-on-sand, and granular materials) are available when surface stability is needed. They rely on open pores that detain runoff, filter pollutants, and allow water to infiltrate the underlying soil. Porous pavement may substitute for conventional pavement on parking areas, areas with light traffic, and the shoulders of airport taxiways and runways, provided that the grades, subsoils, drainage characteristics, and groundwater conditions are suitable.

Porous asphalt and porous concrete consist of a stone aggregate held together with either asphalt or Portland cement as a binder. Fear of clogging is a concern that often limits the use of porous paving, although proper design, installation and maintenance can minimize loss of porosity over time.

Properly designed modular pavement or unit pavers are the one form of porous pavement that has been in use since the mid-1970s with very few reported problems. Unlike poured-in-place concretes or asphalts, which create one continuous surface, unit pavers are discrete units that are set in a pattern on a prepared base. They come in the form of turf block, brick, natural stone, and concrete unit pavers. Among the most permeable parking surfaces are grassed paving systems that allow turf grass to grow through an open cell of concrete or plastic that transfers the weight of vehicles to an underlying base course.

Grassed paving is somewhat limited in its applications because grass will not survive constant daily traffic but can be used for emergency fire lanes or for temporary overflow parking. Pavers can also be filled with fine gravel or other permeable materials when more frequent parking is expected.

A wide variety of loose aggregates can be made to form permeable pavements suitable for walking, jogging, biking, or light vehicular traffic. They include gravel, cobbles, and wood mulch. An example of the application of the principle that no surface should be harder than needed to perform its function is a hybrid parking lot. Hybrid parking lots differentiate paving, combining impervious aisles with permeable stalls. Impervious aisles are designed to carry moving vehicle traffic and can accommodate turning movements. Permeable stalls are designed for stationary or very slow moving cars.

(BASMAA, 1999).

Additional Resources

Bay Area Stormwater Management Agencies Association (BASMAA), 1999. *Start at the Source: Design Guidance Manual for Stormwater Quality Protection.*

Low Impact Development Center. Information about permeable pavers on website.

Thompson, J.W. and K. Sorvig, 2000. *Sustainable Landscape Construction: A Guide to Green Building Outdoors,* Island Press, Washington, D.C.

USEPA, *Field Evaluation of Permeable Pavements.* Available on EPA website.

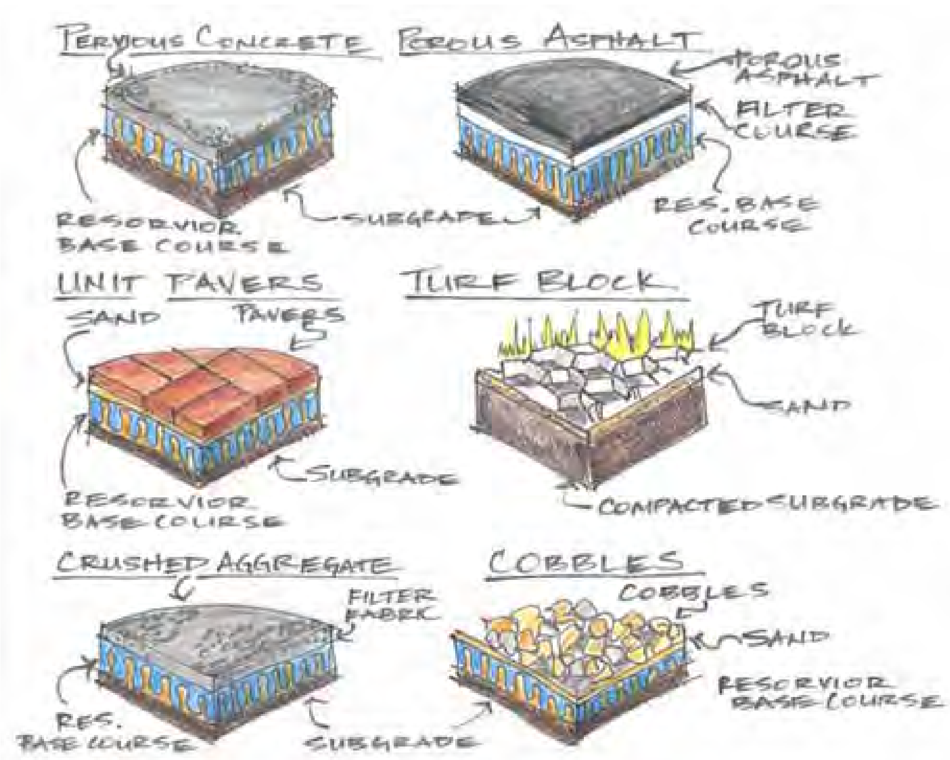
USEPA, *Low Impact Development Literature Review.* Available on EPA website.

USEPA, *Storm Water BMPs: Alternative pavers.* Available on EPA website.

USEPA, *Storm Water BMPs: Porous pavement.* Available on EPA website.

USEPA, *Storm Water Technology Fact Sheet: Porous pavement*. Available on EPA website.

Figure 11-1. Alternative surfaces



Trail and Path Network BMP 12

Description

The creation of trails and paths within a neighborhood and connecting adjacent neighborhoods and to commercial centers in order to reduce reliance on automobiles and their associated environmental impacts.

General Information

The walkability of a neighborhood is a major component of the new urbanism. This practice involves using existing and new routes for non-motorized human movement within a development and within a community. On-street trails consist of sidewalks, bike lanes, and crosswalks. Off-street trails consist of the more typical type of trail: wooded paths, hiking trails, equestrian trails, and bike trails.

Trails and paths, like those for any transportation mode, are most effective when they are part of a system that assures connections, continuity, access, and safety. A community-wide system of facilities that is well designed and maintained is essential. Where appropriate these routes should link with other existing long distance routes. Greenways, river corridors, canal right of ways, and abandoned railroad lines present opportunities for the creation of paths and trails serving larger areas.

It is important to consider the needs of pedestrians during transportation and development projects. In an interconnected pedestrian system, sidewalks are continuous; crossing streets safely is made possible; and, where appropriate, measures are taken to slow automobile traffic. Wherever possible access to a network from public transport networks should be encouraged and developed. Unlike bicyclists who sometimes want to traverse an entire city or region, pedestrians tend to do most of their walking close to home, work, school and commercial activity areas, like central business districts and shopping centers.

Some of the areas where pedestrian considerations should and often do occur, include:

- Central business districts
- School routes
- Residential areas
- University/college areas

Additional areas of attention where pedestrian considerations should, but often do not, occur include:

- Access to downtown from surrounding neighborhoods
- Arterial and collector roadways that serve commercial and residential areas
- Neighborhood commercial areas
- Access to parks and community centers
- Hospitals and elderly housing facilities

Because sidewalks and trails provide such fundamental services to the public, they should be designed to meet the needs of the widest possible range of users. Trail and path networks should also be developed in an environmentally sensitive way, reconciling the needs of path users with those of nature conservation.

Both the basic development pattern and the design of individual sites can encourage or discourage bicycling and walking. For example, large parking lots in the front of buildings, berms that discourage easy access, and blank walls are intimidating. However, interesting facades and buildings that face the street and are closer to sidewalks create a more pedestrian "friendly" environment. Parking for cars should either be provided on the street or behind the development. Parking for bikes should also be provided in a protected location and close to the building to encourage non-motorized access.

Additional Resources

Little, C.E., 1995. *Greenways for America,* Johns Hopkins University Press.

Smith, D.S. and P.C. Helmund, eds., 1993. *Ecology of Greenways,* University of Minnesota Press, Minneapolis, NM.

Federal Highway Administration, no date. *Designing Sidewalks and Trails for Access.* Available on website.

Iowa Department of Transportation, no date. *Connecting People and Trails: Local Community Planning for Bicyclists and Pedestrians.* Available on website.

Walkable Communities, Inc. Information available on website.

Florida Department of Transportation, no date. *Twelve Steps Toward Walkable Communities.* Available on website.

Figure 12-1. Trail and path network

Alternative Development Configurations BMP 13

Description

Alternative development configurations can be implemented using site-planning techniques that concentrate development on one or more portions of a site, and conversely maintain more of the site in open space. This approach has been called open space design, conservation development, and cluster development.

General Information

Reconfigured development forms offer an attractive alternative to conventional subdivision design and are applicable to most forms of residential development, with special opportunities in rapidly growing rural settings and within suburban fringes of growing communities. Reconfiguring a development project is an effective way to significantly reduce stormwater runoff and the contributed pollution from an area since the percentage of imperviousness can be considerably reduced (as much as 10% to 50% based on the lot size and layout).

Other characteristics of this technique include:

- A *clustering* technique that targets the rural setting experiencing growth pressures and the growing fringes of a community.
- The *central theme* of this technique revolves around allowing the size and location of the open space to drive the subdivision design.
- The approach is *density-neutral*, which respects private property rights.
- The approach is adaptable to situations where central water and sewer are not available.
- The approach is adaptable to areas previously zoned as low-density residential.

Clustering development can guide development to the least sensitive areas of a subdivided parcel and provide protection for sensitive resource areas as open space. Primary conservation areas consist of land within a designated floodplain zone, regulatory wetlands, locally designated stream buffer zones, and delineated wellhead protection zones (i.e., a groundwater recharge area designated by a municipality). Secondary conservation areas are those areas that may be non-essential based on local circumstances; they are typically prime agricultural soils, optimal soils for cluster or community septic system(s), historical/cultural features, or woodlands.

Arendt (1999) describes clustering as part of the design process for conservation subdivisions. This approach distinguishes open space first, allowing the size and location of the open space to drive the subdivision design. The act of delineating characteristic open space for preservation also defines the potential development area. This step virtually assures the protection of sensitive open spaces, but also serves as a basis for identifying local amenities, which enhances the marketability and value of the property, provides recreational opportunities, maintains fish/wildlife habitat, and overall improves the quality of life. The houses, street alignments, neighborhood trails and lot lines are then drawn in. Open space preservation is achieved through set-aside or purposely limited with respect to types of development through development easements, transfer of development rights or purchase programs.

Additional Resources

Arendt, R.G., 1996. *Conservation Design for Subdivisions: A Practical Guide to Creating Open Space Networks,* Island Press.

Maguire, T.D., 1997. *Environmental Planning Tools and Techniques.* Idaho Department of Environmental Quality, Boise, ID.

Maryland Office of State Planning, October 1994. *Clustering for Resources Protection.* Available on website.

Metropolitan Washington Council of Government, *Cluster Development Strategies for Urban Watersheds*

Schueler, 1995. *Site Planning for Urban Stream Protection.* Available at Center for Watershed Protection website.

Schueler, "Use of Cluster Development to Protect Watershed", *Watershed Protection Techniques.* Available at Stormwater Center website.

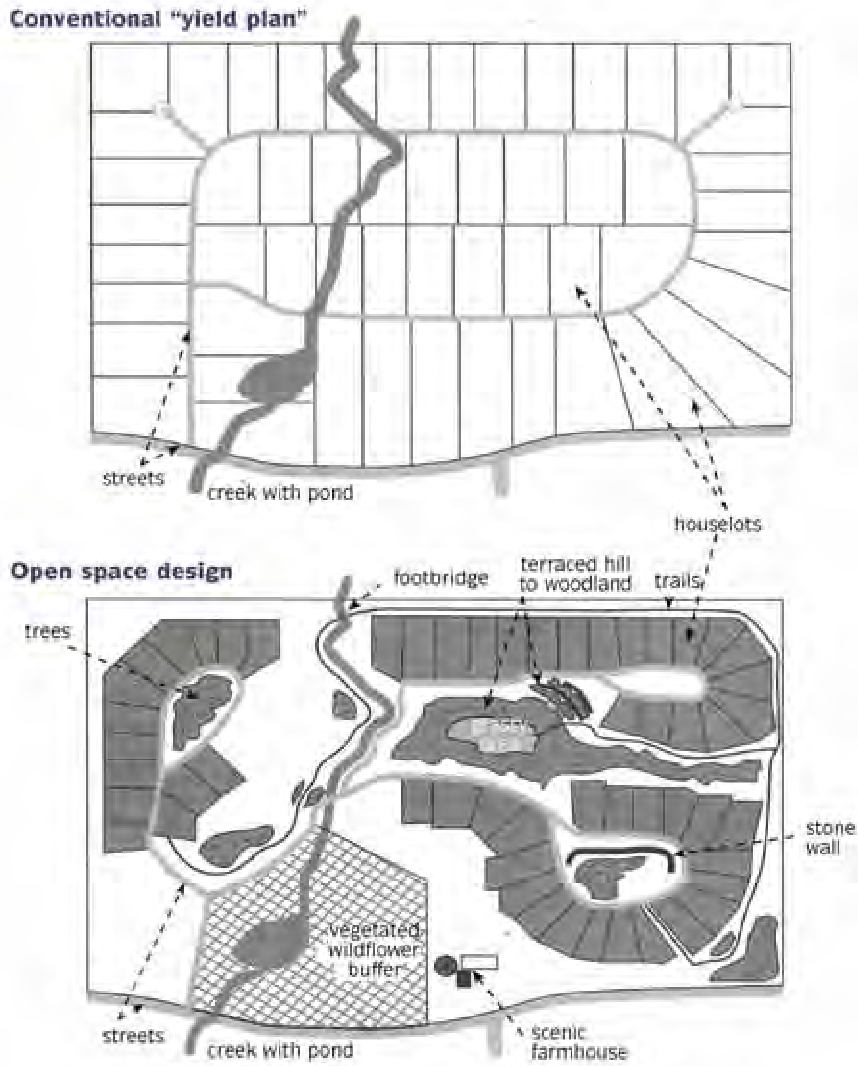
USEPA, *Storm Water BMPs: Conservation easements.* Available on EPA website.

USEPA, *Storm Water BMPs: Infrastructure planning.* Available on EPA website.

USEPA, *Storm Water BMPs: Open space design.* Available on EPA website.

Figure 13. Alternative development configuration

Comparision between a conventional "yield plan" and the open space methodology for the same parcel of land (after Arendt, 1996a). Note that both plans have the same density yield of 54 houses.



Define Development Envelope BMP 14

Description

The development envelope is defined by identifying protected areas, setbacks, easements and other site features, and by consulting applicable local standards and requirements.

General Information

The development envelope is defined by identifying protected areas, setbacks, easements and other site features. The property features may consist of unbuildable wetlands, floodplains, and steep slopes and parts of the buildable uplands that are most sensitive environmentally, most significant historically or culturally, most scenic, or which possess unusual attributes. These areas are protected with the remaining areas as potential areas for development.

The local standards and requirements contained in the zoning code and subdivision regulations are also analyzed. Applicable local standards and requirements are intended to regulate the density and geometry of development, specify roadway widths and parking and drainage requirements, and define natural resource protection areas.

The development envelope is then defined as those areas that appear to be least important to conserve, looking at the site as a whole. Construction can only take place only within the development envelope, which is selected on the basis of buildability, accessibility, visual unobtrusiveness, clearance from natural features, and distance from adjacent building areas.

Additional Resources

Arendt, R.G., 1996. *Conservation Design for Subdivisions: A Practical guide to Creating Open Space Networks,* Island Press, Washington, D.C.

Delaware Department of Natural Resources and Brandywine Conservancy, 1997. *Conservation Design for Stormwater Management.* Available on website.

Schueler, 1995. *Site Planning for Urban Stream Protection.* Available on Center for Watershed Protection website.

Identify Sensitive Areas BMP 15

Description

Sensitive areas may include wetlands, floodplains, riparian buffers, steep slopes, shallow bedrock, high water table areas, and other constraining features. Sensitive natural factors can provide special positive functions or may limit development.

General Information

Environmentally sensitive site design depends on knowledge of the nature and degree of constraints and opportunities offered by a given site. Identification of unsafe or unsuitable land is an integral part of this process, both from the standpoint of providing safe and habitable buildings and for providing protection and conservation of natural resources.

Wetlands, floodplains, riparian buffers and natural drainages should be identified and mapped for consideration throughout the design process. The objective is to integrate these site resources into the final design in a way that allows them to function as assets rather than problems. Other sensitive site features to be protected may include woodland conservation zones and important existing trees; steep slopes; and highly permeable and erosive soils.

Floodplains perform valuable functions including wildlife habitat; recreational, aesthetic, and scientific needs; open space; groundwater recharge; water quality maintenance; and sediment control. Development in flood plains usually reduces, modifies, or eliminates their ecological functions.

Wetlands are areas that are inundated or saturated by surface and ground water at a frequency and duration sufficient to support vegetation typically adapted for life in saturated soil conditions. Wetlands generally support diverse vegetation species, which filter suspended sediment and dissolved nutrients from local runoff. Wetlands provide flood control, functioning as temporary storage areas.

Aquifers are thick, porous, and permeable layers of rock that underlie many areas in Idaho that provide groundwater. Over 90% of Idaho communities rely on ground water as a source for drinking water and other domestic uses. Aquifers are usually recharged by local precipitation and are vulnerable to contamination from overlying land uses.

Riparian buffers include the many types of plants that grow in the wetted perimeter along creeks, streams, and rivers. Riparian vegetation stabilizes stream channel perimeters and plays an indispensable role in preventing erosion. Vegetation functions as a filter trap for suspended sediment from upstream locations. Trees and shrubs provide shade and habitats for fish and other wildlife.

Sensitive areas, such as steep slopes, shallow bedrock, high water table areas, and other constraining features are also important because land development in these areas may have negative impacts and should be avoided. Observations and mapping should extend beyond the basics forms to potential "problems", such as noxious vegetation; erosion gullies, boggy ground, rocky areas, or compacted, leached soils.

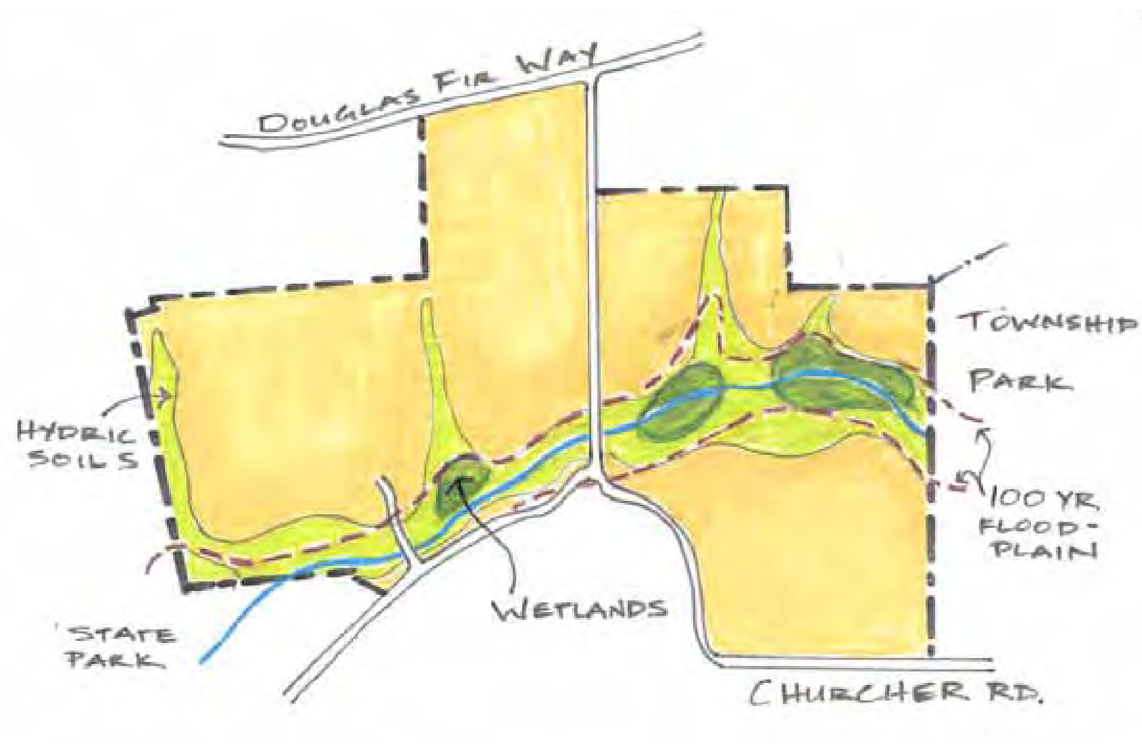
Additional Resources

Delaware Department of Natural Resources and Brandywine Conservancy, 1997. *Conservation Design for Stormwater Management.* Available on website.

Lyle, John Tillman, 1994 (2nd ed. of 1985 pub.). *Regenerative Design for Sustainable Development,* John Wiley & Sons, Inc.

Steiner, Frederick, 1999. *The Living Landscape: an Ecological approach to Landscape Planning,* McGraw-Hill, Inc.

Figure 15. Identify sensitive areas



Alternative Lot Configuration BMP 16

Description

Lot configuration relates to both the size of lots and their arrangement. A waiver from local zoning requirements may be necessary for alternative lot configurations.

General Information

Conventional zoning standards usually dictate that each lot have a minimum area, specify each home should be set back a fixed distance from front, side and rear property lines, and require a minimum frontage width (i.e., mandatory width of the front yard. Together, these standards tend to increase the total size of each lot, which in turn increases the distance between lots. The length of roads, sidewalks and other impervious surfaces is directly correlated with the distance between lots. Thus, as the distance between lots is extended, more impervious cover will be created.

Alternative lot configurations increase design flexibility in creating alternative development configurations, protecting sensitive areas, and reducing the amount of impervious surface on a site. Alternative lot configurations relate both to the size of the lots and their arrangement.

Lot size reduction is governed by local zoning requirements and may require a waiver to implement. Lot size is related physically to structural type. As lot size decreases to less than one half acre for example, certain types of conventional structure types may be difficult to accommodate on the reduced size lot. Once lots are reduced in size, then these lots can be located on the total site in ways that avoid disturbance of critical site features.

Current subdivision codes may also have strict requirements regarding lot geometry that limit flexibility in setbacks and lot shape. These requirements limit the use of cluster development and can increase the amount of impervious surface on a lot. Structures typically should be set back from streets and highways, and lot lines on the side and rear of the lot. Driveway length is generally determined by garage setback requirements. If garages are set back from the street, long driveways are required.

The overall lot imperviousness can be reduced when front setback requirements are relaxed to minimize driveway and sidewalk lengths. When side yard setbacks are flexible and allow for narrower frontages, the length of public sidewalks and streets can also be reduced. Shared driveways that allow access to two or more garages further reduce impervious surface.

Additional Resources

Arendt, R.G., 1996. *Conservation Design for Subdivisions: A Practical Guide to Creating Open Space Networks,* Island Press.

Schueler, 1995. *Site Planning for Urban Stream Protection.* Available at Center for Watershed Protection website.

Water Harvesting and Reuse BMP 17

Description

Water harvesting is the collection and storage of rainwater from roofs, paved surfaces and the landscape. Tanks, cisterns, or sealed wells store roof water. Water harvesting for landscape use is simply grading the site to drain toward planted beds or ponds.

General Information

Rain and snow fall as naturally distilled water that could be used to provide many beneficial uses when collected on site, such as irrigation, recreational lakes, groundwater recharge, industrial cooling and process water, and other nonpotable domestic uses. The collection and storage of rainwater from roofs, paved surfaces and the landscape is called water harvesting.

One technique is to fit tanks, cisterns, or sealed wells to take house roof water. The effect of using roof-generated runoff for domestic water supply is to eliminate roof impervious surfaces from contributing stormwater runoff. This elimination of runoff reduces the total volume of stormwater runoff from a site. Rainwater-holding cisterns are affordable when measured against the water supply and stormwater-drain investments they make unnecessary.

A rainwater harvesting system consists of three basic elements: a collection area, a conveyance system, and storage facilities. The collection area in most cases is the roof of a house or a building. The effective roof area and the material used in constructing the roof influence the efficiency of collection and the water quality (OAS, 1995). A conveyance system usually consists of gutters or pipes that deliver rainwater falling on the rooftop to a storage unit. Both drainpipes and roof surfaces should be constructed of chemically inert materials such as wood, plastic, aluminum, or fiberglass, in order to avoid adverse effects on water quality (Ibid).

The water ultimately is stored in a rain barrel, storage tank, or cistern, which should also be constructed of an inert material. Reinforced concrete, fiberglass, or stainless steel are suitable materials for storage tanks or cisterns. Storage tanks may be constructed as part of the building, built as a separate unit located some distance away from the building, or used as an underground storage tank. Premanufactured residential use cisterns come in sizes ranging from 100 to 1,400 gallons.

Rain barrels can be incorporated into the site's landscape. Rain barrels are equipped with a drain spigot that has garden hose threading, suitable for connection to an irrigation system. An overflow outlet should be provided to bypass runoff from large storm events. The size of the rain barrel is a function of the rooftop surface areas that drains to the barrel, as well as the amount of rainfall to be stored.

Choosing the best materials for rainwater-harvest depends on the ultimate use of the water. The Texas Water Development Board (1997) and the

Organization of American States (1995) have developed guidelines for water harvesting and reuse systems. In roof systems, stainless steel, tile, terra cotta, and slate are frequently used. Paved non-vehicular surfaces are generally suitable for water harvesting; vehicular paving with light traffic is also often clean enough.

Perhaps the simplest form of water harvesting for landscape use is simply grading the site to drain toward planted beds or ponds. In hillside areas, terracing at a small scale can be used to capture runoff for irrigation. Shallow ditches roughly following contours (often called "key lines") can be used to gather erosive sheet flows into series of small hillside ponds (Thompson and Sorvig, 2000). Low stonewalls or check-dams can also be used to hold back and infiltrate water at strategic points in a watershed.

At the University of Arizona's Casa del Aqua in Tucson, and at the Environmental Showcase home maintained in Phoenix by Arizona Public Service, harvested water supplements greywater to meet irrigation needs. Water harvesting is also extensively used at the Lady Bird Johnson Wildflower Center in Texas. A horticultural nursery in Thomson, Georgia has paved most of the watershed with plastic sheets and greenhouses. A pond captures the abundant runoff; from the pond, pumps recycle the water for the nursery's irrigation. This on-site "water harvesting" makes the use of water resources efficient and the future of this water consuming sustainable (Ferguson, 2000).

Additional Resources

Bay Area Stormwater Management Agencies Association (BASMAA), 1999. *Start at the Source: Design Guidance Manual for Stormwater Quality Protection.*

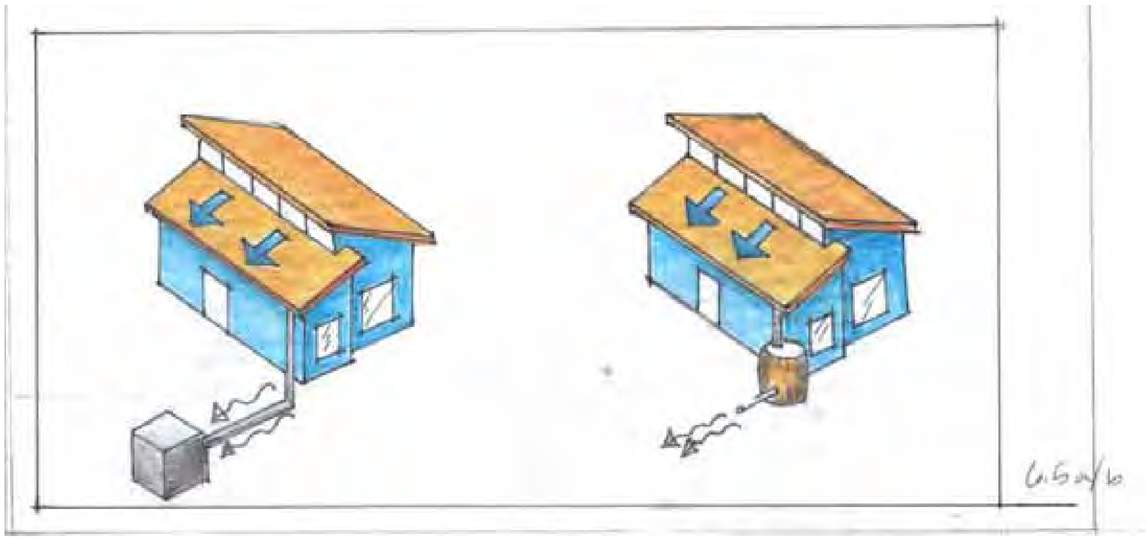
Coffman, L., 2000. *Low-Impact Development Design Strategies, An Integrated Design Approach.* Available on EPA website.

Organization of American States, 1995. *Rainwater Harvesting from Rooftop Catchments.* Available on website.

Pima County Flood Control District, no date. *How to Harvest Rainwater*. Available on website.

Texas Water Development Board, 1997. *Texas Guide to Rainwater Harvesting.* Available on website.

Figure 17-1. Rainwater harvesting and reuse



Green Roofs BMP 18

Description

Green rooftops are veneers of living vegetation installed atop buildings, from small garages to large industrial structures. Green roofs help manage stormwater by mimicking a variety of hydrologic processes normally associated with open space. Plants capture rainwater on their foliage and absorb it in their root zone, encouraging evapotranspiration and preventing much stormwater from ever entering the runoff stream.

General Information

Green roofs provide an opportunity to mitigate the developmental impacts of construction practices by replicating the functions eliminated by the building footprint through the design of rooftops. Green roofs embody many environmental benefits, especially when applied to urban settings, where nature is at a premium. They can help restore the ecological value of open space to densely developed city centers

On-site stormwater retention and runoff control from expansive roof surface areas of buildings can be accomplished through green roofs. Green roofs reduce the volume of stormwater flowing into streams and drainage channels, resulting in the control of sediment transport and overall soil erosion.

Depending on rain intensity and green roof soil depths, between 15 to 90 % of the precipitation can be absorbed, thereby considerably reducing runoff and potential pollutants from traditional impervious roofing surfaces. Plants intercept and delay rainfall runoff and the peak flow rate, and eventually return water to the surrounding atmosphere by evaporation and transpiration. Average runoff absorption rates are between 50 and 60%.

The green roof concept is akin to the garden roofs found atop buildings worldwide, which are traditionally heavy and difficult to maintain,. Green roofs are the result of a complete underlying roof build-up system, providing continuous, uninterrupted layers of protection and drainage. Recent strides in technology have advanced the properties of green roofs, making them lighter, more durable and better able to withstand the extreme climatic conditions of the rooftop.

Green roofs are thoroughly engineered systems which address all the critical aspects of design, including: the saturated weight of the system and load bearing capacity of the underlying roof deck; moisture and root penetration resistance of the waterproofing membrane; resistance to wind shear; management of drainage; and the suitability of the proposed plant material.

All green rooftops include the following basic component layers, listed from the bottom up:

- Waterproofing and root barrier
- Insulation (optional)
- Drainage and filter layer

- Soil and plants

Green rooftops can be built in a variety of ways, but the simplest involves a relatively light system of drainage and filtering components and a thin layer of soil mix (2 to 4 inches), which is installed and planted with drought-tolerant herbaceous vegetation.

Vegetation is typically succulents, grass, herbs, and/or wildflowers adapted to harsh conditions (minimal soils, seasonal drought, high winds, and strong sun exposure – i.e., alpine conditions) prevalent on rooftops. Proven hardy green roof plants are the alpine types and those that can retain a certain amount of moisture within their leaves or bulbs. Other plants known to flourish in areas of high heat, drought, wind, direct sun, and temperature extremes should be particularly adaptable to the sometimes harsh conditions of a green roof. Some examples of species include: sempervivum, sedum, creeping thyme, allium, phloxes, and anntenaria. Most plants naturally occurring along county roads, expressways, abandoned sites, and similar sites, that do not receive irrigation would adapt well to the green roof environment.

Additional Resources

Environmental Building News, 2003. “A Garden Overhead: the benefits and challenges of green roofs”, Vol. 10, No. 11, Special Reprint.

London Ecology, *Building Green: A Guide to Using Plants on Roofs, Walls and Pavements*

Peck, Steven W. *The Green Roof Infrastructure Monitor,* The Cardinal Group Inc. Available at Greenroofs website.

Additional information also available at Greenroofs website: www.greenroofs.com

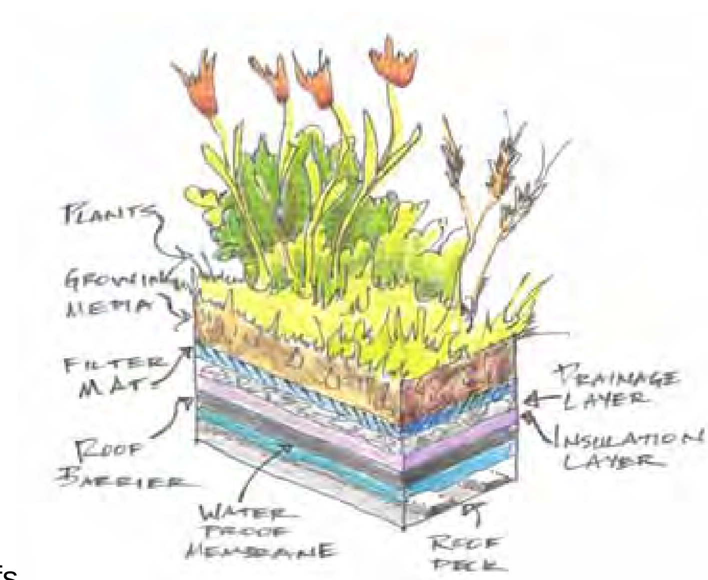
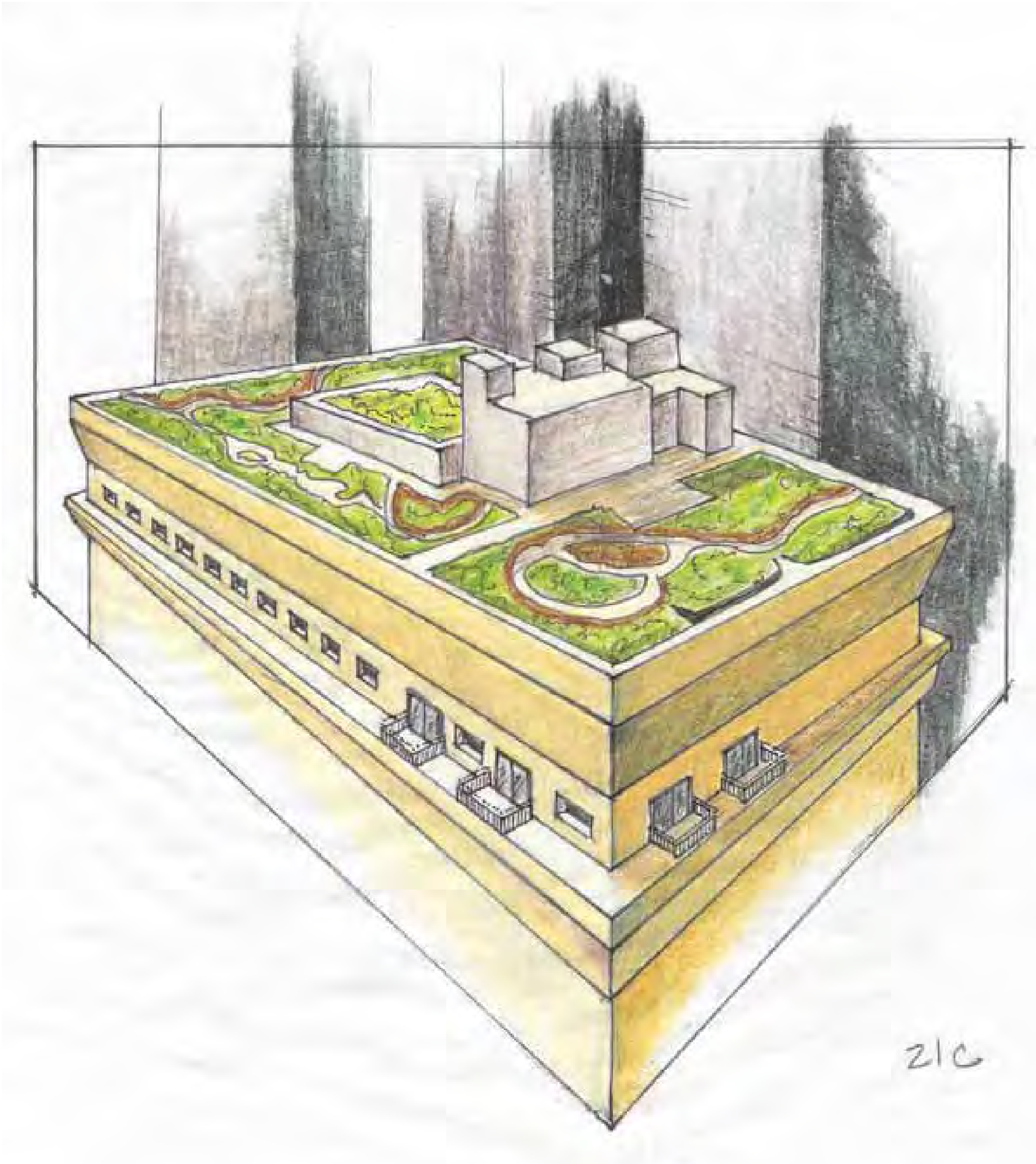


Figure 18-1. Green roofs

Figure 18-2. Green roofs



Description

Residential streets are designed with the minimum pavement width necessary to support traffic volume, on-street parking needs, and emergency, maintenance, and service vehicles. Streets are scaled to traffic volume, where the function and use of the particular roadway are linked to the width and other characteristics relating to imperviousness.

General Information

In many developing areas, minimum street widths have been established which are excessive and which do not reflect functional needs. Access streets in subdivisions often are wider than the collector and "higher order" streets that receive their traffic (Delaware, 1997). For the type of "first order" street system designed to service low density residential subdivisions, unneeded width is costly to construct, requires expensive real estate, and creates far more storm water than otherwise would be necessary.

The design standards of the American Association of State Highway and Transportation Officials (AASHTO) and the Institute of Transportation Engineers (ITE) have generally been accepted and are followed for roadway projects built with state and federal funds. But these design standards are often inappropriately applied by default to local streets.

One approach that meets the access requirements while reducing impervious land coverage is based on the concept of "headwaters streets", which suggests that streets be scaled to traffic volume (BASMAA, 1999). Street systems can be designed based on a hierarchical system where the function and use of the particular roadway can be linked to the width and other characteristics relating to imperviousness (Delaware, 1997). Alternative design standards for five categories of headwater streets are contained in, Site Design for Urban Stream Protection, p. 135 (Schueler 1995).

The resulting roadway standards have significantly narrower asphalt sections and drainage swales. The pavement width for the collector, major residential, and minor residential roadways can be decreased while keeping existing right of way widths. The reduced roadway widths and impervious areas will decrease runoff amounts and improve runoff water quality.

On both sides of each roadway section, the decrease in pavement width allows for a larger landscape area (consisting of a drainage swale and vegetation) that will increase visual appeal, convey stormwater runoff, and increase water quality. A flat concrete curb placed on both sides of the roadway can be used instead of the traditional curb and gutter. These surfaces serve to convey runoff to the swales, secure the edge of asphalt from erosion, and create a clean separation from the driveable/parkable surface to the landscaped surface. The collector roadway can be designed with an optional "high-back" curb if deemed necessary for traffic and storm water control (Utah ASC, 2001).

Additional Resources

Coffman, L., 2000. *Low Impact Development Design Strategies.* Available on EPA website.

Delaware Department of Natural Resources and Brandywine Conservancy, 1997. *Conservation Design for Stormwater Management.* Available on website.

METRO, no date. *Green Streets.* Available on website.

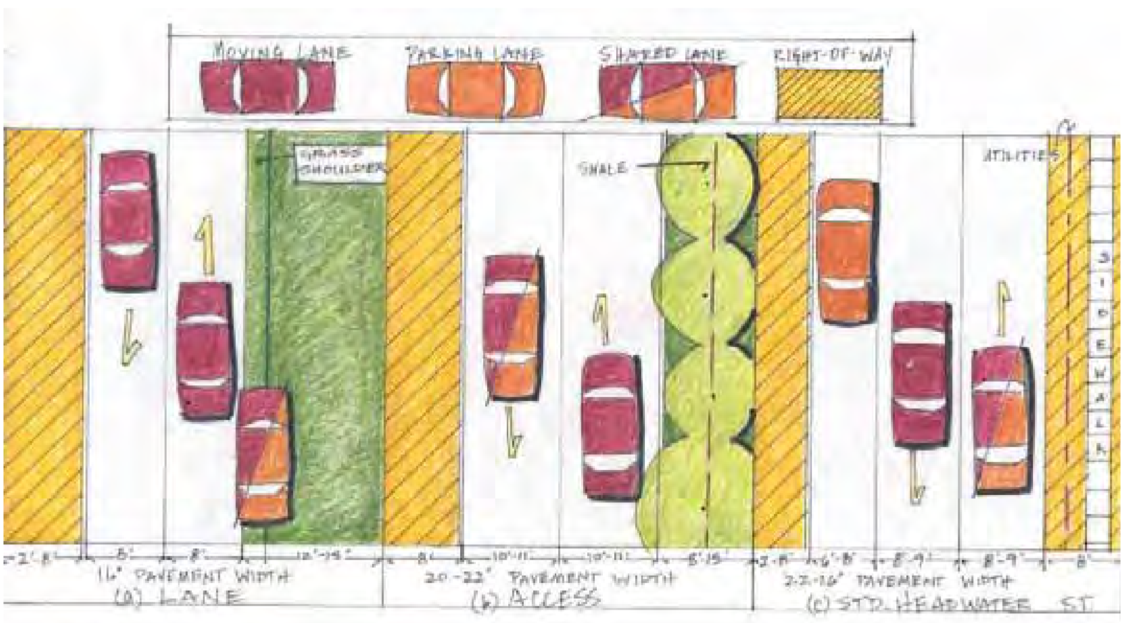
Schueler, 1995. *Site Planning for Urban Stream Protection.* Available on Center for Watershed Protection website.

USEPA, *Storm Water BMPs: Eliminating curbs and gutters.* Available on EPA website.

USEPA, *Storm Water BMPs: Narrower residential streets.* Available on EPA website.

Utah Association of Conservation Districts, 2001. *North Logan Low Impact Development Roadway Design Standards.* Available on City of North Logan, UT website.

Figure 19-1. Narrow roadways



Reconfigure Driveways BMP 20

Description

Driveway impacts are reduced by reducing driveway width and length, limiting impervious surfaces to tracks, and utilizing a shared driveway to connect several units together.

General Information

Driveways generate a surprisingly large fraction of the impervious cover created by a residential street. Driveway length is generally determined by garage setback requirements, and width is usually mandated by municipal codes and ordinances. If there is flexibility in the front yard setback in local codes, the length of driveways can be shortened. Driveway length can be limited to 30 to 40 feet in most large lot residential lots that have two car garages, and still fully meet residential parking demand. Driveway width can be decreased from 20 to 18 feet. If shared driveways are permitted, a single driveway can access two or more garages, further reducing required land area. Other options to reduce the driveway impacts include:

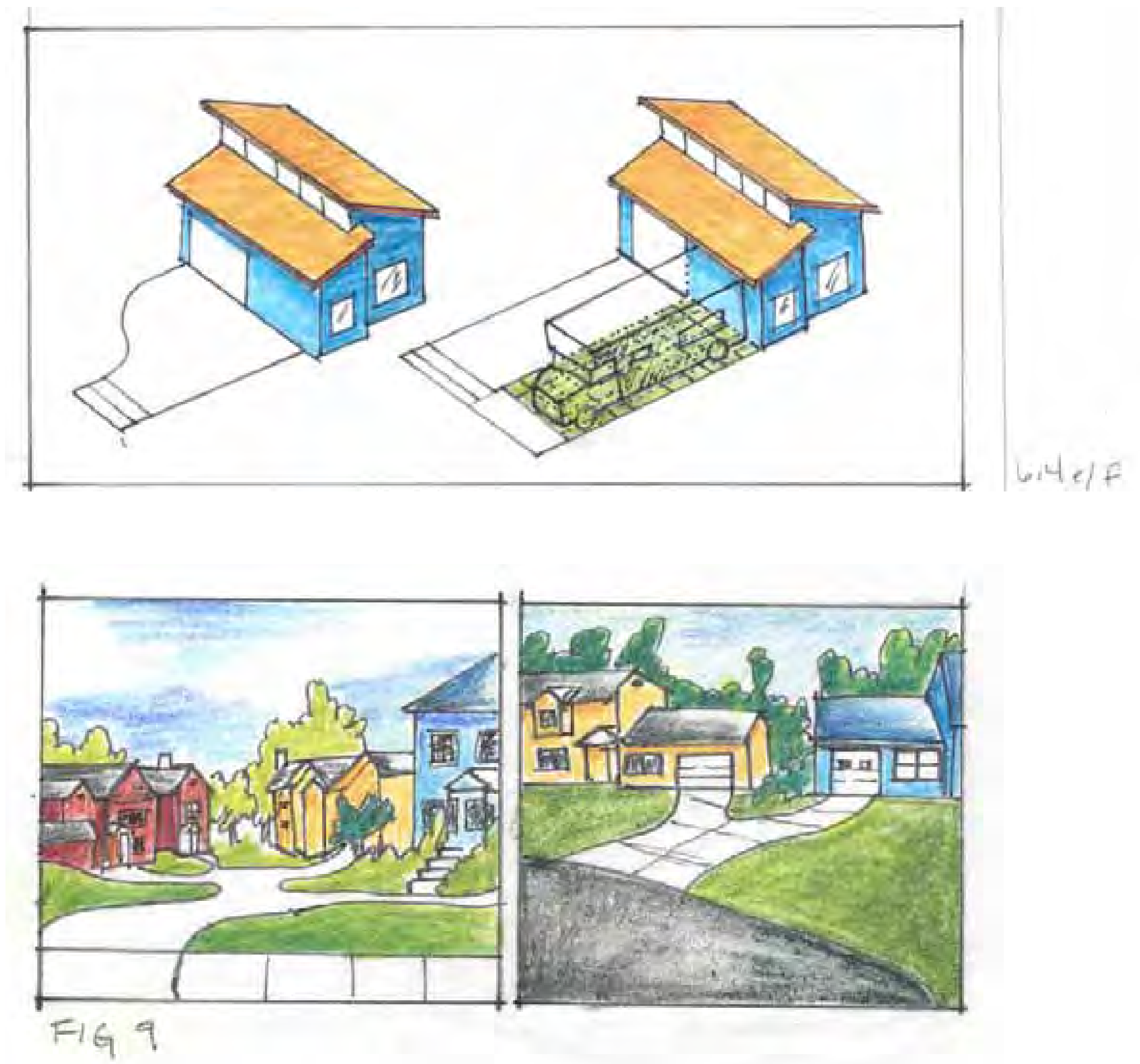
- Disconnecting the driveway from the storm drain system and sloping it to drain onto an adjacent turf or groundcover area
- Using concrete paving only under the wheels and leaving the center strip open to be planted with grass or groundcover or filled with permeable material
- Using crushed aggregate or unit pavers to create a more permeable driveway
- Using a single lane for the access to the street and flaring the driveway to provide access to all garage doors
- Using a permeable surface, such as turf-block or open-celled unit pavers for areas used for temporary parking.

Additional Resources

Bay Area Stormwater Management Agencies Association (BASMAA), 1999. *Start at the Source: Design Guidance Manual for Stormwater Quality Protection.*

Schueler, 1995. *Site Planning for Urban Stream Protection.* Available on Center for Watershed Protection website.

Figure 20-1. Reconfigure driveways



Alternative Turnarounds BMP 21

Description

The size of residential street cul-de-sacs is minimized and landscaped areas incorporated to reduce impervious cover. The radius of cul-de-sacs should be the minimum required to accommodate emergency and maintenance vehicles.

General Information

Dead end streets in residential subdivisions are usually required to have an acceptable option for vehicles to turnaround, with the circular cul-de-sac being the most common. Figure 21-1 depicts a range of different turnaround options. Each provides a minimum internal turning radius of 17 to 20 feet to accommodate the larger vehicles, but there are differences in the amount of impervious cover of each option.

The amount of impervious cover can be reduced from the standard impervious 40-foot radius circle. For most residential streets serving less than 25 homes, a minimum cul-de-sac open turnaround radius of 30 feet is recommended. A landscaped island can be placed in the center of the cul-de-sac turnaround as long as it maintains an internal turning radius of 17 to 20 feet. This island can be designed as a depression to accept stormwater runoff from the surrounding pavement, thus furthering infiltration. A flat apron curb will stabilize roadway pavement and allow for runoff to flow into the cul-de-sac's open center. Alternative turnarounds such as the T-shaped "hammerhead," create even less impervious cover than any circular option, and should be encouraged in shorter cul-de-sacs, particularly in rural areas (Schueler, 1995a).

Alternative turnarounds can be applied in the design of residential, commercial, and mixed-use development. Combined with alternative pavers, green parking, curb elimination, and other techniques, the total reduction to site impervious cover can be dramatic, reducing the amount of storm water runoff from the site.

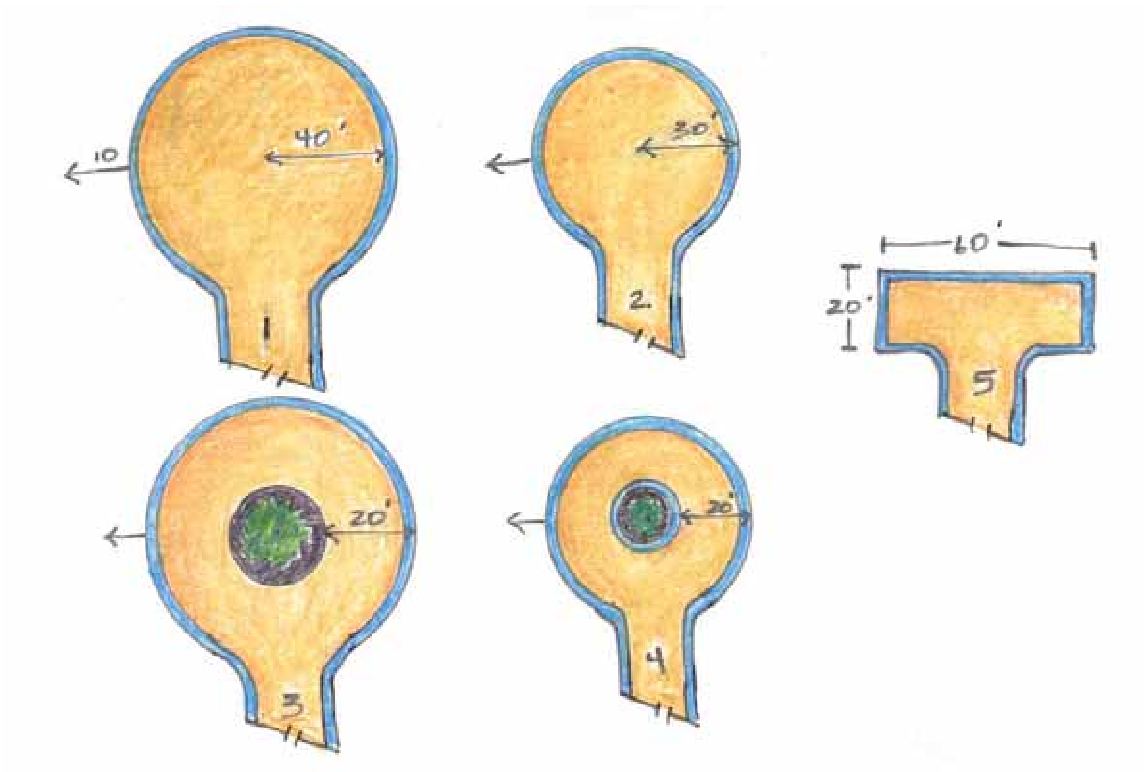
Additional Resources

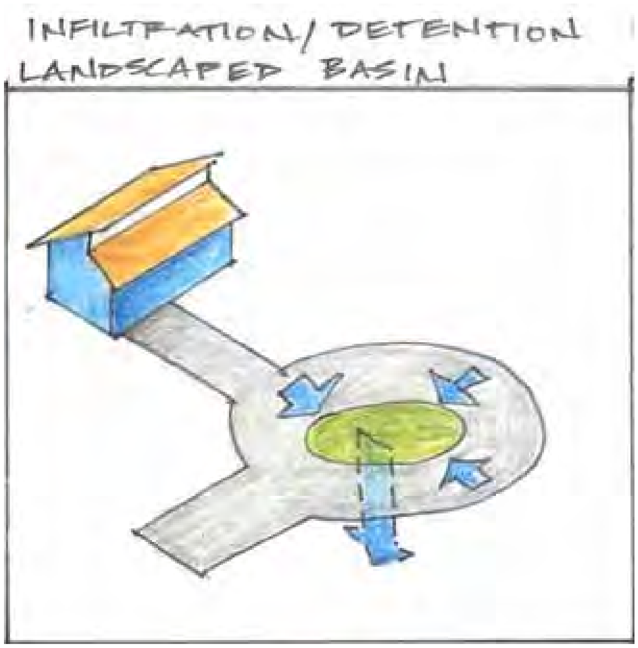
Coffman, L., 2000. *Low Impact Development Design Strategies.* Available on EPA website.

Schueler, 1995. *Site Planning for Urban Stream Protection.* Available on Center for Watershed Protection website.

USEPA, *Storm Water BMPs: Alternative turnarounds.* Available on EPA website.

Figure 21-1. Alternative turnarounds





Reduced Sidewalk Application BMP 22

Description

The impact of impervious sidewalk surfaces is reduced through the use of narrow sidewalks, by building sidewalks on only one side of the street, and by sloping sidewalks that drain to vegetated swales or gravel strips.

General Information

Most communities require that sidewalks be installed on one or both sides of the street. The minimum width of sidewalks is four feet (which allows a wheelchair adequate passage, under the requirements of the Americans with Disabilities Act), but some communities often require that they be five or even six feet wide. Safe pedestrian movement does not always entail wide sidewalks on both sides of the street.

Sidewalk design should emphasize the connections between neighborhoods, schools, and shops, instead of merely following the road layout. Sidewalks can be replaced by walkways located within community open space and away from streets and still ensure that people can travel effectively between neighborhoods and services. In less dense areas sidewalks that follow road layout may only be needed on one side of a roadway. The width of the sidewalk should also be in direct proportion to the estimated number of users. Low-use sidewalks can be narrowed to four feet or less in width.

To further minimize impacts, sidewalks can be located to follow site contours and sloped to drain to adjacent vegetated areas. Sidewalks can also be disconnected from the roadway with a vegetated area that can treat stormwater runoff.

Additional Resources

Gibbons, Jim, 1999. *Sidewalks,* Nonpoint Education for Municipal Officials. Available on NEMO website.

Schueler, 1995. *Site Planning for Urban Stream Protection,* Available on Center for Watershed Protection website.

Figure 22-1. Reduced sidewalk application

FIG 8

Green Parking Lots BMP 23

Description

Green parking is based on a number of techniques that incrementally shrink the surface area of the parking lots and then use the space saved to integrate functional landscaping and better stormwater treatment within the parking lot.

General Information

The first step towards green parking lots is reducing the number of parking spaces required. Excess parking can be controlled through standards that reflect average parking needs instead of single peak day projections. The primary justification for high parking requirements is to avoid spillover of parking from one parcel of land to others. However, if all facilities are designed for peak demand, often specified as the demand that only occurs 15 to 30 hours per year, then, by definition, large amounts of excess capacity will exist in the system since these peaks are not coincident. According to the Urban Land Institute (1982), specifying a design hour of the 20th busiest hour of the year leaves spaces vacant more than 99% of the time and leaves half the spaces vacant at least 40% of the time. (In Heaney et al., 1999)

Providing credits for mass transit and cooperative parking can also reduce the number of spaces required. A shared parking arrangement could include usage of the same parking lot by an office space that experiences peak parking demand during the day with a restaurant that experiences parking during the weekend and evening.

The next step involves modest changes in parking lot design to shrink parking lot area. This includes shrinking stall sizes, narrowing drive aisles, and using grid pavers for spillover parking areas. Better landscaping and storm water treatment measures can then be implemented within the saved space.

Thompson and Sorvig (2000) recommend that parking be scattered on sensitive sites. Scattered parking requires much more detailed siting and construction but facilitates the use of natural drainage systems by breaking up parking lots into smaller units so that each parking area can drain to an adjacent unpaved area. At an office site in Atlanta, Robert Marvin dispersed 200 parking spaces access the wooded site, tucking a space or two at a time between the preexisting trees, and carefully preserving the forest floor adjacent to each pavement edge. The vegetated soil infiltrates and eliminates the runoff from each bit of pavement (Ferguson, 2000).

Parking groves can be created which use a grid of trees and bollards to delineate parking stalls and create a shady environment (BASMAA, 1999). Runoff is reduced through interception of rainfall by tree canopies and is enhanced when parking stalls are stabilized with permeable materials.

Additional Resources

Center for Watershed Protection, *Better Site Design: A Handbook for Changing Development Rules in Your Community.* Available on Stormwater Center website.

Coffman, L., 2000. *Low Impact Development Design Strategies.* Available on EPA website.

Olympia Washington Impervious Surface Study. Available on website.

Schueler, 1995. *Site Planning for Urban Stream Protection.* Available on Center for Watershed Protection website.

Thompson, J.W. and K. Sorvig, 2000. *Sustainable Landscape Construction: A Guide to Green Building Outdoors,* Island Press, Washington, D.C.

USEPA, *Storm Water BMPs: Green parking.* Available on EPA website.

Zielinski, J. "The Benefits of Better Site Design in Commercial Development", *Watershed Protection Techniques*. Available on Stormwater Center website.

Figure 23-1. Green parking lots

Bioretention BMP 24

Description

Bioretention is a technique for mimicking natural drainage systems that emphasizes the use of soils and both woody and herbaceous plants in a conditioned planting soil bed to remove pollutants from storm water runoff.

General Information

Bioretention is a soil and plant-based design solution employed to filter runoff. Also called a "rain garden", a bioretention facility consists of a porous soil covered with a thin layer of mulch. Grasses, shrubs, and small trees promote evapotranspiration, maintain soil porosity, encourage biological activity, and promote uptake of some pollutants.

The system can include a pretreatment filter strip of grass channel inlet area, a shallow surface water ponding area, a bioretention planting area, a soil zone, an underdrain system, and an overflow outlet structure, depending on the site conditions and land use.

Bioretention facilities can be used in highly urbanized landscapes such as commercial or office developments as depressed landscaping beds in lawns, parking lot islands, and swales. They can also be used in common use open space on residential projects. In arid and semi-arid climates, xeriscape plants, use of gravel instead of mulch as ground cover, and better pretreatment should be used. Sprinkler irrigation of bioretention areas should be avoided.

Typically, bioretention practices are integrated throughout a land development project and are strategically placed to intercept runoff near the source, preferably lot by lot. Originally designed to provide an element of water quality control, recent studies have shown that quantity control can be achieved as well. Bioretention systems function similar to infiltration/filtration practices with the added advantage of aesthetically pleasing landscaping.

Bioretention systems can be designed to mimic natural hydrologic processes that occur in vegetated areas to absorb and filter water through evapotranspiration and soil filtering mechanisms.

Also see Idaho Stormwater BMP Catalog, Volume 4: BMP # 2 – Bioretention Swale and BMP #9 – Bioretention Basin.

Additional Resources

Bitter and Bowers, "Bioretention as a Water Quality Best Management Practice", *Watershed Protection Techniques*. Available on Stormwater Center website.

Engineering Technologies Associates, Inc. (ETA), 1993. *Design Manual for Use of Bioretention in Stormwater Management..*

Low Impact Design Center: Bioretention information available on website.

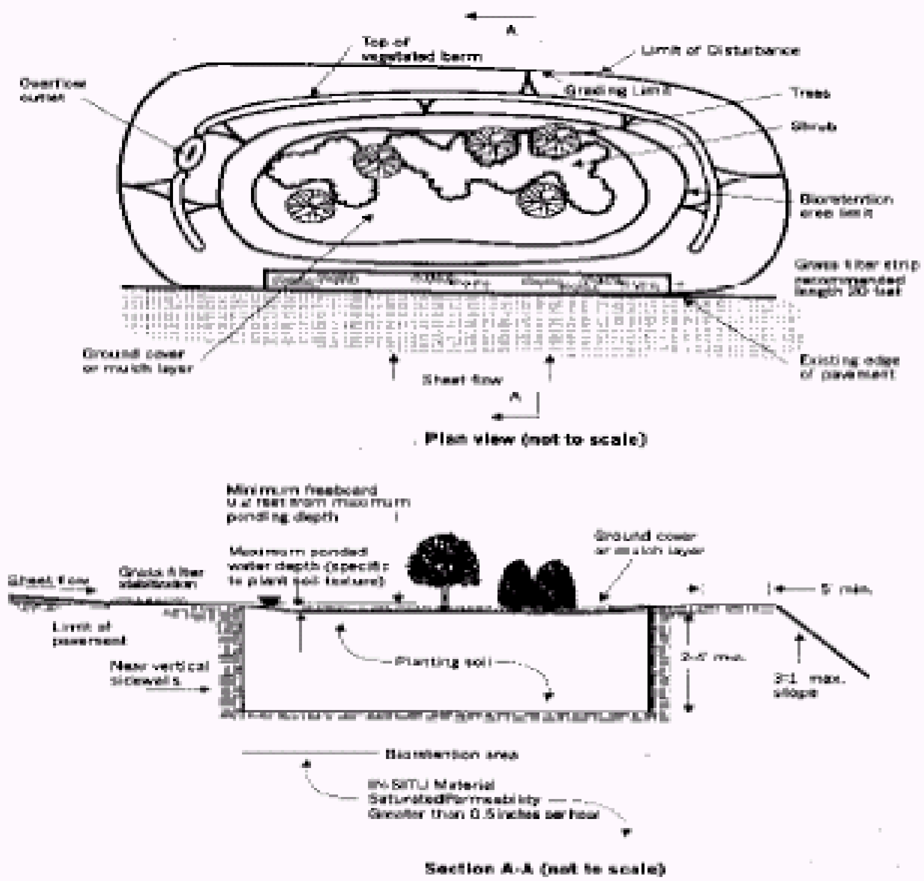
Metropolitan Council Environmental Services: Bioretention information available on website.

Prince George's County Department of Environmental Resources, 1993. *Design Manual for Use of Bioretention in Storm Water Management.*

USEPA, *Storm Water BMPs: Bioretention.* Available on EPA web site.

USEPA, Storm Water Technology Fact Sheet: Bioretention. Available on EPA web site.

Figure 24-1. Bioretention



Soil Amendments BMP 25

Description

Soil amendments are used to reduce soil compaction and improve soil functions, especially permeability. Soil amendments can also be used to improve the performance of grass swales, biofilters and filter strips. Soil amendments consist of organic matter that has a low bulk density, such as compost, fly ash or peat.

General Information

Soils may be compacted by the construction process or compacted soil may already exist on the site because of previous land-use patterns. The use of soil amendments with organic matter that has a low bulk density reduces compaction. The potential hydrologic benefits of compost-amended soils include increasing the soil's permeability and water holding capacity, thereby delaying and often reducing the peak stormwater runoff flow rate, and decreasing irrigation water, fertilizer and pesticide requirements. Materials such as compost, leaf mold, partially rotted manure, or composted sewage sludge are excellent, inexpensive sources that can often be found commercially.

In addition to compost, soil conditioners, amendments, and fertilizers may be appropriate for use where the existing soil is badly damaged. Care should be taken in the use of soil amendments. Their application is site-specific, based on the soil type or lithology of the soil to be amended. The goal should be to produce a soil with chemistry and fertility similar to those found in healthy regional soils. There is usually enough variety in regional soils to allow for most reasonable landscape purposes (Thompson and Sorvig, 2000).

Additional Resources

Chollak and Rosenfeld, no date. *Guidelines for Landscaping with Compost-Soils.* Available on City of Redmond, WA website.

Craul, P.J., 1992. *Urban Soil in Landscape Design,* John Wiley and Sons.

Schueler, "Can Urban Soil Compaction be Reversed?", *Watershed Protection Techniques.* Available on Stormwater Center website.

Tugel, Arlene, Ann Lewandowski, Deb Happe-Von Arb, eds., 2000. *Soil Biology Primer,* Soil and Water conservation Society, Ankeny, Iowa.

Thompson, J.W. and K. Sorvig, 2000. *Sustainable Landscape Construction: A Guide to Green Building Outdoors,* Island Press.

US Composting Council, 2000. *Field Guide to Compost Use.* Available on US Composting Council website.

University of Washington Soils Lab, 1997. *Soil Amendment Use in Lawn Soils.* Available on website.

Description

Soil restoration is achieved by aeration through mechanical loosening, and addition of organic matter and soil amendments, as appropriate. Some practices, such as bioretention, require special attention to soils and vegetation to ensure their effectiveness.

General Information

Topsoil, the top few inches in which 70 to 100 percent of all root activity occurs, is a living part of every site. A healthy soil supports plant growth, protects air and water quality, and ensures human and animal health. Soils offer critical pollutant removal functions through filtration, biological processing by microbial action, and chemical processing.

The structure of any healthy soil is permeable, with spaces between solid particles where water, air, and soil organisms can move. Soil compaction occurs when weight on the soil surface collapses these spaces, creating a hard, solid mass. Water, air, and roots may be completely unable to penetrate compacted soil, reducing or destroying its capacity to sustain life.

If grading or excavation has removed soil from the site, healthy soil may need to be recreated. Methods that rebuild the soil on-site are more sustainable than importing topsoil. Only in rare occasions should soil materials be imported in quantity, and never at the expense of another site.

In areas where soil disturbance occurs, there are techniques that can be used to reverse its effects. Aeration, mechanical loosening, dense vegetation, and soil amendments reduce compaction and increase infiltration rates into soil. Methods for addressing compaction include deep-water jetting and air injection, in which compressed air or water is injected to fracture the compressed soil; the fractures are then backfilled with some dry material such as vermiculite. Other approaches include deep plowing, subsoiling or the use of a backhoe to loosen the soil profile. The addition of organic matter that has a low bulk density such as compost, leaf mold, partially rotted manure, or composted sewage sludge are excellent, inexpensive soil amendments that can reduce compaction and can often be found commercially.

There are also many situations where a loss of soil fertility has occurred and conditions are present which make soil improvement appropriate. In these cases, soil life processes can be encouraged by provision for green crop, humus, mulch, and the root associates (mycorrhiza) of plants.

A sustainable approach to creating landscapes should protect healthy soils and limit “improvement” to carefully chosen areas. Soils should not be improved when the existing soil is an undamaged local type as it may have negative effects. Increased fertility can cause problems to native plants and may hasten the growth of invasive weeds. The objective for soil fertility should be the approximate fertility levels of the best soils in the local region. Use regional plant species, tolerant of poor soils, as alternatives to soil amendment and irrigation.

Specimen plantings that require high soil fertility can be grouped together and the remainder of the site can then retain unamended soils, an unirrigated water regime, and native plants. Selected areas of soil can be amended for specimen planting and vegetable gardens.

To reduce the need for soil restoration, topsoil should be scooped off of all parts of the site that will be built on, as well as access paths and the staging area, prior to construction. In addition to stockpiling existing topsoil in areas of construction, soils in other areas should be protected to minimize compaction.

Suggested Practices for Soil Restoration (Thompson and Sorvig, 2000).

- Wherever possible, avoid bringing in fresh topsoil to a construction site.
- Don't over improve soils; aim to approximate fertility levels of the best soils in the local region.
- Use regional plant species, tolerant of poor soils, as alternatives to soil amendment and irrigation.
- Wherever possible, remove the topsoil from areas on which construction will occur. Stockpile it on-site and respread as soon as possible.
- Where there is only fill dirt on-site, amend that to create a viable soil rather than bring in new soil.
- Build the soil by adding compost and other recycled materials or by planting restorative plants.
- Where necessary, consult with a soils scientist to develop a soils specification appropriate to your site.
- Wherever soil amendments and erosion control materials are needed, specify recycled local materials, if possible.

Additional Resources

Craul, P. J., 1992. *Urban Soil in Landscape Design,* John Wiley and Sons.

Schueler, "Can Urban Soil Compaction be Reversed?", *Watershed Protection Techniques.* Available on Stormwater Center website.

Society of Ecological Restoration. Information available on website.

Tugel, Arlene, Ann Lewandowski, Deb Happe-Von Arb, eds., 2000. *Soil Biology Primer,* Soil and Water conservation Society, Ankeny, Iowa.

Thompson, J.W. and K. Sorvig, 2000. *Sustainable Landscape Construction: A Guide to Green Building Outdoors,* Island Press.

Created Wetlands BMP 27

Description

Created wetlands have a significant percentage of the facility covered by wetland vegetation.

General Information

Constructed wetlands are built specifically for treating storm water runoff. They are not wetlands created as mitigation for the loss of natural wetlands. Consequently, there is no intention to replicate the complete array of ecological functions of a wetland (e.g., the presence of wildlife), although it can be done.

The simplest form of a constructed wetland includes a rectangular basin with a forebay and wetland vegetation area. The deeper forebay (3 to 6') traps floatables and the larger settleable solids, facilitating maintenance as well as protecting the wetland vegetation. Alternatively, a detention pond may be placed before the wetland, to remove settleable solids and to protect the wetland from extreme increases in water elevation. The wetland vegetation is placed in a shallow pool that extends laterally across the basin. Construction of low flow channels through emergent vegetation can cause storm water to short circuit through channels rather than through the wetland vegetation.

Placing the vegetation across the facility improves settling of particulates and uptake of dissolved contaminants. As the constructed wetland is shallower than a wet pond, there may be better contact between the water and soil, which may be the primary remover of dissolved phosphorus and metals. The vegetation reduces the effect of wind, which can cause significant short-circuiting in a wet pond.

Complexity is promoted by varying water depth through the vegetated area rather than keeping the depth uniform. The following guidelines should aid in wetland plant selection:

Choose at least three plant species suitable to each of the depth zones in the system. Include native species to minimize maintenance, and include some plants that are aggressive colonizers. Each plant species has a fairly narrow tolerance with respect to soil moisture and inundation. Emergent plants grow in the zone from 0-18" below the normal pool level. The greatest variety of plants grow in the 0-6" depth zone.

- Plant about half the wetland surface area at a constant density throughout the wetland. If appropriate plants are selected, the wetland should be colonized within three years.
- Order plants three to nine months in advance of anticipated planting.
- Finalize the landscaping plan after the wetland has been constructed to confirm soil and moisture/inundation conditions.
- Provide a detailed program for maintenance and possible reinforcement of the plantings for up to two growing seasons after the

wetland is colonized.

Additional Resources

Environmental Protection Agency website: www.epa.gov/owow/wetlands

Stormwater Planters BMP 28

Description

A stormwater planter is a structure that can detain and convey water from roof downspouts. It is most appropriate for smaller sites or adjacent to hardscape because water can be prevented from seeping into the soil.

General Information

Planter area is based on 18 inches of planting mix on top of 6 inches of drain rock. These minimum dimensions are required for planter construction. More than one planter can be constructed to meet square foot requirements.

Roof Area	**Stormwater Planter Area**
Under 500 square feet	Not needed
500-1000 square feet	60 sf
1000-1750 square feet	100 sf
Over 1750 square feet	Engineer calculations required

Additional Resources

SvR Design Company, June 2004. *High Point Community Site Drainage Technical Standards.* Prepared for High Point Community, Seattle WA.

Portland Environmental Services, September 2004. *Stormwater Management Manual*, Portland OR.

Vegetation Restoration BMP 29

Description

This technique involves revegetation of portions of a site and should emphasize creation of sustainable landscapes. This means limiting the use of lawns, using regionally appropriate vegetation, planting based on patterns of plant growth that occur naturally in the region, and controlling invasive species.

General Information

Sustainability is the most important consideration in vegetation restoration. Lawns are not sustainable because they use more supplemental water and require more maintenance (in the form of fertilizers and pesticides) than any other parts of the landscape. Alternative groundcovers require less maintenance and decrease the potential for pollutants to leave the site in runoff.

Rethinking turf as the primary groundcover does not imply that all grassy areas should be replaced. Turf should be planted only where it will be used, and in an appropriate amount. The following are some suggested guidelines for lawn establishment in residential areas:

- Limit turf to 10% to 15% of the landscape.
- Place turf in rear yards close to the residence where the bulk of recreational activity is likely to occur.
- Use a drought-tolerant species of grass.

Whenever possible, revegetation should be done with native plants or regionally adapted plants. In general, they require less water, fertilizer and pesticides than introduced species. Plants native to a region are almost always more resistant to the insects and diseases of the region than other plants. Native plant restoration usually involves management of communities rather than individual plants. Plants grow in communities and understanding the importance of this pattern in essential to creating self-sustaining landscapes. Planting should be based on patterns of plant growth that occur naturally in the region. A simple method for understanding patterns is to field sketch the growth patterns of regional trees and shrubs. Create maps of these patterns on graph paper as roughly scaled plans of the major plants. The plan is like a designers' planting plan, but derived from naturally occurring patterns. These plant patterns can then be used as models on which to base designed and constructed plantings.

Dividing the landscape of a site into zones when designing the planting takes advantage of the varying conditions or microclimates that exist in every landscape to ensure that vegetation remains healthy while requiring minimal care. These microclimate zones are based on the amount of water required for the vegetation present to flourish.

Revegetation is not just about the replanting of appropriate species – it is also about the control and removal of ecologically inappropriate plants. Restoring a site requires attention to altered soil, grading, and drainage patterns that may have invited the weedy species. Correcting these problems is essential to restoring a healthy plant community. For instance, changing soil conditions to favor native plants can eliminate some invasive plants. Invasive plant removal may also be necessary and require grubbing, forking the soil to remove roots or tubers, or the selective use of herbicides through low-volume and targeted application.

Revegetation generally is done at the site level but is appropriate at the project level and throughout of community through the creation of urban forests. Increasing the urban forest is a useful technique for mitigating the effects of past practices.

Additional Resources

American Forests, no date. *CITYgreen.* Available on American Forests website.

Thompson, J.W. and K. Sorvig, 2000. *Sustainable Landscape Construction: A Guide to Green Building Outdoors,* Island Press.

USEPA, *Storm Water BMPs: urban forestry.* Available on website.

Urban Forestry — BMP 30

Description

Urban forests, the trees and forests in and around towns and cities, absorb water. These patches of forest and the trees that line streets can help provide some of the storm water management required in an urban setting. Urban forests also help break up a landscape of impervious cover, provide small but essential green spaces, and link walkways and trails.

General Information

Urban forestry provides numerous environmental and storm water benefits. These include the absorption of carbon dioxide by trees, reduction of temperature, and provision of habitat for urban wildlife. Urban forests can also act as natural storm water management areas by filtering pollutant gases, airborne particulates, sediment, nitrogen, phosphorous, and pesticides and by absorption of water. Urban forestry also reduces noise levels, provides recreational benefits, and increases property values.

Successful urban forestry requires a conservation plan for individual trees as well as forest areas larger than 10,000 feet^2. A local forest or tree ordinance is one technique for achieving conservation, and when specific measures to protect and manage these areas are included, urban forests and trees can also help reduce storm water management needs in urban areas.

Increasing the urban forest is a useful technique for mitigating the effects of past practices. Communities faced with requirements for pollutant reductions in storm water runoff should seriously consider tree-planting programs. Trees and other vegetation can be incorporated into community open space, street rights-of-way, parking lot islands, and other landscaped areas.

One of the biggest limitations to urban forestry is development pressure. Ordinances, conservation easements, and other techniques that are designed into a management program can help alleviate future development pressures. A forest preservation ordinance is one way to set design standards outlining how a forest should be preserved and managed. An urban forestry plan can also be developed and include measures to establish, conserve, and/or reestablish preservation areas.

