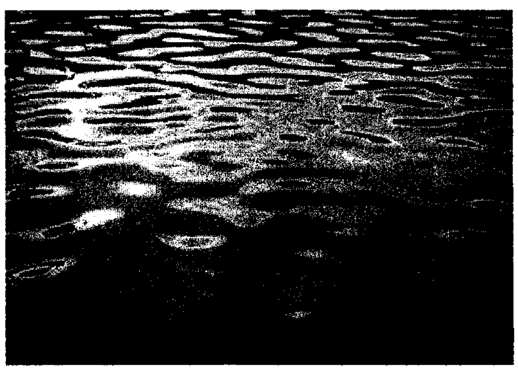
CORVALLIS
ENHANCING COMMUNITY LIVABILITY THROUGH IMPROVED WATER QUALITY

CITY OF CORVALLIS

NPDES PHASE II
STORM WATER MANAGEMENT
PROGRAM PLAN



SUBMITTED TO

OREGON DEPARTMENT OF ENVIRONMENTAL QUALITY

FEBRUARY 2007

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Stormwater Management Program Plan

EXECUTIVE SUMMARY

Urban stormwater runoff has the potential to negatively impact the quality of Corvallis' urban streams and the Willamette River. The City of Corvallis is working to decrease the amount of stormwater pollution in the community through a national program required by the Environmental Protection Agency, called the National Pollution Discharge Elimination System (NPDES) Phase II.

The EPA expanded the Clean Water Act of 1972 to include stormwater regulation to help control pollutants from entering waterways and protect water quality. In 1990, the EPA began regulating stormwater in Phase I communities (populations of 100,000 or more). On December 8, 1999, the EPA published final regulations for Phase II communities (population less than 100,000), which includes the City of Corvallis.

In compliance with the Phase II regulations, the City has developed a comprehensive stormwater management program plan (SWMPP) that is designed to protect water quality by reducing the discharge of pollutants to the storm drain system and receiving waters. Submittal of this document to the Oregon Department of Environmental Quality (DEQ) by February 2007 meets NPDES Phase II permit application requirements.

The SWMP plan includes six elements, termed "minimum control measures," required by the EPA as part of the Phase II program. Each of these elements is included as a section in the plan:

Section 1: Public Education and Outreach
Distributing educational materials and performing public outreach to increase community awareness about urban runoff pollutants, and inform citizens on how they can make a difference to reduce stormwater pollution.

Section 2: Public Participation/Involvement
Providing opportunities for citizens to participate in water quality improvement projects. Examples include stream cleanup, storm drain stenciling, and tree planting projects.

Section 3: Illicit Discharge Detection and Elimination
Developing and implementing a plan to detect and eliminate illicit discharges to the storm sewer system. Includes developing a system map, informing the community about hazards associated with illegal discharges and improper disposal of waste, and adopting and implementing an ordinance.

Section 4: Construction Site Runoff Control
Developing, implementing and enforcing an erosion prevention and sediment control program to reduce pollutants from construction sites.

Section 5: Post-Construction Runoff Control
Developing, implementing, and enforcing a program to reduce the impact of new development and redevelopment on post-construction water quality and quantity. Controls include

preventative actions such as protecting sensitive areas, or the use of structural best management practices such as grassed swales or detention ponds.

Section 6: Pollution Prevention/Good Housekeeping
Developing and implementing a program with the goal of preventing or reducing pollutant runoff from municipal operations. The program includes municipal staff training on pollution prevention measures and techniques (e.g. regular street sweeping, reduction in the use of pesticides, and frequent catch-basin cleaning).

In addition, the SWMPP includes measurable goals that will be used to assess the effectiveness of individual control measures and the stormwater management program as a whole, through a five-year implementation schedule. DEQ reporting requirements will be met as part of the SWMP plan implementation.

The City of Corvallis supports the NPDES Phase II program and recognizes that reducing stormwater pollution is essential to the quality of life for our citizens and our environment. The City is dedicated to implementing the Stormwater Management Program plan, in compliance with DEQ stormwater permit requirements, in order to protect water quality.

SUMMARY OF STORMWATER POLLUTION PREVENTION WORK COMPLETED TO DATE

The City of Corvallis initially submitted a SWMPP to DEQ in March 2004 as part of the NPDES Phase II Stormwater permit application process. Since that time, the City has developed and implemented a number of stormwater pollution prevention projects. A summary of work completed to date is included in the following table.

SUMMARY OF STORMWATER POLLUTION PREVENTION WORK COMPLETED TO DATE
Public Education and Outreach Program
Developed general stormwater pollution prevention educational learning program for school children.
Developed a storm drain marking program; worked with volunteers to mark "Dump No Waste, Drains to Stream" on hundreds of storm inlets throughout the City.
Created and distributed door-hangers with stormwater pollution prevention information.
Distributed news releases and articles with stormwater pollution prevention information to local news media.
Developed a stormwater pollution prevention program tailored to homeowners addressing auto care, landscaping, pet waste disposal, etc.
Public Participation and Involvement Program
Developed a stream cleanup/invasive plant removal program. Purchased equipment. Worked with volunteers to clean up stream sections.
Hosted a stormwater/pollution prevention booth at multiple community events.
Illicit Discharge Detection and Elimination Program
Developed a hotline that citizens can call in to report suspected illicit discharges or connections.
Developed a storm sewer map that shows the location of all outfalls and the names and locations of all streams that receive discharges from those outfalls.
Developed inspection/reporting forms and a database to track IDDE information. Associated database with the storm sewer map.
Conducted dry weather outfall surveys to identify illicit discharges or connections.
Created draft of updated IDDE ordinance to prohibit illicit discharges and connections to the municipal separate storm sewer system.
Construction Site Stormwater Runoff Control Program
Created and implemented an Erosion Prevention and Sediment Control (EPSC) Ordinance.
Created and distributed an EPSC Manual.

Construction Site Stormwater Runoff Control Program Cont.
Created and distributed educational materials on the erosion prevention and sediment control ordinance, and permitting and Best Management Practices (BMPs) for single and multiple lot development.
Identified inspection and permitting protocol for construction site construction site pollution prevention. Applied to applicants and sites. Developed and initiated related inspection procedures.
Developed and implemented EPSC record keeping procedure for permitting, BMP inspections, and workshop training programs.
Post-Construction Stormwater Management in New Development and Redevelopment Program
Reviewed existing development criteria and standards.
Gathered technical information on post-construction stormwater management.
Initiated review and development of draft criteria and standards for post-construction stormwater management structural BMPs.
Pollution Prevention/Good Housekeeping for Municipal Operations Program
Initiated stormwater pollution prevention program for municipal operations. Identified key components of process including inventory, assessment, BMP selection and implementation.

City of Corvallis Stormwater Phase II
Public Education and Outreach Program

This document discusses the Public Education and Outreach Plan that the City of Corvallis will implement to meet the conditions of its NPDES Phase II stormwater permit. This is one of six measures an operator of a Phase II regulated small municipal separate storm sewer system (MS4) is required to address in its stormwater management program.

I. INTRODUCTION

An informed and knowledgeable community is crucial to the success of Corvallis's stormwater management program. Without a public knowledge of local water quality problems caused by urban runoff it will be difficult to obtain public support for the comprehensive stormwater Phase II program. This support ranges from individuals changing their daily actions to community backing for all of the six minimum control measures. As with all of the six minimum measures the goal of this measure is to improve the chemical, physical and biological quality of state waters. In order to achieve the water quality benefits, the objectives of the education and outreach program are to:

- Develop an understanding of stormwater issues and pollution sources;
- Foster acceptance of appropriate solutions;
- Develop the knowledge and skills needed to implement solutions; and
- Provide the motivation to take action.

II. ELEMENTS OF THE PUBLIC EDUCATION AND OUTREACH PROGRAM

The stormwater Phase II education and outreach requirements based on federal code are summarized below. The City of Corvallis' Public Education and Outreach Program will incorporate these elements:

A. Implement a public education program to distribute educational materials to the community, or conduct equivalent outreach activities about the impacts of stormwater discharges on local water bodies and the steps that can be undertaken to reduce pollutants in stormwater runoff. Design the program to address urban stormwater pollutants and targeted audiences.

B. Develop and use appropriate educational strategies and tools for public education and outreach

C. Determine measurable goals for the Stormwater Public Education and Outreach Program

A. Public Education Program

The public education program will provide information to the community about the impacts of stormwater discharges on local water bodies and the steps that can be undertaken to reduce pollutants in stormwater runoff.

1. Urban Stormwater Pollutants

Non-point source (NPS) pollution in urban areas comes from many diffuse sources. NPS pollution is caused by rainfall or snowmelt moving over surfaces like pavement and lawns, picking up pollutants along the way, and finally depositing them into waterways. The focus of the Public Education and Outreach Program will be designed to reduce the impact on urban streams from the following categories of pollutants.

- Nutrients
  Phosphorous and nitrogen are transported into streams when runoff picks up fertilizer and animal waste residues. Excessive nutrient loading to aquatic systems can result in eutrophication and depressed dissolved oxygen levels. Eutrophication-induced hypoxia and anoxia can result in fish kills. Surface algal scum, water discoloration and the release of toxins from sediment may also occur.

- Heavy metals
  Heavy metal pollutants in stormwater consist primarily of lead, zinc and mercury. Sources include batteries, fuels, paints, pesticides, cleaners (e.g. algaecides), and industrial rubber. Heavy metals are of concern because of toxic effects on aquatic life. High metal concentrations may bioaccumulate in fish and other aquatic organisms, harming their metabolic and reproductive processes.

- Hydrocarbons
  Petroleum hydrocarbons are derived from oil products. The source of most such pollutants found in urban runoff is vehicle related, including oil, gas and grease from engine lubricants and fuel. Hydrocarbons have a high affinity for sediment; they collect in streambeds where they may persist for long periods of time, harming benthic habitat and sensitive spawning areas. They can also cause damage by floating on the water surface and blocking sunlight needed by underwater plants and fish.

- Toxic Chemicals
  Many different toxic compounds have been associated with urban runoff. Toxic chemicals in cleaning products, fuels, paints, pesticides and herbicides can harm water quality and aquatic life when they are improperly handled and allowed to enter the stormwater system. Chemicals have a wide range of toxic effects on fish and aquatic life, including causing tumors and skin lesions, and disrupting metabolic and reproductive functions.

- Sediment
  When stormwater flows across exposed soil at construction sites or in other bare areas it picks up dirt, which can be carried into streams where it causes sedimentation pollution. When too much sediment accumulates on streambeds it damages fish spawning areas, alters habitat where bottom-dwelling organisms live and reproduce, and interferes with fish migration. In addition, dirt and sand often pick up and carry toxics along their path, which introduces more chemical contaminants that are harmful to fish and other aquatic organisms.

- Bacteria
  Urban runoff typically contains elevated levels of bacteria and pathogenic (disease-causing) organisms. Sources include waste from pets that is left in yards or parks, and waste from failing septic systems. The presence of bacteria and pathogens in runoff may result in water body impairment such as contaminated drinking water sources. Bacteria, viruses and parasites from waste can pose health risks to human and aquatic life.

- Thermal Pollution
  Temperature changes in urban streams result from removal of vegetative cover and associated shade in riparian corridors, loss of cool groundwater inflow in summer as base flows are reduced due to changes in water infiltration and storage, and increased heating of runoff as it travels over impervious surfaces, such as streets, which act as heat collectors. Thermal loading disrupts aquatic organisms that have a narrow range of tolerance for temperature variations.

- Gross Pollutants
  Gross pollutants such as trash, litter, plant debris, animal excrement, and floatables may introduce heavy metals, toxics, excess nutrients and bacteria into stormwater as the materials break down. Trash and floatables may also create an aesthetic "eye-sore" in waterways.

Watersheds and Runoff
The Stormwater Education and Outreach Program will also include basic information about the structure and function of watersheds, impacts of development on runoff, and pathways of runoff from yards and streets through the storm system into streams and rivers. This will help residents understand the connections between their activities in a larger watershed context and consequent impacts to streams, no matter where they live in a watershed.

2. Targeted Audiences

The public education program will use a mix of strategies to address a variety of target audiences and reach a diverse population. Educational materials and approaches appropriate for the target audiences will be developed and implemented to most effectively educate these audiences and to solicit their input. The program will be primarily directed towards four constituencies:

a. General Residential Community and School Children

b. Commercial/Business Owners and Operators

c. Construction Site Owners and Operators

d. Municipal Departments and Personnel

Examples of stormwater information that will be provided to these target audiences can be found in Table PE-1. Further descriptions of targeted audiences follow the table.

Table PE-1. Summary Table of Stormwater Information for Target Audiences

Type	Content/Information	Residential	Business	Construction	Municipal
Legal and Regulatory Requirements	State and Federal water quality laws	X	X	X	X
	Requirements of local municipal permits and ordinances	X	X	X	X
Watershed and Water Quality Concepts	Impacts of urban runoff/nonpoint source pollution on receiving waters	X	X	X	X
	Watershed concepts	X	X	X	X
	Distinction between MS4s, combined, and sanitary sewers	X	X	X	X
General Best Management Practice (BMP) Information	General pollution prevention and safe alternatives - compiled information and tips	X	X	X	X
	Household hazardous waste collection	X	X	X	X
	Proper liquid waste disposal, non-stormwater disposal alternatives to reduce input of paint, oil, fuels, detergents etc.	X	X	X	X
	Pet and animal waste disposal	X	X	X	X
	Integrated pest management, pesticide and herbicide alternatives	X	X	X	X
	Green waste disposal, composting of lawn clippings, weeds, leaves, shrub and tree trimmings	X	X	X	X
	Traffic reduction, alternative transportation	X	X	X	X
	Planting native vegetation along streams and in general landscaping	X	X	X	X

Type	Content/Information	Residential	Business	Construction	Municipal
General Best Management Practice (BMP) Information Cont.	Erosion prevention and sediment control ordinance, permitting and BMPs for single and multiple lot development	X	X	X	X
	Equipment and vehicle maintenance and repair	X	X	X	X
	Good storage practices	X	X	X	X
	Equipment and vehicle washing	X	X	X	X
	Spill prevention and cleanup	X	X	X	X
	Property maintenance	X	X	X	X
	Illicit discharge detection and elimination	X	X	X	X
	Designing yards, landscaped areas and parking lots to include storm water management features (i.e. rain gardens, bioswales, collection areas for roof runoff, and shared parking)	X	X	X	X
	Residential and charity car washing to reduce suds/pollutants into storm system	X			
Public and Community Resource Information	General stormwater tip line and information services	X	X	X	X
	Public reporting mechanisms (i.e. for illicit discharge complaints)	X	X	X	X
	Community activities (i.e. storm drain stenciling, stream clean-up activities, riparian planting efforts)	X	X	X	X
Municipal Employee Training Information	Basic urban runoff and pollution prevention training for all personnel	X	X	X	X

Type	Content/Information	Residential	Business	Construction	Municipal
Municipal Employee Training Information Cont.	Additional and more specific urban runoff, pollution prevention and site inspection training for appropriate personnel. Designed for specific types of municipal employees/departments (i.e. parks maintenance workers, stormwater system maintenance staff, stream clean-up crews)				X
	Federal, state and local water quality laws and permits		X	X	X
	BMP function and maintenance for source control (to provide stormwater treatment and pollution prevention)		X	X	X
	BMP function and maintenance for water quantity control (to lower peak runoff from developed areas)		X	X	X
	Illicit discharge detection and elimination observations and follow-up		X	X	X
	Spill response, containment and recovery		X	X	X
	Erosion prevention and sediment control program (tailored for municipal staff, single and multiple lot developers, and construction site personnel)		X	X	X
	How to conduct a stormwater system inspection		X	X	X
	Waste management		X	X	X
	De-chlorination techniques		X		X

a. General Residential Community and School Children

The education program will include materials and activities to increase the knowledge of residents and schoolchildren regarding stormwater pollution. As with other areas addressed by the stormwater program, numerous residential activities have the potential to contribute to urban runoff pollution. Examples of residential pollutants and sources include household hazardous wastes, litter and debris, residential and charity car washing, pool and spa care, auto repair, lawn maintenance, home improvement projects and pet waste. The education program will utilize general stormwater messages to raise awareness; provide residents with basic information abut water pollution problems, causes and solutions;

and promote environmentally friendly behaviors regarding water quality. The program will include the message that many small sources of pollution add up to cause water quality problems, but in turn many small changes in behavior can improve water quality.

With respect to the residential community, two general target groups are the general residential population and school children. In addition to basic stormwater educational messages, the program will incorporate specific content that reflects the relative contribution to stormwater pollution by particular sub-groups within the residential community (i.e. pet owners). Residential audience sub-groups will also be chosen based on geographic area (i.e. a neighborhood) or common interest or activity (i.e. a garden group). Selection of these audiences will guide the types of recommended alternative actions and outreach approaches used.

There are more than 50,000 people in the Corvallis stormwater permit area. Within the residential population, a number of general and specific audiences will be considered when implementing the education program. These include the following:

- Individual Residents

  Many residents are unaware of the contribution they make to stormwater pollution in their daily lives. Providing basic information to residents about pollution sources and solutions to these problems will be a priority in the stormwater education and outreach program.

- Do-It-Yourselfers

  Residents who engage in home improvement projects will be provided information about the various ways in which the activities they undertake and the materials they use can contribute to stormwater pollution. Alternative materials and methods will be discussed. Examples of do-it-yourselfers include gardeners, painters, home remodelers, and automotive hobbyists.

- Homeowners/Neighborhood Associations

  Coordination with local homeowners or neighborhood associations will be done to reach groups of residents with information on improving water quality around their homes and neighborhoods. These audiences may feel a greater sense of community and be able to better see how their efforts added together will make a difference to improve water quality and stream health. This will also be a way to gain support for group activities that reduce stormwater pollution, such as storm drain stenciling events.