Additional Resources

American Forests, no date. *CITYgreen.* Available on American Forests website.

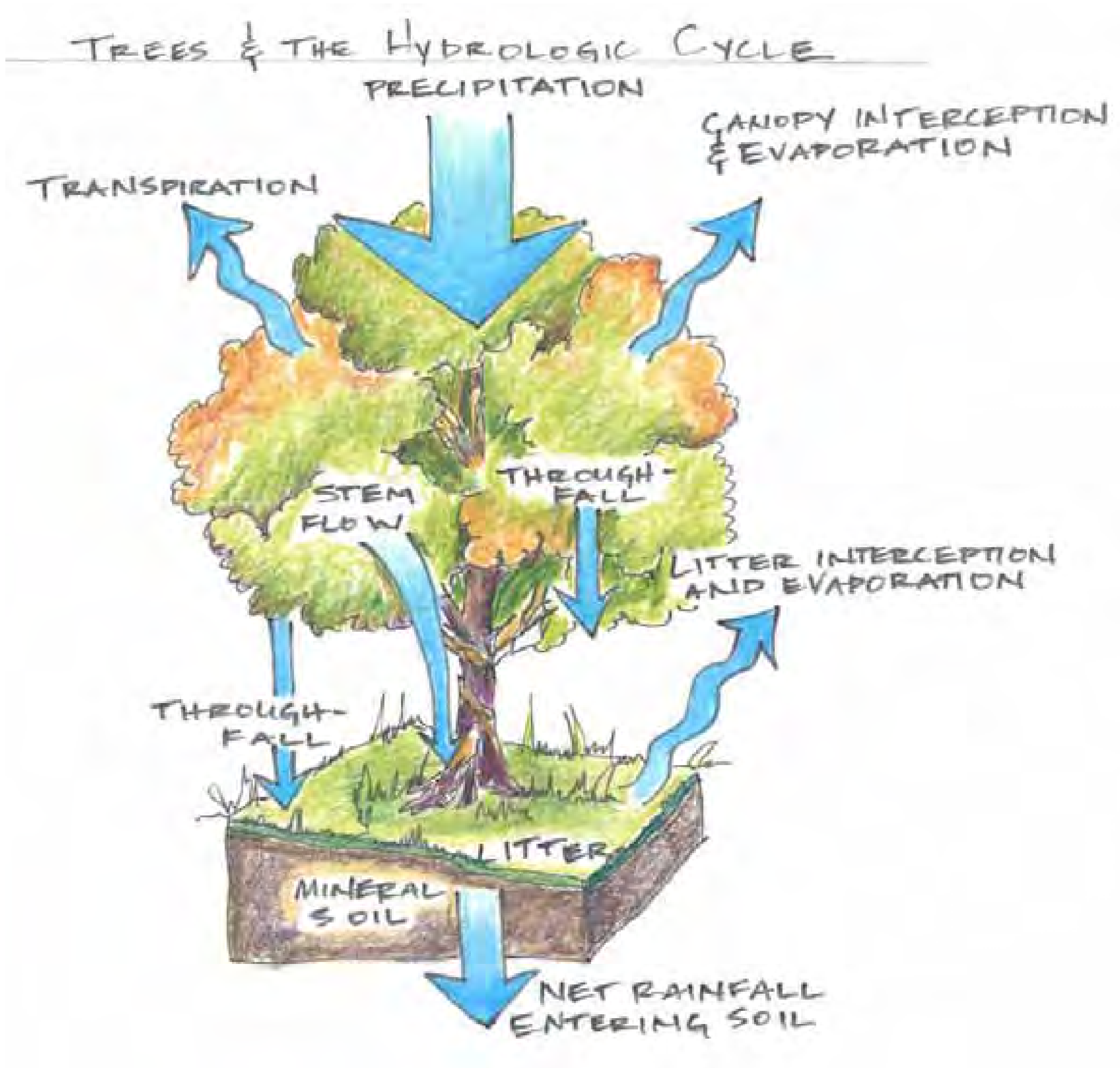
National Arbor Foundation, *Tree Guide.* Available on website.

National Park Service, 1995. *Economic Impacts of Protecting Rivers, Trails and Greenway Corridors.*

Thompson, J.W. and K. Sorvig, 2000. *Sustainable Landscape Construction: A Guide to Green Building Outdoors,* Island Press, Washington, D.C.
74

USEPA, *Storm Water BMPs: Urban forestry.* Available on EPA website.

Figure 30-1 Urban forestry – tree functions.



Alternative Street Layouts BMP 31

Description

Reducing the total length of residential streets and using alternative street layouts that increase the number of homes per unit length. Standards for road length and road width should be addressed within a larger planning context of a community or watershed as well as at the site level.

General Information

Street design offers opportunities to protect natural site functions and to reduce impervious surfaces and thus decrease runoff and associated stormwater management requirements. Areas of opportunity include the siting and layout of streets, street width, and drainage design.

Road siting is an important consideration. To maximize stormwater filtration and infiltration, designers should aim to preserve natural drainage patterns whenever possible and avoid locating streets in low areas or on highly permeable soils. Good road layouts avoid placing roads on steep slopes, by designing roads to follow grades and run along ridgelines. Roads that follow contour lines increase cut and fill and make driveways difficult. Roads that go straight uphill reduce cut and fill, but may become excessively steep.

Street layout is also important because the type of street network affects the total amount of pavement. A typical grid system, for example, results in approximately 20,800 linear feet of pavement, while a scheme of "loops and lollipops" (cul-de-sacs) results in 15,300 linear feet of pavement. Depending on the selection, the percent of impervious surface can be reduced by as much as 26%.

Alternative street layouts are most effective in reducing the impacts of development when done in conjunction with other techniques such as bioretention.

Additional Resources

Coffman, Larry, 2000. *Low Impact Development Design Strategies,* EPA 841-B-00-003. Prepared by Prince George's County, Maryland. Available on EPA website.

Forman, R. T. et al, 2002.*Road Ecology: Science and Solutions,* Island Press, Washington, D.C.

Schueler, 1995. *Site Planning for Urban Stream Protection.* Available on Center for Watershed Protection website.

Parking Lot and Street Storage BMP 32

Description

Parking lot and street storage of runoff can be achieved through detention or retention strategies in multifunctional landscaped areas.

General Information

When open space is available or when narrower roadways are used, the decrease in pavement width allows for a larger landscape area on both sides of the roadway that will increase visual appeal, store or convey stormwater runoff, and increase water quality. Storage space for stormwater runoff can also be created in parking lots through the use of landscape islands that act as infiltration/detention areas.

Stormwater runoff is directed, trapped, and treated by vegetation and microbes in stormwater bioretention areas, vegetated swales, and filter strips that have been integrated into the landscape areas and traffic islands. These bioretention areas include specific layers of soil, sand, and organic mulch that naturally filter the storm water. Detention or temporary storage can be achieved in these areas through low-gradient swales; swales with check dams and linear detention basins. Retention, or permanent storage, can be provided by infiltration trenches and linear infiltration basins. If designed properly, these areas would be both functional and attractive.

A flat concrete curb placed on both sides of the roadway can be used instead of the traditional curb and gutter. These surfaces serve to convey runoff to the swales or other treatment areas, secure the edge of asphalt from erosion, and create a clean separation from the driveable/parkable surface to the landscaped surface.

Medians can also be used for stormwater management if the soil level in the median is designed as a concave surface slightly depressed below the pavement section so that water is directed from the street into the median. The same opportunity is presented in cul-de-sacs where a landscaped area is created in the center of the cul-de-sac.

Also see BMP 11, Alternative Surfaces for additional techniques to maximize parking lot and street storage.

Additional Resources

Coffman, Larry, 2000. *Low Impact Development Design Strategies.* Available on EPA website.

Delaware Department of Natural Resources and Brandywine Conservancy, 1997. *Conservation Design for Stormwater Management.* Available on website.

METRO, *Green Streets.* Available on website.

Schueler, 1995. *Site Planning for Urban Stream Protection.* Available on

Center for Watershed Protection website.

USEPA, *Storm Water BMPs: Eliminating curbs and gutters*, available on website.

Utah Association of Conservation Districts, *North Logan Low Impact Development Roadway Design Standards*. Available on City of North Logan, UT website.

Biofiltration BMP 33

Description

Biofiltration refers to several techniques including vegetated filter strips, buffers, and swales. They are zones of vegetation, either natural or planted, which are used to receive runoff from upslope impervious areas, slow water flow and remove suspended materials by filtration, absorption, and gravity sedimentation.

General Information

Vegetated filter strips, buffers, and swales can function as biofiltration systems. Filter strips and buffers are zones of vegetation, either natural or planted, which are used to receive runoff in the form of sheet flow from upslope impervious areas. Such strips slow overland water flow and remove suspended materials by filtration, absorption, and gravity sedimentation. The objective is to intercept stormwater flows before they have become substantially concentrated and then to distribute this flow evenly though the vegetated filter strip.

Filter strips often include some form of level spreading device to ensure an even distribution of storm water across the vegetated area. Level spreading into natural areas of undisturbed vegetation such a riparian zones performs a similar function. A level spreader typically is an outlet designed to convert concentrated runoff to sheet flow and disperse it uniformly across a slope to prevent erosion. One type of level spreader is a shallow trench filled with crushed stone (Coffman, 2000).

Redirecting stormwater runoff from impervious surfaces to filter strips could be categorized as "hydrologic disconnection" where the objective is to disconnect flow paths and provide for runoff distribution close to the point of generation. Sidewalks and driveways can be designed to drain evenly onto adjacent vegetated zones.

Site suitability and slope are critical considerations in the use of filter strips. Applications are residential developments and campus-type commercial and office developments offering expanses of grassed or otherwise vegetated zones distributed among the building and parking areas (Delaware, 1997). Filter strips may be placed between parking bays and integrated into overall design in other ways. Filter strips function best when slopes are kept at five percent or less.

Swales slow water, trap sediment, and increase infiltration. Swales can be used for conveyance or infiltration facilities. When used as storm water conveyance systems, vegetated swales are located adjacent to a roadside, in a highway median, in a parking lot, or on the back or side of residential properties. Stormwater is directed into these channels and then conveyed to a storm water treatment area or off-site.

When used primarily as infiltration systems, swales are designed to move stormwater runoff as slowly as possible along a gentle incline, keeping the runoff on the site as long as possible and allowing it to soak into the ground, boosting the soil's water retention by as much as 75 percent (Shapiro and Harrison, 2000). Swales are all built on contour or level survey lines. Check dams can be integrated into the design if necessary to increase infiltration and provide for management of larger volumes of runoff. The swale depth and width can be varied according to the site's infiltration rate, so that wider and shallower swales are made in sands, narrower and deeper swales in clay-fraction soils. Swales are ripped, graveled, sanded, or planted at the base to assist rapid water infiltration. They should be large enough to take all pavement run-off, and additional harvested and diverted overland water from the drainage area.

Along with the infiltrating function, swales cleanse runoff via their plants and soil microbes. Swales can be designed to be dry most of the time or normally wet and rely on wetland vegetation to provide water quality treatment. Trees can be used as essential components of swale planting systems to avoid waterlogged soils, even in arid areas (Mollison, 1988). Early in the life of an unplanted swale, water absorption can be slow, but the efficiency of absorption increases with age due to tree root and humus effects. As this happens, it is possible to admit water to swales from other areas, leading it in via diversion drains.

There are many examples in European cities of projects incorporating natural drainage as a key design element. The Dutch now frequently utilize what they call wadis, natural drainage ditches, as key ecological features in a number of residential projects. In Oikos, an ecological project in Enschede, the wadis are a main feature. Here, instead of conventional storm sewers, water is directed into these green swales from sidewalks and rooftops. Within these linear swales is a perforated drainpipe, surrounded by a fabric cocoon of clay pellets. The pellets actually accommodate the growth of bacteria, which provide a treatment function for collected storm water (Beatley, 2001).

Also see Idaho Stormwater BMP Catalog, Volume 4, Post-Construction BMPs: BMP #1 – Biofiltration Swale and BMP #3 – Vegetative Filter Strip.

Additional Resources

Beatley, Timothy, 2000. *Green Urbanism, Learning from European Cities,* Island Press, Washington, D.C.

Municipality of Metropolitan Seattle, *Biofiltration Swale Performance, Recommendations, and Design Considerations*

Schueler, 1995. *Site Planning for Urban Stream Protection.* Available on Center for Watershed Protection website.

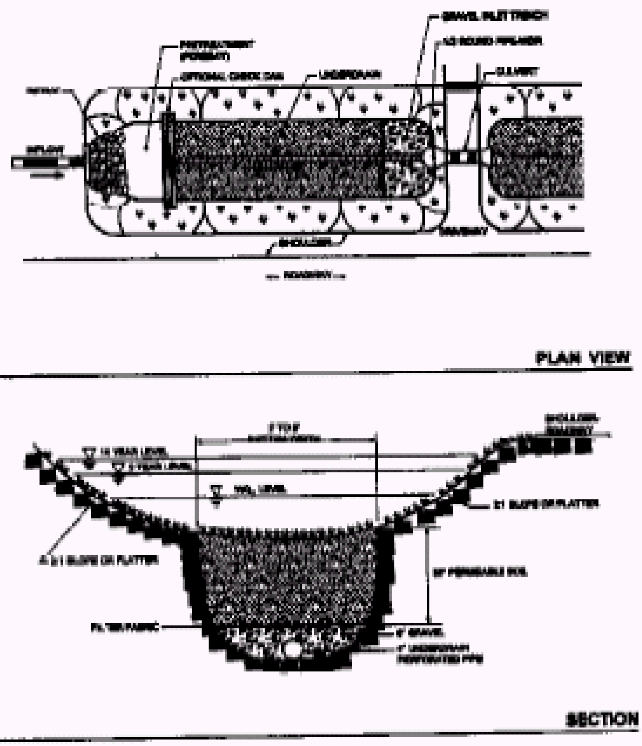
Storm Water Managers Resource Center Fact Sheets: Stormwater Management - grassed channel. Available on Stormwater Center website.

USEPA, *Storm Water BMPs: grassed filter strips.* Available on EPA web site.

USEPA, *Storm Water BMPs: grassed swales.* Available on EPA web site.

USEPA, *Storm Water Technology Fact Sheet: vegetated swale.* Available on EPA web site.

Figure 33.1. Biofiltration



Eliminate Curb and Gutter **BMP 34**

Description

Curbs and gutters are replaced with gravel shoulders that are graded to form a drainage way, with opportunities for infiltration basins, ponding, and landscaping.

General Information

While curb-and-gutter is often considered the “standard” in road design, it tends to amplify stormwater volume and velocity while discouraging infiltration and groundwater recharge. Curbless road design, such as the so-called “rural residential section,” encourages infiltration via roadside swales. On low-traffic streets without curbs, grass shoulders can serve as an occasional parking lane, allowing a narrower paved area. Flush concrete bands, steel edge, or wood headers can be used on streets where roadway edge protection is needed.

Curb choice relates to land use and the volume and speed of vehicular traffic. In areas where high-speed vehicular traffic is combined with high foot traffic, a curb may be desired to enforce the separation of these uses. Where a more urban character is desired, or where a rigid pavement edge is required, curb and gutter systems can be designed to empty into drainage swales. These swales can run parallel to the street, in the parkway between the curb and the sidewalk, or can intersect the street at cross angles, and run between residences, depending on the topography. Multiple openings in the curb direct runoff into swales or bioretention areas. Medians can also be designed with a concave surface slightly depressed below the pavement section, and water from the street directed into the median.

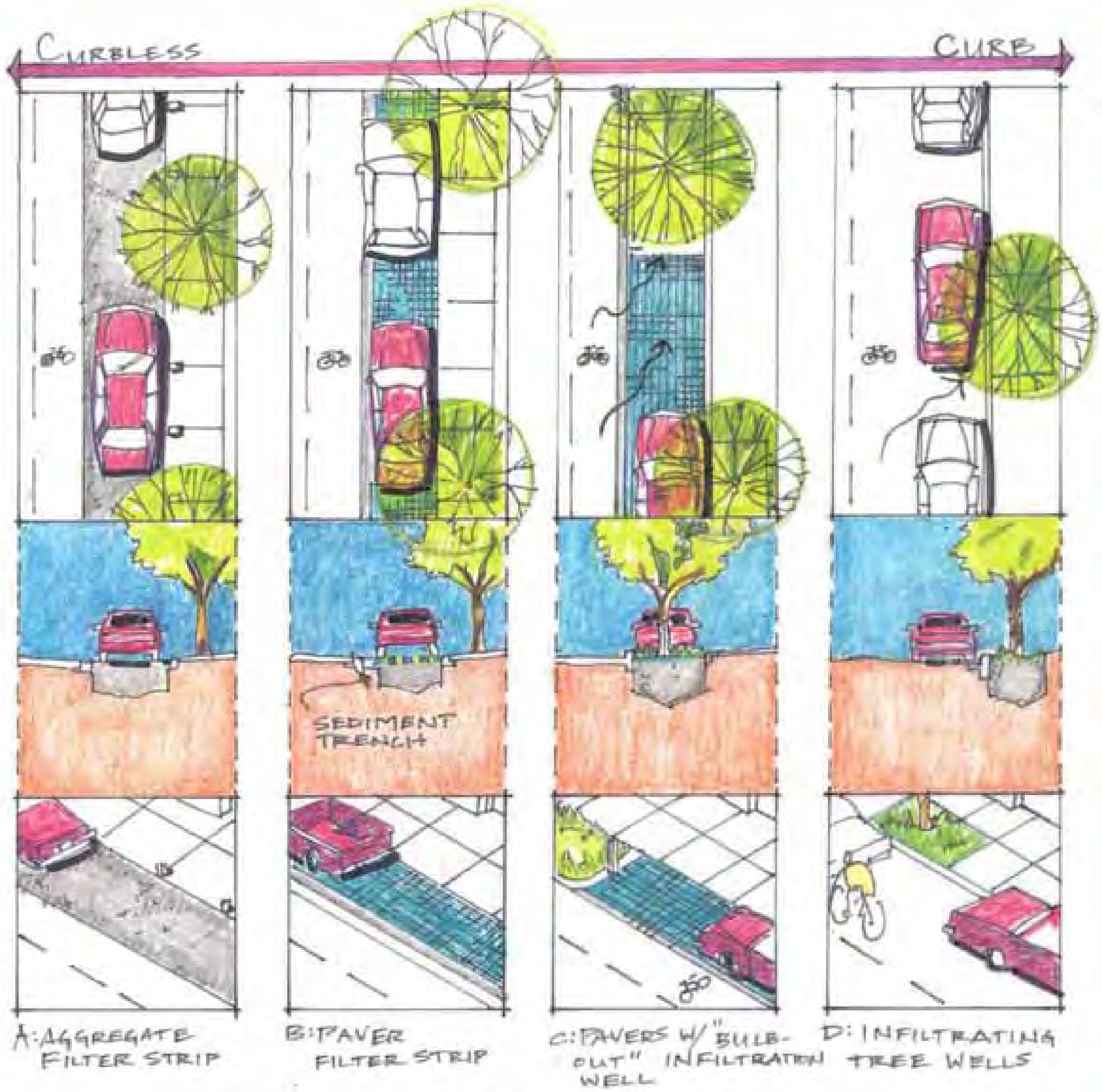
Additional Resources

Bay Area Stormwater Management Agencies Association (BASMAA), 1999. *Start at the Source: Design Guidance Manual for Stormwater Quality Protection.*

METRO, *Green Streets.* Available on website.

Figure 34-1. Eliminate curb and gutter – edge options

Figure 34-2. Eliminate curb and gutter.



Conveyance Furrows — BMP 35

Description

A conveyance furrow is a linear or gradually meandering depression that conveys water from the downspout zone to the transition to the right of way zone.

General Information

Conveyance furrows can vary in form, from meandering, irregular, and vegetated to straight and grass-lined, and can be graded and planted to reflect the individual identity of the residences. There may be stormwater infiltration and filtering depending on the soil quality, shape and length of the conveyance furrow, however, its primary purpose is to slow and convey runoff.

The following guidelines apply to conveyance furrows:

- Sides should have a slope of no more than 3(H):1(V).
- The conveyance furrow should slope at least 1% longitudinally toward a transition to the right of way zone.
- Uncompacted and amended soil is preferable.
- Vegetated conveyance furrows are recommended, though grass or drain rock conveyance furrows are acceptable.
- Vegetated conveyance furrows should be planted with a variety of grasses, annuals, perennials or woody herbaceous plants.
- A conveyance furrow 4(H):1(V) (25%) or steeper requires velocity reduction measures.
- Conveyance furrow depth should be sized as shown in Table 35 – 1.

Terraced conveyance furrows are appropriate for slopes of 4(H):1(V) (25%) or more. Terraced conveyance furrows act as a series of cells and berms that slow the velocity of water by allowing water to pool. In addition to meeting the requirements for a conveyance furrow, a terraced conveyance furrow should include the following:

- Berms should be earth or drain rock (similar to a gravel check dam).
- One berm should be provided for every six inches drop in elevation.
- Berm slopes should be a maximum of 2:1.
- Berm height should be at or below conveyance furrow sides.
- Earth berms and cells should be vegetated.
- Vegetated furrows should be lined with an erosion control mat to minimize erosion until plants are established.
- Conveyance furrow depth should be sized as shown in Table 35 – 1.

Additional Resources

SvR Design Company, June 2004. *High Point Community Site Drainage Technical Standards.* Prepared for High Point Community, Seattle WA.

Table 35-1. Conveyance furrow depth

Roof Area	Less than 1% positive slope	1-8% positive slope	8-25% positive slope	25%+ positive slope
Under 500 square feet	Not needed	Not needed	Not needed	Not needed
500-100 square feet	Piped flow necessary	3 inches	3 inches	3” with velocity reduction
1000-1750 square feet	Piped flow necessary	4 inches	4 inches	4” with velocity reduction
Over 1750 square feet	Piped flow necessary	Engineer calculations required	Engineer calculations required	Engineer calculations required

Dispersal Trench BMP 36

Description

A dispersal trench is appropriate for situations where the slope from the building does not meet the minimum 1% requirement or is greater than 25% or there is not enough distance to surface convey between a building and the right of way.

General Information

A downspout may be piped directly to a dispersal trench as long as the trench meets the eight-foot minimum required conveyance distance. The pipe is connected to a perforated or slotted pipe that allows water to seep into the drain rock and surrounding soil as well as overflow across the site or sidewalk to a designated discharge point. The following guidelines apply:

- Runoff from impervious area should be surface flow on a slope between one and 20% or be piped to the dispersal trench.
- The dispersal trench should be a minimum of two feet wide and 18 inches deep.
- The dispersal trench should be a minimum of eight feet long.
- The dispersal trench should be lined with geotextile fabric and filled with drain rock.
- The dispersal trench should be a minimum of five feet from any building.
- Perforated pipes should be a minimum of six inches below grade.
- The dispersal trench bottom and length should be level and the trench width should have a slope of 1% toward a discharge point.
- The trench should be placed parallel to site contours.
- A yard drain with a sump should be installed upstream of the dispersal trench at a minimum of three feet upstream of the downspout.
- The dispersal trench may be toped with geotextile fabric and six inches of soil for planting.

Additional Resources

SvR Design Company, June 2004. *High Point Community Site Drainage Technical Standards.* Prepared for High Point Community, Seattle WA.

California Stormwater Quality Association, January 2003. *California Stormwater Best Management Practices Handbook, New Development and Redevelopment.* www.cabmphandbooks.com

King County, Department of Natural Resources and Parks, 2005. *King County Surface Water Design Manual.* Seattle WA.

Pop-up Emitter   BMP 37

Description

A pop-up drainage emitter is similar to daylighting piped flow and is appropriate when it is not possible to convey water directly from the downspout due to grading, paving or other site constraints.

General Information

Roof runoff is piped to a conveyance area and is released through a capped device that opens with water pressure – a pop-up emitter. The following guidelines apply:

- The pipe should be at least six inches below the surface.
- The pipe should be a minimum of four inches in diameter.
- The emitter elevation should be lower than the finished grade elevation of the base of the downspout and the yard drain.
- The yard drain should have a minimum sump depth of one foot.

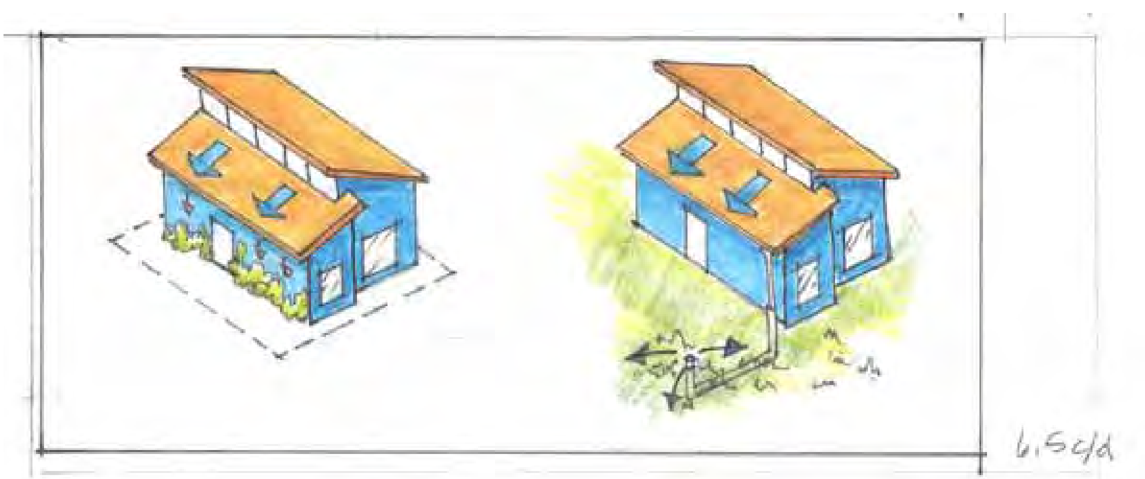
Additional Resources

SvR Design Company, June 2004. *High Point Community Site Drainage Technical Standards.* Prepared for High Point Community, Seattle WA.

California Stormwater Quality Association, January 2003. *California Stormwater Best Management Practices Handbook, New Development and Redevelopment.* www.cabmphandbooks.com

Bay Area Stormwater Management Agencies Association (BASMAA), 1999. *Start at the Source: Design Guidance Manual for Stormwater Quality Protection*, 1999 Edition.

Figure 37-1. Pop-up emitter.



References

Arendt, R.G., 1996a. Conservation Design for Subdivisions: A Practical Guide to Creating Open Space Networks, Island Press.

Arendt, R.G., 1996b. "Creating Open Space Networks", Environment and Development, American Planning Association.

Arendt, R.G., 1999. Growing Greener, Putting Conservation into Local Plans and Ordinances, Island Press.

Arnold, C.L., and C.J. Gibbons, 1996. "Impervious Surface Coverage: The Emergence of a Key Environmental Indicator", Journal of American Planning Association, 62(2): 243-258.

Bay Area Stormwater Management Agencies Association (BASMAA), 1999. Start at the Source: Design Guidance Manual for Stormwater Quality Protection, 1999 Edition.

Beatley, Timothy, 2000. Green Urbanism, Learning from European Cities, Island Press, Washington, D.C.

Bitter, S., and J. Keith Bowers, 1994. "Bioretention as a Water Quality Best Management Practice", Watershed Protection Techniques, 1(3).

Boettger, S.D., 1996. "Some Design Considerations for Community Trails", Land Trust Alliance Exchange, 8-11.

Booth, D.B. and C. R. Jackson, 1997. "Urbanization of aquatic systems-degradation thresholds, stormwater detention, and limits of mitigation". Journal of American Water Resources Association, 33(5): 1077-1090.

Brown, Whitney and Deborah Caraco, 2000. "Muddy Water In – Muddy Water Out?", Watershed Protection Techniques, 2(3). Available on Stormwater Center website.

California Stormwater Quality Association, January 2003. California Stormwater Best Management Practices Handbook, New Development and Redevelopment. www.cabmphandbooks.com

Center for Sustainable Design, no date. Tree Preservation and Protection, Mississippi State University. Available on website.

Center for Watershed Protection, 1998, Rapid Watershed Planning Handbook: A comprehensive guide for managing urbanizing watersheds.

Chollak, Tracy and Paul Rosenfeld, no date. Guidelines for Landscaping with Compost-Amended Soils. Prepared for City of Redmond Public Works and available on website.

Coffman, Larry. 2000. Low-Impact Development Design Strategies, An Integrated Design Approach. EPA 841-B-00-003. Prepared by Prince George's County, Maryland. Department of Environmental Resources, Programs and Planning Division.

Corish, K.A., 1995. Clearing and Grading Strategies for Urban Watersheds. Environmental Land Planning Series, Metropolitan Washington Council of Governments.

Craul, P.J., 1992. *Urban Soil in Landscape Design,* John Wiley and Sons.

Delaware Department of Natural Resources and Environmental Control and Brandywine Conservancy, 1997. Conservation Design for Stormwater Management: A Design Approach to Reduce Stormwater Impacts from Land Development and Achieve Multiple Objectives Related to Land Use.

Dramstad, Wenche E., James D. Olson, and Richard T.T. Forman. 1996. Landscape Ecology Principles in Landscape Architecture and Land-use Planning, Harvard University Graduate School of Design, Island Press and the American Society of Landscape Architects.

Engineering Technologies Associates, Inc. (ETA), 1993. Design Manual for Use of Bioretention in Stormwater Management. Prepared for Prince George's County, Maryland, Department of Environmental Resources.

Environmental Building News, 2003. "A Garden Overhead: the benefits and challenges of green roofs", Vol. 10, No. 11, Special Reprint.

Flink, C.A., and Searns, R.M., 1993. Greenways: A Guide to Planning, Design, and Development, The Conservation Fund, Island Press.

Florida Department of Transportation, 1995. *Twelve Steps Toward Walkable Communities.* Available on U.S. Department of Energy website.

Forman, R. T., 1995. *Land Mosaics: The Ecology of Landscapes and Regions,* Cambridge University Press.

Forman, R. T. et al, 2002.*Road Ecology: Science and Solutions,* Island Press, Washington, D.C.

Gibbons, Jim. 1999. *Sidewalks,* Nonpoint Education for Municipal Officials. Available on NEMO website.

Herson-Jones, L.M., 1995. Riparian Buffer Strategies for Urban Watersheds, Environmental Land Planning Series, Metropolitan Washington Council of Governments.

Idaho Department of Environmental Quality, 1997. Environmental Planning Tools and Techniques, prepared by Todd Maguire.

Iowa Department of Transportation, 2000. Connecting People and Trails: Local Community Planning for Bicyclists and Pedestrians. Available on website.

Johnson, B. R. and K. Hill, eds. 2001. *Ecology and Design: Frameworks for Learning,* Island Press.

Johnston, Jacklyn and John Newton, no date. Building Green, A Guide to Using Plants on Roofs, Walls and Pavements, London Ecology Unit, Great Britain.

King County, Department of Natural Resources and Parks, 2005. King County Surface Water Design Manual. Seattle WA.

Labaree, J.M., 1992. How Greenways Work: A Handbook on Ecology, Ipswich, MA: National Park Service and Atlantic Center for the Environment.

Lee-Ryan, K., ed., 1993. Trails for the Twenty-First Century: Planning, Design, and Management Manual for Multi-Use Trails, Island Press.

Lehner, P. H., G. Aponte Clark, D. Cameron and A. Frank, 1999. Stormwater Strategies, Community Responses to Runoff Pollution, Natural Resources Defense Council. Available on website.

Little, C.E., 1995. Greenways for America, The Johns Hopkins University Press.

Lyle, John Tillman, 1994 (2nd edition of 1985 publication). Regenerative Design for Sustainable Development, John Wiley & Sons, Inc.

Lyle, J. T., 1999. Design for Human Ecosystems, Island Press.

Maryland Office of State Planning, October 1994. *Clustering for Resources Protection.* Available for ordering on website.

May, C.R., R. Horner, J. Karr, B. Mar, and E. Welsh, 1997. "Effects of Urbanization on Small Streams in the Puget Sound Lowland Ecoregion". Watershed Protection Techniques, 2(4): 483-494.

Metro, 1997. Green Streets, Innovative Solutions for Stormwater and Stream Crossings, Portland, Oregon. Available for ordering through Metro website.

Metropolitan Washington Council of Governments, no date. *Cluster Development Strategies for Urban Watersheds.*

National Park Service, 1995. Economic Impacts of Protecting Rivers, Trails, and Greenway Corridors: A Resource Book, Rivers Trails and Conservation Assistance.

Organization of American States, 1995. Rainwater Harvesting from Rooftop Catchments. Available on website.

Peck, Steven W. *The Green Roof Infrastructure Monitor,* The Cardinal Group Inc.

Pima County Flood Control District, no date. How to Harvest Rainwater. Available on website.

Portland Environmental Services, September 2004. Stormwater Management Manual, Clean River Works, Portland OR.

Prince George's County Department of Environmental Resources, 1993. Design Manual for Use of Bioretention in Storm Water Management, Division of Environmental Management, Watershed Protection Branch. Landover, MD.

Prince George's County, Department of Environmental Resources, 1999. Low-Impact Development: An Integrated Environmental Design Approach.

Puget Sound Action Team, March 2003. *Natural Approaches to Stormwater Management,* Washington. Available on website.

Puget Sound Action Team, January 2005.*Low Impact Development Technical Guidance Manual for Puget Sound,* Washington. Available on website.

Schor, H., "Landform Grading: Building Nature's Slopes." Pacific Coast Builder, June 1980, pp. 80-83.

Schor, H. "Hills Like Nature Makes Them." Urban Land, pp. 40-43. March 1992.

Schor, H. and D.H. Gray. "Landform Grading and Slope Evolution." ASCE Journal of Geotechnical and Geoenvironmental Engineering, Vol. 121, No. 10, pp. 729-734. 1995.

Schueler, T. 1994. "The Importance of Imperviousness", Watershed Protection Techniques, 1(3): 100-111.

Schueler, T., 1994a. The Stream Protection Approach: Guidance for Developing Effective Local Nonpoint Source Control Programs in the Great Lakes Region, Prepared for the Dept of Environmental Programs.

Schueler, T., 1994b. "Use of Cluster Development to Protect Watersheds", Watershed Protection Techniques, 1(1): 3-5.

Schueler, T., 1995a. Site Planning for Urban Stream Protection, Center for Watershed Protection. Available on Center for Watershed Protection website.

Schueler, T., 1995b, "The Architecture of Urban Stream Buffers", Watershed Protection Techniques, 1(4): 155-163.

Schueler, T., 2000. "Can Urban Soil Compaction be Reversed?", Watershed Protection Techniques, 3 (2): 666-669.

Shaver, Earl. 2000. Low Impact Design Manual for the Auckland Region. Auckland Regional Council, Technical Publication No. 124.

Smith, Daniel S. and Paul Cawood Hellmund, eds., 1993. Ecology of Greenways, University of Minnesota Press, Minneapolis, MN.

Steiner, Frederick, 1991. The Living Landscape: an Ecological Approach to Landscape Planning, McGraw-Hill, Inc.

SvR Design Company, June 2004. High Point Community Site Drainage Technical Standards. Prepared for High Point Community, Seattle WA.

Texas Water Development Board, 1997. Texas Guide to Rainwater Harvesting. Available on website.

Thompson, J. William and Kim Sorvig, 2000. Sustainable Landscape Construction: A Guide to Green Building Outdoors, Island Press.

Thompson, G. F. and Steiner, F. R., 1997. Ecological Design and Planning, John Wiley and Sons, New York.

Tugel, Arlene, Ann Lewandowski, Deb Happe-Von Arb, eds., 2000. *Soil Biology Primer,* Soil and Water conservation Society, Ankeny, Iowa.

US Composting Council, 2000. Field Guide to Compost Use. Available on website.

USEPA, 2000. Low Impact Development: A Literature Review, EPA-841-B-00-005. USEPA, Office of Water.

US Federal Highway Administration, 2002. *Designing Sidewalks and Trails for Access.* Available on website.

University of Washington Soils Lab, 1997. Soil Amendment Use in Lawn Soils. Available on website.

Utah Association of Conservation Districts, 2001. North Logan Low Impact Development Roadway Design Standards. Available on City of North Logan, UT website.

Wells, Cedar, 1997. “Skinny Streets and One-sided Sidewalks: A Strategy for Not Paving Paradise”, Watershed Protection Techniques. 1(3): 135-137.

Zielinski, J., 2000. “The Benefits of Better Site Design in Commercial Development”, Watershed Protection Techniques, 3(2): 647-656.

Glossary

Assimilation	Everything produced in the landscape returns to the landscape. An example, dead biomass or human wastes can serve as essential food for vast populations of decomposing organisms that include numerous species of insects, worms, bacteria, and fungi. Their work activity comprises most of the earth's biological processes.
Barrier	An inhibition of materials and energy from passing through or between two adjacent paths, serving in degrees to block or create impenetrable conditions for movement and flows. Some common examples are rivers, roads, railways, hedgerows, and power lines.
Conduit	Nature provides a number of mechanisms for the distribution of energy and materials over the landscape. The distribution patterns of winds cover the earth. Water itself is first distributed in the atmosphere by the wind and, after it falls back to earth, by gravity within a single watershed. Water often carries a great many other materials such as suspended solids and other constituents in suspension.
Conversion	In the process of conversion, one thing becomes something else. Solar energy provides ample supply to sustain life on earth. In photosynthesis, solar rays become life: producing the sources of food we eat and the oxygen we breathe.
Corridor	A linear strip of a particular type differing from the adjacent land on both sides possessing several vital potential functions including conversion, conduit, barrier, assimilation, storage, and networking.
Filtration	As air and water flow over and through the landscape, plants and soil act as filters, removing materials that have been dissolved or otherwise taken up and carried along. The leaves, in effect, cleanse the air as it moves through them. Grasses and ground covers perform the same service as water flowing over the surface of the landscape. Soil and decomposing rock filter out most particles from water making its way from the surface to underground storage in an aquifer.

Interconnectivity	The ability to interconnect or link more than one structure or function through design resulting an aggregation. Human intellect encompasses the earth. In the context of development, it becomes hard reality; human thought becomes part of the natural processes. The scope and complexity of most development situations require thought in the forms of cognition, planning, design, engineering, and ongoing management. In this instance, cognition refers to an internalized understanding of natural processes (knowledge of the whole).
Network	Nodes and linkages in the form of corridors usually surrounded by a matrix.
Node	An intersection and linkage between a corridor and patch and their various corresponding functions.
Patch	A relatively homogeneous nonlinear area that differs from its surroundings possessing several vital potential functions including conversion, conduit, filter, assimilation, storage, and networking.
Source and Sink	A source is an area or reservoir where outputs exceed input in contrast with a sink where input is greater than output.
Storage	In the natural system materials are held inactive at some points awaiting eventual reuse. For example, water is stored for varying lengths of time in the soil, in the voids of underground rock strata that serve as aquifers, and in lakes and ponds.

Volume 4: Permanent Stormwater Controls

Appendix A: References

Appendix B: Glossary

Appendix C: Stormwater Plant Materials

Appendix F: Mosquitoes and Stormwater Management

Appendix G: General Guidance for Hydrologic/Hydraulic Design

Appendix H: Disposal Alternatives Table

Section 1 - Introduction

The *Catalog of Stormwater Best Management Practices for Idaho Cities and Counties*, a series of five compact discs (CDs), provides technical guidance for construction site design and the selection of stormwater best management practices (BMPs). The catalog is a guidance document containing voluntary controls that could be formally adopted by a jurisdiction to establish standards, if desired. Measures, such as those described and other recognized equivalents, should be used to manage the quantity and quality of stormwater runoff from land development.

This information is primarily intended for design professionals (e.g., landscape architects, geologists, engineers, soil scientists, etc.) and their contractors. It is also applicable for local public officials or staff who are responsible for the review and approval of development applications.

There are several reasons why technical guidance regarding stormwater management is necessary:

- . Idaho remains one of the fastest growing states in the nation. The increase in population leads to an increase in land development, a recognized source of nonpoint source pollution, more commonly termed "polluted runoff." The catalog includes BMPs that help to prevent discharge of pollutants from developing areas, both during the construction phase and for the life of the development. The BMPs can also be used to reduce polluted runoff from existing land uses.
- Many water bodies throughout the state are not in compliance with state water quality standards. Beneficial uses such as domestic water supply, fishing, swimming, boating, and agricultural water supply can often be impaired due to excessive pollutants from stormwater runoff. The catalog provides guidance for controls to reduce "conventional" pollutants, with special consideration for phosphorus and sediment, both common pollutants in Idaho.
- Federal National Pollutant Discharge Elimination System (NPDES) stormwater regulations have mandated that some communities develop and implement stormwater management programs to ensure that pollutants in stormwater runoff are controlled to the maximum extent practicable. Because polluted runoff has the potential to contribute to the degradation of receiving water quality, improved stormwater management program implementation at the local level will play an ever-increasing role in attaining and maintaining water quality standards.

In general, there are two types of BMPs for stormwater pollution control:
1. Source control BMPs focus on minimizing or eliminating the source of the pollution so that pollutants are prevented from contacting runoff or entering the drainage system.
2. Treatment control BMPs which tend to be more expensive to implement than source control BMPs, are designed to remove pollutants after they have entered runoff. Examples of source control BMPs include spill controls and employee education, while treatment control BMPs include detention ponds and oil/water separators. Most source control BMPs tend to be non-structural, and most treatment control BMPs tend to be structural in nature, although there can be exceptions. For example, a roof over a materials storage area at an industrial site would be considered a structural source control.

The majority of the practices focus on controlling pollution at its source, before runoff enters a drainage conveyance such as a sewer system or river. However, some BMPs are also included that can be used to treat runoff and remove pollutants that have already entered the drainage conveyance. The structural measures will reduce pollutant loads in post-construction site runoff, provided that the facilities are properly designed, installed, and maintained on a periodic basis.

The catalog presents general technical guidelines. Specific conditions or local regulations may require modification of the recommended BMPs, and alternative practices that are approved by a local permitting authority may also require modification or replacement of recommended BMPs. The BMP selection matrix should be used as a screening tool to assist the design professional, landowner, or reviewer in selecting the most appropriate or suitable measure based on site-specific conditions.

In order to illustrate the use and application of certain BMPs, manufacturer and product names may be used in the catalog. This does not represent an endorsement of a specific manufacturer or product.

1.1 Organization

The first volume of the CD series includes a brief discussion of stormwater runoff impacts; an overview of agencies responsible for stormwater permitting and authority in Idaho; and a step-by-step procedure for site design.

The second volume of the CD series contains construction BMPs including both erosion and sediment controls and source controls.

The third volume of the CD series introduces the concept of low-impact development and provides techniques that can minimize changes to the hydrologic functioning of a development site.

The fourth volume of the CD series contains post-construction/ permanent BMPs.

The fifth volume of the CD series provides BMPs for specific land use activities, including industrial, commercial, and residential activities.

The catalog is intended for use in conjunction with local governmental requirements, such as applicable planning and building codes. The catalog is not all-inclusive and should be used along with other reference books and manuals published by other agencies as necessary or appropriate based on local conditions and policies.

1.2 Updates

The practice of stormwater management is quickly evolving. Design information for various BMPs is expected to change as more people apply the practices and learn from their experience. New BMPs will also be added to the mix. To accommodate these changes, periodic updates and amendments will be made to the catalog. These will be posted on the Department of Environmental Quality (DEQ) Web site as they become available.

Section 2 – Permanent Stormwater Controls

This volume presents a range of permanent BMPs for continued control of stormwater pollution after construction is complete. The categories of BMPs addressed in this chapter include stormwater filters, infiltration, detention, and other structural facilities. Each BMP fact sheet presents application and limitation information, as well as design parameters, construction guidelines, and operation and maintenance recommendations. The most important requirements for successful performance of post-construction facilities are proper sizing and regular inspection and maintenance.

The local permitting authority should be contacted for additional requirements or restrictions that may apply to any of the BMPs.

2.1 Basic Considerations for Stormwater Site Design

The following considerations apply to all new and redevelopment projects and to projects that will discharge directly to a water body.

New Development and Redevelopment Projects

Preserve Natural Drainage Systems

Preserve and maintain natural drainage systems and allow discharges from the site to occur at the natural location. Do not disturb naturally vegetated buffers along streams, unless the vegetated buffer is part of the water quality treatment facility.

Floodplains

The Idaho Department of Water Resources (IDWR) should be consulted if the project is within a designated floodplain or below the mean high-water level.

Subsurface Disposal and Infiltration

In areas that have poorly drained soil conditions and/or a high water table, subsurface disposal systems, including dry wells and injection wells, are not recommended in most cases. If dry wells or injection wells are constructed, they should be permitted by the IDWR. Facilities such as infiltration trenches and basins could be approved, if it is demonstrated by the developer that the site can handle infiltration. This will require site-specific testing to determine the infiltration rate at the site. In general, the infiltration rate should be greater than 0.4 inches per hour.

Operation and Maintenance

A maintenance plan that outlines the scope of activities, schedule, and responsible parties for inspecting and maintaining the facility should be prepared. Use the BMP fact sheets to determine the level of maintenance needed for each BMP.

Vegetation, sediment management, access, and safety are primary issues to be addressed by any maintenance plan. In general, it is important to schedule maintenance around sensitive wildlife and vegetation seasons. Most industrial site facilities will generally require more frequent maintenance than facilities on commercial or residential sites. Section 3 provides general information about operation and maintenance. The individual BMP fact sheets in the catalog provide specific information on operation and maintenance.

Sites that Drain Directly to a Water Body

Before developing the site plan, check with the responsible authority to learn about any special restrictions or permitting that may be required for the new site discharge, including carrying capacity of the receiving system. Depending on the type of discharge, the following list provides guidance on the responsible party to contact:

- Piped storm drain system within the city limits: contact the city or local highway jurisdiction; in the unincorporated areas, contact the county or the local highway jurisdiction
- Irrigation or drainage ditch canal: contact the responsible irrigation district, drainage district, or ditch company
- State highway ditch: contact the Idaho Transportation Department
- Other local road ditch within the city limits: contact the city or local highway jurisdiction; in the unincorporated areas, contact the county or local highway jurisdiction
- Any lake or reservoir: contact the regional DEQ office, Idaho Department of Fish and Game (IDFG), and EPA Region 10
- A stream: see the following basic requirements for stream bank erosion then contact a regional DEQ office, the IDFG, and/or U.S. Environmental Protection Agency (EPA) Region 10
- Natural wetlands: see the following basic requirements for wetlands. Note that dredging, filling, utilities work, and construction in wetlands is governed by Section 404 of the Clean Water Act Permitting, which is administered by the Army Corps of Engineers.

Stream Bank Erosion Control

For direct stormwater discharges to streams, control stream bank erosion by limiting the peak rate of runoff from the site to 50% of the predevelopment condition 2-year, 24-hour design storm and maintaining the predevelopment condition peak runoff rate for the 10- and 100-year, 24-hour design storms. Stormwater treatment BMPs should not be built within a naturally vegetated buffer, unless the vegetated buffer is part of the stormwater treatment by way of providing infiltration.

Wetlands

In situations where stormwater discharges directly or indirectly to existing wetlands, follow these guidelines:

- Contact the Corps of Engineers and the nearest DEQ regional office prior to commencing any work.
- Stormwater discharges to wetlands should be controlled and treated to the extent necessary to meet the state water quality standards (WQS), as appropriate.
- Discharges to wetlands should maintain the flows of existing site conditions to the extent necessary to protect the characteristic uses of the wetland. Prior to discharging to a wetland, alternative discharge locations should be evaluated, and natural water storage and infiltration opportunities outside the wetland should be maximized.
- Constructed wetlands can be integrated as a stormwater BMP. Discharges from constructed wetlands to waters of the state (including discharges to natural wetlands) are regulated under WQS and Water Treatment Rules (WTR), IDAPA Sections 16.01.02.080; 16.01.02.400.04; 16.01.02.350; and 16.01.02.800. Constructed wetlands that are intended to mitigate the loss of wetland acreage and/or function and value are not to be utilized for the treatment of stormwater.
- Dredging, filling, utilities work, and construction in wetlands is governed by Section 404-Permitting, administered by the Army Corps of Engineers, and Section 401-Certification, administered by DEQ.

2.2 Development Site Planning

To ensure cost-effective site design and to reduce pollutants in stormwater runoff, design professionals should work with the site developer or property owner as early as possible in the project development process to create an integrated site plan. Even before a preliminary site plan is drawn, the design professional and the developer or property owner should consider stormwater BMPs as part of the project plan. This type of planning will reduce the amount of pollutants entering the stormwater system and avoid costly construction delays.

The following process is recommended when developing a project site plan. This process can be used on small infill projects as well as large development projects. It provides a general overview of site planning considerations and suggestions for choosing BMPs that most effectively fit the conditions of the site and the type of development project. For the selection of the most appropriate or suitable BMP, the user should refer to Table 2.1. It is essential to check with the local permitting authority for other requirements.

Step 1—Evaluate Site Conditions

Basic information should be gathered for the project site before using the catalog to select BMPs. To obtain some types of information, contacting the local permitting authority is recommended. For example, local agency staff can help by identifying locations of environmentally sensitive areas on or near the site and by providing local planning and building code requirements.

Step 2—Identify Performance Goals and Regulatory Considerations for the Development Site

Stormwater management performance goals and objectives should be identified for the development site. These goals and objectives are based on applicable regulatory requirements for quantity (flood and drainage) control, peak flow reduction, and any special local area needs such as fisheries protection, water supply watershed protection, ground water protection and other issues of local importance. While the selection of the appropriate level of control is usually a local mandate, in some cases the downstream receiving waters will influence the regulatory requirements. Examples include Total Maximum Daily Load (TMDL) requirements, protection of endangered species, and/or federal stormwater regulations and associated NPDES Stormwater Permits conditions.

The regulatory requirements of the local jurisdiction should be considered in the selection of BMPs. Many jurisdictions have requirements for control of the rate of discharge (or peak runoff rate) from new construction or redevelopment to control increased flooding, channel protection, or water quality. This control is usually accomplished by detention of the flow, discharging at a controlled release rate through an orifice (small opening). Other performance goals and objectives may include specific pollutant guidelines, water quality control, multi-parameter controls, including ground water recharge and channel protection, and habitat protection strategies.

The local permitting authority should be contacted to obtain the permit application forms and any other applicable requirements for the project site area. These could include planning and building codes, flood control and water quality design standards, and seasonal restrictions for earthmoving and grading.

The storm-drain system or waterway where site runoff will drain should be identified. Identifying the site runoff drain locations will determine which requirements must be followed.

The agency managing the receiving drainage system for the site should be contacted to learn about any special restrictions or permitting that may be required, including the maximum carrying capacity of the receiving system. Local requirements may change periodically, so the local agencies should be consulted for each new construction project.

Step 3—Develop Conceptual Site Design

At the early stages of site design, opportunities should be identified to reduce the quantity and improve the quality of site stormwater runoff. Sites should be designed to preserve and minimize disturbance to existing soils, vegetation, and water quality sensitive areas. The following are suggested techniques to use on a development site:

- Design the site to limit impervious areas
- Design on-site water re-use facilities
- Reduce impervious areas by using cluster development and rooftop or basement parking
- Disconnect impervious surfaces
- Identify preliminary stormwater disposal space allocation requirements early

Vegetation may be one of the most cost effective resources for improving water quality. Integrating stormwater controls within the landscape saves money and keeps pollutants, such as sediments, oil, and grease, out of stormwater runoff. Controls such as vegetated swales and irrigated grass buffer strips can be part of the landscape with minimal construction costs. The following are techniques that can be used on site:

- Preserve existing vegetation or plant native vegetation in disturbed areas
- Preserve and maximize vegetative canopy, particularly shrubs and coniferous trees

A preliminary construction schedule should be prepared early in the development of the project. Seasonal weather conditions impact many construction activities, and strategic schedule and sequence planning can facilitate construction, as well as minimize impacts on stormwater. Timing can be especially important at higher elevations because of the relatively short construction season. Careful planning is needed to minimize the potential impact of construction near water bodies, for stream and river crossings (pipelines and utilities), and for projects that require revegetation during the short growing season.

The conceptual plan and preliminary construction schedule should be presented to the local permitting agency for feedback before proceeding with the design drawings. For larger projects, this would likely take the form of a pre-application meeting. This important check-in is recommended in order to save time and money later in the process.

Step 4—Characterize Stormwater Flows (Runon and Runoff)

The characteristics of the runon that enters the site from adjacent and upstream properties should be evaluated, as well as the runoff that will be discharged from the site post-construction. The following are considerations that may potentially influence the quantity (volume), peak flow, and quality of runon to and runoff from the site:

- Upstream activities currently affecting the site
- Planned upstream land use likely to affect the site in the future
- Type and capacity of the downstream receiving water or drainage system
- Amount of impervious area planned for the site
- Activities that will take place on the site (e.g., industrial and commercial activities may generate different pollutants and may require different BMPs than residential activities)

Hydrologic calculations should be performed for both the pre-developed and post-development stages, with upstream and downstream conditions in mind. Use local design standards for flood control and water quality control. Calculate the required volume and peak flow of the discharge and determine the amount of runoff to be detained and/or treated on site. Appendix D contains guidance for calculating runoff.

Step 5—BMP Selection

BMP selection should be based on BMP performance goals, identified in Step 2, and the physical constraints of the development site. Site suitability is one of the key factors to successful BMP performance, especially for structural BMPs. Physical site constraints may include soil suitability, depth to water table, depth to bedrock, slope, and watershed size. In many instances, individual BMPs may be modified to account for site constraints, while in other cases, they may eliminate an option altogether.

Table 2.1 shows site selection criteria and site selection restrictions for each BMP. Use the table to give a general sense of the BMPs that could be appropriate for your site.

The following describes the information presented in Table 2.1:

- Targeted pollutants—The pollutant removal for typical pollutants of concern, including sediment, phosphorus, trace metals (e.g., lead, copper, cadmium), bacteria, and hydrocarbons (e.g., gasoline, oil and grease), in urban stormwater runoff (Estimated values are provided for phosphorus and sediment removal for most of the permanent BMPs, based on available data. Due to the variable nature of BMPs, numerically reported efficiencies should be considered general estimates only. For the other pollutants, a more qualitative estimate is provided through full, half, and empty circles.)
- Drainage area—The maximum contributing drainage area for the BMP
- Maximum slope—The maximum allowable site slope for placement of the BMP
- Minimum depth to bedrock—The minimum allowable depth to bedrock for placement of a BMP on a site
- Depth to high water table—The minimum allowable depth to the high water table for locating a BMP on a site
- Natural Resources Conservation Service (NRCS) soil type—Soil type is classified as A, B, C, or D. "A" has the best infiltration rate (e.g., sands), while "D" allows little or no infiltration (e.g., clays). The BMP is best suited for the soil types given on the table.
- Use with freeze/thaw cycle—BMP performance during the winter and spring freeze/thaw cycles are indicated as good, fair or poor.
- Drainage/flood control—A checkmark in this column of the table indicates that the BMP can be used to provide drainage and flood control as well as water quality control.

Pollutant removal has become one of the main objectives for using BMPs. The quantification of efficiency of BMPs has often centered on examinations and comparisons of "percent removal" defined in a variety of ways. There is no single value for percent pollutant removal for a particular BMP. Pollutant removal efficiency is site specific and highly variable between storm events even within the same area. Assuming routing and design volumes are properly designed, BMP performance will vary with influent loadings and characteristics.

BMPs do not typically function with a uniform percent removal across a wide range of influent water quality concentrations. For example, a BMP that demonstrates a large percent removal under heavily polluted influent conditions may demonstrate poor percent removal where low-influent concentrations exist. Other factors that affect variability in BMP water quality performance include active pollutant removal mechanisms, BMP design characteristics, and conditions within the BMP.

The goal in watershed management should be to reduce the pollutant load either through source control (the most effective way to do it) or through multi-stage treatment (treatment trains). Although individual BMPs may be less effective on a percent basis, if they cumulatively still result in a lower effluent concentration (or load), they benefit the watershed.

Some site situations, such as steep slopes, will severely limit options in selecting BMPs. Steep slopes will require more complex engineering, and BMPs tend to be structural in nature, requiring less land space than facilities on flat sites. The site plan should include slope protection and vegetative controls to reduce the amount of erosion and sediments in site runoff. Also, upstream conditions should be investigated, and any off-site sources of sediment from neighboring properties should be eliminated. After applying these measures, if high sediment loads are still unavoidable, select a detention facility that will initially treat the stormwater through simple settling. Stormwater filters and vegetated detention should be used only after pretreatment settling has been applied to reduce the sediment load. Otherwise, excessive sediment may clog the infiltration facilities and damage vegetation.

Where quantity control is an issue, an off-line water quality facility should be considered as an option. In this situation, the water quality device is located off-line from the primary drainage facility. The water quality portion is designed only to treat a small volume of water, typically associated with smaller, more frequent storm events. The runoff from large storm events bypasses the facility to avoid flooding. In this type of combination system, stormwater runoff is directed to off-line facilities through flow-splitting and diversion structures.

Combining BMPs to improve effectiveness should be considered. Combination or "treatment train" facilities (i.e., several facilities in a row or series) can be designed so that upfront facilities pretreat the runoff, allowing the main device to function optimally. This concept also allows different mechanisms to clean different portions of the pollutant load. For example, sedimentation ponds are good at removing coarse particulates but are not effective with dissolved pollutants.

Many possible treatment train options exist. Generally, smaller BMPs are used as pretreatment for and/or conveyance to larger BMPs. Using smaller BMPs as pretreatment has the added benefit of extending the maintenance intervals and useful life of the primary BMP. Examples of such BMP treatment trains are as follows:

- Vegetated filter strips → sand filter or infiltration basin
- Grassed swales → dry extended detention pond, wet pond or wetland
- Bioretention → dry extended detention pond or infiltration basins
- Manufactured products for stormwater inlets or catch basins and catch basin inserts → dry extended detention ponds or infiltration basins.

Using structural BMPs in treatment trains, such as those listed above, can improve both the water quality as well as total runoff volume of the final effluents, thereby minimizing the effects on receiving waters. The most effective combinations are made between BMPs with different dominant pollutant removal mechanisms, such as integration of a sand filter (filtration) with a wet retention pond (sedimentation). Combining strong water quantity control BMPs (e.g., dry detention ponds) with strong water quality control BMPs (e.g., sand filters) will also make effective treatment trains.

With some land uses, more than one treatment method may be needed. For example, if stormwater runoff is expected to contain high concentrations of oil, it may be necessary to use an oil/water separator to pretreat the water before it enters other treatment devices. Many jurisdictions require pretreatment in the form of solids removal or spill control by providing catch basins or gravity oil/water separators. These pretreatment measures are often used in conjunction with detention and water quality treatment devices.

Source controls should be incorporated in your site design. Source controls are stormwater BMPs that prevent pollutants from entering a stormwater system. Compared to treatment controls, source controls are more cost effective for controlling stormwater pollution on a site. Some examples of source controls are as follows:

- Providing covered (roofed) structures for outdoor storage or outdoor work areas to prevent rain from washing pollutants off the site
- Preventing run-on into storage areas by using properly designed berms or grading around storage areas
- Using designated vehicle wash areas and disposing wash water into the sanitary sewer, where allowed

Industrial sites can have more toxic pollutants on site compared to commercial or residential sites. Consequently, the BMPs used on an industrial site will be different from those used on a commercial or residential site. When planning for stormwater controls on an industrial site, source controls that reduce or remove toxic pollutants should be used before treatment controls are used. Treatment controls may still be needed, however, to treat pollutants that are not completely removed by source controls.

Treatment controls are more comprehensive and more costly than source controls. Treatment controls for industrial sites may require installing or constructing water quality controls, such as oil/water separators and water quality inlets, or hydraulic controls, such as retention ponds. Each industrial site should be evaluated to determine which BMPs (either singly or in combination) will be appropriate for a site. In addition, some controls are less costly to install during new construction than to retrofit afterwards. Therefore, design professionals should consider what potential pollutants may originate from the site throughout the life span of the facility, not just during construction.

When planning BMPs for a site, how the controls can be used together (that is, multiple systems) should be considered. Multiple systems can remove pollutants more effectively than individual source and treatment control BMPs. Also, multiple systems can provide additional secondary benefits such as controlling floods, enhancing fish and wildlife habitats, providing aesthetics and recreation, and complying with landscaping requirements.

Step 6—Prepare Preliminary Project Design (Stormwater Site Plan)

A stormwater site plan is recommended for all new developments, whether commercial, industrial, or residential. A stormwater site plan should include the following elements:

- Project overview (brief description)

- Site plans (attach)
- Preliminary conditions summary, including soil types and depth to high ground water
- Identification of adjacent land uses and environmentally sensitive areas (such as wetlands, natural streamside riparian areas that provide wildlife habitat, or other areas designated by the local permitting agency)
- Analysis of off-site upstream and downstream conditions, including capacity of the downstream system
- Hydrologic calculations –(Two formulas are commonly used to calculate the peak discharge rates from pre- and post-development conditions: the NRCS TR-55 method and the rational method. The rational method should only be used for projects that are less than 100 acres in size. Other hydrologic methods may be accepted for determination of runoff rate and volume, if approved by the local permitting jurisdiction.)
- Design and placement planning of proposed construction BMPs, including erosion and sediment controls (construction BMP plan)
- Design and placement of proposed permanent stormwater BMPs (include preliminary sizing calculations)
- Operation and maintenance plan for the temporary and permanent stormwater BMPs
- Other permits for the site (either issued or planned)

An example stormwater site plan is included in Appendix E. If permanent BMPs are not planned for the site, a rationale for why this is not necessary (e.g., low risk) or not possible (e.g., space constraints) should be provided. In such cases, the local agency staff may not agree with the rationale and may provide assistance to select and locate appropriate BMPs.

Step 7—Prepare the Preliminary Landscape Plan

When designing the site landscape plan and choosing plants for vegetated stormwater BMPs, species of trees, shrubs, plants, and grasses that are native to the area should be considered before non-native plant species. In this way, irrigation will only be required during the plant establishment period (typically 1 to 2 years, depending on the particular species). Using native plants reduces the water requirement and reduces pesticide/herbicide and fertilizer use. Additionally, using native plants in stormwater BMPs will help ensure proper plant establishment and performance of the BMP.

Properly selecting the plants and preparing the site are crucial to successful plant establishment. Plants should be planted during favorable planting and seeding seasons. In addition, irrigating, mulching, and providing weed and pest control on the site may be necessary to encourage proper plant growth. For additional plant selection and establishment information, see Appendix C.

Step 8—Submit the Preliminary Project Design

The preliminary project design or stormwater site plan and preliminary landscape plan should be presented to the local permitting authority for approval before proceeding further. At this time, the opportunity should be taken to ask questions, if any, about the permit application forms or fee.

All submittals should include the preliminary design calculations to demonstrate that the facilities will meet the applicable standards. It is recommended that professionals licensed in the state of Idaho prepare the submittal or oversee its preparation.

Step 9—Complete the Design

Once the preliminary plans have been approved, the final plans for design and construction of the project should be completed. In addition to the plans normally required for development (e.g., grading and drainage, erosion and sediment control, building), the final design package should include the following:

- Type and location of BMPs for use during construction (Stormwater Pollution Prevention Plan or Erosion and Sediment Control Plan)
- Size/design and location of permanent stormwater BMPs
- Landscape plan
- Maintenance plan for BMPs and vegetation during construction and after construction

A maintenance plan should be prepared that outlines the scope of activities, schedule, and parties responsible for inspecting and maintaining the stormwater BMPs on the site both during construction and post-construction. At a minimum, the maintenance plan should identify safety provisions, site access, sediment disposal, and vegetation maintenance.

Facility access should be provided for inspection and operation and maintenance activities. All stormwater control facilities should be located in designated and reserved stormwater easements. Easements should be located to provide access for routine inspection and be sized for access of construction equipment and activities that may be needed for maintenance and repair work. If maintenance roads are necessary, they should be a minimum of 12 ft width, and have an HS-20 load capacity with a minimum inside turning radius of 30 ft. Roads should also be topped with gravel or some other pervious surface that allows access in wet weather.

In cases when the sediment is suspected to contain a high level of pollutants, provisions should be included in the maintenance plan for testing the sediment. For example, if the site is located in an area with a history of upstream industrial spills, then testing could include parameters such as oil and grease, metals, or nutrients. Sediments removed from stormwater BMPs should be stored and disposed of in accordance with applicable local, state, and federal regulations.

Step 10—Submit Final Plan and Obtain Permits

The final documents should be submitted to the appropriate permitting agency for final approval and permitting. More than one permit may be required for the site and more than one agency may be involved. This will include, at a minimum, approvals from the local municipality and/or local highway jurisdictions and the filing of a Notice of Intent with the EPA and preparation of a Stormwater Pollution Prevention Plan, if the construction site is larger than 1 acre or part of a larger plan of development.

Step 11— Install and Maintain BMPs

Once the permits are obtained, the final construction schedule can be developed. The following points should be kept in mind when establishing the schedule:

- Comply with seasonal restrictions for earthmoving and exposed soil established by the local permitting authority
- Schedule installation of BMPs (Some of the temporary BMPs should be installed before earthmoving activities begin.)
- Implement housekeeping BMPs (e.g., covering stockpiles) as soon as possible after the project breaks ground
- Schedule regular inspections of the site and the stormwater BMPs throughout the construction process and repair or replace BMPs as needed
- Maintain the BMPs as specified in the maintenance plan
- Schedule removal of the temporary BMPs (or retrofit them for permanent use) at the end of the construction project

Section 3 – Permanent Stormwater Controls

3.1 Stormwater Filters

Stormwater filters are designed to filter pollutants out from runoff. The primary removal mechanisms employed by these facilities are straining and settling, which allow capture of coarse to fine sediments and the pollutants adhered to them. Vegetated filters, such as bioswales, also offer limited nutrient uptake in plants as well as sorption in underlying soils. The term *biofiltration* has been coined to describe the more or less simultaneous process of filtration, infiltration, adsorption, and biological uptake of pollutants in stormwater that takes place when runoff flows over and through vegetated treatment facilities.

In vegetated systems, the degree to which the biofiltration 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 design criterion 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 should be designed so 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.

Stormwater filters can be used for a variety of land uses. However, they may not be suitable where the runoff contains high sediment loads over long periods, unless the facility is inspected and maintained frequently. Vegetated filters may also be unsuitable for direct runoff from commercial and industrial sites with a greater than average potential for toxic pollutants or where infiltration of these pollutants to ground water could be of concern. In such cases, the use of liners should be considered if the design meets the approval of the local permitting authority.

Vegetated filters can be less expensive than piped systems for conveying stormwater runoff. They are also typically more economical than separators, vaults, or other structural controls. As an added benefit, vegetated filters can be aesthetically pleasing, can reduce peak flows in site runoff, and can be considered part of the on-site landscaping.

The next few pages are BMP fact sheets for the following types of stormwater filters:

Biofiltration Swale (Vegetated Swale) BMP 1

Description

Biofiltration swales are flow-through vegetated channels with a slope similar to that of standard storm drains channels (less than 6%) but are wider and shallower to maximize flow residence time and promote pollutant removal by filtration through the use of properly selected vegetation and settling. Some adsorption and uptake of dissolved pollutants also occurs.

Applications

- A vegetated swale is designed to provide runoff treatment of conventional pollutants but is less effective with nutrients. Vegetated swales, when used as a primary treatment measure, 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 sand filter (BMP 4), then it will be necessary to locate it off-line.
- In cases where a vegetated swale is located on-line, it should be sized as 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 should not exceed the height of the grass. Use of a level spreader (BMP 20) should be considered if concentrated flows are too deep for the vegetation.
- Biofiltration should be regarded as one possible element of an integrated stormwater management plan for any given site or class of sites. Since flexibility exists in many design features, biofiltration success depends more on proper construction and maintenance than any other factor; effective inspection and enforcement programs should be emphasized to ensure that approved plans are implemented.
- Natural drainage courses should be regarded as significant local resources that are generally to be kept in use for stormwater management. 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.
- 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.
- Opportunities to fit biofiltration retroactively to areas already developed should be explored whenever possible. Roadside swales, however, are less feasible because of increased numbers of driveways with culverts unless there is sufficient space between driveways to infiltrate runoff and eliminate culverts.
- Biofilters should be protected from siltation by a presettling basin (BMP 16) when the erosion potential is high; 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 sensitive receiving waters, due to the complementary pollutant removal mechanisms that can operate in the two devices. Equipping both sides of the swale with vegetative buffers or filter strips

will also help reduce loading and decrease swale maintenance.

Limitations

Drainage area – 15 ac.
Minimum bedrock depth – 3 ft
NRCS soil type – B, C
Drainage/flood control – yes
Max slope – 6%
Minimum water table – 2 ft
Freeze/thaw – fair

Targeted Pollutants

Sediment – 65%
Total phosphorus – 15%
Trace metals
Hydrocarbons

Design Parameters

The design, planning, and operation and maintenance details in this fact sheet will ensure that the velocity of the water does not exceed 1.5 feet per second along a swale of 200 feet in length during the water quality design storm. As a general rule, the total surface area of the swale should be approximately 1% of the total drainage area.

The swale should have side slopes of at least 3:1 run over rise and provide at least 1 foot of freeboard. The facility should be able to convey the peak flow from the drainage basin for the 2-year, 24-hour design storm. The maximum depth of flow should not exceed 0.25 feet. A Mannings "n" of 0.35 should be used to calculate the flow depth and velocity. It may be that for situations in which swales are infrequently mowed, such as rural roads, a higher Manning's n value (0.235 is suggested) should be used for design.

General Criteria:

- For biofiltration, it is important to maximize water contact with vegetation and the soil surface. The soils at the site should support a dense growth of vegetation. Gravelly and coarse sandy soils cannot be used for biofiltration unless the bottom of the swale is lined to prevent infiltration. Also, avoid very heavy clay soils that will not support good vegetative growth.
- 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. Appendix C contains information on the selection of plant materials. In general, select fine, close-growing, water-resistant grasses. Protect these plants from predation during establishment by netting. Selecting different, low-growing ground covers for the swale's side slopes lessens the amount of mowing required.
- Alternative vegetation may be necessary where some period of soil saturation is expected. Where particular pollutant uptake characteristics are desired or the soil may be inundated, select emergent wetland plant species. In swales next to roadways where de-icer is regularly used, salt-tolerant species should be used.
- Select a grass height of 6 inches or less. Grasses over that height tend to flatten down when water is flowing over them, which prevents

sedimentation. To attain this height requires regular maintenance.

- 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 installing subdrains.
- The channel slope should normally be between 2 and 4%. A slope of less than 2% can be used to prevent ponding if underdrains are placed beneath the channel. For a slope of greater than 4%, check dams can be used if they are placed in a channel, to slow flows accordingly.
- Prevent bare areas in biofilters by avoiding gravel, rocks, and hardpan near the surface; fertilize, water, and replant as needed; and ensure effective drainage. Note: to help prevent ground-water pollution, fertilizer should only be used at an application rate and formula that is compatible with plant uptake and in relation to soil type. Soil tests may be necessary to determine existing soil fertility and determine proper application rate. High application rates of nitrogenous fertilizer in very permeable soils can result in leaching of nitrate into ground water.
- 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.
- Attempt to avoid compaction during construction. If compaction occurs, till before planting to restore lost soil infiltration capacity.

Specific Criteria for Biofiltration Swales

- Base the capacity design for biofiltration on the vegetation height equal to the design flow depth and the locally specified water quality design storm of an area. Base the capacity design for flood passage on local agency specifications for flood control.
- 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 3:1.
- A detention time of 9 minutes provides good pollutant removals (greater than 80% TSS), including metals, oil and grease, and TPH. In no case should residence time be less than 5 minutes. For better pollutant removals, a longer detention time is recommended.
- A maximum bottom width selection should be based on the design flow depth to accommodate uniform sheet flow with average depth between 1 and 3 inches for maximum effectiveness. A practical minimum swale width for trapezoidal swales should also be established for ease of maintenance. A minimum 2-foot bottom width is recommended to facilitate swale mowing with standard lawn mowers. However, narrower widths are possible if space is very constrained.
- Provide a minimum of 200 feet of continuous 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 should 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.

- Install log or rock check dams approximately every 50 feet, if longitudinal slope exceeds 4%. Adjust check dam spacing in order not to exceed 4% slope within each channel segment between dams.
- Below the design water depth, install an erosion control blanket, at least 4 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.
- If a swale should convey high flows, consideration should be given to the control of channel erosion and destruction of vegetation, and a stability analysis should be performed. Flow can also be bypassed by installing a pipe parallel to the swale and a flow-regulating device inside the inlet structure.

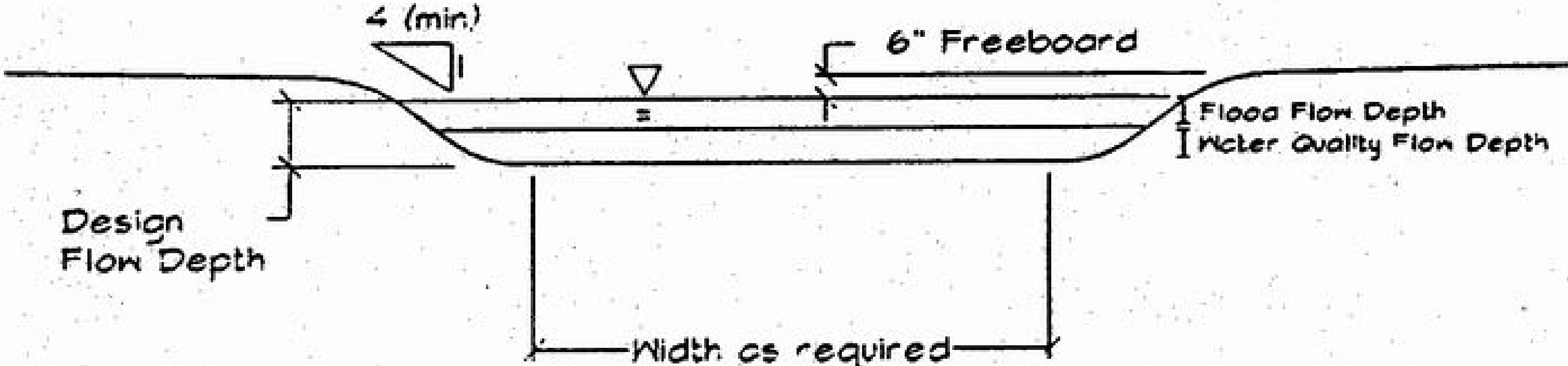
Construction Guidelines

- The flow should be distributed evenly across the channel bottom. Swale design should incorporate a flow-spreading device at the inlet such as a shallow weir across the channel bottom, a stilling basin, perforated pipe, or other means. It should include a sediment clean-out area and should have low maintenance requirements.
- If possible, divert runoff (other than necessary irrigation) during the period of vegetation establishment. Sodding is an alternative when rapid establishment should occur. Where runoff diversion is not possible, cover graded and seeded areas with a suitable erosion control slope covering material.
- Biofilters should generally not receive construction-site runoff; if they do, presettling of sediments should be provided. Such biofilters should be evaluated for the need to remove sediments and restore vegetation following construction.