- Pet Owners

  Household pets can be significant contributors to stormwater pollution; waste that is left to decay and enter stormwater runoff causes pollution in the form of bacteria and excess nutrients. Pet owners will be educated on how pet waste adds to stormwater pollution and their obligation to ensure that these wastes are not left on lawns, parks and other areas.

- Community Groups

  An effective means of reaching a large number of citizens is to educate local community groups (e.g. service, political, civic and business organizations). By attending presentations or workshops citizens will learn more about specific measures they can take to reduce stormwater pollution, and can ask questions or raise concerns directly to staff. Stormwater education and outreach for these types of organizations may also provide the motivation for them to participate in community-based projects such as riparian planting events.

- School Children

  Students are open to learning about the world around them. Pollution prevention and stream health education will be promoted and encouraged as an established part of classroom and outdoor schooling. Focused education of stormwater pollution issues through elementary, junior high, high school and college will establish a foundation for incorporating pollution prevention choices as part of a person's lifestyle. Stormwater youth programs will be a vital investment in producing better informed voters and decision makers. In addition, many students will bring home information to their parents and carry out activities learned in the classroom as "the right thing to do." Students may also provide input for decisions related to chores such as washing the car, taking care of the lawn, walking the dog and picking up pet waste; their educated behaviors will have a long-term impact on reducing common sources of pollution.

<u>b. Commercial/Business Owners and Operators</u>

Because many business practices use materials and chemicals that can be harmful to the environment if not used or disposed of properly, it is important to inform owners, operators and employees about which practices should be avoided that could degrade water quality. Many commercial activities can contribute to stormwater pollution; examples include vehicle washing, landscape fertilization, and improper hazardous waste disposal. Pollution prevention awareness and strategies enable commercial operators to reduce the volume of solid, liquid and hazardous wastes that might otherwise reach the stormwater system and urban streams. Such strategies can be incorporated into the standard operating procedures of any commercial facility, whether a franchise, corporate chain store, an independent shop, or "mom 'n' pop" operation. Examples of commercial activities that may be included in Corvallis' stormwater education and outreach plan follow:

- Automobile Repair and Related Servicing Facilities

  Automobile and other servicing shops have the potential to contribute pollution while repair, maintenance, fueling, cleaning or painting work is being done. Pollutants may also come from salvage areas. Pollution prevention activities such as employee training, preventive maintenance, and development of spill response plans are measures that can be implemented to minimize pollutants entering the storm drain system.

- Restaurants

  Activities and areas that can be sources of pollution at eating and drinking establishments include leaking or uncovered dumpsters, grease bins, cleaning equipment, parking lots, loading and unloading stations, exterior pest control and landscaping. Training programs for employees and implementation of proper BMPs can reduce or prevent stormwater pollution from these potential sources.

- Mobile Carpet, Drape or Furniture Cleaning Services

  When mobile carpet and furniture cleaning is performed at residences and businesses, the wastewater that is produced can be a pollution source if it is disposed of in the stormwater system rather than into the sanitary sewer. Employees need to be trained in proper storage and wastewater disposal methods.

- Pest Control Services

  Workers that handle and apply pesticides may introduce pesticides to the storm drain system through improper handling, equipment leaks, overspray, or continual or excessive use of pesticides. Pollution prevention measures such as employee training, good housekeeping, preventative maintenance and implementation of spill response plans are methods to reduce pollution potential.

- Masonry, Cement Mixing or Cutting Businesses

  Employees who work at masonry, cement mixing or cutting businesses can introduce pollutants into stormwater systems while mixing, pouring or cutting cement, and during washing activities. Proper employee training and good housekeeping BMPs are important for pollution prevention.

- Painting and Coating Services

  Painting and coating service activities can contribute to pollution if the paints, solvents and other materials used are not stored, mixed, applied or disposed of properly. Training for employees in the use of BMPs can reduce the potential for stormwater pollution. BMPs include storing paints and solvents in approved containers under cover, using tarp enclosures to prevent drift, using washing areas that connect to the sewer system, and covering storm drains to protect from dust, chips and rinsate.

- Landscaping Services, Plant Nurseries, Cemeteries

  Landscaping services, plant nurseries and cemeteries all conduct a number of activities that can contribute to stormwater pollution. These activities and sources include watering/irrigation, fertilizer and pesticide application, sprinkler system installation, mowing, land clearing, construction and maintenance. Pollutants generated such as excess nutrients, pesticides, organic matter, sediment, oil and grease can be transported by irrigation or rainwater runoff. Training employees to implement BMPs and pollution prevention procedures reduces the risk of polluting stormwater and receiving waters.

- Portable Toilet Servicing

  Potential pollution sources and activities from portable sanitary toilet facilities include leaks, spills, vandalism, cleaning and emptying tanks. Bacteria, organic matter, disinfectant and suspended solids may enter the stormwater system unless proper BMPs are implemented. Implementing spill response plans, and maintaining hoses, tanks and other equipment in good condition can help prevent pollution.

c. Construction and Development Personnel

Construction and development activities can alter natural drainage patterns and contribute pollutants to stormwater conveyance systems. Improperly managed stormwater runoff from construction sites can be a significant source of water pollution. Pollutants of concern typically associated with these activities include sediment, debris, hazardous materials, concrete, slurry and wood products. The adoption and implementation of effective pollution prevention BMPs and development practices can greatly reduce the potential for such pollution. A major goal of Corvallis' stormwater program will be to reduce pollutants from construction sites by raising public awareness, and helping city staff and construction industry personnel develop the knowledge and skills needed to comply with site development and erosion control regulations.

Different types of personnel will collaborate in this process, and will also be the target audiences for the construction and development component of Corvallis' Stormwater Education and Outreach Program. Both internal staff and external project applicants will be provided information on water quality regulations, required permits, the connection of construction and/or land development to water quality impacts, how erosion can be prevented, and methods for minimizing impacts to receiving waters. Outreach will generally encourage owners, developers and contractors to address potential water quality problems early in the site design process, and to utilize a variety of BMPs such as scheduling, erosion prevention and sediment control, flow controls, site management, and materials and waste management.

- Municipal Staff

  Applicable municipal staff will be trained in various aspects of working with the public on erosion control and site development issues, permitting, BMP design and implementation, assessing compliance with plans and specifications, and enforcement procedures.

- Property Owners

  Property owners for single and multiple lot developments will need to be informed about erosion control requirements, and ensure that developers, contractors and builders are aware of and comply with erosion prevention and sediment control procedures to effectively prevent sediment from leaving their property both during and after construction.

- Developers

  Developers will need to be informed about erosion control requirements, acquire project approvals and permits, include erosion prevention and sediment control BMPs in project design and implementation, address sensitive sites, coordinate activities with city staff, and ensure appropriate site development and erosion prevention and sediment control procedures are being carried out.

- Contractors, Builders and Excavators
  Contractors, builders and excavators will need to be informed about erosion control requirements, and make sure that as they carry out "on-the-ground" activities that they follow effective erosion control procedures, and that BMPs are in place and functioning properly. Examples of targeted areas include exposed soil, construction site entrances and exits, construction material storage areas, storm inlets, and vehicle washing and equipment maintenance areas.

d. Municipal Departments and Personnel

The types of activities conducted at municipal facilities are often similar to those at construction sites, commercial and industrial facilities, and in some cases residential areas. A variety of pollutants may be discharged as a result of these activities. Examples include soaps, paints, heavy metals, litter and organic debris, cigarette buts, sediment, petroleum hydrocarbons, pesticides and fertilizers. Education and training will be provided to municipal employees to prevent or reduce the introduction of these and other pollutants into runoff from municipal land use areas and activities. General stormwater education will be included for all staff. The following municipal operations will be considered a high priority: roads, streets and parking facilities, storm system lines/waterways, street sweeping debris and general storage areas, maintenance shops, parks and open spaces, and the municipal airfield. Municipal staff already participate in a wide variety of work practices and activities that reduce or prevent pollution from entering the storm system and impacting receiving waters. The stormwater education and outreach program will include and build upon BMPs and procedures already in place.

Training will be targeted to City staff as follows:

- Managerial and Administrative Staff
  Management staff from city Public Works, Parks and Recreation, and Community Development departments will participate in the stormwater education and outreach program by assessing practices for water quality impacts, learning related measures to protect water quality, and providing support and guidance to staff regarding stormwater issues. They will develop or adapt management programs and budgets, and assist with ordinance development and enforcement.

- Utilities Staff
  Public Works Department staff that will be involved in stormwater education/implementation includes stormwater system operation and maintenance staff. This groups are responsible for maintaining catch basins, stormwater inlets, and other stormwater conveyance structures on a regular basis to remove pollutants, prevent clogging of the downstream conveyance system, restore catch basins' sediment trapping capacity, and ensure the system functions properly hydraulically. Additionally, water

and wastewater utility operations and maintenance staff perform job duties that could affect stormwater and receiving water quality. These include water line maintenance, sanitary sewer maintenance, spill/leak/overflow control, response and containment. Proper procedures and responses to prevent stormwater pollution in these cases will be included in the stormwater education/implementation program.

Other stormwater resources personnel within the Public Works Department will provide stormwater training and assistance; and design, publicize, implement and maintain participation in pollution prevention programs.

- Transportation System Personnel
  The street maintenance work group deals with all aspects of street maintenance including paving, patching, slurry sealing and crack filling, street cleaning, street/traffic area marking, and providing and maintaining street signs. During the fall, leaf collection service is also provided. Street maintenance staff will participate in stormwater education/implementation to identify potential pollution generating activities such as repair and paving jobs; and to learn about associated BMPs to reduce or prevent transportation related pollutants from entering storm systems.

- Landscape and Recreational Facilities Personnel
  Personnel in the Parks and Recreation Department are responsible for landscape maintenance activities including vegetation removal, fertilizer application, pest and weed control, watering and other gardening and lawn care practices. All of these maintenance practices have the potential to contribute pollutants to the storm drain system. Examples of landscape related education objectives include minimizing or preventing the discharge of fertilizers to the storm drain system and urban streams, and preventing the disposal of landscape waste into the storm drain system. Approaches to pollution prevention include proper timing and rate of fertilizer application, implementing an integrated pest management program for selected areas, placing temporarily stockpiled landscaping materials away from watercourses and storm drain inlets, and composting leaves or other collected vegetation.

- Engineering Personnel
  The Public Works Department Engineering Division covers a broad spectrum of activities related to new construction, capital improvement projects, repairs, and maintenance of city facilities and infrastructure. Development Review staff evaluates privately designed and funded projects for development within the city limits. Stormwater education/implementation for city staff engineers will address technical issues such as how to design, build, review and inspect stormwater and pollution prevention controls and BMPs.

  Development services staff in Community Development will develop an erosion control manual and permitting process for erosion control procedures required for construction projects. This erosion control plan will address issues of runoff from private and public construction sites and city maintenance procedures.

- Municipal Buildings and Grounds Staff
  Activities undertaken to maintain City owned or operated buildings and grounds that could potentially introduce pollution to the stormwater system and receiving waters will be addressed in the stormwater education and outreach program.

- Planning Personnel
  Planners make decisions that affect how landscapes are developed, ranging from individual lot size to watershed scale. The way that the landscape is developed under differing development scenarios affects runoff quantity and quality. Planning staff will consider development options to reduce impervious cover per unit household/business area added, mitigation measures to reduce impacts including adding buffer strips along streams; incorporating bioswales, water quality/quantity treatment ponds and wetlands in site and neighborhood design; and leaving open spaces within the landscape.

B. Outreach Strategies and Tools

The effective implementation of the stormwater management program relies on educating the people who ultimately must be motivated to make behavioral changes including: the general public, school children, business community, or City personnel. A number of different ways will be used to educate people; the program will incorporate a variety of educational strategies and materials to ensure a wide audience is included. Outreach will include information on both non-structural (pollution prevention, good housekeeping) and structural (treatment control) Best Management Practices, but will generally emphasize non-structural measures and behavioral change. The descriptions below summarize the types of outreach tools which may be used during Corvallis' Stormwater Education and Outreach Program.

- Brochures/Printed Materials
  Educational brochures and fact sheets are useful in documenting and conveying specific content regarding water quality, stream health and Best Management Practice information. Examples of topics include: yard care pollution prevention tips, recipes for a non-toxic home, pet waste and water quality, benefits of streamside vegetation, and erosion prevention and sediment control techniques. Providing readily understandable printed educational information to the public will be an important part in promoting and implementing BMPs and other stormwater program elements. Other similar types of printed materials that will be used include cards or door hangers with listings of phone numbers, websites, or referral pages for community members to contact regarding specific stormwater program resources or volunteer opportunities.

- News Media Releases
  Sharing information through newspaper articles or advertisements and newsletters will be another form of stormwater education and outreach. Articles and news releases will

be distributed for inclusion in local papers and City newsletters. Media releases will be used to announce special events, clean up days or promotions.

- Municipal Facilities/Public Lobbies
  Stormwater program information may be distributed in the public lobbies of appropriate municipal buildings. Locations include Libraries, the City's Development Services and Public Works lobbies, and the City Hall kiosk. For example, building/construction permit counters may be especially effective for sharing erosion prevention and sediment control informational materials with the development sector.

- Promotional Items
  Promotional items will also be used as a tool to disseminate stormwater program information. Commonly used promotional items such as pencils, magnets, water bottles and other tokens will be imprinted with useful stormwater tips and resources, and will be a way to keep information readily available to residents and business owners. For example, a refrigerator magnet printed with a stormwater hotline number will be a reminder to people to contact the City regarding any illicit discharge activity they may see or know about.

- Training Sessions/Workshops
  Workshops and training sessions may be used to provide specific information to agency personnel and target audiences. Because of their immediacy and "hands-on" approach, these forums may be especially useful for increasing awareness and knowledge of stormwater topics, conveying complex or technical information, and instructing attendees on the use of specific best management practices and pollution prevention techniques. Workshops may be geared toward the involvement of groups that are similar in nature and activities. They may likely also be coordinated with other local agencies and organizations to maximize impact, increase participation and reduce overall costs. Examples of potential workshop topics include: home, garden and lawn care; erosion prevention and sediment control Best Management Practices; and spill response and cleanup.

- Community/Watershed Events
  Stormwater educational activities and display booths at fairs and festivals may provide a way to distribute information and resources directly to target communities. Providing practical information and involving the public is the most effective way to promote BMP implementation. These events may provide City stormwater utility personnel with an opportunity to gain the attention of a wide variety of community members. Examples of events and activity booths include: (1) fish painting at DaVinci Days, where people can stencil paint in an image of a fish on a background sheet of paper that includes pollution prevention tips, (2) a stream simulator table set-up, where children can use a model watershed to see how a stream forms, what happens in a watershed that impacts the streams within it, and what they can do to promote stream health; and (3) storm drain marking, where volunteers can mark storm inlets with the message "Dump no waste,

drains to stream" (or a similar message) as a reminder that storm drains are connected to streams, and pollutants should be kept out of them.

- Hotline

  A stormwater hotline will provide a direct and effective way for citizens to learn stormwater tips, and request information. The hotline will also provide an opportunity for community members to report about activities they see that may be harmful to local streams, such as someone dumping a pollutant down a storm inlet. The hotline will provide a voice mail message for 24-hour public access. Through this hotline, complaint information will be forwarded to the appropriate City personnel for follow up and/or investigation.

- Internet Website

  The City of Corvallis maintains an Internet web site. A special stormwater section will be added with information on streams and watersheds, stormwater basics, pollution prevention tips, stormwater BMPs, community events and contact numbers. Links to other agencies and educational institutions will be provided, to broaden the scope of materials and opportunities for learning about stormwater and stream health.

- Videos

  Videos can be a very effective way to provide watershed and stormwater related information, and may be used in stormwater presentations. They may also be made available for checkout to the public, local agencies and school groups. Videos are effective ways to reach people because audiences feel engaged in watching them. It's easier for citizens to imagine situations in which pollution occurs, and how they can participate in improving water quality when they see this information on screen, and hear accompanying descriptions. Potential sources of videos may include the Environmental Protection Agency, Oregon Public Broadcasting, and the Center for Watershed Protection.

- Recognition Awards

  Recognition awards may be provided to business community members who take an active and preventative approach for managing pollution. The City may develop a partnership program for businesses and industries to provide training, technical assistance, and public recognition of participants. Businesses with management programs or employee activities that incorporate pollution prevention strategies will be affirmed through posters or certificates for display. An advertisement and public recognition program will be sponsored so that citizens understand the recognition program, and can choose to support these businesses. By participating in and sharing information about pollution prevention, businesses can become more competitive and environmental quality can be enhanced.

- School Programs
  Education of school children is essential for promoting stormwater awareness, and will be a large component of Corvallis' stormwater education and outreach effort. School presentations and activities will be incorporated into curricula ranging from kindergarten through high school, and may be implemented in individual classrooms, school workshops and special events.

C. Measurable Goals

As previously discussed, in order to meet NPDES stormwater permit requirements Corvallis is required to implement an education program to measurably increase people's knowledge regarding MS4s, and the impacts of urban runoff on receiving waters, and potential BMP solutions. People's behavior should be measurably changed as a result of these education efforts, and through time cause reductions in pollutant releases to MS4s and downstream receiving waters. Development of a long-term implementation schedule and means of assessing the effectiveness of the stormwater education and outreach plan will be an important aspect of a successful comprehensive stormwater pollution prevention program.

The five-year implementation schedule for the Public Education and Outreach Plan is shown in Table PE-2.