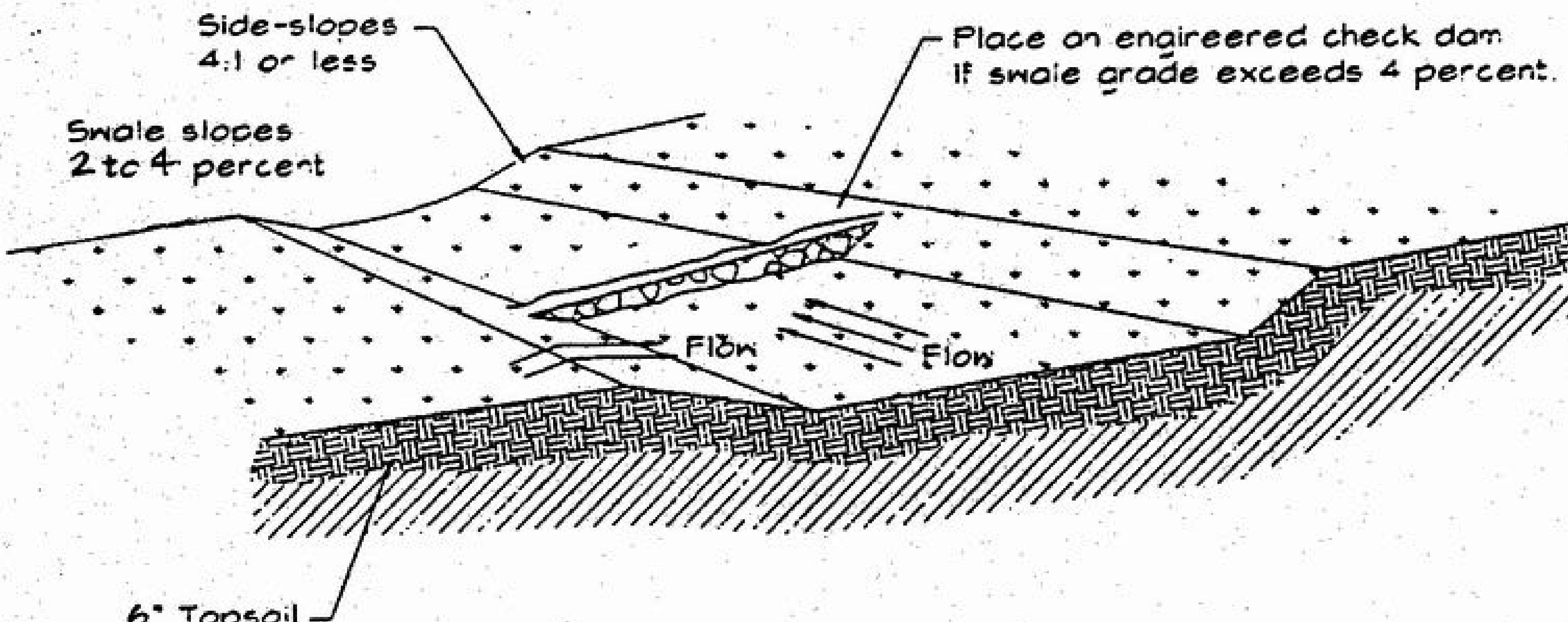
Maintenance

- Groomed biofilters planted in grasses should be mowed regularly during the summer to promote growth and to increase density and pollutant uptake. Be sure not to cut below the design flow (maintenance personnel should be made aware of this requirement). Remove cuttings promptly and dispose in such a way as to ensure that no pollutants 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 2 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, reseed them immediately.
- Inspect biofilters periodically, especially after periods of heavy runoff. Remove sediments and reseed as necessary.
- 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 debris.
- See that litter is removed in order to keep biofilters attractive in appearance.
- Base cleaning methods and frequency 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.



SECTION
No Scale



SECTION
No Scale

Bioinfiltration Swale BMP 2

Description

Bioinfiltration swales (BI swale) are depressions created by excavation, berms or small dams placed in channels intended to infiltrate the design storm runoff from impervious surfaces through a grass or vegetative root zone. Bioinfiltration swales represent a cross between a biodetention basin and a vegetated swale. They are designed for conveyance as well as infiltration.

Work done in Spokane County, Washington, on the adjoining Spokane Valley aquifer shows that infiltration of the design storm runoff from impervious surfaces provides treatment for approximately 90% of contaminant load carried in stormwater. The BMP 2 design is based on treatment of a precipitation rate of 0.10 inches per hour. This is expected to treat greater than 90% of flows and the design treatment flow of runoff from precipitation events in Kootenai County. The design flow will need to be adjusted for other areas based on precipitation records.

Applications

An open basin BI swale at the ground surface can be used where sufficient open space is available. This takes advantage of existing natural surface depressions and swales on the site where a berm or a low dam could very simply create the needed area. Alternatively, the landscape can be designed to include a depressed area in which to place the bioinfiltration swale. Road ditch areas are suited to use for bioinfiltration swales given the proper soil conditions.

Bioinfiltration swale (BI swale) construction involves proper soil profile modification, grading, and planting. The number, size, shape, construction, and planting of a BI swale should be suited to the slope, configuration, and human use of the site. Runoff can be delivered through a swale, armored flume, drop structure, or a buried culvert discharging directly to the basin floor. These structures can be designed to be consistent with the characteristics of the site.

The appropriate soil conditions for infiltration and the protection of ground water are the most important considerations limiting the use of this BMP. Soils should be permeable enough to infiltrate runoff but should also contain enough fine soils and organic material to remove pollutants and promote the growth of deep rooted, healthy vegetation. Planting soils should be at least loamy, with a clay content of less than 15%. The soil should contain 3-5% organic material and have a pH of 5.5 to 6.5 (Examples of appropriate soil types in Idaho are the Garrison, Avonville and McGuire soil types on the Rathdrum Prairie.). As with any type of infiltration facility, BI swales should not be used in areas with shallow aquifers used for drinking water. An official inventory form should be submitted to the Idaho Department of Water Resources (IDWR). Contact the closest regional office for further information.

Because soils can vary tremendously over short distances, site-specific evaluation may be required to determine if the minimum infiltration rate is attainable. If the tested infiltration rate cannot meet minimum values, more permeable material should be imported, and the soil profile should be modified to allow these swales to properly function.

Limitations

Drainage area – 5 ac.
Minimum bedrock depth – 6 ft
NRCS soil type – A, B
Drainage/flood control – yes
Max slope – 4%
Minimum water table – 3 ft
Freeze/thaw – fair

As with any type of infiltration facility, BI swales should not be used in areas with shallow aquifers. An official inventory form for shallow injection wells, used in association with the swales, should be submitted to the IDWR or, in some cases, the local health district. Contact the closest IDWR regional office for further information.

Targeted Pollutants

Sediment – 75%
Phosphorus – 30%
Trace metals
Bacteria
Hydrocarbons

Design Parameters

The following are general design parameters for bioinfiltration swales:

- Impervious surface area of a tributary area should be less than 1 acre
- Use several small BI swales rather than one large BI swale
- Dry-well rim elevation should be above the base of the BI swale to provide some assurance of infiltration of the design storm prior to overflow
- Planting soil depth of 4 feet. Adequate nutrient removal requires a minimum of 2.5 feet

The following specific design parameters given in this BMP have been developed as trial and error methods in Spokane County, Washington, and Kootenai County, Idaho. A technical advisory committee for stormwater design compiled this accumulated knowledge for the Rathdrum Prairie Aquifer, convened in the summer of 2000. Design parameters may need to be adjusted for other parts of the state due to variations in conditions.

Any design should keep in mind the leading causes of failure for BI swales:
1. Pre-silting during construction. This occurs generally after the contractor has roughed in the swales during the excavation phase of construction. Loose soil from the development is washed from the streets and off of building sites into the swales. This fine soil lowers the permeability to the point of swale failure, even though the original soil permeability was adequate.

2. Over-compaction of soils during construction. Equipment operated improperly in the swale will decrease swale permeability and may cause failure.

3. Improper incorporation of imported soils. Soils (e.g., topsoil, compost) imported for landscape development need to be properly incorporated into existing soils.

4. Excessive irrigation of grass. Vegetation in the swale is irrigated excessively to the point where almost constant soil saturation is occurring and when a rainfall event does occur the infiltration rate is not adequate.

Soils. Infiltration should be measured using ASTM D 5126 single ring infiltrometer test, but this is a local option. Soil infiltration capacity should be a minimum 0.5 inches per hour for the life of the swale. The maximum infiltration rate is 3.0 inches per hour. A higher maximum infiltration rate may be acceptable if an adequate vegetative cover can be maintained without excessive irrigation. Infiltration rate should be tested if the swale has the appearance of non-compliance with the required infiltration rate. This generally shows up as prolonged ponding around the dry-well intake.

Slopes. The BI swale should have slopes that do not result in erosive velocities for the design storm. This is usually less than or equal to 4% unless check dams (Volume 2, BMP #22) are installed.

Water Velocity. Water velocity as it enters and flows across the swale should not exceed the erosional velocity.

Shallow Injection Well (Dry well) Capacity. The outflow capacity of the dry wells should be based on the infiltrative capacity of the surrounding soil. The maximum design outflow capacity of a double-depth dry well is 1 cubic foot per second (cfs) and 0.3 cfs for a single depth unless it can be adequately demonstrated that the infiltrative capacity of the surrounding soil will allow for a greater capacity.

Dry well Rim Height and Placement. Infiltration swales should be designed to infiltrate the design flow before reaching the dry-well rim. Local jurisdictions will determine the minimum dry well rim height, but the rim should be elevated above the lowest point of the swale. The dry well should be placed as far as possible from any points of inflow.

Design Storm Treatment Area. The BI swale design storm intensity for the Rathdrum Prairie Aquifer (90 % of stormwater treated) is 0.1 inch (0.25 cm) per hour (Dobler, 2000). The minimum swale area is determined by matching the infiltrative capacity with the rate of flow into the swale. This calculation can be done incrementally with the Manning's flow equation (Chow, 1959 page 111). An acceptable method for calculating inflow into the swale from the impervious area is the rational method (Soil Conservation service). None of the design stormwater runoff should reach the dry well prior to infiltration for the design to be acceptable. Figure 2 is an illustration of the BI swale and accompanying dry well.

The county or municipality where the facility is located should provide the design storm for the facility and any minimum sizing requirements. Do not confuse the requirements for stormwater treatment with the need to control and dispose of extreme storm flows.

Vegetative Cover. The BI swale and associated side slopes should be vegetated. The species selected may vary to include both water-oriented native and non-native/domestic species. Trees and brushy buffer strips may also be used to slow water velocities and enhance infiltration. Non-native/domestic species should not be allowed to grow more than 3 inches in height when finally established. Water-oriented native species may be allowed to grow to its maximum un-mowed height to achieve the goals of both stormwater cleansing and those of the proposed landscape development component of the project.

If sod is chosen to vegetate the swale, select sod that has been grown in permeable soils. Sod grown in clay soils will not be effective because the clay soil can restrict water infiltration reducing the expected infiltration rate of the system. If sod grown in clay soils is the only sod available, ask the grower to wash off the soil from the sod to remove all clay material.

Construction Guidelines

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

Specifications for swale construction should state the earliest point in construction progress when storm drainage may be directed to the swales. Due to the wide variety of conditions encountered among projects, each should be separately evaluated in order to postpone use as long as reasonably possible.

The final phase of excavation should remove all accumulated sediment. Light, tracked equipment is recommended for this operation to avoid compaction of the swale floor.

Maintaining adequate infiltration rates is critical to the function of the grassed swale. An option to maintain infiltration rates is to over excavate the swale and fill with permeable soils (see design infiltration rates). After the final grading is completed, the swale floor should be scarified to provide a well-aerated, highly porous surface texture.

Soils imported for landscape development need to be properly incorporated into existing soils. This may include tilling the soils to a depth of 6 inches for optimal blending.

Infiltration Test. A double ring infiltrometer test (ASTM D5126) should be conducted (a local option) after final grading, and the determined rate of infiltration should be at a minimum 0.5 inches per hour. The maximum allowable rate is 3.0 inches per hour, unless it can be shown that a satisfactory vegetative cover can be maintained without excessive irrigation. Testing may be required by the local permitting agency to ensure infiltration rates are within the required range. Should the swale not meet the minimum infiltration rate of 0.5 inches per hour, more permeable material should be brought in and incorporated or replace the first 6 to 10 inches of the existing material and the infiltration test redone. If the soil cannot be treated to reach the minimum infiltration rate, an alternative design should be made.

Small-scale infiltration tests, such as a double ring infiltrometer, may not adequately measure variability of conditions in test areas and, if used, measurements should be taken at several locations within the area of interest. Soil pit excavation may still be necessary if highly variable soil conditions or seasonal high water tables are suspected. A pilot infiltration test or small-scale test infiltration pits may also be necessary for large facilities or to verify design infiltration rates for the local jurisdiction. If the infiltration rates are less than what was used for the system design, the system shall be reconditioned or redesigned to match the design infiltration rate.

Erosion and Sediment Control. A healthy stand of broad leaf grass should be established on the swale floor and slopes. This vegetation will prevent erosion and sloughing and will also provide a natural means of maintaining infiltration rates and removing pollution. Erosion protection of inflow points to the basin should also be provided (e.g., riprap, flow spreaders, energy dissipaters). 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.

Maintenance

Goal. To ensure that the BI swale operates as designed by maintaining the infiltration and treatment capabilities of the physical and biological portions of the system.

Access. Provide enough access space for maintenance activities. Check with local permitting authority to determine if a dedicated maintenance easement is required for the BI swale.

Inspection. When BI swales are first placed into use, they should be inspected on a monthly basis and after large storm events. During the period October 15 though April 15, inspections should be conducted monthly. Thereafter, once it is determined that the basin is functioning in a satisfactory manner and there are no potential sediment problems, inspections can be reduced to a semi-annual basis with additional inspections following the occurrence of a large storm. Inspectors should check for functional inlet, erosion, condition of vegetation, ponded water, disposal of other waste in the swale or dry well, and conformance with original design.

Sediment Control. The BI swale should be designed with maintenance in mind. Access should be provided for vehicles to easily maintain the BI swale. Grass bottoms in BI swales 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 swale floor will grow up through sediment deposits forming a porous turf and preventing the formation of an impenetrable layer. Grass planted on swale side slopes will prevent erosion.

Vegetation Maintenance. Maintenance of vegetation established on the BI swale floor and side slopes is necessary in order to promote dense turf with extensive root growth to enhance infiltration, prevent erosion and consequent sedimentation, and prevent invasive weed growth. Bare spots should be immediately stabilized and re-vegetated.

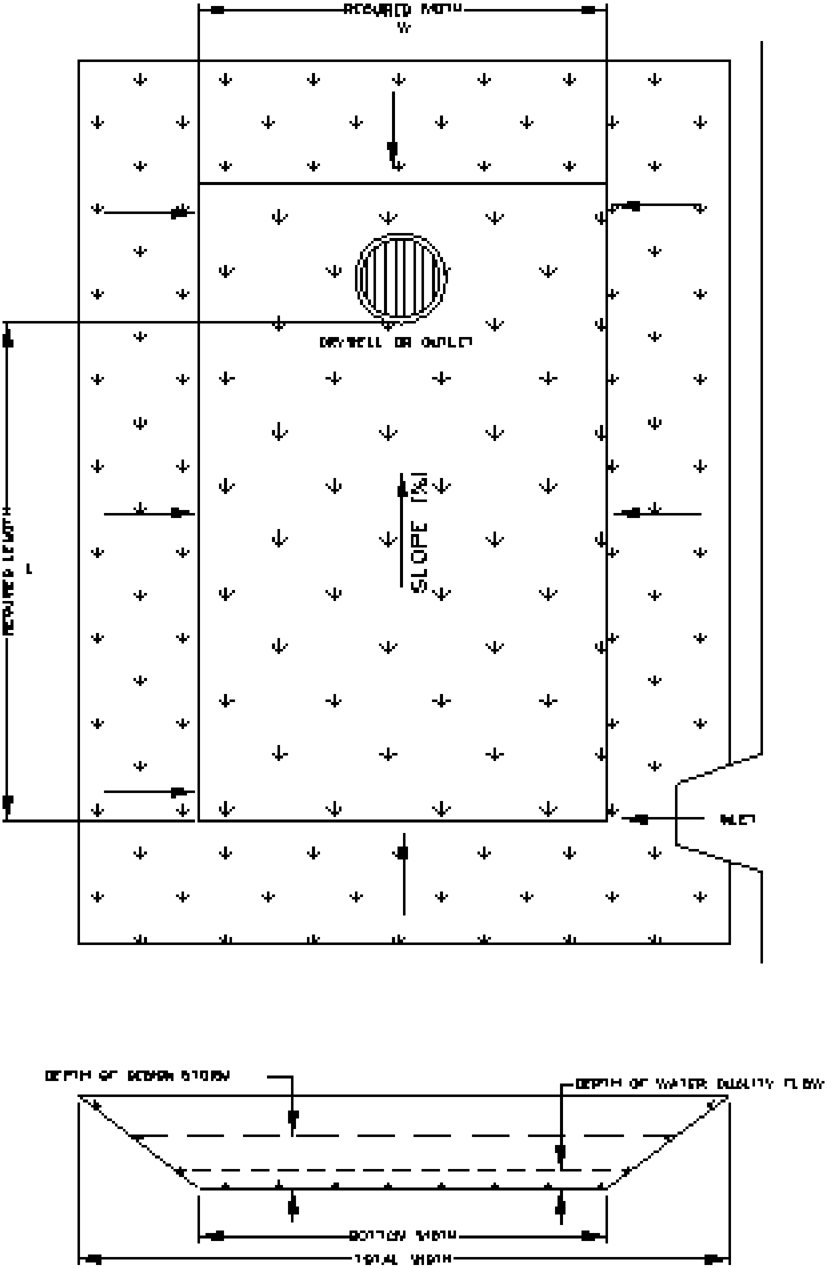
If the intent of the finished look of the BI swale is that of maintained turf grass, mowing at regular intervals will be required to keep the grass at 3 inches or less in height. Clippings should be collected as they contribute to a decline in BI swale porosity. If the intent of the finished look of the BI swale is more natural through the use of native plants, regular mowing will not be necessary. However, at the end of the growing season native grasses should be cut to a height of 3 inches, collected, and removed to maintain an optimal level of BI swale porosity. Fertilizers should be applied only as necessary and in limited amounts to avoid contributing to the pollution problems that the swale is intended to solve. Excessive irrigation should be avoided as saturated soils have a lower infiltration capacity than dry soils, and the intent of the swale is to infiltrate water from the drainage area.

Additional Information

This swale BMP for the Rathdrum Prairie Aquifer was created by a Technical Advisory Committee (TAC) convened in June 2000. The BMP was completed in December 2000 for inclusion into the *Catalog of Best Management Practices for Idaho Cities and Counties*. Revised: April 2004.

DEQ would like to acknowledge and thank the following individuals for serving on the TAC: Gordon Dobler, City of Coeur d'Alene; Stan Miller, Spokane County; Mike Hartz, ITD; Bill Melvin and Rob Palus, Post Falls; Ed Hale, Rick Barlow and Annette Duerock, PHD; Paul Klatt and Rob Wright, J-U-B; Dave LePard, IDWR; Jack Smetana, Frame & Smetana; Rand Wichman and Shireene Hale, Kootenai County; Jon Mueller, Hatchmueller Consultants; Gary Gaffney, June Bergquist, Brian Painter (Chair) and Dan Remmick, DEQ. In addition, DEQ would like to thank Calvin Terrada, EPA; Mark Slifka, Bob Haynes and Mike Piechowski, IDWR; and David Karsann, ITD for attending

the first meeting to help decide the need for a Technical Advisory Committee.



TRAPEZOIDAL CROSS SECTION

Figure 1 - Example of a grassed infiltration area showing characteristics used in design equations.

Vegetative Filter Strip — BMP 3

Description

A vegetative filter strip is a band of vegetation located between a pollutant source (such as a parking lot) and a stream, pond, or wetland. The key to a successfully functioning filter strip is the use of dense vegetation (typically grass) and allowing only overland sheet flow to cross the strip while avoiding concentrated flows.

Applications

A vegetative filter strip is designed to provide runoff treatment of conventional pollutants but not nutrients. 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, and the filter strip would likely be prohibitively large for this application.

Vegetative filter strips can be effective at pre-treating runoff to protect filtration BMPs from siltation. It may also be a viable treatment measure for small, less intensely developed sites. The maximum recommended drainage area for a vegetative filter strip is 5 acres.

Vegetative filter strips should not receive concentrated flow discharges as their effectiveness will be destroyed, and the potential for erosion could cause filter strips to become sources of pollution.

Vegetative filter strips should not be used on slopes greater than 10% 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%; it simply means that effective treatment of runoff is unlikely for slopes greater than 10%. 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 measure.

Limitations

Drainage area – 5 ac.
Minimum bedrock depth – 5 ft
NRCS soil type – B, C, D
Drainage/flood control – no
Max slope – 14%
Minimum water table – 3 ft
Freeze/thaw – fair

Targeted Pollutants

Sediment – 50%
Phosphorus – 50%
Heavy metals
Hydrocarbons

Design Parameters

Criteria have been developed 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.

General Criteria
See BMP 2 —Bioinfiltration Swale.

Specific Criteria for Vegetative Filter Strips

- Design vegetative filter strips according to the same method detailed for vegetated swales (BMP 1). Calculate the necessary filter strip width (perpendicular to flow) on the basis of the water quality design storm (1/3 the volume) and a hydraulic radius approximately equal to the design flow depth. Note: The design flow depth will normally be no more than 0.5 inches because of the need to maintain sheet flow over the strip.
- Calculate the necessary length (parallel to flow) to produce a water residence time of at least 20 minutes and a velocity of 0.5 feet per second (fps) or less. The length should normally be in the range of 100 to 200 feet.
- 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.
- Vegetative filter strips should not normally be used for slopes in excess of 10%, and preferably less, because of the difficulty in maintaining the necessary sheet flow conditions.
- The flow length of the area draining to the filter strip should be 75 feet or less for impervious surfaces and 150 feet or less for pervious areas.
- If necessary, filter strips should be fenced to keep vehicles, pedestrians, and animals out.

Construction Guidelines

See BMP 2 —Biofiltration Swale.

Maintenance

See BMP 2 —Biofiltration Swale.

Sand Filter BMP 4

Description

Sand filters are devices that filter stormwater runoff through a sand layer into an underdrain system that conveys the treated runoff to a detention facility or to the ultimate point of discharge. The sand-bed filtration system consists of an inlet structure, sedimentation chamber, sand bed, underdrain piping, and liner to protect against infiltration.

There are several variations of sand filters, including the sand filtration trench (also referred to as a sand filter inlet) and the sand filtration basin, both of which are discussed in this fact sheet.

Applications

In general, sand filters take up little space and can be used on highly developed sites and sites with steep slopes. They can be added to retrofit existing sites. This BMP is not recommended where high sediment loads are expected, unless pretreatment (e.g., sedimentation) is provided, since the fine sediment clogs sand filters, or where the runoff is likely to contain high concentrations of toxic pollutants (e.g., heavy industrial sites).

- Sand filtration trenches are generally used for smaller drainage areas than sand filtration basins. A typical use of a trench is along the perimeter of a parking lot. Trenches have experienced fewer problems with clogging than basins, perhaps because their use in the field has been limited more to high-impervious cover sites that may generate less suspended solids.
- Sand filters rely on physical straining, pollutant settling and pollutant adsorption to remove pollutants. They are very effective at removing total suspended solids with moderate removal for total phosphorus.
- Depending on agency approval, sand filtration may substitute for API and CPS-type oil/water separators to remove oil from runoff.
- To improve the effectiveness of sand filtration basins and to protect the media from clogging, basins should be located off-line from the primary conveyance/detention system and should be preceded by a pretreatment BMP.
- Disturbed areas that are sediment sources in the contributing drainage area should be identified and stabilized to the maximum extent practicable. Smaller filters, such as a sand filtrations trench in a parking lot, can be installed on-line.
- Because of the potential for clogging, sand filtration BMPs should never be used as sediment basins during construction.
- In areas with high water table conditions and the possibility of ground-water contamination liners are recommended for trenches and basins.

Limitations	Drainage area – 5 ac. inlets; 50 ac. basins Minimum bedrock depth – 3 ft NRCS soil type – NA Drainage/flood control – yes	Max site slope – 10% Minimum water table – 3 ft Freeze/thaw – fair

Targeted Pollutants

Sediment – 85%
Phosphorus – 65%
Trace metals
Bacteria
Hydrocarbons

Design Parameters

Off-Line Isolation/Diversion Structure:
By locating sand filtration systems off-line from the primary conveyance/detention system, the long-term effectiveness of the treatment system can be maintained. Off-line systems are designed to capture and treat the locally specified design storm; this is typically achieved by using isolation/diversion baffles and weirs. A typical approach for achieving isolation of the water quality volume is to construct an isolation/diversion weir in the stormwater channel such that the height of the weir equals the maximum height of water in the filtration basin during the water quality design storm. When additional runoff greater than the water quality storm enters the stormwater channel, it will spill over the isolation/diversion weir; mixing with the already-isolated water quality volume will be minimal.

Sizing Sand Filtration BMPs
The Darcy's Law method for sizing the BMP should be used:

$$Q = (f)(i)(As)$$

Where:
Q = flowrate at which runoff is filtrated
f = infiltration rate of sand
i = hydraulic gradient
As = surface area of the filtration bed

Conservative values of "f" should be used. For infiltration BMPs, a factor of safety of two should be applied to the infiltration rate determined from the textural analysis, and, hereafter, the design infiltration rate will be labeled "fd" where fd = 0.5 * f. For sand infiltration BMPs, a "fd" value of about 2 inches per hour is recommended for design purposes. This appears to be a low value but reflects actual rates achieved by operating sand infiltration systems treating urban runoff.

The hydraulic gradient is given by the equation:

$$i = \frac{h + L}{L}$$

Where h is the height of the water column over the top of the sand bed and L is the thickness of the sand bed (typically 18 inches).

A conservative value for the filtration rate (f) should be used. Design filtration rates of about 2 inches per hour are used in Austin, Texas, which are much lower than published values for sand but reflect actual field permeability rates. The lower rates reflect the effects of suspended solids and sediment on the sand's permeability.

Drawdown Time (basins)
Sand filtration basins are to be designed to completely empty in 24 hours or less.

Inlet Structure
The inlet structure to the sand filter should spread the flow uniformly across the surface of the filter media. Flow spreaders, weirs, or multiple-orifice openings are recommended. Stone riprap or other dissipation devices should be installed to prevent gouging of the sand media and to promote uniform flow.

Sand Bed
A sand bed depth of 18 inches is recommended. This is the final bed depth; consolidation of the sand is likely during construction.
Two sand bed configurations can be selected from; one with a gravel layer and the other a trench design which utilizes drainage matting as a substitute for the gravel layer. The top surface layer should be level so that equal distribution of runoff will be achieved in the basin.

1. Sand Bed with Gravel Layer
The top layer is to be a minimum of 18 inches of 0.02-0.04 inch diameter sand (smaller sand size is acceptable). Under the sand should be a layer of 0.5 to 2 inch diameter gravel that provides a minimum of 2 inches of cover over the top of the underdrain lateral pipes. No gravel is required under the lateral pipes. The sand and gravel should be separated by a layer of geotextile fabric
2. Sand Bed with Trench Design
This configuration can be used on flatter sites that may restrict the applicability of the previous design. The top layer should be 12 to 18 inches of 0.02-0.04 inch diameter sand (smaller sand size is acceptable). Laterals should be placed in trenches with a covering of 0.5 to 2 inch gravel and geotextile fabric. The lateral pipes should be underlain by a layer of drainage matting. The geotextile fabric is needed to prevent the filter media from infiltrating into the lateral piping. The drainage matting is needed to provide adequate hydraulic conductivity to the laterals.

Sand Filtration Liners
Liners for sand filters are recommended in areas with drinking water aquifers and should meet the specifications below.
- Impermeable liners may be clay, concrete, or geomembrane.
- The clay liner should have a minimum thickness of 12 inches.
- If a geomembrane liner is used instead of clay, it should have a minimum thickness of 30 mils and be ultraviolet resistant. The geomembrane should be protected from puncture, tearing, and abrasion by installing geotextile fabric on the top and bottom of the geomembrane. The local permitting

authority may consider equivalent methods for protection of the geomembrane liner.

- Concrete liners may also be used for sedimentation chambers and for sedimentation and filtration basins less than 1,000 square feet in area. Concrete should be 5 inches thick Class A or better and should be reinforced by steel wire mesh. Adding fiberglass fibers to the mix (3 pounds per cubic yard) will decrease risk of cracking. The steel wire mesh should be 6-gauge wire or larger and 6 inch x 6 inch mesh or smaller. An "ordinary surface finish" is required. When the underlying soil is clay or has an unconfined compressive strength of 0.25 tons per square foot or less, the concrete should have a minimum 6-inch compacted aggregate base consisting of coarse sand and river stone, crushed stone, or equivalent with diameter of 0.75 to 1 inch. Where visible, the concrete should be inspected annually and all cracks should be sealed.

Underdrain Piping

The underdrain piping consists of the main collector pipe(s) and perforated lateral branch pipes. The piping should be reinforced to withstand the weight of the overburden. Internal diameters of lateral branch pipes should be 4 inches or greater and perforations should be 3/8 inch. All piping is to be schedule 40 polyvinyl chloride or greater strength. A maximum spacing of 10 feet between laterals is recommended. Lesser spacings are acceptable. The maximum spacing between rows of perforations should not exceed 6 inches.

The minimum grade of piping should be 1/8 inch per foot (1% slope). Access for cleaning all underdrain piping is needed; this can be provided by installing cleanout ports that tee into the underdrain system and surface above the top of the sand filtration media.

Pretreatment for Sand Filters

It is recommended that a presettling basin and/or vegetated swale be used to pretreat runoff discharging to the sand filter. If a presettling basin is used for pretreatment, careful attention should be given to designing the inlet and outlet structures. The presettling basin consists of an inlet structure, outlet structure, and basin liner if permeable soils underlay the basin. The presettling basin design should maximize the distance between the locations where the heavier sediment is deposited near the inlet to where the outlet structure is located. This will improve basin performance and reduce maintenance requirements.

Inlet Structure

The inlet structure design should be adequate for isolating the water quality volume from the larger design storms and to convey the peak flows for the larger design storms past the basin. The water quality volume should be discharged uniformly and at low velocity into the presettling basin in order to maintain near quiescent conditions that are necessary for effective treatment. It is desirable for the heavier suspended material to drop out near the front of the basin; thus, a drop inlet structure is recommended in order to facilitate sediment removal and maintenance. Energy dissipation devices may be necessary in order to reduce inlet velocities which exceed three 3 feet per second.

Outlet Structure
The outlet structure conveys the water quality volume from the presettling basin to the filtration basin. The outlet structure should be designed to provide for a residence time of 24 hours for the 6-month, 24-hour storm. The residence time should be achieved by installing a throttle plate or other flow control device at the end of the riser pipe (the discharges through the perforations should not be used for drawdown time design purposes).

A trash rack should be provided for the outlet. Openings in the rack should not exceed one-half the diameter of the vertical riser pipe. The rack should be made of durable material, resistant to rust and ultraviolet rays. The bottom rows of perforations of the riser pipe should be protected from clogging. To prevent clogging of the bottom perforations it is recommended that geotextile be wrapped over the pipe's bottom rows and that a cone of 1- to 3inch diameter gravel be placed around the pipe. If a geotextile fabric wrap is not used then the gravel cone should not include any gravel small enough to enter the riser pipe perforations.

Basin Liner
The pretreatment BMP may need to have a basin liner to prevent runoff from being lost to soil infiltration prior to treatment by the filtration basin.

Observation Well
An observation well should be installed every 50 feet of BMP 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.

The observation well should consist of perforated PVC pipe, 2 to 4 inches in diameter. It should be located in the center of the structure and be constructed flush with the ground elevation of the trench. The top of the well should be capped to discourage vandalism and tampering. More specific construction information can be obtained by contacting Idaho Department of Water Resources (IDWR) or DEQ.

Sand Filters for Oil Removal
If a sand filtration basin is used as a substitute for an API- or CPS-type oil/water separator, then pretreatment may not be necessary if the contributing drainage area is small and completely impervious (the restrictions which apply to oil/water separators will also apply to sand filtration basins in this case).

Construction Guidelines

- The final sand bed depth should be 18 inches; consolidation of sand will likely occur during installation and this should be taken into account. The sand should be periodically wetted, allowed to consolidate, and then extra sand added. Repeat this procedure until the bed depth has stabilized at 18 inches.

- Provisions should be made for access to the basin for maintenance purposes. A maintenance vehicle access ramp is necessary. The slope of the ramp should not exceed 4:1.
- The design should minimize susceptibility to vandalism by use of strong materials for exposed piping and accessories.
- Side slopes for earthen embankments should not exceed 3:1 to facilitate mowing.
- No runoff is to enter the sand filtration basin prior to completion of construction and site revegetation.

Maintenance

Follow the guidelines below for inspection and maintenance of sand filters.

Inspection Schedule:

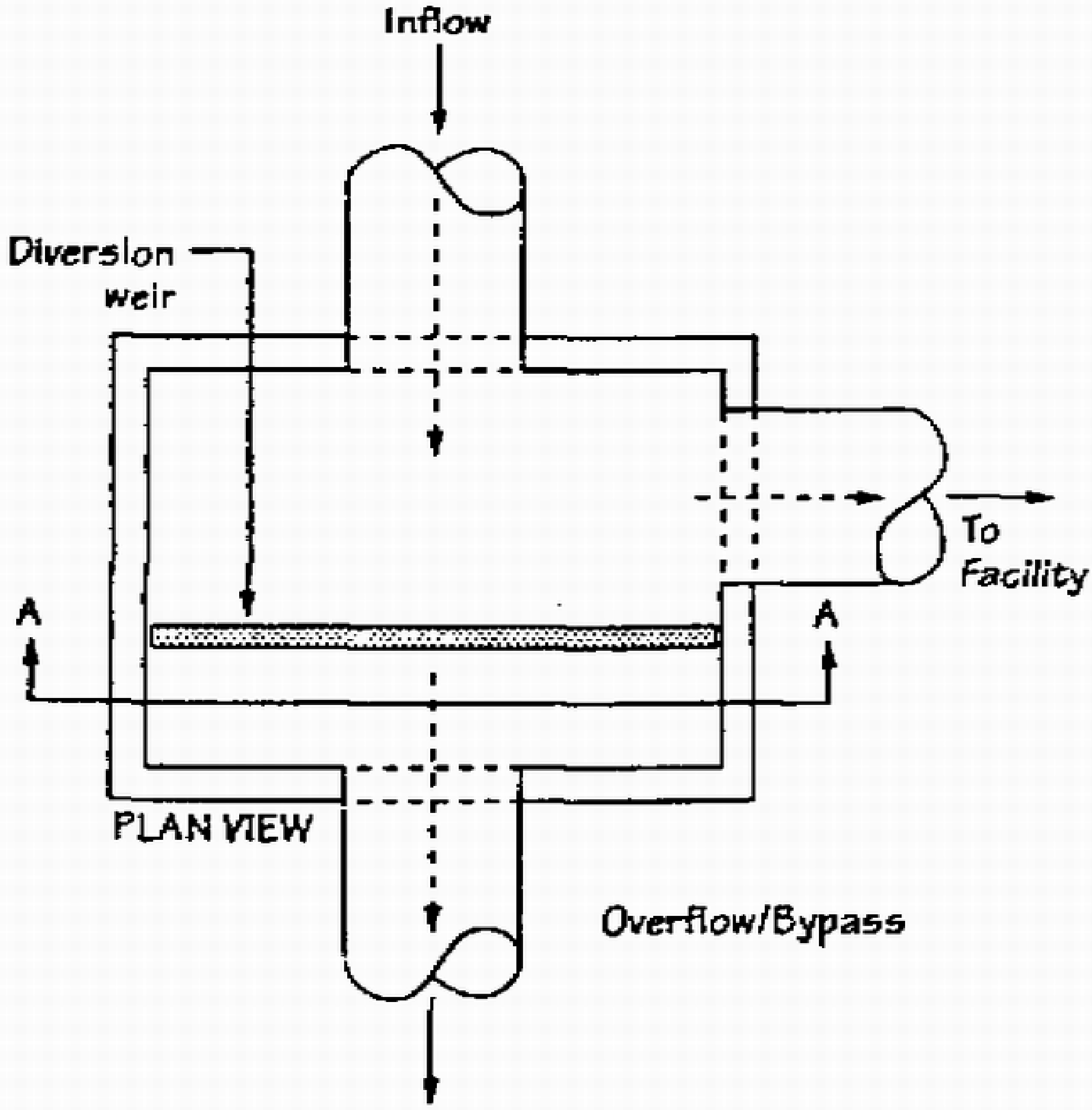
Inspect the sand filters at least annually. Additionally, the observation well in a filtration trench should be monitored for water quality periodically. For the first year after completion of construction, the well should be monitored after every large storm (greater than 1 inch in 24 hours), and during the period from October 1 to March 31, inspections should be conducted monthly. From April 1 through September 30, the facility should be monitored on a quarterly basis. A logbook should 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 and Debris Removal:

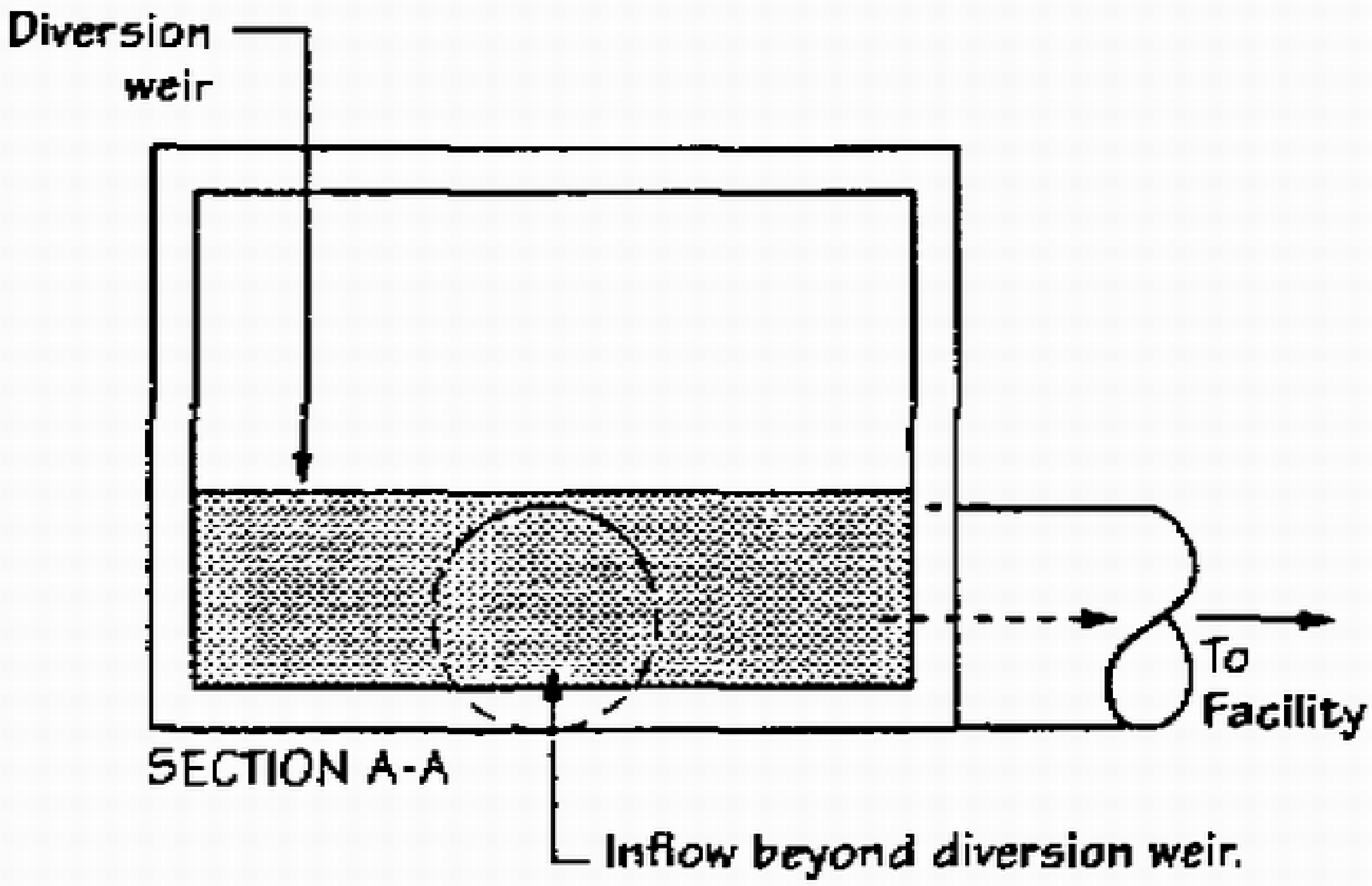
Sediment buildup in the top foot of stone aggregate or the surface inlet should be monitored on the same schedule as the observation well. A monitoring well in the top foot of stone aggregate should be required when the trench has a stone surface. Sediment deposits should not be allowed to build up to the point where they will reduce the rate of infiltration into the device. As a rule of thumb, remove silt when accumulation exceeds 0.5 inch. Remove accumulated paper, trash and debris every 6 months or as necessary.

Sand Media Rehabilitation and Replacement:

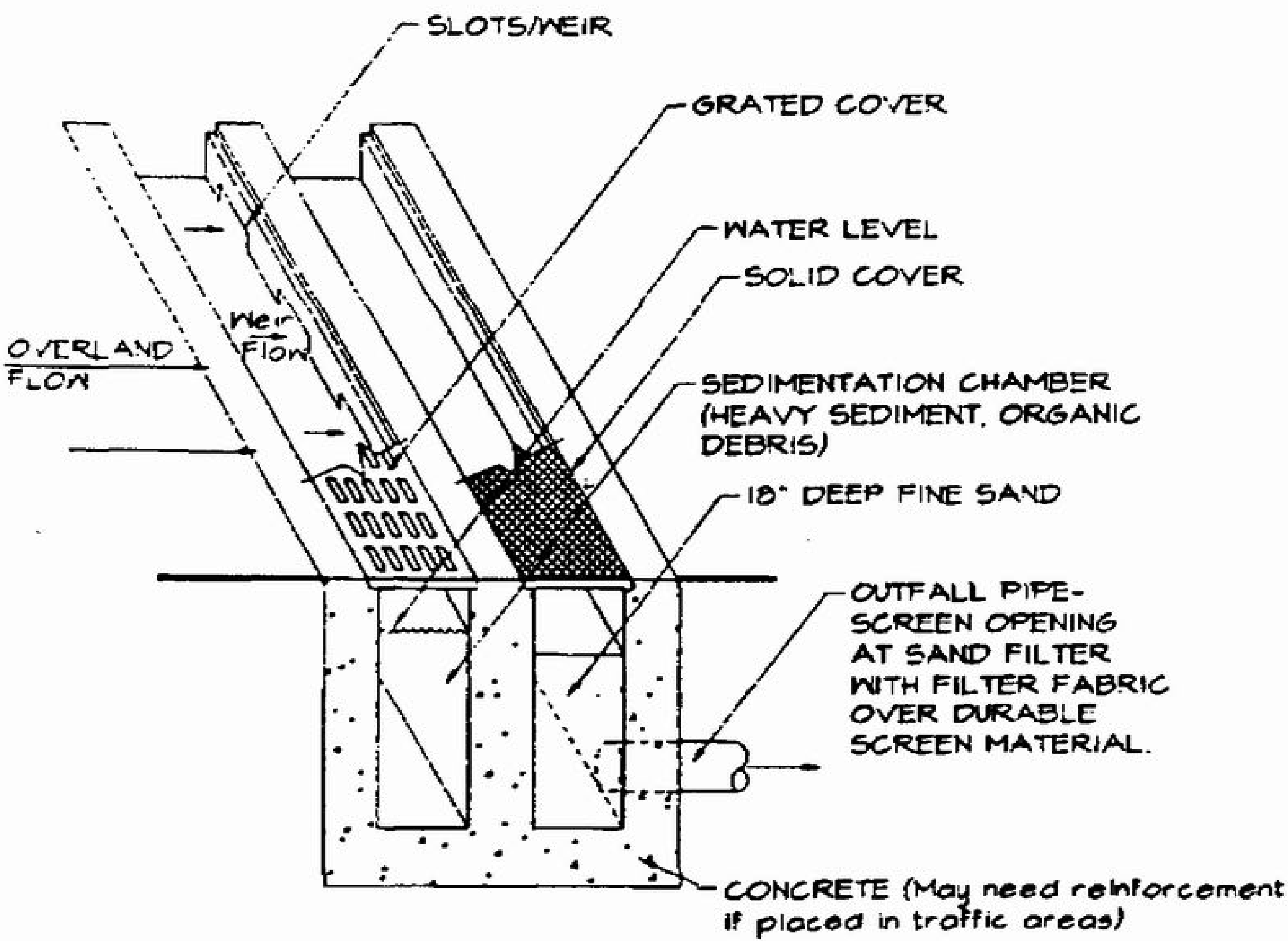
Over time, a layer of sediment will build up on top of the filtration media that can inhibit the percolation of runoff. Experience has shown that this sediment can be readily scraped off during dry periods with steel rakes or other devices. Once sediment is removed, the design permeability of the filtration media can typically be restored by then striating the surface layer of the media. Eventually, however, finer sediments that have penetrated deeper into the filtration media will reduce the permeability to unacceptable levels, thus necessitating replacement of some or all of the sand. The frequency in which the sand media should be replaced is not well established and will depend on the suspended solids levels entering the system. Drainage areas that have disturbed areas containing clay soils will likely necessitate more frequent replacement. Properly designed and maintained sand filtration BMPs in arid climates, have functioned effectively, without complete replacement of the sand media, for at least 5 years and should have design lives of 10 to 20 years.



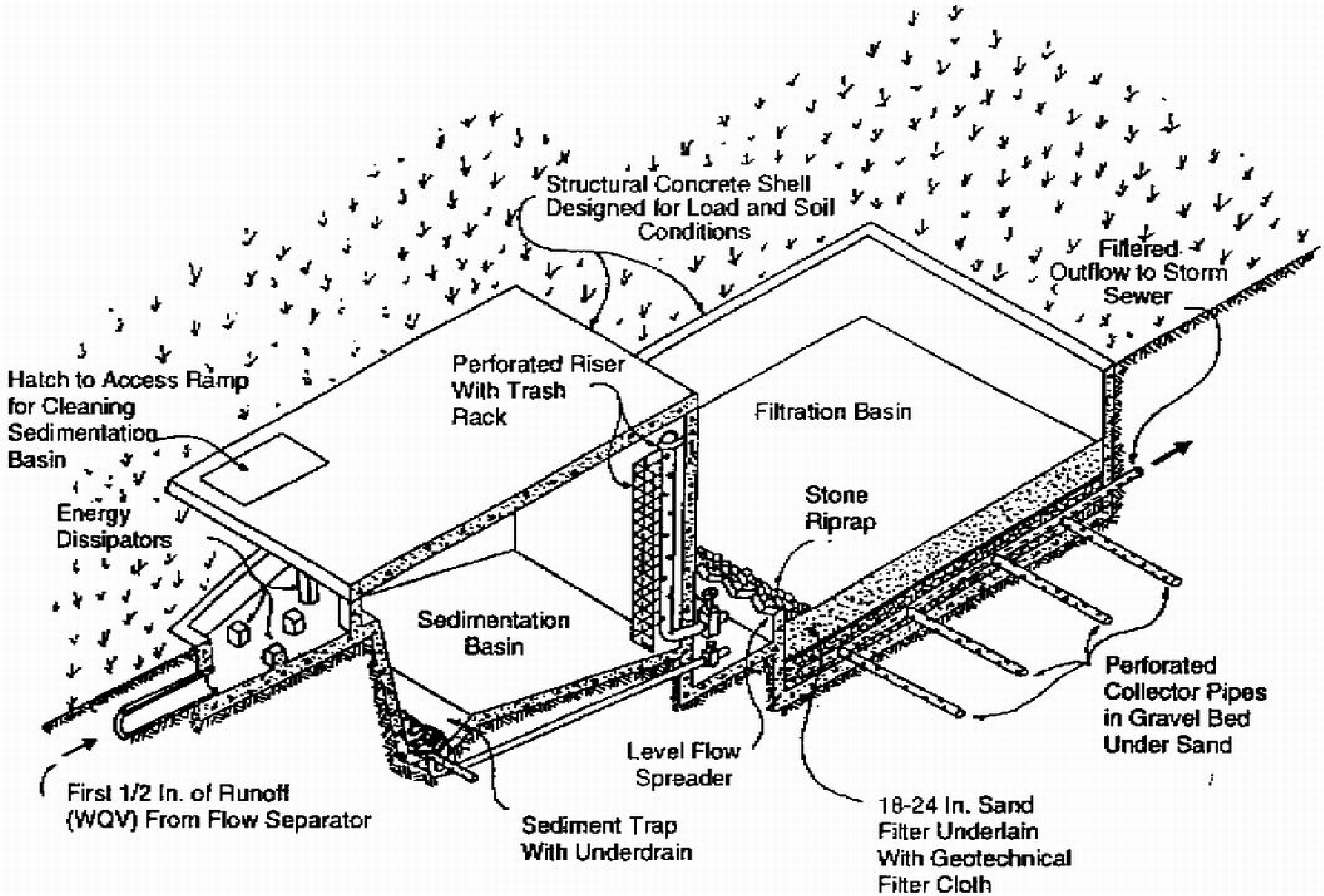
Inflow
Diversion weir
A
A
To Facility
PLAN VIEW
Overflow/Bypass



Diversion weir
To Facility
SECTION A-A
Inflow beyond diversion weir.



SLOTS/WEIR
GRATED COVER
WATER LEVEL
SOLID COVER
OVERLAND FLOW
Weir Flow
SEDIMENTATION CHAMBER (HEAVY SEDIMENT, ORGANIC DEBRIS)
18" DEEP FINE SAND
OUTFALL PIPE- SCREEN OPENING AT SAND FILTER WITH FILTER FABRIC OVER DURABLE SCREEN MATERIAL.
CONCRETE (May need reinforcement if placed in traffic areas)


Structural Concrete Shell Designed for Load and Soil Conditions
Filtered Outflow to Storm Sewer
Hatch to Access Ramp for Cleaning Sedimentation Basin
Perforated Riser With Trash Rack
Filtration Basin
Energy Dissipators
Stone Riprap
Sedimentation Basin
Perforated Collector Pipes in Gravel Bed Under Sand
Level Flow Spreader
First 1/2 In. of Runoff (WQV) From Flow Separator
Sediment Trap With Underdrain
18-24 In. Sand Filter Underlain With Geotechnical Filter Cloth

Compost Stormwater Filter — BMP 5

Description

Compost stormwater filters (CSFs), work by percolating stormwater through compost, which traps particulates and adsorbs dissolved materials such as metals and nutrients. Floating surface scums along with oil and grease are also removed. After filtering through the compost media, the filtered water is channeled into a collection pipe or discharges to an open channel drainageway.

Compost filters act as mechanical filters to remove fine sediments, as ion exchangers to remove solubilized ionic pollutants such as metals, as molecular absorption sites to remove organics, and provide biological substrate to aid in microbial degradation of organic compounds such as oil and grease. Compost filters are not intended for use as stormwater detention systems.

There are two main configurations for compost filters. The larger, stand-alone unit (open) is set into the surrounding soil and stormwater flows are routed across its surface, where infiltration occurs. The smaller unit, constructed from standard size precast concrete vaults (drop-in), is installed in-line with tight line (non-perforated) storm drains. Maintenance proved to be problematic with the open unit; therefore, only drop-in units are included in this BMP for possible use in Idaho.

As with other filtration systems, including sand and peat filters, sediments will accumulate on the filter surface, thus slowing the infiltration capacity of the filter. To reduce sediment loading, the compost filters are designed with sediment forebays and upstream sediment trapping facilities such as trapped catch basins and sedimentation manholes.

Limitations

Drainage area – 1 ac.
Minimum bedrock depth - N/A
NRCS soil type – N/A
Drainage/flood control – no
Max slope – N/A
Minimum water table – N/A
Freeze/thaw – fair

Targeted Pollutants

Sediment-95%
Phosphorus- 45%
Trace Metals
Bacteria
Hydrocarbons

Removal Efficiencies

The CSF has been shown to consistently remove in excess of 85% of the oil and grease entering the filter and 82% of the heavy metals. Phosphorus removal rates vary greatly according to the loadings. In general, data shows good performance with total phosphorus but poor performance with dissolved (soluble) phosphorus. For total phosphorus, the CSF performs best during the first flush flows when total phosphorus loading rates are their highest, yielding removal efficiencies as high as 77%. Based on 2 years of data, the overall total phosphorus removal rate was approximately 40% (plus or minus 10%). For soluble phosphorus, study data show that compost filters actually release soluble phosphorus, rather than absorb it. For this reason, they are not recommended in areas with a phosphorus problem.

Design Parameters

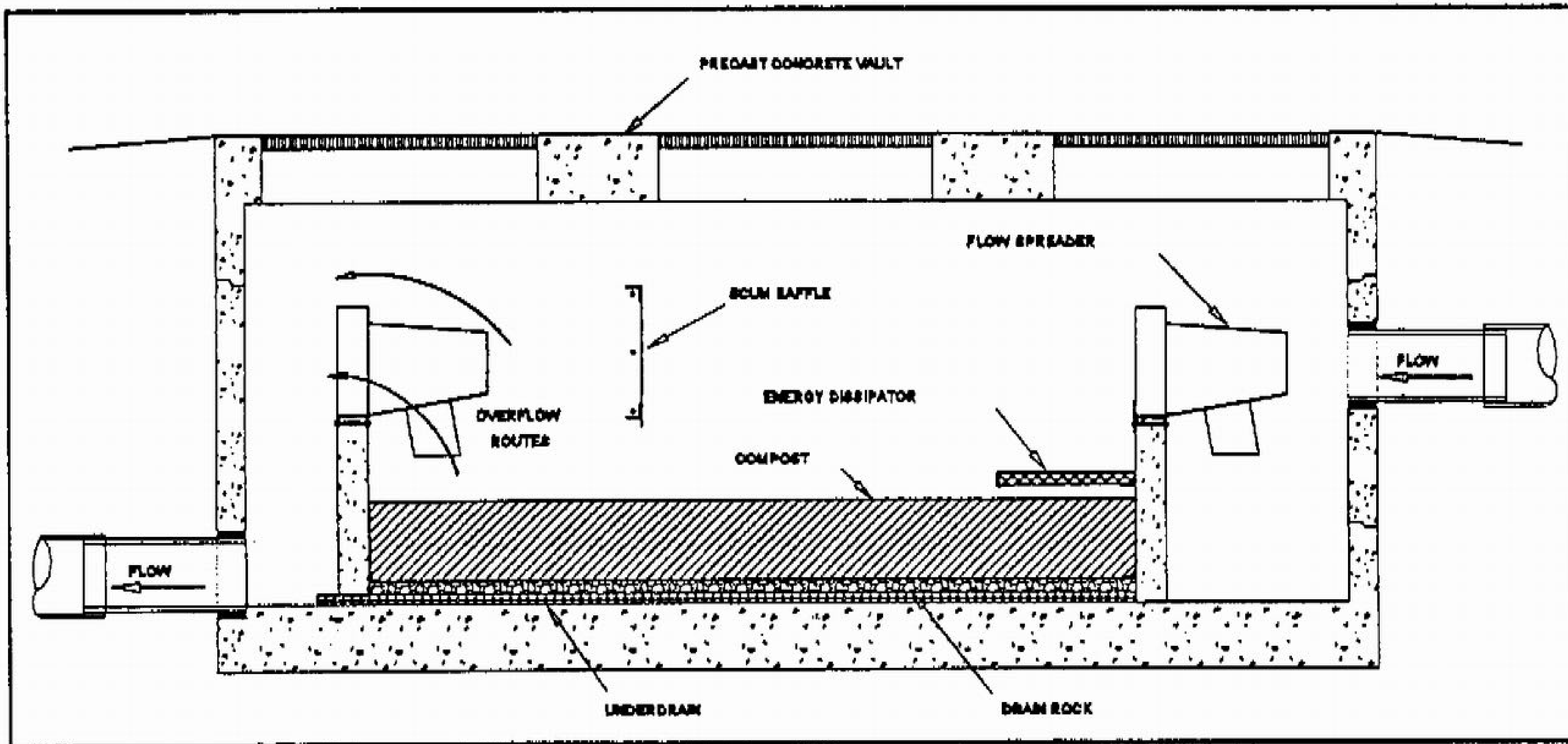
Both the open and drop-in units are designed with overflows. Overflows operate when the inflow rate is greater than the filtration capacity. The flow capacity of the filter is exceeded when the flow into the filter exceeds the design level or sediment accumulation has reduced the filter's infiltration capacity.

The drop-in unit requires a minimum distance of 2.2 feet between the elevation inverts of the inlet and outlet pipes. In addition, there should be at least 2.5 feet between the elevation invert of the inlet pipe and the top of the drop-in unit. Drop-in units can be specified with traffic bearing lids to enable them to be installed directly into a paved area.

Maintenance

Compost filters are a relatively new technology (about 3 years), and precise maintenance procedures are still being refined. The drop-in filters are sized for an annual maintenance that involves replacing the compost and cleaning out the sediment from the inlet bay. The sediment in the inlet bay is removed and disposed of in a manner similar to street catch basin maintenance.

The inclusion of the CSF system in this guidance manual is merely to illustrate different forms of media filtration for stormwater and does not in any way constitute a product endorsement.



Drop-In Unit - Compost Stormwater Filter Schematic
U.S. Patent No. 5,322,629

Catch Basin Inserts BMP 6

Description

Catch basin inserts are devices installed under a storm-drain grate that provide water quality treatment through filtration, settling, or adsorption. Catch basin inserts are commercially available products and are generally configured to remove one or more of the following contaminants: coarse sediment, oil and grease, and litter and debris. Units should be routinely maintained to achieve maximum removal efficiency. Maintenance frequency will vary depending on the amount and type of pollutant targeted.

Applications

Studies performed by King County, WA, have found catch basin inserts to be nominally effective at removing fine (silt and clay) sediment and associated pollutants. Inserts were successful in capturing coarse material and debris. Hydrocarbons. Product removal efficiencies for inserts in good condition ranged from 20 to 90% when exposed to oil concentrations near the high end for urban runoff, and performance dropped off rapidly with use. Possible locations for catch-basin insert implementation include parking lots, gas stations, golf courses, streets, driveways, industrial or commercial facilities, and municipal corporation yards.

Limitations

Drainage area – 5000 square feet
Minimum bedrock depth - N/A
NRCS soil type – N/A
Drainage/flood control – no
Max slope – unlimited
Minimum water table – N/A
Freeze/thaw – fair

The greatest difficulties facing those implementing catch-basin inserts for stormwater treatment lie in the small space inside the catch basin, the tendency for sediments to clog or blind filter media, and the fluctuating nature of the flow. Catch-basin inserts are very maintenance-intensive. Check with the parties that will be required to maintain these systems prior to design and installation. The problems may be compounded from street sanding and other activities.

Targeted Pollutants

Sediment – 35%
Phosphorus – 5%
Trace metals
Hydrocarbons

Design Parameters

The catch-basin insert should meet the following criteria:

- The total maximum tributary area should be 5,000 square feet (+ 5%) per unit for new development projects and 7, 000 feet per unit for redevelopment projects.
- A catch-basin insert for a new development project should be designed to fit with a standard grate. If the insert is installed in an existing catch basin, the insert should be demonstrated to fit properly so that there is a positive

seal around the grate to prevent low-flow bypass. The maximum height of the grate above the top of the frame, with the insert installed, should not exceed 3/16 inch, and the grate should be non-rocking.

- The bottom of the filter media (oil absorbent/absorbent material) should be above the level of normal low flows. If the media is above the crown of the outlet pipe, it is assumed to be above the normal low flows. An alternative method to demonstrate that the media is above the normal low flow is to show (by backwater analysis method) that the bottom of the media is above the water surface elevation corresponding to the water quality design flow.
- The catch basin insert should be located to be accessible as needed for maintenance and not limited by continuous vehicle parking. This may require elimination of a parking stall for redevelopment projects.
- While no pretreatment is required with a catch-basin insert, the use of source control BMPs on the site will decrease maintenance needs.

Construction Guidelines

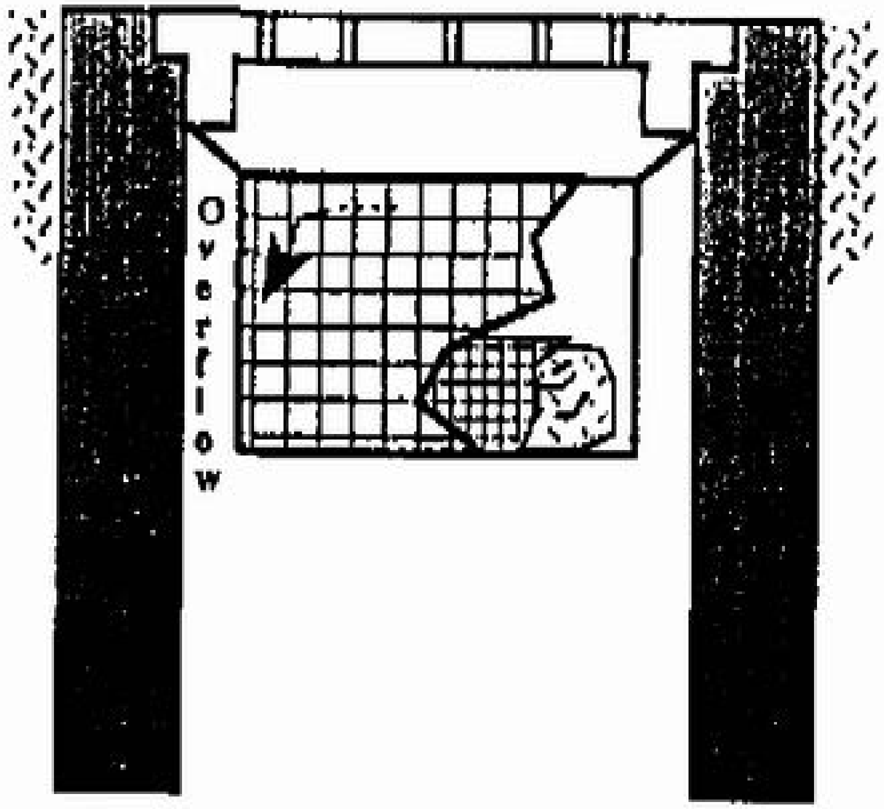
Installation of a catch-basin insert for a new or redevelopment project should follow the manufacturer's recommended procedures. The catch-basin insert should be installed in the catch basin after the site has been paved or stabilized (for new development) or after completion of construction (for a redevelopment site that is already paved).

If the catch-basin insert is used for sediment control during construction, it should be reconfigured in accordance with the manufacturer's recommendations. When used for sediment control, the insert should be inspected at least weekly and maintained if needed.

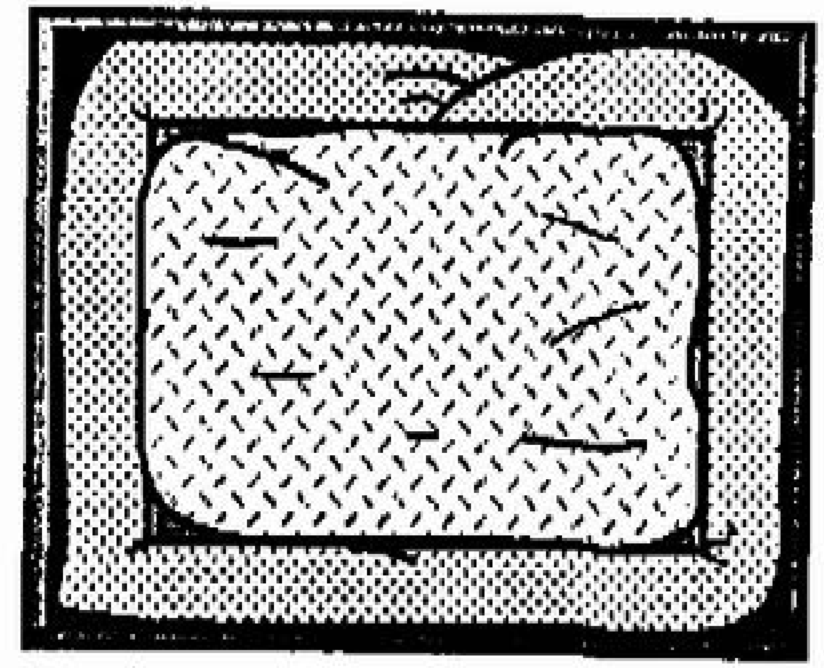
To minimize the generation of solid waste and the consumption of natural resources, systems constructed of or using recycled products are preferred. Reusable filter materials should be refreshed according to the manufacturer's instructions.

Maintenance

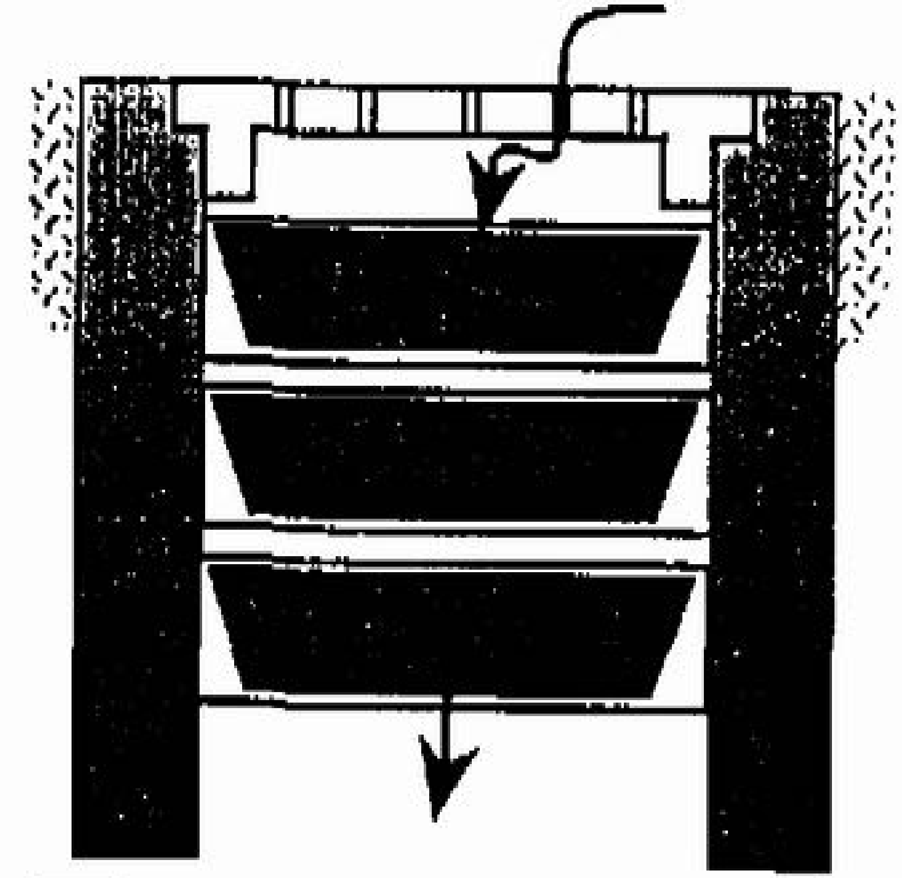
The catch-basin insert should be fitted with oil-absorbent/absorbent filter media, which should be inspected monthly and changed whenever the filter media surface is covered with sediment. Inspections are especially important during the wet season. Acceptable filter media include absorbent W, whole fibrous moss (not necessarily sphagnum moss), Petrolok, and general purpose absorbent (i.e., wood fiber).



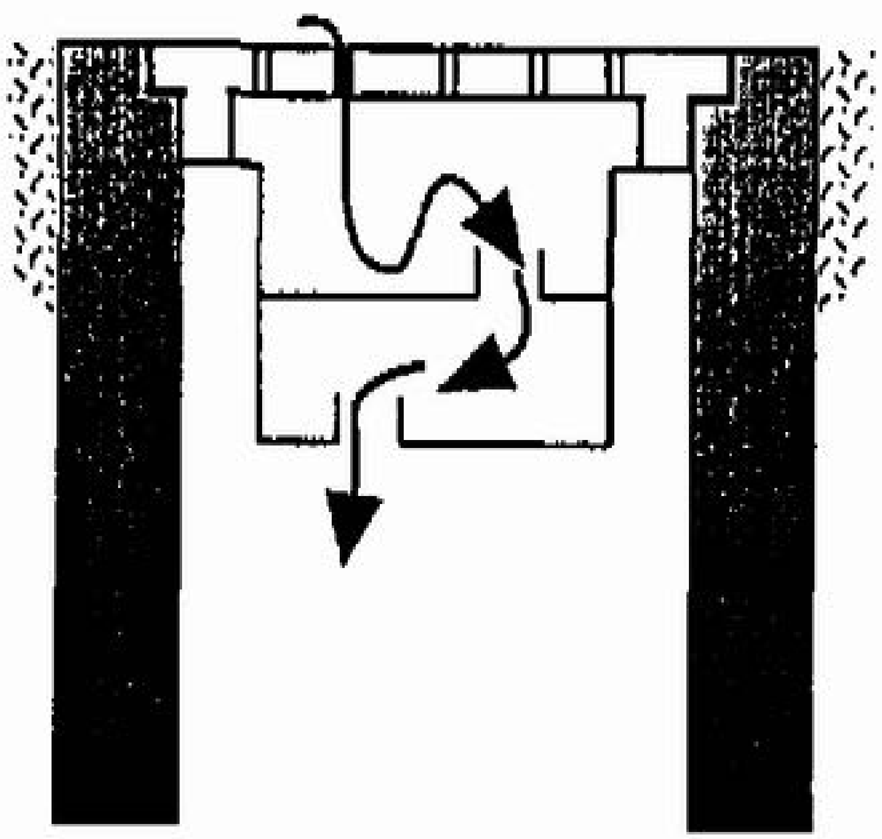
a. **Aqua-net Gullywasher Model 10001**
Side view with cut-outs to show interior



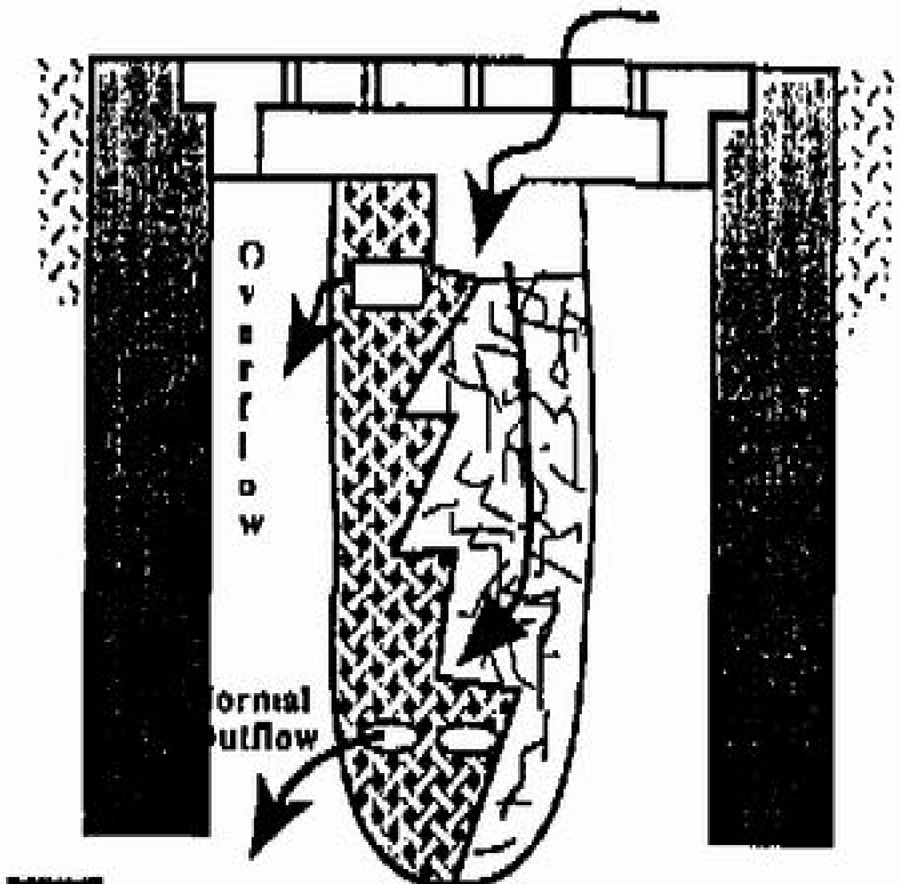
b. **Aqua-net Gullywasher Model 10003**
Top view shows revised containment system



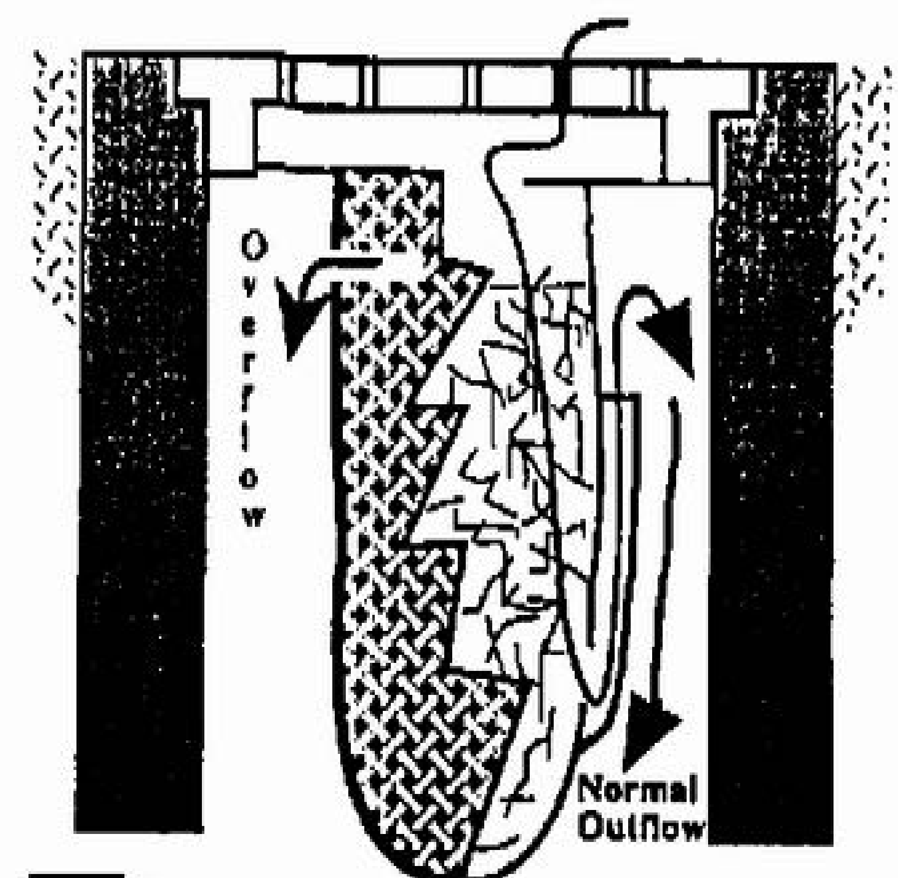
c. **Enviro-drain**
Side view



d. **Stormwater Services type I**
Cross section



e. **Stormwater Services Type II**
Side view with cut-outs to show absorbent



f. **StreamGuard (replaced c)**
Side view with cut-outs to show absorbent

Figure	Detail Notes
a)	Aqua-Net Gullywasher Model 10001: A wire mesh outer basket fitted with an inner basket made of fine stainless-steel screen. The inner basket contains an "onion sack" filled with an absorbant made from a wood by-product. The primary outlet is through the bottom of the sack, while high-flow relief is through the sides of the upper part of the wire mesh basket.
b)	Aqua-Net Gullywasher Model 10003: A more advanced version of the "Gullywasher" described above. In this version, the stainless steel inner basket has been replaced with a second wire mesh basket. A long sock filled with oil-absorbing material is coiled between the inner and outer basket. As with the above product, an "onion sack" filled with absorbant is inserted in the bottom of the basket. The primary outlet is through the absorbant in the bottom and sides. High-flow relief is through the upper part of the basket.
c)	Enviro-Drain: A system of up to three trays, each with solid sides and mesh bottoms. The trays may be filled with an absorbant, activated carbon, or used simply as a debris-catching screen. The screens may be changed to meet specific site conditions. The system is typically installed with the top tray in a screen-only configuration, and the second two trays filled with an absorbant. All components are stainless steel.
d)	Stormwater Services Type I: A set of two interlocking trays that create standing water in which solids are allowed to settle. The overflow from the upper tray discharges to the second tray. The trays are molded in a standard size from recycled plastic. A variety of steel adapters allow the unit to be used in larger drain inlets.
e)	Stormwater Services Type II: A filter fabric sack filled with a polypropylene absorbent. Primary discharge is through the small holes near the bottom of the sack. A secondary outlet is near the top of the device. This model was discontinued during the study.
f)	StreamGuard: This product replaced the Stormwater Services Type II-O, with the principle difference being that the primary outlet has been routed through a pocket on the outside of the sack. A secondary outlet is still provided near the top of the device.

Media Filter BMP 7

Description

A sedimentation chamber and a filtering chamber characterize filtering structures. The media is housed in cartridge filters enclosed in concrete vaults, or in fixed beds such as sand filters. An assortment of filter media are available, including leaf compost, pleated fabric, activated charcoal, perlite, amended sand and perlite, and zeolite. The system functions by routing the stormwater through the filtering or sorbing medium, which traps particulates and/or soluble pollutants.

Applications

- These manufactured systems are used solely for water quality enhancement in urban and ultra-urban areas where surface BMPs are not feasible.
- These systems may be designed as on-line systems for small drainage areas, or as off-line systems
- For off-line applications, flows greater than the design flow should be bypassed.

Limitations

Drainage area – Based on manufacturer's sizing criteria
Minimum bedrock depth - N/A
NRCS soil type – N/A
Drainage/flood control – no

Max slope of filter – 1%
Minimum water table – N/A
Freeze/thaw – fair

- Pretreatment is required for high TSS and/or hydrocarbon loadings and debris that could cause premature failures due to clogging.
- Media filtrations, such as amended sand, should be considered for some metals treatment applications to remove soluble metals and soluble phosphates.

Targeted Pollutants

Sediment
Phosphorus
Trace metals
Hydrocarbons

Design Parameters

Design Criteria for TSS Removal

Determine TSS loading and peak design flow

- Determine TSS loading capacity per cartridge based on manufacturer's loading and flow design criteria to determine number and size of cartridges.
- Evaluate for pre-treatment needs. Typically, roadways, single family dwellings, and developments with steep slopes and erodible soils need pretreatment for TSS. Developments producing sustained oil and grease loads should be evaluated for oil and grease pretreatment.
- Select media based on pollutants of concern, which are typically based on land use and local agency guidelines.

Pretreatment and Bypassing

- Use source control where feasible, including gross pollutant removal, sweeping, and spill containment. Maintain catch basins as needed to minimize inlet debris that could impair the operation of the filter media.
- Use sedimentation vaults/ponds/tanks, innovative and more efficient catch basins, oil/water separators for oil concentrations greater than 2.5 parts per million (ppm), or other appropriate pretreatment system to improve and maintain the operational efficiency of the filter media.
- Bypassing of flows above design flows should be included.

Construction Guidelines

- A precast or cast-in-place vault is typically installed over an underdrain manifold pipe system. This is followed by installation of the cartridges. Other arrangements exist, depending on the product.
- Prior to cartridge installation, construction sites should be stabilized to prevent erosion and solids loading.

Maintenance

- Follow manufacturers operation and maintenance guidelines to maintain design flows and pollutant removals.
- Calculate maintenance frequency, based on TSS loading and cartridge capacity.

3.2 Infiltration Facilities

Infiltration facilities are designed to intercept and reduce direct site surface runoff. They hold or retain runoff long enough to allow it to enter the underlying soil. These devices can include layers of coarse gravel, sand, or other filtering media to filter the runoff before it infiltrates the soil. Infiltration BMPs remove pollutants by means of settling, percolation/filtering, soil sorption, and degradation. They can effectively remove sediments, nutrients such as phosphorus, heavy metals, toxic materials, floatable materials, oxygen demanding substances, oil and grease, and bacteria and viruses.

Infiltration cannot be applied everywhere. It may be more appropriate to work from a case-by-case basis, depending on the soil and water table conditions of a site. Site-specific testing should be conducted to demonstrate site infiltration rates of at least 0.4 inches per hour. Good design and maintenance of infiltration BMPs are critical to ensure that they don't clog and seal up after a year or two of operation. To help prevent clogging, it is recommended that pretreatment be provided whenever possible. To facilitate maintenance, observation wells are required for infiltration BMPs.

The following pages contain fact sheets for three BMPs:

BMP 8 Infiltration trench
BMP 9 Bioretention basin
BMP 10 Porous pavement

Infiltration Trench BMP 8

Description

Infiltration facilities, such as trenches, seepage beds, and bioretention basins, are designed to intercept and reduce direct site surface runoff. They hold runoff long enough to allow it to enter the underlying soil. They can include layers of coarse gravel, sand, or other filtering media to filter the runoff before it infiltrates the soil.

Infiltration trenches are shallow (3 to 12 feet deep) trenches in relatively permeable soils that are backfilled with a sand filter, coarse stone, and lined with filter fabric. The trench surface can be covered with grating and/or consist of stone, gabion, sand, or a grassed covered area with a surface inlet. Depending on the design, trenches allow for the partial or total infiltration on stormwater runoff into the underlying soil. 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.

Applications

An infiltration trench will generally be used in relatively small drainage areas (usually less than 10 acres), such as on residential lots. 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. Unlike infiltration basins installed at the surface, the land above a subsurface trench system can be reclaimed and used. A trench may also be installed under a drainage swale to increase the storage of the infiltration system.

Appropriate soil conditions and the protection of ground water are the most important considerations limiting the use of this BMP. Infiltration rates should be 0.5 inches per hour or greater). Generally speaking, SCS Type A and B soils will convey water at this rate, but site-specific testing should be done to confirm the infiltration rate. Other soil conditions that will not support the use of infiltration trenches include the following:

- Soils with more than 40% clay content (subject to frost heave)
- Fill soils, unless the fill material is specially designed to accommodate the facility
- Steep site slopes (greater than 25%) which can contribute to slope failures

Infiltration facilities are not suitable in many areas of Idaho where the ground-water table is very shallow. Conditions should be observed at the site during the winter and early spring when the water table is at its highest. If the minimum depth to ground water at these times is 3 feet from the proposed bottom of the infiltration trench bed and the other noted soil conditions are right, infiltration can be used. If depth to the water table is shallower, there is an increased risk of ground-water contamination.

One advantage to trenches is that they are less likely to become clogged with sediment than do other infiltration BMPs, such as basins, if properly maintained. However, clogging is still an issue. This BMP should typically be located "off-line" from the primary conveyance/detention system in order to effectively treat pollutants and protect the infiltration soils from clogging. Infiltration trenches should always be preceded by a pretreatment BMP to remove sediments that could clog the infiltration soils. Infiltration trenches are not suitable for sites with exposed chemical or toxic materials. If there is the potential for a toxic spill, a spill prevention and control plan should be in place.

As with any type of infiltration facility, infiltration trenches should not be used in areas with shallow aquifers. An official inventory form should be submitted to the Idaho Department of Water Resources (IDWR). Contact the closest IDWR regional office for further information.

Conservatively speaking, the longevity of trenches is expected to be about 2 years before partial or full clogging/sealing of the floor. The life span can be significantly increased given good permeable soils and pretreatment to prevent clogging. The relatively short life span of infiltration facilities can be significantly increased through proper design and maintenance.

Limitations

Drainage area – 10 ac.
Minimum bedrock depth – 4 ft
NRCS soil type – A, B
Drainage/flood control – N/A
Max slope – 20%
Minimum water table – 3 ft
Freeze/thaw – fair

Targeted Pollutants

Sediment – 75%
Phosphorus – 55%
Trace metals
Bacteria
Hydrocarbons

Design Parameters

The procedure for sizing infiltration trenches should follow a Darcy's Law approach, as described in BMP 4 (Sand Filters). Typical dimensions are 3 feet wide and 3 to 12 feet deep. Additional design parameters specific to infiltration trenches are given below.

Soils Investigation

A minimum of 1 soils log should be collected for every 50 feet of trench length, and in no case less than 2 soils logs for each proposed trench location. Each soils log should extend to a minimum depth of the high water table below the bottom of the trench, describe the NRCS series of the soil, the textural class of the soil horizon(s) through the depth of the log (soil and structures), and note any evidence of high ground water level, such as mottling. In addition, the location of impermeable soil layers or dissimilar soil layers should be determined. The design infiltration rate (fd) will be equal to one-half the infiltration rate found from the soil textural and structural analysis.

Pretreatment

It is recommended that all infiltration trenches be preceded by a pretreatment

BMP, such as a presettling basin, a vegetated swale or a simple sump. A vegetated filter strip at least 20 feet wide appears to work well. A level spreader may be used to spread out concentrated flows. Regular maintenance of the pretreatment device is critical.

Drawdown Time
Infiltration trenches should be designed to completely drain stored runoff within 24 hours. This will ensure that the necessary aerobic conditions exist in order to provide effective treatment of pollutants. If a presettling basin precedes the infiltration trench, the combined drawdown time for both BMPs should be 24 hours.

Backfill Material
The aggregate material for the infiltration trench should 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 to 40%.

Geotextile Fabric
The aggregate fill material should be completely surrounded with an engineering geotextile. In the case of an aggregate surface, the fabric should surround all of the aggregate fill material except for the top 1 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 should be provided.

Seepage Analysis and Control
An analysis should be made to determine any possible adverse effects of seepage zones when there are nearby building foundations, basements, roads, parking lots or sloping sites. 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
Trenches should be a minimum of 100 feet upslope and 20 feet downslope from any building foundation or water supply well.

Land Use
Infiltration facilities are not recommended under surfaces that are expected to have traffic loads, such as driveways and parking lots. Soils become too compacted and access is difficult.

Observation Well
An observation well should 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. The observation well should consist of perforated PVC pipe, 2 to 4 inches in diameter. It should be located in the center of the structure and be constructed flush with the ground elevation of the trench. The top of the well should be capped to discourage vandalism and tampering. More specific construction information can be obtained by contacting IDWR or DEQ.

Construction Guidelines

Construction Timing
An infiltration trench should not be constructed or placed into service until all of the contributing drainage area has been stabilized and approved by the appropriate agency.

Trench Preparation
Excavate the trench to the design dimensions. Excavated materials should be placed away from the trench sides to enhance 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.

Fabric Laydown
The geotextile fabric (a fabric that is defined as "non-woven, spunbonded and needlepunched") should be cut to the proper width prior to installation. The cut width should include sufficient material to conform to the trench perimeter irregularities and for a 12-inch minimum top overlap.

Place the geotextile 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 geotextile 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 geotextile continuity and allows the geotextile 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 geotextile conformity to the excavation sides, thereby reducing potential soil piping, geotextile clogging, and settlement problems.

Overlapping and Covering
Following the stone aggregate placement, the geotextile fabric should be folded over the stone aggregate to form a 12-inch minimum longitudinal overlap. The desired fill soil or stone aggregate should be placed over the lap

at sufficient intervals to maintain the lap during subsequent backfilling. Care should be exercised to prevent natural or fill soils from intermixing with the stone aggregate. All contaminated stone aggregate should be removed and replaced with uncontaminated stone aggregate.

Voids Behind Geotextile
Voids that may be created between the geotextile and excavation sides should be avoided. Native soils should be placed in these voids at the most convenient time during construction to ensure fabric conformity to the excavation sides. Utilizing this remedial process will minimize soil piping, fabric clogging, and possible surface subsidence.

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; a 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 should be restricted from traveling over the infiltration areas to minimize compaction of the soil. The trench should be flagged or marked to keep equipment away from the area.

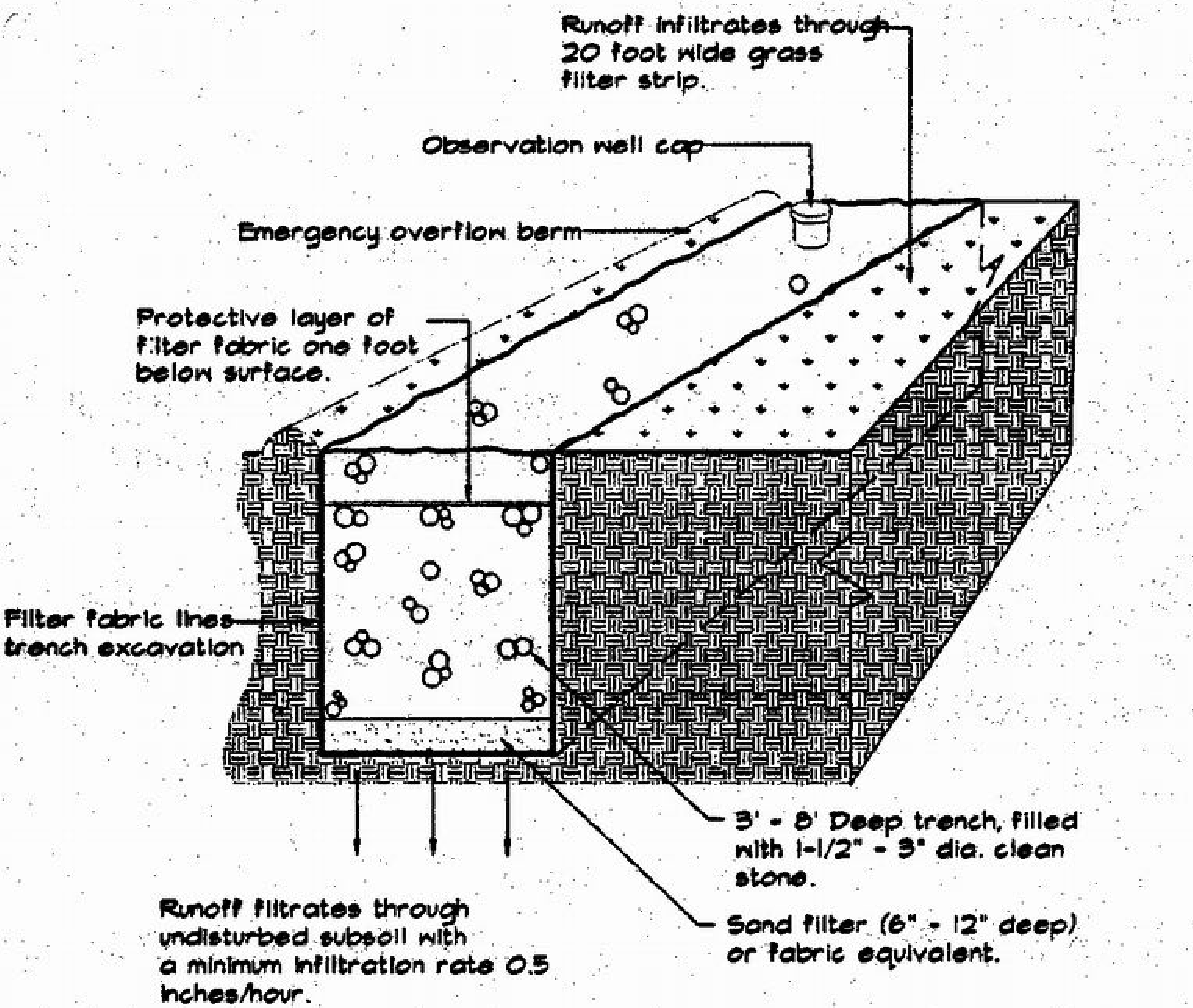
Maintenance

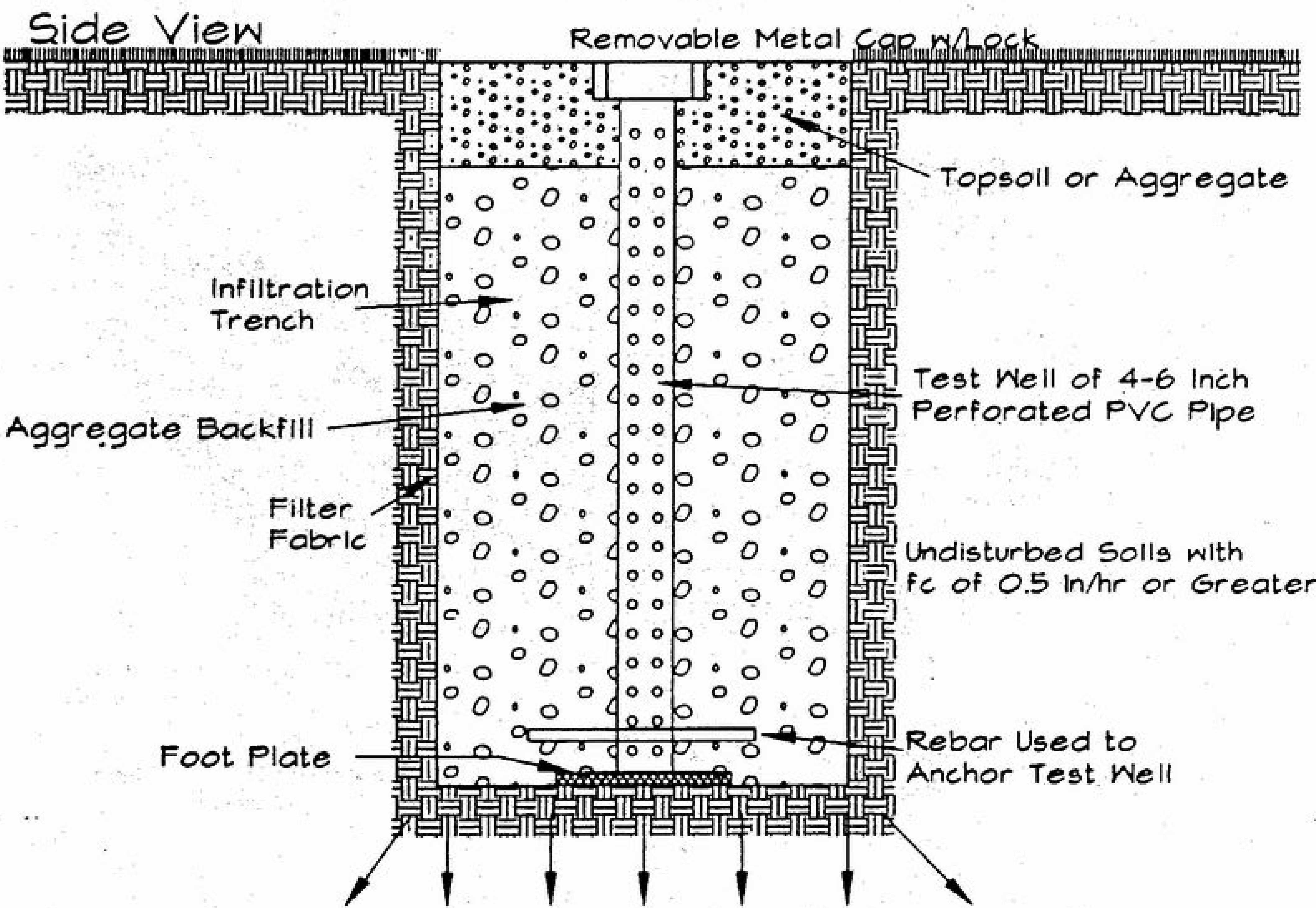
Inspection Schedule
The observation well should be monitored periodically for water level. For the first year after completion of construction, the well should be monitored after every large storm (greater than 1 inch in 24 hours), and during the period from October 15 to April 15, inspections should be conducted monthly. From April 16 through October 14, the facility should be monitored on a quarterly basis. A log book should 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 should be required when the trench has a stone surface. Sediment deposits should not be allowed to build up to the point where it will reduce the rate of infiltration into the trench.

Pretreatment BMPs
BMPs used for pretreatment should be inspected regularly. Sediment deposits should be removed and grassy swales or filter strips should be mowed. Repair any erosion (e.g., rills) in pretreatment swales or filter strips that might

concentrate runoff flow and cause erosion prior to the infiltration trench.


Runoff infiltrates through 20 foot wide grass filter strip.
Observation well cap
Emergency overflow berm
Protective layer of filter fabric one foot below surface.
Filter fabric lines trench excavation
3' - 8' Deep trench, filled with 1-1/2" - 3" dia. clean stone.
Runoff filtrates through undisturbed subsoil with a minimum infiltration rate 0.5 inches/hour.
Sand filter (6" - 12" deep) or fabric equivalent.



Side View
Removable Metal Cap w/Lock
Topsoil or Aggregate
Infiltration Trench
Test Well of 4-6 Inch Perforated PVC Pipe
Aggregate Backfill
Filter Fabric
Undisturbed Soils with fc of 0.5 In/hr or Greater
Rebar Used to Anchor Test Well
Foot Plate

Bioretention Basin BMP 9

Description

A bioretention basin emulates the hydrology of an upland forest or meadow with an overstory of trees, an understory of shrubs, and grasses underneath. Most of the rainfall is either infiltrated or lost through evapotranspiration, resulting in very little runoff. Bioretention facilities usually contain the following components: a temporary ponding area, a mulch layer, a sandy or loamy planting soil, the plants, and, where necessary, underdrains.

Most bioretention devices are off-line basins designed to infiltrate all flow up to the design storm. Bioinfiltration swales, on the other hand, represent a cross between a biodetention basin and a vegetated swale. They are designed for conveyance as well as infiltration.

Applications

Bioretention typically treats stormwater runoff from impervious surfaces found in residential, commercial, and industrial areas. Bioretention facilities should be constructed as part of a site's overall landscaping and can reduce the size of the pipe drainage system required. Take advantage of existing natural surface depressions and swales on the site, where a berm or low dam could very simply create the needed ponding area. Alternatively, design the landscape to include a depressed area in which to place the basin. When incorporated into the site design, bioretention involves little cost other than proper soil profile modification, grading, and planting. Drainage areas should be stabilized before beginning to use the facility to minimize sediment loading to the treatment area.

The size of the drainage area should ideally be less than 1 acre with slopes of less than 20%. Sites with mature trees that would be removed should be avoided.

The appropriate soil conditions for infiltration and the protection of ground water are the most important considerations limiting the use of this BMP. Planting soils should be loamy, with a clay content of 10 to 25%. Higher clay content drains too slowly and is subject to frost heave. Some clay is necessary to help adsorb pollutants, however.

The soil should contain 3 to 5% organic material and have a pH of 5.5 to 6.5. Because soils can vary tremendously over short distances, site specific testing is required to determine if the minimum infiltration rate is sufficient. If the tested infiltration rate cannot meet minimum values, more permeable material should be imported.

As with any type of infiltration facility, bioretention facilities should not be used in areas with shallow aquifers. An official inventory form should be submitted to the Idaho Department of Water Resources (IDWR). Contact the closest IDWR regional office for further information.

Limitations

Drainage area – 5 ac.
Minimum bedrock depth – 6 ft
NRCS soil type – A, B
Drainage/flood control – yes
Max slope – 25%
Minimum water table – 3 ft
Freeze/thaw – fair

Targeted Pollutants

Sediment – 90%
Phosphorus – 75%
Trace metals
Bacteria
Hydrocarbons

Design Parameters

General design parameters for bioretention facilities include the following:

- Facility size, less than 1 acre, 5 to 7% of the impervious drainage area
- Grass buffer strip surrounding facility
- Ponding area depth limited to 6 inches
- Minimum of 3 feet from bottom of facility to ground-water table. If underdrain and/or monitoring well installed to verify pollutant removal, then depth can be reduced to 3 feet.
- Mature mulch 3 inches deep lining ponding area
- Planting soils should be a loam mixture. A depth of 4 feet is desirable. Adequate nutrient removal requires a minimum of 2 feet.
- Sand bed underlying the planting soil
- Plant mixture of trees, shrubs, and grasses
- The grass buffer strip reduces the velocity of the incoming runoff and filters some of the coarser particulates. The ponding area provides temporary storage. The mulch layer filters pollutants and protects the planting soil from drying out and eroding. Vegetation reduces the potential for erosion and provides evapotranspiration. Planting soil filters pollutants and provides temporary storage for runoff. The underlying sand bed provides aeration and ensures infiltration across the entire bottom of the facility. In addition, a level spreader should be used to spread out concentrated flows across the bioretention basin.

Facility size

The facility size should be 5 to 7% of the drainage area multiplied by a runoff coefficient, such as that of the rational method. (Facilities with an underlying sand bed may be as little as 5%; those without will need the larger 7%.) Flows to the facility should not exceed 5 cubic feet per second during the 10-year storm. Multiple bioretention facilities should be used for drainage areas yielding higher flows than this.

Recommended minimum dimensions of the bioretention facility are 15 feet wide by 40 feet long. The preferred dimensions are 25 by 50 feet. Any facilities wider than 20 feet should be twice as long as they are wide to promote flow distribution. Planting soils should be 4 inches deeper than the bottom of the largest plant root ball and 2 to 4 feet altogether.

Buffer strip: The grassed buffer strip should be at least 5 feet wide.

Ponding area
The maximum recommended ponding depth is 6 inches. This provides some storage while preventing standing water for long periods of time.

Mulch
If a ground cover or grass is not immediately established after the trees and shrubs are planted, 2 to 3 inches of aged, fine shredded hardwood should be applied to prevent erosion (Mulch deeper than this interferes with the cycling of oxygen and carbon dioxide in the soil.). Other types of mulch, such as Beauty Bark, tend to float and may clog overflow outlets.

Soils
Planting soils should be loam, with clay content from 10 to 25%. Infiltration may be measured using ASTM D 5126 single ring infiltrometer test. Soil infiltration capacity should be a minimum 0.5 inches per hour for the life of the facility. The maximum desirable infiltration rate is 3.0 inches per hour. A higher maximum infiltration rate may be acceptable if an adequate vegetative cover can be maintained without excessive irrigation. The design infiltration rate should be considered equal to one-half the infiltration rate found from the soil textural analysis due to decreases in infiltration rate as the planting mix ages. To increase the life of the facility, therefore, measured infiltration rate of the soils should be 1 to 6 inches per hour. If the surrounding soils have considerably lower rates of infiltration than the planting soil, an underdrain may be required to avoid water ponding. The soil should contain 3% organic material and have a pH of 5.5 to 6.5. Within this pH range, nitrogen and phosphorus can be readily adsorbed by the soil. Soluble salts should be less than 500 parts per million.

Sand bed
Adding 1.5 feet of sand underneath the planting soil helps with aeration and drainage. If the sand bed is extended to the sides of the planting soil, it acts as a sand filter and filters particulates and reduces the velocities of flows across the facility.

Vegetation
The plantings should emulate a terrestrial forest community ecosystem. Three species of trees and three of shrubs should be planted. Native species that are tolerant to pollutant loads and varying soil moisture (referred to as predominantly facultative) should be selected. The trees should be smaller ones similar to those found in the forest understory, since it is more difficult to perform maintenance with the tall trees that are normally part of the forest canopy. Ground cover, such as grasses or legumes, should be planted after the trees and shrubs are in place.

If sod is chosen to vegetate the basin, select sod that has been grown in permeable soils. Sod grown in clay soils will not be effective because the clay soil can restrict water infiltration reducing the expected infiltration rate of the system. If sod grown in clay soils is the only sod available, ask the grower to wash off the soil from the sod to remove all clay material.

Construction Guidelines

Construction Schedule
The sequence of various phases of basin construction should be coordinated with the overall project construction schedule. The project should schedule rough excavation of the basin with the rough grading phase to permit use of the material as fill in earthwork areas. The partially excavated basin may 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 should 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 excavation should be carried to within 1 foot of the final elevation of the basin's floor. Final excavation to the finished grade should be deferred until all disturbed areas on the site 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. Fill bioretention area with planting soil, sand, and underdrains. Placement of the planting soil should be in lifts of 1.5 feet or less and lightly compacted. Expect the soil to settle by up to 20% during the first storm event.

Infiltration Test
A ring infiltrometer test (ASTM D5126) should be conducted (a local option) after final grading and the determined rate of infiltration should be 1 to 6 inches per hour. The maximum allowable rate should only be allowed if it could be shown that a satisfactory vegetative cover can be maintained without excessive irrigation. The local permitting agency should provide this inspection. Should the facility not meet the minimum infiltration rate of 0.5 inches per hour, more permeable material should be brought in and incorporated into (or replace) the first 6 to 10 inches of the existing material. The infiltration test should then be redone. If the soil cannot be treated to reach the minimum infiltration rate then an alternative design should be used. If the planting mix has an acceptable rate of infiltration but the underlying soil is not

permeable enough, an underdrain may be needed to provide adequate drainage.

Vegetation
The trees and shrubs should be planted at a rate of 1,000 per acre. The shrub to tree ratio should be 2 to 3 shrubs per tree. In order to avoid damage to the plant and possible channelization of flow, woody plants should not be placed where flows enter the bioretention facility. The microclimate of the facility should be considered in placement of vegetation. For example, evergreen trees or other wind-tolerant species may be placed on the northern end of the area to block cold winter winds. Finally, the plant layout should resemble a natural, random placement as much as possible.

Maintenance

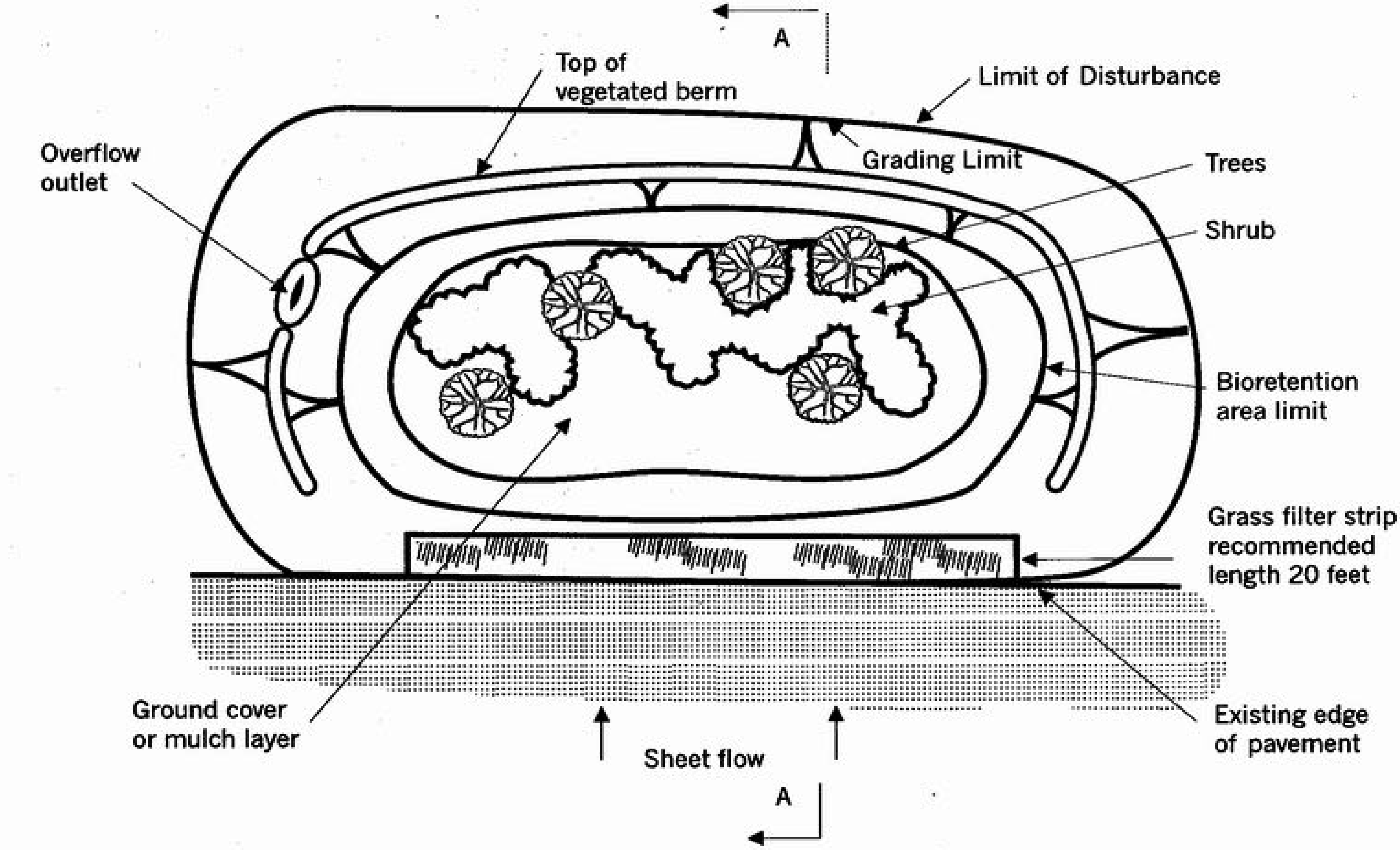
Access
Provide enough access space for maintenance activities. Check with the local permitting authority to determine if a dedicated maintenance easement is required for the basin.

Inspection Schedule
When bioretention 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. 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.

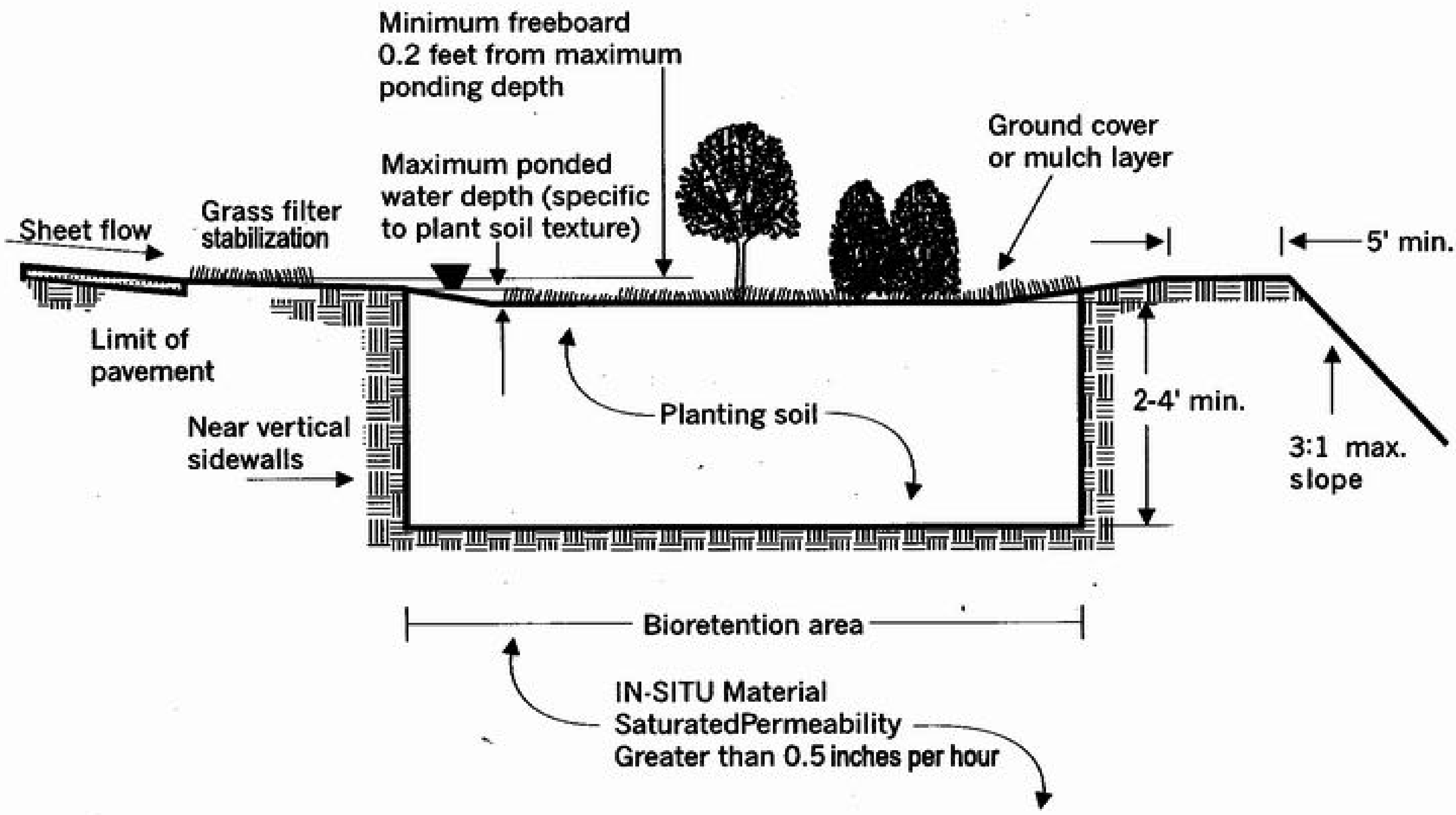
The facility should be observed after storms to ensure adequate drainage. Water standing longer than 4 days will severely limit the growth of most plants. Mosquitoes and other insects may start to breed as well. The microbial processes of the planting soil that remove nutrients will not work as well if the facility becomes waterlogged and anaerobic.

Vegetative Maintenance
Trees and shrubs should be inspected twice per year. Any dead or severely diseased vegetation should be removed. Prune and weed to maintain the bioretention area’s appearance. Spot mulch when bare spots appear. Every 2 to 3 years, the entire area should be remulched.

Soil should be tested annually to detect toxic concentrations of pollutants. As toxins accumulate, they may impair plant growth and bioretention effectiveness, and soil replacement may be required.



Plan view (not to scale)



Section A-A (not to scale)

Porous Pavement BMP 10

Description

Porous pavement is a permeable pavement surface with an underlying stone reservoir that temporarily stores surface runoff before infiltrating into the subsoil. This porous surface replaces traditional pavement, allowing parking lot runoff to infiltrate directly into the soil and receive water quality treatment.

There are several pavement options, including porous asphalt, pervious concrete, and grass pavers. Porous asphalt and pervious concrete appear the same as traditional pavement from the surface, but are manufactured without "fine" materials, and incorporate void spaces to allow infiltration. Grass pavers are concrete interlocking blocks or synthetic fibrous grid systems with open areas designed to allow grass to grow within the void areas.

Applications

- The ideal application for porous pavement is to treat a low-traffic or overflow parking area.
- Porous pavement may also have some application on highways, where it is currently used as a surface material to reduce hydroplaning.
- Ultra urban areas are densely developed urban areas in which little pervious surface exists. Porous pavement is a good option for these areas because they consume no land area.
- Porous pavement can be applied in most regions of the country, but the practice has unique challenges in cold climates.

Limitations

Drainage area – unlimited	Max slope – N/A
Minimum bedrock depth - N/A	Minimum water table – N/A
NRCS soil type – A, B, CD	Freeze/thaw – fair
Drainage/flood control – no	

- Since porous pavement is an infiltration practice, it should not be applied on stormwater hotspots due to the potential for ground-water contamination.
- Not ideal for high traffic areas, however, because of the potential for failure due to clogging.
- Porous pavement cannot be used where sand is applied to the pavement surface because the sand will clog the surface of the material. Care also needs to be taken when applying salt to a porous pavement surface since chlorides from road salt may migrate into the ground water.

Targeted Pollutants

Sediment – 95%
Phosphorus – 82%
Trace metals – 98%

Design Parameters

Siting Considerations

Porous pavement has site constraints as other infiltration practices. A potential porous pavement site needs to meet the following criteria:

- Soils need to have permeability between 0.5 and 3.0 inches per hour.
- The bottom of the stone reservoir should be completely flat so that infiltrated runoff will be able to infiltrate through the entire surface.
- Porous pavement should be located at least 2 to 5 feet above the seasonally high ground-water table, and at least 100 feet away from drinking water wells.
- Porous pavement should be located only on low-traffic or overflow parking areas, which are expected to be not sanded during wintertime conditions.

Design Considerations

Five basic features should be incorporated into all porous pavement practices:

1. Pretreatment- In most porous pavement designs, the pavement itself acts as pretreatment to the stone reservoir below. Because the surface serves this purpose, frequent maintenance of the pavement surface is critical to prevent clogging. Another pretreatment element is a fine gravel layer above the coarse gravel treatment reservoir. The effectiveness of both of these pretreatment measures are marginal, which is one reason frequent vacuum sweeping is needed to keep the surface clean.
2. One design option incorporates an “overflow edge,” which is a trench surrounding the edge of the pavement. The trench connects to the stone reservoir below the surface of the pavement. Although this feature does not in itself reduce maintenance requirements, it acts as a backup in case the surface clogs. If the surface clogs, stormwater will flow over the surface and into the trench, where some infiltration and treatment will occur.
3. Treatment - The stone reservoir below the pavement surface should be composed of layers of small stone directly below the pavement surface, and the stone bed below the permeable surface should be sized to attenuate storm flows for the storm event to be treated. Typically, porous pavement is sized to treat a small event, such as the water quality storm (i.e., the storm that will be treated for pollutant removal) which can range from 0.5 to 1.5 inches. Like infiltration trenches, water can only be stored in the void spaces of the stone reservoir.
4. Conveyance - Water is conveyed to the stone reservoir through the surface of the pavement and infiltrates into the ground through the bottom of this stone reservoir. A geosynthetic liner and sand layer should be placed below the stone reservoir to prevent preferential flow paths and to maintain a flat bottom. Designs also need some method to convey larger storms to the storm drain system. One option is to set storm drain inlets slightly above the surface elevation of the pavement. This allows for temporary ponding above the surface if the surface clogs but bypasses larger flows that are too large to be treated by the system.
5. Maintenance Reduction - One non-structural component that can help ensure proper maintenance of porous pavement is the use of a carefully worded maintenance agreement that provides specific

guidance to the parking lot, including how to conduct routine maintenance and how the surface should be repaved. Ideally, signs should be posted on the site identifying porous pavement areas.
6. Landscaping - The most important landscaping objective for porous pavements is to ensure that its drainage area is fully stabilized, thereby preventing sediment loads from clogging the pavement.

Regional Adaptations
In cold climates, the base of the stone reservoir should extend below the frost line to reduce the risk of frost heave.

Maintenance

Porous pavement requires extensive maintenance compared with other practices. In addition to owners not being aware of porous pavement on a site, not performing these maintenance activities is the chief reason for failure of this practice. Typical requirements follow below:

Monthly:
- Ensure that paving area is clean of debris
- Ensure that paving dewaters between storms
- Ensure that the area is clean of sediments

As Needed:
- Mow upland and adjacent areas, and seed bare areas
- Vacuum Sweep frequently to keep the surface free of sediment (typically three to four times per year)

Annual: Inspect the surface for deterioration or spalling

3.3 Detention Facilities

Detention facilities capture stormwater runoff and provide pollutant removal primarily through settling and, if they include vegetation, biological uptake. Biological uptake of dissolved pollutants can be an important mechanism for controlling nutrients. Detention BMPs can be used to handle runoff from a variety of land uses. When used in areas with high dissolved concentrations of heavy metals or toxic organic chemical loads in the runoff (e.g., industrial sites), they should be lined to prevent ground-water contamination. These facilities can reduce streambank erosion and flooding by temporarily detaining runoff before releasing it at flow rates and frequencies similar to those occurring under natural hydrologic conditions. They can be designed to enhance wildlife habitat, provide an aesthetic amenity and satisfy some of the landscape needs.

Detention BMPs may be either “wet” or “dry” and either above ground (ponds) or below ground (tanks or vaults). A wet pond, as the name implies, maintains a permanent pool of water (dead storage) for runoff treatment purposes. In contrast, a dry facility does not contain this dead storage (except for a few inches for sediment storage) and tends to dry out between storms.

A typical detention BMP configuration maintains a permanent pool of water as a dead storage area for treatment purposes and a live storage area above the permanent pool in order to temporarily detain runoff for streambank erosion control purposes. Wet detention BMPs that use a permanent pool of water are considered the most effective treatment BMPs. The permanent pond improves the removal efficiency for particulate pollutants in the following ways:

- Dissipating the inflow energy of the stormwater as it enters the basin
- Preventing scour of material settled to the bottom
- Allowing exchange of incoming stormwater with previously captured water, thus providing additional time between storms to settle pollutants

Wet detention BMPs that establish vegetation within the permanent pool volume can provide additional pollutant removal. The vegetation in such shallow wetland (marsh) areas serves as a filtration medium for removing particulate pollutants. Aquatic plants in the permanent pool can assimilate dissolved pollutants. Biological uptake and/or transformation of pollutants into less toxic materials can be an important means of pollutant removal. In cases where a permanent pool cannot be established, the pollutant removal efficiency of detention facilities can be improved by extending the detention period of the runoff from smaller, more frequent storms. Such facilities are called "extended detention" facilities.

Sediments accumulating over long periods in a detention facility may contain high levels of toxics and require expensive disposal methods. To avoid this problem, regular inspection and maintenance should be scheduled. Testing may be done for a period of time after construction to verify that the maintenance schedule is working effectively.

The next few pages are BMP fact sheets for the following types of detention facilities:

The primary difference between a detention pond BMP that controls conventional pollutants compared with one that treats nutrients is that the latter has a shallow marsh system established within the permanent pool volume. The permanent pool in the conventional treatment BMP does not have to be vegetated.

Wet Pond (Conventional Pollutants) BMP 11

Description

This BMP is designed to provide runoff treatment for conventional pollutants but not nutrients. A wet pond is an open pond with the outlet set higher than the bottom of the facility. This usually results in a permanent pool of water that serves as “dead storage” and is very effective at removing pollutants. In an arid environment, the pool of water may evaporate in between storms, but the pollutants are still trapped. As an option, a shallow marsh area can be created within the permanent pool volume to provide additional treatment.

Applications

If well planned, wet ponds can meet a variety of objectives. These may include protection of infrastructure and property, improving water quality, enhancing wildlife habitats, and providing recreational opportunities. In order to serve as a multi-purpose facility, the wet pond should function in such a manner as to be compatible with overall stormwater systems both upstream and downstream. This provides a watershed approach to stormwater management as well as local flood control.

If the facility is planned as an artificial lake to enhance property values and promote the aesthetic value of the land, pretreatment in the form of landscape retention areas or perimeter swales should be incorporated into the stormwater management facility. If possible, catch basins should be located in grassed areas. By incorporating this “treatment train” concept into the overall collection and conveyance system, the engineer can prolong the utility of these permanently wet installations and improve their appearance. Any amount of runoff waters, regardless of how small, that is filtered or percolated along its way to the final detention area, can remove oil and grease, metals, and sediment. In addition, this will reduce the annual nutrient load to prevent the wet pond from becoming eutrophic with excessive algal blooms, low oxygen levels, and odor.

Detention system site selection should consider both the natural topography of the area and property boundaries. Aesthetic and water quality considerations may also dictate locations. The permanent pool of the wet pond is an integral part of the environment and, therefore, should serve as an aesthetic improvement to the area if possible. Use of good landscaping principles is encouraged. The planting and preservation of desirable trees and other vegetation should be an integral part of the storage facility design.

In planning new detention facilities, it should be kept in mind that the goal of improved water quality downstream may conflict with certain desired uses of the facility. It is only logical that, if the basin is used to remove pollutants, the water quality within the basin itself will be lowered, thus reducing the applicability for uses such as water supply, recreation, and aesthetics. In planning the facility, the engineer or planner should have a good knowledge of site-specific runoff constituents and an understanding of the possible effects on the quality of the stored water.

The design of urban detention facilities should be coordinated with a basin plan for managing stormwater runoff. In a localized situation, an individual property owner can, of course, by his or her actions alone, provide effective assistance to the next owner downstream if no other areas contribute to that owner's problems. However, uncontrolled proliferation of impoundments within a watershed can severely alter natural flow conditions, causing compounded flow peaks or increased flow duration that can contribute to downstream degradation. In addition, upstream impacts due to future land use changes should be considered when designing the structure. Land use planning and regulation may be necessary to preserve the intended function of the impoundment.

Limitations

Drainage area – 15 to 20 ac.
Minimum bedrock depth – 3 ft
NRCS soil type – C, D
Drainage/flood control – yes
Max slope – 10%
Minimum water table – 2 ft
Freeze/thaw – good

Targeted Pollutants

Sediment – 80%
Phosphorus – 45%
Trace metals
Bacteria
Hydrocarbons

Design Parameters

Site Constraints

- All facilities should be a minimum of 20 feet from any structure, property line, and any vegetative buffer required by the local or state government, 100 feet from any septic tank/drainfield (except wet vaults should be a minimum of 20 feet), and 100 feet from any wells or water supplies.
- All facilities should be a minimum of 50 feet from any steep (greater than 15%) slope. A geotechnical report should address the potential impact of a wet pond on a steep slope.

Permanent Pool Volume

The permanent pool volume should be equal to the runoff volume of one-third of the 2-year, 24-hour design storm. Review Appendix D for additional information on sizing the detention facility.

Overflows

Detention facility design should take into consideration the possibility of overflows. An overflow device should be installed in all facilities to bypass flows over or around the restrictor system. The most common overflow event is snowmelt, but overflows may also result from higher intensity or longer duration storms than the design storm or result from plugged orifices or inadequate storage due to sediment buildup in the facility.

Pond Configuration and Geometry

- Wet ponds may be single-celled or multi-celled. The multi-celled version requires more planning and maintenance due to the extra berms involved;

however, some studies have shown it to be more effective at pollutant removal. Regardless of the configuration, the total pond area and volume should be consistent with the sizing criteria given in Appendix D.

- Long, narrow ponds are preferred, as these are less prone to short-circuiting and tend to maximize available treatment area. The length-to-width ratio should be at least 3:1 and preferably 5:1. The inlet and outlet should be at opposite ends of the pond where feasible. If this is not possible, then berms can be installed to increase the flow path and water residence time. Slightly irregular ponds may perform more effectively and will have a more natural appearance.
- Interior side slopes up to the maximum water surface should be no steeper than 3H:1V. Exterior side slopes should be no steeper than 2H:1V.
- The pond bottom should be level to facilitate sedimentation.

Liner To Prevent Infiltration
Detention BMPs should have a negligible infiltration rate through the bottom of the pond. Infiltration will impair the proper functioning of detention BMPs and can contaminate ground water.

Berm Embankment/Slope Stabilization
- Pond embankments higher than 6 feet should require design by a geotechnical-civil engineer licensed in the state of Idaho. For berm embankments of 6 feet or less (including 1 foot freeboard), the minimum top width should be 6 feet or as recommended by the geotechnical-civil engineer.
- Pond berm embankments should be constructed on native consolidated soil (or adequately compacted and stable fill soils analyzed by a geotechnical report) free of loose surface soil materials, roots and other organic debris.
- Exposed earth on the side slopes should be sodded or seeded with the appropriate seed mixture as soon as is practicable. If necessary, geotextile or matting may be used to stabilize slopes while seeding and sodding become established.

Gravity Drain
A gravity drain for maintenance should provide an outlet invert of 1 foot above the bottom of the facility and should be sized to drain the facility in four hours or less.

Construction Guidelines

Widely acceptable construction standards and specifications, such as those developed by the USDA – Natural Resources Conservation Service (NRCS) or the U.S. Army Corp of Engineers, for embankment ponds and reservoirs may aid in building the impoundment. Additional information is also available from the Idaho Transportation Department's Design manual. It is important that appropriate erosion control techniques be used during construction of a wet pond.

Maintenance

Failure of large impoundment structures can cause significant property damage and even loss of life. Only professional engineers registered in the state of Idaho who are qualified and experienced in impoundment design should design such structures. Where they exist, local safety standards for impoundment design should be followed. Impoundment structures should also be regularly inspected for signs of failure, such as seepage or cracks in the berm.

The presence of wet ponds and marshes in established urban areas is perceived by many people to be undesirable. They are often thought of as mud holes where mosquitoes and other insects breed. If the wet pond has a shallow marsh established, the pond can become a welcomed addition to a residential community. Constructed fresh water marshes can provide miniature wildlife refuges, and while insect populations are increased, insect predators also increase, often reducing the problem to a tolerable level. More information about mosquito control can be found in Appendix F. Nevertheless, local government and homeowners associations may wish to drain the ponds during late spring and summer if there if sufficient concern. However, it is imperative that the vegetation in shallow marsh areas not die off during draindown periods; otherwise, the pollutant removal effectiveness of the wet pond can be severely impacted. In addition, the decaying vegetation can create nuisance conditions.

Periodic mowing will keep weeds and grass under control and usually helps with neighborhood acceptance. Trash and debris removal should also be done regularly to avoid the facility becoming a convenient dumping ground for trash, construction debris, and yard waste.

Safety, Signage and Fencing
Ponds that are readily accessible to populated areas should incorporate all possible safety precautions. Steep side slopes (steeper than 3H: 1V) at the perimeter should be avoided and dangerous outlet facilities should be protected by enclosure. Warning signs for deep water and potential health risks should be used wherever appropriate. Signs should be placed so that at least one is clearly visible and legible from all adjacent streets, sidewalks or paths. A notice should be posted warning residents of potential waterborne disease that may be associated with swimming or fishing in these facilities.

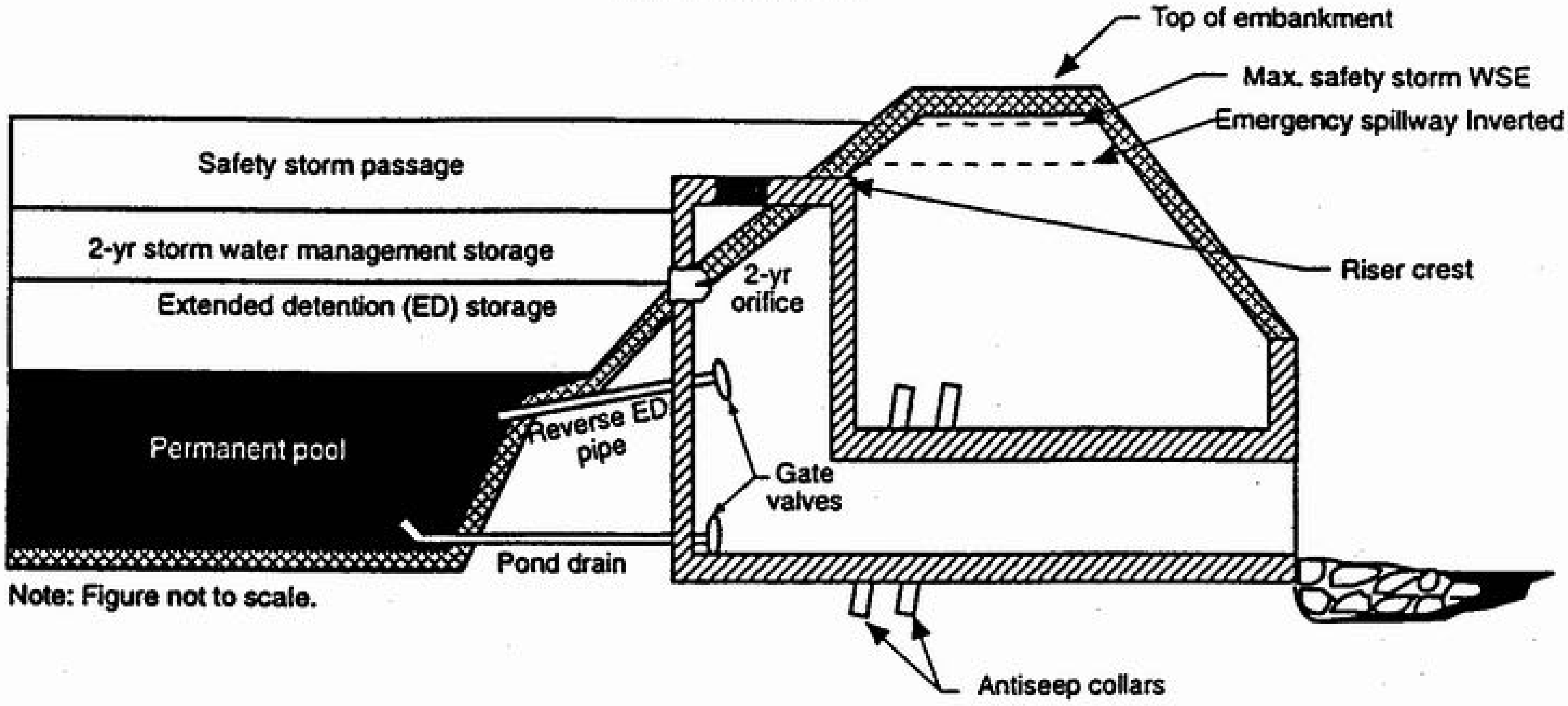
If the pond surface exceeds 20,000 square feet, include a safety bench around the basin with a width of 5 feet, and with a depth not exceeding 1 foot during non-storm periods. Emergent vegetation such as cattails should be placed on the bench to inhibit entry by unauthorized persons.

A fence is required at the maximum water surface elevation, or higher, when a pond slope is a wall. Local governments and homeowners associations may also require appropriate fencing as an additional safety requirement in any event. Native shrubs with thorns may provide a low-cost alternative to fencing, which also enhances natural habitat.

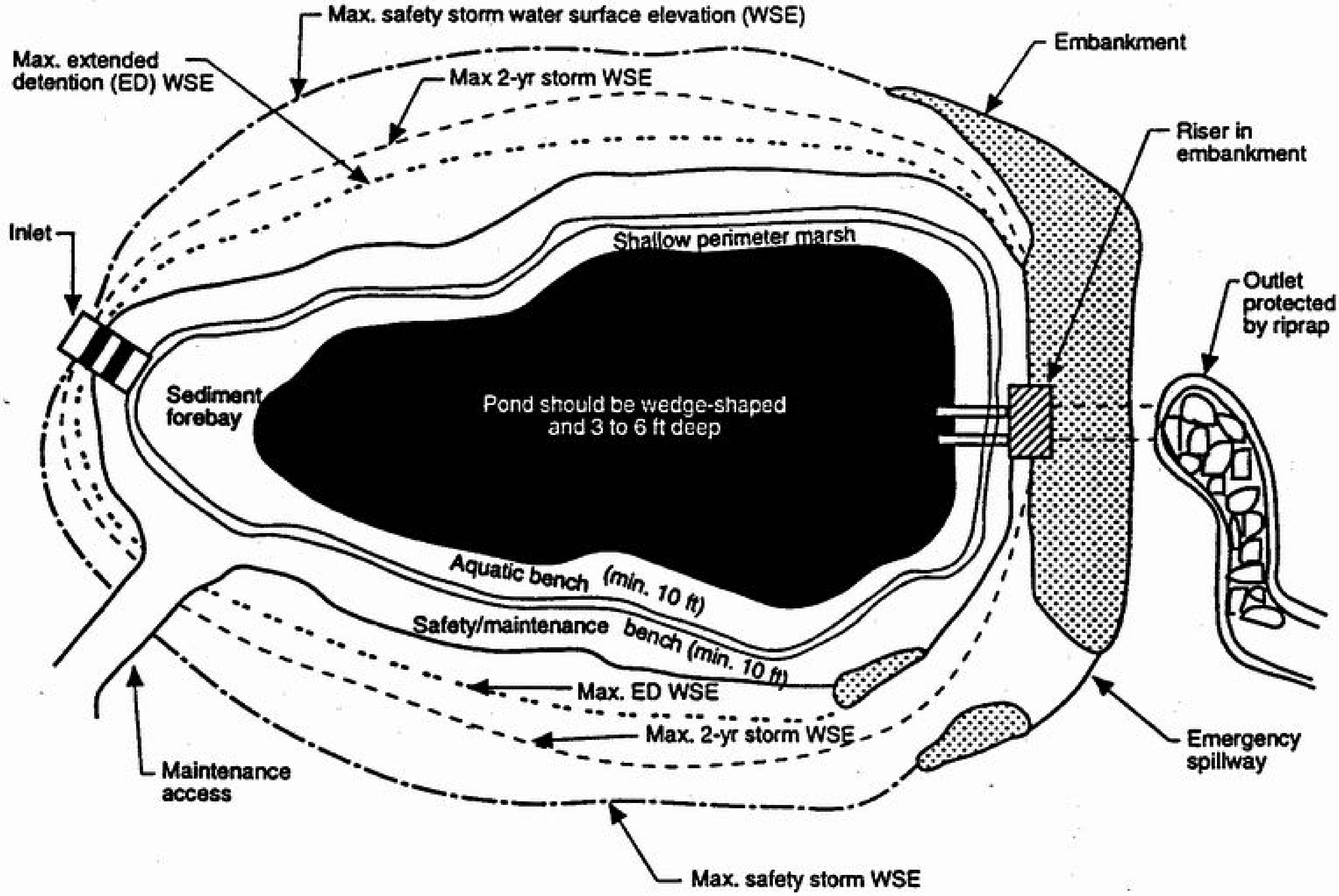
Heavy Metal Contamination

Studies have shown high accumulation rates of lead, zinc, and copper on and near heavily traveled highways and streets. Runoff from highways and streets can be expected to carry significant concentrations of these heavy metals. If a significant portion of the drainage area into a pond consists of highways, streets, or parking areas or other known sources of heavy metal contamination, there is a potential environmental health hazard. In such cases the multiple use functions of the pond should be limited and accessibility should be restricted. Additionally, liners may be required in order to prevent these types of pollutants from migrating into the underlying soil or ground-water system.

Cross Section



Plan View



Comparative Capability of 10 Pond/Wetland Alternatives—Physical, Environmental, and Maintenance Constraints

Pond/Wetland Alternative	Minimum Drainage Area[a]	Space Index[b]	Water Balance	Clogging Risk	Sediment Cleanout	Waters of U.S. (404)	Stream Warming	Safety Risk
1. Conventional dry ponds	5	0.5	No restrictions	Moderate	Basin (10-20 yr)	?	Low	Low
2. Dry ED ponds	10	1.0	No restrictions	High	Basin (10-20 yr)	Yes	Moderate	Low
3. Micropool dry ED ponds	15	1.0	May require base flow	Low	Forebay (2-5 yr)	Yes	Moderate	Low
4. Wet ponds	25+	1.0	Climate	Low	Forebay (2-5 yr)	Yes	High	High
5. Wet ED ponds	25+	1.0	Climate	Low	Forebay (2-5 yr)	Yes	High	High
6. Shallow marsh systems	25+	2.5	Climate, base flow	Low	Forebay (2-5 yr)	Yes	High	Moderate
7. ED wetlands	10+	1.5	Climate, base flow	Low	Forebay (2-5 yr)	?	High	Moderate
8. Pocket wetlands	1-5	2.0	Climate, ground water	Moderate	Basin (5-10 yr)	No	Moderate	Moderate
9. Pocket ponds	1-5	1.0	Climate, ground water	Moderate	Basin (5-10 yr)	No	Moderate	Moderate
10. Pond/marsh systems	25+	1.5	Climate, base flow	Low	Pool (10-15 yr)	Yes	High	High

[a]Maximum of 400 acres in most cases.
[b]Space consumption index (1 = space required for wet pond).

Wet Pond (Nutrients) BMP 12

Description

This BMP is similar to BMP 11— Wet Pond for Conventional Pollutants, but has a shallow marsh area that provides additional treatment of pollutants, especially nutrients. The shallow marsh is contained within the "permanent pool" volume.

Applications

If well planned, wet ponds can meet a variety of objectives. These may include protection of infrastructure and property, improving water quality, and providing recreational opportunities. Due to their marsh areas, wet ponds used for nutrient removal provides greater habitat enhancement than conventional wet ponds. Marsh establishment may be impossible in some arid environments.

In order to serve as a multi-purpose facility, the wet pond should function in such a manner as to be compatible with overall stormwater systems both upstream and downstream. This provides a watershed approach to stormwater management as well as local flood control.

If the wet pond facility is planned as an artificial lake to enhance property values and promote the aesthetic value of the land, pretreatment in the form of landscape retention areas or perimeter swales should be incorporated into the stormwater management facility. If possible, catch basins should be located in grassed areas. By incorporating this "treatment train" concept into the overall collection and conveyance system, the engineer can prolong the utility of these permanently wet installations and improve their appearance. Any amount of runoff waters, regardless how small, that is filtered or percolated along its way to the final detention area can remove oil and grease, metals, and sediment. In addition, this will reduce the annual nutrient load to prevent the wet pond from becoming eutrophic with excessive algal blooms, low oxygen levels, and odor.

The site selection for the nutrient control wetland should consider both the natural topography of the area and property boundaries. Aesthetic and water quality considerations may also dictate locations. The facility will become an integral part of the environment and, therefore, should be designed to be seen as an amenity, if possible. Use of good landscaping principles is encouraged. The planting and preservation of water-tolerant trees and other vegetation should be an integral part of the design of the wet pond and marsh areas of the facility.

In planning new detention facilities, keep in mind that the goal of improved water quality downstream may conflict with certain desired uses of the facility. It is only logical that if the basin is used to remove pollutants, the water quality within the basin itself will be lowered, thus reducing the applicability for uses such as recreation, aesthetics, and natural habitat. If the facility treats runoff from large paved areas, high levels of metals and other pollutants may be trapped in sediments in the facility. Consumption of fish in this situation

should be discouraged.
The design of urban detention facilities should be coordinated with a basin plan for managing stormwater runoff. In a localized situation, an individual property owner can, of course, by his or her actions alone, provide effective assistance to the next owner downstream if no other areas contribute to that owner's problems. However, uncontrolled proliferation of impoundments within a watershed can severely alter natural flow conditions, causing compounded flow peaks or increased flow duration that can contribute to downstream degradation. In addition, upstream impacts due to future land use changes should be considered when designing the structure. Land use planning and regulation may be necessary to preserve the intended function of the impoundment.

Limitations

Drainage area – 5 to 20 ac.
Minimum bedrock depth – 3 ft
NRCS soil type – C, D
Drainage/flood control – yes
Max slope – 5%
Minimum water table – 2 ft
Freeze/thaw – fair

Targeted Pollutants

Sediment – 80%
Phosphorus – 65%
Trace metals
Bacteria
Hydrocarbons

Design Parameters

Site Constraints
The same site constraints apply as in BMP11— Wet Pond (Conventional Pollutants). The primary difference is that a wet pond for nutrient removal requires the establishment of a shallow marsh in order to provide additional treatment of runoff, particularly nutrients. A relatively constant supply of water throughout the summer is necessary as well as a shallower depth. The latter requires that the pond's surface area will need to be greater to contain the same runoff volume.

Marsh Establishment
Establishment of fresh water marshes in ponds can aid in water quality improvement. Marsh areas create a sink for many pollutants with a high degree of water treatment or purification, depending upon the runoff detention time and the availability of wetland plants and aquatic life to assimilate pollutants.

Wetland-associated plants will establish themselves naturally in shallow, wet ponds. It may be beneficial, however, to accelerate marsh establishment by planting appropriate native vegetation in shallow areas. Certain wetland plant species have a greater capacity for pollutant assimilation and are less maintenance intensive than others.

The shallow marsh areas should be planted according to the advice of a wetlands specialist. Nursery sources are recommended wherever possible. Small (2 to 4 inch) containers are encouraged to avoid transporting large amounts of potting soil to the pond. White roots and active basal budding

indicate a healthy stock.
Most wetlands specialists prefer to have someone on site during the construction phase to ensure that the littoral shelf where the marsh plants will be located is positioned and graded properly. Knowing the exact elevation of the normal water level of the facility after construction is essential to the success of the marsh element of the system.

Marsh establishment in facilities that also serve as temporary sediment basins may be difficult during construction due to the need for frequent clean-out of accumulated sediment. Wet ponds should be designed with the need for periodic sediment removal in mind. To continue functioning, marshes also require periodic sediment removal. Sediment should be removed from the deepest parts of the basin where vegetation is sparse. Heavily vegetated areas should be disturbed as little as possible. Overhead scooping equipment works well for dredging selected portions of marsh areas.

Permanent Pool Volume
The permanent pool volume should be equal to the runoff volume of one-third of the 2-year, 24-hour design storm. Review Appendix D for additional information on sizing the detention facility.

Overflows
Detention facility design should take into consideration the possibility of overflows. An overflow device should be installed in all facilities to bypass flows over or around the restrictor system and possibly the marsh portions of the facility. The most common overflow event is snowmelt, but overflows may also result from higher intensity or longer duration storms than the design storm or result from plugged orifices or inadequate storage due to sediment buildup in the facility.

Pond Configuration and Geometry
Wet ponds may be single-celled or multi-celled. The multi-celled version requires more planning and maintenance due to the extra berms involved; however, some studies have shown it to be more effective at pollutant removal. This is especially important, as a sedimentation area will help protect plants in the marsh area from being smothered under excessive sediments.

The total pond area and volume should be consistent with the sizing criteria given in Appendix D, but should be allocated using the following surface area-depth relationship (for the permanent pool volume):

70% of the area @ 2 to 6 feet
30% of the area @ 0 to 2 feet

Liner To Prevent Infiltration
Minimizing fluctuations of the water table is important for successful establishment of marsh vegetation. A nutrient control wet pond should be lined with clay to prevent infiltration rate through the bottom of the pond.

Berm Embankment/Slope Stabilization
Embankment stabilization is similar to that of conventional wet ponds. Exposed earth on the side slopes should be sodded or seeded with the appropriate seed mixture as soon as is practicable. If necessary, geotextile or matting may be used to stabilize slopes while seeding and sodding become established.

Gravity Drain
If vegetation is to be harvested, a gravity drain should be provided similar to that mentioned in BMP 11 Wet Pond (Conventional Pollutants).

Construction Guidelines

Widely acceptable construction standards and specifications such as those developed by the USDA - NRCS or the U.S. Army Corps of Engineers for embankment ponds and reservoirs may aid in building the impoundment. Additional information is also available from the Idaho Transportation Department's Design manual. It is important that appropriate erosion control techniques be used during construction of a wet pond.

Maintenance

Failure of large impoundment structures can cause significant property damage and even loss of life. Only professional engineers registered in the state of Idaho who are qualified and experienced in impoundment design should design such structures. Where they exist, local safety standards for impoundment design should be followed. Impoundment structures should also be regularly inspected for signs of failure, such as seepage or cracks in the berm.

The presence of wet ponds and marshes in established urban areas is perceived by many people to be undesirable. They are often thought of as mud holes where mosquitoes and other insects breed. If the wet pond has a shallow marsh established, the pond can become a welcomed addition to a residential community. Constructed fresh water marshes can provide miniature wildlife refuges, and while insect populations are increased, insect predators also increase, often reducing the problem to a tolerable level. More information about mosquito control can be found in Appendix F. Nevertheless, local government and homeowners associations may wish to drain the ponds during late spring and summer if there if sufficient concern. However, it is imperative that the vegetation in shallow marsh areas not die off during draindown periods; otherwise, the pollutant removal effectiveness of the wet pond can be severely impacted. In addition, the decaying vegetation can create nuisance conditions.

If the facility is a permanent one, some experts suggest harvesting the marsh vegetation in the fall before it dies and releases stored nutrients back into the system. Harvesting should be minimized, especially if heavy equipment is used that will compact the soil. Trash and debris removal should also be done regularly to avoid the facility becoming a convenient dumping ground for trash, construction debris, and yard waste.

Safety, Signage and Fencing
As in BMP 11 Wet Pond (Conventional Pollutants), the use of thorny vegetation as a barrier instead of fencing enhances the habitat aspects of a nutrient removal wet pond.

Heavy Metal Contamination
Studies have shown high accumulation rates of lead, zinc, and copper on and near heavily traveled highways and streets. Runoff from highways and streets can be expected to carry significant concentrations of these heavy metals. If a significant portion of the drainage area into a pond consists of highways, streets, or parking areas or other known sources of heavy metal contamination, there is a potential environmental health hazard. This is of more concern with the nutrient removal wet pond than the conventional pond because of the attractiveness to wildlife of the marsh areas.

Wet Extended Detention Pond BMP 13

Description

A wet extended detention pond combines the pollutant removal effectiveness of a permanent pool of water (see BMP 11 Wet Pond for Conventional Pollutants) with the flow reduction capabilities of an extended storage volume (see BMP 14 Dry Extended Detention Pond).

Applications

Wet extended detention ponds require careful planning in order to function correctly. Throughout the design process the designer should be committed to considering the potential impacts of the completed facility. Generally speaking, the completed facility should provide for safety to people as well as protection of real property, water quality, and wildlife habitats.

Detention system site selection should consider both the natural topography of the area and property boundaries. Aesthetic and water quality considerations may also dictate locations. A storage facility is an integral part of the environment and, therefore, should serve as an aesthetic improvement to the area if possible. Use of good landscaping principles is encouraged. The planting and preservation of desirable trees and other vegetation should be an integral part of the storage facility design.

The two goals of the wet extended pond may limit other uses of the facility, such as enhancing natural habitat. The fluctuating water elevations in the extended detention part of the facility will alternately flood and dry out the soils, making it more difficult to establish plants.

The design of urban detention facilities should be coordinated with a basin plan for managing stormwater runoff. In a localized situation, an individual property owner can, of course, by his or her actions alone, provide effective assistance to the next owner downstream if no other areas contribute to that owner's problems. However, uncontrolled proliferation of impoundments within a watershed can severely alter natural flow conditions, causing compounded flow peaks or increased flow duration that can contribute to downstream degradation. In addition, upstream impacts due to future land use changes should be considered when designing the structure. Land use planning and regulation may be necessary to preserve the intended function of the impoundment.

Limitations

Drainage area – 10 to 50 ac.
Minimum bedrock depth – 3 ft
NRCS soil type – C, D
Drainage/flood control – yes

Max slope – 10%
Minimum water table – 2 ft
Freeze/thaw – good

Targeted Pollutants

Sediment – 80%
Phosphorus – 65%
Trace metals
Bacteria
Hydrocarbons

Design Parameters

Site Constraints
All facilities should be a minimum of 20 feet from any structure, property line, and any vegetative buffer required by the local or state government, 100 feet from any septic tank/drainfield (except wet vaults should be a minimum of 20 feet), and 100 feet from any wells or water supplies.

All facilities should be a minimum of 50 feet from any steep (greater than 15%) slope. A geotechnical report should address the potential impact of a wet pond on a steep slope.

Permanent Pool Volume
The permanent pool volume should be equal to the runoff volume of one-third of the 2-year, 24-hour design storm. Review Appendix D for additional information on sizing the detention facility.

Overflows
Detention facility design should take into consideration the possibility of overflows. An overflow device should be installed in all facilities to bypass flows over or around the restrictor system. The most common overflow event is during snowmelt, but overflows may also result from higher intensity or longer duration storms than the design storm or result from plugged orifices or inadequate storage due to sediment buildup in the facility.

Pond Configuration and Geometry
Wet ponds may be single-celled or multi-celled. The multi-celled version requires more planning and maintenance due to the extra berms involved; however, some studies have shown it to be more effective at pollutant removal. Regardless of the configuration, the total pond area and volume should be consistent with the sizing criteria given in Appendix D.