Table PE-2. Stormwater Phase II Measurable Goals for Public Education and Outreach Program Implementation Schedule for Five Years

Activities	Year 1	Year 2	Year 3	Year 4	Year 5
School Pollution Prevention Program	Develop general stormwater pollution prevention educational learning program. Work with at least 4 classroom groups using materials.	Update and continue.	Update and continue.	Update and continue.	Update and continue. Evaluate.
Storm Drain Marking	Work with volunteers to mark at least 100 storm drains.	Update and continue.	Update and continue.	Update and continue.	Update and continue. Evaluate.
Stormwater Pollution Prevention Door-Hangers		Create door-hangers with stormwater pollution prevention (IDDE) information. Distribute at least 400 door-hangers.	Update and continue in new areas.	Update and continue in new areas.	Update and continue in new areas. Evaluate.
IDDE Hotline	Develop a hotline that citizens can call in to report suspected illicit discharges or connections. Monitor calls, follow up.	Update and continue.	Update and continue.	Update and continue.	Update and continue. Evaluate.

Activities	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Media Releases	Distribute news releases or articles with pollution prevention/stormwater information to local news media. Distribute at least 6 releases or articles.	Update and continue.	Update and continue.	Update and continue.	Update and continue. Evaluate.
Residential Pollution Prevention Program			Develop pollution prevention program tailored to homeowners addressing auto care, landscaping, pet waste disposal, etc. Include educational flyers. Present to at least 20 individuals or 6 groups.	Update and continue in new areas.	Update and continue in new areas. Evaluate.
Municipal Employee Training Program			Initiate stormwater pollution prevention program for municipal operations. Identify key components of planning process including inventory, assessment, BMP selection and implementation.	Develop program to include specific pollution prevention processes for municipal personnel. Develop training schedule, implement program.	Update and continue. Evaluate.

Activities	Year 1	Year 2	Year 3	Year 4	Year 5
Erosion Prevention and Sediment Control Education	•	Create and distribute educational materials on erosion prevention and sediment control ordinance, permitting and BMPs for single and multiple lot development. Make available to all persons requesting building/site planning and inspection services through the City.	Update and continue.	Update and continue.	Update and continue. Evaluate.
Business Pollution Prevention Program				Develop pollution prevention program tailored to business owners. Address multiple pollution prevention related issues and BMPs. Examples include proper waste disposal, equipment maintenance, landscaping, etc. Include educational handouts or booklets and certificates. Present to at least 10 business or work groups.	Update and continue in new areas. Evaluate.

City of Corvallis Stormwater Phase II
Public Participation and Involvement Program

This document outlines the Public Participation/Involvement plan that the City of Corvallis will implement to meet the conditions of its NPDES Phase II Stormwater permit. The Public Participation/Involvement component is one of six measures the operator of a Phase II regulated small municipal separate storm sewer system (MS4) is required to include in its stormwater management program.

I. INTRODUCTION

The public can provide valuable input and assistance to the City's municipal storm water management and pollution prevention program. Since it is the activities of the public within urban landscapes that produce diffuse pollution, it is important that the public be given opportunities to play an effective role in the implementation of the program. An active and involved community will be crucial to the success of the stormwater management program because it allows for:

- Broad public support because citizens who participate in the development and decision making process are invested in the program, and are therefore more likely to take an active role in program implementation.

- Development of conduits to other valuable programs, as citizens involved in the process provide important cross-connections with other community and government groups involved in stormwater and watershed related work.

- A broader base of expertise since the community can be a valuable resource for ideas and implementation.

The public involvement efforts will be closely tied with the public education and outreach efforts that form another component of Corvallis' Phase II stormwater program.

II. ELEMENTS OF THE PUBLIC PARTICIPATION AND INVOLVEMENT PROGRAM

The EPA Phase II regulations include guidelines for the Public Participation and Involvement component that permittees must include in their stormwater programs. Federal code requirements for this measure are summarized below, and the City of Corvallis will develop a stormwater Public Participation and Involvement program that incorporates these elements:

A. Comply with state and local public notice requirements when implementing the stormwater management programs required under this permit.

B. Use a variety of implementation approaches to involve a diverse audience in stormwater pollution prevention activities.

C. Identify measurable goals intended to gage Public Participation and Involvement Program effectiveness.

A. Public Notice Requirements

Notice of all public hearings will be published in order to reach a majority of citizens, and to meet public notice requirements. Public interest will be gained through notification and recruitment; potential methods include:

- Advertising in local newspapers;
- Postings where the public commonly gathers;
- Announcements in neighborhood association flyers, city newsletters, mass mailings; and
- Announcements at civic organization meetings.

Advertising and soliciting for participation will be targeted at diverse population sectors. Examples include:

- General citizens;
- Neighborhood and community groups;
- Academia and educational institutions;
- Natural resource agencies;
- Business and industry entities;
- Outdoor recreation groups; and
- Ethnic, low income and minority communities.

B. Public Involvement and Participation

The goal of the public involvement and participation program will be to effectively involve a diverse cross-section of people who can participate in stormwater pollution prevention activities. Means of public involvement in the City's Phase II Stormwater Program will include:

1. Public participation through activities; and
2. Public participation through meetings and exchange.

1. Public Participation Through Activities

There are a variety of ways the public will be actively involved in the City's Phase II Stormwater Program. Examples of programs/activities the City will undertake are outlined below:

a. Storm drain marking;

b. Stream cleanup projects;

c. Riparian, upland and wetland planting; and

d. Adopt-A-Stream programs

a. Storm Drain Marking

Storm drain marking involves labeling storm drain inlets with messages reminding citizens not to dump pollutants (e.g. paint, fertilizer, soap or oil) into the drains. Marking may be done with stenciled paint, or plastic or metal disks. The messages raise awareness and let passersby know that the storm drains connect to local waterbodies, and that dumping pollutes those waters. An image of a fish is included to reinforce the message, and provides a symbolic connection to the aquatic life in local streams.

Volunteers will undertake marking projects throughout Corvallis. Drains leading to waterbodies where illegal dumping has been identified as a source of pollution will be especially targeted for marking.

Corvallis Public Works Department staff will provide materials and training needed to accomplish the marking, and help coordinate the volunteers. When volunteers participate in the storm drain marking program they will be provided with kits containing all materials needed to carry out a marking project. Corvallis Public Works staff will provide training for volunteers on safety procedures and on the techniques for marking. Training will include educational information regarding water quality, the connection between storm drains and receiving waters, activities that contribute to non-point source pollution, and what citizens can do to reduce or prevent such pollution. Volunteers will also be given the opportunity to distribute door hangers that offer tips on how citizens can help prevent urban runoff problems.

b. Stream Cleanup Projects

Stream clean up activities may be hosted by the City as a way to involve citizens and promote pollution prevention awareness. Trash and other debris accumulates along streams and not only looks aesthetically unappealing, but it degrades water quality and riparian habitat. Stream cleanup projects will allow concerned citizens to become directly involved in water pollution prevention. Participants will volunteer to walk (or paddle) a length of stream or river and collect debris. Volunteers will also note anything related to stream health, such as potential signs of illicit discharge for later follow up by City staff.

Corvallis' urban streams will be targeted as the cleanup sites. Site priority will depend on the ecological sensitivity of stream reaches, and/or how accessible and exposed they are. Permission to conduct cleanup projects on private property will be necessary and secured in advance.

Once candidate stream reaches have been identified, cleanup project opportunities will be advertised through various means, such as newspaper advertisements, flyers, posters and announcements to groups that are likely to participate. Volunteers may include neighborhood associations, school groups, service organizations, environmental groups, or individuals. The City will provide volunteers with instructions, stream reach maps, gloves and trash bags. Safety will be stressed.

In addition to trash and debris removal, cleanup events will also be used to increase public awareness of pollutant sources and pollution prevention activities. City staff will be on hand to answer questions, describe water resources, and discuss non-point source pollution issues with volunteers. These cleanup efforts will help citizens feel more involved in their community and foster a sense of responsibility for water resources.

c. Riparian, Wetland and Upland Planting

Vegetation in the Corvallis community has changed dramatically as urbanization has occurred and many native species have been replaced by invasive and non-native plants. Vegetation has been removed along some stream corridors and within upland areas. Revegetation efforts with native tree and understory species will be part of Corvallis' Public Participation/Involvement program, and will be essential to the improvement of many natural areas that will, over time, improve urban stream water quality and riparian habitat. Invasive plant species will be removed as a first step in areas targeted for revegetation.

Revegetation is essential to the restoration of many natural habitats, and volunteers will be given the opportunity to participate in a variety of planting projects throughout Corvallis. Sites suitable for revegetation efforts will be chosen based on information from the City's Natural Features Inventory, Stormwater Master Plan studies, ESA 4d Rule Plan, or other local resource inventories. Other areas may be selected based on proximity to schools so students can participate, or where there is strong interest by a local group or neighborhood association.

The City of Corvallis staff will participate in native revegetation projects by involving volunteers, helping to coordinate events, publicizing tree planting efforts and programs, providing water quality related educational materials, providing basic tools and equipment, potentially providing some financial resources, participating in site preparation, assisting with planting, and potentially aiding with maintenance such as weeding and watering. City staff will also educate volunteers about the influence of upland watershed and streamside areas on stream health and water quality, activities that contribute to non-point source pollution and what citizens can do to reduce or prevent such pollution.

There will be multiple benefits to public participation in planting projects. People will feel more directly connected to and interested in their local streams and watersheds, and they will want to continue their involvement in pollution prevention and stream health related activities.

d. Adopt-A-Stream Programs

Adopting a stream is a way for residents to become involved in improving the health of their local streams. Adopt-A-Stream programs are a public outreach tool through which volunteers "adopt" a section of stream or river to clean up, restore, monitor and protect. Adopt-A-Stream activities can be undertaken by neighborhood associations, community groups, service organizations, environmental organizations, and students. The City of Corvallis may participate in Adopt-A-Stream partnerships as opportunities and resources become available; participation will include meeting with groups to demonstrate support for their efforts, acting as a technical resource, and providing in-kind services and financial contributions as resources allow.

The Adopt-A-Stream program will potentially allow participation from any group or organization within any watershed within the Corvallis urbanized area. Possible activities include:

- Doing stream cleanups;
- Conducting stream and streambank surveys;
- Working on streambank enhancement projects, such as tree planting, to help control erosion and stabilize streambanks;
- Monitoring water quality and gauging flow;
- Marking storm drains;
- Being aware of and reporting illicit discharges; and

- Promoting pollution prevention education through stream walks, workshops and other activities.

Adopt-A-Stream projects generally involve identifying and researching stream areas, developing short- and long-term goals for improvement and implementing projects to do so. Once the stream sites have been identified, a monitoring and reporting plan to evaluate the conditions on the stream will be developed.

Guidance on the Adopt-A-Stream program can be found on the national Adopt-A-Stream website. The Benton Soil and Water Conservation District, along with the support of local groups including Corvallis Public Works, has developed the handbook *How to Adopt a Stream in Benton County*. It includes many useful guidelines and local, state and regional contacts that can provide support for participants as they work on stream projects. Corvallis will use these and other resources to guide this program. Participants will work together to improve natural resource values within their urban landscape, and make areas in their watershed more visually attractive.

2. Public Participation Through Meetings and Exchange

Individuals and groups will be given the opportunity to participate in the City's stormwater management program by attending public meetings and workshops. Citizens will be informed of water quality and stormwater issues in the community.

Public meetings may be in the form of citizen meetings, public workshops or any other types of interactive, information-sharing events. Stormwater topics will be presented and discussed, and participants will be able to hear what others have to say and can share their own ideas. General information about watersheds, runoff and non-point source pollution will be discussed to provide background, in addition to more specific information related to the stormwater Phase II program. For example, issues regarding erosion control may be a topic for an audience of contractors, developers and builders, whereas issues regarding business facility pollution reduction may be discussed with restaurant, shop, hotel, gas station, and car wash owners and managers.

Participants will be invited through a variety of methods, such as: direct mail, the internet, flyers, posters and through "word of mouth".

A number of different types of community involvement methods may be used as public meeting formats; examples are described in the following table.

Table PI-1. Community Involvement Methods

Type	Description & Purpose	Strengths	Weaknesses
Public Meeting	Meet with general or specific audiences to present information and address questions and comments.	Flexible format. Builds community understanding. Opportunity to engage in dialogue and provide information to a large number of people.	May need more time to explore issues. May be attended by groups with specific agendas or who may dominate the meeting.
Open House/ Community Fair	Event over a period of time (usually 4 to 6 hours) to provide information and receive comments from a broad audience. Meet people informally to discuss issues.	Target to broad audience. Opportunity for two-way dialogue. Opportunity for feedback and exchange.	Generally a one-time event; ongoing dialogue or follow-up can make this more useful. Requires significant staff involvement.
Personal Interviews	Individual discussions with specific individuals. Inform person(s) and obtain in-depth opinions and reactions.	Helps build understanding. Provides valuable information. Personal contact is effective.	Involves limited number of people.
Media Contacts	Written releases, briefings or interviews. Communicate information to the general public through newspapers, radio or television.	Opportunities for exposure to people who may not otherwise be involved.	Limited control over content. Not likely to promote two-way dialog with the public.
Web Page	Information available to computer users with access to the Internet. Provides information to individuals who may not otherwise be reached.	Available to growing segment of the public. Moderate set-up costs.	Precludes use by those without computers. User must take initiative to access information. Requires periodic updating.
Hotline	Phone number and message line that citizens can call in to report a water quality problem or illicit discharge issue. Calls are followed up on by City stormwater personnel. Greatly expands the monitoring network	Serves as a link between the citizens and the City stormwater program and response team. A good way to stop polluters or accidental spills that might go otherwise unnoticed.	The hotline needs to be staffed and monitored on a regular basis, and response to calls needs to be prompt. Advertisement is needed in order for the effort to be successful.

C. Measurable Goals

Program measures, which are required for each component of the Phase II stormwater plan, provide a way to gauge permit compliance and program effectiveness. The measurable goals will be based on an integrated approach that fully addresses the requirements and intent of the Public Involvement minimum control measure. Table PI-2 includes measurable goals and an implementation schedule for the first five years of the City's stormwater Public Participation and Involvement Program.

Table PI-2. Stormwater Phase II Measurable Goals for Public Involvement and Participation Program Implementation Schedule for Five Years

Activities	Year 1	Year 2	Year 3	Year 4	Year 5
Storm Drain Marking	Work with volunteers to mark at least 100 storm drains.	Update and continue in new areas.	Update and continue in new areas.	Update and continue in new areas.	Update and continue in new areas. Evaluate.
Stormwater Pollution Prevention Door-Hangers		Create door-hangers with stormwater pollution prevention (IDDE) information. Distribute at least 400 door-hangers.	Update and continue in new areas.	Update and continue in new areas.	Update and continue in new areas. Evaluate.
Stream Cleanup Projects		Develop stream cleanup/invasive plant removal program. Purchase equipment. Work with volunteers to clean up at least two stream sections.	Continue in new areas.	Continue in new areas.	Continue in new areas. Evaluate.
Tree Planting			Initiate tree planting program, talk with tree supplier purchase equipment. Write informational letter. Develop plant list.	Distribute information about program to streamside residents. Work with volunteers to plant at least two stream sections.	Continue in new areas. Evaluate.
Adopt-A-Stream Programs				Work with other Corvallis agencies/groups on at least one Adopt-A-Stream project.	Continue program. Evaluate.

Activities	Year 1	Year 2	Year 3	Year 4	Year 5
Public Meetings and Exchange	Host stormwater/ pollution prevention booth at community event.	Update and continue.	Update and continue.	Update and continue.	Update and continue. Evaluate.
			Develop pollution prevention program tailored to homeowners addressing auto care, landscaping, pet waste disposal, etc. Include educational flyers. Present to at least 20 individuals or 6 groups.	Update and continue.	Update and continue. Evaluate.
				Develop program and presentation materials for business/commercial pollution prevention program. Present to at least ten businesses or work groups.	Update and continue. Evaluate.
			Expand City internet site to include information on stormwater and pollution prevention. Provide number to call to talk to water resources specialist.	Update and continue.	Update and continue. Evaluate.

Activities	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Public Meetings and Exchange Cont.	Develop a hotline that citizens can call in to report suspected illicit discharges or connections. Monitor calls, follow up.	Update and continue.	Update and continue.	Update and continue.	Update and continue.

City of Corvallis Stormwater Phase II
Illicit Discharge Detection and Elimination Program

The Illicit Discharge Detection and Elimination Minimum Control Measure is one of six measures the City of Corvallis, as an operator of a Phase II regulated municipal separate storm sewer system (MS4), is required to include in its stormwater management program, and will implement to meet the conditions of its stormwater permit. An illicit discharge is defined in EPA's Phase II stormwater regulations as "any discharge to a municipal separate storm sewer system that is not composed entirely of stormwater, except discharges pursuant to an NPDES permit and discharges resulting from firefighting activities." Stormwater is defined as urban runoff consisting only of those discharges that originate from precipitation events.

I. INTRODUCTION

The goal of the Illicit Discharge Detection and Elimination Program is to detect and eliminate illegal discharges and illicit connections to the storm drain system. Illegal discharges to the storm sewer from industrial facilities, commercial businesses, and residents can be a significant source of water pollution. Deteriorating piping in the sanitary sewer and storm drain systems may also be a source of pollution, if sanitary sewage seeps into the storm water system.

Illicit discharges can enter the storm system through either direct or indirect sources. Examples of direct illicit discharges include:

- Wastewater from piping that is directly connected from a home to the storm sewer;
- Materials (e.g. oil, paint) that have been dumped into a storm drain catch basin;
- Discharges from a shop floor drain that is connected to the storm sewer; and

Examples of indirect sources of illicit discharges include:

- An old or damaged sanitary sewer line that is leaking wastewater into a cracked storm sewer line; and
- An abandoned septic system that is leaking into a cracked storm sewer line or causing surface discharge into the storm sewer

Non-stormwater discharges are exempt from the Illicit Discharge Detection and Elimination program requirements unless they are identified as significant contributors of pollutants to the City's municipal separate storm sewer system. Non-stormwater consists of all discharges to and from a stormwater conveyance system that do not originate from precipitation events. Examples of these non-stormwater discharges include: diverted stream flows, flows from riparian habitats and wetlands, rising ground waters, uncontaminated ground water infiltration, uncontaminated pumped groundwater, discharges from springs, irrigation water, flows from lawn or landscape watering, discharges from potable water sources, water from foundation drains, air conditioning condensation, water from crawl space pumps, water from footing drains, discharges from individual residential car washing, street wash water, dechlorinated swimming pool discharges, and discharges from water line flushing.

II. ELEMENTS OF THE ILLICIT DISCHARGE DETECTION AND ELIMINATION PROGRAM

The City of Corvallis will develop an Illicit Discharge Detection and Elimination (IDDE) program generally based on EPA guidelines. The EPA's Phase II regulations state that an IDDE program must incorporate the following elements:

A. A storm sewer system map showing the location of all outfalls, and the names and locations of all waters of the United States that receive discharges from those outfalls;

B. An ordinance, or other regulatory mechanism, to effectively prohibit illicit discharges into the separate storm sewer system and implement appropriate enforcement procedures and actions as needed;

C. A plan to detect and address illicit discharges, including illegal dumping, to the system. Develop procedures to locate priority areas, identify illegal discharges, trace their sources, and remove the sources of the illegal discharges. Include an education component; and

D. Appropriate measurable goals as a means of evaluating and assessing the IDDE Program.

A. Storm Sewer System Map

The creation of a storm sewer map is the first mandatory element of an IDDE program. Phase II requires that the operator of a regulated MS4 develop a map of the storm sewer system that shows, at a minimum, the location of all outfalls and the names and locations of all waters of the United States that receive discharges from those outfalls.

A storm sewer map for Corvallis already exists and is based on stream and outfall location information in the City's GIS database. The purpose of the map is to provide a way to locate outfalls within a geobased reference system so that any specific outfall can be located when discharges are being located. The GIS mapping program used combines a geo-referenced database with mapping capability so that different system attributes (e.g. storm system outfalls, storm pipes, manholes, and streams) can be mapped as "layers", and displayed separately or in combination. Appendix ID-A includes a copy of the map.

Each outfall point will be linked with other site-specific information related to IDDE surveys, records and actions as the IDDE program evolves. The map will continue to be regularly updated through periodic review, and addition of any IDDE related information regarding monitoring and follow-up activities. Storm system infrastructure updates will be added as they are completed.

B. Illicit Discharge Ordinance

The City's current municipal IDDE ordinance will be updated and will include a prohibition of illicit discharges and an enforcement mechanism. A draft of this updated ordinance is included for reference in Appendix ID-B.

The purpose of this ordinance will be to regulate non-stormwater discharges to the storm drainage system, and will establish methods for controlling the introduction of pollutants into the municipal separate storm sewer system (MS4) in order to comply with the requirements of the National Pollutant Discharge Elimination System (NPDES) permit process. The objectives of the ordinance are to:

- Regulate the contribution of pollutants to the municipal separate storm sewer system, via stormwater discharges, by any user;

- Prohibit illicit discharges and connections to the municipal separate storm sewer system; and

- Establish legal authority to carry out all inspection, surveillance, and monitoring procedures necessary to ensure compliance with the ordinance.

C. Plan to Detect and Address Illicit Discharges

1. Locating Priority Areas

Priority areas are areas that are considered to be likely sources of illicit discharges based on available information. Identifying areas prone to illicit discharges will assure better implementation of the IDDE program, and that scarce resources are used more effectively. The following kinds of areas are examples of potential "hot spots" and will potentially be included in the City of Corvallis IDDE program.

Commercial and industrial areas have been found in some communities to have significant numbers of illicit connections and/or have discharges with a high potential to affect water quality. These business sectors within Corvallis will be identified, mapped and included as priority areas for survey and evaluation as part of the IDDE program.

Older areas of the community that were developed prior to implementation of construction codes regarding illegal connections may have deteriorating sewer and/or storm sewer infrastructure that may lead to water quality problems, and will be of high concern. Polluted water may enter the storm system through direct illegal connections between the sewer and storm lines. In addition, indirect illicit discharge problems may occur as infiltration seeps through old cracked or broken sewer and storm lines.

Areas where there have been multiple complaints of illegal dumping or apparently contaminated discharges have been reported will be considered priority areas. Reports may come from City employees who have been trained how to recognize and report suspected problems, or from citizen calls to a public IDDE hotline. Complaint report locations will be mapped through GIS.

Locations identified from ambient water quality sampling data, or areas that drain to stream locations that have high levels of particular contaminants (e.g. bacteria) will also be considered high priority for illicit discharge investigation and determination. Water quality data collected by the City and potentially by volunteer groups will be reviewed to help identify these areas.

2. Identifying Illegal Discharges

The City will respond to reports and complaints of spills and illegal discharges to the storm drain system as soon as possible. Field inspections and investigations will be conducted as a result of the following:

- Complaints received from the general public;
- Staff observations of suspicious activities;
- Line blockages, leaks or breaks; and
- Physical indications that a spill or illegal discharge has occurred.

Investigations of spills and illegal discharges may be conducted in a variety of locales and under a variety of conditions. Field investigations include inspecting streams and storm drains, residential areas, or business sites.

Storm drain inspections will generally be conducted after a complaint or tip is received or when City staff working in the field notice a suspicious discharge. Storm drains will be checked in order to detect illegal discharges; this process may include the visual inspection of storm drain outfalls, drainage channels, manholes, and catch basins for signs of illicit discharge or connection. Signs of an illicit discharge or connection include dry weather flows; flows with "off"odors; oil and grease, or other pollutants; or unusual or unexplainable pipes or connections to the City's system.

Dry weather surveys of outfalls will be undertaken on a periodic basis to look for non-stormwater flows and to identify more focused areas of concern for illicit discharge problems. The presence of flow in a storm sewer outfall or manhole during dry weather may indicate a likely illicit discharge. Dry weather flows will be observed for odor, color, turbidity, and floatable matter. Outfalls will be observed for deposits and stains, vegetation, and damage to outfall structures. This survey may be combined with water quality sampling of the discharges. This information may help identify contaminants present in the discharge and/or the likely nature of the discharge (e.g. sanitary, industrial).

3. Tracing the Source of Illegal Discharges

Once storm drain outlets with evidence of illicit discharges have been located, various methods will be used to find the source of the discharge. In many instances the initial investigation or report will not identify a specific source of contamination and further field investigation may be required. Depending on the particular situation, source investigations may include some or all of the following steps:

a. Following flows or discharges upstream;

b. Conducting field screening sampling;

c. Tracking illegal dumping; and

d. Documenting source investigations.

a. Following Illicit Discharges Upstream

A key tracing technique will be to follow an illicit discharge from the location where it is first observed in an upstream direction along the conveyance system to bracket the location of the source. This will be accomplished by first consulting the drainage system map to locate the outlet with signs of illicit discharge, and the storm system that flows to that outlet. After this, the next "upstream" manhole with a junction will be checked to see if there is evidence of discharge. These steps will be repeated until a junction is found with no evidence of discharge; the discharge source will likely to be located between the first junction with no evidence of discharge and the next downstream junction.

In further locating the source of the flow, catch basins and inlets between manholes will be checked for evidence of flows and/or pollutant sources. Evidence of recent or past dumping such as wet or stained pavement or gutters will be investigated. Also, new or illicit connections to the system may be found through review of recent and past records for storm and sewer system connections.

The field investigation will be documented. In some cases it might not be possible to determine the source of the flow using the method described. If the source is still not found, the field investigation notes will include the location of the last place that the polluted flow was observed, then marked on a map so that the area can be investigated again at a later date.

Dye testing may be conducted to confirm hydraulic connections; this technique involves discharging dye near the source of the potential illicit discharge then observing storm sewer and sanitary sewer manholes and storm sewer outfalls for the presence of the dye. Dye testing may be used when the likely source of an illicit discharge has been narrowed down to a few specific locations or sections of the storm sewer system.

Smoke tests may also be used to confirm the hydraulic connection between a potential source and a downstream location. This procedure involves injecting non-toxic smoke into storm sewer lines and then noting the emergence of smoke from sanitary sewer vents in illegally connected buildings or from cracks and leaks in storm sewer lines.

Video inspections are another method that may be used to identify illicit discharge and/or connection problems. Mobile video cameras can be guided remotely through storm sewer lines to observe possible illegal connections into storm sewer systems; observations are recorded on a videocassette or DVD. The videos can then be reviewed and any visible illegal connections or sources of illicit discharge noted.

b. Conducting Field Screening Sampling

The collection of samples for field screening analysis and comparison with downstream samples may be used during a source investigation. Field screening sampling will include various site descriptions and a series of qualitative and quantitative observations of chemical, physical and biological conditions at the site such as abnormal discharge conditions, water quality indicators, and flow. An analytical monitoring component may also be included, which involves the collection of samples for a more extensive laboratory analysis.

c. Tracking Illegal Dumping

A means of collecting and tracking reports of illegal dumping will be included in the IDDE program to help locate sources of illicit discharge. Tracking will involve noting the materials that have been illegally dumped, recording where dumping occurs, and the date and time of day the illicit discharge occurs. Seeing patterns and documenting them may help identify illicit discharge sources and responsible parties.

d. Documenting Source Investigations

Proper documentation of illicit discharge investigations will be done, and will be completed regardless of the particular measures taken to locate the source. During an investigation photographs may be taken to document suspected illicit discharges and illegal connections, whether or not they are confirmed. An incident response report will be completed after each field investigation. Field investigation observations and forms, any sample results, correspondence and other associated documents will be collected and filed in a complaint database.

4. Removing the Source of an Illicit Discharge

Removing the source of an illicit discharge will be crucial to the successful implementation of the IDDE program. Because there are potentially various sources of illicit discharges to the City's storm sewer systems, there will be different kinds of actions taken to prevent illicit discharges from entering the storm system and remove those sources. These actions are grouped as:

a. Community outreach and involvement;

b. Compliance assistance and enforcement; and

c. Proper construction and maintenance of MS4s.

a. Community Outreach and Involvement

An important part of the City's IDDE program will be to inform the general public, businesses and public employees of hazards associated with illegal discharges and improper disposal of wastes. It is more effective to keep wastes from entering the storm drain system than identify and locate entities responsible for illegal dumping after the fact. Therefore a program to address illegal dumping that is focused on prevention through education will be emphasized. The requirement for public education and outreach on stormwater impacts is also one of the six minimum control measures in the City's stormwater management program. The IDDE outreach efforts will help meet this minimum control measure, and be integrated into the broader stormwater education program.

There are a number of ways in which the general public will be made aware of the IDDE program and the actions they can take to prevent illicit discharges. Example actions the City may take include:

- Inform and involve the public by distributing printed outreach materials, including flyers, posters and door-hangers. Examples of the information these materials will provide includes a description of stormwater pollution, a definition of what constitutes an illicit discharge, measures to prevent illicit discharges, ways to properly dispose of wastes, information about the City's illicit discharge ordinance, and legal consequences of illegally disposing of waste into the storm drain system;

- Support a program to promote, publicize, and facilitate public reporting of illicit connections or discharges through a hotline that citizens can call in to report suspected illicit discharges. The hotline will be monitored so that City staff can follow up quickly on violations.; and

- Work with citizen groups to mark storm inlets with a fish symbol and the message "Dump No Waste, Drains to Stream" (or a similar message). The message will increase awareness and remind people to keep pollutants out of storm drains.

Most businesses are willing to comply with environmental requirements and take a proactive approach to prevent pollution if they understand the issues and the possible solutions. There are several steps that the City will take to reach the business sector with information about illicit discharges and related pollution prevention that include:

- A general brochure or handout will be created to inform businesses about the IDDE program. This information will be presented and/or made available to the Downtown Business Association, Chamber of Commerce, and other business forums;

- Compliance assistance outreach will be conducted for specific business types, such as auto repair, mobile carpet cleaning, and restaurants. Methods of outreach will include distribution of printed materials, visits, and/or group training.

- Contractors and developers will be provided with information on preventing illegal connections.

City employees will play a role as partners in the detection and/or prevention of illicit discharges, both on City property and in the community. Public Works and Community Development staff will receive training on the requirements of the IDDE program and the techniques that will be used to carry it out. Other municipal employees and departments will also be included in the IDDE program training and implementation. For example:

- Public Works employees who maintain catch basins and do street sweeping will look for signs of illicit discharges;

- Municipal building inspectors will help ensure that illegal connections to the storm sewer system do not take place in construction and renovation projects;

- Police officers, Public Works employees, and other municipal staff whose jobs involve traveling around the city will help spot illegal dumpers; and

- Fire and police department personnel will assist with hazardous material spill response and work with hazardous material response agencies to help keep these spills out of the storm sewer system and adjacent water bodies.

A training program for municipal employees on pollution prevention techniques is required under the "Pollution Prevention and Good Housekeeping for Municipal Operations" minimum control measure. Preventing non-stormwater discharges into the storm sewer system from municipal operations will be one part of this training for City of Corvallis employees.

b. Compliance Assistance and Enforcement

There will be a range of methods by which the City will handle illicit discharge violations and removal of illegal connections between homes or businesses and the storm sewer system, depending on what is appropriate in a given situation. Typically, the City will respond to the discovery of an illegal discharge or connection in a graduated manner, beginning with efforts to obtain voluntary compliance and escalating to enforcement actions if compliance is not obtained. Voluntary return to compliance will be used for first-time, minor violations, whereas more serious violations or continued non-compliance will warrant a more aggressive and enforcement oriented approach.

Violations of the Illicit Discharge and Connection Control Ordinance will generally fall under one of two categories: *i*) illegal dumping or discharges and *ii*) illicit connections to the storm drain system. When the City determines that a violation has occurred, the City typically will contact the responsible party, evaluate the situation and conduct a site inspection. The responsible party or facility will then be required to take appropriate corrective measures to cease the illegal discharge or to eliminate any illicit connection as soon as possible.

If the responsible party is a resident or private home owner, then staff will inform them about the stormwater ordinance and explain why illegal discharges are harmful to the environment. The City's preference is to focus on educational efforts to correct residential pollution problems. Increasingly severe enforcement actions will be taken until compliance is achieved, or the illicit connection or illegal discharge is otherwise eliminated.

Industrial facilities and commercial businesses will be informed of the City's IDDE program, and will be requested to take certain measures such as implementing employee education programs related to IDDE, completing structural improvements, eliminating illicit connections, and/or preventing the reoccurrence of illegal discharges. The City will provide them with educational materials on stormwater issues, pollution prevention practices and IDDE.

Enforcement actions may be taken, depending on the seriousness of the violation. The appropriate enforcement actions will be determined on a "case by case" basis. If the situation involves a chronic violator or if compliance is not achieved in a timely fashion, enforcement actions will be escalated until the violations have ceased and the problem is corrected.

A variety of enforcement actions may be taken by the City. They are briefly summarized below:

- Warning: A warning may consist of a verbal notice or a written informational letter to the person, facility owner or responsible party. Often, home or business owners are not aware of the existence of illegal connections between their buildings and the storm sewer systems. Residents may not understand that a storm sewer inlet that they have dumped waste into is not connected to the City's waste water treatment system, but rather discharges to local streams. In these cases, providing the responsible party with information about the connection or discharge, its environmental consequences, the applicable regulations, and how to remedy it may be enough to secure voluntary compliance. The violator may be required to perform compensatory action such as attending pollution prevention workshops or participating in stream restoration projects.

- Notification of Violation: A Notification of Violation is a written notice to the facility owner or manager stating that the site has violated the City Municipal Code. In general, violation letters will state the nature of the violation, a date by which time the noncompliance must be corrected, and will include a statement warning of additional enforcement actions, including fines, if the situation is not corrected.

- Abatement and Urgency Abatement Measures: The City may enforce the ordinance by abatement proceedings, stop work order, civil action, criminal action for intentional and flagrant violations, or as otherwise authorized by law. The City of Corvallis may be authorized to enter onto private property to prevent or terminate an illegal discharge.

- Penalties: The City may pursue remedies including civil monetary penalties or jail sentencing.

c. Proper Construction and Maintenance of MS4s

Deteriorating or leaking pipes in the sanitary sewer or storm drain system can contribute to storm system pollution. Infiltration of sewage and other pollutants into the storm drain system can occur as the underground pipes age and develop cracks, leaks and breaks. Sanitary sewer and storm drain pipelines are often laid in close proximity to each other making them particularly susceptible to infiltration and eventual discharge of pollutants through the storm system to local streams.

The City has been and will continue to implement a sanitary sewer and storm system rehabilitation program to repair and/or replace cracked, broken, faulty or aging pipes. In general, the City fixes deteriorating or leaking sanitary sewer pipes by either replacing the line or lining the inside to seal off cracks, holes and leaking areas. Repair and maintenance efforts are prioritized based on a survey that takes into account pipe condition, evidence of breaks, cracks or leakage, complaint history and pipe age. Both MS4 and sanitary sewer systems will be inspected periodically and maintained as resources allow to keep them in good repair.

D. Measurable Goals

The basis for measuring the overall effectiveness of the IDDE program will be a comprehensive assessment of the activities implemented within the program. Evaluation procedures will include documentation of actions taken to locate and eliminate illicit discharges. A variety of measures of the program will be developed and tracked at both the programmatic and activity-specific level. Table ID-1 includes measurable goals and an implementation schedule for the first five years of the City's Illicit Discharge Detection and Elimination Program.