Long, narrow ponds are preferred, as these are less prone to short-circuiting and tend to maximize available treatment area. The length-to-width ratio should be at least 3:1 and preferably 5:1. The inlet and outlet should be at opposite ends of the pond where feasible. If this is not possible, then berms can be installed to increase the flow path and water residence time. Slightly irregular ponds may perform more effectively and will have a more natural appearance.

Interior side slopes up to the maximum water surface should be no steeper than 3H:1V. Exterior side slopes should be no steeper than 2H:1V. The pond bottom should be level to facilitate sedimentation.

Liner To Prevent Infiltration
Detention BMPs should have a negligible infiltration rate through the bottom of the pond. Infiltration will impair the proper functioning of detention BMPs and can contaminate ground water.

Berm Embankment/Slope Stabilization
Pond embankments higher than 6 feet should require design by a geotechnical-civil engineer licensed in the state of Idaho. For berm embankments of 6 feet or less (including 1 foot freeboard), the minimum top width should be 6 feet or as recommended by the geotechnical-civil engineer.

Pond berm embankments should be constructed on native consolidated soil (or adequately compacted and stable fill soils analyzed by a geotechnical report) free of loose surface soil materials, roots, and other organic debris.

Exposed earth on the side slopes should be sodded or seeded with the appropriate seed mixture as soon as is practicable. If necessary, geotextile or matting may be used to stabilize slopes while seeding and sodding become established.

Gravity Drain
A gravity drain for maintenance should provide an outlet invert of 1 foot above the bottom of the facility and should be sized to drain the facility in 4 hours or less.

Construction Guidelines

Widely acceptable construction standards and specifications such as those developed by the NRCS or the U.S. Army Corps of Engineers for embankment ponds and reservoirs may aid in building the impoundment. Additional information is also available from the Idaho Transportation Department's Design manual.

Maintenance

Failure of large impoundment structures can cause significant property damage and even loss of life. Only professional engineers registered in the state of Idaho who are qualified and experienced in impoundment design should design such structures. Where they exist, local safety standards for impoundment design should be followed. Impoundment structures should also be regularly inspected for signs of failure, such as seepage or cracks in the berm.

The presence of wet ponds and marshes in established urban areas is perceived by many people to be undesirable. They are often thought of as mud holes where mosquitoes and other insects breed. If the wet pond has a shallow marsh established, the pond can become a welcomed addition to a residential community. Constructed fresh water marshes can provide miniature wildlife refuges, and while insect populations are increased, insect predators also increase, often reducing the problem to a tolerable level. More information about mosquito control can be found in Appendix F. Nevertheless, local government and homeowners associations may wish to drain the ponds during late spring and summer if there if sufficient concern. However, it is imperative that the vegetation in shallow marsh areas not die off during draindown periods, otherwise the pollutant removal effectiveness of the wet pond can be severely impacted. In addition, the decaying vegetation can create nuisance conditions.

Safety, Signage and Fencing

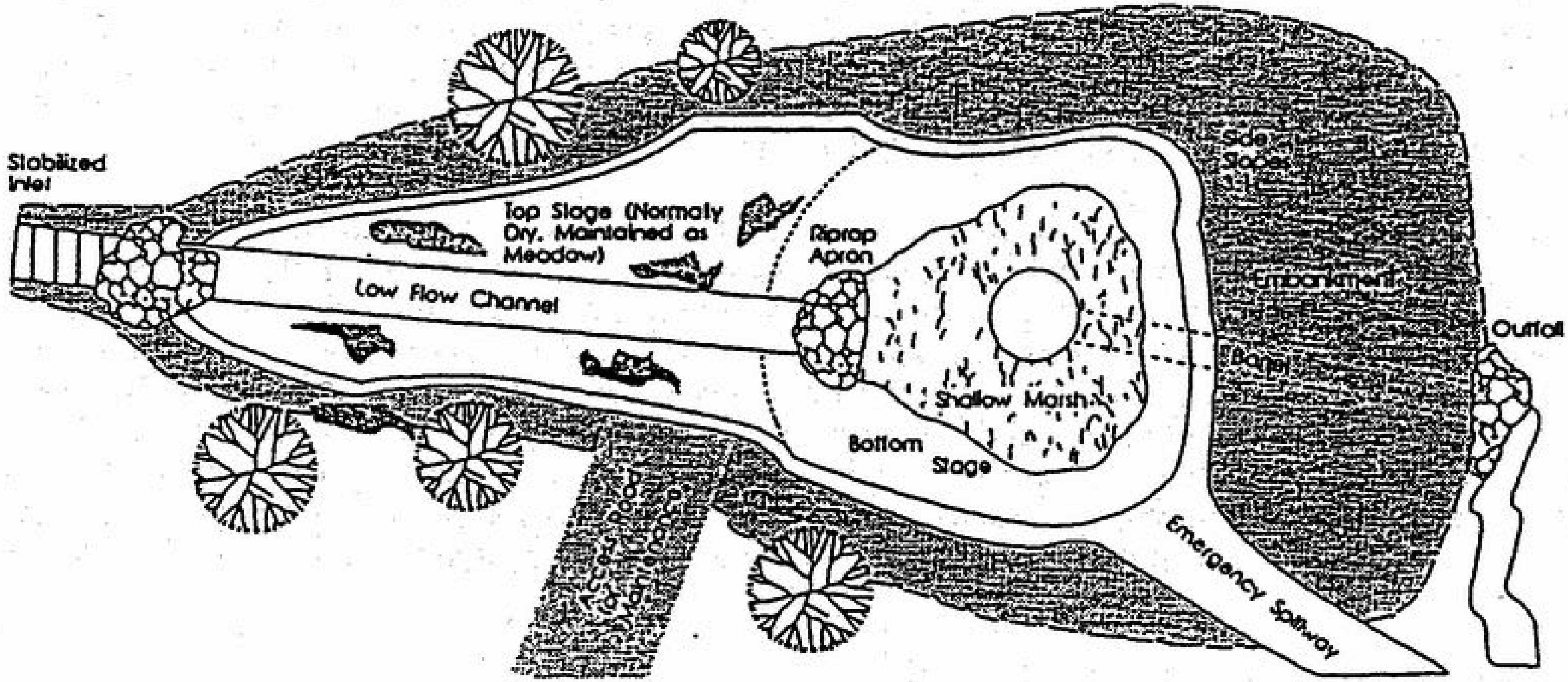
Ponds that are readily accessible to populated areas should incorporate all possible safety precautions. Steep side slopes (steeper than 3H: 1V) at the perimeter should be avoided and dangerous outlet facilities should be protected by enclosure. Warning signs for deep water and potential health risks should be used wherever appropriate. Signs should be placed so that at least one is clearly visible and legible from all adjacent streets, sidewalks or paths. A notice should be posted warning residents of potential waterborne disease that may be associated with swimming or fishing in these facilities.

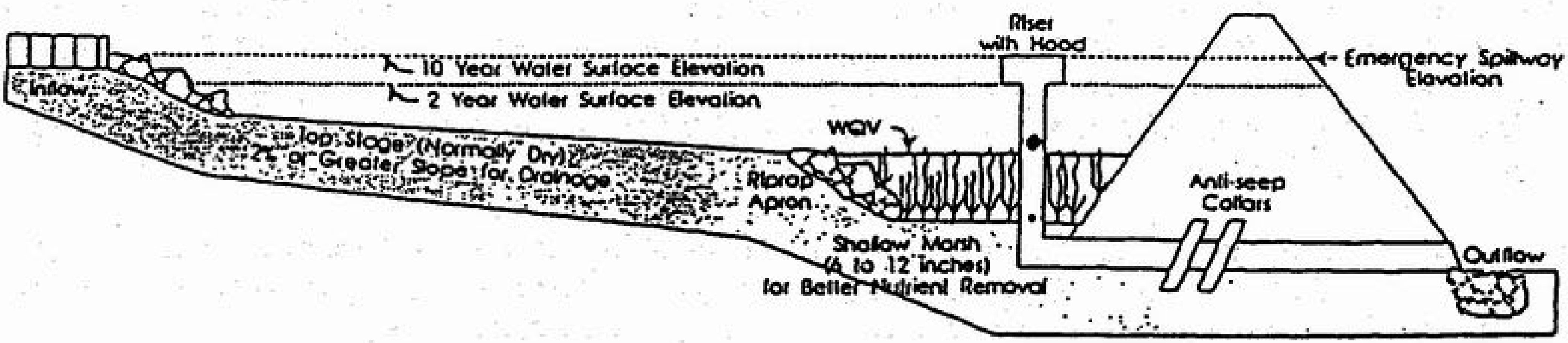
If the pond surface exceeds 20,000 square feet, include a safety bench around the basin with a width of 5 feet, and with a depth not exceeding 1 foot during non-storm periods. Emergent vegetation such as cattails should be placed on the bench to inhibit entry by unauthorized persons.

A fence is required at the maximum water surface elevation, or higher, when a pond slope is a wall. Local governments and homeowners associations may also require appropriate fencing as an additional safety requirement in any event.

Heavy Metal Contamination

Studies have shown high accumulation rates of lead, zinc, and copper on and near heavily traveled highways and streets. Runoff from highways and streets can be expected to carry significant concentrations of these heavy metals. If a significant portion of the drainage area into a pond consists of highways, streets, or parking areas or other known sources of heavy metal contamination, there is a potential environmental health hazard. In such cases the multiple use functions of the pond should be limited and accessibility should be restricted. Additionally, liners may be required in order to prevent these types of pollutants from migrating into the underlying soil or ground-water system.


Stabilized Inlet
Top Stage (Normally Dry, Maintained as Meadow)
Low Flow Channel
Riprap Apron
Side Slopes
Embankment
Outfall
Barrel
Shallow Marsh
Bottom Stage
Emergency Spillway


Riser with Hood
10 Year Water Surface Elevation
2 Year Water Surface Elevation
Emergency Spillway Elevation
Inflow
Top Stage (Normally Dry) 2% or Greater Slope for Drainage
WQV
Riprap Apron
Anti-seep Collars
Shallow Marsh (6 to 12 Inches) for Better Nutrient Removal
Outflow

Dry Extended Detention Pond — BMP 14

Description

Dry extended detention ponds do not maintain a permanent pool between storm events. Outlets are designed to detain the volume of a water quality design storm for a minimum (usually 48 hours) to allow for the settling of particles and associated pollutants. In addition, dry extended detention ponds provide flood control by including additional temporary storage for peak flows above the dead storage. Extended detention ponds are also capable of managing smaller floods that contribute to channel erosion problems and occur more frequently than the annual or 2-year flood.

Applications

Dry extended detention ponds require careful planning in order to function correctly. Of critical importance is prediction of flow volumes and the design of an outlet structure to drain slowly enough to provide some water quality benefits but rapidly enough to be empty for the next storm. Since it drains completely between storms, the first flush of the next storm tends to resuspend sediments deposited during the last.

Dry ponds often serve multiple purposes. In addition to flood control and water quality benefits, the pond may be used for recreation, such as a playground or picnic area, when dry. Thus, aesthetic considerations are important in siting dry ponds. Use of good landscaping principles is encouraged. The planting and preservation of desirable trees and other vegetation should be an integral part of the storage facility design.

The design of urban detention facilities should be coordinated with a basin plan for managing stormwater runoff. In a localized situation, an individual property owner can, of course, by his or her actions alone, provide effective assistance to the next owner downstream if no other areas contribute to that owner's problems. However, uncontrolled proliferation of impoundments within a watershed can severely alter natural flow conditions, causing compounded flow peaks or increased flow duration that can contribute to downstream degradation. In addition, upstream impacts due to future land use changes should be considered when designing the structure. Land use planning and regulation may be necessary to preserve the intended function of the impoundment.

Limitations

Drainage area – 10 to 50 ac.
Minimum bedrock depth – 6 ft
NRCS soil type – A, B, C
Drainage/flood control – yes

Max slope – 10%
Minimum water table – 4 ft
Freeze/thaw – good

Targeted Pollutants

Sediment – 45%
Phosphorus – 35%
Trace metals

Hydrocarbons

Design Parameters

Site Constraints

For dry ponds, constraints are similar to wet ponds. Since the dry pond does not permanently store a pool of water, it has some potential for locations that are inappropriate for wet ponds. However, a geotechnical report should be completed if any restrictions are to be relaxed, especially if a high infiltration rate is expected.

Pool Volume

The permanent pool volume should be equal to the runoff volume of one-third of the 2-year, 24-hour design storm. Review Appendix D for additional information on sizing the detention facility.

Overflows

Detention facility design should take into consideration the possibility of overflows. An overflow device should be installed in all facilities to bypass flows over or around the restrictor system. The most common overflow event is during snowmelt, but overflows may also result from higher intensity or longer duration storms than the design storm or result from plugged orifices or inadequate storage due to sediment buildup in the facility.

Pond Configuration and Geometry

Dry ponds are normally single-celled. The total pond area and volume should be consistent with the sizing criteria given in Appendix D.

Long, narrow ponds are preferred, as these are less prone to short-circuiting and tend to maximize available treatment area. The length-to-width ratio should be at least 3:1 and preferably 5:1. The inlet and outlet should be at opposite ends of the pond where feasible. If this is not possible, then berms can be installed to increase the flow path and water residence time. Slightly irregular ponds may perform more effectively and will have a more natural appearance.

Interior side slopes should be no steeper than 3H: 1V. Exterior embankment slopes should be 2H: 1V or less. The pond bottom should have a 2% slope to allow complete drainage. A low flow channel should run from inlet to outlet as well to route the last remaining runoff, dry weather flow and ground water to the permanent pool and outlet. These channels should be installed in the upper stage of the basin to ensure that the basin dries out completely. Low flow channels also serve to prevent erosion of the upper stage of the pond outside as runoff first enter the pond.

Berm Embankment/Slope Stabilization

Pond embankments higher than 6 feet should require design by a geotechnical-civil engineer licensed in the state of Idaho. For berm embankments of 6 feet or less (including 1 foot freeboard), the minimum top width should be 6 feet or as recommended by the geotechnical-civil engineer.

Pond berm embankments should be constructed on native consolidated soil (or adequately compacted and stable fill soils analyzed by a geotechnical report) free of loose surface soil materials, roots and other organic debris.

Exposed earth on the side slopes and bottom should be seeded with the appropriate seed mixture as soon as is practicable. If necessary, geotextile or matting may be used to stabilize slopes while seeding and sodding become established.

Construction Guidelines

Widely acceptable construction standards and specifications such as those developed by the NRCS or the U.S. Army Corps of Engineers for embankment ponds and reservoirs may aid in building the impoundment. Additional information is also available from the Idaho Transportation Department's Design manual.

Maintenance

Failure of large impoundment structures can cause significant property damage and even loss of life. Only professional engineers registered in the state of Idaho who are qualified and experienced in impoundment design should design such structures. Where they exist, local safety standards for impoundment design should be followed. Impoundment structures should also be regularly inspected for signs of failure, such as seepage or cracks in the berm.

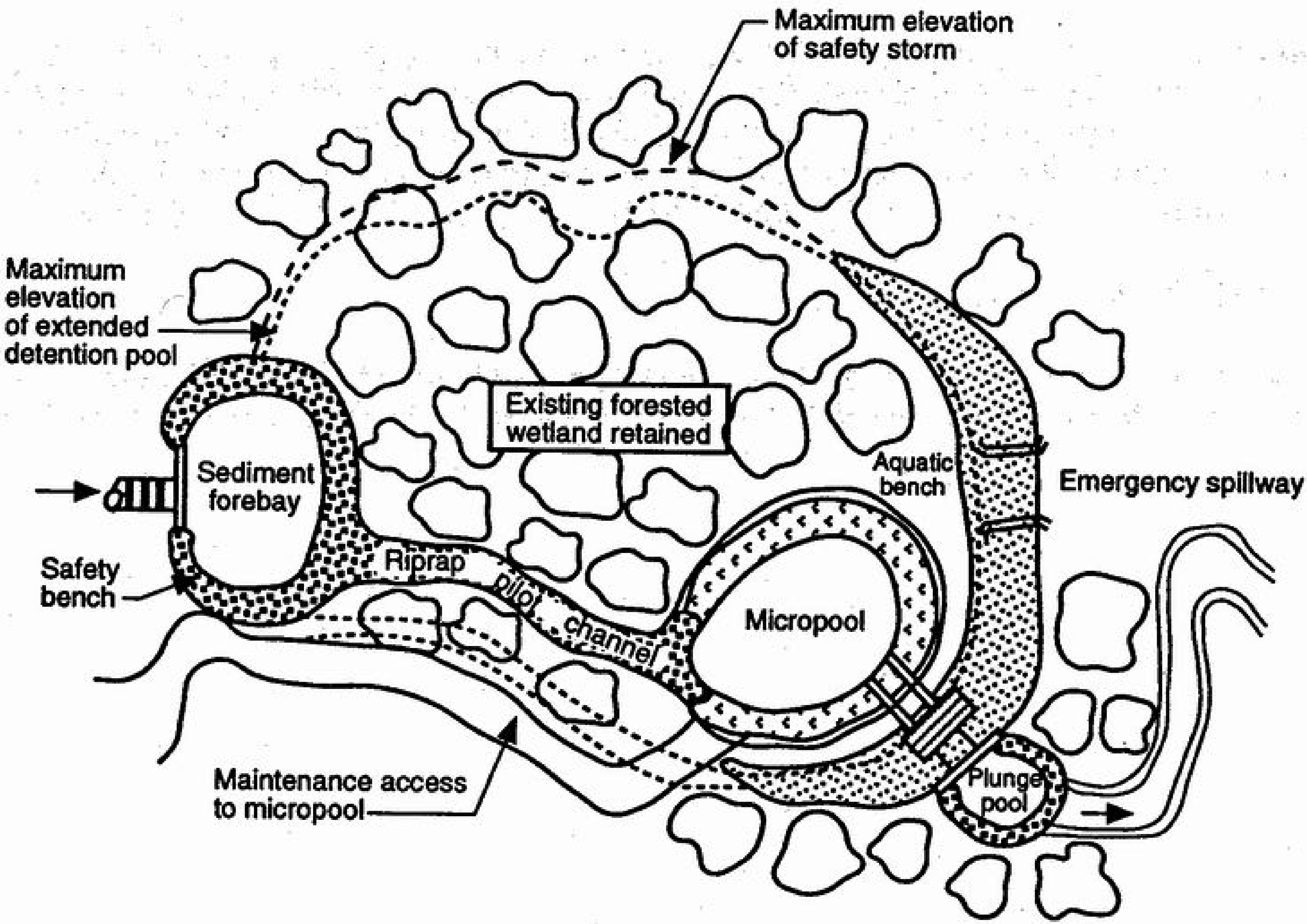
If used for recreational purposes between rain events, the dry pond will require regular maintenance, such as mowing. Activities involving intense use resulting in bare soil, such as soccer fields should be discouraged. Any exposed soil should be promptly revegetated with sod or seed.

Safety, Signage and Fencing

Ponds that are readily accessible to populated areas should incorporate all possible safety precautions. Steep side slopes (steeper than 3H: 1V) at the perimeter should be avoided and dangerous outlet facilities should be protected by enclosure. Warning signs should be used wherever appropriate. In the case of dry ponds, posted signs may help prevent calls about the flooded playground. Signs should be placed so that at least one is clearly visible and legible from all adjacent streets, sidewalks or paths.

Heavy Metal Contamination

Dry ponds are less likely to build up excessive levels of heavy metals from sediments washed off impervious areas than wet ponds. Routine maintenance should remove any significant sediment deposits.


Maximum elevation
of safety storm
Maximum
elevation
of extended
detention pool
Existing forested
wetland retained
Sediment
forebay
Aquatic
bench
Emergency spillway
Safety
bench
Riprap
pilot
channel
Micropool
Plunge
pool
Maintenance access
to micropool

Biodetention Basin BMP 15

Description

A biodetention basin is an artificial wetland intentionally constructed on a non-wetland site for the purpose of managing stormwater runoff. The primary function of a biodetention basin is to provide runoff treatment of both conventional pollutants and nutrients, using a permanent pool of water that has extensive shallow marsh area. A secondary function is to provide recreational opportunities, wildlife habitat, and to be an aesthetic amenity.

Applications

A well-planned biodetention basin can meet a variety of objectives. These may include protection of infrastructure and property, improving water quality, and providing recreational opportunities. Due to their emphasis on vegetation, biodetention basins provide greater habitat enhancement than conventional wet ponds.

In order to serve as a multi-purpose facility the biodetention basin should function in such a manner as to be compatible with overall stormwater systems both upstream and downstream. This provides a watershed approach to stormwater management as well as local flood control.

In planning biodetention basins, it should be kept in mind that the goal of improved water quality downstream may conflict with certain desired uses of the facility. It is only logical that if the biodetention basin is used to remove pollutants, the water quality within the biodetention basin itself will be lowered, thus reducing the applicability for uses such as recreation, aesthetics, and natural habitat. If the facility treats runoff from large paved areas, high levels of metals and other pollutants may be trapped in sediments in the facility.

Limitations

Drainage area – 25 to 50 ac.
Minimum bedrock depth – 3 ft
NRCS soil type – C, D
Drainage/flood control – yes
Max slope – 5%
Minimum water table – 2 ft
Freeze/thaw – fair

Targeted Pollutants

Sediment – 75%
Phosphorus – 45%
Trace metals
Bacteria
Hydrocarbons

Design Parameters

Site Constraints

Many of the same site constraints apply as in BMP 11, Wet Pond (Conventional Pollutants). The primary difference is that a biodetention basin is much shallower, requiring a greater surface area to contain the desired runoff volumes. A constant supply of water throughout the summer is necessary as well as a shallower depth.

The following hydrologic factors need to be considered to ascertain whether the site being considered is suitable for a biodetention basin:

- Flow. A careful hydrologic analysis of flow is needed to determine depth-area relationships. A qualified professional should do this before construction of the biodetention basin. Excessive fluctuations in water level should be avoided.
- Climatic Conditions. Overall climatic conditions determine the types of plants that may be used and the seasonality of flow rates.
- Ground-water Conditions and Soil Permeability. Permeable soils may require that a biodetention basin be lined.

Biodetention Basin Configuration and Geometry
The biodetention basin volume should be equal to the runoff volume of one-third of the 2-year, 24-hour design storm. Review Appendix D for additional information on sizing detention facilities.

A forebay, a deeper area where sediments can settle out, should be established along the biodetention basin inflow points to capture sediment. The forebay should have a water depth of about 3 feet and may occupy up to 25% of the normal pool area.

A biodetention basin has different surface area-pool relationships than a wet pond:

50% of the area = 0.5 feet (approximately)
15% of the area @ 0.5 to 1 foot
15% of the area @ 2 to 3 feet
20% of the area 3+ feet deep with a maximum of 6 feet

Soil
The soil in which the vegetation is planted should be appropriate for the plants selected. Either soil tests indicating the adequacy of the soil or a soil enhancement plan should be submitted with the overall biodetention basin design.

To maintain a permanent pool of water in a biodetention basin, inflow from stormwater, baseflow, and ground water should be greater than outflow via infiltration, evapotranspiration, and discharge. If the rate of infiltration is high and a permanent pool cannot be maintained, a clay liner (or equivalent) will be necessary. The discharge rate may also be reduced to increase residence time.

The soil substrate should, however, be soft enough to permit easy insertion of the plants. If the basin soil is compacted or vegetation has formed a dense root mat, the upper 6 inches of soil should be disced prior to plating. If soil is brought in, it needs to be laid at least 4 inches deep in order to provide sufficient depth for plant rooting. Soil may be taken from a wetland or from ditch cleaning operations if available. However, if this type of soil is used, the plant species composition may be influenced by volunteer vegetation. Studies have shown up to 32,430 seeds per square meter in marsh soils. Enriching non-wetland soils with organic matter seems to increase vegetative yields.

Vegetation Establishment
Wetland-associated plants will establish themselves naturally in shallow, wet ponds. It may be beneficial, however, to accelerate marsh establishment by planting appropriate native vegetation in shallow areas. Certain wetland plant species have a greater capacity for pollutant assimilation and are less maintenance intensive than others.

Artificial establishment of vegetation is done to influence future plant species composition and to establish a vegetated marsh as quickly as possible. Complete coverage and optimum treatment potential can often take 5 years or more. Biodetention basins with a smaller vegetative cover can still significantly reduce pollution.

Selection of vegetation needs to be done by a wetlands specialist. The selection will be based on climate, hydroperiod of the biodetention basin, sensitivity to pollution, and aesthetic appeal. The detrimental effects of wind, waves, and water currents will also need to be taken into account. A well-planned biodetention basin will also need a diverse mixture of floating, emergent and submergent plants. Above all, the plants will need to be able to withstand the pollutant concentration of the incoming water and tolerate some fluctuation in the water level of the biodetention basin.

Marsh establishment in facilities that also serve as temporary sediment basins may be difficult during construction due to the need for frequent clean-out of accumulated sediment. Wet ponds should be designed with the need for periodic sediment removal in mind. To continue functioning, marshes also require periodic sediment removal. Sediment should be removed from the deepest parts of the basin where vegetation is sparse. Heavily vegetated areas should be disturbed as little as possible. Overhead scooping equipment works well for dredging selected portions of marsh areas.

Wildlife
The species of vegetation chosen should maximize heterogeneity and value to all types of wildlife. Although not required, measures to further enhance habitat for wildlife are encouraged. Maximizing vegetation density around the biodetention basin will discourage the entry of domestic animals that would prey on wildlife. In larger biodetention basins, provision of an island for nesting birds is encouraged.

Overflows
Detention facility design should take into consideration the possibility of overflows. An overflow device should be installed in all facilities to bypass flows over or around the restrictor system and possibly the marsh portions of the facility. The most common overflow event is snowmelt, but overflows may also result from higher intensity or longer duration storms than the design storm or result from plugged orifices or inadequate storage due to sediment buildup in the facility.

Biodetention basins are better at polishing water quality than they are at lessening flooding problems.

Gravity Drain
If vegetation is to be harvested, a gravity drain should be provided.

Construction Guidelines

Widely acceptable construction standards and specifications such as those developed by the NRCS or the U.S. Army Corps of Engineers for embankment ponds and reservoirs may aid in building the impoundment. Additional information is also available from the Idaho Transportation Department's Design manual.

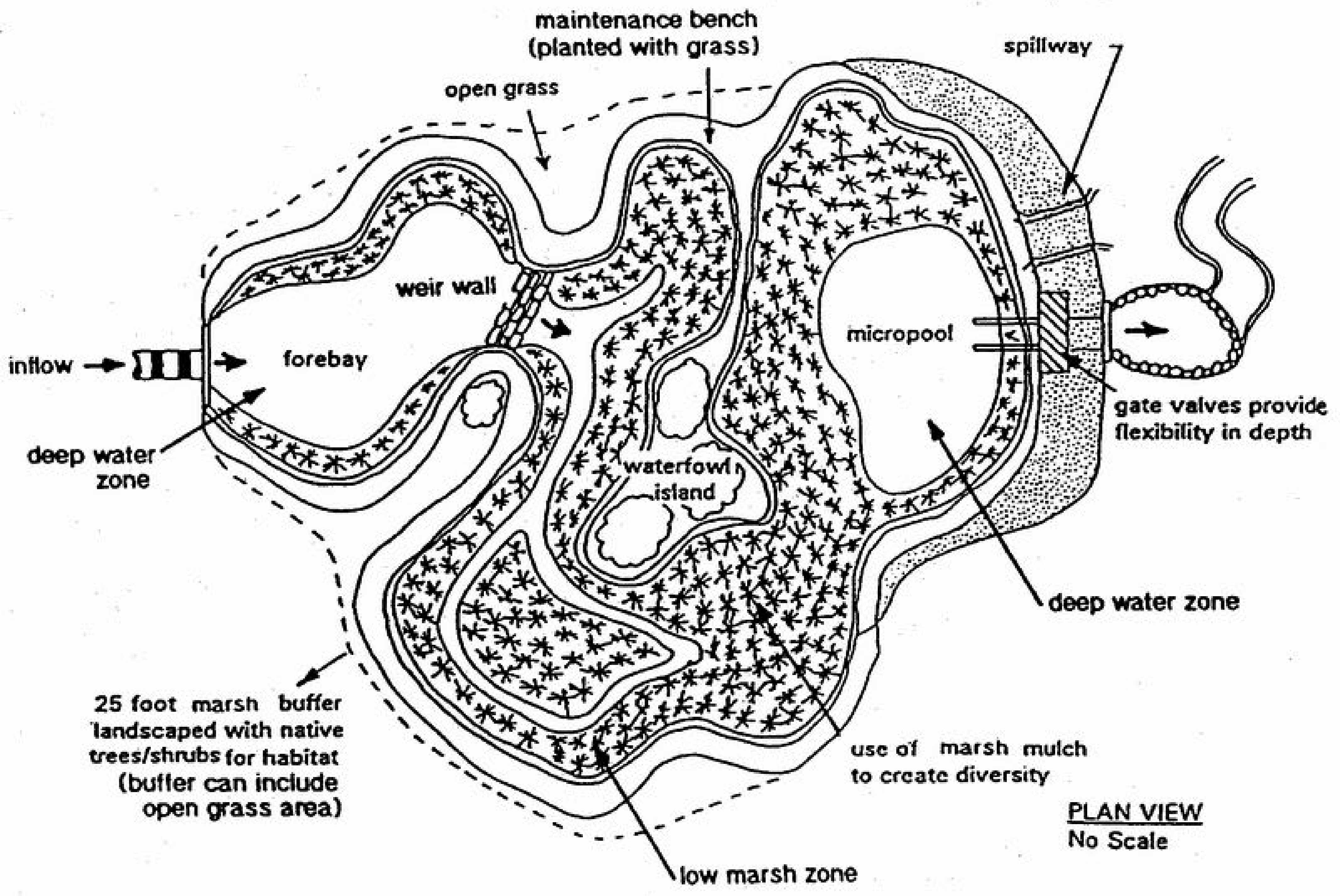
Maintenance

The presence of wetlands in established urban areas is perceived by many people to be undesirable. They are often thought of as mud holes where mosquitoes and other insects breed. Due to its ability to attract wildlife, the biodetention basin can become a welcomed addition to a residential community. Constructed fresh water marshes can provide miniature wildlife refuges, and while insect populations are increased, insect predators also increase, often reducing the problem to a tolerable level. More information about mosquito control can be found in Appendix F. Nevertheless, local government and homeowners associations may wish to drain the ponds during late spring and summer if there if sufficient concern. However, it is imperative that the vegetation in shallow marsh areas not die off during draindown periods; otherwise, the pollutant removal effectiveness of the wet pond can be severely impacted. In addition, the decaying vegetation can create nuisance conditions.

If the facility is a permanent one, some experts suggest harvesting the marsh vegetation in the fall before it dies and releases stored nutrients back into the system. Harvesting should be minimized, especially if heavy equipment is used that will compact the soil. Trash and debris removal should also be done regularly to avoid the facility becoming a convenient dumping ground for trash, construction debris, and yard waste. Ensure that an access road is included and can withstand the weight of heavy equipment.

Safety, Signage and Fencing
As in BMP 11 Conventional Wet Ponds, the use of thorny vegetation as a barrier instead of fencing enhances the habitat aspects of a biodetention basin.

Heavy Metal Contamination
Studies have shown high accumulation rates of lead, zinc, and copper on and near heavily traveled highways and streets. Runoff from highways and streets can be expected to carry significant concentrations of these heavy metals. If a significant portion of the drainage area into the biodetention basin consists of highways, streets, or parking areas or other known sources of heavy metal contamination, there is a potential environmental health hazard. This is of more concern with the biodetention basin than the conventional wet pond because of the attractiveness to wildlife of the marsh areas.



maintenance bench
(planted with grass)
spillway
open grass
weir wall
micropool
inflow
forebay
deep water
zone
gate valves provide
flexibility in depth
waterfowl
island
deep water zone
25 foot marsh buffer
landscaped with native
trees/shrubs for habitat
(buffer can include
open grass area)
use of marsh mulch
to create diversity
PLAN VIEW
No Scale
low marsh zone

Presettling/Sedimentation Basin BMP 16

Description

A presettling basin provides pretreatment of runoff in order to remove suspended solids that can impact other primary treatment BMPs. A presettling basin has no "permanent pool" volume; runoff is detained so that particulates can settle out before being discharged to another BMP. Runoff treated by a presettling basin should be further treated by a water quality filtration BMP, a wet pond-type BMP, or a biofilter. Presettling basins may need to be located "off-line" from the primary conveyance/detention system if used to protect infiltration or filtration BMPs from siltation.

Applications

Presettling basins basically fill one purpose: to protect more sensitive downstream facilities such as wetlands, from excessive sediment loads. Little effort is put on landscaping. The emphasis is on access for maintenance. Presettling basins are often constructed of concrete for easier sediment removal by heavy equipment. Presettling basin remove little or no pollutants besides those directly associated with sediments, such as some of the metals.

Limitations

Drainage area – 10+ ac.
Minimum bedrock depth – 3 ft
NRCS soil type – C, D
Drainage/flood control – no
Max slope – 10%
Minimum water table – 2 ft
Freeze/thaw – good

Targeted Pollutants

Sediment – 60%
Phosphorus – 30%
Trace metals

Design Parameters

Site Constraints
Constraints are similar to wet ponds. Presettling basins tend to be smaller in size, however, and are easier to fit into small spaces.

Pool Volume
The temporary pool volume should be equal to the runoff volume of one-third of the 2-year, 24-hour design storm. Review Appendix D for additional information on sizing the detention facility.

Pond Configuration and Geometry
Presettling basins are normally single-celled. The total pond area and volume should be consistent with the sizing criteria given in Appendix D. If possible, a long, narrow basin is preferred, as this is less prone to short-circuiting and tends to maximize available treatment area. The length-to-width ratio should be at least 3:1 and preferably 5:1. The inlet and outlet should be at opposite ends of the pond where feasible. If this is not possible, then baffles can be installed to increase the flow path and water residence time.

Interior side slopes may be vertical, if concrete. Otherwise, they should be no steeper than 3H: 1V. Exterior embankment slopes should be 2H: 1V or less. The bottom of the basin should have a 2% slope to allow complete drainage.

Berm Embankment/Slope Stabilization
If a basin has embankments higher than 6 feet should require design by a geotechnical-civil engineer licensed in the state of Idaho. For berm embankments of 6 feet or less (including 1 foot freeboard), the minimum top width should be 6 feet or as recommended by the geotechnical-civil engineer.

Pond berm embankments should be constructed on native consolidated soil (or adequately compacted and stable fill soils analyzed by a geotechnical report) free of loose surface soil materials, roots and other organic debris.

Exposed earth on the side slopes and bottom should be sodded or seeded with the appropriate seed mixture as soon as is practicable. If necessary, geotextile or matting may be used to stabilize slopes while seeding and sodding become established.

Inlet Structure and Isolation/Diversion Structure
The inlet structure design should be adequate for isolating the water quality volume (i.e., runoff volume from the 6-month, 24-hour storm) from the larger design storms and to convey the peak flows for the larger design storms past the basin. The water quality volume should be discharged uniformly and at low velocity into the presettling basin in order to maintain near quiescent conditions that are necessary for effective treatment. It is desirable for the heavier suspended material to drop out near the front of the basin; thus, a drop inlet structure is recommended in order to facilitate sediment removal and maintenance. Energy dissipation devices may be necessary in order to reduce inlet velocities that exceed 3 feet per second.

Off-line Isolation/Diversion Structure
Presettling basins may need to be located off-line when used to protect filtration BMPs from siltation. Off-line systems are designed to capture and treat one-third of the 2-year, 24-hour design storm; this is typically achieved by using isolation/diversion baffles and weirs. A typical approach for achieving isolation of the water quality volume is to construct an isolation/diversion weir in the stormwater channel such that the height of the weir equals the maximum height of the water in the downstream facility during the water quality storm. When additional runoff greater than the water quality storm enters the stormwater channel, it will spill over the isolation/diversion weir and mixing with the already isolated water quality volume will be minimal.

Outlet Structure
The outlet structure conveys the water quality volume from the presettling basin to the primary treatment BMP (e.g., wetland, sand filtration basin). A perforated pipe or equivalent is the recommended outlet structure. The 24-hour

drawdown time should be achieved by installing a throttle plate or other flow control device at the end of the riser pipe (the discharges through the perforations should not be used for drawdown time design purposes).
A trash rack should be provided for the outlet. Openings in the rack should not exceed one-third the diameter of the vertical riser pipe. The rack should be made of durable material, resistant to rust, and ultraviolet rays. The bottom rows of perforations of the riser pipe should be protected from clogging. To prevent clogging of the bottom perforations it is recommended that geotextile be wrapped over the pipe's bottom rows and that a cone of 1 to 3 inch diameter gravel be placed around the pipe. If a geotextile is not used then the gravel cone should not include any gravel small enough to enter the riser pipe perforations.

Overflows
Presettling basin design should take into consideration the possibility of overflows. An overflow device should be installed in all facilities to bypass flows over or around the restrictor system. The most common overflow event is during snowmelt, but overflows may also result from higher intensity or longer duration storms than the design storm or result from plugged orifices or inadequate storage due to sediment buildup in the facility.

Construction Guidelines

Widely acceptable construction standards and specifications such as those developed by the NRCS or the U.S. Army Corps of Engineers for embankment ponds and reservoirs may aid in building the impoundment. Additional information is also available from the Idaho Transportation Department's Design manual.

Maintenance

Failure of large impoundment structures can cause significant property damage and even loss of life. Only professional engineers registered in the state of Idaho who are qualified and experienced in impoundment design should design such structures. Where they exist, local safety standards for impoundment design should be followed. Impoundment structures should also be regularly inspected for signs of failure, such as seepage or cracks in the walls or berm. Include an access road in the design and ensure that it can handle the weight of heavy equipment.

Safety, Signage and Fencing
Basins that are readily accessible to populated areas should incorporate all possible safety precautions. Dangerous outlet facilities should be protected by enclosure. Warning signs should be used wherever appropriate. In the case of dry ponds, posted signs may help prevent calls about the flooded playground. Signs should be placed so that at least one is clearly visible and legible from all adjacent streets, sidewalks or paths.

Heavy Metal Contamination
Presettling basins are less likely to build up excessive levels of heavy metals from sediments washed off impervious areas than wet ponds. Routine maintenance should remove and properly dispose of any significant sediment deposits.

Wet Vault/Tank BMP 17

Description

Wet vaults and tanks are on-line underground facilities used for the storage of surface water and are typically constructed from reinforced concrete (vaults) or corrugated pipe (tanks). A wet vault has a temporary and permanent water pool and may also have a constructed outlet that causes a temporary rise of the water level during each storm.

The water that is captured in these vaults and tanks may be used later for irrigation of parking strips, common areas, and general landscaping activities. Wet vaults and tanks are typically concrete or structural facilities designed to provide runoff treatment through the use of a permanent pool of water.

Limitations

Drainage area – 5 ac.	Max slope – 15%
Minimum bedrock depth – 12 ft	Minimum water table – 12 ft
NRCS soil type – A, B, C	Freeze/thaw – fair
Drainage/flood control – yes	

Wet vaults/tanks cannot provide the equivalent level of treatment accomplished by wet ponds and constructed wetlands because neither biological uptake nor vegetative filtration are available as pollutant removal mechanisms; however, re-use of stormwater runoff for landscaping purposes does provide a beneficial nutrient treatment mechanism. Gravity settling of suspended solids is the primary removal mechanism but vaults/tanks are unlikely to be as effective as open ponds in removing particulates because little or no soil layer exists in which to permanently stabilize trapped sediments.

Also, being underground, vaults and tanks are more difficult to inspect and maintain. Therefore, they should only be permitted for use on small sites, and then only after it has been demonstrated to the satisfaction of the local government that more desirable BMPs are not practicable.

Wet vaults/tanks should be a minimum of 20 feet from any structure, property line, and from any septic tank. Wet vaults/tanks should be a minimum of 100 feet from any domestic well or natural spring. All facilities should be a minimum of 50 feet from any steep slope. A geotechnical report should address the potential impact on a steep slope.

Targeted Pollutants

Sediment – 60%
Phosphorus – 30%
Trace metals

Design Parameters

The design volumes for a wet vault/tank should be the same as for BMP 11, Wet Pond-Conventional Pollutants.

Forebay
The vault should be divided into 2 cells using a baffle, with the first cell, the

forebay, occupying about 25% of the area. The top of the baffle wall should be coincident with the depth of the permanent pool.

Construction Guidelines

Selected guidelines were excerpted from the Idaho Transportation Department (ITD) catalog of BMPs (July, 1994). ITD materials should be consulted for more detailed construction guidelines.

Materials

- Vaults: Minimum 3,000 pounds per square inch structural reinforced concrete. All construction joints should be provided with water stops. A structural engineer should design pre-cast vaults.
- Tank: Pipe material, joints, and protective treatment for tanks should be in accordance with Idaho State Department of Transportation (ISDOT) standards and specifications, and AASHTO designations as noted below:

Structural Stability

- Vaults: All vaults should meet structural requirements for overburden support and HS-20 traffic loading. Cast-in-place wall sections should be designed as retaining walls. A structural engineer licensed in the state of Idaho should stamp all structural designs. Structural designs for cast-in-place vaults may require a separate commercial building permit from the local government. Vaults should be placed on native material with suitable bedding. Vaults should not be allowed in fill slopes unless analyzed in a geotechnical report for stability and construction practices.
- Tanks: All tanks should meet structural requirements for overburden support and traffic loading, if appropriate. HS-20 live loads should be accommodated for tanks lying under roadways or parking areas. Metal tank end plates should be designed for structural stability at maximum hydrostatic loading conditions. Flat end plates generally require thicker gauge material than the pipe and/or require reinforcing ribs. Tanks should be placed on native material with suitable bedding. Tanks should not be allowed in fill slopes.

Buoyancy

Tanks: In moderately pervious soils where seasonal ground water may induce flotation, buoyancy tendencies should be balanced by ballasting with either backfill or concrete backfill, providing concrete anchors, increasing the total weight, or by providing subsurface drains to permanently lower the ground-water table. Calculations should be submitted which demonstrate stability.

Minimum Access Requirements

- Vaults: Provide one access cover per 50 feet of length or width and at least one access cover with ladder to the bottom of the vault per cell. The minimum internal height should be 7 feet and the minimum width should be 4 feet. The maximum depth to the vault invert should be 20 feet. (Note: concrete vaults may be a minimum of 3 feet in height and width if used as tanks with access manholes at each end).
- Tanks: The maximum depth to the bottom of the tank should be 20 feet. Spacing between access openings for tanks should not exceed 100 feet.

All tank access openings should be readily accessible by maintenance vehicles.

Locking Lids
All vault access openings should have round, solid, locking lids using 0.5- inch diameter allen head screw locks.

Maintenance

Access Roads
Access roads are required to at least one access cover for each cell. The access roads should meet the requirements for access roads described in the maintenance details for wet ponds.

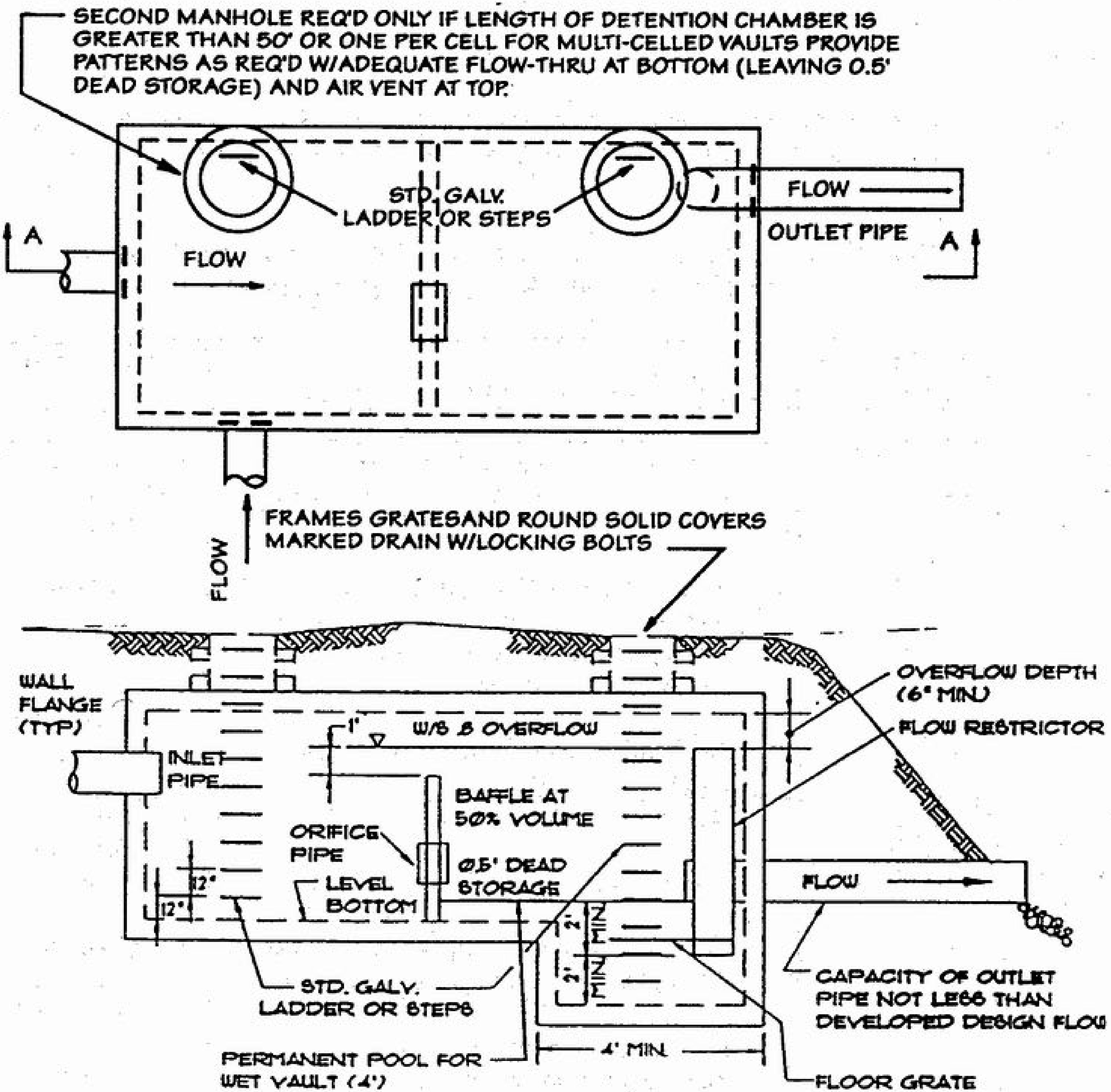
Vaults should be inspected regularly and maintenance performed as indicated in Table 7-1 below.

Table 17-1. Specific Maintenance Requirements for Detention Vaults/Tanks (Stormwater Management Manual, Puget Sound Basin)

Defect	**Maintenance Component**	**Conditions When Maintenance is Needed**	**Results Expected When Maintenance is Performed**
I. Storage Area - Plugged air vents	Debris and sediment	One-half of the end area of a vent is blocked at any point with debris and sediment. Accumulated sediment depth is 10% of the diameter of the storage area for one-half the length of the storage vault or any point exceeds 15% of the diameter. Any crack allowing material to be transported into the facility.	All sediment and debris removed from storage area. Vents free of debris and sediment. All joints between tank/pipe sections are sealed.
II. Manhole cover not in place	Locking mechanism not working	Cover difficult to remove Ladder rungs unsafe Cover is missing or only partially in place. Any open manhole requires maintenance. Mechanism cannot be opened by one maintenance person with proper tools. Bolts into frame have < 1/2 inch of thread (may not apply to self-locking lids). One maintenance person cannot remove lid after applying 800 pounds of lift. Intent is to keep cover from sealing off access to maintenance. Local Government Safety Officer and/or maintenance person judge that	Manhole is closed. Mechanism opens with proper tools. Cover can be removed and reinstalled by one maintenance person. Ladder meets design standards and allows maintenance persons safe access.

		ladder is unsafe due to missing rungs, misalignment, rust or cracks.	

TYPICAL DETENTION VAULT

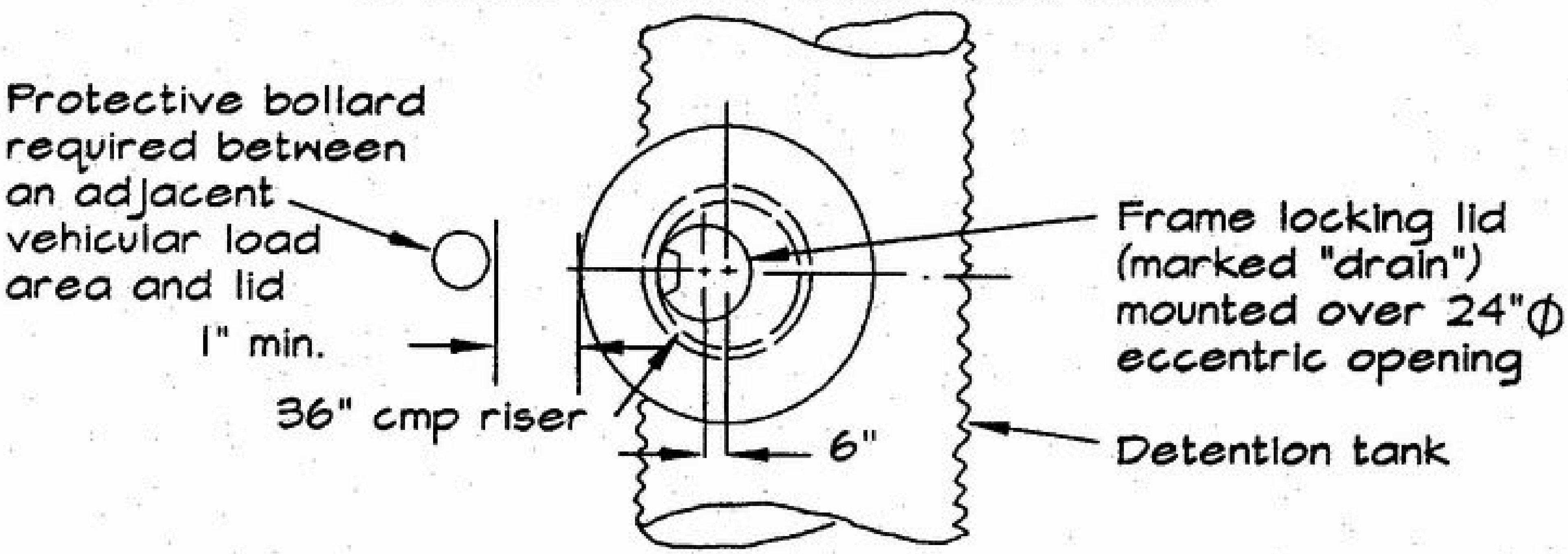


SECTION A-A

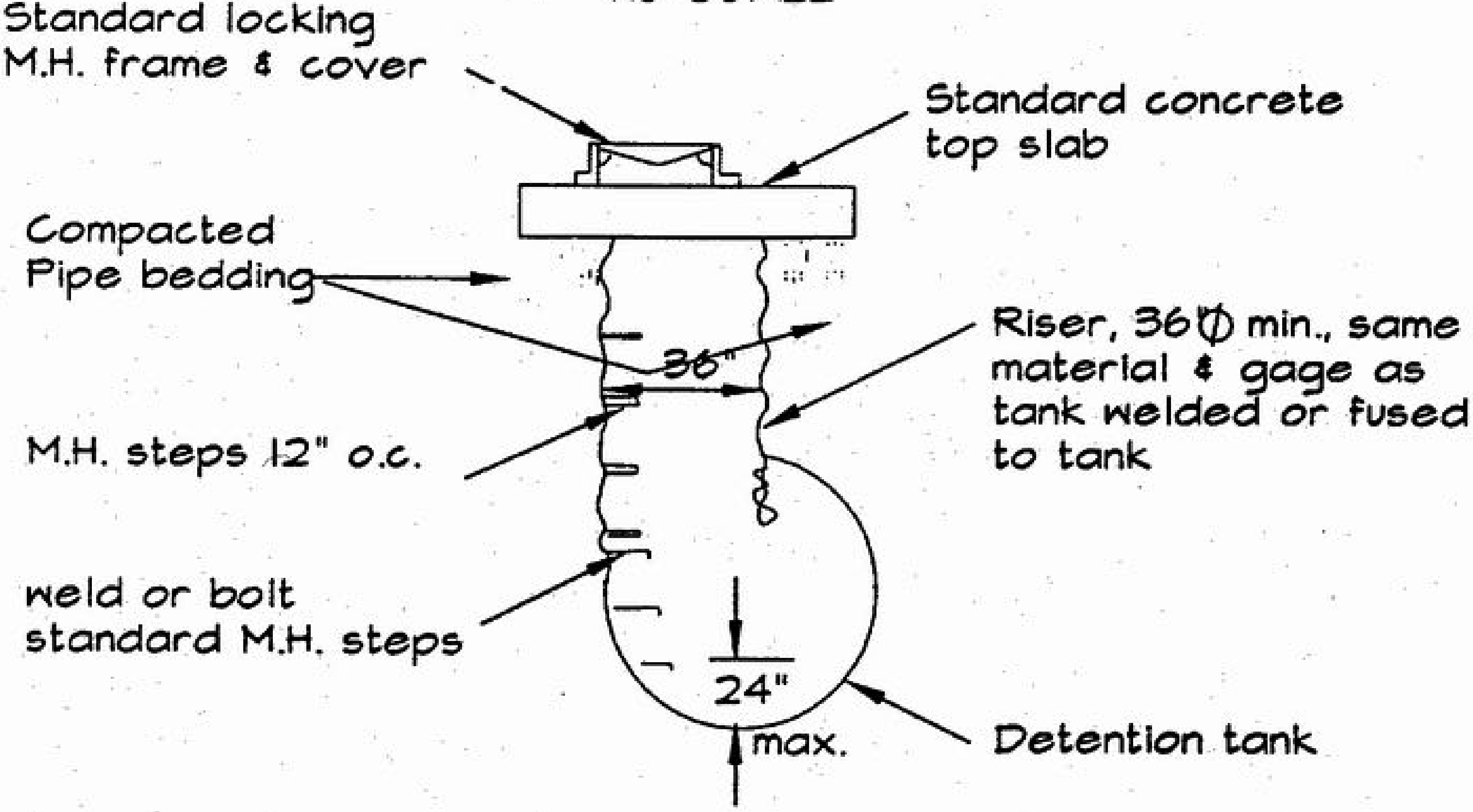
NO SCALE

DETENTION TANK ACCESS DETAIL

Restrictions for application: Use only for access to detention tanks. Not allowed for use in roadways, driveways, parking stalls or where vehicular loads would occur



PLAN VIEW
NO SCALE



SECTION
NO SCALE

NOTES:

1. Use adjusting blocks as req'd to bring frame to grade
2. All materials to be aluminum or galvanized & asphalt coated (treatment 1 or better)
3. Must be located for access by maintenance vehicles

3.4 Other Structural Controls

Oil/water separators and other structural controls are installed as part of the piped stormwater drainage system. They function by slowing flows and allowing both settling of particulates and separation of floatable materials and oil/grease. They are most applicable to urbanized or industrial sites where land availability is low or for pretreatment preceding other types of stormwater BMPs. Regular cleaning is essential to ensure effectiveness. This type of BMP works best when designed as an off-line device allowing high flows from large storm events to bypass the device without resuspending previously deposited materials. In general, these facilities have low pollutant removal capabilities and high maintenance requirements. The following pages contain a fact sheet for the following BMPs:

BMP 18 Oil/Water Separator
BMP 19 Centrifugal or Vortex-Separation Structures
BMP 20 Level Spreader

Oil/Water Separator BMP 18

Description

Oil/water separators are multi-chambered devices designed to remove hydrocarbons from stormwater runoff as it moves through the device. Three variations are presented in this manual:

Spill control (SC) separators are the least expensive and complex of the three. The device is a simple underground vault or manhole with a "T" outlet designed to trap small spills.

American Petroleum Institute (API) separators are long vaults with baffles designed to remove sediment and hydrocarbon loadings from urban runoff. Large API separators may include sophisticated mechanical equipment for removing oil from the surface and settled solids from the bottom. Note: Many studies conducted on the east coast refer to this multi-chambered (generally three chambers) design with baffles as a "water quality inlet."

Coalescing plate (CP) separators include a series of parallel inclined plates to encourage separation of materials of different densities. The plates are typically made of fiberglass or polypropylene and are closely spaced to improve the hydraulic conditions in the separator and promote oil removal.

Applications

Oil/Water separators have limited application in stormwater treatment because their treatment mechanisms are not well suited to the 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. Their inclusion in these guidelines is merely to provide as wide a range as possible of stormwater BMPs. While the use of oil/water separators may be appropriate for high traffic areas such as multi-family dwellings and apartment complexes, the decision to use an oil/ water separator should be made on a case-by-case basis.

If an oil/water separator is to be used for treatment, 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. Under no circumstances should any portion of the contributing drainage area contain disturbed pervious areas that can be sources of sediment.

Limitations

Drainage area – 1 ac.
Minimum bedrock depth – 8 ft
NRCS soil type – A, B, C
Drainage/flood control – no
Max slope – 15%
Minimum water table – 8 ft
Freeze/thaw – fair

Targeted Pollutants

Sediment – 15%
Phosphorus – 5%
Trace metals
Hydrocarbons

Design Parameters

The following design parameters apply to all three separator types:

- Separators should precede all other stormwater treatment.
- Appropriate removal covers should be provided that allow access for observation and maintenance.
- Stormwater from building rooftops and other impervious surfaces are not likely to be contaminated by oil and should not be discharged to the separator.
- Any pump mechanism should be installed downstream of the separator to prevent oil emulsification.

Additional requirements for API and CPS separators:

- Separators should be sized for the water quality design storm (one-third of 2-year event). Larger storms should not be allowed to enter the separator; the use of an isolation/diversion structure is recommended.
- Separators should have a forebay to collect floatables and the larger settleable solids. Its surface area should not be less than 20 square feet per 10,000 square feet of the area draining to the separator.

The following are additional requirements for CPS separators:

- Plates should not be less than 3/4 inch apart.
- The angle of the plates should be from 45 to 60 degrees 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 that 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 projects storage terminals. These data indicate that, by volume, about 80% of the droplets are greater than 90 micron. Less than 30% are greater than 150 microns. For these guidelines, both the API and CPS separator are sized to remove 60 microns and larger droplets at a temperature of 10 ^{o}C giving a rise rate of 0.033 feet per minute (10 millimeters). 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 feet per minute or 15 times the rise rate whichever is smaller (rise rate of 0.033 feet per minute 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:

Depth = (Q/2Vh).5

Where,

Q = design flow (cfm)
Vh = design horizontal velocity ft/min = 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:
Length = depth/rise rate * Vh = [(Q/2Vh).5/0.033] * 0.50

CPS-Separator Sizing
Calculate the projected (horizontal) surface area of plates required using the following equation:

Ap = Q/rise rate
where,
Ap = projected surface area of the plate (ft2); note that the actual surface area, As = Ap *
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 that are rated at a particular flow (usually gallons per minute). However, as the manufacturer's flow rating is for conditions different than used above, the engineer should compare the plate surface area with the above calculation. Do not confuse projected plate area with actual plate area.

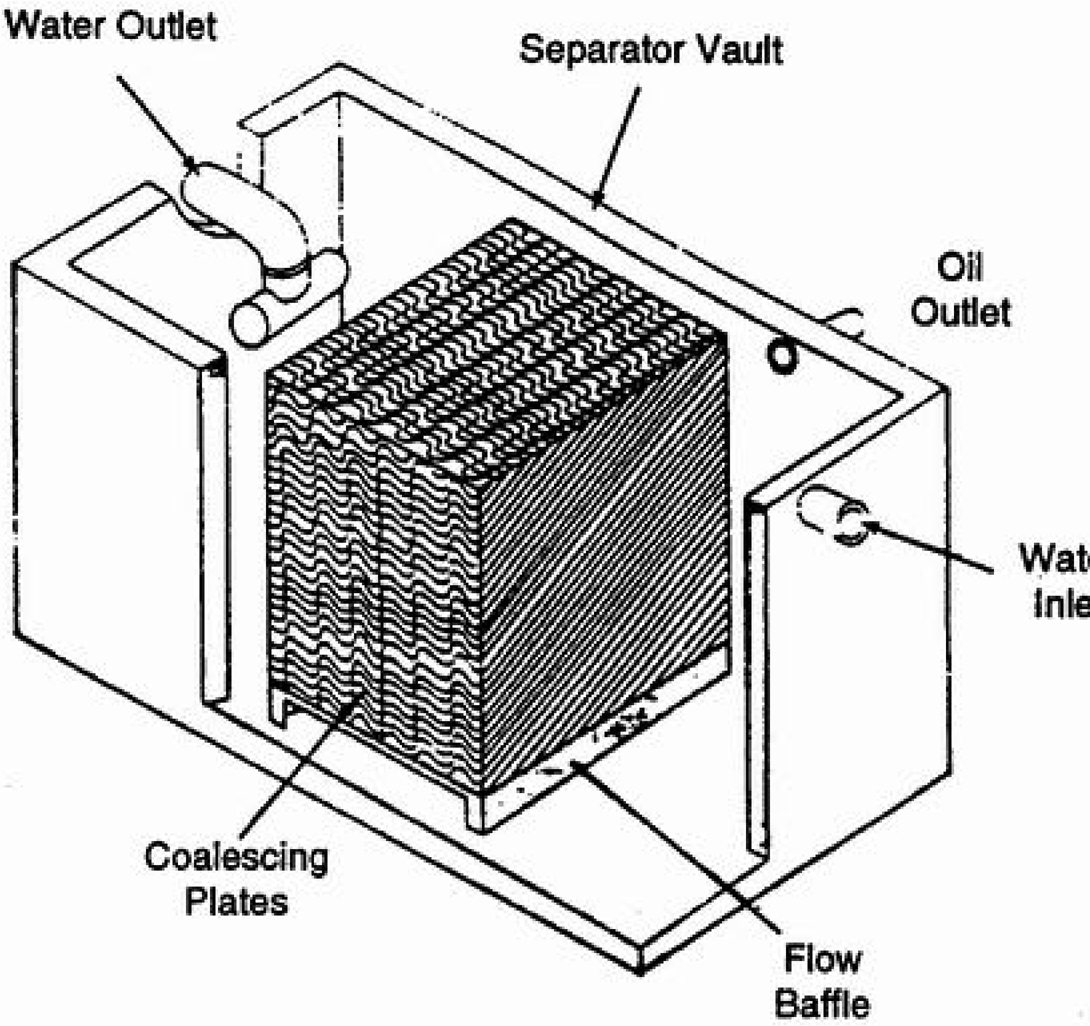
The width, depth, and length of the plate pack and the chamber in which the plate pack is placed is completely flexible and is a function of the plate sizes provided by the particular pack manufacturer and standard size vaults that are available for small sites.

Refer to the King County Surface Water Management Manual for additional design and sizing details.

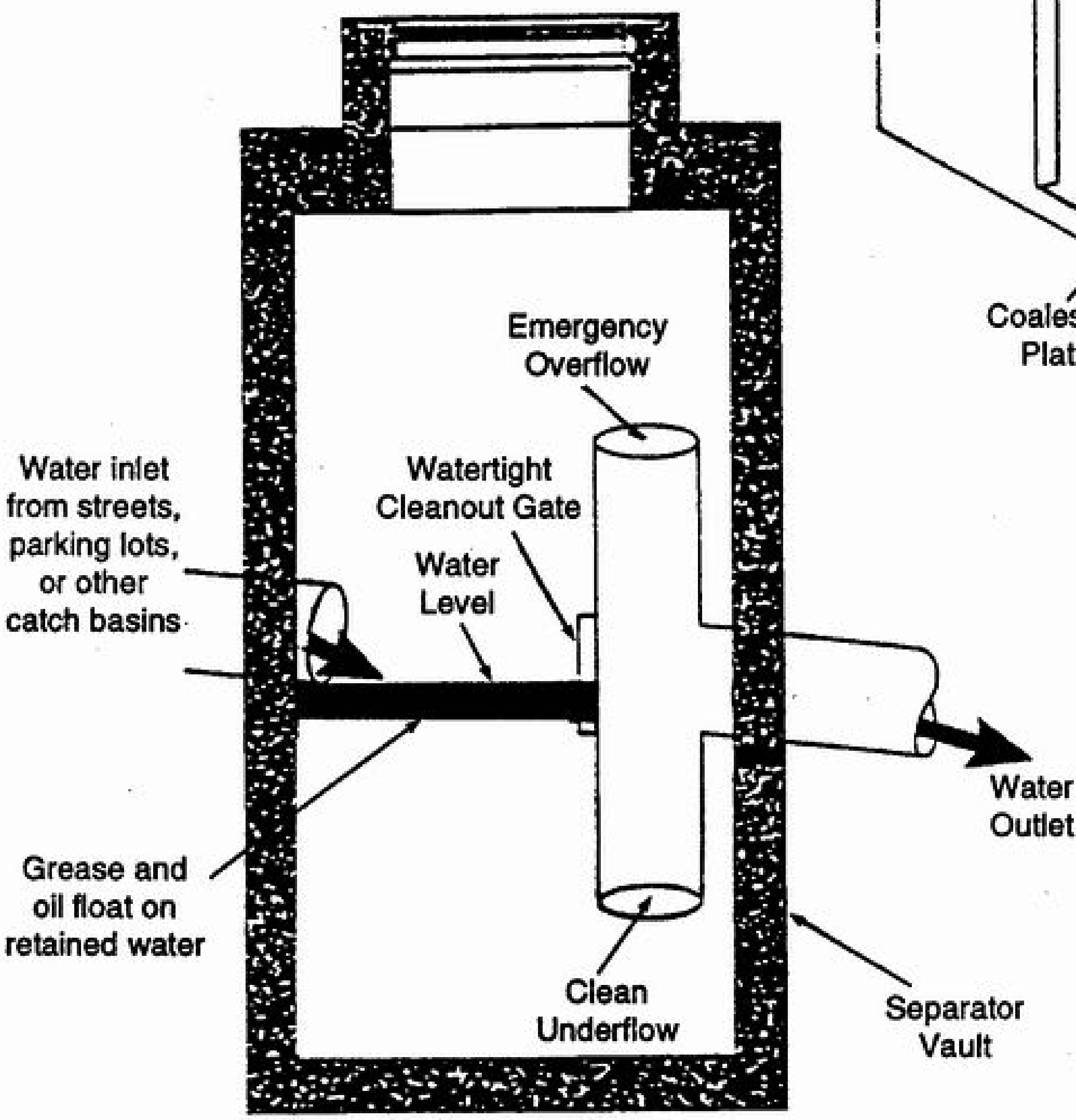
Maintenance

- Oil/water separators should be cleaned frequently to keep accumulated oil from escaping during storms. As a rule of thumb, they should always be cleaned by mid-October to remove material that has accumulated during the dry season, and again after a significant storm.

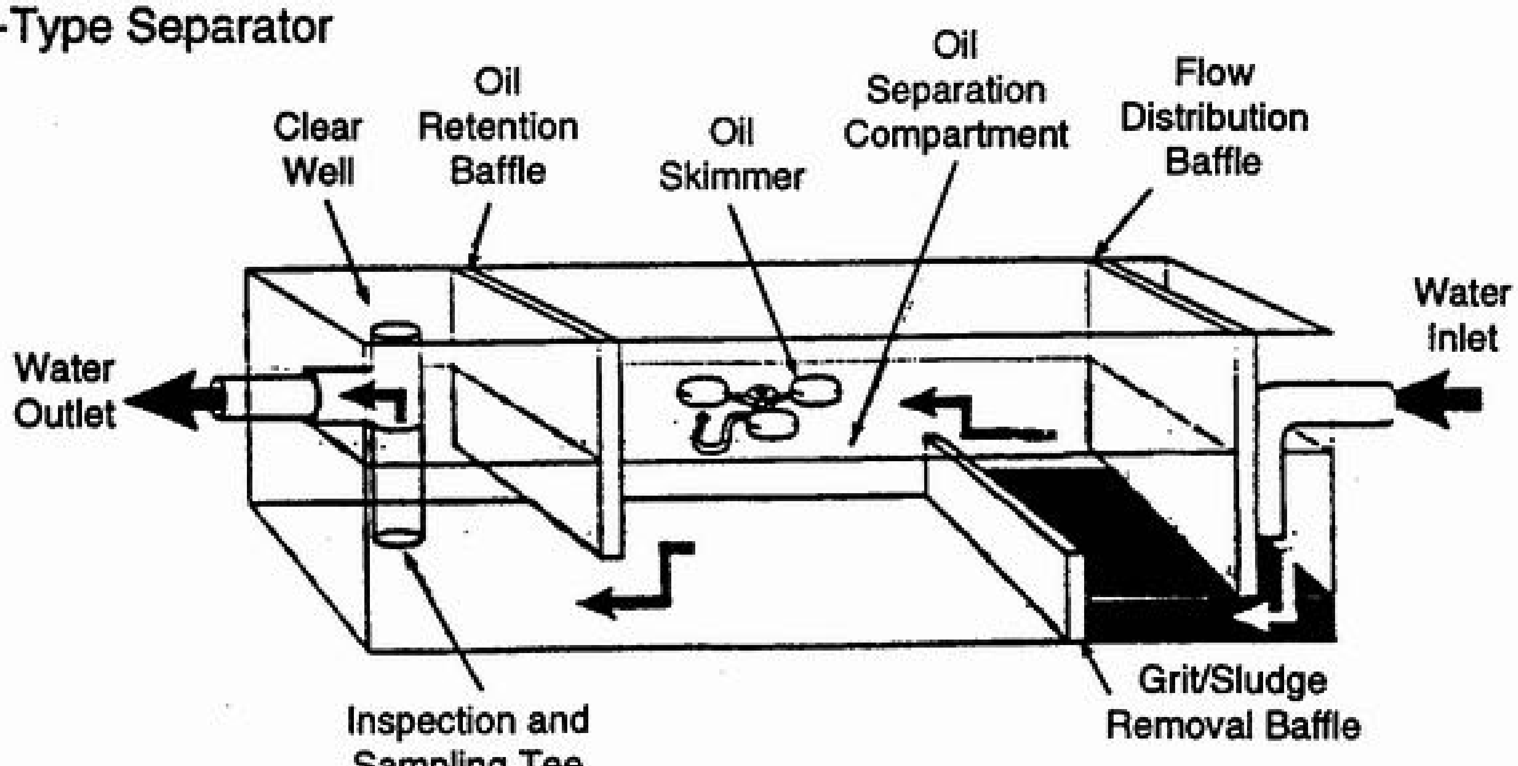
- The owner should inspect the facility weekly.
- Oil absorbent pads are to be replaced as needed but should always be replaced in the fall prior to the wet season and in the spring.
- The effluent shutoff valve is to be closed during cleaning operations.
- Waste oil and residuals should be disposed in accordance with current local government health department requirements.
- Any standing water removed during the maintenance operation should be disposed to a sanitary sewer at a discharge location approved by the local government.
- Any standing water removed should be replaced with clean water to prevent oil carry-over through the outlet weir or orifice.



CPS Separator



SC-Type Separator



API Separator

Centrifugal or Vortex-Separation Structures BMP 19

Description

Centrifugal-separation structures are characterized by an internal component that creates a swirling motion. This is typically accomplished by a tangential inflow location within a cylindrical chamber. The solids settle to the bottom and are trapped by the swirling flow path. Additional compartments or chambers act to trap oil and other floatables. These systems may include a wall to separate TSS from oil.

Applications

These systems are ideal for use in ultra-urban areas since they are space efficient. These systems can be placed under parking lots or simply installed as a manhole junction box or inlet structure. In general, these structures are recommended for the following:

- Pretreatment for other BMPs
- Retrofit of existing development or redevelopment
- Ultra-urban development areas

Limitations

Drainage area – depends on manufactures specifications
Minimum bedrock depth - N/A
NRCS soil type – A, B, C, D
Drainage/flood control – no
Max slope – N/A
Minimum water table – N/A
Freeze/thaw – fair

Targeted Pollutants

Sediment –
Phosphorus – 15 - 20%
Trace metals –

Design Parameters

The sizing criteria should be obtained from the manufacturer to ensure that the latest design and sizing criteria is used. In general, the flow-through configuration and treatment limitations will force drainage areas to remain relatively small. The system should be sized for the water quality design storm. If the system is too large it will not have the volume/velocity relationship to achieve the swirl action.

An overflow, or bypass, is needed to divert flow that exceeds the design rate, or a storage facility is needed to store the appropriate volume of runoff for treatment.

Maintenance

This system requires regular inspection and maintenance to maximize effectiveness. The specific maintenance requirements and schedule should be prepared by the manufacturer and signed by the owner/operator. It should be noted that the frequency of maintenance is not only dependent on the type of manufactured system chosen but also the pollutant load from the contributing drainage area.

Level Spreader — BMP 20

Description

A level spreader receives concentrated flow from channels, outlet structures, or other conveyance structures and converts them to sheet flow. Although a level spreader by itself is not considered a pollutant reduction device, it improves the efficiency of other facilities, such as vegetated swales, filter strips, or infiltration devices, which are dependent on sheet flow to operate properly.

Applications

Level spreaders are used in wide, level areas where concentrated runoff occurs. The site should be undisturbed soil stabilized by vegetation. Disturbed soil is subject to more erosion and may settle. If the spreader is not absolutely level, flows will concentrate at the low point and may make cause more problems than if no level spreader were used. Flows to the spreader should be relatively free of sediment or the spreader will be quickly overwhelmed by sediment and lose its effectiveness.