Table ID-1. Stormwater Phase II Measurable Goals for Illicit Discharge Detection and Elimination Program Implementation Schedule for Five Years

Activities	Year 1	Year 2	Year 3	Year 4	Year 5
Storm Sewer Map	Develop a storm sewer map that shows the location of all outfalls and the names and locations of all streams that receive discharges from those outfalls.	Update and continue.	Update and continue.	Update and continue.	Update and continue. Evaluate.
IDDE Ordinance	Continue enforcement of current IDDE code.	Continue enforcement of current IDDE code.	Create draft updated IDDE ordinance.	Create final draft and pass updated IDDE ordinance to prohibit illicit discharges and connections to the municipal separate storm sewer system.	Continue enforcement of updated code.
IDDE Database and Tracking System		Develop inspection/reporting forms and a database to track IDDE information. Associate database with storm sewer map.	Update and continue.	Update and continue.	Update and continue. Evaluate.
Dry Weather Outfall Surveys	Conduct dry weather outfall surveys to identify illicit discharges or connections. Perform on 20 percent of outfalls.	Update and continue in new areas.	Update and continue in new areas.	Update and continue in new areas.	Update and continue in new areas. Evaluate.

Activities	Year 1	Year 2	Year 3	Year 4	Year 5
Storm Drain Marking	Continue the City's current storm drain marking program. Work with volunteers to mark at least 100 storm drains.	Continue in new areas.	Continue in new areas.	Continue in new areas.	Continue in new areas. Evaluate.
IDDE Door-Hangers		Create and distribute door hangers with illicit discharge detection and elimination information. Distribute at least 400 door-hangers.	Update and continue in new areas.	Update and continue in new areas.	Update and continue in new areas. Evaluate.
IDDE Hotline	Develop a hotline that citizens can call in to report suspected illicit discharges or connections; monitor and follow up on calls.	Update and continue.	Update and continue.	Update and continue.	Update and continue. Evaluate.
Residential Pollution Prevention Program			Develop pollution prevention program tailored to homeowners addressing auto care, landscaping, pet waste disposal, etc. Supply information on IDDE ordinance. Provide educational flyers. Present to at least 20 individuals or 6 groups.	Update and continue in new areas.	Update and continue in new areas. Evaluate.

Activities	Year 1	Year 2	Year 3	Year 4	Year 5
Business Pollution Prevention Program				Develop pollution prevention program tailored to business owners. Include information on IDDE ordinance. Address multiple pollution prevention related issues and BMPs. Include educational handouts and certificates. Present to at least 10 business or work groups.	Update and continue in new areas. Evaluate.
Municipal Operation Stormwater Pollution Prevention BMP Implementation				Continue to implement stormwater pollution prevention BMPs already in place. Implement additional BMPs as resources allow. Train municipal staff on how to identify and report illegal discharges of pollutants into the stormwater system when they are on the job and/or driving around the City.	Update and continue.

City of Corvallis Stormwater Phase II
Illicit Discharge Detection and Elimination Program

Appendix ID-A

STORMWATER SYSTEM MAP

City of Corvallis Stormwater Phase II
Illicit Discharge Detection and Elimination Program

Appendix ID-B

DRAFT CORVALLIS IDDE ORDINANCE

Month Date, 2007

DRAFT

Ordinance Number 2007 - *

AN ORDINANCE CREATING A NEW CHAPTER 4.04 "URBAN STORMWATER QUALITY MANAGEMENTAND DISCHARGE CONTROL," TO THE CORVALLIS MUNICIPAL CODE.

THE CITY OF CORVALLIS ORDAINS AS FOLLOWS:

Section 1. Municipal Code Chapter 4.04, Urban Stormwater Quality Management and Discharge Control, is added as follows:

URBAN STORMWATER QUALITY MANAGEMENTAND DISCHARGE CONTROL

Sections:

Section 4.04.010 Title, Purpose and General Provisions

Section 4.04.010.010 Title

This Article shall be known as the "Urban Stormwater Quality Management and Discharge Control Ordinance" of the City of Corvallis and may be so cited.

Section 4.04.010.020 Purpose and Intent

The purpose and intent of this Article is to protect the health, safety and general welfare of citizens, and protect the water quality of watercourses and waterbodies in a manner pursuant to and consistent with the Federal

Clean Water Act (33 U.S.C. 1251 et seq., 86 Stat. 816, Pub. L. 92-500) by reducing pollutants in stormwater discharges to the maximum extent practicable. The objectives of this Article are:

1) To prohibit non-stormwater discharges or pollutants to the storm drainage system by any user;

2) To prohibit illegal connections to the storm drainage system; and

3) To establish legal authority to carry out all inspection, surveillance and monitoring procedures necessary to ensure compliance with this Article.

Section 4.04.010.030 Applicability

This Article shall apply to all areas contributing flow to the City owned storm drainage system generated on any developed and undeveloped lands lying within the City limits of Corvallis.

Section 4.04.010.040 Compatibility with Other Regulations

This Article is not intended to modify or repeal any other article, ordinance, rule, regulation, or other provision of law. The requirements of this Article are in addition to the requirements of any other article, ordinance, rule, regulation or other provisions of laws and where any provision of this Article imposes restrictions different from those imposed by any other article, ordinance, rule, regulation or other provision of law, whichever restriction is more restrictive or imposes higher protective standards for human health or the environment shall control. Any remedies or penalties established in this article are intended to be cumulative and in addition to, not in place of any other remedy or penalty imposed by any other article, ordinance, rule, regulation or provision of law.

Section 4.04.010.050 Severability

The provisions of this Article are hereby declared to be severable. If the provisions of any section, subsection, paragraph, subdivision or clause of this Article shall be adjudged invalid by a court of competent jurisdiction, such judgment shall not affect the other provisions or application of this Article.

Section 4.04.010.060 Responsibility for Administration

The City of Corvallis shall administer, implement, and enforce the provisions of this Article.

Section 4.04.020 Definitions

1) Accidental Discharge means a discharge prohibited by this Article which occurs by chance and without planning or thought prior to occurrence.

2) Best Management Practices (BMPs) means procedures, practices, prohibition of practices, activities, and educational activities used to prevent or reduce the discharge of pollutants directly or indirectly to streams, water courses, and waters of the state or United States. BMPs include but are not limited to treatment requirements; operating and maintenance procedures; proper waste disposal; practices to control site runoff, spillage or leaks, and drainage of materials from storage; and the prohibition of specific activities, practices and procedures.

3) City of Corvallis means the designated authority(s) employed by or duly representing the City, and charged with the administration and enforcement of this Article.

4) Clean Water Act means the Federal Water Pollution Control Act (33 U.S.C. ' 1251 et seq., 86 Stat. 816, Pub. L. 92-500) and any subsequent amendments thereto.

5) Construction Activity means ground disturbing activities whether or not a permit is required, or any ground-work activities that include but are not limited to clearing and grubbing, grading, excavating, demolition and building.

6) Hazardous Materials means any material, including any substance, waste, or combination thereof, which because of its quantity, concentration, or physical, biological, chemical, or infectious characteristics may cause, or significantly contribute to, a substantial present or potential hazard to human health, safety, property, or the environment when improperly treated, stored, transported, disposed of, or otherwise managed.

7) Illicit Discharge means any direct or indirect non-stormwater discharge to the storm drainage system, except as exempted in Section 4.04.030 of this Article.

8) Illegal Connection means any of the following:

a) Any drain or conveyance, whether on the surface or subsurface, which allows an illegal discharge to enter the storm drainage system including, but not limited to, any conveyances which allow any non-stormwater discharge including sewage, process wastewater, and wash water to enter the storm drainage system or;

b) Any connections to the storm drain system from indoor drains and sinks, regardless of whether said drain or connection had been previously allowed, permitted, or approved by an authorized enforcement agency or;

c) Any pipe, open channel, drain or conveyance connected to the storm drainage system which has not been documented in plans, maps, or equivalent records and approved by an authorized enforcement agency.

9) Industrial Activity means any activity subject to NPDES Industrial Permits as defined in 40 CFR, Section 122.26 (b)(14), or any activity of, relating to, or resulting from industry.

10) National Pollution Discharge Elimination System Stormwater Discharge Permit means a permit issued by the Oregon Department of Environmental Quality under authority delegated pursuant to 33 USC ' 1342(b) that authorizes the discharge of pollutants to waters of the United States, whether the permit is applicable on an individual, group, or general area-wide basis.

11) Non-Stormwater Discharge means any discharge to the storm drainage system that contains pollutants and is not composed entirely of stormwater.

12) Person means, except to the extent exempted from this Article, any individual, partnership, firm, association, joint venture, public or private corporation, trust, estate, commission, board, public or private institution, utility, cooperative, city, county, or other political subdivision of the State, any interstate body or other legal entity.

13) Pollutant means anything which causes or contributes to pollution. Pollutants may include, but are not limited to: paints, varnishes, and solvents; oil and other automotive fluids; non-hazardous liquid and solid wastes and yard wastes; refuse, rubbish, garbage, litter, or other discarded or abandoned objects and accumulations, so that same may cause or contribute to pollution; floatables; pesticides, herbicides, and fertilizers; hazardous substances and wastes; sewage, fecal coliform and pathogens; dissolved and particulate metals; animal wastes; wastes and residues that result from constructing a building or structure; and noxious or offensive matter of any kind.

14) Pollution means the contamination or other alteration of any water's physical, chemical or biological properties by the addition of any constituent and includes but is not limited to, a change in temperature, color, turbidity, taste or odor of such waters, or the discharge of any liquid, gaseous, solid, radioactive, or other substance into any such waters as will or is likely to create a nuisance or render such waters harmful, detrimental or injurious to the public health, safety, welfare or environment, or to domestic, commercial, industrial, agricultural, recreational or other legitimate beneficial uses, or to wild animals, birds, fish or other aquatic life.

15) Premises mean any building, lot, parcel of land, or portion of land whether improved or unimproved including adjacent sidewalks and parking strips.

16) State Waters means any and all rivers, streams, creeks, lakes, reservoirs, ponds, drainage systems, springs, wells and other bodies of surface or subsurface water, natural or artificial, lying within or forming a part of the boundaries of the State of Oregon which are not entirely confined and retained upon the property of a single person.

17) Storm Drainage System means any facility designed or used for collecting and/or conveying stormwater, including but not limited to any roads, highways, or municipal streets with drainage systems, curbs, gutters, inlets, catch basins, piped storm drains, structural stormwater controls, streams, ditches, swales, natural and man-made or altered drainage channels, and other drainage structures.

18) Storm Sewer System means municipal drainage systems, curbs, gutters, inlets, catch basins, piped storm drains, structural stormwater controls, and other drainage structures.

19) Stormwater Runoff or Stormwater means any surface flow, runoff, and drainage consisting entirely of water from any form of natural precipitation, and resulting from such precipitation.

Section 4.04.030 Prohibitions

Section 4.04.030.010 Prohibition of Illicit Discharges

No person shall discharge or cause to be discharged into the municipal storm drainage system or watercourses any pollutants or waters containing any pollutants.

1) The commencement, conduct or continuance of any discharge other than stormwater to the storm drainage system is prohibited except as described as follows:

a) The following discharges are exempt from the prohibition provision above: flow from landscape irrigation or lawn watering; discharge from water line flushing or other potable water sources; uncontaminated discharge from a foundation drain, crawl space pump, or footing drain; discharge from individual residential or non-commercial car washing; discharge from cold water (or hot water with prior permission of the City of Corvallis) used in parking lot washing that is not contaminated with any detergent, emulsifier or any other harmful cleaning substance; air conditioning condensation; drainage from a private residential swimming pool containing no harmful quantities of chlorine or other chemicals; discharge of uncontaminated storm water pumped from an excavation; discharge from fire fighting activities; flow from a diverted stream or natural spring; groundwater infiltration into the storm drain system; uncontaminated pumped groundwater or rising groundwater; flow from a natural riparian habitat or wetland; and any other source not containing pollutants.

b) Discharge specified in writing by the City of Corvallis as being necessary to protect public health and safety.

c) Dye testing is an allowable discharge, but requires written approval by the City of Corvallis prior to the time of the test.

d) The prohibition shall not apply to any non-stormwater discharge permitted under an NPDES permit, waiver, or waste discharge order issued to the discharger and administered under the authority of the Federal Environmental Protection Agency, provided that the discharger is in full compliance with all requirements of the permit, waiver, or order and other applicable laws and regulations, and provided that written approval has been granted by the City of Corvallis for any discharge to the storm drain system.

e) The prohibition shall not apply to any uncontaminated surface discharge provided that written approval has been granted by the City of Corvallis for any discharge to the storm drain system.

2) The City of Corvallis may require best management practices to reduce pollutants, and may prohibit a specific discharger from engaging in a specific activity identified in subsection 1) if at any time the City of Corvallis determines that the discharge is, was, or will be a significant source of pollution.

3) Any action by any person that imperils permits granted by any other regulatory agency to the City of Corvallis, or causes a violation of the terms of a permit granted to the City of Corvallis by any other regulatory agency is prohibited.

(Ord. 2000-10 § 3, 05/15/2000; Ord. 91-19 § 1, 1991; Ord. 83-3 § 3, 1983; Ord. 82-79 § 4, 1982)

Section 4.04.030.020 Prohibition of Illegal Connections

The construction, connection, use, maintenance or continued existence of any illegal connection to the City of Corvallis storm sewer system is prohibited.

1) This prohibition expressly includes, without limitation, illicit connections made in the past, regardless of whether the connection was permissible under law or practices applicable or prevailing at the time of connection.

2) A person is considered to be in violation of this Article if the person connects a line conveying sewage to the storm sewer system, or allows such a connection to continue.

3) Improper connections in violation of this Article must be disconnected and redirected, if necessary, to an approved onsite wastewater management system or the sanitary sewer system upon approval of the City of Corvallis.

(Ord. 2000-10 § 3, 05/15/2000; Ord. 91-19 § 1, 1991; Ord. 83-3 § 3, 1983)

Section 4.04.040 Discharges in Violation of Industrial or Construction Activity Permit

1) Any person subject to an industrial or construction activity NPDES stormwater discharge permit and/or any City of Corvallis issued permits shall comply with all provisions of such permit(s). Proof of compliance with said permit(s) may be required in a form acceptable to the City of Corvallis prior to or as a condition of a site plan, building permit, or development or improvement plan; upon inspection of the facility; during any enforcement proceeding or action; or for any other reasonable cause.

2) In addition to any other criminal or civil penalty for violation of any NPDES stormwater discharge permit and/or City of Corvallis issued permit, a person who knowingly violates such a permit and discharge into a City system has violated this chapter.

(Ord. 2004-17 § 1, 10/01/2004; Ord. 2000-10 § 3, 05/15/2000; Ord. 97-24, 1997; Ord. 90-03 § 6, 1990; Ord. 83-3 § 3, 1983)

Section 4.04.050 Access and Inspection of Properties and Facilities

When it may be necessary to inspect to enforce the provisions of this Article, a City of Corvallis representative shall be permitted to enter and inspect properties and facilities at reasonable times as often as may be necessary to determine compliance with this Article.

1) If such a property or facility is occupied, City staff credentials will be presented to the owner or other person having charge or control of the building and entry requested. If such a property or facility is unoccupied, the

City of Corvallis may enter the property if emergency abatement is required, as described in Section 4.04.070.050 of this Article.

2) The owner or operator shall allow the City of Corvallis ready access to all parts of the premises for the purposes of inspecting, sampling, photographing, videotaping and examining activities subject to this Article.

3) The City of Corvallis shall have the right to set up on any property or facility such devises as are necessary in the opinion of the City of Corvallis to conduct monitoring and/or sampling of flow discharges.

4) Whenever the City of Corvallis determines that any person engaged in any activity and/or owning or operating any facility which may cause or contribute to stormwater pollution or illicit discharge to the storm drainage system, a City of Corvallis representative may, by written notice, order that such a person undertake such monitoring activities and/or analyses and furnish such reports as the City of Corvallis may deem necessary to demonstrate compliance with this Article. The written notice shall set forth the basis for such order and shall particularly describe the monitoring activities and/or analyses and reports required. The sampling and monitoring equipment shall be maintained at all times in a safe and proper operating condition by the owner or operator at his/her own expense. All devices used to measure flow and quality shall be calibrated to ensure their accuracy. The burden to be borne by the owner or operator, including costs of these activities, analyses and reports, shall bear a reasonable relationship to the need for the monitoring, analyses, and reports, and the benefits to be obtained. The recipient of such order shall undertake and provide the monitoring, analyses, and reports within the time frames set forth in the order.

5) Unreasonable delays in allowing the City of Corvallis access to a facility are a violation of this Article.

6) If the City of Corvallis has been refused access to any part of the premises from which the stormwater is discharged, and the City of Corvallis is able to demonstrate probable cause to believe that there may be a violation of this Article, or to protect the overall public health, safety, environment and welfare of the community, then the City of Corvallis shall have recourse to the remedies provided by Municipal Code Chapter 1.15 Administrative Search Warrants to secure entry.

(Ord. 90-03 § 7, 1990; Ord. 83-3 § 71, 1983)

Section 4.04.060 Response to Discovery of Discharges and Spills

Notwithstanding other requirements of law, as soon as any person responsible for a facility, activity or operation, or responsible for emergency response for a facility, activity or operation has information of any known or suspected release of pollutants or non-stormwater discharges into the storm drain system, streams, water courses and waters of the state or United States, said person shall take all necessary steps to ensure the discovery, containment, and cleanup of such release so as to minimize the effects of the discharge. Said person shall also take immediate steps to ensure no recurrence of the discharge or spill.

Section 4.04.070 Notification of Discharges and Spills

1) In the event of a release of hazardous material, as soon as any person responsible for a facility, activity or operation, or responsible for emergency response for a facility, activity or operation has information of any known or suspected release of pollutant or non-stormwater discharge into the storm drain system, stream, water course and water of the state or United States, said person shall immediately notify emergency response agencies of the occurrence via emergency dispatch services (911).

2) In the event of a release of non-hazardous material, said person shall notify the City of Corvallis in person, or by phone or facsimile as soon as known but no later than the next business day. Notification shall include information on the location, nature, quantity and time of occurrence of the discharge.