Limitations

Drainage area – 5 ac.
Minimum bedrock depth - N/A
NRCS soil type – A, B, C, D
Drainage/flood control – no

Max slope – 1%
Minimum water table – N/A
Freeze/thaw – fair

Targeted Pollutants

N/A

Design Parameters

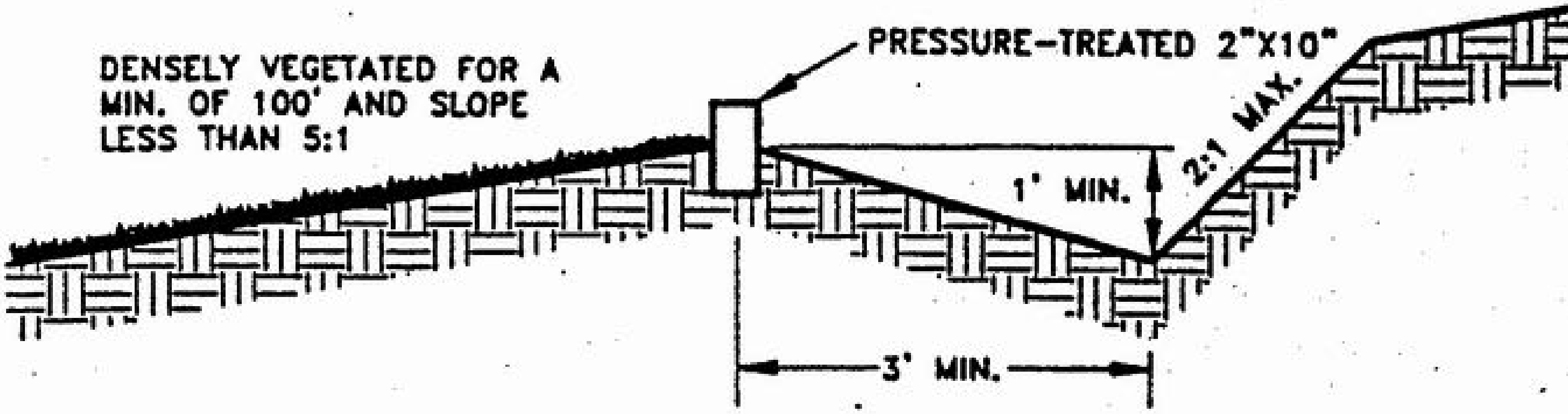
The spreader should be constructed absolutely level. Height of the spreader is based on depth of design flow, allowing for sediment and debris deposition. The length of the spreader is based on the 10-year design flow for the site, as follows:

Drainage Area, acres	Minimum Spreader Length, ft
1	10
2	10
3	15
4	18
5	20

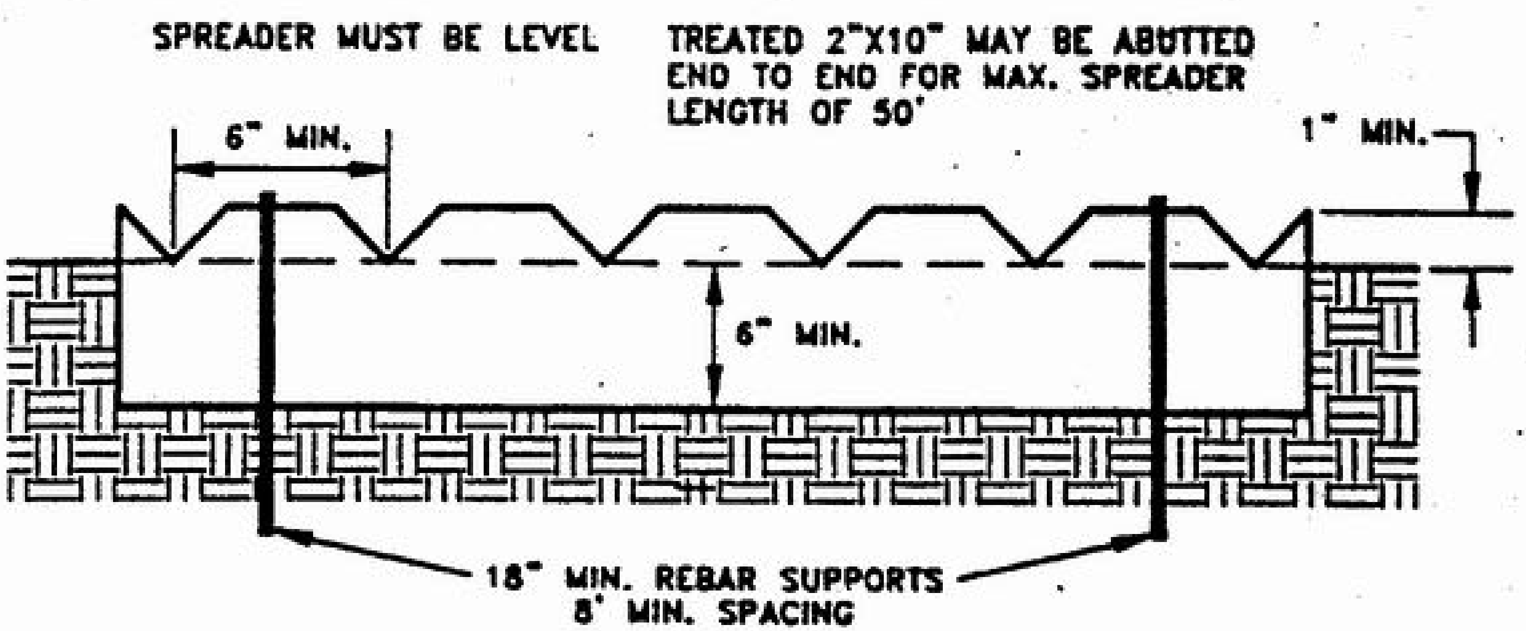
The slope leading to the level spreader should be less than 1% for at least 20 feet immediately upstream in order to keep velocities less than 2 feet per second at the spreader during the 10-year storm event. Slope of the outlet from the spreader should be 6% or less.

Maintenance

The level spreader should be regularly inspected, including after large rainfall events. Inspection should note and repair any erosion and low spots in spreader. Sediment should be removed from behind spreader.



CROSS SECTION



ALTERNATIVELY, 6" DIA. CMP MAY BE USED AS A SPREADER.
THE PIPE SHALL BE BURIED SO THAT ONLY 1" EXTENDS ABOVE GROUND.

DETAIL OF SPREADER

Source: King County
Surface Water Design Manual

Section 4 - BMP Operation and Maintenance

Stormwater systems that are properly operated and maintained function better and reduce maintenance costs and liability problems. This section provides information on properly operating and maintaining stormwater systems for residential, commercial, or industrial developments. This information should be used in conjunction with best professional judgment and sound engineering principles.

At the end of this section, you will find inspection and maintenance forms. These forms describe problems that could occur in system components of a stormwater system and provide recommendations for maintenance. These forms should be used as checklists during inspections and as records for identifying which system components require maintenance. These forms can be included in the site's Operation and Maintenance (O&M) Plan.

4.1 The Importance of Proper Maintenance

Every stormwater system needs to be properly maintained to reduce or eliminate costly repair problems and to properly treat stormwater. The lack of proper maintenance is the most common cause of stormwater system failure. The following reasons explain why properly maintaining your stormwater system is critical.

Properly maintaining a stormwater system reduces the risk of flooding due to system failure. For example, detention systems (such as detention ponds) are designed to detain sediments and still function properly. Sediments trapped in the sediment trapping area need to be removed regularly to reduce excessive sediment buildup. If the sediments accumulate beyond what the system is designed for, the system could fail and cause stormwater to backup and flood an area.

Properly maintaining a stormwater system improves the level in which pollutants are effectively removed. For example, a vegetated swale is designed to remove sediment, oil, grease, and toxic chemicals by filtering out these pollutants. Stormwater flows slowly through the swale filtering through the grass and infiltrating into the underground sand and rock layers. But, if the swale lacks a grass cover or the swale has severely eroded, then the stormwater will flow too quickly through the swale, and the level in which these pollutants are removed is significantly reduced.

Properly maintaining a stormwater system reduces the likelihood that sediment or other debris will have to be disposed of as hazardous waste. For example, high vehicle-use areas or industrial sites can produce heavy metals and toxic chemicals that can end up in a stormwater system. If the stormwater system is not maintained regularly, then the debris may be characterized as hazardous waste while regular maintenance may prevent this. Hazardous waste disposal is quite costly; regularly removing sediment or other debris is not.

Properly maintaining a stormwater system reduces safety hazards on the site. For example, a poorly functioning infiltration system may cause stormwater runoff to pond. This runoff can freeze in the winter and become a safety hazard to site employees or the public. Also, keeping good inspection and maintenance records can help the owner or operator with liability issues should safety problems arise. In addition, regularly inspecting the stormwater system will alert the operator if hazardous materials (which may have been illegally dumped into the system) are present.

Properly maintaining a stormwater system improves its visual appeal and preserves its value as a neighborhood amenity. A well-maintained natural area can act as a stormwater collection area and as a neighborhood park. Because these stormwater systems are considered amenities, the value of homes that are located near these systems can be higher than the value of home located in other parts of a subdivision.

Properly maintaining a stormwater system ensures that nuisance situations do not develop into big problems. For example, mosquitoes can be controlled near ponds or constructed wetlands by installing inexpensive predacious bird and bat boxes and encouraging these wildlife species to live near the site. More information about mosquito control is found in Appendix F. Similarly, regularly removing a few nuisance weeds is much more time and cost-efficient than controlling the weeds after they have invaded the entire area.

4.2 Developing an Operation and Maintenance Plan

This section describes the guidelines that should be followed to develop a customized O&M plan. An O&M plan helps to coordinate inspection and maintenance activities for type of system and track any problems that might have been observed when performing inspection and maintenance. Having an O&M plan will make the operation and maintenance of the system easier and more cost-effective. An O&M plan can be developed for new or existing stormwater systems.

New Systems

An O&M plan should be prepared at the time a new stormwater system is being designed because it will be easier to maintain the system once an O&M plan is in place. Preparing an O&M plan for new systems is more convenient than preparing a plan for existing systems because new system information is more readily available.

Responsible parties should work closely with a design professional when developing an O&M plan for a new system: The design professional can specify maintenance procedures, material specifications, and operation practices specifically for each individual system. Remember to discuss with the design professional any design problems encountered while inspecting or maintaining the system. These comments will help the design professional modify the design so that the same problem will not occur in the future.

Existing Systems

Preparing an O&M plan for an existing stormwater system is also recommended. Although the information may be harder to find, the extra steps taken to develop an O&M plan for an existing system will make long-term operation and maintenance easier and more effective.

To prepare an O&M plan for an existing system, available design plans and past maintenance information should be collected. If the original stormwater systems design plans on site, contact the design professional who originally designed the system. If design plans cannot be located for the system, the system and its components can be identified by reviewing the permanent stormwater controls in Section 2.

The O&M plan consists of the following items:

- Site plans, design plans and material specifications for the stormwater system
- Landscape design plan
- Inspection frequency information
- Inspection and Maintenance forms
- Safety information
- Scope of work, responsible personnel, waste disposal, and maintenance budget, if known.
- Source control BMPs

4.3 Inspecting the Stormwater System

Frequent, thorough, and consistent inspections are the key to the successful operation and maintenance of a stormwater system. Inspections reveal the operational status of the system, identify needed maintenance actions, and provide the information to update the O&M plan. It is recommend that the stormwater systems be inspected at least twice annually after construction and after any rainstorm event that produces more than 0.5 inches of rainfall.

Regular inspections should be performed until the system's routine maintenance requirements have been identified. The time interval in which subsequent inspections will be performed should be determined by actual maintenance requirements. This section addresses inspection frequency, conducting inspections safely, and using the inspection and maintenance forms.

Inspection frequency

The frequency in which a stormwater system should be inspected depends on the type of system, including pretreatment, seasonal weather conditions, and the characteristics of the drainage area. The type, size, and design of a stormwater system determine how frequently the system should be inspected. For example, a vegetated swale should be inspected frequently to ensure that the grass cover is thriving and that sediment and debris are not accumulating in the swale; whereas, a retention pond, once constructed, may only have to be inspected once or twice per year.

Seasonal weather conditions can also determine the inspection schedule. Because of their intensity, summer storms may cause more problems for a system than storms that occur at other times of the year. Therefore, a stormwater system should be inspected before and after the summer months when the system can experience its greatest use. Detention and evaporation ponds should be inspected at least once each time the pond is empty. Inspections may need to be done more frequently if rainfall is above average.

The type of drainage area and the activities that occur in the drainage area will affect inspection frequency. A stormwater system may require more frequently in drainage areas where construction is taking place and creating a large amount of sediment. Likewise, stormwater systems located in the Boise foothills may require more frequent inspections because the combination of vast open areas and steeper slopes increases the potential for sediment to accumulate more quickly in a stormwater system. Finally, sites that may generate more wastes, such as industrial and high vehicle-use areas, should be inspected more frequently.

Inspecting Stormwater Systems Safely

Individuals who are responsible for inspecting stormwater systems should always consider safety as the first priority. The inspector should have the proper safety equipment (e.g., heavy-duty gloves, boots, and first aid kits) and training before conducting any inspections. Although the safety precautions listed here are, for the most part, common sense, they should not be disregarded. Neglecting to follow even the simplest safety precaution can potentially cause serious injury. If the stormwater system inspection reveals a safety problem, site activities may have to be modified to reduce or eliminate the safety risk. The following is a list of safety precautions an inspector should be aware of when conducting stormwater system inspections:

- Never enter a confined space unless you have proper Occupational Health and Safety Administration (OSHA) training. Do not enter any confined space unless the atmosphere has been checked and proper safety equipment is worn and/or erected. Avoid entering pipes or conduits without another individual present. If the structural strength of a pipe or conduit is questionable, do not enter the pipe or conduit at all.
- Check the ventilation in the stormwater system before using any type of ignitable materials (e.g., lighters, matches, and cigarettes) Some stormwater systems may be sealed and have poor ventilation, posing a safety risk to the inspector if the flammable vapors come in contact with an open flame. Also, be sure to allow the stormwater system to vent for a period of time if a peculiar odor is present.
- Wear gloves if any mechanical parts or structural components are going to be handled. Wearing gloves reduces the risk of getting cuts and abrasions and also reduces the exposure of pollutants to the skin.
- Lift manhole covers or other structural covers (trash racks, access covers, etc.) carefully. These items can be very heavy and slippery if wet. Also, learn the correct way to lift heavy items to avoid back injury.
- Check the water depth of the system before taking a step in the water. The water may be deeper it appears or there may be steep slopes below the water line.
- Be aware that nails, broken glass, or other sharp debris may be in the stormwater system. Wearing the proper safety clothing will reduce the safety risk associated with these objects.
- Check for poison ivy, poison oak, or other poisonous plants when inspecting ponds or other large stormwater systems. Inform the

individual who will perform maintenance on the system that these plants are present.

- Look where you walk. Rodent holes may be present around ponds or constructed wetlands. Some holes may be partially covered and not easily seen at first glance.
- Check for spiders and other biting or stinging insects.

Using the Inspection and Maintenance Forms

To use the inspection and maintenance forms, identify the system components that compose your stormwater system. Photocopy the applicable inspection and maintenance forms and the *Inspection Cover Sheet*. Inspect each system design feature to determine if any of the conditions are present. If the current condition of the drainage system feature matches the description on the inspection and maintenance form, then place a checkmark in the appropriate column. The system design features that have been checked will need to be maintained if it is determined that a problem exists.

4.4 Performing Maintenance on a System

A stormwater system may require either routine or non-routine maintenance. Routine maintenance is the maintenance an individual performs on a stormwater system to ensure that the stormwater system is functioning as designed and that the system aesthetics are well maintained. Non-routine maintenance is the maintenance an individual performs as a result of a catastrophic event, such as a hazardous chemical spill. This section discusses routine and non-routine maintenance, performing maintenance safely, and completing the Maintenance Report form.

Routine Maintenance

The type and frequency of maintenance for a specific stormwater system is determined by inspection results and the maintenance schedule in the O&M plan. Maintenance should be performed in accordance with system design information and safety procedures provided in the site's O&M plan. Performing timely maintenance is important in preventing system failure and will be less expensive in the long-term. An annual maintenance budget should be prepared to ensure that the necessary resources are available to perform maintenance adequately.

You may need to obtain permits from federal, state, or local agencies to conduct stormwater maintenance activities. The following permits may be required:

- A 404 (dredge and fill) permit is required if you remove sediment and vegetation from a wetland that meets the legal definition of a jurisdictional wetland. The U.S. Army Corps of Engineers also requires a 404 permit to place fill in any water body considered "waters of the United States." Most commercial stormwater ponds are not-considered wetlands or waters of the United States.
- If dewatering a stormwater system is needed as part of maintenance operations, pumping uncontaminated ground water or stormwater into the storm sewer system may be acceptable with permission. These activities may require a permit. Contact the local municipality or highway jurisdiction.
- If stormwater will be discharged from stormwater ponds to surface water, then a short-term activity exemption must be obtained from the Idaho Department of Environmental Quality (DEQ).
- If storm water will be discharged from a stormwater dewatering system to land, then a land application permit from must be obtained from DEQ.

Performing Maintenance Safely

The individuals performing maintenance on the stormwater system should always consider safety as the first priority. All maintenance work should be done in accordance with OSHA regulations. Maintenance personnel should have the proper safety equipment (e.g., heavy duty gloves, steel-toed boots, first aid kits) and training before performing any maintenance on a stormwater system. Relevant safety information should be included in the O&M plan. The following is a list of safety precautions maintenance personnel should be aware of when performing maintenance on stormwater systems:

- Operate equipment safely and in accordance with manufacturers' specifications.
- Equipment operators should be aware of site personnel at all times to avoid causing injury to others.
- Contact utility companies before excavating a site. Underground utility wires may be present. Cover or clearly mark excavated areas that cannot be filled in at the end of the day to alert site employees of the potential risk. Also, be aware of overhead electrical wires that could come in contact with maintenance equipment.
- Identify where removed sediment or wastes will be disposed of prior to cleaning the stormwater system. Use shovels, trowels or a high-suction vacuum to remove wastes. Do not clean out sediment or waste with bare hands. The sediment or waste may be hazardous or contain medical wastes such as needles. Place the sediment or waste in an area where it will not wash into a storm drain, water body, or waterway.

- Wear gloves if any mechanical parts or structural components are going to be handled. Wearing gloves reduces the risk of getting cuts and abrasions and also reduces skin exposure to pollutants.
- Take caution when mowing detention ponds, retention ponds, or other stormwater systems that have steep slopes.

Non-routine Maintenance

In addition to routine maintenance, situations may occur which require non-routine maintenance, such as illegal dumping into the system, accidental spills, or massive sediment and debris inflows from major storm events. If there is an illegal dumping or sediment and debris inflow, it must be determine if these situations caused a problem for the stormwater system.

If an accidental spill occurs, the spill must be isolated to keep it from reaching other water bodies (including ground water). Stormwater system flow-control points, such as gates, valves, orifices, and outlet pipes, should be checked to be sure that those points are closed to help isolate the spill. Spill kits should be purchased, kept on site, and placed in areas that are easily accessible by maintenance personnel. If the spill consists of flammable or hazardous materials, emergency 911 must be called for assistance.

The owner of the stormwater system is responsible for cleaning the spill and disposing of the waste properly. If the spill contains hazardous materials, a qualified environmental consultant who specializes in spill containment may be called to assist in cleanup and disposal. These consultants are listed in the yellow pages of the telephone book under "Environmental Services."

Maintenance report

After a stormwater system has been maintained, a Maintenance Report form should be completed. In the report, the maintenance activities should be described, including descriptions of the type of work, completion dates, contractors used, time needed, and costs. Documenting the maintenance performed on a stormwater system will be useful in planning future maintenance activities.

4.5 Properly Disposing of Wastes

Most stormwater system wastes consist of trash, leaves, grass, and sediment. For many system owners, maintaining a stormwater system is not difficult because the quantity of wastes is small or the wastes may not be hazardous. For others, however, disposing of stormwater system wastes may be more complex because the quantity of wastes is large or the wastes are hazardous. The purpose of this section is to provide information on how to properly and legally dispose of both hazardous and non-hazardous wastes.

Sediment and debris removed from stormwater systems located in residential and commercial areas generally do not contain pollutants that would characterize the sediment or debris as hazardous waste. Those stormwater systems located in industrial facilities or vehicle-related, high-use areas, however, have the greatest potential for sediments and debris to be characterized as hazardous waste.

If s facility uses hazardous materials or generates hazardous waste as part of daily operations (for example, automotive repair shops or fueling stations), it should be determined whether stormwater system maintenance waste is considered hazardous waste under federal and state law, regardless of where the stormwater system is located on the site. It should be determine if the sediment or debris is hazardous prior to disposing of the waste. It can be determined if the waste is hazardous by using one of the following two methods: process knowledge or analytical testing.

Process knowledge

Process knowledge is the term used to describe "the understanding of the processes and activities conducted at a site and the waste resulting from those activities." In most cases, process knowledge can be used to show that hazardous materials or wastes are not stored, handled, or used in a process within an area that discharges to a stormwater collection system. It may also be possible to show that access to the stormwater system is controlled so that unauthorized activity or illegal dumping will not occur.

However, there may be cases where process knowledge may not be adequate to determine if a waste is hazardous. The following are situations to consider:

- The access to the stormwater system is uncontrolled.
- The stormwater system is located in an area where hazardous chemicals or materials are used.
- The stormwater system is located in an area where used oil or antifreeze is handled or stored.

- The stormwater system is located in an area where engine washing/steam cleaning or other degreasing processes are conducted.

If any of these situations exists, then the process-knowledge method of determining if the maintenance waste is hazardous cannot be used. The analytical testing method will have to be used to determine if the waste is hazardous.

Analytical testing

Analytical testing requires that a sample be taken from the sediment and/or liquids and that it be tested to determine if any of the three categories of physical properties or associated chemical analyses applies:

1. Flash point (to determine ignitability)
2. pH (to determine corrosivity)
3. Toxicity characteristic leaching procedure (to determine toxicity)

A pesticide screening analysis may also be required if your facility handles or uses pesticides.

If samples are taken without the assistance of an expert, the following procedures should be followed:

1. Choose an analytical laboratory. Analytical laboratories are listed in the yellow pages of the telephone book under "Laboratories - Analytical and Laboratories - Testing." When contacting a laboratory, make sure the laboratory conducts a hazardous waste analysis. Some laboratories limit their services to construction-related testing and will not be able to provide the necessary analysis.

   Explain to the laboratory representative how to characterize stormwater system waste. The laboratory personnel will be able to provide the appropriate sampling bottles, explain how the samples should be taken, demonstrate show how to fill out the associated paper work, and provide the appropriate container for transporting the samples back to the laboratory for analysis.

2. Collect the sampling results from the laboratory and interpret the analysis. A laboratory representative or technical staff at DEQ can provide assistance in interpreting the sampling results. Analytical results, whether indicating a hazardous waste characteristic or not, should be kept on file at the facility where the samples were taken for a minimum of 3 years. Idaho regulatory agencies strongly urge facilities to keep sampling results on file indefinitely.

Sampling Frequency

The following sampling frequencies are recommended:

- If there are no changes in the types of activities or processes and access to the stormwater system is controlled without oversight , it may be possible to characterize the stormwater system sediment and liquid only once.
- If the facility restricts access to the stormwater system and there are site activities that could result in the release of a hazardous substance, it may be necessary to test on a yearly basis.
- If there is unrestricted access to your system, or site activities that could result in the release of a hazardous substance to the stormwater systems, system sediments will need to be tested each time prior to removal and disposal.

4.6 Non-hazardous and Hazardous Waste Disposal

The following section discusses how to properly dispose of maintenance wastes once it has been determined whether the wastes are non-hazardous or hazardous.

Non-hazardous Waste Disposal

Non-hazardous sediment and debris can be routinely disposed of at the local landfill, in accordance with Idaho and local solid-waste regulations. Solid-waste requirements require that the sediment or debris does not contain any liquid. The liquid must be removed from the sediment, and the liquid must be returned to the stormwater system. To remove residual liquid, sediment or debris should be spread out on the ground (away from storm drains, gutters, or waterways) and dried in the sun before disposing of the material with the rest of the facility’s solid waste.

The solid waste contractor should be provide with documentation that the facility’s stormwater system sediment is non-hazardous waste. If there are any questions concerning the disposal of sediment with solid waste, the site’s solid waste contractor should be contacted.

Another way to dispose of non-hazardous sediment is to incorporate the sediment into landscape areas, such as shrub beds. Remember to remove any litter or non-biodegradable material from the sediment and incorporate the sediment in areas where there is a minimal chance it being washed back into the stormwater system.

Any yard wastes (such as leaves or grass) can be used as mulch around flowers, shrubs, and trees. Apply the mulch 3 to 4 inches deep or use the mulch as a soil amendment by mixing it into the surrounding soils. Shredded leaves and grass may also be spread thinly over established turf. Mulching adds valuable nutrients to the soils, retains moisture, and protects plant roots during the cold weather months.

Hazardous Waste Disposal

If sampling results indicate that the sediment in a facility's stormwater system is classified as a hazardous waste, then the sediment should be disposed of as hazardous waste in accordance with federal and state regulations. Two general disposal options are available, and the chosen option will depend on the facility's hazardous waste generator status. Under federal and state regulations, the amount of hazardous waste generated by the facility in a calendar month determines the generator status category the site falls into:

- A Conditionally Exempt Small Quantity Generator (CESQG) generates less than 220 pounds of hazardous waste in a calendar month.
- A Small Quantity Generator (SQG) generates between 220 and 2,200 pounds of hazardous waste in a calendar month.
- A Large Quantity Generator (LQG) generates 2,200 pounds or more of hazardous waste in a calendar month.

To calculate the generator status, all hazardous wastes generated by the facility should be added together, showing the total number in units of pounds. The exceptions to this include the following:

- Used motor oil that is recycled or collected for fuel blending
- Antifreeze that is recycled on site or sent to a recycling facility
- Automotive batteries that are returned to the distributor for recycling

If serviced parts washers or other solvent-based cleaning systems are on site, the amount of spent solvent removed from the facility during servicing should be included in the generator status calculations. If no serviced parts washers are on site (either in-house or by contractor), the number of gallons of spent solvent should be converted to pounds. Most servicing companies will provide the conversion factor to and may even assist in converting and calculating the facility's generator status.

If you do not know the generator status or do not have a servicing contractor's assistance, DEQ may be called to request technical assistance from a hazardous materials/waste specialist. Based on the facility's generator status, disposal options for sediment that characterizes as hazardous waste are as follows:

- If your generator status is CESQG, you may qualify if the site's county has a hazardous waste disposal program. To participate, wastes should be preregistered with the program, and the CESQG should be called for an appointment to turn in the wastes. A disposal fee will have to be paid; however, the fee will be much less than what it would cost to hire a disposal contractor.
- If the site is determined to be a small or large quantity generator, the facility's hazardous waste should be disposed of through a qualified hazardous waste management firm. To locate a qualified firm, look under "Waste Disposal – Hazardous" in the yellow pages in the telephone book.

One way to avoid having a site's stormwater system sediment characterize as hazardous waste is to maintain the facility's stormwater system regularly. Maintaining the system regularly reduces the potential of contaminants accumulating to a level where they are characterized as hazardous waste.

4.7 Operation and Maintenance Record Keeping

Keeping adequate records on the operation and maintenance of a stormwater system is important. Proper record keeping provide a useful record of past operation and maintenance practices and also documents that the stormwater system has been properly operated and maintained. In addition, proper record keeping provides the following advantages:

- It provides a new system owner or operator with needed information on routine operation and maintenance procedures, frequencies, and associated costs.
- It contains information that may be useful in updating the O&M plan.
- It provides a central source of information to any federal, state, or local agency that may request information on the stormwater system.

Information that can be included in your records includes the O&M plan, maintenance reports, invoices for materials or work contracted, copies of permits, and laboratory analysis results that characterize clean-out wastes.

Inspection Cover Sheet

Date: ________________________

Facility Name: ____________________________________

Facility Address: ____________________________________

Facility Owner: ____________________________________

Inspector Name: ____________________________________

Inspector Phone Number: _________________________________

IMPORTANT-SAFETY INFORMATION

- Never enter a confined space or trench unless you have proper Occupational Health and Safety (OSHA) training. Do not enter any confined space unless the atmosphere has been checked and proper safety equipment is worn or erected.
- Check the ventilation in the stormwater system before using ignitable materials. Some stormwater systems may be sealed and have poor ventilation, posing a safety risk to the inspector if the vapor comes in contact with an open flame.
- Excavated areas that cannot be filled at the end of a workday should be covered or clearly marked as a potential safety risk.

Inspection comments:

Maintenance Report Form

Date: _______________

Facility Name: ____

Facility Address: ____

Name of Person Overseeing Maintenance: _______________________________

Type of System: ____

Date of Last Inspection: ____

Describe maintenance activities, including type of work, completion dates, contractors, time needed to complete task, and cost.

Table 4-1. Selection Matrix for Best Management Practices	Targeted Pollutants					Physical Constraints							
	Sediment	Phosphorus	Trace Metals	Bacteria	Petroleum Hydrocarbons	Drainage area (acres)	Maximum slope (%)	Minimum depth to bedrock, ft	Depth to high water table, ft	SCS soil type[1]	Use with freeze/thaw cycle	Drainage/flood control	Expected life[2]
Stormwater Filters													
Vegetated swale	65%	15%	◖	○	◖	15	4	3	2	BCD	Fair	Yes	Permanent
Bioretention swale	75%	30%	●	◖	●	5	4	3	3	AB	Fair	Yes	Permanent
Vegetative filter strip	50%	40%	◖	◖	◖	5	6	5	3	BCD	Fair		Permanent
Sand filter	85%	55%	◖	◖	◖	5(inlets) 50 (basin)	6	3	3	NA	Fair	Yes	25 yrs
Compost filter	95%	40%	●	◖	●	1	6	NA	NA	NA	Fair		20+ yrs
Catchbasin insert	35%	5%	◖	○	◖	0.1	NA	NA	NA	NA	Fair		
Media filter	●	50%	●	◖	●	According to manufacturer's specifications				NA	Fair		20+ yrs
Infiltration Facilities													
Infiltration trench	75%	65%	●	●	●	10	15	3	3	AB	Fair		10 yrs
Bioretention basin	90%	75%	●	●	●	5	2	3	3	AB	Fair	Yes	25 yrs
Porous pavement	85%	64%	●	●	◖	0.25-10	2	2-5	2-5	AB	Fair	No	
Detention Facilities													
Wet pond (conventional pollutants)	80%	45%	●	◖	◖	15-20	10	3	2	CD	Good	Yes	Permanent
Wet pond (nutrient control)	80%	65%	●	◖	◖	5-20	5	3	2	CD	Fair	Yes	Permanent
Wet extended detention pond	80%	65%	●	◖	◖	10-50	10	3	2	CD	Good	Yes	Permanent
Dry extended detention pond	45%	25%	◖	○	◖	10-50	10	6	4	ABC	Good	Yes	Permanent

Table 4 -1. Selection Matrix for Best Management Practices (cont.)	Targeted Pollutants					Physical Constraints							
	Sediment	Phosphorus	Trace Metals	Bacteria	Petroleum Hydrocarbons	Drainage area (acres)	Maximum slope (%)	Minimum depth to bedrock, ft	Depth to high water table, ft	SCS soil type[1]	Use with freeze/thaw cycle	Drainage/flood control	Expected life[2]
Biodetention basin	75%	45%	●	◖	●	25-50	5	3	2	CD	Fair	Yes	Permanent
Presettling/sedimentation basin	60%	30%	◖	○	○	10+	10	3	2	CD	Good		Permanent
Wet vault/tank	60%	30%	◖	○	○	5	15	12	12	ABC	Fair	Yes	Permanent
Other Structural Controls													
Oil/water separator	15%	5%	◖	○	●	1	15	8	8	ABC	Fair		20+ yrs
Swirl concentrator	35%	15-20%	◖	○	◖	According to manufacturer's specifications				NA	Fair		
Level spreader	NA	NA	○	○	○	5	1	NA	NA	ABCD	Fair	Yes	

● = very effective, removes > 70% of pollutant ◖ = moderately effective, removes 25-70% of pollutant ○ = least effective, removes < 25% of pollutant

N/A = Not applicable

[1] NRCS soil types (A,B,C,D) range from A = high infiltration to D = little or no infiltration

[2] Longevity data collected from various sources, including Panhandle Health District 1996, Boise City 1997, and EPA 1993. The numbers shown represent industry guidelines; the actual life expectancy is dependent on proper design, placement, and maintenance of BMPs.

The pollutant removal efficiencies given above are for planning purposes only. Actual removal rates are dependent on specific site characteristics, maintenance, and other factors. The following sources were used to determine the most likely average removal rate for conditions prevalent in

Idaho: California 1993, Debo and Reese 1995, King County 1994, King County 1995, Maine 1995, Minnesota 1989, Panhandle Health District 1996, Portland 1991, and USEPA 1995.

Appendix A - References

Cahill Associates. 1993. Stormwater Management Systems: Porous Pavement with Underground Recharge Beds. West Chester, PA

California, 1993. Camp Dresser and McKee, Larry Walker Associates, Resources Planning Associates for Stormwater Quality Task Force. March 1993. "California Storm Water Best Management Practice Catalogs."

Center for Watershed Protection (CWP). 1998. Better Site Design: A Handbook for Changing Development Rules in Your Community**.** Center for Watershed Protection, Ellicott City, MD.

Center for Watershed Protection (CWP). 1997. Stormwater BMP Design Supplement for Cold Climates. Prepared for: US EPA Office of Wetlands, Oceans and Watersheds, Washington, DC.

Center for Watershed Protection (CWP). August 2003. New York State Stormwater Management Design Manual. Prepared for: New York State Department of Environmental Conservation, Albany, N.Y.

Debo, T. and A. Reese, 1995. "Municipal Storm Water Management." Ann Arbor: Lewis Publishers.

Galli, J. 1992. Preliminary Analysis of the Performance and Longevity of Urban BMPs Installed In Prince George's County, Maryland. Prepared for the Department of Natural Resources, Prince George's County, MD.

Gburek, W. and J. Urban, 1980. Storm Water Detention and Groundwater Recharge Using Porous Asphalt - Experimental Site. For: USDA-SEA-AR Northeast Watershed Research Center, University Park, PA. International Symposium on Urban Storm Runoff, University of Kentucky.

Goforth, G., E. Diniz, and J. Rauhut. Stormwater Hydrological Characteristics of Porous and Conventional Paving Systems. Prepared for: US EPA Office of Research and Development. Cincinnati, OH.

Hossain, M. and L. Scofield, 1991. Porous Pavement for Control of Highway Runoff. Arizona Department of Transportation. Phoenix, AZ.

IDEQ, 1995. Idaho Department of Environmental Quality. September 1995. "Guidelines for the Treatment and Disposal of Stormwater Runoff."

IDEQ, 1996. Idaho Department of Environmental Quality, Southwest Idaho Regional Office. January 1996. "Cascade Reservoir Phase 1 Watershed Management Plan."

King County, 1994. King County Surface Water Management, Washington. Originally published in 1990 and updated regularly, including a major revision in 1994. "Surface Water Design Manual."

King County, 1995. King County, Snohomish County, Seattle Drainage and Wastewater Utility, and Port of Seattle. October 1995. "Evaluation of Commercially-Available Catchbasin Inserts for the Treatment of Stormwater Runoff from Developed Sites."

Maine, 1995. Maine Department of Environmental Protection. November 1995. "Stormwater Management for Maine: Best Management Practices."

Minnesota, 2000. Minnesota Pollution Control Agency. March 2000. "Protecting Water Quality in Urban Areas. Best Management Practices for Dealing with Storm Water Runoff from Urban, Suburban, and Developing Areas of Minnesota.

North Carolina, 1993. State of North Carolina. Originally published in 1988 and updated regularly. "North Carolina Erosion and Sediment Control Planning and Design Manual."

Panhandle Health District, 1996. Panhandle Health District, Coeur d'Alene, Idaho. August 1996. "Estimating and Mitigating Phosphorus from Residential and Commercial Areas in Northern Idaho."

Portland, 1991. City of Portland, City of Lake Oswego, Clackamas County, Unified Sewerage Agency. August 1991. Surface Water Quality Facilities Technical Guidance Catalog." Prepared by Brown and Caldwell Consultants.

Portland, 1995. City of Portland. March 1995. City of Portland Stormwater Facilities: A Design Guidance Manual." Prepared by Woodward-Clyde Consultants.

Schueler, T. 1987. Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs. Metropolitan Washington Council of Governments. Washington, DC.

Seattle 1992. Municipality of Seattle (Dr. Richard Horner). October 1992. "Biofiltration Swale Performance, Recommendations and Design Considerations."

Stenmark, C. 1995. An Alternative Road Construction for Stormwater Management. Water Science and Technology, 32(1): 79-84.

Strecker, E.W., M.M. Quigley, B. Urbonas, and J. Jones. 2004. "Analyses of the expanded EPA/ASCE international BMP database and potential implications for BMP design". In: Proceedings of the World Water and Environmental resources

Congress – Critical Transitions in Water and Environmental Resources Management, June 27 – July 1, 2004, Salt Lake City, UT.

U.S. EPA, 1993. United States Environmental Protection Agency, Office of Research and Development. September 1993. "Urban Runoff Pollution Prevention and Control Planning." (EPA/625/R-93/004).

U.S. EPA, 1995. United States Environmental Protection Agency, Center for Environmental Research Information. April 1995. "National Conference on Urban Runoff Management: Enhancing Urban Watershed Management at the Local, County and State Levels." (EPA/625/R-95/003).

U.S. EPA, 1999. United States Environmental Protection Agency, Office of Water. August 1999. "Preliminary Data Summary of Urban Storm Water Best Management Practices." (EPA-821-R-99-012).

U.S. EPA, 1999. United States Environmental Protection Agency, Office of Water. September 1999. "Storm Water Technology Fact Sheet: Bioretention." (EPA-832-F-99-012).

U.S. EPA, 1999. United States Environmental Protection Agency, Office of Water. September 1999. "Storm Water Technology Fact Sheet: Infiltration Trench." (EPA-832-F-99-019).

U.S. EPA, 1999. United States Environmental Protection Agency, Office of Water. September 1999. "Storm Water Technology Fact Sheet: Vegetated Swales." (EPA-832-F-99-006).

U.S. EPA, 2004. United States Environmental Protection Agency, Office of Research and Development. September 2004. "The Use of Best Management Practices (BMPs) in Urban Watersheds." (EPA/600/R-04/184)

U.S. EPA, 2004. United States Environmental Protection Agency, Office of Research and Development. September 2004. "Stormwater Best Management Practice Design Guide: Volume 1, General Considerations". (EPA/600/R-04/121)

Virginia Department of Conservation and Recreation. 1999. Virginia Stormwater Management Handbook, Volumes 1 and 2, Richmond, VA.

Watershed Management Institute (WMI). 1997. Operation, Maintenance, and Management of Stormwater Management Systems. Prepared for: US EPA Office of Water. Washington, DC.

Appendix B – Glossary

AASHTO	American Association of State Highway and Transportation Officials
ADJUSTABLE GATE VALVE	A knife gate valve, activated by a handwheel, used to control the internal diameter of reverse-slope pipe, or to allow rapid opening of the pond drain pipe.
ADSORPTION	Adhesion of the molecules of a gas, liquid or dissolved substance to a surface. Adsorption differs from absorption in that adsorption is the assimilation or incorporation of a gas, liquid, or dissolved substance into another substance.
AGGREGATE	Term for the stone or rock gravel needed to fill in an infiltration device such as a trench or porous pavement. Clean-washed aggregate is simply aggregate that has been washed clean so that no sediment is included
API	American Petroleum Institute
AQUATIC BENCH	A ten to fifteen foot bench around the inside perimeter of a permanent pool that is approximately 1 foot deep. Normally vegetated with emergent plants, the bench augments pollutant removal, provides habitat, conceals trash and water levels, and enhances safety.
AREAL	Of an expanse of land or region.
ARTIFICIAL MARSH CREATION	Simulation of natural marsh features and functions via topographic and hydraulic modifications on nonmarsh landscapes. Typical objectives for artificial marsh creation include ecosystem replacement or stormwater management.
ASTM	American Society for Testing and Materials
BMP	Best Management Practice
BACTERIA	Single-celled microorganisms that lack chlorophyll; some cause disease, others are necessary to sustain life (see Fecal Coliform Bacteria).
BACTERIAL DECOMPOSITION OR MICROBIAL DECOMPOSITION	Microorganisms, or bacteria, have the ability to degrade organic compounds as food resources and to absorb nutrients and metals into their tissues to support growth.

BANK RUN	Gravelly deposits consisting of smooth round stones, generally indicative of the existence of a prehistoric sea. Such deposits are normally found in coastal plain regions.
BANK STABILIZATION	Methods of securing the structural integrity of earthen stream channel banks with structural supports for prevention of bank slumping and undercutting of riparian trees, and overall erosion prevention. To maintain the ecological integrity of the system, recommended techniques include the use of willow stakes, imbricated riprap, or brush bundles.
BANKFULL DISCHARGE	A flow condition where streamflow completely fills the stream channel up to the top of the bank. In undisturbed watersheds, the discharge condition occurs on average every one and a half to two years and controls the shape and form of natural channels.
BASEFLOW	The portion of stream flow that is not due to storm runoff, and is supported by groundwater seepage into a channel.
BERM, EARTHEN	An earthen mound used to direct the flow of runoff around or through a BMP.
BEST MANAGEMENT PRACTICE (BMP)	In this Catalog, the term refers to source or treatment controls designed to reduce pollution in stormwater runoff. Source controls are measures or devices designed to keep pollutants out of runoff. Examples include covers and roofs on outdoor storage processing areas and berms and sumps around outdoor source areas. Treatment controls are typically structural devices designed to temporarily store or treat urban stormwater runoff to reduce flooding, remove pollutants, and provide other amenities (e.g. enhance aesthetics and wildlife habitat).
BIOCHEMICAL OXYGEN DEMAND (BOD)	The quantity of dissolved oxygen used by microorganisms (e.g., bacteria) during the biochemical oxidation of matter (both organic and oxidizable inorganic matter) over a specified period of time.
BIOFILTRATION	The use of natural materials and vegetation to trap and remove pollutants from stormwater. Grass swales and constructed wetlands can both be used for biofiltration.

BIOLOGICAL MONITORING	Periodic surveys of aquatic biota as an indicator of the general health of a waterbody. Biological monitoring surveys can span the trophic spectrum, from macro-invertebrates to fish species.
CATCHBASIN	A structure at the point where a street gutter empties into a sewer, built to catch debris that would not easily pass through the sewer.
CATCHMENT AREA	See CONTRIBUTING WATERSHED AREA. Also known as drainage catchment area.
CBR	California Bearing Ratio
CEC	Cation Exchange Capacity
CHANNEL	A natural or artificial waterway that periodically or continuously contains moving water. It has a definite bed and banks that confine the water.
CHANNEL EROSION	The widening, deepening, and headward cutting of small channels and waterways, due to erosion caused by moderate to larger floods.
CHECK DAM	A small dam (a) placed perpendicular to a stream to enhance aquatic habitat, or (b) placed perpendicular in biofiltration swales to reduce water velocities, promote sediment deposition, and enhance infiltration.
CHECK VALVE	A device to provide positive closure that effectively prohibits the flow of material in the opposite direction of normal flow when operation of the irrigation system, pumping plant, or injection unit fails or is shut down (ASAE, 1989).
CHEMICAL OXYGEN DEMAND (COD)	The quantity of maximum oxidizable matter in a sample.
COE	Army Corps of Engineers
COMPOST STORMWATER FILTER (CSF)	A device that uses leaf compost to treat stormwater runoff.
CONTRIBUTING WATERSHED AREA	Portion of the watershed contributing its runoff to the site or BMP in question.
CONVEYANCE SYSTEM	The drainage facilities, both natural and human-made, which collect, contain, and provide for the flow of surface water and urban runoff from the highest points on the land down to a receiving water. The natural elements of the conveyance system include swales and small drainage courses, streams, rivers, lakes, and wetlands. The human-made elements of the conveyance system include gutters, ditches, pipes, channels, and most retention/detention

	facilities.
CPEP	Corrugated High Density Polyethylene Pipe
CPS	Coalescing Plate Separator
CROSS SECTION	A vertical section of a stream channel or structure that provides a side view of the structure; a transect taken at right angles to flow direction.
CSF	Compost Stormwater Filter
CULVERT	A covered channel or a large-diameter pipe that directs flow below the ground level.
CWA	Clean Water Act
DEQ	Department of Environmental Quality, State of Idaho
DEBRIS	Any material, organic or inorganic, floating or submerged, moved by a flowing stream.
DECIDUOUS	Trees that shed leaves in the fall/winter.
DELTA-t	The magnitude of change in the temperature of downstream waters.
DESIGN STORM	A rainfall event of specified size and return frequency (e.g., a storm that occurs only once every 2 years) that is used to calculate the runoff volume and peak discharge rate to a BMP. Design storm information is presented in Appendix D of this Catalog.
DETENTION	The temporary storage of stormwater runoff in a structural device (BMP) to reduce the peak discharge rates and to provide settling of pollutants.
DETENTION POND	A constructed pond or vault that temporarily stores stormwater runoff and releases it at controlled rates.
DETENTION TIME	Time required for detention of stormwater runoff in a stormwater quality facility (also see "Detention").
DE-WATERING	Refers to a process used in detention/retention facilities, whereby water is completely discharged or drawn down to a pre-established pool elevation by way of a perforated pipe. De-watering allows the facility to recover its design storage capacity in a relatively short time after a storm event.
DISCHARGE	Outflow; the flow of a stream, canal, or aquifer. One may also speak of the discharge of a canal or stream into a lake, river, or ocean. (Hydraulics) Rate of flow, specifically fluid flow; a volume of fluid passing a point per unit of time, commonly expressed as cubic feet per second, cubic meters per second, gallons per minute, gallons per day, or millions of gallons per day.
DISSOLVED OXYGEN (DO)	Oxygen which is present (dissolved) in water and available for use by fish and other aquatic animals. If

	the amount of dissolved oxygen in the water is too low, aquatic animals will suffocate.
DIVERSION	A channel, embankment, or other man-made structure constructed to divert water from one area to another (Soil Conservation Society of America, 1982).
DOWNSTREAM SCOUR	Downstream channel erosion usually associated with an upstream structure that has altered hydraulic conditions in the channel.
DRAINAGE BASIN OR SUBBASIN	See WATERSHED.
DRAWDOWN	The gradual reduction in water level in a pond BMP due to the combined effect of infiltration and evaporation.
DRIPLINE	An imaginary line around a tree or shrub at a distance from the trunk equivalent to the canopy spread.
DROP STRUCTURE	Placement of logs with a weir notch across a stream channel. Water flowing through the weir creates a plunge pool downstream of the structure and creates fish habitat.
DRY POND CONVERSION	A modification made to an existing dry stormwater management pond to increase pollutant removal efficiencies. For example, the modification may involve a decrease in orifice size to create extended detention times, or the alteration of the riser to create a permanent pool and/or shallow marsh system.
DRY-WEATHER FLOW	Flow occurring during the dry season (generally considered to be May through September) which may be associated with reservoir releases or releases of water from industrial or residential activities.
DRYWELL	A well to which stormwater is disposed for purposes of infiltration. These devices are not recommended for areas with high water table conditions.
EMBANKMENT	A bank (of earth or riprap) used to keep back water.

EMERGENT PLANT	An aquatic plant that is rooted in the sediment but whose leaves are at or above the water surface. Such wetland plants provide habitat for wildlife and waterfowl in addition to removing stormwater pollutants.
END OF PIPE CONTROL	Water quality control technologies suited for the control of existing urban stormwater at the point of storm sewer discharge to a stream. Due to typical space constraints, these technologies are usually designed to provide water quality control rather than quantity control.
ENERGY DISSIPATION	The loss of kinetic energy of moving water due to internal turbulence, boundary friction, change in flow direction, contraction, or expansion.
EPA	Environmental Protection Agency
EROSION	The wearing away of the land surface by running water, wind, ice, or other geological processes.
EXFILTRATION	The downward movement of runoff through the bottom of an infiltration BMP into the subsoil.
EXTENDED DETENTION (ED)	A stormwater design feature that provides for the gradual release of a volume of water (0.25 - 1.0 inches per impervious acre) over a 12 to 48 hour interval time to increase settling of urban pollutants, and protect channel from frequent flooding.
EXTENDED DETENTION (ED) CONTROL DEVICE	A pipe or series of pipes that extend from the riser of a stormwater pond that are used to gradually release stormwater from the pond over a 12 to 48 hour interval.
EXTENDED DETENTION (ED) POND	A conventional ED pond temporarily detains a portion of stormwater runoff for up to 24 hours after a storm using a fixed orifice. Such extended detention allows urban pollutants to settle out. The ED ponds are normally dry between storm events and do not have any permanent standing water. An enhanced ED pond is designed to prevent clogging and resuspension. It provides greater flexibility in achieving target detention times. It may be equipped with plunge pools near the inlet, a micropool at the outlet, and utilize an adjustable reverse-sloped pipe at the ED control device.

EXTENDED DETENTION ZONE	A pondscaping zone that extends from the normal pool to the maximum water surface elevation during extended detention events. Plants within this zone must be able to withstand temporary inundation from 5 to 30 times per year.
FHWA	Federal Highway Administration
FILTER FABRIC	See Geotextile Fabric
FLOODPLAIN	Any lowland that borders a stream and is inundated periodically by its waters.
FLOW SPLITTER	An engineered, hydraulic structure designed to divert a portion of stream flow to a BMP located out of the channel, or to direct stormwater to a parallel pipe system, or to bypass a portion of baseflow around a pond.
FOREBAY	An extra storage area provided near an inlet of a BMP to trap incoming sediments before they accumulate in a pond BMP.
FRAGIPAN	A loamy, brittle subsurface horizon low in porosity and content of organic matter and low or moderate in clay but high in silt or very fine sand.
FREEBOARD	The vertical distance between the design water surface elevation and the elevation of the bank, levee or revetment that contains the water.
FREQUENT FLOODING	A phenomenon in urban streams whereby the number of bankfull and sub-bankfull flood events increases sharply after the development. The frequency of these disruptive floods is a direct function of watershed imperviousness.
FRINGE MARSH CREATION	Planting of emergent aquatic vegetation along the perimeter of open water to enhance pollutant uptake, increase forage and cover for wildlife and aquatic species, and improve the appearance of a pond.
GEOMEMBRANE	Lining of filter fabric on the bottom and sides of porous pavement to prevent lateral or upward movement of soil into the stone reservoir.
GEOTEXTILE FABRIC	Textile of relatively small mesh or pore size that is used to (a) wallow water to pass through while keeping sediment out (permeable), or (b) prevent both runoff and sediment from passing through (impermeable). Also known as filter fabric.
GRADING	The cutting and/or filling of the land surface to a desired slope or elevation.
GRASSED SWALE	An earthen conveyance system in which the filtering action of grass and soil infiltration are utilized to

remove pollutants from urban stormwater. An enhanced grass swale, or biofilter, utilizes checkdams and wide depressions to increase runoff storage and promote greater settling of pollutants.

GRAVEL Sediment particles larger than sand and ranging from 2 to 64 mm (0.25 to 3 inches) in diameter.

GRAVITATIONAL SETTLING The tendency of particulate matter to drop out of stormwater runoff as it flows downstream when runoff velocities are moderate and/or slopes are not too steep.

GROUNDWATER TABLE The level below which the soil is saturated, that is, the pore spaces between the individual soil particles are filled with water. Above the groundwater table and below the ground surface, water in the soil does not fill all pore spaces.

HABITAT A place where a biological organism lives. The organic and non-organic surroundings that provide life requirements such as food and shelter.

HEAD Pressure.

HEAVY METALS Metals of relatively high atomic weight, including but not limited to chromium, copper, lead, mercury, nickel, and zinc. These metals are generally found in minimal quantities in stormwater, but can be highly toxic even at trace levels.

IDAPA Idaho Administrative Procedures Act

IDWR Idaho Department of Water Resources

IMPERMEABLE Properties that prevent the movement of water through the material.

IMPERVIOUS SURFACE Material which resists or blocks the passage of water.

INFILTRATION The penetration of water through the ground surface into subsurface soil or the penetration of water from the soil into sewer or other pipes through defective joints, connections, or manhole walls. The infiltration rate is expressed in terms of inches/hour. Infiltration rates will be slower when the soil is dense (e.g., clays) and faster when the soil is loosely compacted (e.g., sands). Can also refer to seepage of groundwater into sewer pipes through cracks and joints.

INLET	(1) A drainage passway. (2) A short, narrow waterway connecting a bay, lagoon, or similar body of water with a large parent body of water. (3) An arm of the sea (or other body of water) that is long compared to its width and may extend a considerable distance inland.
ITD	Idaho Transportation Department
LEVEL SPREADER	A device used to spread out stormwater runoff uniformly over the ground surface as sheet flow (i.e., not through channels). The purpose of level spreaders is to prevent concentrative, erosive flows from occurring, and to enhance infiltration.
LOWFLOW CHANNEL	An incised or paved channel from inlet to outlet in a dry basin which is designed to carry low runoff flows and/or baseflow, directly to the outlet without detention.
MICROPOOL	A smaller permanent pool used in a stormwater pond due to extenuating circumstances, i.e., concern over the thermal impacts of larger ponds, impacts on existing marshes, or lack of topographic relief.
MICROTOPOGRAPHY	Refers to the contours along the bottom of a shallow wetland system. A complex microtopography creates a great variety of environmental conditions that favor the unique requirements of many different species of marsh plants.
MULTIPLE POND SYSTEM	A collective term for a cluster of pond designs that incorporate redundant runoff treatment techniques within a single pond or series of ponds. These pond designs employ a combination of two or more of the following: extended detention, permanent pool, shallow marsh, or infiltration. The wet ED pond is an example of a multiple pond system..
NATURAL BUFFER	A low sloping area of maintained grassy or woody vegetation located between a pollutant source and a waterbody. A natural buffer is formed when a designated portion of a developed piece of land is left unaltered from its natural state during development. A natural vegetative buffer differs from a vegetated filter strip in that it is natural and in that they need not be used solely for water quality purposes. To be effective, such areas must be protected against concentrated flow.

NPDES	National Pollutant Discharge Elimination System
NUTRIENTS	Elements or substances, such as nitrogen or phosphorus, that are necessary for the growth and development of living things (e.g., plants). Large amounts of these substances reaching water bodies can lead to reduced water quality and eutrophication by promoting excessive aquatic algae growth. Some nutrients can be toxic at high concentrations.
OBSERVATION WELL	A test well installed in certain infiltration and filtration BMPs to monitor draining times after installation.
OFF-LINE BMP	A water quality facility designed to treat a portion of stormwater which has been diverted from a stream or storm drain.
OFF-LINE TREATMENT	A BMP system that is located outside of the stream channel or drainage path. A flow splitter is typically used to divert runoff from the channel and into the BMP for subsequent treatment.
OIL/WATER (OR OIL/GRIT) SEPARATOR	A best management practice consisting of a three-stage underground retention system designed to remove heavy particulates and absorbed hydrocarbons. Also known as a WATER QUALITY INLET.
OUTFALL	The point of discharge for a river, drain, pipe, etc.
PARALLEL PIPE SYSTEM	A technique for protecting sensitive streams. Excess stormwater runoff is piped in a parallel direction along the stream buffer instead of being discharged directly into the stream.
PASSIVE TREATMENT FACILITY	A facility which uses natural materials and vegetation to cleanse stormwater and/or reduce stormwater flow. Examples include grass swales, constructed wetlands, etc.
PERCOLATION	The downward movement of water through the soil.
PERMANENT POOL	A three to ten foot deep pool in a stormwater pond system that provides removal of urban pollutants through settling and biological uptake. (Also referred to as a wet pond).
PERMEABILITY	The quality of a soil horizon that enables water or air to move through it.

PHYSICAL INFILTRATION	The separation of particulates from runoff by grass, leaves and other organic matter on the surface, as the runoff passes across or through the ground.
PILOT CHANNEL	A riprap or paved channel that routes runoff through a BMP to prevent erosion of the surface.
PLUNGE POOL	A small permanent pool located at either the inlet to a BMP or at the outfall from a BMP. The primary purpose of the pool is to dissipate the velocity of stormwater runoff, but it also can provide some pre-treatment, as well.
POLLUTANT	Generally, any substance introduced into the environment that adversely affects the usefulness of a resource.
POLLUTION	Impairment of water quality caused by man-made waste discharges or natural processes.
PONDSCAPING	A method of designing the plant structure of a stormwater marsh or pond using inundation zones. The proposed marsh or pond system is divided into zones which differ in the level and frequency of inflow. For each zone, plant species are chosen based on their potential to thrive, given the inflow pattern of the zone.
POROUS PAVEMENT	An alternative to conventional pavement whereby runoff is diverted through a porous asphalt layer and into an underground tone reservoir. The stored runoff then gradually infiltrates into the subsoil. Porous pavement is not recommended for use in areas with high water table conditions.
RETROFIT	The creation/modification of stormwater management systems in developed areas through the construction of wet ponds, infiltration systems, marsh plantings, streambank stabilization, and other BMP techniques for improving water quality and creating aquatic habitat. A retrofit can consist of the construction of a new BMP in the developed area, the enhancement of an older stormwater management structure, or a combination of improvement and new construction.
REVERSE SLOPE PIPE	A pipe that extends downward from the riser into the permanent pool that sets the water surface elevation of pool. The lower end of the pipe is located up to 1 foot below the water surface. This is a very useful technique for regulating ED times in a stormwater wetland, and they seldom clog.

RIPARIAN	A relatively narrow strip of land that borders a stream or river, often coincides with the maximum water surface elevation of the one-hundred year storm.
RIPARIAN REFORESTATION	The replanting of the banks and floodplain of a stream with native forest and shrub species to stabilize erodible soils, improve both surface and groundwater quality, increase stream shading, and enhance wildlife habitat.
RIPRAP	A combination of large stone, cobbles, and boulders used to line channels, stabilize banks, reduce runoff velocities, or filter out sediment.
RISER	A vertical pipe extending from the bottom of a pond BMP that is used to control the discharge rate from a BMP for a specified design storm.
ROOT ZONE	The part of the soil that is, or can be, penetrated by plant roots (Soil Conservation Society of America, 1982).
ROTOTILLING	Mechanical means of tilling, or rotating, the soil.
RUNOFF	See "Stormwater Runoff."
RUNOFF CONVEYANCE	Methods for safely conveying stormwater to a BMP to minimize disruption of the stream network, and promote infiltration or filtering of the runoff.
RUNOFF FREQUENCY SPECTRUM	The frequency distribution of unit are runoff volumes generated by a long, term continuous time-series of rainfall events. Used to develop BMP and stormwater sizing rules.
RUNOFF PRETREATMENT	Techniques to capture or trap coarse sediments before they enter a BMP to preserve storage volumes or prevent clogging with in the BMP. Examples include forebays and micropools for pond BMPs, and plunge pools, grass filter strips, and filter fabric for infiltration BMPs.
RUNON	Off-site flows which flow onto a site.
SAFETY BENCH	A ten to fifteen foot wide bench located just outside the perimeter of a permanent pool. The bench extends around the entire shoreline to provide for maintenance access and eliminate hazards.
SAND FILTER	A technique for treating stormwater, whereby the first flush of runoff is diverted into a self-contained bed of sand. The runoff is then strained through the sand, collected in underground pipes and returned back to the stream or channel. An enhanced sand filter utilizes layers of peat, limestone, and/or topsoil, and may also have a grass cover crop. The adsorptive

	media of an enhanced sand filter is expected to improve removal rates.
SCOUR	Concentrated erosive action of flowing water in streams that removes material from the bed and banks.
SCS	Soil Conservation Service of USDA. Note: New name for this agency, as of 1996, is Natural Resources Conservation Service (NRCS).
SEDIMENT	The product of erosion processes; the solid material, both mineral and organic, that is in suspension, is being transported, or has been moved from its site of origin by air, water, gravity, or ice (USDA-SCS, 1991).
SEDIMENTATION	The process of sand and mud settling and building up on the bottom of a creek, river, lake, or wetland.
SEDIMENT FOREBAY	Stormwater design feature that employs the use of a small settling basin to settle out incoming sediments before they are delivered to a stormwater BMP. Particularly useful in tandem with infiltration devices, wet ponds, or marshes.
SEEDBANKS	Refers to the large number and diversity of dormant seeds of plant species that exist within the soil. The seeds may exist within the soil for years before they germinate under the proper moisture, temperature, or light conditions. Within marsh soils, this seedbank helps to maintain above-ground plant diversity and can also be used to rapidly establish marsh plants within a newly constructed stormwater marsh.
SEEPAGE	Water escaping through or emerging from the ground along an extensive line or surface as contrasted with a spring, where the water emerges from a localized spot (Soil Conservation Society of America, 1982).
SEPTIC	Produced by anaerobic decomposition of organic matter with accompanying foul odors.
SHEET FLOW	Water, usually storm runoff, flowing in a thin layer over the ground surface (Soil Conservation Society of America, 1982).
SHORT CIRCUITING	The passage of runoff through a BMP in less than the theoretical or design treatment time.

SINUOSITY	(From Gordon, McMahon, and Finlayson, 1992) A measure of the wiggliness of a watercourse. While sinuosity has a number of definitions, the most commonly used one is the sinuosity index, which is given as: $SI = \frac{\text{Channel (Thalweg) Distance}}{\text{Downvalley distance}}$
SLOPE	The degree of deviation of a surface from horizontal, measured as a percentage, as a numerical ratio, or in degrees (Soil Conservation Society of America, 1982).
SOURCE CONTROL	A pollution control measure which operates by keeping pollutants from entering stormwater
STORM DRAIN (or STORM SEWER SYSTEM)	Above and below ground structures for transporting stormwater to streams or outfalls for flood control purposes.
STORMWATER RUNOFF	Excess precipitation that is not retained by vegetation, surface depressions, or infiltration, and thereby collects on the surface and drains into a surface water body.
STORMWATER SITE PLAN (SSP)	A plan prepared during the project design phase to show the BMPs and techniques that will be used to control stormwater pollution during construction and after construction is complete. Appendix E provides a description of the recommended contents of a stormwater site plan.
STORMWATER TREATMENT	Detention, retention, filtering, or infiltration of a given volume of stormwater to remove urban pollutants and reduced frequent flooding.
STREAM BUFFER	A variable width strip of vegetated land adjacent to a stream that is preserved from development activity to protect water quality, aquatic, and terrestrial habitats.
SUBSOIL	The bed or stratum of earth lying below the surface soil.
SUBSTRATE AMENDMENTS	A technique to improve the texture, and organic content of soils in a newly excavated pond system. The addition of organic rich soils is often required to ensure the survival of aquatic and terrestrial landscaping around ponds.
SUSPENDED SEDIMENT	The very fine soil particles that remain in suspension in water for a considerable period of time (Soil Conservation Society of America, 1982).
SWALE	A natural depression or wide shallow ditch used to temporarily store, route, or filter runoff.

TOPOGRAPHY	The relative positions and elevations of the natural or man-made features of an area that describe the configuration of its surface (Soil Conservation Society of America, 1982).
TOXIC	Related to or caused by a poison, hazardous waste, or toxin.
TRASH AND DEBRIS REMOVAL	Mechanical or manual removal of debris, snags, and trash deposits from the streambanks to improve the appearance of the stream.
UNDERDRAIN	Plastic pipes with holes drilled through the top, installed on the bottom of a sand filter, which are used to collect and remove excess runoff.
URBAN RUNOFF	Stormwater that passes through and out of developed areas to a stream or other body of water. (See Stormwater Runoff.)
USDA	United States Department of Agriculture
VACUUM SWEEPING	Method of removing quantities of coarse-grained sediments from porous pavements in order to prevent clogging. Not effective in removing fine- grained pollutants.
VEGETATED FILTER STRIP	A vegetated section of land designed to accept runoff as overload sheet flow from upstream development. It may adopt any natural vegetated form, from grass meadow to small forest. The dense vegetative cover facilitates pollutant removal. A filter strip cannot treat high velocity flows; therefore, they have generally been recommended for use in agriculture and low density development. A vegetated filter strip differs from a natural buffer in that the strip is not natural ; rather, it is designed and constructed specifically for the purpose of pollutant removal. A filter strip can also be an enhanced natural buffer, however, whereby the removal capability of the natural buffer is improved through engineering and maintenance activities such as land grading or the installation of a level spreader. A filter strip also differs from a grassed swale in that a swale is a concave vegetated conveyance system, whereas a filter strip has a fairly level surface.

VELOCITY	The distance that water travels in a given direction in a stream during an interval of time.
WATERSHED OR DRAINAGE BASIN	A geographic area within which all surface water drains into a particular body of water (e.g., a river or stream).
WEEPHOLE	A small opening or pipe left in a revetment or bulkhead to allow groundwater drainage.
WEIR	A structure that extends across the width of a channel and is intended to impound, delay or in some way alter the flow of water through the channel. A CHECK DAM is a type of weir as is any kind of dam.
WET POND	A conventional wet pond has a permanent pool of water for treating incoming stormwater runoff. In enhanced wet pond designs, a forebay is installed to trap incoming sediments where they can be easily removed; a fringe marsh is also established around the perimeter of the pond.
WET-WEATHER FLOW	Water derived primarily from rain, melting snow or irrigation during the wet season (generally considered to be October through April) that flows over the surface of the ground.
WETLAND	A conventional wetland for stormwater quality control is a shallow pool that creates growing conditions suitable for the growth of marsh plants. Designed to maximize pollutant removal through marsh uptake, retention, and settling. A wetland is a constructed system and typically is not located within delineated a natural wetland. In addition, a stormwater wetland differs form an artificial wetland created to comply with mitigation requirements in that the stormwater wetland does not replicate all the ecological functions of natural wetlands. An enhanced stormwater wetland is designed for more effective pollutant removal and species diversity. It also includes design elements such as a forebay, complex microtopography, and pondscaping with multiple species of marsh trees, shrubs, and plants.
WETLAND MITIGATION	Regulatory requirement to replace marsh areas destroyed or impacted by proposed land disturbances with artificially created marsh areas.
WETLAND MULCH	A technique for establishing low or high marsh areas

	where the top twelve inches of marsh soil from a donor marsh are spread thinly over the surface of a created marsh site as a mulch. The seedbank and organic matter of the mulch helps to rapidly establish a diverse marsh system.
WETLAND PLANT UPTAKE	Marsh plant species rely on nutrients (i.e., phosphorous and nitrogen) as a food source; thus, they may intercept and remove nutrients from either surface or subsurface flow.

Appendix C - Stormwater Plant Materials

This section includes information that can aid in the selection of plant materials for vegetated stormwater Best Management Practices (BMPs). This information was developed by Daniel G. Ogle, Plant Materials Specialist, and J. Chris Hoag, Wetland Plant Ecologist, of the USDA Natural Resources Conservation Service.

Selecting the proper plant materials for these BMPs is essential because many of these BMPs rely on the plants to perform important functions. Plants can purify the water by removing suspended solids (sediment) and a wide variety of nutrients and minerals such as nitrate, phosphorus, heavy metals, and fecal coliform bacteria. The plants also provide bank protection by reducing the wave energy before it hits the bank. By reducing the wave energy, the plants will cause the water to drop sediment around the base of the plants thereby cleaning the water by removing suspended solids. The above ground plant biomass provides sites for algae and other microorganisms to live and multiply. The root systems provide colony sites for microbes that break down nutrients into usable proteins and amino acids in addition to basic elements and nitrogen gas.

If the wrong plants are selected, they may not tolerate site conditions and either become weak or die. Weakened or dead plants will need to be replaced so that the BMP will work properly. Continual plant replacement increases project costs and reduces BMP effectiveness. Similarly, other plants may require significant short-term and long-term maintenance. Consequently, the designer should choose plants wisely.

1.1 Vegetative BMPs

Vegetative stormwater BMPs provide a variety of uses, depending on the objective. BMPs such as biofiltration swales and grass buffer strips are primarily pretreatment systems that are used in conjunction with other stormwater facilities for on-site disposal. Infiltration swales and ponds are systems that could be used alone or with some type of pretreatment. Detention ponds are designed exclusively for flood control and may be either wet or dry. Plant materials used in detention ponds are primarily for stabilization and aesthetics. Extended detention ponds are multifunctional; with a longer detention time in order to provide both water quality treatment and flood control. Table 1 shows the different uses of vegetative stormwater BMPs.

Table 1. Vegetative BMPs and their uses

Facility Type	Maximum Period of Standing Water	Comments
Detention pond	24-48 hours	Water quantity control
Extended detention pond	48-72 hours	Water quality control
Evaporation pond	Varies	Water quantity/quality control
Infiltration basin	48-72 hours	On-site disposal; requires pretreatment
Biofiltration swale	No standing water	Used for pretreatment only
Grass buffer strip	No standing water	Used for pretreatment only
Grass channel	Duration of storm	Used for conveyance only

Another type of vegetative BMP is bioretention. Bioretention is a method to manage stormwater runoff using native plants and soil conditioning. Bioretention areas capture sheet flow from impervious surfaces. The captured water usually flows through a grass buffer strip and then is infiltrated into a filtration bed. Bioretention capitalizes on the biological abilities and physical attributes of specific plants and native grasses.

1.2 Understanding Your Site

Understanding the site's characteristics will help determine which plant materials and planting methods the designer should select. Selecting the appropriate plant materials and planting methods will improve plant establishment. This section will discuss the soil properties that are integral to successful plant establishment: soil characteristics, soil fertility, and topsoil.

Soil characteristics

Plant growth can be limited by certain soil characteristics. Species must be able tolerate the soil's limitations in order to successfully establish on a site. Soil limitations can include the following:

- fine or coarse textures
- impermeable soil layers
- extended periods of wetness or high ground water
- salinity or alkalinity
- acidity
- shallow depth
- toxicity

- severe nutrient imbalance

The designer should consider other soil characteristics that may or may not be a limitation to the plant. For example, the soil's water-holding capacity affects the composition of natural vegetation and selection of species. In addition, slope is also important in each plant's ability to adapt within the climatic range.

Soil fertility

Disturbed areas can be extremely deficient in available nitrogen and phosphorus. Consequently, unless topsoil is applied, soil material can be nearly devoid of organic matter. To remedy this problem, the use of compost or annual applications of nitrogen fertilizer may be needed to sustain a plant community until the plants can establish their own nutrient cycle.

Disturbed areas can also be phosphorus deficient because the pH is at or above 8.3 and abundant calcium carbonate keeps the phosphorus largely unavailable. Phosphate fertilizer increases the plant-available supply for only a few years. Applying topsoil to the site greatly increases the available phosphorus levels on disturbed areas.

Prior to amending the soil, the soil should be analyzed to determine nutrient content. Additional fertilizer may be unnecessary or even harmful.

A general guideline to increasing soil fertility is to apply fertilizer to the site. Apply a minimum of 30 pounds of nitrogen and 40 pounds of phosphate (P_20_5) per acre to disturbed areas. Subsequent soil tests will determine if fertilizer rates will need to be adjusted.

Topsoil

All topsoil and soil-like material should be saved and redistributed on the reclaimed area. Direct placement of topsoil (moved and replaced) provides a source of viable native plant seeds and vegetative structures, which volunteer into the reclaimed plant community. If topsoils are not available, subsoils should be amended with compost and other organic amendments that will ensure better soil tilth, improved infiltration characteristics, and improved soil biologic activity.

1.3 Plant Material Selection

Selecting plants requires more than understanding the soils on the site. It requires selecting the appropriate plants that will work for the BMP. Section 3 contains plant tables that list information on grass and grass-like plants, riparian trees and shrubs, and upland trees and shrubs that are suitable for vegetative stormwater BMPs.

Species selection

As previously mentioned, vegetative stormwater BMPs provide a variety of uses, depending on the stormwater objective. To meet that objective, the designer must select the plants that will meet the system requirements of the BMP.

For example, detention ponds are designed to collect and temporarily hold surface and stormwater runoff. They are specifically used for flood control. System components of a wet detention pond include using plant materials to stabilize pond slopes (for dust control) and to improve pond aesthetics. Therefore, if a designer wanted to construct a wet detention pond on the site, the combination of plants selected for the pond should meet the criteria of soil stabilization and pond aesthetics.

In addition, the designer should consider the environmental factors of a site to determine which plants are appropriate for the BMP. Expected precipitation, irrigation supply, site exposure, elevation, temperature, and soil type and properties all play a role in selecting the appropriate plants. If the designer chose plants that are good soil stabilizers, but do not tolerate acidic soils then the plants will have limited establishment and will not meet the system requirements of the BMP.

Also, the designer must consider the location of the BMP in relation to land use activities. For example, if a vegetated BMP is going to be located next to a roadway, the plants should have high salt tolerance in case excessive amounts of de-icing salts run off the pavement into the BMP.

Finally, the designer must consider the extreme conditions under which the plant must survive. For example, plants have an extremely difficult time establishing in the Intermountain West because of the severe conditions. Plants must withstand long periods of drought and low temperatures without snow cover. Some wetland plants, however, can tolerate a variety of growing conditions. These wetland plants are rushes and sedges. Rushes can withstand up to six months of drought without supplemental irrigation and up to two months of total inundation. Rushes have extensive root systems and when the plant becomes inundated with sediment, they continue to grow. Also, the larger root systems allow the plant to take up and transpire a larger volume of water.

Rushes are also used in constructed wetlands to remove heavy metals from mine tailings, nutrients from domestic wastewater, and petrochemicals from urban runoff. The extensive root system allows the plant to survive even when pollutants have damaged a portion of the plant.

Rushes require little maintenance. They have hollow-stemmed blades that produce less residue and because of the small plant size, do not require mowing. However, mowing will not harm the plant.

Other considerations for vegetative BMPs

A designer should consider four planning-related issues when selecting plants for vegetative BMPs: use or function, plant characteristics, availability and cost, and long-term maintenance. Each consideration will be briefly discussed.

- Use or function **-** In selecting plants; consider their desired function in the landscape. Is the plant needed as ground cover, soil stabilizer, water quality treatment, or a shade source? Will the plant be placed to frame a view, create focus, or provide an accent? Nearly every plant and plant location should serve some function in addition to adding aesthetic appeal.

- Plant characteristics - Plant characteristics should also be considered when selecting plants for vegetative BMPs. Consider the following example of how the plant characteristics can affect the landscape and the function of vegetative BMPs. Catalpa sop. produce large seed pods in the autumn that ultimately fall off the tree and onto the ground. As the tree matures, it produces more seedpods. Designers should consider where they plant this type of tree in relation to a vegetative BMP so that seed pods (and other tree matter) do not land in the BMP and either increase maintenance costs (i.e., requiring unclogging of system pipes) or reduce BMP treatment effectiveness.

  In addition, the designer should determine how the plant would fit in the landscape today as well as years to come. Growth rate, color, seasonal interest, and texture all play a role in the characteristics of a plant and its relationship to the landscape and vegetative BMPs.

- Water availability - Most stormwater systems located in urban areas are located on sites where supplemental irrigation is provided. Supplemental irrigation allows for a wider diversity of plant materials. Supplemental irrigation also makes the season of seeding less critical than if the area had no additional irrigation.

- Availability and cost - These two factors can ultimately determine if the plants you have selected will be used in the vegetative BMP. As a result, the designer may have to check different plant suppliers for best price and selection. Also, choosing native plants over exotic or ornamental plants increases the chance that the plants will perform better than those species accustomed to more temperate zones.

Local suppliers should be contacted first, since local suppliers stock plants and seeds adapted to this area. Successful plantings are directly related to the source of the plant materials and the conditions under which they were propagated.

- Long-term maintenance - Like structural BMPs, vegetative BMPs require long-term maintenance. As previously mentioned, the designer should determine how the plant will fit in the landscape today as well as in the future. Will the plant sustain growth in the same location for several years or will it aggressively take over the site? Does the plant, over time, produce large amounts of litter that form a mat over the soil reducing seedling growth? Will irrigation be required? If the designer has carefully considered the plant characteristics, then the plants will continue to serve their function and will not require substantial maintenance.

1.4 Plant Establishment

To ensure that plant establishment is successful, the designer should consider the following planting guidelines. The guidelines discuss the importance of proper seed bed preparation, seeding rates, seasons and methods of seeding, mulching, and herbicide use.

Seedbed preparation

Good seedbed preparation is essential in revegetating disturbed land, such as those found on construction sites. Often, this is the most important stage in revegetation because, in many cases, subsurface layers have been compacted during construction operations. Compaction hinders root penetration and water infiltration.

Good seedbed preparation scarifies and loosens the soil surface creating a favorable environment for seed planting and subsequent seedling emergence. Generally, the seedbed is properly prepared if a person walking across the area does not sink more than1/8”into the soil. Scrapers should be used to apply subsoil and topsoil over the construction site. These machines compact the soil as it is applied, therefore, the subsoil and topsoil must be treated for compaction. Ripping with a bulldozer with ripper tooth is the first step to good seedbed preparation. After ripping the subsoil, topsoil can be applied to the desired thickness. Usually the topsoil is shallow enough that ripping is unnecessary. Poorly prepared seedbeds require higher than normal seeding rates; however, increased seeding rates will not compensate for poor seedbed preparation.