3) If the discharge of pollutant emanates from a commercial or industrial establishment, notifications in person or by phone shall be confirmed by written notice addressed and mailed to the City of Corvallis within five business days of the phone notice. Additionally, the owner or operator of such establishment shall retain an on-site written record of the discharge and the actions taken to prevent its recurrence. Such records shall be retained for at least three years and provided to the City of Corvallis at its request.

4) Failure to notify the City of Corvallis as requested by this section shall be a violation of this Chapter.

Section 4.04.080 Violations, Enforcement and Penalties

Section 4.04.080.010 Violations

It shall be unlawful for any person to violate any provision or fail to comply with any of the requirements of this Article. Any person who has violated or continues to violate the provisions of this Article may be subject to enforcement actions outlined in the following provisions and/or may be subject to abatement and/or to any other remedy provided by law.

Section 4.04.080.020 Notification of Violation

Whenever the City of Corvallis finds that a violation of this Article has occurred, the City of Corvallis may issue a written notice of violation to the responsible person.

1) The notice of violation shall contain:
   a) The name and address of the alleged violator;
   b) The address when available or a description of the building, structure or land upon which the violation is occurring or has occurred;
   c) A statement specifying the nature of the violation;
   d) A statement of the penalty or penalties that shall or may be assessed against the person to whom the notice of violation is directed; and
   e) A statement that the determination of violation may be appealed to the City Manager by filing a written notice of appeal within ten days of service of the violation.
2) Such notice may require without limitation:
   a) The performance of monitoring, analysis and reporting;
   b) The elimination of illicit discharges and illegal connections;
   c) The abatement of stormwater pollution and the restoration of any affected property;
   d) The implementation of source control or treatment Best Management Practices (BMPs); and
   e) Payment of costs to cover administrative, abatement and remediation expenses.
3) If abatement of a violation and/or restoration of affected property is required, the notice shall set forth a deadline within which such remediation or restoration must be completed. Said notice shall further advise that, should the violator fail to remediate or restore within the established deadline, the work will be done by the City or contractor designated by the City of Corvallis and the expense thereof shall be charged to the violator, pursuant to Section 4.04.080.040 below.

(Ord. 90-03 § 6, 1990; Ord. 83-3 § 73, 1983)

Section 4.04.080.030 Appeal of Notice of Violation

Any person receiving a Notice of Violation may appeal the determination of the City of Corvallis to the City Manager. The Notice of Appeal must be received within ten days from the date of the Notice of Violation. Hearing on the appeal before the City Manager. or his/her designated authority, shall take place within thirty days of the date of receipt of the notice of appeal. The decision of the City Manager or his/her designee may be appealed to the City Council pursuant to Municipal Code Chapter 1.11.

Section 4.04.080.040 Abatement Measures

In addition to any other remedies, the City of Corvallis may enforce this chapter by abatement proceedings; stop work order; civil action; criminal action for intentional and flagrant violations of this Article; or as otherwise authorized by law. If the violation has not been corrected pursuant to the requirement set forth in the Notice of Violation, or, in the event of an appeal, within ten days of the decision of the City Manager upholding the decision of the City of Corvallis, then the City or a contractor designated by the City of Corvallis is authorized to take any and all measures necessary to abate the violation and/or restore the property.

Section 4.04.080.050 Urgency Abatement

The City of Corvallis is authorized to require immediate abatement of any violation of this Article that constitutes an immediate hazard to public health, safety, water resources or aquatic life. If any such violation is not abated immediately as directed by the City of Corvallis, a City of Corvallis representative is authorized to enter onto private property if necessary and to take all measures required to remediate the violation. Any relief obtained under this section shall not prevent the City of Corvallis from seeking other and further relief authorized under this Article.

Section 4.04.080.060 Costs of Abatement of the Violation

1) The City of Corvallis is authorized to charge any person in violation of this Article for the cost of abatement, including sampling and monitoring, containing and cleaning up the polluted discharge, administrative and legal costs, and any other expenses associated with enforcement of this Article.

2) The City of Corvallis shall notify the person who committed the violation of the amount of the cost for abatement within thirty days after abatement of the violation is complete. The person who committed the violation may file a written protest objecting to the abatement or to the amount of the charges within ten days of such notice.

3) If the amount due is not paid within thirty days after receipt of the notice, or if an appeal is taken, within thirty days after a decision on said appeal, the City may bring a claim for these charges to the Municipal Court. The Municipal Judge shall enter a judgement against that person for the amount of the costs, and for the interest on the judgement at the statutory rate if the City establishes by a preponderance of evidence that:

a) abatement was required for a discharge and the person was responsible for the discharge, or
b) that person violated this article, and
c) that the City incurred costs for abatement, and
d) that the person has not paid the City the amount in full.

4) The Municipal Judge may not, under any circumstances, reduce or waive any portion of the cost expended by the City for abatement.

5) The Municipal Judge shall order the City to take whatever action is required to perfect a judgement lein against the property of the person in favour of the City.

(Ord. 83-3 § 73, 1983)

Section 4.04.080.070 Penalties

1) Any person who is found to have negligently violated this Article or who negligently failed to comply with any provisions herein, and the orders, rules and regulations issued hereunder may be fined not less than $100 nor more than $1000 for each violation. Each day on which a violation occurs or continues to occur shall be deemed a separate and distinct offense.

2) Any person who is found to have intentionally or knowingly violated this Article or who intentionally or knowingly failed to comply with any provisions herein, and the orders, rules and regulations issued hereunder may be fined not less than $250 nor more than $1500 for each violation or may be sentenced to jail for no more than 30 days for each violation, or both. Each day on which a violation occurs or continues to occur shall be deemed a separate and distinct offence.

3) Any person who knowingly makes any false statement, representation or certification in any application, record, report, plan or other document filed or required to be maintained pursuant to this Article, or who falsifies, tampers with or knowingly renders inaccurate any monitoring device or method required hereunder may, upon conviction, be fined not less than $100 nor more than $20,000, or by imprisonment for not more than 6 months or both.

4) Any person who negligently, knowingly, or intentionally violates this Article in a manner that causes the City of Corvallis to be fined by any regulatory agency shall be subject to a fine that trebles the amount of any fine to the City, or may be sentenced to jail for no less than 60 days and no more than 180 days, or both.

5) Penalties imposed under this section shall be separate from, and in addition to, any cost of abatement of the violation.

(Ord. 97-24 § 4, 1997; Ord. 90-03 § 8, 1990; Ord. 83-3 § 73, 1983)

Section 4.04.080.080 Compensatory Action

In lieu of enforcement proceedings, penalties, and remedies authorized by this Article, the City of Corvallis may issue a verbal warning in response to minimal and isolated occurrence of non-compliance by any person in violation of this Article. The City of Corvallis may require alternative compensatory action(s) from that violator; such as participating in public education efforts, attending pollution prevention workshops, or participating in stream restoration projects. Failure to perform a required alternative compensatory action shall be a violation of this Article, subject to the penalties in section 4.04.080.070.

Section 4.04.080.090 Remedies Not Exclusive

The remedies listed in this Article are not exclusive of any other remedies available under applicable local, State or Federal law and the City of Corvallis may seek cumulative remedies.

Section 4.04.080.100 Ultimate Responsibility of Discharger

The standards set forth herein and promulgated pursuant to this Article are minimum standards; therefore this Article does not intend nor imply that compliance by any person will ensure that there will be no contamination, pollution, nor unauthorized discharge of pollutants into streams, water courses and waters of the state or United States caused by said person. This Article shall not create liability on the part of the City of Corvallis, or any agent or employee thereof for any damages that result from any discharger's reliance on this Article or any administrative decision lawfully made thereunder.

PASSED by the City Council this ________ day of ________________, 2006

APPROVED by the Mayor this ________ day of ________________, 2006

EFFECTIVE this ________ day of ________________, 2006

____
Mayor

ATTEST:

____
City Recorder

City of Corvallis Stormwater Phase II
Construction Site Stormwater Runoff Control Program

The Construction Site Stormwater Runoff Control Measure is one of six measures the City of Corvallis, as an operator of a Phase II regulated municipal separate storm sewer system (MS4), is required to include in its stormwater management program to meet the conditions of its stormwater permit. The following document outlines the City's construction site erosion prevention plan that will be implemented as part of the stormwater management program.

I. INTRODUCTION

Activities at construction sites can result in the release of significant amounts of pollutants into the storm drain system unless proper erosion prevention and sediment control techniques are used. Construction projects often involve the removal of vegetation and excavation of soils; runoff can carry disturbed soil off-site to storm inlets and pollute waterways. Other activities conducted at construction sites, including materials storage, fueling, and vehicle and equipment use can also result in the release of pollutants to the storm drain system. The primary pollutants generated by or resulting from construction activities include sediment, particulates and debris. Construction site activities must be addressed through a planning, permitting and Best Management Practice (BMP) implementation process to minimize pollutants from entering the City's drainage system and local waterbodies.

II. ELEMENTS OF THE CONSTRUCTION SITE STORMWATER RUNOFF CONTROL PROGRAM

The City of Corvallis will develop a Construction Site Stormwater Runoff Control Program based on EPA guidelines. The Phase II regulations for the Construction Site Stormwater Runoff Control component described in federal code are summarized below:

The permittee must develop, implement, and enforce a program to reduce polluted runoff resulting from construction activities and the risk of related water quality problems. The Environmental Protection Agency recommends that the permittee consider the following in developing and implementing the program:

A. 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;

B. Procedures for project site plan review which evaluate erosion control measures and construction activity potential water quality impacts; requirements for construction site operators to implement appropriate erosion and sediment control best management practices; requirements for construction site operators to control waste materials/products 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 inspection and enforcement of control measures; procedures for receipt and consideration of information submitted by the public;

C. Plans to educate the construction community and municipal staff; and

D. Appropriate measurable goals as a means of assessing the Construction Site Runoff Control Program.

The City is also considering entering into an agreement with the Oregon Department of Environmental Quality to administer the National Pollutant Discharge Elimination System 1200-C General Permit for Stormwater Discharges from Construction Activities (NPDES 1200-C) at the local level.

A. Erosion and Sediment Control Ordinance

A municipal erosion prevention and sediment control ordinance has been developed by City staff. The current version of this ordinance is included in Appendix EP-A. The purpose of this ordinance is to establish uniform requirements for construction related activities in order to minimize erosion and sediment transport during construction and development. This ordinance is intended to:

- Minimize the amount of sediment and other construction related pollutants entering the municipal storm sewer system and surface waters from ground disturbing activities;
- Establish authority to develop procedures and policies to administer erosion control provisions;
- Establish Erosion Prevention and Sediment Control Plan requirements for qualifying development projects; and
- Establish authority for conducting inspections, granting approvals and enacting monitoring and enforcement procedures necessary to ensure compliance with the ordinance.

B. Erosion Prevention and Sediment Control Manual

The City of Corvallis has developed an Erosion Prevention and Sediment Control Manual. The manual is designed to meet the requirements of the City's NPDES Phase II Stormwater permit, and fulfills guidelines for site plan review, BMP selection and implementation, site inspection and enforcement measures, and receipt and consideration of information submitted by the public. A draft of this document can be found in Appendix EP-B. The manual includes procedures for plan review, and provides technical guidance for the design, installation, maintenance and inspection of temporary and permanent erosion prevention and sediment control BMPs. The manual is intended for use by site designers, developers, contractors and inspectors during the construction process. The manual is also intended to have educational value to the public.

The manual is divided into five chapters plus appendices:

Chapter 1 - Introduction and Background
This chapter provides an introduction to the manual and educational information regarding the background and basis for the City's development of erosion prevention and sediment control standards and an overview of erosion processes and the environmental impacts created by erosion from construction sites.

Chapter 2 - Erosion Control Planning and Design
This chapter discusses the issues important to the planning and design process for an effective erosion prevention and sediment control plan. Section 2.6 discusses plan submittal and permit requirements.

Chapter 3 - Erosion Prevention and Sediment Control Measures
This chapter presents best management practices for erosion prevention and sediment control for

construction sites and is intended to help the designer choose the most appropriate measure(s) or control(s).

Chapter 4 - Construction Site Pollution Control Measures
This chapter gives an overview of the environmental impacts created by pollution generated by construction site activities. The chapter describes planning and implementation of controls that can be used on a construction site.

Chapter 5 - Maintenance and Inspection
This chapter provides guidelines for the proper implementation, maintenance and inspection of erosion prevention and sediment control measures.

Appendices
This section provides sample plans, forms and recommended standards.

C. Education and Outreach

The City will conduct education and outreach to the general construction community, including developers, contractors, designers and builders on construction site requirements and BMPs. Materials will also be provided to homeowners and the general public regarding the requirements and the permit process. For example, erosion prevention and sediment control brochures and/or handouts will be available at the public counters of both the Planning and Public Works Departments, and through Development Services staff (who issue construction permits). The City will also consider doing a mailing to all area construction contractors. Workshops may also be held by the City to inform local contractors, construction workers, and the general public. Topics will likely include:

- Permit requirements;
- Policies and regulations;
- Erosion processes;
- Erosion control planning strategy;
- Best management practices;
- Erosion control plan preparation; and
- Installation, inspection and maintenance requirements.

Training and education of City staff will also be an important component of the Construction Site Stormwater Runoff Control Program. Appropriate Development Services and Public Works staff members will be trained on the new requirements and BMPs. Training will include periodic meetings to discuss erosion prevention and construction site pollution prevention issues and procedures. Training materials may include the City's Erosion Prevention and Sediment Control Manual, information published by the EPA, State of Oregon, the International Erosion Control Association, and other sources.

D. Measurable Goals

Developing a long-term strategy for implementing and evaluating the Construction Site Stormwater Runoff Control Program will be an important part of implementing a comprehensive stormwater pollution prevention program. The five-year implementation schedule for the Construction Site Stormwater Runoff Control Program is shown in Table CR-1.

Table CR-1. Stormwater Phase II Measurable Goals for Construction Site Stormwater Runoff Control Program Implementation Schedule for Five Years

Activities	Year 1	Year 2	Year 3	Year 4	Year 5
EPSC Ordinance	Develop draft EPSC ordinance.	Complete final edits of EPSC ordinance; obtain approval of City Council.	Update and continue.	Update and continue.	Update and continue. Evaluate.
EPSC Manual	Develop draft EPSC manual.	Complete final edits of EPSC manual. Distribute to construction community and appropriate municipal staff.	Update and continue.	Update and continue.	Update and continue. Evaluate.
BMP Fact Sheets		Create fact sheets that describe construction site pollution prevention BMPs; include in manual.	Update and continue.	Update and continue.	Update and continue. Evaluate.
Erosion Prevention and Sediment Control Education		Create and distribute educational materials on erosion prevention and sediment control ordinance, permitting and BMPs for single and multiple lot development. Provide to municipal staff and the construction community. Make available to all persons requesting building/site planning and inspection services through the City's Community Development Department.	Update and continue.	Update and continue.	Update and continue. Evaluate.

Activities	Year 1	Year 2	Year 3	Year 4	Year 5
EPSC Permitting and Inspection Program		Identify inspection and permitting protocol for construction site construction site pollution prevention. Apply to applicants and sites. Develop and initiate related inspection procedure.	Update and continue.	Update and continue.	Update and continue. Evaluate.
Record Keeping			Develop and implement EPSC record keeping procedure for permitting, BMP inspections, and workshop training programs.	Update and continue.	Update and continue. Evaluate.

City of Corvallis Stormwater Phase II
Construction Site Stormwater Runoff Control Program

Appendix CR-A

Erosion Prevention and Sediment Control Ordinance

Chapter 9.03

Erosion Prevention and Sediment Control

Sections:

Section 9.03.010 Title.

These regulations contained herein, together with the Erosion Prevention & Sediment Control Manual, shall be known as the "City of Corvallis Erosion Prevention and Sediment Control Standards," may be cited as such and will be referred to herein as "these Standards."
(Ord. 2004-17 §1, 09/20/2004)

Section 9.03.020 Purpose.

The purpose of these Standards is to establish uniform requirements for development and construction related activities in order to control the occurrence of erosion and to prevent the creation, migration and/or transport of erosion at the source during construction and development.
(Ord. 2004-17 §1, 09/20/2004)

Section 9.03.030 Scope.

1) These Standards apply to all ground disturbing activities whether or not a permit is required, unless such activities otherwise are exempted by Corvallis Municipal Code.

2) Compliance with Other Laws.

a) The requirements of these Standards are minimum requirements. Compliance with these Standards does not in any way imply, either directly or indirectly, compliance with any other law. Where the provisions of these Standards are more restrictive than those set forth in other regulations under the City Municipal Code, Land Development Code, or ordinance, the provisions of these Standards shall control. Where State or Federal natural resource agency permit requirements address erosion prevention and sediment control, the responsible party shall ensure that the State or Federal resource protection requirements have been resolved.
(Ord. 2004-17 §1, 09/20/2004)

Section 9.03.040 Severability.

If any section, paragraph, subdivision, clause, sentence, or provisions of this title shall be adjudged by any court of competent jurisdiction to be unconstitutional or invalid, such judgment shall not affect, impair, invalidate, or nullify the remainder of the title, but the effect thereof shall be confined to the section, paragraph, subdivision, clause, sentence or provision immediately involved in the controversy in which such judgment or decree shall be rendered, it being the intent of the governing body to enact the remainder of this title notwithstanding the parts to be declared unconstitutional and invalid.
(Ord. 2004-17 §1, 09/20/2004)

Section 9.03.050 Liability.

The City officials charged with the enforcement of this code, acting in good faith and without malice in the discharge of the duties required by this code or other related laws and ordinances shall not thereby be rendered personally liable for damages that may accrue to persons or property as a result of an act or by reason of an act or omission in the discharge of such duties.
(Ord. 2004-17 §1, 09/20/2004)

Section 9.03.060 Definitions.

For the purpose of this chapter, the following definitions shall apply:

1) **Approval or Approved** - a determination by the City Manager or his/her designee that the provisions of these Standards have been met.