Seeding rate

Seeding rate computations are based on pure live seed (PLS) per square foot. Pure live seed (PLS), expressed as a percentage, designates the calculated quantity of viable seed to plant. The percent PLS of a lot of seed is obtained by multiplying the percent purity times the percent germination and dividing the product by 100. PLS is important in determining the amount of material needed for planting and in determining the quality of the seed to be purchased. It is the best way to determine the actual cost of the seed.

In most cases, individual plant materials are used to vegetate a stormwater BMP. The BMP is generally small so the cost of using plants in comparison to direct seeding is not prohibitive. Seeding can be used when the area to be vegetated is large or plants are not available.

A seeding rate from 30 to 40 seeds per square foot is generally adequate. Seeding rates should provide adequate seed for a good stand and limit the reduction of future stands because of too much competition among seedlings. Increased seeding rates may increase initial plant densities, but there is usually an inverse relationship between initial high density and survivability the first year after the stand is established. Seed mixes should include about 25 to 50 pure live seeds per square foot when drilled and 50 to 100 pure live seeds per square foot when broadcast. Dry areas need less seed and critical areas need more seed.

Season of seeding

A late fall or dormant seeding prior to winter is the most common seeding period in the Intermountain West. The timing of seeding is important on disturbed lands. Plant late enough in the fall so seed does not germinate or emerge before winter weather sets in. The closer to winter the planting can be made, the more successful the seeding will usually be. Overwintering helps break seed dormancy in some species and cool season grasses germinate readily under the snow when temperatures are slightly above freezing. Seedlings are protected from rodents by the snow pack and emerge quickly with early spring moisture.

Most legumes and grasses are seeded in the spring to allow the seedling to become well established before being subjected to freezing temperatures. The designer should schedule spring plantings as early in the spring as possible to provide for optimum germination temperatures and to allow seedling to get a jump on the weeds. A few species, such as cider milk vetch and other legumes, require warmer soil temperatures and should not be planted until mid spring. Ideally, the site should be prepared the previous fall if a spring seeding is desired. Usually spring seedings are planted between periods of wet and dry weather. If spring seedings are to be effective, they should be made prior to spring rains. There may be a problem of I getting heavy equipment onto the site to prepare a seedbed in the spring following a wet winter that has saturated the soil profile. In addition, flows should be diverted away from the seedbed until the area is stabilized.

Method of seeding

Direct seeding can be accomplished by any of the following methods: broadcast seeding, drill seeding, or hydroseeding. Each of these methods will be discussed in some detail.

- Broadcast seeding is recommended in small areas or in seedbeds that are relatively uniform and rough. Dry method - hand cyclone seeders, air guns, or blowers are good inexpensive means for broadcast seeding of grass and legume seeds. There should be an even distribution of light and heavy seeds over the area. When using the broadcast seeding method, the designer should double the seeding rates normally used for drilled planting.

  One advantage of broadcast seeding is that all seed types can be contained in the seeding mixture. Using a seed mixture is recommended on highly disturbed construction sites because it increases the chance that the plants will successfully establish and improve vegetation diversity.

  Heavy, awned or fuzzy seed are suited for the broadcast seeding method because they can clog a drill, making drill seeding a tedious process.

  One requirement for using the broadcast planting method is that the seed should be adequately covered by the soil following sowing. Using a heavy sheepsfoot roller is an acceptable method to cover seed. It compresses some seed to approximately 1” depth while others are only slightly covered.

- Drill seeding is most effective when only a few species are included in the mixture and larger sites are involved. Large and small seeded species can be placed in separate boxes and depth bands can be set to plant the seed at a specific depth. Seed spacing is also more controlled with a drill. Row widths of 6-14 inches produces good stand establishment. A sound practice, although not commonly used, is alternate row seeding. Seeding grass, legumes, and shrubs into alternate rows increases the survivability of the slower developing legumes and shrubs by reducing competition during the establishment year(s).

  Sometimes a slope is too steep to use tillage equipment to prepare a seedbed. On some sites, ripping can be completed across the contour and then seeding with equipment is completed on the contour. When this is not possible and the slopes are accessible from a level area, hydroseeding may be an acceptable planting technique.

- Hydroseeding is commonly used for planting road cuts and embankments.

Ideally, the seed and fertilizer are applied first then the site is mulched with hydromulch. A small amount of green dye and hydromulch (100 - 200 lbs/ acre) is included in the seed and fertilizer slurry to provide a tracer for judging seed distribution. The wood fiber, straw, or paper mix is then placed into the water vat and is applied as a cover for seed in a second operation.

The hydroseeding method is recommended over the more common method of applying seed, fertilizer, and mulch in one operation because when seed is suspended in the mulch, the seed may not come in contact with the soil and poor stand establishment may result. The seed may dry out and die after germination unless the relative humidity is constantly high enough to maintain high moisture levels when the seed is suspended in the mulch.

Disadvantages of hydroseeding include: damage to some of the seed as it goes through the pump and operations require large crews, water tankers, supply trucks, adequate water supplies and relatively smooth, flat areas from which to operate the equipment.

To reduce damage to the seed, apply the seed and fertilizer from separate bins. Avoid mixing the seed and fertilizer for more than a few hours or seed germination may be adversely affected.

Other seeding methods

Most shrubs are difficult to establish using direct seeding methods. Transplanting bare rootstock or tubed plants improves establishment success. Bare rootstock or tubed plants are planted into previously dug holes. Plant bareroot stock and tubed plants about 1 inch lower than the soil surface, cover with soil and compact the soil firmly around the roots. Plants should be thoroughly watered following planting. Tree spades can be used to transplant larger dormant shrubs and small trees onto disturbed sites or road cuts.

If a sod-forming plant species is desired for quick vegetative cover, a sprig digger or modified potato harvester can be used to gather vegetative sprigs. Plant sprigs using a manure spreader or a specially designed sprig planter. If a manure spreader is used, sprigs must be lightly disked into the soil so that the sprigs are in contact with moist soil at all times. Another alternative would be to place sod.

Mulching

Mulching is the most common and widely used method of rapidly stabilizing soils on moderate to steep slopes. Mulching materials such as straw, hay, jute and other appropriate materials should also be used to protect the new seeding (especially late summer and fall seedings). Mulches increase water infiltration of water and provide a microclimate for establishment of vegetative cover.

Wood fiber, erosion control blankets, hay and straw are the most commonly used commercial mulches. Net or blanket type mulches include straw or other fibers secured with jute or polypropylene netting and wire staples. Net mulches can be utilized on either slopes or flat surfaces, provided the net is attached securely to the ground. Straw or native grass hay is perhaps the most commonly used mulch because it is available, inexpensive, and easy to apply, and gives reasonably good results.

Straw or hay must be crimped by disking into the soil surface from 2 to 3 inches deep to prevent the mulch from being blown from the site by high winds. Because of this incorporation requirement, it is not a viable technique on steep slopes unless a tackifiers or polypropylene netting anchors the mulch.

Straw is generally more weed-free than grass hay, but good native grass hay can also provide a source of adapted seed. These mulches can be spread by hand or with mechanical blowers.

Straw mulch can be used on high, steep slopes along roads to help hold the seed and fertilizer in place. Organic tackifiers and netting can be used to hold the straw in place. Wind, water and gravity should be evaluated to determine the amount and method used to hold the mulch in place. Anchor mulch 2 -4 inches deep with no more than two passes of the anchoring equipment.

For mulching with straw, a minimum of 4,000 pounds per acre to a maximum of 6,000 pounds per acre of clean small grain straw is recommended. Additional nitrogen needs to be applied when mulching with organic materials because nitrogen will be tied up in the process of breaking down the mulch. The following amounts should be applied for straw:

Mulch	Nitrogen
4,000 pounds/acre	15 pounds/acre
5,000 pounds/acre	20 pounds/acre
6,000 pounds/acre	25 pounds/acre

1.5 Herbicides

Restrictions and limitations

Herbicides are chemicals formulated to control broadleaf and grass weeds. All have limitations as to type and degree of control. Many have restrictions on their use. The label for each herbicide should be read thoroughly and mixing and application directions followed carefully.

When choosing an herbicide, the applicator must consider its effectiveness in controlling specific weeds. Will it injure other plants? What effect will it have on beneficial organisms within the treated area? Will it have any ill effects on nontarget areas?

Label information indicates product restrictions and limitations when applied to certain plants and in various habitats. These restrictions and limitations should be understood before an herbicide is selected to control a certain weed(s) in a specific planting. The limitations will help determine which herbicide(s) to purchase.

Herbicides and the environment

Weed control practices and environment protection require time-consuming precautions. The designer must select herbicides that will kill the weeds without damaging other plants. They must restrict the drift to nearby sensitive vegetation. Succeeding plant damage from herbicidal residues in the soil must be avoided. When weeds are treated in or near irrigation ditches or streams, special precaution must be taken to avoid contamination of water and injury to fish or other beneficial forms of life. The use of herbicides in and around stormwater systems should be restricted and avoided, when possible, because of the potential to contaminate surface and ground water.

Section 2 – Specific Guidance for Stormwater BMPs

This section discusses specific guidance for vegetative BMPs. The BMPs included in this section are ponds, biofiltration systems, and infiltration systems.

2.1 Ponds

General information

The guidelines below are primarily for ponds that exhibit hydrologic zones.

Hydrologic zones

The depth of the water and the period of standing water define hydrologic zones. Knowing what hydrologic zones are present in a BMP will help the designer determine where plants can be successfully planted based on the water levels that are expected with each BMP. The hydrologic zones would include the following:

Zone #	Zone Description	Hydrologic Conditions
Zone 1	Deep-water pool	3-6+ feet deep, permanent pool
Zone 2	Shallow water bench	2-18 inches deep, fluctuating water
Zone 3	Shallow water fringe	0-2 inches deep, fluctuating water, regularly inundated
Zone 4	Shoreline fringe	Permanent moisture zone, periodically inundated
Zone 5	Terrace	Rarely inundated
Zone 6	Upland	Seldom or never inundated

Zone 1: Deep Water Pool (3—6+ feet)

Ponds and wetlands generally have deep pools that are a minimum of 3 feet deep. Emergent wetland vegetation generally will not grow in permanent water depths that are deeper than 3 feet.

Many species can withstand deeper water for short periods of time. However, they will tend to die out in these water depths over time. Most plants that are found in water with these depths are called submergent species. Submergent species root in the pool bottom and extend their stems up toward the water surface. Occasionally, they will emerge out of the water. These plant species can provide excellent fish and aquatic invertebrate habitat. They can also provide water cleaning functions, such as removal of nitrates and phosphorous. Submergent plant materials are not readily available on the retail market at the present time. However, plant parts and seeds are mobile and will come in from other wetland areas, so planting may not be necessary.

Zone 2: Shallow Water Bench (2- 18 inches), fluctuating water

Zone 2 is a bench that is added to wetlands and ponds specifically to allow plants to become established and grow. Emergent wetland plants grow in this zone and are generally limited to long-term permanent water depths of less than 3 feet and more often, 18 inches and less. Species such as Hardstem bulrush can withstand water depths of 8 feet for short periods of time. However, they typically prefer water depths of 10-18 inches. Fluctuating water levels are important for maintaining wetland plant populations, keeping plant vigor high, and allowing for the rapid spread of the plants after planting.

Establishing wetland plants in this zone can provide additional benefits. First, the plants contribute extensive wildlife and fish habitat to the wetland areas. Second, the plants provide resident sites for phytoplankton: a microscopic aquatic plant that significantly reduces nutrients in the water. Third, the plants can also soften the engineered contours of wetlands or ponds and conceal lower water levels caused by water drawdown.

Zone 3: Shallow Water Fringe (0-2 inches), fluctuating water, regularly inundated

Zone 3 is the fringe around the edge of the water in the wetland or pond area. This area is regularly inundated, but will dry out frequently as the water level fluctuates. Although fluctuating water levels makes it difficult to establish plants in this zone, it is critical to have good plant cover so that soil erosion and wave motion are reduced. Wetland plant plugs (as opposed to seed) should be used in this zone. The seed of wetland plants require light to germinate and cannot be covered by soil. If water is introduced into the systems prior to seed germination and rooting, the seed may float and form a ring of plants at water level. Designers should consider diverting water flow until the plants become established.

This zone will support wetland plants and water-tolerant shrubs such as willows, birch, dogwood, and other shrubs. The shrubs provide wildlife habitat and water quality improvement through shade, nutrient uptake and breakdown, and sediment deposition.

Zone 4: Shoreline Fringe, permanent moisture zone, periodically inundated

This zone extends about 1-4 feet horizontally (-2 feet vertically) above the normal pool level. It can be periodically inundated after significant storms or high water events. Water will typically move off of this zone fairly rapidly, so designers should consider this zone characteristic when evaluating design storm frequency. Plants in this zone typically like ”wet feet” and do well under fluctuating water conditions. This zone is saturated for a majority of the growing season except when droughty conditions cause the water level in the wetland or pond to drop below normal levels for an extended period of time. Herbaceous plants should be planted to protect the ground from overland drainage flows moving into the wetland or pond.

Zone 5: Terrace, infrequently inundated

Zone 5 is normally dry but can be inundated by floodwaters that normally drop in one day or less. In general, zone 5 extends from the maximum 2-year water surface elevation to the 10- or 100-year maximum water surface elevation. Plants in this zone should be capable of withstanding occasional inundation and common drought conditions. Supplemental irrigation may be needed to maintain this zone during the hot summer months. The designer should carefully select the herbaceous plants that will grow in this zone because it may be difficult to mow the area because of steep slopes. Woody plants may be used in this zone to discourage waterfowl use.

Zone 6: Upland, seldom or never inundated

This zone is usually above the 100-year water surface elevation and generally does not extend down into the design area. The variety of plants established in this zone can also be used for foothills revegetation and site stabilization. The plants should be selected based on the soil conditions, water schedule potential, and function within the landscape.

Section 3 contains plant tables that list information on grass and grass-like plants, riparian trees and shrubs, and upland trees and shrubs that are suitable for vegetative stormwater BMPs.

Establishment year

Wetland plants can survive in anaerobic soils (soil without oxygen) because they have spongy plant tissue that acts like a straw to bring oxygen from the atmosphere to the root system. The establishment year is the most critical for young pond plants because they need to grow and develop the spongy plant tissue. A mature pond plant can withstand months of total inundation, but young plants will die under the same conditions. Refer to the plant tables in the Section 3 for more information on appropriate plant species for ponds.

Fluctuating water levels for at least the first year are extremely important to successfully establishing a wetland plant community. Fluctuating water levels allow the plants to spread more quickly than if the water level is kept constant. Water levels must be maintained at a maximum of 1-2 inches for the first two months. After that time, 1-2 inches can be added over the next few months. Fluctuating the water level from 2 inches of standing water down to saturated soils will allow the root system to spread and increase chances of plant survival.

Plants

When purchasing plants, always obtain plant plugs that are a minimum of 12- 21 cubic inches. These plants have a much bigger root system and more developed spongy plant tissue. As a result, the plants will withstand wider variations in water depth than small plugs.

Pay particular attention to the wetland plant species when designing the landscape plan. Some species such as sedges and rushes cannot survive in deep water (more than 1-2 inches). Hardstem bulrush can withstand water depths of up to 8 feet for short periods of time, but normal water levels are about 10-18 inches.

2.2 Evaporation Ponds

Selection factors

Evaporation ponds should be stabilized to with vegetation, rock, or other acceptable material to prevent erosion and provide dust control. If vegetation is chosen, use a deep-rooted grass that can withstand extreme water level changes (i.e., long periods of drought and of total inundation). Barrier shrubs, such as barberry, planted around the facility should be considered when there is a possibility that the public could damage the facility or hinder its function. Trees and shrubs should be planted high on the side slopes or above the design stormwater line elevation. Plant trees and shrubs at least 15 feet away from the toe of the slope.

Operation and Maintenance

Grass should be mowed to maintain an average grass height between 3” and 9” depending on site characteristics, Grass clippings should be removed and disposed of properly. Sediment deposition at the head should be removed if grass growth is being inhibited or if the sediment is blocking the entry of water. Annual sediment removal and spot reseeding should be anticipated.

2.3 Vegetative Buffers

Vegetative buffer strips are required around the pond perimeter. Buffer strips will reduce erosion and provide additional sediment and nutrient removal. Native plants should be used instead of introduced plants. Native plants require less maintenance and replacement than plants that are introduced to a region because the native plants have adapted to the climatic conditions. As a result, maintenance costs will be lower with native plants than with introduced plants.

Operation and Maintenance

As the plants become established in the pond, they will need to be inspected periodically to ensure they are thriving. Seeding failures are common during the establishment year, so it is critical that the pond is inspected regularly. Generally, if plants are uniformly distributed, with a minimum amount of weeds or undesirable vegetation, the seeding is establishing properly. Non-native plant species should be monitored carefully since they can quickly invade the area. Seasonal weather conditions will determine the frequency of subsequent inspections.

In addition, ponds will need to be maintained to work properly. Over time, problems such as compaction, overgrown vegetation, and weed infestations will occur and must be corrected. Also, the owner or operator will be required to identify how these problems will be corrected in an Operation and Maintenance (O&M) Plan.

2.4 Biofiltration Systems

Definition

Biofiltration systems include grass buffer strips and swales. Grass buffer strips are uniformly graded and densely vegetated areas of grass or grass-like plants. Swales are a natural or constructed channel that is shaped or graded to specified dimensions and established in suitable vegetation for the stable conveyance and treatment of runoff. Biofiltration systems rely on the use of vegetation to slow runoff velocities, filter sediment and other pollutants, and to improve or maintain water quality.

Design

Flow must be evenly distributed across the entire strip to be most effective. Once flow concentrates to form a channel, the filtering effectiveness is significantly reduced. Select grass or grass mixtures that have stiff upright stems (even after mowing) to promote filtering of sheet flows. Native woody plants may be desirable on channel back slopes and top of bank to improve screening, erosion control, wildlife habitat, space definition, and climate control. Avoid planting woody species in the filtration area. See Table 2 for plant characteristics of common cover types.

Table 2. Vegetal Retardance – Cover type – Biofiltration Swales

n Value Range[1]	Cover	Average Expected Height[2]	Preferred Slope
0.17 – 0.37	Reed canarygrass Creeping Foxtail	20-36”	5-10%
0.1 – 0.31	Smooth bromegrass Reed canarygrass Tall Fescue Grass/legume/forb mix[3]	12 – 20”	<5%
0.06 – 0.27	Redtop Smooth bromegrass Streambank wheatgrass Intermediate wheatgrass Pubescent wheatgrass Western wheatgrass Grass/legume/forb mix[3]	6 - 15”	< 5%
0.05 – 0.2	Kentucky bluegrass Red fescue Intermediate wheatgrass Grass/legume/forb mix[3]	2 – 6”	<5%

[1]n values vary according to product velocity and hydraulic radius (low velocity and shallow flows result in higher Mannings “n”; high velocity and deep flows result in lower Mannings “n”). Refer to SCS-TP-61 “Handbook of Channel Design for Soil and Water Conservation” for experimental results of Vegetal Retardance/VR/Mannings “n” relationships.
[2] During normal critical flow periods, if vegetation has been mowed or flattened due to snow cover, the appropriate n value should be used.
[3]These are bunchgrasses or bunch type legumes and should be used only in seed mixtures and on slopes less than or equal to 5%.

Selection factors

The vegetation selected for a biofiltration swale must have characteristics that provide vegetal retardance of water or a Mannings “n” of between 0.20 and 0.24. For grass bufferstrips, the Mannings “n” must be 0.40. Mannings equation of open channel flow is used to obtain the width of a facility for a given flow, slope, and selected water depth.

Species should be selected on the basis of filtering abilities, inundation tolerance, and soil protection qualities. Local factors that will influence the plant selection are:

- Discharge to be handled - In general, the greater the discharge the more root mass, ground cover, and stiffness of above ground vegetal lining required.

- Gradient - As gradient increases, channeling of the flow is more likely to occur. For this reason, bunchgrasses should not be used on slopes steeper than 5 percent. For slopes above 5 percent, only sod-forming covers should be used on the portion of channel where the main flow occurs.

- Establishment - Ease of establishment and time required to develop a protective cover are extremely important considerations in selecting species. Generally, any type of temporary cover during establishment of permanent cover is better than none at all. Use of temporary cover plantings and geotextile products should be considered. Refer to slope protection and stabilization BMPs (BMP 15 – BMP 27) in Volume 2 of the BMP Catalog.

  If a sod cover is required, as determined by discharge and slope, but is objectionable to the user because of likely spreading, a combination of species may be selected. This type of planting may have, for example, Kentucky bluegrass on the bottom and partially up the sides of biofiltration system and a mix of sod wheatgrass, bunch wheatgrass, and alfalfa or forbs on the upper sides and top of bank.

- Deposition - Deposition may be controlled to some extent by the selection of vegetation. Low, shallow flows encounter very high retardance when flowing through dense sod covers such as reed canarygrass. Dense sod covers keep the flows from channeling and result in low velocities conducive to deposition. Only when the vegetation bends and submerges will high, non-depositional velocities develop. Low growing sod species, bunchgrasses and open covers like alfalfa offer less resistance to shallow flows than dense sod-forming covers, therefore, velocities are higher, owing primarily to development of channeled flow with less deposition. These covers offer less erosion protection than dense sod covers and are limited to flatter slopes.

Operation and Maintenance

As with vegetated buffers, as the plants become established in the biofiltration system, they will need to be inspected periodically to ensure they are thriving. Seeding failures are common during the establishment year, so it is critical that the system is inspected regularly. Generally, if plants are uniformly distributed, with a minimum amount of weeds or undesirable vegetation, the seeding is establishing properly. Seasonal weather conditions and land use activity will determine the frequency of subsequent inspections.

Biofiltration systems will need to be maintained to work properly. Over time, problems such as overgrown vegetation and weed infestations will occur and must be corrected. In addition, the owner or operator will be required to identify how these problems will be corrected in an Operation and Maintenance (O&M) Plan.

2.5 Infiltration systems

General information

Infiltration systems that require incorporation of plant materials include infiltration basins and infiltration swales. An infiltration basin impounds water in a surface pond until it infiltrates the soil. Infiltration basins do not maintain a permanent pool between storm events and should drain within 48-72 hours after a design event. Infiltration swales are vegetated channels designed to retain, treat, and infiltrate stormwater runoff.

Design

The side slopes above infiltration basins and swales should be vegetated to prevent erosion. Additional grass or nonaggressive ground covers are appropriate. Other types of plants materials can also be used. If infiltration swales are to be constructed the following standards apply:

- Up to 15% of the total area of the swale designated for stormwater infiltration may be covered with ground cover plants.
- Up to 10% of the total area of the swale designated for stormwater infiltration may be elevated above the bottom of the swale to allow the planting of trees and shrubs.

If trees and shrubs will be used, plant them on the top perimeter of the side slopes. A spacing of at least 20’ is appropriate for trees planted close to a swale.

Selection factors

Infiltration basins should be stabilized to prevent erosion, minimize sediment transport and plugging, and provide dust control. Vegetating the basin with a deep-rooted grass will provide erosion control and promote infiltration.

Infiltration swales must be grass-covered. Uniformly fine, close-growing, water-tolerant grasses should be used. If sod is chosen to vegetate the basin, select sod that has been grown in permeable soils. Sod grown in clay soils will not be effective because the clay soil can restrict water infiltration reducing the expected infiltration rate of the system. If sod grown in clay soils is the only sod available, ask the grower to wash off the soil from the sod to remove all clay material.

Barrier shrubs, such as barberry, planted around the facility should be considered when there is a possibility that the public could damage the facility or hinder its function. Trees and shrubs should be planted high on the side slopes or above the water line elevation for the design storm. Trees and shrubs should be planted at least 15 feet away from perforated pipes and 25 feet away from a riser structure.

Operation and maintenance

Grass should be mowed to maintain an average grass height between 3” and 9” depending on site characteristics, Grass clippings should be removed and disposed of properly. Sediment deposition at the head should be removed if grass growth is being inhibited or if the sediment is blocking the entry of water. Annual sediment removal and spot reseeding should be anticipated.

Section 3 - Stormwater Plant Materials Tables

The following tables contain information on grass and grass-like plants, riparian trees and shrubs and upland trees and shrubs that are suitable for stormwater management facilities. The tables are to be used as a guide for general planning and planting purposes. Landscape architects and nursery suppliers may be able to provide more information about specific site conditions that are necessary for successfully establishing plants within different hydrologic zones.

Below is a list of some of the information provided in the tables:

- Scientific name – arranged alphabetically; common name is also provided
- Hydrology zones (as described in Section 2.1 above) – indicates the most suitable planting location for successful plant establishment
- Plant indicator status – shows the estimated probability of a species occurring in wetlands or non-wetland areas
- Flood tolerance – used in conjunction with plant indicator status; provides additional information on the plant's ability to withstand the depth or duration of flooding

To access each table, click on the link below.

Table 1. Native Shrubs and Trees
Table 2. Willows for Riparian Areas and Biofiltration Systems
Table 3. Herbaceous Grass and Grass-Like Plants
Table 4. Upland Shrubs and Trees

Appendix F - Mosquitoes and Stormwater Management

1.0 Introduction

This appendix discusses stormwater management measures designed and maintained to eradicate or control mosquito habitat to prevent the spread of diseases carried by mosquitoes. Recently, some concerns have been raised about disease vectors associated with structural stormwater BMPs. Specifically of interest is the mosquito which is known to be a potential carrier of the West Nile Virus. Various studies have found, as would be expected, that some structural water quality BMPs can support mosquito production. However, the significance of these BMPs as a risk of West Nile Virus is debatable, and many municipalities may make the determination that further action is not required. However, if a municipality determines that further efforts to control mosquito production in structural BMPs are needed, certain measures can be taken while still maintaining compliance with the requirements of the federal stormwater regulations.

In order for mosquitoes to breed, specific conditions must be present. A mosquito's life cycle consist of four stages: egg, larvae, pupa, and adult. Mosquitoes must lay their eggs in stagnant water, or on damp soil that will soon be flooded with water. Mosquitoes need water to breed since all mosquitoes spend their larval and pupal states in water. Most mosquitoes breed in temporary standing waters that are less than one foot deep when nutrients are available for feeding and the water temperature is acceptable. It will take 24-48 hours for the eggs to 'hatch' into larvae. The larvae and pupa must have standing water in order to survive, and this stage will typically take 5 to 18 days before the production of an adult mosquito (Floore, 2002).

Stormwater management facilities (such as temporary erosion and sediment control basins and traps, permanent retention ponds, storm sewers, and stormwater ditches to a lesser degree) may increase mosquito-breeding habitats. Improperly locating and designing new stormwater management facilities may increase the mosquito population. Also, poor maintenance or improperly constructed stormwater management facilities (for both temporary erosion and sediment control and permanent stormwater management) may result in mosquito propagation. Therefore, there are several steps that a stormwater system operator may take to reduce the risk of mosquito production in structural BMPs, with the primary focus being on preventing standing water for prolonged periods. Proper design and maintenance of structural BMPs is key to meeting this goal.

To prevent production of mosquitoes, most sources indicate that water should not be allowed to remain stagnant for over 48 hours. This appears to be a conservative estimate. When a new stormwater BMP is being installed, a design that does not rely on extended retention of stormwater without flushing (exceeding 48 hours) should be considered. There are many options for structural BMPs that meet these criteria Examples include, but are not limited to, grass swales, porous pavement, landscape detention, extended detention basins, sand filters, and reducing directly connected impervious areas. Proper design and maintenance are important to ensure the ponds continue to operate as intended to prevent stagnant water being available for mosquito production. Designing BMPs with the proper slope, using easily accessed forebays to allow for removal of accumulated materials, and adequately inspecting and maintaining basins are some key practices that should be considered.

For existing basins that include retention of stormwater sufficient to promote mosquito production, it may be possible to retrofit these designs to allow for complete drainage in a shorter period. However, it should first be determined if the BMP in its current state is actually allowing for mosquito production.

For wet detention basins or wetlands where retrofitting is not an option, stocking these BMPs with a population of minnows is recommended. A healthy population of minnows will feed on the mosquito larvae and prevent them from reaching the hatching stage. However, only a species of minnow native to the area should be used. Contact the Idaho Department of Fish and Game for stocking and species information. Other natural predators of mosquitoes include birds, dragonflies, many other aquatic insect species, fish, and spiders.

1.0 Site Design for Mosquito Control

New stormwater management structures that may foster mosquito propagation include the vegetative fringe encircling ponds where mosquitoes breed and avoid predators; shallow or semi-permanent ponds such as catch basins and riprap settling basins; structures that take longer to drain than they are designed to, and pools of water in storm drains. These areas can create stagnant pools without a resident predator population to keep mosquitoes under control naturally.

The following stormwater management design tips may limit mosquito-breeding potential.

1. Reduce the need for stormwater management facilities. Design sites to preserve natural drainage and natural treatment systems to reduce the need for additional structural stormwater management facilities. Urban

development impacts on natural hydrology and water quality can be reduced significantly when better site design (such as Low Impact Development, discussed in Volume 3 of this BMP catalog) is utilized. Better site design reduces the amount of stormwater runoff, provides for natural on-site control of runoff, and thereby reduces the number of structural measures needed.

2. Improve designs of permanent pools. There are two methods for designing a permanent pool pond to reduce mosquito propagation: minimizing shallow depths (1.0 foot or less) and increasing circulation in ponds. Deep pools of water are preferable to shallow ones for mosquito control. Wet ponds and man-made wetlands should be designed to support continuous water flow to prevent stagnation and vegetative growth. Prevent shallow water by steeply grading both the banks of the pond and the impoundment. Include mechanical aerators in wet ponds, such as a fountain in the middle of a pond, which make the site more attractive, deter the growth of unwanted vegetations, and improve the habitat for predators of mosquitoes. The principal outlet, such as a weir or riser, should have positive drainage; such as a 0.1-foot vertical drop from the low flow inlet to the outlet barrel. Also, 'inlet shaping' should be utilized in risers and junctions. Inlet shaping (or a sweep) is a construction method that installs concrete at a curve at the junctions of drop inlets or risers and storm sewer pipe and helps maintain hydraulic efficiency of risers and pipes while preventing stagnant pools of water.

3. Select stormwater management measures based on site-specific conditions. Site conditions, such as soils, topography, depth to rock, and depth of seasonal high groundwater table significantly affect the performance of stormwater management facilities. Designs that the site conditions take into account will improve drainage and limit the occurrence of stagnant water.

4. Take special care for ponds that temporarily impound water. Some stormwater management measures, such as dry ponds and man-made wetlands, pond water for an extended period. These facilities must drain the water completely within 30 hours of the storm event. The bottoms of the ponds must have positive drainage and be free of depressions. Avoid the placement of dry ponds and underground structures in areas where they are likely to remain wet (i.e., high water tables). Ensure that pond bottoms have a low-flow channel and a minimum of 1 to 2% bottom slope to prevent scour and stagnation. The principal outlet, such as a weir or riser, should have positive drainage, such as a 0.1-foot vertical drop from the low flow inlet to the outlet barrel. Also, if water quality orifices are required in the principal outlet structure, ensure that the minimum size is greater than 2”-3”, to

prevent clogging and stagnant pools of water ponding at the outlet structure. Also, there are manufactured methods to prevent clogging of the primary water quality outlet without restricting the hydraulic capacity of the outlet control orifices, including the installation of trash racks.

5. Take care in the design of storm sewer systems. The sheltered environment inside storm drains can be ideal for mosquito breeding. Design and construct pipes at a rate of flow that flushes the system of sediment and prevents water backing up in the pipe (an acceptable minimum slope is 2%, as site conditions allow). Construct storm drains (such as manholes, inlets and boxes) so that the invert out is at the same elevation as interior bottom to prevent standing water. Also, ‘inlet shaping’ should be utilized in risers and junctions. Inlet shaping (or a sweep) is a construction method that installs concrete at a curve at the junctions of drop inlets or risers and storm sewer pipe and helps maintain hydraulic efficiency of risers and pipes while preventing stagnant pools of water. Verify that newly constructed storm sewer systems have positive drainage and that standing water does not exist inside the system. Corrugations in storm sewers may cause standing water.

6. Require “as –built drawings.” As-builts are survey drawings of stormwater management facilities after construction and provide sufficient information to demonstrate that the facility as constructed conforms to all specifications and requirements of the approved design plan. As-builts provide assurance that stormwater management facilities are effectively minimizing mosquito propagation. At a minimum, as-builts should include spot elevations (high and low points), contour lines, and should indicate the slope of the ground. For example, the as-built confirms that dry ponds are draining and permanent pools have the necessary depth.

7. Require a written maintenance agreement and compliance with the agreement. The maintenance agreement should require weed control and the removal of grass cuttings and other debris from the outlet structures. Also, the agreement should identify landowners and successors to maintenance requirements and obligations.

1.1 Maintenance

Some mosquito habitats may be fostered by the lack of maintenance and improper construction of stormwater management facilities (for both temporary erosion and sediment control structures and permanent stormwater management ponds and storm sewers and stormwater ditches). Vegetative overgrowth including floating algae, sediment, trash, dead grass, emergent aquatic grasses and weeds, and cattails provide hiding places and a nutrient-rich environment for mosquitoes. Clogged outlets that temporarily pond water will provide good mosquito breeding habitats. Small temporary bodies of water do not support the predator populations that keep mosquito populations in check. Inadequate drainage in constructed wetlands and dry ponds causes small puddles to remain at the base, especially adjacent to the outflow pipe. Corrugations in storm sewers may cause standing water. The following list itemizes some maintenance principles that may reduce the mosquito population.

- Maintain and clean out temporary erosion and sediment control traps and basins.
- Maintain stormwater ditches (such as road side ditches) to ensure positive drainage.
- Conduct annual vegetative management, such as removing weeds and restricting growth of aquatic vegetation to the periphery of wet ponds.
- Remove grass cuttings, trash and other debris, especially at outlet structures.
- Avoid producing ruts when mowing (water may pool in ruts).
- Dry ponds and underground structures usually detain water for periods less than 30 hours. If they retain water for longer than five days, they are poorly maintained.
- Infiltration trenches and sand filter structures should not hold water for longer than 24 hours. If they retain water for longer than 48 hours, they are poorly maintained.

1.2 Mosquito Control Using Pesticides

When source reduction and water management are not feasible or have failed, the judicious application of insecticides, including larvicides and adulticides, may be used to control both immature and adult mosquito populations. "Larvicides" are used to kill immature mosquitoes (larvae) when applied to standing water where larvae are present. Adulticides are used to kill adult mosquito populations in an area where a vector population has escaped larval control. Pesticides generally do not provide long-term solutions to controlling mosquitoes, but may be the only choice available to control mosquitoes from some habitats. Contact your local health district or mosquito abatement district for more information about programs to control disease-carrying mosquitoes in your area.

References

Floore, T. 2002. Mosquito Information. The American Mosquito Control Association. Eatontown. NJ. http://www.mosquito.org/index.php?option=com_content&view=article&id=37&Itemid=114

"Public Works and Public Health Are Dependent Upon One Another", Dean F. Messer [Stormwater, The Journal for Surface Water Quality Professionals, March/April 2002]

"Disease Vectors Associated with Structural BMPs", Dean F. Messer, et. al. [Stormwater, The Journal for Surface Water Quality Professionals, March/April 2002]

"More Than One Risk From Mosquitoes", Janice Kaspersen [Stormwater, The Journal for Surface Water Quality Professionals, March/April 2002]

APPENDIX G: General Guidance for Hydrologic/Hydraulic Design

Local issues and concerns will dictate the regulatory requirements for flood control, peak discharge, and water quality management, which should be considered in the selection and design of Best Management Practices (BMPs). Many jurisdictions have requirements for control of the rate of discharge (or peak runoff rate) from new development or redevelopment to control increased flooding, channel protection, or water quality. This control is usually accomplished by detention of the flow, discharging at a controlled release rate. Other performance goals and objectives may include specific pollutant guidelines; water quality control; multi-parameter controls, including groundwater recharge and channel protection; and habitat protection strategies.

Stormwater runoff control requirements are expressed differently. Requirements for flood control address peak discharges to a predevelopment level in order to control increased flooding or channel protection and are usually expressed as a design storm event for one or more design storms. Nationally, the two most frequently used design storms are the 2- and 10-year storms (EPA, 2004).

One of two criteria is typically used for water quality control: 1) a specified runoff depth and/or 2) a percentage removal rate. Typically the runoff depth required is either ½ or 1 inch. With respect to the percentage removal requirement, the most frequently used requirement nationally is 80% removal of suspended solids (Ibid).

Selection of a return period for the design storm is generally the purview of the local regulatory authority and may correspond to controlling discharge or runoff volume. In general, the return periods selected are based on a perception that controlling the design storm will result in some intended benefit such as flood control, control of downstream damage to stream geomorphology, and water quality. Examples are given in Table D-1.

Design for Flood Control Facilities

Local design standards for sizing stormwater facilities for flood control should be used if they exist. The most commonly used method for sizing facilities to control flooding is to compare pre-development runoff with projected post-development runoff. The developer is then responsible for the difference. For example, a new subdivision of single-family residential ½-acre lots is to be created from an existing ranch. Modeling shows that the estimated peak flow from the ranch during a 10-year storm is 40 cfs. After development, the projected flow will be 320 cfs. The developer is responsible for the additional 280 cfs. The developer may provide on-site detention of adequate volume to maintain the peak flow at the existing 40 cfs. He may contribute "in-lieu of" fees towards a regional detention facility, which would decrease flows from his development and adjacent ones. Or she may help pay for the increased culvert sizes and ditches necessary to carry the excess flow. If the latter is chosen, the developer will also need to evaluate the impact of these flows downstream and get permission from the downstream property owners affected by the increased flows and the affected jurisdictions.

Table D-1. Design Storm Frequencies and Assumed Benefits (EPA, 2004)

Design Storm	Assumed Benefits	Comments
½ - 1 in. rainfall	Intended to capture 70-80% of annual runoff volume in an attempt to improve water quality.	Used by many municipalities. Some studies have shown that capturing the first ½ in. will control 70% of the annual runoff.
1-in. rainfall	Intended to capture 90% of annual runoff volume in an attempt to improve water quality.	Replacing ½ in. as basis for water quality control. Some studies have shown that capturing the first 1 in. of runoff will control 90% of the annual runoff.
1-yr	Intended to capture sufficient runoff volume to improve water quality and provide down stream channel protection.	Used by some municipalities for water quality management and is based on the supposition that the channel-forming event is the annual storm.
2-yr	Intended to provide protection from accelerated channel erosion and habitat protection.	Used by many municipalities. Limited field monitoring indicates that the strategy is flawed, as increased volume in post-development runoff results in pond discharges at flow rates near the peak discharge for much longer times than in the predevelopment state. This results in more erosion over the storm duration which subsequently result in wider and deeper channels than in the predevelopment state, even though the peak flow rates for pre- and post-development are equal.
10-yr	Intended to provide flood protection from intermediate sized storm events by matching post-disturbed peaks to pre-disturbed peaks.	When used for on-site detention, flood control benefits are provided primarily to local areas with limited protection of larger downstream channels. In some cases there is increased potential for downstream flooding due to timing of runoff events.
100-yr	Used for flood control protection from major storms; also used to maintain 100-yr floodplain limits.	When used for on-site detention, flood control benefits are provided primarily to local areas with limited protection of larger downstream channels. In some cases there is increased potential for downstream flooding due to timing of runoff events.

Design for Water Quality Facilities

The tendency for solids and associated constituents to be washed off of paved areas during the initial portion of the storm event is referred to as the first flush. In general, the potential for first flush is determined by the storm characteristics, the size of the subwatershed and the partitioning characteristics of the pollutants of concern. Nationally, many jurisdictions specify a treatment volume that is designed to capture the first flush component of the stormwater runoff. In practice, this is achieved by specifying a rainfall amount (such as the first ½-inch, 1-inch or other rainfall depth over impervious areas) or the capture of a stormwater runoff volume that correlates to a design storm (such as the 6-month, 1-yr or 2-yr frequency storm). Ideally, several decades of storm volume and intensity information for a given county would be analyzed to determine rainfall volumes for the various design storms. The Idaho Transportation Department has done that analysis, but only for 2-year storms and larger.

The second water quality control approach is to require that a specified amount of the pollutant(s) of concern be removed from the stormwater runoff before it is discharged from the point of compliance. The reduction is commonly specified as a percentage reduction of the pollutant(s) of concern, and the compliance point is usually the municipal separate storm sewer system (MS4) or final stormwater discharge location in the watershed. An example is the federal coastal zone guidance that specifies that urban runoff from a new and stabilized development site have 80% of the suspended solids removed before it is discharged from the site. Implementing the pollution reduction strategy requires knowledge of the pre-construction and post-development average mass of pollutant(s). The strategy is generally considered to be effective if the regulating municipality selects an achievable pollutant reduction, and ensures that the stormwater controls are properly selected, designed, constructed, operated, and maintained.

Estimating Runoff During Snowmelt

Most stormwater facilities are designed for design storms that are usually assumed to consist of precipitation entirely in the form of rain. In most parts of the country the largest storms are intense summer thunderstorms. In the Pacific Northwest the largest rainfall volumes occur in less intense, but prolonged winter storms. A different type of event that often contributes to flooding is snowmelt, especially in conjunction with a rainstorm. One characteristic that makes snowmelt so damaging is that the heavy flows are not lessened by absorption into ground that is saturated and frozen. Due to the significant amount of water tied up in the snowpack, snowmelt can cause significant capacity and erosion problems. This problem is worsened if a significant rain event occurs during the melt when the ground is still frozen.

Three factors must be considered to arrive at an estimate of flows occurring during snowmelt. First, the storm should be derived from the Intensity/Duration/Frequency (IDF) curves in the same manner as the regular design storm. Since the IDF curves represent the greatest intensity expected during a given time period and since this usually occurs during summer thunderstorms, assuming that this storm intensity occurs during snowmelt is being quite conservative.

Second, the Carbon:Nitrogen (CN) number should be adjusted. The CN numbers given for the various land uses in the tables in this appendix is for an antecedent moisture condition of II. An AMC of II is defined as average conditions. The following table should be used to convert these AMC II numbers to those of AMC III. AMC III is defined as heavy rainfall, or light rainfall and low temperatures occurring within the last five days, leading to saturated soils.

Third, the water contributed from the snowmelt itself needs to be computed. The Degree-Day Method outlined in the HEC-1 model developed by the Army Corps of Engineers is recommended for making this estimate.

The Degree-Day Method is based on the following equation:

SNWMT = COEF (TMPR – FRZTP)

Where SNWMT is the melt in inches per day,
TMPR is the air temperature in degrees F,
FRZTP is the temperature in degrees F at which snow melts, and
COEF is the melt coefficient in inches per degree-day, usually about 0.07.

Assuming the worst conditions, a sudden thaw of 40 degrees, the snowmelt = 0.07 (40-32) or 0.56 inches/day. This should be added to the rainfall from the storm and used in conjunction with the increased CN read from the following table.

Calculating Peak Discharge Rates and Volumes

The following sections contain basic steps for calculating the peak discharge rates from pre- and post-development conditions and the volume of stormwater that must be retained onsite to control for peak discharge rates from specified design storms. Two formulas are presented: The Natural Resources Conservation Service (NRCS) TR-55 Method and the Rational Method. Other hydrologic methods may be accepted for determination of runoff rate and volume, however, the design professional should obtain approval from the approving jurisdiction prior to beginning hydrology studies for the project if an alternate hydrologic method is selected.

The Rational Method should only be used for projects that are less than 100 acres in size. The NRCS TR-55 can be used for projects greater than 100 acres in size. Consult the local permitting authority to determine whether there are additional requirements or preferred alternatives for sizing storm designs. Local design standards should be used if they exist.

Rational Method

The rational method is a method for computing peak runoff rates for flow-based runoff treatment BMPs such as biofiltration swales and oil-water separators. It is also a common method for computing the peak runoff rate for design of infiltration trenches and conveyance systems. The greatest accuracy is obtained for areas smaller than 100 acres and for developed conditions with large areas of impervious surface (e.g., pavement, roof tops).

Procedure: Design peak runoff rates may be determined by the Rational formula:

$Q_p = CIA$

A = site area (acres)
C = dimensionless runoff coefficient
T_c = time of concentration
I = average rainfall intensity (in/hr) for a duration equal to the time of concentration and for the recurrence interval chosen for design
Q_p = peak discharge

1. Calculate the site area (A).

Use USGS topographic maps, site visits, and other available information.

2. Determine the runoff coefficient C.

This value is obtained from Tables 1 and 2 based on pre-development and post-development conditions. For mixed surfaces, determine a weighted coefficient using the following formula:
C = [(C1 * A1) + (C2 * A2) . . . + (Cn * An)]/A

3. Calculate the time of concentration in minutes (Tc).

The time of concentration, (in/hr), over a duration equal to the time of concentration for the contributing area can be estimated using the surface flow time curve

4. Determine the average rainfall intensity (I).

This value is obtained from the intensity-duration-frequency curves included based on the time of concentration (Tc) from step 3.

5. Calculate the peak discharge (Qp).

Q_p = (C) * (i) * (A)
Calculate both pre-development and post-development Q_p .

<u>Steps to Calculate Onsite Storage Volumes for Control of Peak Discharge Rates</u>

V_r = volume of runoff
C = dimensionless runoff coefficient
I = average rainfall intensity
T = storm duration
A = contributing area to site (acres)

6. Calculate the contributing drainage area (A).

Use value from step 1 above.

7. Determine the average rainfall intensity (i).

For the 50-year event, use 1 inch/hour. For the 100-year event, I minimum is 1.1 inches/hour.

8. Determine the storm duration (T).

For this value, use one hour.

9. Determine the runoff coefficient (C).

Use value from step 2 above.

10. Calculate the volume of runoff (V).

$V_r = C * (i) * T * A$

Table 1. Recommended "C" coefficients (Modified for ASCE (1972) and the Southeastern Wisconsin Regional Planning Commission)

Description of Runoff Area	Runoff Coefficients "C"
Business Central business areas District and local areas	 0.70-0.95 0.50-0.70
Residential Single-family Multi-family, detached Multi-family, attached	 0.35-0.45 0.40-0.60 0.60-0.75
Residential .5 acre lots or larger	0.25-0.40
Industrial and Commercial Light areas Heavy areas	 0.50-0.80
Parks, cemeteries	0.10-0.25
Playgrounds	0.20-0.35
Unimproved areas	0.10-0.30
Landscaped areas	0.20
Streets (Asphalt, Concrete), Drives and Walks, Roofs	0.90-0.95

Table 2. Pervious Surface Coefficients

	Runoff Coefficient			
Slope	A soils	B soils	C soils	D soil
Flat 0-2%	0.04	0.07	0.11	0.15
Average 2-6%	0.09	0.12	0.15	0.20
Steep >6%	0.13	0.18	0.23	0.28

<u>NRCS TR-55 Method</u>

The TR-55 Method is a single event hydrograph method for designing flow control BMPs. It can also be used for computing peak runoff rates and runoff volumes for design of runoff treatment BMPs.

The following sections are taken from the TR55 Manual published by the SCS in 1986. The use of the excerpts is to assist and provide general guidance for sizing stormwater volumes and peak flows for stormwater BMP design.

Reference

U.S. Environmental Protection Agency, September 2004. Stormwater Best Management Practice Design Guide: Volume 1 General Considerations. Office of Research and Development, Washington DC, EPA/600/R-04/121.

Appendix H - Disposal Alternatives Table

General Construction, Painting and Maintenance

Discharge/Activity	Disposal Techniques
Excess oil-based paint	▪ Recycle/reuse; donate to nonprofit organization ▪ Dispose of as hazardous waste
Excess water-based paint	▪ Recycle/reuse; donate to nonprofit organization ▪ For small quantities, let the paint residue dry in the cans; remove lid; dispose in trash ▪ For large quantities, solidify with cat litter, air dry, then dispose in trash
Clean-up of oil-based paint	Wipe paint out of brushes, then: ▪ Filter and reuse thinners and solvents ▪ Donate to nonprofit organization or dispose of as hazardous waste
Clean-up of water based paint	Wipe paint out of brushes, then: ▪ Rinse to sanitary sewer ▪ Dispose in trash
Empty paint cans (dry)	Remove lids, dispose lids and cans in trash
Paint stripping (with solvent)	Dispose of as hazardous waste
Exterior cleaning of buildings (high pressure water)	▪ Prevent entry into storm drain and remove offsite ▪ Wash onto soil-covered area, spade in ▪ Mop up washwater and discharge to sanitary sewer
Exterior cleaning of buildings (mercury, chromium, or other hazardous materials in paints)	▪ Use dry cleaning methods (e.g., sand blasting) ▪ Mop up wash water, reduce volume by evaporating liquid mixture ▪ Dispose of as hazardous waste
Exterior cleaning of buildings (paint contains lead)	▪ Dispose of as hazardous waste ▪ For assistance, contact EPA 1-800-LEAD-FYI
Paint scraping/sand blasting (no hazardous materials in paints)	▪ Dry sweep, dispose in trash

General Construction, Painting, and Maintenance (cont.)

Construction and demolition debris (no hazardous materials in debris)	▪ Reduce/reuse concrete, wood, or other construction materials ▪ Transport to land fill as construction and demolition waste
Construction and demolition debris (hazardous materials such as asbestos in debris)	▪ Follow landfill packaging requirements; transport to landfill as asbestos or other hazardous waste

Building & Property Management/Maintenance

Leaking garbage dumpsters	▪ Collect and contain leaking material ▪ Repair leak, return dumpster for repair.
Washwater from cleaning garbage dumpsters	Filter wash water through grease interceptor; contact wastewater treatment plant staff before discharging to sanitary sewer
Cleaning driveways, paved areas	Sweep & dispose in trash. For vehicle leaks: ▪ Clean up leaks with rags or absorbents ▪ Sweep using granular absorbent material (e.g., cat litter) ▪ Mop & dispose of mop water in sanitary sewer
Cleaning sidewalks, paved areas	▪ Clean up leaks with rags or absorbents ▪ Sweep using granular absorbent material (e.g. cat litter) ▪ Either mop and dispose of mop water in sanitary sewer of collect all water from cleaning and pump to sanitary sewer.

Vehicle Maintenance – Industrial/Commercial

Discharge/Activity	**Disposal Techniques**
Used motor oil	Use secondary containment while storing; send to recycler
Antifreeze	Use secondary containment while storing; send to recycler
Other vehicle fluids and solvents	Dispose of as hazardous waste
Automobile batteries	Send to auto battery recycler

Vehicle Maintenance – Industrial/Commercial (cont.)

Vehicle washing	▪ Recycle wash water ▪ Contact local wastewater treatment plant before discharging to oil/water separator connected to sanitary sewer
Mobile vehicle washing	▪ Recycle wash water ▪ Contact local wastewater treatment plant before discharging to oil/water separator connected to sanitary sewer
Rinse (new car fleets)	▪ Contact local wastewater treatment plant before discharging to oil/water separator connected to sanitary sewer ▪ Contact operator of storm drain system regarding approval to discharge, if rinse water is free of detergents or other cleaners
Vehicle leaks (auto repair shops)	▪ Sweep up leaks using granular, absorbent material (e.g., cat litter ▪ Mop and dispose of mop water to oil/water separator connected to sanitary sewer

Vehicle Maintenance - Residential

Discharge/Activity	Disposal Techniques
Used motor oil	▪ Use curbside recycling, where available, or ▪ Return to retail outlet for recycling, or ▪ Recycle through local Household Hazardous Waste Collection events/facilities
Antifreeze	Dispose of through local Household Hazardous Waste Collection events/facilities
Other vehicle fluids and solvents	Dispose of through local Household Hazardous Waste Collection events/facilities
Automobile batteries	Send to auto battery recycler

Landscape/Garden Maintenance

Discharge/Activity	Disposal Techniques
Pesticides	▪ Use up, rinse containers, use rinse water as product ▪ Dispose rinsed containers in trash ▪ Dispose unused pesticide as hazardous waste
Garden clippings	Compost or take to landfill
Tree trimmings	Chip, if necessary, before composting, or take to landfill
Swimming pool, spa or fountain water	▪ Avoid using metal-based algaecides (copper sulfate) ▪ Determine when chlorine residual is 0, wait 24 hours, then use for irrigation water.
Swimming pool, spa filter backwash	▪ Reuse for irrigation water ▪ Dispose on dirt area ▪ Contact local wastewater treatment plant before discharging to sanitary sewer

Other Wastes

Discharge/Activity	Disposal Techniques
Carpet cleaning discharge	Contact wastewater treatment plant before discharging to sanitary sewer
Contaminated pumped ground water, infiltration/foundation drainage	Treat as necessary; with prior approval from wastewater treatment plant, discharge to sanitary sewer
Kitchen grease	Provide secondary containment; collect, send to recycler
Exhaust hood filter cleaning	Discharge wash water through a grease interceptor, then to sanitary sewer
Clean-up wastewater from sewer back-up	▪ Block storm drain, contain, collect and return material to the sanitary sewer ▪ Block storm drain, rinse remaining material to collection point and pump to sanitary sewer (no rinse water may flow to storm drain)

Volume 5: Commercial, Industrial, Residential Controls

Section 1 - Introduction

The *Catalog of Stormwater Best Management Practices for Idaho Cities and Counties*, a series of five compact discs (CDs), provides technical guidance for construction site design and the selection of stormwater best management practices (BMPs). The catalog is a guidance document containing voluntary controls that could be formally adopted by a jurisdiction to establish standards, if desired. Measures, such as those described and other recognized equivalents, should be used to manage the quantity and quality of stormwater runoff from land development.

This information is primarily intended for design professionals (e.g., landscape architects, geologists, engineers, soil scientists, etc.) and their contractors. It is also applicable for local public officials or staff who are responsible for the review and approval of development applications.

There are several reasons why technical guidance regarding stormwater management is necessary:

- . Idaho remains one of the fastest growing states in the nation. The increase in population leads to an increase in land development, a recognized source of nonpoint source pollution, more commonly termed “polluted runoff.” The catalog includes BMPs that help to prevent discharge of pollutants from developing areas, both during the construction phase and for the life of the development. The BMPs can also be used to reduce polluted runoff from existing land uses.
- Many water bodies throughout the state are not in compliance with state water quality standards. Beneficial uses such as domestic water supply, fishing, swimming, boating, and agricultural water supply can often be impaired due to excessive pollutants from stormwater runoff. The catalog provides guidance for controls to reduce “conventional” pollutants, with special consideration for phosphorus and sediment, both common pollutants in Idaho.
- Federal National Pollutant Discharge Elimination System (NPDES) stormwater regulations have mandated that some communities develop and implement stormwater management programs to ensure that pollutants in stormwater runoff are controlled to the maximum extent practicable. Because polluted runoff has the potential to contribute to the degradation of receiving water quality, improved stormwater management program implementation at the local level will play an ever-increasing role in attaining and maintaining water quality standards.

In general, there are two types of BMPs for stormwater pollution control:
1. Source control BMPs focus on minimizing or eliminating the source of the pollution so that pollutants are prevented from contacting runoff or entering the drainage system.
2. Treatment control BMPs which tend to be more expensive to implement than source control BMPs, are designed to remove pollutants after they have entered runoff. Examples of source control BMPs include spill controls and employee education, while treatment control BMPs include detention ponds and oil/water separators. Most source control BMPs tend to be non-structural, and most treatment control BMPs tend to be structural in nature, although there can be exceptions. For example, a roof over a materials storage area at an industrial site would be considered a structural source control.

The majority of the practices focus on controlling pollution at its source, before runoff enters a drainage conveyance such as a sewer system or river. However, some BMPs are also included that can be used to treat runoff and remove pollutants that have already entered the drainage conveyance. The structural measures will reduce pollutant loads in post-construction site runoff, provided that the facilities are properly designed, installed, and maintained on a periodic basis.

The catalog presents general technical guidelines. Specific conditions or local regulations may require modification of the recommended BMPs, and alternative practices that are approved by a local permitting authority may also require modification or replacement of recommended BMPs. The BMP selection matrix should be used as a screening tool to assist the design professional, landowner, or reviewer in selecting the most appropriate or suitable measure based on site-specific conditions.

In order to illustrate the use and application of certain BMPs, manufacturer and product names may be used in the catalog. This does not represent an endorsement of a specific manufacturer or product.

1.1 Organization

The first volume of the CD series includes a brief discussion of stormwater runoff impacts; an overview of agencies responsible for stormwater permitting and authority in Idaho; and a step-by-step procedure for site design.

The second volume of the CD series contains construction BMPs including both erosion and sediment controls and source controls.

The third volume of the CD series introduces the concept of low-impact development and provides techniques that can minimize changes to the hydrologic functioning of a development site.

The fourth volume of the CD series contains post-construction/ permanent BMPs.

The fifth volume of the CD series provides BMPs for specific land use activities, including industrial, commercial, and residential activities.

The catalog is intended for use in conjunction with local governmental requirements, such as applicable planning and building codes. The catalog is not all-inclusive and should be used along with other reference books and manuals published by other agencies as necessary or appropriate based on local conditions and policies.

1.2 Updates

The practice of stormwater management is quickly evolving. Design information for various BMPs is expected to change as more people apply the practices and learn from their experience. New BMPs will also be added to the mix. To accommodate these changes, periodic updates and amendments will be made to the catalog. These will be posted on the Department of Environmental Quality (DEQ) Web site as they become available.

Section 2 – Industrial Facilities

Those industrial facilities identified by the Environmental Protection Agency (EPA) as needing an NPDES industrial stormwater permit should obtain an NPDES permit if they discharge stormwater either directly to surface waters or indirectly through separate municipal storm drains. Categories of industrial facilities that should obtain coverage for their stormwater discharges can be found at http://cfpub1.epa.gov/npdes/stormwater/swcats.cfm?program_id=6.

2.1 Industrial Controls

This section describes industrial control BMPs. Industrial control BMPs are specific design features that should be considered when designing industrial facilities. The BMPs in this section are not all inclusive, but provide a starting point for planning. These BMPs should be used in conjunction with best professional judgment and sound engineering practices. They include:

BMP 1 Loading dock design features
BMP 2 Equipment yard design features
BMP 3 Fleet or equipment fueling design features
BMP 4 Access roads and rail corridors

Loading Dock Design Features BMP 1

Description

Properly designed outdoor loading docks can control stormwater pollution by reducing or eliminating pollutants entering stormwater.

Limitations

Berming and diking can be difficult to maintain if stormwater ponding occurs inside a containment dike.

Installation Application Guidelines

- Pave and grade the sloped or recessed loading area to direct flow toward either a central collection point, the inlet for which includes a shutoff valve, or toward a dead end holding tank.
- Pave the area with concrete if materials such as gasoline will be handled; gasoline can react with asphalt. If the area is already paved with asphalt, apply a sealant to the surface. Ensure that the paved surface is free of gaps and cracks.
- Use berms, curbs, dikes, or slopes to prevent run-on so stormwater is not added to waste in a holding tank. Dikes can be made of timbers, concrete curbing, or other similar materials.
- Assure the inlet carries liquid to a holding tank with large enough capacity to contain the entire volume of a potential spill while the valve is closed. The tank should be equipped with an outflow pipe to allow discharge of normal uncontaminated runoff to the storm drain. Keep the holding tank outlet valve closed at all times except when stormwater or other acceptable fluids need to be discharged.
- If the inlet connects to a storm drain, test accumulated liquid before discharging to the storm drain. Make sure the liquid does not contain pollutants before you discharge it to the storm drain. This discharge may require an NPDES permit.
- If the inlet connects to a sanitary sewer, test accumulated liquid before discharging to the sanitary sewer. Make sure its quality is within the parameters specified in the wastewater discharge permit before opening the valve for discharge.
- Consider using a roof structure to cover the loading dock and berm areas completely to prevent contact with stormwater. The roof cover should be sufficiently sized to prevent any precipitation from reaching the protected contents underneath.

Maintenance

- Inspect the holding tank regularly to ensure it is not overfilled.
- Test the holding tank contents prior to discharge or disposal.
- Inspect and maintain berms, curbs, dikes, or slopes regularly.

Equipment Yard Design Features BMP 2

Description

Properly designed equipment yards can control stormwater pollution by reducing or eliminating pollutants entering stormwater.

Limitations

Space limitations may prevent facility work from being performed in covered areas.

Installation/ Application Guidelines

- Pave and grade the area to drain to a longitudinal drain or install curbs to direct all stormwater to a central collection point in the yard. Pave the surface with concrete, not asphalt, which may react with spilled liquids.
- Fit the inlet(s) with a sand filter or other oil control BMPs if you determine that the equipment yard contributes large amounts of oily materials to stormwater.
- Segregate the area where vehicles are serviced and install special permanent controls:
  - ✓ Drain the area to a single collection-point, preferably connected to a holding tank and then to the sanitary sewer. The drain may require an oil/water separator or sand/grease trap and should be approved by local wastewater treatment plant staff.
  - ✓ Grade the activity area higher than the parking lot or surround the activity area with a berm, curb, or dike to prevent stormwater run-on.
  - ✓ Construct a special area that segregates the "dirtiest" equipment (roof tar equipment, asphalt paving equipment, etc.) from other equipment. Use berms, curbs, or dikes to keep discharges, leaks, and runoff separate from other activity areas.
- Cover storage areas, maintenance areas, and process areas to prevent exposure to stormwater. The particular roof cover option used at a given site is subject to the site layout, available space, affordability, and limitations imposed by other regulations. The following are examples of storage options:
  - ✓ A prefabricated storage shed to enclose and cover materials (ensure these structures meet applicable building and fire codes).
  - ✓ A lean-to structure against an existing building to cover materials and prevent contact with rain.
  - ✓ A stand-alone canopy that provides cover but no walls.

Maintenance Requirements

Oil/water separators and sand/grease traps will need to be maintained regularly.

Fleet or Equipment Fueling Design Features BMP 3

Description

Properly designed fleet or equipment fueling areas can control stormwater pollution by reducing or eliminating pollutants entering stormwater.

Limitations

Retrofitting existing fueling areas to minimize stormwater exposure or spill runoff can be expensive. Good design should occur during initial installation of fueling areas.

Installation/ Application Guidelines

- Cover the fueling area to prevent rain from falling directly on the activity area. Install a roof over the fueling island, the area where vehicles park while fueling, and as much of the approach area as practical.
- Equip the storm drain and sewer inlets that drain the fueling area with a shutoff valve to keep fuel out of the drain in the event of a fuel spill. The valve should be kept closed at all times except during a rainfall. Curtail fueling activities when the shutoff valve should be open or use a large drip pan under the vehicle to capture any spilled fuel.
- Separate the fueling area from the rest of the facility, not only to contain any fuel spills, but also to prevent stormwater run-on. Select from the following drainage design guidelines:
  - ✓ Grade the fueling area so that it is either "mounded" or elevated. A mounded grading scheme is recommended.
  - ✓ Grade the entire fueling area to drain to a single collection point inlet. Design the grading to prevent run-on.
  - ✓ Install high berms around the area that will redirect water from a large storm to a single collection point inlet.
  - ✓ Install a holding tank that accumulated liquids can be pumped to.

Maintenance Requirements

- Inspect the holding tank regularly to ensure it is not overfilled.
- Test holding tank contents prior to discharge or disposal.
- Inspect and maintain berms, curbs, dikes, or slopes regularly.

Access Roads and Rail Corridors BMP 4

Description

Properly designed access roads and rail corridors can control stormwater pollution by reducing or eliminating pollutants entering stormwater.

Limitations

No information available.

Installation/ Application Guidelines

- Grade access roads high in the center and slope the access road outward to divert water to the sides of the road. Stormwater should not be allowed to drain across the road, but be carried in ditches or culverts alongside the road.
- Line the roadside ditches with grass or other vegetation to remove stormwater pollutants, control erosion, and promote infiltration. Also, maintain ditches to ensure they do not clog or fill with sediment.
- Use less-toxic wood preservatives (instead of creosote and pentachlorophenol) on railroad ties or use concrete or other non-wooden ties.
- Control spills and dust from railroad unloading. If the rail line delivers or picks up liquids in bulk or in containers, add spill-control loading docks with shutoff valves. See BMP1, Loading Dock Design Features for more information. If parked railroad cars drip fluids, install a drip pan between the rails at the loading dock.

Maintenance Requirements

- Inspect vegetation regularly and remove sediments as needed.
- Inspect and maintain drip pans and holding tanks regularly.

2.2 Day-to- Day Operations for Industrial Sites

This section describes day-to-day operations BMPs for industrial sites. The BMPs in this section are not all-inclusive, but provide a starting point for planning. Pollutants such as heavy metals, oil and grease, and toxic chemicals can be significant components in industrial stormwater. Industrial operations BMPs include:

BMP 5	Non-stormwater discharges to drains
BMP 6	Vehicle and equipment fueling
BMP 7	Vehicle and equipment cleaning
BMP 8	Vehicle and equipment maintenance & repair
BMP 9	Outdoor loading/unloading of materials
BMP 10	Outdoor container storage of liquids
BMP 11	Outdoor process equipment operations and maintenance
BMP 12	Outdoor storage of raw materials and products
BMP 13	Waste handling and disposal
BMP 14	Contaminated or erodible surface areas
BMP 15	Building and grounds maintenance
BMP 16	Building repair, remodeling & construction
BMP 17	Employee training
BMP 18	Spill prevention and cleanup

Non-Stormwater Discharges to Drains BMP 5

Description

Eliminate non-stormwater discharges to the stormwater collection system. Examples of non-stormwater discharges are process wastewaters, cooling waters, wash waters, and sanitary wastewater.

Approach

The following approaches may help you identify non-stormwater discharges:

- Visual Inspection: The easiest method is to inspect each discharge point during dry weather. Drainage from a storm event can continue for three days or more and groundwater may infiltrate the underground stormwater collection system.
- Piping Schematic Review: A review of the "as-built" piping schematic is a way to determine if there are any connections to the stormwater collection system. The piping schematic is a map of pipes and drainage systems used to carry wastewater, cooling water, sanitary wastes, etc.
- Smoke Testing: Smoke testing of wastewater and stormwater collection systems is used to detect connections between the two systems. During dry weather, the stormwater collection system is filled with smoke and then traced to sources. The appearance of smoke at the base of a toilet indicates that there may be a connection between the sanitary and the stormwater systems.
- Dye Testing: A dye test can be performed by releasing a dye into either your sanitary or process wastewater system and examining the discharge points from the stormwater collection system for the dye color.
- Video Inspection: Mobile video cameras can be guided remotely through storm sewer lines to observe possible illicit connections into storm sewer systems and record observations on a videocassette or DVD. Public works staff can observe the videos and note any visible illegal connections.

Limitations

- Many facilities do not have accurate, up-to-date schematic drawings.
- TV and visual inspections can identify illicit connections to the storm sewer, but further testing is sometimes required (e.g. dye, smoke) to identify sources.

Additional Information

An illicit connection is any physical connection to a publicly maintained storm drain system composed of non-stormwater that has not been permitted by the public entity responsible for the operation and maintenance of the system. Facilities subject to EPA stormwater permit requirements should include a certification that the stormwater collection system has been tested or evaluated for the presence of non-stormwater discharges.

Non-stormwater discharges to the stormwater collection system may include any water used directly in the manufacturing process (process wastewater), air conditioning coolant, outdoor secondary containment water, vehicle and equipment wash water, sink and drinking fountain wastewater, sanitary wastes, or other wastewaters. See Appendix A, Disposal Alternatives table, for more information.

To ensure that the stormwater system discharge contains only stormwater, you should:

- Locate and evaluate all discharges to the industrial storm sewer system (including wet weather flow) using one of the following:
  - ✓ “As built” pipeline schematics
  - ✓ Visual observation
  - ✓ Dye tests
  - ✓ TV camera
  - ✓ Chemical field test kits
  - ✓ Smoke tests
- Develop a plan to eliminate illicit connections:
  - ✓ Identify appropriate connection or disposal alternatives
  - ✓ Replumb sewer lines
  - ✓ Isolate problem areas
  - ✓ Plug illicit discharge points
- Document that non-stormwater discharges have been eliminated by recording tests performed, methods used, dates of testing, and any on-site drainage points observed.
- Provide well-marked proper disposal or collection sites for wastewater.
- Employee training should especially emphasize proper disposal of non-stormwater.
- Label all storm drains and catch basins with “Dump No Waste” stenciling so employees and customers know which inlets are part of the storm drain system.
- Periodically inspect and maintain storm drain inlets. Clean out catch basins so that accumulated pollutants do not wash down the storm drains.

Vehicle and Equipment Fueling BMP 6

Description

Prevent fuel spills and leaks from vehicle and equipment fueling, and reduce their impacts to stormwater (covers large-size gas station, single pump maintenance yard installation, and mobile fueling operations).

Approach

Design the fueling area to prevent stormwater run-on of and the spill runoff:

- Cover fueling area if possible.
- Use a perimeter drain or slope the pavement inward directing drainage to a holding tank.
- Pave fueling area with concrete rather than asphalt; asphalt can react with gasoline and other materials.
- Apply a suitable sealant that protects the asphalt from spilled fuels in areas where covering the asphalt is not feasible and the fuel island is surrounded by pavement.
- Install an oil/water separator to collect spills, if a dead-end holding tank is not used.
- Install vapor recovery nozzles to help control drips as well as air pollution.
- Discourage "topping off" of vehicle fuel or underground storage tanks. Topping off tanks increases the risk of spilling fuel onto the ground.
- Use secondary containment when transferring fuel from the tank truck to the fuel tank.
- Store and maintain appropriate spill cleanup materials in a location known to all employees near the fueling operation; ensure that employees are familiar with the site's spill control plan and proper spill cleanup procedures.
- Use absorbent materials on small spills and general cleaning rather than hosing down the area. Remove the absorbent materials promptly and dispose as hazardous waste.
- Use absorbent pillows in or around storm drain inlets to filter oily runoff. Use the pillows for short-term situations only.
- Obey all federal and state requirements regarding underground storage tanks or install above ground tanks.
- Avoid mobile fueling of industrial equipment around the facility; rather, transport the equipment to designated fueling areas.
- Train employees in proper fueling and cleanup procedures and have them check the area daily for vehicle or equipment leaks.

Limitations

- Oil/water separators are only effective if they are maintained regularly.
- The retrofitting of existing fueling areas to minimize stormwater exposure or spill runoff can be expensive. Good design should occur during the initial installation. An extruded curb up gradient from the fueling area is relatively inexpensive and prevents stormwater run-on.

Maintenance Requirements

- Regularly clean oil/water separators at the appropriate intervals.
- Keep ample supplies of spill cleanup materials on-site.

- Inspect fueling areas and storage tanks regularly.

Additional Information

Fueling vehicles or equipment or transferring fuels to a storage tank can be significant sources of pollution. Fuels carry contaminants that are harmful to humans and wildlife, such as heavy metals, toxic materials, and oil and grease. These contaminants are not easily removed by stormwater treatment controls. Consequently, source control is particularly important. Carefully designing the initial installation, retrofitting existing installations, and using proper spill control and cleanup procedures can also provide adequate control.

Design:
With new installations, design the fueling area to prevent stormwater run-on and spill runoff. Contour the site in such a way that it is contained. Covering the site is the best approach but may not be feasible if very large mobile equipment is to be fueled. Stormwater run-on can be diverted around the fueling area by an extruded curb; or with a "speed bump" if vehicle access is needed from this direction. Contain spills within the fueling area either by using a perimeter drain or by sloping the pavement inward with drainage to a holding tank. Pave the fueling area with concrete rather than asphalt, since asphalt will gradually disintegrate and wash from the site.

Spill Control:
The following spill control measures will reduce spilling or reduce the loss of spilled fuels from the site:

- Install vapor recovery nozzles.
- Avoid "topping off" tanks. Topping off tanks can increase the risk of spilling fuel onto the ground.
- Place secondary containment around the fuel truck when it is transferring fuel to the storage tank. The truck operator should remain with the truck while the transfer is in progress.
- Place a stockpile of spill cleanup materials where it will be readily accessible.
- Use dry methods to clean the fueling area whenever possible. If you periodically clean by using a pressure washer, place a temporary plug in the downstream drain and pump out the accumulated water. Properly dispose of the water.
- Train employees on proper fueling and cleanup procedures.

Designated Fueling Area:
If your facility has a large amount of mobile equipment and you currently use a mobile fuel truck to fuel the equipment, consider establishing a designated area for fueling. With the exception of tracked equipment such as bulldozers or small forklifts, most vehicles should be able to travel to a designated area with little lost time. Place temporary "caps", such as a bentonite mat or a spill mat, over nearby catch basins or manhole covers. If a spill occurs, the spilled fluid will not enter the storm drain. Upon completion, remove mat and dispose as hazardous waste.

Vehicle and Equipment Cleaning BMP 7

Description

Prevent or reduce the discharge of pollutants to stormwater from vehicle, equipment, and tool cleaning.

Approach

- Consider using off-site commercial washing and steam cleaning businesses.
- Use designated wash areas, that are covered and bermed to prevent contact with stormwater, to contain wash water.
- Discharge wash water to the sanitary sewer only after contacting local wastewater treatment plant staff to find out if pretreatment is required.
- Consider filtering and recycling wash water.

Limitations

Steam cleaning can generate significant pollutant concentrations and may require permitting, monitoring, pretreatment, and inspections. Contact local wastewater treatment plant staff for additional information. The guidelines described in this fact sheet are insufficient to address all the environmental impacts and compliance issues related to steam cleaning.

Maintenance Requirements

- Repair and patch berms as needed.
- Inspect and maintain holding tanks, oil/water separators, and on-site treatment or recycling units regularly.

Additional Information

- Washing vehicles and equipment outdoors or in areas where wash water flows onto the ground can pollute stormwater and ground water. If your facility washes or steam cleans a large number of vehicles or pieces of equipment, consider contracting out this work to a commercial business. These businesses are better equipped to handle and dispose of the wash water properly. Contracting out this work can also be economical by eliminating the need for a separate washing/ cleaning operation at your facility.
- Steam cleaning and washing should be conducted on-site only if the site is equipped to capture all the water and other wastes. If washing/cleaning must occur on-site, wash vehicles inside the building to direct the liquid to an area where it can be pretreated to remove pollutants and subsequently discharged to the sanitary sewer.
- Properly dispose of all sludge left in tanks, containers, trucks, and holding tanks. Avoid discharging sludge to the storm drain system. Limit the amount of water used and recycle wash water if possible.
- Conduct outside washing operations in a designated wash area. Make sure the area has the following:
  - ✓ It is designated clearly.
  - ✓ It is paved with concrete.
  - ✓ It is covered and bermed to prevent contact with stormwater.
  - ✓ It is sloped for wash water collection.
  - ✓ It is connected to the sanitary sewer or to a dead-end holding tank.
  - ✓ It is equipped with an oil/water separator.

Vehicle and Equipment Maintenance & Repair BMP 8

Description

Prevent or reduce the discharge of pollutants to stormwater from vehicle and equipment maintenance and repair by running a dry shop.

Approach

- Keep equipment and equipment yard clean, make sure oil and grease accumulations do not buildup excessively.
- Make sure incoming vehicles are checked for oil and fluid leaks.
- Use a drip pan underneath leaking vehicles and equipment when storing vehicles or performing maintenance.
- Store idle equipment under cover.
- Inspect equipment for leaks on a regular basis, particularly vehicles parked or stored long term.
- Use an indoor garage or vehicle maintenance area designed to prevent stormwater pollution. Avoid changing motor oil or performing equipment maintenance in non-appropriate areas.
- Use fewer solvents; switch to nontoxic chemicals or clean vehicles and equipment with a wire brush or bake oven when possible.
- Recycle greases, used oil or oil filters, antifreeze, cleaning solutions, automotive batteries, hydraulic fluids, and transmission fluids. Collect and store these recyclable materials separately. Provide secondary containment.
- Make sure oil filters are completely drained for at least 24 hours before recycling or disposing of them.
- Do not pour materials down storm drains or hose down work areas; sweep work areas instead.
- Use rags for small spills, a damp mop for general cleanup, and dry absorbent materials for larger spills. Avoid hosing down areas.
- Stencil “DO NOT DUMP WASTE” signs on storm drain inlets.
- Clean equipment yard storm drain inlet(s) regularly and especially after large storms.
- Train employees in spill prevention and cleanup procedures.