2) **Best Management Practices (BMPs)** - a physical, chemical, structural or managerial practice that prevents, reduces, or treats contamination of water or which prevents or reduces soil erosion.

3) **City Manager** - the City Manager or other designated authority charged with the administration and enforcement of these Standards, or the City Manager's duly authorized representative.

4) **Erosion** - the wearing away of the earth's surface due to the action of gravity, wind, water or other mechanical forces.

5) **Ground Disturbing Activity** - any activity that exposes soil.

6) **Pollutants** - substances that contaminate the soil or water originating on a construction site. Pollutants commonly associated with construction sites include sediment, solid and sanitary wastes, fertilizers, pesticides, oil and grease, concrete truck washout, sheet rock taping compound, glues, epoxies, paints, construction chemicals and construction debris.

7) **Responsible Party** - the property owner or person authorized to act on the owner's behalf; or any person allowing, causing or contributing to a violation of the Code.

8) **Sediment** - mineral or organic matter generated as a result of erosion.

9) **Visible and Measurable Erosion and Sediment Release -**

a) sloughing, mud flows, gullies, sediment laden water, or other visual evidence that erosion has occurred or is likely to occur.

b) the presence of deposits or tracking of sediment exceeding one half cubic foot in volume at any one time on public or private streets, in drainage systems, and/or on adjacent property.

c) in streams or drainage systems, an increase in total suspended solids and/or turbidity relative to a control point immediately upstream of the discharge point of the sediment generating activity.

d) evidence of off site airborne sediment clearly visible to the eye.

(Ord. 2004-17 §1, 09/20/2004)

Section 9.03.070 Authority.

1) These Standards shall be administered and enforced by the City Manager.

2) The City Manager shall have the authority to develop and implement procedures, forms,

policies, and interpretations for administering the provisions of these Standards.
(Ord. 2004-17 §1, 09/20/2004)

Section 9.03.080 Erosion Prevention and Sediment Control.

Erosion and sediment release shall be minimized to the greatest extent practicable utilizing best management practices and the standards in the Erosion Prevention and Sediment Control Manual. The City Manager shall make minimization determinations based upon the visible and measurable erosion and sediment release criteria versus the best management practices (BMP's) being applied.
(Ord. 2004-17 §1, 09/20/2004)

Section 9.03.090 Permit Required.

An erosion prevention and sediment control (EPSC) permit is required before commencing ground disturbing activity affecting 2000 square feet or greater, cumulatively, throughout the duration of the development.
(Ord. 2004-17 §1, 09/20/2004)

Section 9.03.100 Erosion Prevention & Sediment Control Plan Requirements.

The applicant shall submit an Erosion Prevention & Sediment Control Plan (EPSCP) for projects requiring an EPSC permit prior to commencing any ground disturbing activity. All plans shall comply with the minimum standards set forth in the City of Corvallis Erosion Prevention & Sediment Control Manual.

1) Erosion Prevention and Sediment Control Plans

a) Erosion prevention and sediment control plans shall be prepared in conformance with and shall demonstrate compliance with these Standards and the City of Corvallis Erosion Prevention & Sediment Control Manual in effect at the time of application.

b) The EPSCP shall be reviewed and approved by the City Manager prior to commencing any ground disturbing activity including installation of erosion and sediment control BMPs.

c) The EPSCP shall be implemented only after approval and prior to commencing any ground disturbing activity.

d) Subsequent development permits (Grading, Public Improvement, or Building) will not be issued prior to implementation of the EPSCP unless authorized by the City Manager or his/her designee.

2) Approval of Erosion Prevention and Sediment Control Plan

a) The City Manager or his/her designee shall approve the EPSCP if it demonstrates compliance with these Standards and the adopted City of Corvallis Erosion Prevention & Sediment Control Manual. An EPSC permit shall be issued following approval of the plan and verification from the applicant that all other rules and laws governing this aspect of development have been addressed and are in compliance.

b) The responsible party shall be accountable for obtaining re-authorization for implementing any EPSCP modifications needed due to conflicts, omissions, changed conditions, damage or other factor jeopardizing compliance with these Standards.

c) In cases where erosion is occurring, the responsible party must immediately install interim control measures to stabilize the condition and minimize sediment leaving the site. The responsible party will be required to provide new plans, or revisions to existing plans, for review that provide for long term erosion and sediment control. Upon approval of the plans, the new measures described must be implemented in a timely manner.
(Ord. 2004-17 §1, 09/20/2004)

Section 9.03.110 Enforcement / Penalties.

The City Manager is authorized and directed to enforce all the provisions of these Standards and may conduct inspections whenever it is necessary to enforce any provisions of these Standards to determine compliance or whenever the City Manager has reasonable cause to believe there exists any violation of these Standards.

1) Inspection and Right of Entry. When it may be necessary to inspect to enforce the provisions of these Standards, the City Manager, in accordance with administrative policy, may enter the building or premises at reasonable times to inspect or to perform the duties imposed by this code, provided that if such building or premises be occupied, that credentials be presented to the occupant and entry requested. If such building or premises be unoccupied, the City Manager shall first make a reasonable effort to locate the owner or other person having charge or control of the building or premises and request entry. If entry is refused, the City Manager shall have recourse to the remedies provided by Municipal Code Chapter 1.15 to secure entry.

2) Notification. When it is determined that a violation of this code has occurred, the City Manager shall notify the responsible party and the property owner in writing of the violation observed. The notice of violation shall either be delivered to the responsible party or posted at the property site of the violation, and mailed to all responsible parties.

3) Stop Work Orders. When it is necessary to gain compliance with this code, the City Manager may issue a written stop work order requiring that all work, except work directly related to the elimination of the violation, be immediately and completely stopped. The responsible party shall not resume work until such time as the City Manager provides specific approval in writing.

4) Penalties. Any person violating any of the provisions herein for which a penalty has not been otherwise provided, shall upon court conviction thereof, be punished by a fine of at least $100.00 but not more than $5000.00 per offense. Each day that a violation exists is a separate offense.
(Ord. 2004-17 §1, 09/20/2004)

Section 9.03.120 Appeals.

1) Appeals of orders, decisions or determinations made by the City Manager relative to the application and interpretation of the technical and/or scientific requirements of this Chapter shall be to the Board of Appeals established in Section 9.01.090 of this code, and shall be conducted in the same manner set forth in that Section, except that the City Manager shall be substituted for the Building Official, where appropriate.

2) Appeals of orders, decisions or determinations made by the City Manager related to the application and interpretation of the administrative or procedural requirements of this chapter shall be made to the City Council in the manner set forth under Chapter 1.11 of this Code, and shall be reviewed according to the standards set forth in Chapter 1.11. Decisions about whether a matter is administrative or technical shall be made by the City Manager and any appeal shall be to the City Council in the manner set forth above.

3) Filing Parties

a) Appeals may only be filed by the following parties affected by a decision:

1] Any responsible party as defined in this Standard;

2] Any resident or property owner within 150 feet of a parcel of land that is the subject of the decision; or,

3] Any agency, officer, or department of the City which has the responsibility for providing City facilities and/or services to the parcel of land.

b) Appeals submitted under this chapter shall include a $240 filing fee.

c) Appeals may be filed regarding notices, orders, interpretations and decisions made by the City Manager relative to these Standards.

d) An appeal must be in writing and include the following:

1] name of person filing the appeal
2] copy of the notice and order
3] copy of the section of these Standards which is being appealed
4] a complete explanation of the appeal
5] what is requested of the City Council

e) The City Manager shall schedule a meeting of the board within 30 days of the filing of the appeal. The board of appeals shall grant a hearing or dismiss the appeal. The appeal shall be dismissed if the board finds that the appeal does not meet the criteria in subsection 9.01.090.020 or this Standard. If the appeal is dismissed, the City Manager's decision is final. The hearing shall be held not later than 30 days after filing the appeal.

4) Filing Date. Appeals must be filed within seven (7) calendar days plus three (3) days for mailing from the date of the decision of the Director.
(Ord. 2004-17 §1, 09/20/2004)

Section 9.03.130 Fees.

The City shall collect a fee for the purpose of offsetting administrative costs associated with processing applications, reviewing plans, issuing permits, conducting inspections and enforcing these Standards. Fees charged under these Standards shall be as provided in Chapter 8.03.
(Ord. 2004-17 §1, 09/20/2004)

Section 9.03.140 Nuisance Abatement.

1) Summary Abatement Authorized

The City Manager may determine that the failure or non-existence of erosion, sediment and pollutant control measures as required by this Code constitute a nuisance presenting an immediate threat of injury to the public health, the environment, or public or private property. Such nuisances shall be subject to the requirements of this Section. In cases where the City Manager determines it is necessary to take immediate action in order to meet the purposes of this Code, summary abatement of such nuisance is authorized.

2) Notification Following Summary Abatement

When summary abatement is authorized by this Code, the decision regarding whether or not to use summary abatement shall be at the City Manager's discretion. In case of summary abatement, notice to the responsible party prior to abatement is not required. However, following summary abatement, the City Manager shall post upon the affected site the abatement notice describing the action taken to abate the nuisance and shall cause a notice to be mailed to the owner at the owner's address as recorded in the county assessment and taxation records for the property.

3) Financial Responsibility.

a) Whenever a nuisance is abated under this section, the City Manager shall keep an accurate account of all expenses incurred.

b)The City Manager shall file a statement of such costs with the City Finance Department. Upon receipt of the statement, the Finance Director or his/her designee shall mail a notice to the property owner, stating the City's intent to assess the property in question the amount due plus charges to cover the costs of processing. In the event that amount due set forth in the notice is not paid in full within 30 days of the date of notice, the City Finance Director shall enter the amount of the unpaid balance, plus charges to cover administrative costs in the Docket of City liens which shall therefore constitute a lien against the property.
(Ord. 2004-17 §1, 09/20/2004)

City of Corvallis Stormwater Phase II
Construction Site Stormwater Runoff Control Program

Appendix CR-B

Erosion Prevention and Sediment Control Manual

Erosion Prevention and Sediment Control Manual

CORVALLIS
ENHANCING COMMUNITY LIVABILITY

September 2005

City of Corvallis
Development Services
501 SW Madison Ave.
PO Box 1083
Corvallis, OR 97339
Phone: (541) 766-6929
Fax: (541) 766-6936
www.ci.corvallis.or.us

City of Corvallis
Erosion Control Manual

Overview

This manual provides technical guidance for the design, installation, maintenance and inspection of temporary and permanent erosion prevention and sediment control measures. The manual is intended for use by site designers, developers, contractors and inspectors during the construction process, before, during and after clearing, grubbing, grading and excavation. The manual is also intended to have educational value to the public.

The manual is split into five chapters:

Chapter 1 - Introduction and Background

> This chapter provides an introduction to the manual and provides educational information regarding the background and bases for the City's development of erosion prevention and sediment control guidelines and an educational overview of erosion processes and the environmental impacts created by erosion from construction sites.

Chapter 2 - Erosion Control Planning and Design

> This chapter discusses the issues important to planning and the design process for an effective erosion prevention and sediment control plan. ***Section 2.6 discusses plan submittal and permit requirements.***

Chapter 3 - Erosion Prevention and Sediment Control Measures

> This chapter presents best management practices for erosion prevention and sediment control for construction sites and is intended to help the designer choose the most appropriate measure or control.

Chapter 4 - Construction Site Pollution Control Measures

> This chapter gives an overview of the environmental impacts created by pollution generated by construction site activities. The chapter describes planning and implementation activity controls that can be used on a construction site.

Chapter 5 - Maintenance and Inspection

> This chapter provides guidelines for the proper implementation, maintenance and inspection of erosion prevention and sediment control measures.

This manual is intended to comply with the anticipated requirements of the City of Corvallis' National Pollutant Discharge Elimination System (NPDES) General Permit #MS4, the Endangered Species Act, the anticipated Total Maximum Daily Load (TMDL) levels for streams to be established by the Oregon Department of Environmental Quality (DEQ), the Oregon Structural Specialty Code, and City of Corvallis City ordinances and Council policy.

Goal Statement

It is the intent of this manual to describe proactive practices that can be taken to prevent erosion, releases of sediment and other pollutants generated at a site of ground disturbance. Site planning and good site control are the best practices that can be used to prevent discharges from a development site of ground disturbance. This Manual is organized to emphasize measures to prevent erosion and control stormwater runoff, over practices designed to strictly control sediment.

Disclaimer

The Erosion Prevention and Sediment Control Manual was developed for the sole purpose of providing the most up to date Erosion Prevention and Sediment Control Best Management Practices (BMPs). The contents of this manual should not be interpreted as necessarily representing the policies or recommendations of other referenced agencies or organizations. The mention of trade names, products or companies does not constitute an endorsement.

It is intended that this manual and alternative methods acceptable for use in other jurisdictions, will be reviewed on an annual basis, with the Manual updated as needed.

Acronyms

AOS Apparent Opening Size

BMP Best Management Practice

DEQ Department of Environmental Quality

DSL Division of State Lands

ECRM Erosion Control and Revegetation Mats

EPA Environmental Protection Agency

EPCM Erosion and Pollution Control Manager

EPSC Erosion Prevention and Sediment Control

HDPP High Density Polyethylene Pipe

NPDES National Pollutant Discharge Elimination System

OAR Oregon Administrative Rules

ODOT Oregon Department of Transportation

ORS Oregon Revised Statutes

PCP Pollution Control Plan

USLE Universal Soil Loss Equation

RUSLE Revised Universal Soil Loss Equation

TMDL Total Maximum Daily Load

TRM Turf Reinforcement Mats

TSS Total Suspended Solids

USACE U.S. Army Corps of Engineers

Table of Contents

Appendices

CHAPTER 1
INTRODUCTION AND BACKGROUND

1.1 Requirements

This Erosion Prevention and Sediment Control (EPSC) Manual establishes the minimum standards for EPSC required by Appendix Chapter 33 of the State of Oregon Structural Specialty Code and City of Corvallis Ordinance 2004-17.

The City of Corvallis (the City) requires an EPSC permit before commencing ground disturbing activity affecting 2000 square feet or greater, cumulatively, throughout the duration of the development. Erosion and sediment control measures must be installed prior to any ground disturbance.

Approval of an EPSC plan by the City of Corvallis does not relieve the applicant's responsibility to ensure that the approved erosion control best management practices are constructed and maintained to contain sediment and pollutants on the construction site. Erosion control best management practices (BMPs) in addition to those depicted on an approved erosion control plan may be required based on specific site conditions.

Erosion control BMPs are required during *all* ground disturbing activity until permanent site ground covers are in place. Certain base erosion control BMPs are required for construction sites at all times of the year. Also, additional cover or BMPs are required during the wet weather season (October 1 through April 30). All seed applications shall be completed prior to September 1, and shall be established by October 1, or shall employ additional erosion prevention BMPs.

Visible & measurable erosion and sediment release conditions may be allowed if minimized to the greatest extent practicable through the use of BMPs under valid erosion and sediment control permit issued by the City.

1.2 Introduction

This manual provides technical guidance for the design, installation, maintenance and inspection of temporary and permanent erosion prevention and sediment control BMPs. The manual is intended for use by site designers, developers, contractors and inspectors during the construction process, before, during and after clearing, grubbing, grading and excavation. The manual is also intended to have educational value to the public.

The manual is split into five chapters:

Chapter 1 - Introduction and Background

> This chapter provides an introduction to the manual and provides educational information regarding the background and bases for the City's development of an erosion prevention and sediment control standards and an overview of erosion processes and the environmental impacts created by erosion from construction sites.

Chapter 2 - Erosion Control Planning and Design

> This chapter discusses the issues important to planning and the design process for an effective erosion prevention and sediment control plan. ***Section 2.6 discusses plan submittal and permit requirements.***

Chapter 3 - Erosion Prevention and Sediment Control Measures

> This chapter presents best management practices for erosion prevention and sediment control for construction sites and is intended to help the designer choose the most appropriate measure or control.

Chapter 4 - Construction Site Pollution Control Measures

This chapter gives an overview of the environmental impacts created by pollution generated by construction site activities. The chapter describes planning and implementation activity controls that can be used on a construction site.

Chapter 5 - Maintenance and Inspection

This chapter provides guidelines for the proper implementation, maintenance and inspection of erosion prevention and sediment control measures.

This manual is intended to comply with the anticipated requirements of the City of Corvallis' National Pollutant Discharge Elimination System (NPDES) General Permit #MS4, the anticipated requirements of the Endangered Species Act, the anticipated Total Maximum Daily Load (TMDL) levels for streams to be established by the Oregon Department of Environmental Quality (DEQ), the Oregon Structural Specialty Code, and City of Corvallis City ordinances and Council policy.

1.3 Background and Policies

It is City of Corvallis' goal to comply with all conditions of Federal, State, County, and City regulations or requirements. The City developed its erosion prevention and sediment control (EPSC) program including this EPSC guidance manual to comply with regulations or requirements including, but not limited to:

1.3.1 NPDES Program for Municipal Separate Storm Sewer Systems

The U.S. Environmental Protection Agency (EPA) has delegated the implementation of the NPDES program to the state of Oregon. The Oregon DEQ administers the NPDES program through Oregon Revised Statute (ORS) 468B and associated Oregon Administrative Rules (OAR). ORS 468B.025 explicitly prohibits the discharge or placement of wastes into waters of the state, prohibits the discharge of waste that causes violations of water quality standards, and prohibits violations of permit conditions.

The City of Corvallis operates a municipal separate storm sewer system (MS4) that ultimately discharges into local rivers and streams without treatment. EPA's Storm Water Phase II Rule establishes an MS4 storm water management program that is intended to improve the Nation's waterways by reducing the quantity of pollutants that storm water picks up and carries into storm sewer systems during storm events. Based on the 2000 census, the City's population exceeded 50,000, designating it as a small MS4 operator under the Phase II Rule. The Storm Water Phase II Final Rule requires the City, as operator of regulated small MS4, to obtain a NPDES permit and develop a storm water management program designed to prevent harmful pollutants from being washed by storm water runoff into the MS4 (or from being dumped directly into the MS4) and then discharged from the MS4 into local waterbodies.