Limitations

- Vehicle and equipment maintenance and repair can generate significant pollutant concentrations and may require permitting, monitoring, pretreatment, and inspections. Contact your local wastewater treatment plant staff for additional information. The guidelines described in this fact sheet are insufficient to address all of the environmental impacts and compliance issues related to vehicle and equipment cleaning
- Space and time limitations may preclude all work being conducted indoors.
- It may be difficult to contain and clean up spills from vehicles or equipment brought on-site after working hours.
- Drain pans (usually 1 ft. X 1 ft.) are generally too small to contain antifreeze, so drip pans (3 ft. X 3 ft.) may have to be purchased or fabricated.
- Dry floor cleaning methods may not be sufficient for some spills.

- Engine leak identification may require using solvents.

Maintenance Requirements

Maintenance requirements should be low if guidelines are followed.

Additional Information

Vehicle or equipment maintenance and repair can be a potentially significant source of stormwater pollution. Activities that can contaminate stormwater include engine repair and service (parts cleaning, spilled fuel, oil, etc.), replacement of fluids, and outdoor equipment storage and parking (leaking engines).

Waste Reduction:
- Parts are often cleaned using solvents such as trichloroethylene, 1,1,1-trichloroethane or methylene chloride. Many of these cleaners are harmful and should be disposed of as hazardous waste. Cleaning without using liquid cleaners (e.g. using a wire brush) whenever possible reduces hazardous waste.
- Prevent spills and drips of solvents and cleansers to the shop floor.
- Use liquid cleaners at a centralized station so the solvents and residues stay in one area.
- Locate drip pans, drip boards, and drying racks to direct drips back into a solvent tank or fluid holding tank for reuse.

Safer Alternatives:
If possible, eliminate or reduce the amount of hazardous materials and waste by substituting non-hazardous or less hazardous materials:
- Use non-caustic detergents instead of caustic cleaning agents for parts cleaning (ask your supplier about alternative cleaning agents).
- Use detergent-based or water-based cleaning systems in place of organic solvent degreasers.
- Replace toxic solvents with nontoxic solvents.
- Choose cleaning agents that can be recycled.
- Reducing the number of solvents makes recycling easier and reduces hazardous waste management costs. Often, one solvent can perform a job as well as two solvents.

Recycling:
- Separating wastes allows for easier recycling and may reduce treatment costs. Collect leaking fluids in drip pans or containers and store separately for recycling. Keep hazardous and nonhazardous wastes separate. Avoid mixing recyclable used oil with non-recyclable solvents.
- Many products made of recycled (i.e., refined or purified) materials are available. Engine oil, transmission fluid, antifreeze, and hydraulic fluid are available in recycled form. Buying recycled products supports the market for recycled materials.

Good Housekeeping:
Consider using the following measures:
- Avoid hosing down your work areas. If work areas are hosed down, direct all wash water to the sanitary sewer. Contact local wastewater treatment

plant staff for more information.

- Keep a drip pan under the vehicle while you unclip hoses, unscrew filters, or remove other parts. Use a drip pan under any vehicle that might leak while you work on it to keep splatters or drips off the shop floor.
- Promptly transfer used fluids to the proper waste or recycling drums. Avoid leaving full drip pans or other open containers sitting out for extended periods of time.
- Do not pour liquid waste to floor drains, sinks, outdoor storm drain inlets, or other storm drains-or sewer connections. Used or leftover cleaning solutions, solvents, and automotive fluids and oil are toxic and should not be put in the sanitary sewer. Post signs at sinks to remind employees, and stencil outdoor drains to tell customers and others not to pour wastes down drains.
- Oil filters disposed of in trashcans or dumpsters can leak oil and contaminate stormwater. Drain excess oil by placing the oil filter in a funnel over a waste oil recycling or disposal collection tank for at least 24 hours before disposing of the filter. Oil filters can be recycled. Ask your oil supplier or recycler about recycling oil filters.
- Designate a special area to drain and replace motor oil, coolant, and other fluids where there are no connections to the storm drain or the sanitary sewer and drips and spills can be easily cleaned.
- Be careful with wrecked vehicles, as well as vehicles kept on-site for scrap or salvage. Wrecked or damaged vehicles often drip oil and other fluids for several days.
- Place drip pans under vehicles immediately after they arrive on the site, even if you believe that the fluids have leaked out before the vehicles reach the shop.
- Build a shed or temporary roof over areas where cars awaiting repair or salvage are parked. Build a roof over vehicles you keep for parts. Check vehicles and parts regularly for leaks.
- Drain all fluids, including air conditioner coolant, from wrecked vehicles and “part” cars. Also, drain engines, transmission, and other used parts.
- Store cracked batteries in a non-leaking secondary container, even if you think all the acid has drained out. If you drop a battery, treat it as if it is cracked. Put it in the containment area until you are sure it is not leaking.

Outdoor Loading/Unloading of Materials BMP 9

Description

Prevent or reduce the discharge of pollutants to stormwater from outdoor loading or unloading of materials.

Approach

- Park tank trucks or delivery vehicles in an area where spills or leaks can be contained. Inspect the vehicles regularly.
- Cover outside loading and unloading docks to reduce exposure of materials to rain.
- Add a seal or door skirt between the trailer and building to prevent exposure to rain.
- Design the loading and unloading area to prevent stormwater run-on:
  - ✓ Use grading or berming
  - ✓ Position roof downspouts to direct stormwater away from the loading and unloading areas
- Contain leaks during material transfers.
- Use drip pans under hoses and pipe connections during liquid transfer operations.
- Make sure forklift operators are properly trained.
- Train employees to properly contain and clean up spills and transfer liquids.

Limitations

- Space and time limitations may prevent all transfers from being performed indoors or in covered areas.
- It may not be possible to conduct transfers only during dry weather.

Maintenance

- Conduct regular facility inspections and make repairs as necessary. The frequency of repairs will depend on the age of the facility.
- Check loading and unloading equipment regularly for leaks in valves, pumps, flanges, and connections.

Additional Information

The loading and unloading of materials usually takes place outside. Material loading or unloading can occur in containers or by direct liquid transfer. Materials spilled, leaked or lost during loading and unloading may collect in the soil or on other surfaces and be carried away by runoff or when the area is cleaned. Rainfall may wash pollutants from machinery used to unload or move materials.

To prevent these pollutants from entering the stormwater, limit the exposure of material to rainfall, prevent stormwater run-on, check equipment regularly for leaks, and contain spills during transfer operations.

Loading or unloading of liquids should occur indoors so that any spills that are not completely retained can be discharged to the sanitary sewer or treatment plant, or treated in a manner consistent with local wastewater treatment plant requirements and permit requirements.

The following guidelines can be used for outdoor loading and unloading of materials:

- Use overhangs or door skirts that enclose the trailer.
- Park tank trucks while materials are being delivered so that spills or leaks can be contained.
- Design loading and unloading areas to prevent stormwater run-on. Use design techniques such as grading or berming areas and positioning roof downspouts so they direct stormwater away from loading and unloading areas.
- Check loading and unloading equipment regularly for leaks from valves, pumps, flanges and connections. -
- Have an emergency spill cleanup plan readily available and train employees in spill containment and cleanup.
- Establish disposal areas for cleanup materials next to or near each loading and unloading area.

For loading and unloading tank trucks to above and below ground storage tanks, the following procedures should be used:

- Pave the transfer area. If the liquid is reactive with asphalt, concrete should be used to pave the area.
- Design the transfer area to prevent run-on of stormwater from adjacent areas. Sloping the pad and using a curb, like a speed bump, around the uphill side of the transfer area should reduce run-on.
- Design the transfer area to prevent runoff of spilled liquids from the area.
- Slope the area to a drain to prevent runoff. The drain should be connected to a dead-end holding tank. A positive control valve should be installed on the drain.

For loading and unloading rail cars to outside storage tanks; use the following procedures:

- Place drip pans at locations where spillage may occur, such as hose connections, hose reels, and filler nozzles. Use drip pans when making or breaking connections.
- Install drip pan systems between the rails to collect spillage from tank cars.
- Inspect access roads and parking lots regularly to identify and cleanup spills.
- Remove solid debris as soon as operations permit.
- Avoid hosing off paved surfaces. Use a vacuum truck or sweeper for large areas.

Outdoor Container Storage of Liquids BMP 10

Description

Prevent or reduce the discharge of pollutants to stormwater from outdoor container storage areas by installing safeguards against accidental releases, installing secondary containment, conducting regular inspections, and training employees in standard operating procedures and spill cleanup techniques.

Approach

Protect materials from rainfall, run-on, runoff, and wind dispersal:

- Place tight fitting lids on all containers.
- Minimize stormwater run-on by enclosing the area or building a berm around it.
- Use a "doghouse" shed for storing small liquid containers. A doghouse shed consists of two solid structural walls and two canvas-covered walls. The floor is wire mesh and is above secondary containment.
- Use covered dumpsters for waste product containers.
- Store oil and hazardous materials to meet specific Federal and State standards including:
  - ✓ A Spill Prevention Control and Countermeasure (SPCC) Plan
  - ✓ Secondary containment
  - ✓ Integrity and leak detection monitoring
  - ✓ An emergency preparedness plan.
- Train employees on proper outdoor storage of liquids.
- Use safeguards against accidental releases:
  - ✓ Place drip pans or absorbent materials beneath all mounted taps and at all potential drip and spill locations during filling and unloading.
  - ✓ Install overflow protection devices to warn the operator or provide automatic shut down of transfer pumps.
- Install protection guards (bollards) around tanks and piping to prevent vehicle or forklift damage.
- Label containers or tanks clearly. Restrict access to valves to reduce human error.
- Store and maintain appropriate spill cleanup materials in a location near the storage area and train employees in spill cleanup procedures according to a site spill control plan.
- Berm or surround the tank or container with an appropriate secondary containment system. Dikes, liners, vaults, or double walled tanks (needs to be an impervious surface) are examples of secondary containment systems.
- Install an oil/water separator, if necessary, in facilities with "spill ponds." Facilities using spill ponds designed to intercept, treat, and/or divert spills should contact the appropriate regulatory agency regarding environmental compliance.
- Inspect tanks, containers, and containment holding tanks daily for leaks and spills. Replace leaking and/or deteriorating containers and collect all spilled liquids for proper disposal.

Limitations

Storage sheds often should meet building and fire code requirements.

Maintenance Requirements

Conduct routine weekly inspections.

Additional Information

Accidental releases of materials from above ground liquid storage tanks, drums, and dumpsters present the potential for contaminating storm and ground waters with many pollutants.
The following are the most common causes of unintentional releases:

- External corrosion and structural failure
- Installation problems
- Spills and overfills due to operator error
- Failure of piping systems (pipes, pumps, flanges, couplings, hoses, and valves)
- Leaks during pumping of liquids or gases from truck or railcar to a storage facility or vice versa.

Materials spilled, leaked or lost from storage containers and dumpsters may accumulate in soils or on surfaces and be carried away by stormwater runoff. Facilities should comply with fire codes regarding the storage of reactive, ignitable, or flammable liquids.

Container Management
To limit the possibility of stormwater pollution, containers used to store dangerous waste or other liquids should be kept inside a building unless this is impractical due to site constraints. If the containers are placed outside, the following procedures should be employed:

- Place dumpsters used to store items awaiting transfer to a landfill in a lean-to structure or otherwise covered. Keep dumpsters in good condition.
- Tell employees to avoid dumping liquids in dumpsters and make sure that dumpster lids are always closed.
- Place a fillet on both sides of the curb to facilitate moving the dumpster.
- Keep waste container drums in an area such as a service bay and ensure that the drums have tight fitting lids affixed at all times. If drums are kept outside, store them in a lean-to type structure, shed or wal- in container to keep rainfall from reaching the drums. The storage area should have berms and be paved with an appropriate material.

Facilities storing reactive, ignitable, or flammable liquids should comply with fire codes. In addition, the following practices should be employed:

- Place containers in a designated covered storage area.
- Ensure that designated areas are paved and free of cracks and gaps so that leaks and spills are contained.
- Surround liquid waste by a curb or dike. Provide an area large enough to contain 100% of the volume of the largest container plus the amount of rainwater equal to 25-year storm event. Contact the local fire department for more information.
- Slope the area, located inside the curb, to a drain. Install a dead-end holding tank in the drain for used oil or dangerous waste.
- Place containers used for removing liquid in a containment area. Use a drip pan at all times.
- Secure drums stored in areas where unauthorized persons may gain access

to prevent accidental spillage or unauthorized use.

- Ensure that employees trained in emergency spill cleanup procedures are present when dangerous waste, liquid chemicals, or other wastes are loaded or unloaded.

Operator Training/Safeguards

Employees should be familiar with the Spill Prevention Control and Countermeasure (SPCC) Plan and have the tools and knowledge to immediately begin cleaning up a spill if one should occur. Use engineering safeguards to reduce accidental releases of pollutants and prevent operator errors. The following safeguards can be used:

- Overflow protection devices on tank systems to warn the operator to shut down transfer pumps when the tank reaches full capacity.
- Protective guards (bollards) around tanks and piping to prevent vehicle or forklift damage.
- Clearly tagging or labeling all containers, tanks, and valves.

Secondary Containment

- Tanks should be bermed or surrounded by a secondary containment system with an impervious surface. Leaks can be detected more easily and spills can be contained when secondary containment systems are installed. Berms, dikes, liners, vaults, and double-wall tanks are examples of secondary containment systems. Roofing the containment system prevents rainwater from accumulating in open containers. Portable pumping systems can be used if water accumulates in open containers. Test the water to determine if the water contains hazardous chemicals that require treatment.
- Diking is one of the best protective measures against stormwater contamination. Containment dikes are berms or retaining walls that are designed to hold spills. Diking is also effective for preventing stormwater contamination in loading and unloading areas where above ground storage tanks and railcar or tank trucks are located. The dike surrounds the area and holds the spill, keeping spill materials separated from stormwater. Diking can be used in any industrial facility, but it is most commonly used for controlling large spills or releases from liquid storage transfer areas.
- Containment dikes should be large enough to contain 100% of the volume of the largest container plus the amount of rainwater equal to a 25-year storm event. Contact the local fire department for more information. For trucks, diked areas should be capable of holding an amount equal to the volume of the tank truck compartment.
- Dike construction material should be strong enough to safely hold spilled materials. Dike materials can consist of earth, concrete, synthetic materials, metal, or other impervious materials. Avoid using metal containers, concrete, and some plastics for dike materials if strong acids or bases will be stored outside. These dike materials could react with strong acids or bases if a spill occurs. Some of the more active organic chemicals may require special liners for dikes.

- Dikes should be inspected during and after significant storms or spills to check for washouts or overflows. Earthen dikes may require special maintenance of vegetation. Dike erosion, soggy areas, or changes in vegetation indicate problems with earthen dike structures. Damaged areas should be patched and stabilized immediately.
- Curbing is common at many facilities in small areas where handling and transfer of liquid materials occur. Curbing is usually small scale and does not contain large spills like diking does. Curbing can redirect contaminated stormwater away from the storage area and can be used in areas where liquid materials are transferred from one container to another. Asphalt is a common material used for curbing; however, earth, concrete, synthetic materials, metal, or other impenetrable materials may also be used. Curbs should have manually controlled pump systems rather than common drainage systems for collection of spilled materials. The curbed area should be inspected regularly to clear clogged debris and maintained frequently to prevent overflow of any spilled materials.

Maintenance

Conduct weekly inspections for the following:

- Check for accumulated rainfall in the secondary containment system (remove and discharge properly).
- Check for external corrosion and structural failure.
- Check for spills and overfills due to operator error.
- Check for failure of piping system (pipes, pumps, flanges, coupling, hoses, and valves).
- Check for leaks or spills during pumping of liquids or gases from truck or rail car to a storage facility or vice versa.
- Inspect new tank or container installation for loose fittings, poor welding, and improper or poorly fitted gaskets.
- Inspect tank foundations, connections, coatings, and tank walls and piping system. Look for corrosion, leaks, cracks, scratches, and other physical damage that may weaken the tank or container system. Problems or potential problems should be corrected as soon as possible.

Inspect tank systems and test the integrity of the tanks regularly. Problem areas can often be detected by inspecting the tanks frequently. Registered and specifically trained professional engineers can identify and correct potential problems such as loose fittings, poor welding, and improperly or poorly fitted gaskets on newly installed tank systems.

Outdoor Process Equipment BMP 11

Description

Prevent or reduce the discharge of pollutants to stormwater from outdoor process equipment operations and maintenance (O&M) by reducing the amount of waste created, enclosing or covering all or some of the equipment, installing secondary containment, and training employees.

Approach

- Identify all equipment and activities that may impact stormwater (include all compressors, rooftop cooling towers, and air conditioners, etc.).
- Alter the activity to prevent exposure of pollutants to stormwater.
- Move the activity indoors.
- Cover the area with a permanent roof or reinforced tarpaulin for temporary storage piles.
- Use ground cloths and/or drip pans where applicable.
- Cover outdoor open process tanks (i.e., dip tanks, etc.) when they are not in use.
- Minimize the contact of stormwater with outside manufacturing operations through berming and drainage routing.
- Connect the process equipment area to the sanitary sewer or to the facility wastewater treatment system. Contact your wastewater treatment plant staff before connecting to a system.
- Sweep the processing area everyday. Avoid hosing down the area where water can run into a storm drain.
- Clean the storm drain system regularly.
- Use storm drain inlet protection to capture particulate pollutants.
- Store and maintain appropriate spill cleanup materials in a location known to all employees. Ensure employees are trained in spill control plan and cleanup procedures.

Limitations

- Space and cost limitations may prevent enclosing some equipment.
- Storage sheds should meet building and fire code requirements.

Maintenance Requirements

Routine preventive maintenance, including checking process equipment for leaks.

Additional Information

- Outside process equipment operations include activities such as rock grinding or crushing, painting or coating, grinding or sanding, parts degreasing or cleaning, wastewater and solid waste treatment and disposal, and land application. These process equipment operations use hazardous materials that can contaminate stormwater runoff.
- Pollutants from the wastewater and solid waste treatment and disposal areas come from waste pumping, additions of treatment chemicals, mixing, aeration, clarification, and solids dewatering.
- Source controls are the preferred (and possibly the most economical) way to reduce stormwater pollution. Source controls are practices or structural measures that prevent pollutants from entering stormwater. Performing an activity only during dry periods or substituting nontoxic materials for

toxic materials are examples of source controls.

- Performing an activity in a building that has floor drains connected to the sanitary sewer (with prior approval from your wastewater treatment plant) can also be an effective source control.
- If an area used by an activity is large enough to make enclosure prohibitively expensive, then provide a roof to cover only the top of the area, leaving the sides open. Providing a roof eliminates the need for ventilation and lighting systems, yet still provides protection from rain.
- Air compressors and other equipment sometimes produce small quantities of blowdown water that can contain lubricating oil and other pollutants. Blowdown water may not be discharged to the storm drain. Connect the blowdown to the sanitary sewer (with prior approval from your wastewater treatment plant)and place a drip pan beneath any leaks.
- Condensate on exterior surfaces or compressors, building cooling equipment, and other machinery may be directed to the storm drain. Route condensate to a storm drain so it does not pick up pollutants as it flows across the site. Contact your wastewater treatment plant staff for information on what can be discharged to the sanitary sewer system.

Outdoor Storage of Raw Materials BMP 12

Description

Prevent or reduce the discharge of pollutants to stormwater from outdoor material and product storage areas by enclosing or covering materials, installing secondary containment, and preventing stormwater run-on.

Approach

Protect materials from rainfall, run-on, runoff, and wind dispersal:

- Store material indoors.
- Cover the storage area with a roof.
- Build a berm around the area to minimize stormwater run-on.
- Cover the material at all times with a temporary covering made of polyethylene, polypropylene, or hypalon and secure it with weighted tires or sandbags.
- Use a “doghouse” shed for storing small liquid containers. A doghouse shed consists of two solid structural walls and two canvas-covered walls. The floor is wire mesh and is above secondary containment.
- Sweep parking lots or other areas near bulk materials storage areas periodically to remove debris that has blown or washed from the storage area.
- Sweep paved storage areas monthly. Do not hose down the area to a storm drain. Dispose of waste in trash.
- Keep liquids in a designated area on a paved surface within secondary containment.
- Keep outdoor storage containers in good condition, check regularly for leaks and ensure storage container lids are on tightly.
- Use catch basin sand filters.
- Stock cleanup materials such as brooms, dustpans, and vacuum sweepers near the storage area.
- Use drip pans and/or absorbent materials where needed.

Limitations

- Space limitations may prevent storing some materials indoors.
- Storage sheds should meet building and fire code requirements.

Maintenance Requirements

Berm and curbing repair and patching may be necessary.

Additional Information

- Raw materials, by-products, finished products, containers, and material storage areas exposed to rain or runoff can pollute stormwater. Stormwater can become polluted when contaminants in raw materials wash off or dissolve into water or runoff.
- Slope paved areas to minimize the pooling of water on the site. A minimum slope of 1.5 % is recommended. Minimizing water pooling is particularly important with materials that may leach pollutants into stormwater or ground water, such as compost, logs, and wood chips. Prevent run-on and runoff with berms or curbing.
- Place curbing along the perimeter of the area to prevent the run-on of uncontaminated stormwater from adjacent areas and the runoff from stockpile areas. Design the storm drain system to minimize catch basins in

the interior of the area as catch basins in the interior tend to fill rapidly with manufacturing material. The area should be sloped either to drain stormwater to the perimeter where it can be collected or to internal drainage alleyways where material is not stockpiled. If the raw material, by-product, or product is a liquid, see BMP 10, Outdoor Container Storage of Liquids, for more information.

Waste Handling and Disposal BMP 13

Description

Prevent or reduce the discharge of pollutants to stormwater from waste handling and disposal by tracking waste generation, storage, and disposal; reducing waste generation and disposal through source reduction, reuse, and recycling; and preventing run-on and runoff from waste management areas.

Approach

Prevent waste generation on your site:

- Maintain usage inventory.
- Use substitute materials with less toxic substances.
- Modify processes or equipment to generate less waste.
- Plan and sequence production.

Track waste generated from your site:

- Characterize every waste stream.
- Evaluate the process that generates the waste.
- Prioritize waste streams using: manifests, biennial reports, permits, environmental audits, SARA Title III reports, emission reports, and NPDES monitoring reports.
- Prepare inventory reports.
- Maintain data on chemical spills.
- Track emissions.
- Check for expiration dates of stored chemicals.
- Review design data: process flow diagram, materials and applications diagram, piping and instruction, equipment list, and plot plan.
- Review raw material and production data: composition sheets, material safety data sheets (MSDS), batch sheets, product or raw material inventory records, production schedule, and operator data log.
- Review economic data:
  - ✓ Waste treatment and disposal costs
  - ✓ Product utility and economic costs
  - ✓ Operation and maintenance labor costs.
- Recycle materials whenever possible.
- Maintain a list of materials and the amounts of materials that have been disposed.
- Use waste segregation and separation.
- Cover storage containers with leakproof lids and cover all waste piles.
- Install a paved floor with curbing to contain spills in waste storage areas. Slope the floor to direct flow to a lined holding tank to prevent spilled liquids and/or contaminants from mixing with surface and ground water.
- Cover, enclose, or berm industrial wastewater management areas whenever possible to prevent contact with run-on or runoff.
- Equip waste transport vehicles with anti-spill equipment.
- Completely drain empty drums and sealed them properly so they are watertight; ship them as soon as possible to a drum reconditioner.
- Inspect storage containers for leaks and spills regularly. Replace any leaking and/or deteriorating containers.

- Ensure that sediments or wastes are prevented from being tracked off-site.
- Sweep and clean the storage area monthly. If the storage area is paved, avoid hosing down the area to a storm drain.
- Dispose of rinse and wash water from contained cleaning into a sanitary sewer in accordance with local wastewater treatment plant requirements.
- Store and maintain appropriate spill cleanup materials in a location known to all employees; ensure that employees are familiar with the site spill control plan and proper cleanup procedures.
- Stencil storm drains on the facility's property with "DO NOT DUMP WASTE."
- For a quick reference on disposal alternatives for specific wastes, see Appendix A, Disposal Alternatives table.

Limitations

Hazardous wastes that cannot be reused or recycled should be disposed of by a licensed hazardous waste handler.

Additional Information

Industrial waste management activities, such as waste pumping, treatment, chemicals storage, mixing, aeration, clarification, and solids dewatering occur in areas that can contaminate stormwater. Examples of these areas are landfills, waste piles, wastewater and solid waste treatment and disposal, hazardous and nonhazardous waste storage, and land application.

Waste Reduction

- Waste spilled, leaked, or lost from waste management areas or outside manufacturing activities may build up in soils or in other surfaces and be carried away by stormwater runoff. Likewise, liquid waste from lagoons or surface impoundments can overflow to surface waters or soak into the soil and contaminate surface or ground water. Reducing wastes from manufacturing activities is the best way to reduce the potential of stormwater contamination from waste management areas.
- Reducing the amount of industrial waste generated on a site can be accomplished by using source controls:
  - ✓ Production planning and sequencing
  - ✓ Process or equipment modification
  - ✓ Raw material substitution or elimination
  - ✓ Loss prevention and housekeeping
  - ✓ Waste segregation and separation
  - ✓ Closed loop recycling.
- Starting a waste reduction program is economically beneficial because of reduced raw material purchases and lower waste disposal fees. Also, implementing a material tracking system to increase awareness about material usage can reduce spills, reducing the amount of waste produced.
- To reduce wastes at your facility, first assess process activities where wastes can be reduced. Assessing process activities will not only help determine where waste can be eliminated or reduced, but also where emissions and environmental damage can be minimized. Assessing process activities involves collecting process specific information, setting pollution prevention targets, and developing, screening, and selecting waste reduction options for further study.

Spill/Leak Control

- Prevent waste from contaminating stormwater by inspecting waste management areas for leaking containers or spills. Corroded or damaged containers can leak at any time. Transfer waste from these damaged containers into safe containers.
- Ensure that all containers are properly sealed with tight fitting lids. Cover dumpsters to prevent rain from washing waste out of holes or cracks in the bottom of the dumpster. Repair leaking equipment (valves, lines, seals, or pumps) promptly.
- Ensure that vehicles that transport waste have spill prevention equipment. Examples of spill prevention equipment on vehicles are baffles for liquid waste or sealed gates and spill guards for solid waste.
- Loading or unloading wastes can contaminate stormwater when the wastes are spilled during the transfer. Operate loading system to minimize spills and fugitive emission losses (such as dust or mist). Using vacuum transfer systems can also minimize waste loss.

Run-on and Runoff Prevention

Prevent stormwater run-on from entering the waste management area by enclosing the area or building a berm around the area. In addition, the following source controls can also reduce stormwater pollution:

- Protect waste materials from direct contact with rain.
- Move the activity indoors after ensuring that all safety concerns such as fire hazards and ventilation are addressed.
- Cover the area with a permanent roof.
- Cover waste piles with temporary covering material such as reinforced tarpaulin, polyethylene, polyurethane, polypropylene or hypalon.
- Store waste materials on a paved surface that is bermed or drains to a dead-end holding tank.
- To avoid tracking materials off-site, keep the waste management area clean by sweeping and cleaning up spills immediately. Vehicles should never drive through spills. If necessary, wash vehicles in designated areas before the vehicles leave the site. Collect and dispose of the wash water properly.

Minimizing polluted stormwater runoff from on-site land application of industrial waste can be accomplished by implementing the following guidelines:

- Avoid applying waste to the site when it is raining, when the ground is frozen, or when the ground is saturated with water.
- Grow vegetation on land disposal areas to stabilize soils and reduce the volume of surface water runoff from the site.
- Maintain adequate barriers between the land application site and the receiving waters. Planted strips are particularly good.
- Use erosion control techniques. Refer to construction site BMPs.
- Perform routine maintenance to ensure the erosion control or site stabilization measures are working.
- For specific information on land applying industrial wastes, contact the

nearest regional office of the Idaho Department of Environmental Quality.

Contaminated or Erodible Surface Areas BMP 14

Description

Prevent or reduce the discharge of pollutants to stormwater from contaminated or erodible surface areas by leaving as much vegetation on-site as possible, minimizing soil exposure time, stabilizing exposed soils, and preventing stormwater run-on and runoff.

Approach

Land disturbance, demolition, and material handling areas can produce pollutants that can be carried off in the stormwater or dust. Control contaminated or erodible surface areas by following the erosion and sedimentation controls listed below:

- Preserve natural vegetation.
- Re-vegetate the area.
- Apply chemical stabilization.
- Use geosynthetic materials.
- Remove contaminated soils. See Appendix A for disposal alternatives.

Limitations

Preserving natural vegetation or re-vegetating the area has limitations:

- Substantial planning may be needed to preserve and maintain the existing vegetation.
- It may not be cost-effective with high land costs.
- Lack of rainfall and/or poor soils may limit the success of revegetated areas.
- Chemical mulch has its limitations:
  - ✓ It can create impervious surfaces.
  - ✓ It may cause harmful effects on water quality.
  - ✓ It is usually more expensive than vegetative cover.
  - ✓ It is a temporary measure.

Additional Information

Industrial sites that have disturbed areas can erode and generate a significant amount of dust. These areas can also be contaminated from past or current activities. Industries should identify the areas of contaminated or erodible surfaces and inspect the areas frequently to add or reapply controls as needed. Contaminated or erodible surface areas may be any of the following:

- Heavy activity areas where plants cannot grow
- Soil stockpile areas
- Steep slopes
- Construction and demolition areas
- Roadways and access lanes
- Areas where the soil is disturbed.

Preserving existing vegetation is the most effective way to control erosion, protect water quality, and provide aesthetic benefits. Existing vegetation can act as a natural buffer zone where stormwater can infiltrate and leave pollutants behind in the soil. The vegetation should be properly maintained to ensure that it will control erosion. Plant types, soil types, and climatic conditions will determine the maintenance requirements (such as mulching, fertilizing, irrigating, pruning, and controlling weeds and pests) for the site. Perform maintenance regularly.

Ideally, you should leave as much existing vegetation on-site as possible to reduce or eliminate soil erosion or dust generation; however, if the site already has contaminated or erodible surface areas, you can implement any of the following four courses of action:

- Revegetate the area if it is not currently being used and potentially damaged by site activities. Low water or poor soils may cause poor vegetation growth. Poor soils may be improved by applying fertilizers. Improving soil conditions may be sufficient to support vegetation. Process wastewater may be used for irrigation depending on its quality.
- Stabilize the area by applying chemical stabilization. Chemical stabilization can be used as a temporary control in areas where seeding vegetation cannot be performed because of the season. Follow manufacturer application rates to prevent the product from forming ponds and creating large areas where moisture cannot penetrate the soil.
- Apply geosynthetic materials. Geosynthetics can either act as an impermeable barrier or control large amounts of liquid or solid matter. Geosynthetics come in two types: geomembranes (impermeable) and geotextiles (permeable). Geomembranes are composed of one of three types of impermeable materials: elastomers (rubbers), thermoplastics (plastics), or a combination of the two. Geotextiles are uncoated, synthetic products that are commonly composed of polypropylene and polyester.
- Remove contaminated soils. Removing contaminated soils can be quite expensive. You should determine the extent of the contamination and remove the contaminated soils in accordance with state and federal regulations.

Building and Grounds Maintenance BMP 15

Description

Prevent or reduce the discharge of pollutants to stormwater from buildings and grounds maintenance by washing and cleaning up with as little water as possible, preventing and cleaning up spills immediately, keeping debris from entering the storm drains, and maintaining the stormwater collection system.

Approach

- Leave or plant drought-tolerant vegetation to reduce water, fertilizer, and pesticide needs.
- Use pesticides and fertilizers carefully. Train employees on proper pesticide use.
- Store and maintain appropriate spill cleanup materials in a location known to all employees; ensure employees are trained in the site spill control plan and spill cleanup procedures.
- Implement integrated pest management (IPM) techniques, where appropriate.
- Sweep parking lots, storage areas, driveways, and sidewalks monthly to collect dust, waste, and debris. Avoid hosing down the area to a storm drain.
- Clean the storm drain system (roof gutters, inlets, lines, catch basins, etc.) regularly.
- Dispose of wash water, sweepings, and sediments properly. See Appendix A for disposal alternatives.
- Ensure that rooftop drains drain directly to your on-site storm drain system or a grass-covered area.
- For a quick reference on disposal alternatives for specific wastes, see Appendix A.

Additional Information

Common maintenance activities can generate wastes that should be disposed of properly. Buildings and grounds maintenance involves taking care of landscaped areas around a facility, cleaning parking lots and pavement (other than in the area of industrial activity), and cleaning the storm drain system. Painting and other building repairs are covered in BMP 16, Building Repair, Remodeling, and Construction.

Pesticide and Fertilizer Management

- Landscape maintenance can involve using a large amount of pesticides or fertilizers. Properly using these chemicals reduces the risk of stormwater contamination.
- Avoid applying these chemicals during the wet season as they may be carried away from the site by the next storm.
- When irrigating landscaped areas, avoid over-watering. Over-watering wastes water and increases the risk that any water that has been contaminated with pesticides or fertilizers will flow into a storm drain.
- If you have large vegetated areas, consider using integrated pest management (IPM) techniques to reduce pesticide use.
- Properly store pesticides and application equipment and dispose of the

used pesticide containers responsibly, consistent with state regulations. Personnel who use pesticides should be trained in their use.
- The Idaho Department of Agriculture licenses pesticide dealers, certifies pesticide applicators, and conducts on-site inspections. Contact the Idaho Department of Agriculture (208/332-8600) for more information.

Parking Area and Storm Sewer Maintenance

- Evaluate any parking area that drains to the same storm drain system for suitable BMPs. Sweeping the parking area periodically and cleaning the catch basins (if they are part of the drainage system) are suitable BMPs. A vacuum sweeper is the best method of sweeping, rather than mechanical brush sweeping. Mechanical brush sweeping does not remove fine particulates as effectively as a vacuum sweeper.
- Catch basins in parking lots generally need to be cleaned every 6 to 12 months, or whenever the holding tank is 1/2 full. A holding tank that is more than 1/2 full is not effective at removing additional particulate pollutants from the stormwater. If the storm drain lines have a low gradient, (less than 0.5 feet in elevation drop per 100 feet of line), material may settle in the lines during small, frequent storms. If you have not cleaned the storm drain system recently, check the lines. If the lines are not cleaned, the catch basins will likely fill up (during the next significant storm) with material washed from the lines. Also, install "turndown" elbows or similar devices on the outlets of the catch basins to retain floatables or oil and grease.
- Sediments from parking areas and storm sewer maintenance are generally low in metals and other pollutants. However, to ensure that metals or other pollutants are not present, the material should be tested. If contaminant concentrations are high, then other BMPs may be needed to eliminate or reduce pollutants.
- Using a vactor truck to clean the storm drain system will generate dirty water. This water should be disposed of properly.

Storm Drain Stenciling

Clearly mark the storm drain inlets, either with a color code (to distinguish from process water inlets if present) or with a painted stencil. The stencil should read "DO NOT DUMP WASTE." Ensuring that storm drain inlets are clearly marked will reduce inadvertent dumping of liquid wastes.

Building Repair, Remodeling, & Construction BMP 16

Description

Prevent or reduce the discharge of pollutants to stormwater from building repair, remodeling, and construction by using soil erosion controls, enclosing or covering building material storage areas, using good housekeeping practices, using safer alternative products, and training employees.

Approach

- Use soil erosion control techniques if bare ground is temporarily exposed.
- Use permanent soil erosion control techniques if the remodeling clears buildings from an area where they won't be replaced. See BMP 14, Contaminated or Erodible Surface Areas.
- Use ground or drop cloths under painting, scraping, and sandblasting activities. Use either a ground cloth or oversized tub for spill containment when mixing paint and cleaning tools.
- Store materials that are normally used in repair and remodeling, such as paints and solvents, under cover.
- Use a storm drain cover, inlet protection or other runoff control to keep pollutants, dust, sediment, or wash water from entering the storm drain system.
- Sweep the area weekly. Avoid hosing down the area to a storm drain.
- Store and dispose of waste materials properly. See Appendix A for disposal alternatives.
- Use safer alternative products.

Limitations

- This BMP is for minor construction only.
- Hazardous waste that cannot be reused or recycled should be disposed of by a licensed hazardous waste hauler. For conditionally-exempt small quantity generators (CESQG), either dispose of the waste in the landfill or at a Household Hazardous Waste Collection Facility that may take CESQG waste for a fee.
- Safer alternative products may not be available, suitable, or effective in every case.

Additional Information

Building repair, remodeling, and construction activities are common on any site, including large industrial sites. Building activities may vary from minor building repair to major remodeling or construction of new facilities. These activities can generate contaminants that can pollute stormwater. Solvents, paints, paint and varnish removers, finishing residues, kerosene, adhesive residues, and asbestos materials are some examples of sources of these contaminants.

The following housekeeping practices will reduce the risk of stormwater contamination from building repair, remodeling, and construction activities:

- Keep the work site clean and orderly. Sweep the area regularly to remove debris.
- Store paints, solvents, or others similar materials in a covered area if these materials should be left outdoors.

- Educate employees on proper housekeeping practices.
- Inform on-site contractors of company policy and include appropriate provisions in their contract to make certain proper housekeeping and disposal practices are implemented.
- Make sure that nearby storm drains are clearly marked to minimize the chance of inadvertent disposal of residual paints and other liquids.
- Avoid dumping liquid wastes down a storm drain.
- Advise concrete truck drivers to not wash their trucks over the storm drain. Have a designated wash area that does not drain to a storm drain.
- Clean the storm drain system where construction activities are being conducted after it is completed.
- Put an impermeable tarp over wood, gravel, or other material piles. Sweep up wood chips, paint chips, and other residues daily, and conduct a thorough cleanup at the end of the project.

Soil and Erosion Control

- If the work involves exposing large areas of soil, employ the appropriate soil erosion and control techniques.
- If old buildings are being torn down and not replaced in the near future, stabilize the site using measures described in BMP14, Contaminated or Erodible Surface Areas.

Storm Drainage System

- If a building is to be placed over an open area with a storm drain system, make sure the storm inlets within the building are covered or removed.
- If, because of the remodeling, a new drainage system is to be installed or the existing system is to be modified, consider installing catch basins.
- Catch basins serve as effective “in-line” treatment devices. Include a “turndown” elbow or similar device to trap floatables in each catch basin.

Painting Operations

- If painting requires scraping or sand blasting of the existing surface, use an impermeable ground cloth to collect the chips. Dispose of the residue properly. If the paint contains lead or tributyl tin, it is considered a hazardous waste and should be disposed of as such.
- Spray painting operations should be properly enclosed or covered to avoid drift. Use temporary scaffolding to hang drop cloths or draperies to prevent drift. Use application equipment that minimizes overspray. Avoid spray painting and sand blasting on windy days. Be aware of air quality restrictions on spray paints that contain volatile chemicals. Substitute water-based spray paints for paints that contain volatile chemicals.
- Mix paint indoors so that if a spill occurs, the spill will not be exposed to rain and consequently washed into a storm drain. Even during dry weather, a spill cleanup will never be 100% effective. Dried paint will eventually erode from a surface and be washed away by storms.
- If using water-based paints, clean the equipment in a sink that is connected to the sanitary sewer. Clean up oil-based paint where you can collect the waste paint and solvents to be handled as small quantity hazardous waste. Do not pour the waste paint down a sink or storm drain.

Properly store leftover paints if they are to be kept for the next job, or dispose of them properly. See Appendix A, Disposal Alternatives table, for more information.

Wood Preservatives, Pavement Seal Coating, and Other Outdoor Surface Treatments

- Quickly clean up spills when using sealants on wood, pavement, roofs, etc. When repairing roofs, line the gutters with rags, or if small particles have accumulated in the gutter, either sweep or wash out the gutter and trap the particles at the outlet of the downspout.
- A sock or geofabric placed over the outlet may effectively trap the materials. Remove sock/geofabric upon completion of job and dispose in trash.
- If the downspout is tight-lined, place a temporary plug at the first convenient point in the storm drain and pump out the water with a vactor truck. Clean the catch basin holding tank where you placed the plug.

Employee Training BMP 17

Description

Employee training, like equipment maintenance, is not so much a best management practice as it is a method by which to implement BMPs. Train employees in these BMPs because a single employee's mistake can lead to a costly pollution incident. Train employees to routinely inspect industrial activities and equipment that may be exposed to stormwater. A weekly walk-through can help identify potential difficulties before they become major problems.

Approach

Consider the following when training employees:

- Integrate stormwater training with existing training programs that are required for your business by other regulations such as the Hazardous Waste Operations and Emergency Response (HAZWOPER) standard (29 CFR 1910.120) and the Spill Prevention Control and Countermeasure (SPCC) Plan (40 CFR 112).
- Use Appendix A, Disposal Alternatives table, to train employees in proper and consistent methods for disposal.
- Check employees' work practices periodically to ensure that BMPs are being properly implemented. Post informational and reminder signs and stencil "DO NOT DUMP WASTE" messages at storm drains.
- Be aware that site owners are also responsible for customer activities. Ask customers to avoid discarding liquids into trashcans or liquids or solids into storm drains.

Spill Prevention Control and Cleanup BMP 18

Description

Prevent or reduce the discharge of pollutants to stormwater from accidental spills by preventing spills and leaks, quickly responding to control any spill, and conducting appropriate and thorough cleanups.

Approach

- Maintain a regular inspection and repair schedule to correct potential spill situations before they occur.
- Prepare and post spill response procedures in areas that might be exposed to stormwater.
- Train all employees in proper spill response procedures.
- Notify authorities, as required in the emergency response plan, if a hazardous material spill has occurred on your site.
- Contain spills immediately to prevent them from spreading. Use rags (store used rags in a covered rag bin) to clean up small spills, dry absorbent material, or wet-dry vacuums for nonvolatile materials for larger spills. In addition, you may have to plug storm drain inlets to keep a spill from entering the storm drain system. Keep temporary plugs on hand and train employees in their use.
- Stencil storm inlets so employees are aware of areas to protect during spills.

Limitations

An experienced spill cleanup company may be required for certain types of spills.

General Information

- The best way to prevent pollutants from reaching stormwater is to prevent spills and leaks, maintain a regular inspection and repair schedule, and correct potential spill situations before a spill can occur. In addition, you should respond quickly when a spill occurs. Develop spill procedures that address all circumstances from small, minor releases to large emergency spills, including whom to call for response before the situation gets out of hand. These procedures should be facility-specific.
- Small spills are those that can be wiped up with a shop rag. Avoid putting wet rags in a dumpster with the shop trash. Instead, store them in a covered ragbin. A ragbin similar to the type service stations use is suitable. Do not saturate rags with gasoline, solvents, or other volatile liquids unless appropriate storage facilities are present and allowed by local code.
- Medium spills are too large to wipe up with a rag and require more attention. Contain and soak up the liquid using dry absorbent material such as vermiculite, specially prepared sawdust, or cat litter. Absorbent “snakes” may be used as temporary booms to contain and soak up the liquid. Sweep up the used absorbent and snakes and dispose of them appropriately. Another option is to use a wet-dry shop vacuum cleaner to collect spills, and dispose of the liquid with your liquid or hazardous wastes. Do not use vacuums for gasoline, solvents or other volatile fluids because the enclosed vacuum may become an explosion hazard.

- Large spills should first be contained and then cleaned up. For food waste or other nonhazardous liquid spills, contain and clean up the liquid. Minimize the wash water used in cleanup. Shut off or plug storm drain inlets or sewer inlets where the spill may enter. If necessary, keep temporary plugs on hand to fit the inlets and train employees on how to use them. For hazardous materials spills, immediately contact the local fire department and then initiate emergency procedures.

Section 3 – Commercial Facilities

The following Best Management Practices (BMPs) apply to all types of commercial facilities:

Good Housekeeping

- Us a dry clean up method instead of using a hose or pressure washing system. Use mops, brooms, or wire brushes to clean dumpsters, sidewalks, buildings, equipment, pavement, driveways and other impervious surfaces.
- Minimize the use of cleaning solutions and agents. Wash water should be disposed to the sanitary sewer, never to the storm drain.
- Keep site free of litter and debris. Place trash cans and recycling receptacles around the site to minimize litter.

Preventive Maintenance

- Keep equipment and vehicles in good working condition. Inspect frequently for leaks and repair as needed.
- Regularly inspect and clean gutters, storm drains, catch basins and other storm drainage features should be so that pollutants do not accumulate.
- Label storm drains to remind employees that discharge to these drains flows directly to our waterways.

Materials Storage and Handling

- When possible, store materials indoors or under covered areas not exposed to rain. If materials cannot be stored under cover, place materials on pallets and cover with tarps to avoid contact with stormwater run-on and runoff.
- Store liquids, hazardous waste, and other chemicals in a designated area with secondary containment. Keep outdoor storage areas in good condition.

Waste Management

- Sweep up around dumpsters and other areas frequently to prevent trash from accumulating.
- Place all trash inside dumpsters or containers until it can be hauled away.
- Dumpsters should always be kept closed to prevent rainwater from entering. Never place liquid waste, leaky garbage bags, or hazardous waste in a dumpster or trash bin.
- Recycle cans, bottles, newspaper, office paper, and cardboard.

Employee Training

- Discuss and distribute information on stormwater pollution prevention during employee training session and at employee meetings.
- Post good housekeeping tips and reminders on employee bulletin boards.
- Inform subcontractors about stormwater requirements and their responsibilities.

Specific practices for categories of activities are presented in the following fact sheets. They include:

Description

Control food business practices that allow food particles, oil, grease, trash, and cleaning products to flow into the storm drain system.

General Information

Conduct Employee and Client Education

Employees can help prevent pollution when water quality training is included in employee orientation and reviews. Promote these Best Management Practices (BMPs):

- Storage containers should be regularly inspected and kept in good condition.
- Place materials inside rigid, durable, water-tight, and rodent-proof containers with tight fitting covers.
- Store materials inside a building or build a covered area that is paved and designed to prevent runoff from entering storm drains.
- Place plastic sheeting over materials or containers and secure the cover with ties and weighted objects. (Not appropriate for storing liquids.)
- Post BMPs where employees and customers can see them. Showing customers you protect the environment is good public relations.
- Explain BMPs to other food businesses through your merchant associations or chambers of commerce. Raise employee and customer awareness by stenciling the words “DO NOT DUMP WASTE” on storm drains near the work place.

Cleaning Restaurant Floor Mats, Exhaust Filters, etc.

- Do not wash restaurant equipment outdoors and allow wash water to enter a storm drain. Clean floor mats, filters, etc. inside a building with discharge to a sanitary sewer (sink or floor drain) via an approved grease interception device.
- Cover, repair or replace leaky dumpsters and compactors, and/or drain the pavement beneath them to the sewer. Rain can wash oil, grease, and other substances into storm drains.
- Alternative: Wash greasy equipment such as vents and vehicles in designated wash areas with an appropriate oil/water separator before storing it outside. Ensure that designated wash areas are properly connected to the sanitary sewer system.

Kitchen Grease

- Save oil, grease, and meat fat for recycling in tallow bins or other sealed containers. Never pour them into sinks, floor drains, or storm drains. Do not contaminate recyclable fats with waste grease from an oil/water interceptor or grease trap.
- See "Grease" and/or "Tallow" in the yellow pages for a Recycling/Hauling Company.

Kitchen Waste Disposal

- Purchase recycled products. By doing so, you help ensure a use for recyclable materials. Recycle the following materials:

- ✓ Food waste (non-greasy, non-animal food waste can be composted)
- ✓ Paper and cardboard
- ✓ Glass, aluminum, and tin containers
- ✓ Pallets and drums
- ✓ Oil and grease.

- Separate wastes. Keep your recyclable wastes in separate containers according to the type of material. They are easier to recycle if separated.
- Use non-disposable products. Serve food on ceramic dishware rather than paper, plastic, or Styrofoam and use cloth napkins rather than paper ones. If you do use disposable products, use paper instead of Styrofoam.
- Buy the least toxic products available. Look for "nontoxic," "non-petroleum based," "free of ammonia, phosphates, dye or perfume," or "readily biodegradable" on the label. Avoid chlorinated compounds, petroleum distillates, phenols and formaldehyde. Use water-based products. Look for and use "recycled" and "recyclable" containers.

Outdoor Areas

- Keep outside areas free of trash and debris. Clean outdoor eating areas frequently using dry cleaning methods such as sweeping or vacuuming.
- Dry sweep pavement areas including “drive-through” areas, parking lots, outdoor eating areas and dumpster or tallow bin areas frequently. If you should use water for cleaning, use a mop and bucket and dispose of wash water in mop sink or floor drain that is plumbed to the sanitary sewer.
- Major cleaning of exterior surfaces should include capturing all wash water and disposing it to the sanitary sewer in compliance with local regulations. Wash water should not be allowed to enter the street gutter or storm drain.

Auto Repair and Maintenance Controls BMP 20

Description

Many common vehicle maintenance and washing routines contribute to environmental pollution. Businesses that are unable to comply with the guidelines should have their vehicles washed at a commercial establishment that conforms to the specifications, or by a mobile washer that conforms to specifications.

General Information

Interior Shop Area Cleaning

- Do not hose down your shop floor into streets or parking lots. It is best to dry sweep regularly.
- Use nontoxic cleaning products. Baking soda paste works well on battery heads, cable clamps and chrome; mix the soda with a mild, biodegradable dishwashing soap to clean wheels and tires; for windows, mix white vinegar or lemon juice with water.
- To reduce or eliminate the generation of waste, fix sources of drips or leaks where possible. Routinely inspect the engine compartment, and regularly replace worn seals on equipment.
- To avoid or control spills and leaks do the following:
  - ✓ Prepare and use easy to find spill containment and cleanup kits. Include safety equipment and cleanup materials appropriate to the type and quantity of materials that could spill.
  - ✓ Pour kitty litter, sawdust, or cornmeal on spills.
  - ✓ NEVER sweep or flush wastes into a sanitary sewer or storm drain.
- Change fluids carefully. Use a drip pan to avoid spills. Prevent fluid leaks from stored vehicles. Drain fluids such as unused gas, transmission and hydraulic oil, brake and radiator fluid from vehicles or parts kept in storage. Implement simple work practices to reduce the chance of spills.
- Use a funnel when pouring liquids (like lubricants or motor oil) and place a tray underneath to catch spills. Place drip pans under the spouts of liquid storage containers. Clean up spills immediately.

Fleet Vehicle Washing

It is allowable to rinse down the body of a vehicle with just cold water without implementing any BMPs. Designated wash areas should be well marked with signs indicating where and how washing should be done. Any inlets to the storm drain should be marked DUMP NO WASTE.

If you use soaps or detergents, or heated water, or if you wash/rinse the engine compartment or the underside of the vehicle, you should use one of the following BMPs:

- Use a storm drain cover or other effective method of preventing all wash and rinse water from entering a storm drain or other drainage feature. All runoff from the activity should be collected for proper disposal in a sanitary sewer. There are several products commercially available that enable collection of runoff. This guideline also applies to mobile vehicle washing services.

- Wash water runoff and excess soapy water should be collected and pumped or otherwise discharged as follows:
  - ✓ Sanitary sewer - Pump into sanitary system clean out/sink or into an on-site private sanitary sewer manhole; verify with the facility manager that it is not a storm drain manhole. Solids separation will be required before disposal to prevent clogging the system.
  - ✓ Landscape or soil area (Note: Be aware that soapy wash water may adversely affect landscaping) - Discharge should be directed to an area sufficient to contain all the water. Discuss the practices with property owner. Acceptable for minimum discharge flows only. Repetitive use of the same area or excessive wash volume to the same area may be illegal.
- If disposal to the sanitary sewer and/or to a landscaped area is not possible, then contract with a company capable of hauling the wash water off-site to an authorized disposal site.
- There may be some unavoidable evaporation from paved surfaces. If a significant amount of washwater runoff evaporates at the site before it can be collected, and the site is routinely used for this purpose, the paved area itself should be cleaned every six months, or at the end of the wash service contract, whichever comes first. Any wash water used during this procedure should be collected and discharged to a sanitary sewer.

Cleaning/Degreasing Engines, Equipment, and Auto/Truck Drive Trains

- Clean with or without soap, no storm drain disposal is allowed.
- Requires treatment before discharge to the sanitary sewer system is allowed. Because it is likely that pollutants (petroleum products and metals) are concentrated in these wash waters, the local wastewater treatment plant will require some type of treatment before discharge into the sanitary sewer. Contact the local wastewater treatment plant for requirements and additional information.
- If a sanitary sewer is not available or treatment of the washwater is not feasible, then contact a company capable of hauling (i.e., tanker truck) the washwater off-site to dispose of it at an authorized site.

Mobile and Surface Cleaning Control Practices   BMP 21

Description

This activity applies to mobile steam cleaning and vehicle washing operations. It also applies to many common surface cleaning and washing routines including pressure washing of large objects such as building facades, fences and masonry, rooftops and boats on a site-to-site basis.

Application

- These practices apply to anyone who generates wastewater from pressure washing, including:
  - ✓ Contractors that provide a pressure washing service to others.
  - ✓ Businesses that use pressure washing equipment as part of their operations or maintenance (such as cleaning heavy equipment).
  - ✓ Homeowners.

Limitations

The BMPs in this section do not apply if there has been oil or other hazardous material spilled on the site. In case of a spill, contact the local fire department for guidance.

General Information

General Controls

- Establish regular sweeping and litter pick up routines, preferably daily but at least once a week.
  - ✓ Use a broom and dispose of waste in the trash.
  - ✓ Sweeping, blowing or hosing cigarette butts and other litter into the street is not allowed.
- Illicit connections to the storm drain system should be eliminated.
- Employees should be educated to control washing operations to prevent stormwater contamination.
- Prior to beginning washing activities, determine what collection method you will be using and how you intend to properly dispose of the wastewater generated from each cleaning activity.

Washing Practices: See Table 1 below for guidelines for specific types of surfaces and conditions.

Pressure Washing, General

- All runoff should be collected and disposed of properly, or filtered to remove pollutants. No runoff should leave the site.
- Temporary curbs, dikes or berms can be used to direct the water to one or more collection areas. Catch basin covers can help facilitate collection.
- If the pressure washing wastewater does not collect in a centralized area, such as when the area is very flat or you are on a grassed area, a tarp or sheet should be placed under the washing area to collect paint chips and other debris that is loosened by the spray.

Washing Practices (With Soap)

- Seal storm drains. No storm drain disposal of washwater is allowed.
- Use the least toxic detergents and cleaners that will get the job done.

Select non-phosphate detergents when possible.

- Use wash pads that capture the washwater. Solids separation is required before disposal. Ideally, a separate wash area that captures the washwater should be established, or use of temporary wash pads that can be drained to the sanitary sewer are acceptable.
- Washwater runoff and excess soapy water should be collected and pumped or otherwise discharged as follows.
  - ✓ Pump it into a sanitary sewer system clean-out/sink or into an on-site private sanitary sewer manhole; verify with the facility manager that it is not a storm drain manhole. Solids separation will be required before disposal to prevent clogging the system.
  - ✓ Washwater may be discharged into landscaped areas or graveled areas. Discharge should be directly to an area sufficient to contain all the washwater. Discuss this practice with the property owner. This practice is acceptable for minimal discharge flows only. Repetitive use of the same area or excessive wash volume to the same area may be illegal. (Note: Be aware that soapy washwater may adversely affect landscaping).
  - ✓ If disposal to the sanitary sewer and/or a landscaped area is not possible, then discharge to a holding tank and contract with a company capable of hauling the washwater off-site to an authorized disposal site.

Table 1. Cleaning of Large Surfaces and Structures

Type of Surface	Characteristics	Cleaning Technique	Discharge to Storm Drain	Disposal Alternatives
Sidewalks, Plazas	No oily deposits	Sweeping, collecting and disposing of debris and trash; then washing without soap.	Okay to discharge to storm drain	
Sidewalks, Plazas, Driveways, Drive-Through Windows	Light oily deposits	Sweeping, collecting and disposing of debris and trash. Cleaning oily spots with absorbent; place oil-absorbent boom around storm drain, or a screen or filter fabric over inlet; washing **without** soap.	Okay to discharge to storm drain, provided an oil-absorbent boom or filter fabric is used. No oily sheen should be visible in the water draining into the storm drain.	
Sidewalks, Plazas, Driveways	Light oily deposits	Sweeping , collecting and disposing of debris and trash. Cleaning oily spots with absorbent; washing **with** soap.	Seal storm drains. Cannot be discharged to the storm drain.	Vacuum/pump wash water to a tank or discharge to sanitary sewer.

Type of Surface	Characteristics	Cleaning Technique	Discharge to Storm Drain	Disposal Alternatives
Parking lots and driveways, drive-throughs, parking garages, service stations	Heavy oily deposits	Sweeping, collecting and disposing of debris and trash. Cleaning oily spots with absorbent materials.	Seal storm drains. Cannot be discharged to the storm drain.	Vacuum/pump wash water to a tank or discharge to sanitary sewer.
Building exteriors and walls	Glass, steel, or painted surfaces (post 1978: no lead in paint)	Washing **without** soap.	Okay to discharge to storm drain provided the drain is sealed first with a fabric filter to capture dirt, paint particles and disposed of properly.	Can alternately be sent to soil or landscaped areas.
Building exteriors and walls	Glass, steel, or painted surfaces (post 1978: no lead in paint)	Washing **with** soap.	Seal storm drains. Cannot be discharged to the storm drain.	Vacuum/pump wash water to a tank or discharge to sanitary sewer.
Building exteriors	Painted with lead-based or mercury-additive paint	Washing with or without soap.	Seal storm drains. Cannot be discharged to storm drain.	Vacuum/pump to a tank. Check with POTW for discharge to sanitary sewer.
Graffiti Removal	Graffiti	Using wet sand blasting. Minimize use of water; sweep debris and sand. Using high pressure washing and cleaning compounds.	Can be discharged to storm drain if washwater is filtered through a boom. Seal storm drains. Cannot be discharged to storm drain.	Can alternately be directed to landscaped areas. Vacuum/pump washwater to sanitary sewer. Check with POTW about pretreatment.
Masonry	Mineral deposits	Acid washing	Seal storm drains. Cannot be discharged to storm drain.	Rinse treated area with alkaline soap and direct washwater to landscaped or dirt areas. Alternately, washwater may be collected and neutralized to a pH between 6 and 10, then discharged to landscaping or pumped to sanitary sewer.

Marinas BMP 22

Description

Marinas may pose a threat to the health of aquatic systems and may pose other environmental hazards when these facilities are poorly planned or managed. Ensuring the best possible siting for marinas, as well as the best available design and construction practices and appropriate operation and maintenance practices, can greatly reduce polluted runoff pollution from marinas.

Approach

Marina Siting and Design
In selecting a marina site and developing a design, consideration of the need for the efficient flushing of marina waters should be a prime factor along with safety and vessel protection. For example, sites located on open water or at the mouths of creeks and tributaries usually have higher flushing rates. These sites are generally preferable to sites located in coves or toward the heads of creeks and tributaries, locations that tend to have lower flushing rates.

Shoreline Stabilization
Activities associated with a marina and boating operations can cause shoreline erosion. Planting vegetation can stabilize shorelines. This approach has shown the greatest success in low-wave-energy areas where underlying soil types provide the stability required for plants and where conditions are amenable for sustaining of plant growth. Under suitable conditions, an important advantage of vegetation is its relatively low initial cost. Identification of the cause of the erosion problem is essential for selecting the appropriate technique to remedy the problem.

Structures that can stabilize shorelines and navigation channels are bulkheads, jetties, and breakwaters. They are designed to dissipate incoming wave energy. While structures can provide shoreline protection, unintended consequences may include accelerated scouring in front of the structure and increased erosion of unprotected downstream shorelines. Gabions, riprap, and sloping revetments dissipate incoming wave energy most effectively and result in the least scouring. Bulkheads are appropriate in some circumstances, but where alternatives are appropriate they should be used first.

Stormwater Runoff
Source controls and structural facilities can be used to control storm water runoff from a marina. Structural facilities include sand filters, ponds, wetlands, infiltration basins and trenches, chemical and filtration treatment systems, vegetated filter strips and grassed swales, porous pavement, oil-grit separators, catch basins, absorbents in drain inlets, holding tanks, and swirl concentrators. Source controls are applied to activities that occur on site and reduce or control the potential for pollutants to be discharged. Leak and spill prevention is one example.

Waste Management

Solid waste can be controlled at marinas by designating work areas for boat repair and maintenance, regularly maintaining these areas, providing proper disposal facilities, and providing facilities for recycling appropriate materials. Establishing fish cleaning areas and cleaning rules, educating boaters, and implementing fish composting where appropriate can also control fish waste. Practices to control liquids include building curbs, berms, or other barriers to contain spills around areas used for the storage of liquid material; separating containers for the disposal of waste liquids; and informing marina patrons about the proper disposal of all liquid materials through the use of signs, mailings, and other means.

Fueling Operations
Potential pollution from fueling stations can be prevented by locating and designing fueling stations so that spills can be contained in a limited area, having a spill contingency plan, and designing fueling stations with spill containment equipment.

Fuel and oil are commonly released into surface waters during bilge pumping, during fueling operations through the fuel tank air vent, and during fueling from spills directly into surface waters and into boats. Oil and grease from the operation and maintenance of inboard engines are a source of petroleum in bilges. Petroleum control can be achieved through the use of automatic shut-off nozzles and fuel/air separators on air vents or tank stems of inboard fuel tanks to reduce the amount of fuel spilled into surface waters during boat fueling. The use of oil-absorbing materials in the bilge areas of all boats with inboard engines can also be promoted.

Boat Operations
Management practices that affect boat operations include excluding motorized vessels from areas that contain important shallow-water habitat and establishing and enforcing no-wake zones to decrease turbidity. Boat cleaning practices to protect water quality include washing the boat hull above the waterline by hand and using detergents and cleaning compounds that are phosphate-free and biodegradable.

Section 4 – Residential Activities

The actions we take each day in and around our homes have a profound effect on stormwater quality. Small amounts of pollution from many different sources can significantly affect our waterways. Yard maintenance, waste storage, car washing and maintenance, and pool cleaning are some of the activities that can adversely impact water quality. The best management practices (BMPs) discussed in this section are practical ways to avoid adding pollutants to stormwater. They include:

Automobile Maintenance BMP 23

Description

Control practices for automobile maintenance and repair.

General Information

Automobile Washing

- Wash your car directly over your lawn or make sure the wash water drains to a vegetated area. This allows the water and soap to soak into the ground instead of running off into a local waterbody.
- Ideally, no soap or detergent should be used, but if you do use one, select one without phosphates.
- Sweep driveways and street gutters before washing vehicles to clean up dirt, leaves, trash and other materials that may flow to the storm drain along with your wash water. This helps to reduce storm drain maintenance costs as well as to protect water quality.
- Commercial products are available that allow you to clean a vehicle without water. These were developed for areas where water is scarce, so they save water benefit as well as reduce pollution.
- Use a nozzle on your hose to save water.
- Do not wash your car if rain is expected.
- Consider not washing your car at home. Take it to a commercial car wash that has a recycle system and discharges wastewater to the sanitary sewer for treatment.

Automobile Maintenance

- Recycle all oils, antifreeze, solvents, and batteries. Many local car parts dealers and gas stations accept used oil. There may also be a Household Hazardous Waste facility in your area that accepts oil, oil filters, antifreeze, and solvents. Some communities and counties hold Household Hazardous Waste Turn-In days that will accept car wastes including old batteries. Old batteries can actually be worth money. Call shops listed under Batteries in the Yellow Pages of the phone book to find out if they are paying for used batteries.
- Never dump new or used automotive fluids or solvents on the ground, in a storm drain or street gutter, or in a waterbody. Eventually, it will make its way to local surface waters or groundwater, including the water we drink.
- Do not mix wastes. The chlorinated solvents in some carburetor cleaners can contaminate a huge tank of used oil, rendering it unsuitable for recycling. Always keep your wastes in separate containers that are properly labeled and store them out of the weather.
- To dispose of a used oil filter, punch a hole in the top and let it drain for 24 hours. A large funnel in the top of your oil storage container will come in handy for this. After draining the filter, wrap it in two layers of plastic and dispose of it in your regular garbage or recycle by taking it to a local Landfill Household Hazardous Waste facility, if one is available.
- Use care in draining and collecting antifreeze to prevent accidental

spills. Spilled antifreeze can be deadly to cats and dogs that ingest it.

- Perform your service activities on concrete or asphalt or over a plastic tarp to make spill clean up easier. Keep a bag of kitty litter available to absorb spills. If there is a spill, sprinkle a good layer of absorbent on the spill, let it absorb for a little while, and then sweep it up. Place the contaminated litter in a plastic bag, tie it up, and dispose of it in your regular garbage. Take care not to leave kitty litter out in the rain; it will become difficult to clean up.
- If you are doing auto body work outside, use a tarp to catch material resulting from grinding, sanding and painting. Dispose of this waste by double bagging it in plastic and placing it in your garbage.

Home, Lawn, and Garden Care BMP 24

Description

This fact sheet deals with normal home and yard maintenance activities. Overwatering, overfertilizing, improper herbicide application, and improper disposal of trimmings and clippings can all contribute to serious water pollution problems.

General Information

General Yard Maintenance

- Do not blow or rake leaves into the street, gutter, or storm drains. Never dispose of grass clippings or other vegetation in or near storm drains, streams, or lakes.
- In communities with curbside yard waste recycling, place clippings and pruning waste in approved containers for pickup. Or, take clippings to a landfill that composts yard waste.
- Save water and prevent pollution problems by watering your lawn sensibly. Lawns and gardens typically need the equivalent of 1" of rainfall per week. You can check on how you're doing by putting a wide mouth jar out where you're sprinkling, and measure the water with a small plastic ruler. Overwatering to the point of runoff can carry polluting nutrients to the nearest waterbody.
- Conserve water by using irrigation practices such as drip irrigation, soaker hoses, or micro-spray systems.
- Consider planting a vegetated buffer zone adjacent to streams or other water bodies on your property.
- Compost all yard clippings, or use them as mulch to save water and keep down weeds in your garden. See the Composting section below for more information.
- Practice organic gardening and reduce or eliminate the need for pesticides and fertilizers. Contact the Cooperative Extension or the Ask-A-Master Gardener program for information and classes on earth-friendly gardening.
- Pull weeds instead of spraying them (and get some healthy exercise, too).

Composting

Composting is an earth-friendly activity as long as you follow some common sense rules, outlined below . If you choose to compost, use the following BMPs.

- Compost piles should be located on an unpaved area where runoff can soak into the ground or be filtered by grass and other vegetation. Compost piles should be located in an area of your yard not prone to water ponding during storms, and should be kept well away from wetlands, streams, lakes, and other drainage paths.
- Avoid putting hazardous or non-decomposable waste in the pile.
- Cover the compost pile to keep stormwater from washing nutrients into waterways and to keep excess water from cooling down the pile, which will slow down the rate of decomposition.

- Build bins of wood, chicken wire or fencing material to contain compost so it can't be washed away. Building a small earthen dike around your compost pile is an effective means of preventing nutrient-rich compost drainage from reaching stormwater paths.

Chemical Use

- If you do spray, use the least toxic formulations that will get the job done. The Master Gardener program mentioned above can advise you on which spray to use.
- If you do use a pesticide, use a pesticide that is specifically designed to control your pest. The insect should be listed on the label. Approximately 90% of the insects on your lawn and garden are not harmful.
- Follow the manufacturer's directions exactly for mixing and applying herbicides, fungicides, and insecticides, and use them sparingly. Never apply them when it is windy or when rain is expected. Never apply them over water, within 100 feet of a wellhead, or adjacent to streams or other waterbodies. Triple-rinse empty containers, using the rinsate for mixing your next batch of spray, and then double-bag and dispose of the empty container in your regular garbage.
- Follow the manufacturer's directions when applying fertilizers. More is not better, for your lawn or local waterbodies. Never apply fertilizers over water or adjacent to ditches, streams, or other water bodies. Remember that organic fertilizers release nitrogen slowly, and have less potential to pollute than synthetic fertilizers.
- Use organic or non-toxic fertilizers. Do not over-fertilize and do not fertilize near streets, storm drains, or other water bodies. Store pesticides, fertilizers and other chemicals in a covered area to prevent runoff.
- Work fertilizers into the soil instead of letting them lie on the ground surface exposed to the next rainstorm.
- Make sure all fertilizers and pesticides are stored in a covered location. Rain can wash labels of bottles and convert 50 pounds of fertilizer into either a solid lump or a river of nutrients.

Safe Substitutes for Pest Control

- Garden Aphids and Mites - Mix 1 tablespoon of liquid soap and 1 cup of vegetable oil. Add 1 teaspoon of this mixture to a cup of water and spray. (Oil may harm vegetable plants in the cabbage family.)
- Caterpillars - When caterpillars are eating, apply products containing Bacillus thuringiensis to leaves.
- Ants - Place boric acid powder or hydramethylnon baits in problem areas, cracks and insect walkways. It is a mild poison, so be sure it is inaccessible to children and pets.
- Roaches - Apply boric acid powder to cracks and entry points (see ants above). Place bay leaves on pantry shelves.

General Home Maintenance

- Dispose of all waters from cleaning carpets, upholstery, and other surfaces into the sink or toilet and not the street or storm drain.

- If you hire someone to clean carpets and upholstery for you, make sure they empty the cleaning water tanks into a sink or toilet, and not the street or the storm drain.
- Water from pressure washing decks, driveways, roofs, or other hard surfaces may contain suspended solids and other pollutants that should not be directly discharged to drainage systems. Redirect pressure washing wastewater to vegetated areas or areas such as gravel, lawns, landscaping, or bare soil for infiltration. If this cannot be accomplished, filter the wash water through filter fabric or other filtering media to collect the suspended solids before discharging the water to a drainage system. Remove filter fabric upon completion and dispose of it in the trash.
- If chemicals are used during the pressure washing process, the wastewater should be collected and disposed of in a sanitary sewer system or discharged to a landscaped area where it can infiltrate on site.

Solid and Sanitary Waste Storage and Disposal BMP 25

Description

These control practices address storage of solid waste at residences that can lead not only to water pollution problems, but problems with neighborhood pets and vermin as well. This fact sheet also addresses pet waste and septage.

Septage is waste from a septic system tank, holding tank, or portable toilet. It is called untreated waste because it has not gone through a stabilization process, such as processing at a sewage treatment plant.

Portable toilets are found in motor homes and are common in outdoor and remote workplaces. Portable toilets are also used at cultural and recreational events including county fairs, festivals, and outdoor concerts.

General Information

Solid Waste

- All waste containers kept outside should have lids.
- Leaking waste containers should be replaced.
- Store waste containers under cover if possible, or on grassy areas.
- Inspect the storage area regularly to pick up loose scraps of material and dispose of them properly.
- Recycle as much as you can. Some jurisdictions offer curbside recycling to a majority of residents. Also, look under "Recycling" in the phone book for firms that take other recyclables.
- Purchase products that have the least amount of packaging materials.
- Compost biodegradable materials such as grass clippings and vegetable scraps instead of throwing them away. Your flowerbeds will love the finished compost, and our landfills won't fill up so quickly. A fun alternative to traditional composting is worm composting. You can let worms do all the work for you by keeping a small vermiculture box just outside your kitchen.

Pet Waste

Collect and properly dispose of pet waste (in the garbage or toilet).

Septage

All portable toilet waste is classified as septage. Any group or organization that has portable toilets on site should use a licensed waste hauler to dispose of their waste. Municipal sewage treatment plants are an acceptable disposal option for untreated portable toilet wastes. The volume of this type of waste is relatively small and it is unlikely that accepting portable toilet waste will put an excessive strain on a local treatment system.

Septage from recreational vehicles (RVs) should be disposed of at approved facilities that could include any of the following: wastewater treatment plants, RV parks, dealers or storage facilities, or recreational sites.

Swimming Pool and Spa Maintenance BMP 26

Description

Control practices for swimming pool and spa cleaning and maintenance activities.

General Information

- Pool and spa water should be dechlorinated if it is to be emptied into a ditch, on the ground, or a lawn or to the storm drainage system. Contact your pool chemical supplier to obtain the neutralizing chemicals you will need. The rate of flow into the ditch or drainage system should be regulated so that it does not cause problems such as erosion, surcharging or flooding. **Check with the operator of the system first to determine if discharge of pool and spa water is allowed**.
- Water discharged to the ground or a lawn should not cross property lines and should not produce runoff. If you live in a sewered area, you may be able to discharge pool water to the sanitary sewer. Contact the pre-treatment staff at the local wastewater treatment plant for permission prior to discharge.
- If pool and spa water cannot be dechlorinated, it should be discharged to the sanitary sewer. Prior to draining, your local wastewater treatment plant should be notified to ensure they are aware of the volume of discharge and the potential effects of chlorine levels. A pool service company can help you determine the best frequency for pool cleaning and filter backwashing.
- Diatomaceous earth used in pool filters cannot be disposed of in surface waters, on the ground, into storm drainage systems, or into septic systems. Dry it out as much as possible; bag it in plastic, and dispose of it at the landfill.
- Hire a professional pool service company to collect all pool water for proper disposal. Ask them where they will dispose of it and the kind of permits they hold to do so.

Household Hazardous Material Use and Disposal BMP 27

Description

Oil-based paints and stains, paint thinner, gasoline, charcoal starter fluid, cleaners, waxes, pesticides, fingernail polish remover, and wood preservatives are examples of hazardous materials that should be properly handled.

General Information

- Dispose of hazardous materials and their containers properly. Never dump products labeled as poisonous, corrosive, caustic, flammable, inflammable, volatile, explosive, danger, warning, or caution outdoors, in a storm drain, or into sinks, toilets or drains.
- Check containers containing hazardous materials frequently for signs of leakage. If a container is rusty and has the potential of leaking soon, place it in a secondary container before the leak occurs and prevent a clean-up problem.
- Store hazardous materials containers under cover and off the ground. Keep hazardous materials out of the weather to avoid rusting, freezing, cracking, having their labels washed off, etc.
- Hazardous materials should be stored out of the reach of children. Never transfer to or store these materials in food or beverage containers that could be misinterpreted by a child as something to eat or drink.
- Keep appropriate spill cleanup materials on hand. Kitty litter is good for many oil-based spills.
- Ground cloths and drip pans should be used under any work outdoors that involves hazardous materials such as oil-based paints, stains, rust removers, masonry cleaners, and others that have warnings on the label as listed above.
- Latex paints are not hazardous wastes, but are not accepted in liquid form at the landfill. To dispose, leave it uncovered in a protected place until it is dry, then place it in the garbage. If you wish to dry waste paint quickly, just pour kitty litter in the can to absorb the paint. Once the paint is dry, leave the lid off when you place it in the garbage so your garbage collector can see that it is no longer liquid.
- Use less toxic products whenever possible.
- If an activity involving the use of a hazardous material can be moved indoors out of the weather, then do so. Make sure you can provide proper ventilation, however.
- Follow manufacturers' directions in the use of all materials. Over-application of yard chemicals, for instance, can result in these compounds washing into waterbodies. Never apply pesticides when rain is expected.
- When hazardous materials are in use, place the container inside a tub or bucket to minimize spills.