Conditions of the NPDES Phase II permit will require the City, as the operator of a regulated small MS4, to develop a storm water management program designed to:

1. Reduce the discharge of pollutants to the "maximum extent practicable" (MEP);
2. Protect water quality; and
3. Satisfy the appropriate water quality requirements of the Clean Water Act.

"Construction site runoff control" is one of six minimum control measures that the City is required to include in its storm water management program to meet the conditions of its NPDES permit. This measure requires the City to develop, implement, and enforce a program to reduce pollutants in storm water runoff to its MS4 from construction activities that result in a ground disturbance of greater than or equal to one acre.

1.3.2 Endangered Species Act

The Endangered Species Act (ESA) was enacted to prevent extinction of certain species of fish, wildlife and plants that have seen significant declines in their populations within a defined geographic range or Evolutionary Significant Unit (ESU). In March of 1999, Chinook were listed as "threatened" in the Upper Willamette Basin. Erosion of soil from an unstable landscape can dramatically impact the habitat and survival of the species. Under the ESA, the "take" of a species is prohibited. The term "take" includes: to harass, harm, kill, or injure the listed species. Any act that modifies or degrades their habitat in a manner that significantly impairs essential behavioral patterns such a breeding, spawning, rearing, migrating, feeding or sheltering and results in death or injury to a protected species is considered harmful.

Permitting or participating in construction that occurs in such a way and at such a time that sedimentation significantly impair salmon survival might be construed as a "take." The more direct connection between what the government entity authorizes (or fails to enforce), the contractors actions (or failure to act) and the injury to the species, the more likely that the parties could be held responsible for a "take."

The National Marine Fisheries Service (NMFS) administers provisions of the ESA. The NMFS is a part of the National Oceanic and Atmospheric Administration (NOAA). NMFS administers NOAA's programs to conserve, protect and manage living marine resources. Corvallis is negotiating with NMFS to define programs that when implemented would provide eligibility for exemption from ESA Section 4(d) compliance requirements. For more information on the City of Corvallis' ESA Response Plan visit: http://www.nrpsi.com/CorvallisESA/index.html

1.3.3 Oregon Department of Environmental Quality (DEQ) 303(d) List

Water pollution in the United States is regulated under the Clean Water Act (CWA) of 1972. The CWA requires that each state implement activities to protect the quality of its rivers, streams, and other water bodies. The DEQ has primacy for implementing this law, including the responsibility for developing standards to protect the beneficial uses that have been determined for each water body. The DEQ developed the 303(d) list to identify water bodies that do not meet current standards. Once a water body has been listed, local governments are responsible for working with the DEQ to develop and implement recovery plans to protect the beneficial uses.

The DEQ is working to develop Total Maximum Daily Load (TMDL) levels for each stream on the 303(d) list. TMDLs define the quantity of pollutant that can enter a water body without violating water quality standards. Of importance to Corvallis is the Upper Willamette River which has been listed for not meeting the water temperature, bacteria and mercury concentration standards; and the Marys River which has been listed for not meeting the water temperature, bacteria concentration and flowrate standards. TMDLs have not yet been established for Marys River or the Upper Willamette Basin.

1.3.4 Oregon Structural Specialty Code (OSSC)

The City has adopted Appendix Chapter 33 of the OSSC which sets forth rules and regulations to control excavation, grading and earthwork construction. The OSSC requires erosion control devices or methods be employed to control erosion and provide safety. This EPSC manual provides the minimum standards for design and implementation of erosion control measures referred to in the OSSC Section 3316.2.

1.3.5 City of Corvallis Storm Water Master Plan (SWMP)

The Corvallis City Council adopted the Stormwater Master Plan (SWMP) on March 4, 2002 (Ordinance #2002-06). The SWMP recommends the implementation of an erosion prevention and sediment control program to maintain and improve stormwater quality. The program is recommended to include:

- the requirement for erosion control plans for construction activities with the potential to cause erosion,
- the provision of erosion control guidance to the development community,
- the requirement for sediment removal (to the maximum extent practicable) from construction site runoff,
- the enforcement of an erosion control program including public education and fines for violations, and
- the development of community-specific standards that limit sediment discharge into receiving waterbodies.

1.3.6 City Council Policy CP 91-9.02

Corvallis City Council Policy CP 91-9.02 adopted March 20, 1978, prohibits the deposition of any earth or other debris upon any street or sidewalk.

1.3.7 City Municipal Code Chapter 9.03 and Ordinance 2004-17

The City of Corvallis Municipal Code Chapter 9.03, adopted by City Council through City Ordinance 2004-17 and effective on October 1st, 2004, requires an erosion prevention and sediment control permit before commencing ground disturbing activity affecting 2000 square feet or greater, cumulatively, throughout the duration of the development.

1.3.8 Other Interest Groups & Citizens

Corvallis citizens highly value the health of the City's streams, wetlands, and groundwater. During development of the Stormwater Master Plan, public input for stormwater quality policy development was received through public meetings, a random telephone interview of residents and stakeholder interviews. Following is a brief summary of results of the SWMP public opinion survey:

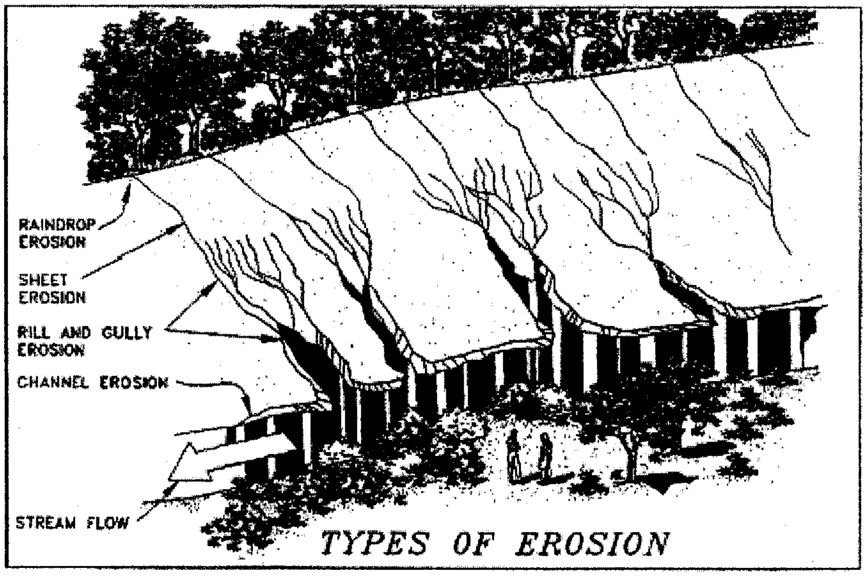
Issue	% Important	% Very Important	% Important/ Very Important
Control Erosion	41%	54%	96%
Surface pollutants entering streams	31%	62%	93%
Protect Stream Habitat	34%	60%	94%

The survey results indicate Corvallis citizens value stormwater quality and would support the development and enforcement of an EPSC program.

1.4 The Erosion and Sedimentation Processes

When the land is disturbed at construction sites the soil erosion rate accelerates dramatically. The major problem associated with erosion at a construction site is the movement of soil from the site and the impact of the soil on water quality in streams and rivers and wildlife habitat.

Erosion occurs when rain or wind loosen soils from the land surface. Rain generated runoff cuts rills and larger gullies into exposed soils to convey sediment laden flows. Wind erosion creates a more consistent,



area-wide stripping of soils from the soil surface. Both types of erosive forces are capable of depositing large amounts of sediment, sometimes at great distances, away from the site of ground disturbance.

There are four main factors that influence erosion:

Soil erodibility

Soil characteristics which influence the potential for erosion by rainfall and runoff are those properties which affect the infiltration capacity of a soil and those which affect the resistance of the soil to detachment and being carried away by falling or flowing water. The following four factors are important in determining soil erodibility:

- Soil texture (particle size and gradation)
- Percentage of organic content
- Soil structure
- Soil permeability

Soils containing high percentages of fine sands and silt are normally the most erodible. As the clay and organic matter content of these soils increases, the erodibility decreases. Clays act as a binder to soil particles, thus reducing erodibility. However, while clays have tendency to resist erosion, once eroded, they are easily transported by water. Soils high in organic matter have a more stable structure which improves their permeability. Such soils resist raindrop detachment and infiltrate more rainwater. Clear, well-drained and well- graded gravel and gravel-sand mixtures are usually the least erodible soils. Soils with high infiltration rates and permeabilities either prevent or delay and reduce the amount of runoff.

Soils containing high percentages of fine sands and silts are usually the most erodible. Clay can help bind soils, but they are easily transported in stormwater runoff. Organic matter helps provide a more stable soil structure that allows for more infiltration and resists erosion. Well-drained soils, sands and gravels resist erosion most, because of their ability to infiltrate.

Vegetative cover

Vegetative cover plays an extremely important role in controlling erosion as it provides the following five benefits:

- Shields soils surface from raindrop and wind erosion.

• Provides root systems which hold soil particles in place.
• Aides soil to absorb water
• Slows velocity of runoff
• Evapotransporates sub-surface water between rain storms.

By limiting and staging the removal of existing vegetation and by decreasing the area and duration of exposure, soil erosion and sedimentation can be significantly reduced. Special consideration should be given to the maintenance of existing vegetative cover on areas of high erosion potential such as moderately to highly erodible soils, steep slopes, drainageways, and the banks of streams.

Topography

Topography or size, shape and slope of a watershed can influence the amount and rate of stormwater runoff. High slope lengths and steep gradients increase the rate of runoff (creating a higher probability for erosion) and can limit abilities to establish and maintain vegetative cover.

Climate

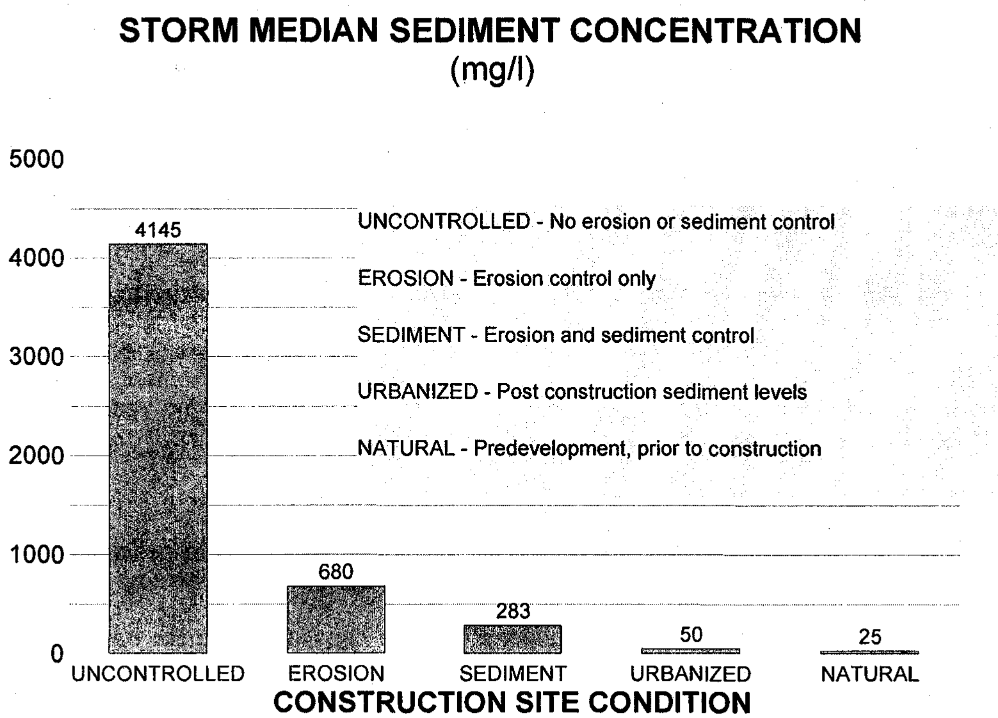
The frequency, intensity, and duration of rainfall are fundamental factors in determining the amounts of runoff produced in a given area. As both the volume and velocity of runoff increases, the capacity of runoff to detach and transport soil particles also increases. Where storms are frequent, intense, or of long duration, erosion risks are high. Seasonal changes in temperature, as well as variations in rainfall, help to define the high erosion risk period of the year. When precipitation falls as snow, no erosion will take place. However, when the temperature rises, melting snow adds to runoff, and erosion hazards are high. Because the ground is still partially frozen, its absorptive capacity is reduced. Frozen soils are relatively erosion-resistant. However, soils with high moisture content are subject to uplift by freezing action and are usually very easily eroded upon thawing. Although both water and wind erosion should be anticipated throughout the year, the likelihood of water erosion increases during the wet weather season (October 1^{st} – April 30^{th}) and wind erosion is more prevalent during the dry weather season.

Every year, tons of sediment are washed and blown from sites of ground disturbance into streams, rivers and lakes. The U.S. Environmental Protection Agency estimates approximately 600 million tons of soil erodes from U.S. construction sites alone each year (1993). As the community continues to grow, our local waterways are being affected by ground disturbance, with the greatest sediment impacts occur during the land grubbing, clearing, grading and other excavation phases of development.

Responsible development requires that steps be taken to control erosion and sedimentation from construction sites. Figure 1-1 demonstrates the ability of good erosion and sediment controls, versus no controls, in minimizing the detrimental effects of sedimentation.

This chart also demonstrates the fact that once a naturally vegetated area has been developed, sediment levels can be twice the pre-development rate. It is well known that the erosion and sediment threat is greatest during construction; once development is complete (stabilization techniques implemented), there is a dramatic decrease in the pollutant level yield.

Figure 1-1



Source: Performance of Current Sediment Control Measures at Maryland Construction Sites, Metropolitan Washington Council of Governments

Sediment, resulting from disturbed soils, can move onto neighboring properties and streets or into drainage systems and other bodies of water. Excessive sediment has significant negative impacts on how the natural watershed runoff and soil conveyance system works. Under natural conditions, runoff moves through a watershed as groundwater through infiltration or as surface water by spreading across floodplains and migrating downstream through stable stream and waterway channels. In a natural watershed system, sediment, cobbles and gravel travel throughout the stream network creating deposition, scour and gravel areas that are important for fish habitat. The natural system survives by its ability to contain flows and balance sediment loads within the stream network.

1.5 Impacts of Erosion and Sedimentation

Erosion and sedimentation cause both environmental and economic impacts. Both are important, but is often only an economic impact that spurs a jurisdiction to take action. Environmental impacts are harder to see and quantify as they tend to build slowly and do not produce dramatic results for many years, when it may be too late to correct the problem. Erosion and sedimentation can cause expensive site damage and construction delays. Lack of maintenance often results in failure of control practices and costly cleanup and repairs.

1.5.1 Environmental Impacts

Many environmental impacts from sediment pollution are cumulative and the ultimate results and costs may not be evident until years later.

- Eroded soil contains nitrogen, phosphorus, and other nutrients. When carried into water bodies, these nutrients trigger algal blooms that reduce water clarity, deplete oxygen, lead to fish kills, and create odors.
- Erosion of streambanks and adjacent areas destroys streamside vegetation that provides aquatic and wildlife habitats.
- Excessive deposition of sediments in streams smothers the bottom fauna, seals stream beds, and destroys fish spawning habitat.
- Turbidity from sediment reduces in-stream photosynthesis, which leads to reduced food supply and habitat.
- Turbidity increases the amount of sunlight absorbed in water, raising stream temperatures.
- Suspended sediment abrades and coats aquatic organisms.
- Erosion removes the smaller and less dense constituents of topsoil - those clays, fine silt particles and organic materials that hold nutrients that plants require for healthy establishment. The remaining subsoil is often hard, rocky, infertile, and fails to hold moisture; thus making reestablishment of vegetation difficult.

1.5.2 Economic Impacts

Many economic impacts are hard to quantify. How can a dollar value be assigned to loss of aquatic habitat or diminished water clarity? Other impacts may be readily quantified, for example the cost of dredging and disposing of the accumulated sediment in a silted-up reservoir.

- Excessive sediment accumulation reduces reservoir storage capacity and more frequent sediment removal is required.
- Sediment deposited into streams reduces flow capacity, interferes with navigation, and increases the risks of flooding.
- Local governments and their tax payers must pay for removing sediment from streets, sewers, ditches, sumps and culverts, and for dredging sediment from harbors and navigation channels.
- Excess sediment creates cloudy or turbid water conditions, interfering with recreational uses.
- Erosion severely diminishes the ability of the soil to support plant growth. To restore this ability is costly.
- Listing additional wildlife as endangered species increases time and fees for permitting, design, and construction in the affected watersheds. Some costs are directly assessed to specific projects while many other costs are distributed statewide by spending additional monies for habitat restoration.
- Litigation is an expensive alternative

Many of these costs could be largely avoided through implementation of adequate erosion control practices.

CHAPTER 2
EROSION CONTROL PLANNING

The purpose of erosion and sediment control planning is to clearly establish the control measures which are intended to prevent erosion and off-site sedimentation during construction. The Erosion Prevention and Sediment Control (EPSC) Plan should describe the site development and serve as a blueprint for the location, installation, and maintenance of practices to control erosion and prevent sediment from leaving the site during construction. It should also be understood that plans are only a blueprint and will require modification throughout the life of the project.

2.1 Prevention vs. Sediment Control

The driving consideration in creating and implementing an effective EPSC plan is to provide erosion prevention measures rather than sediment control. Although every EPSC plan will have elements of both, it is often far more cost effective and practical to emphasize erosion prevention. Erosion prevention measures are designed to prevent exposed soil particles from becoming dislodged by rain or wind. Such measures include temporary ground covers (mulch, temporary grasses, straw mulch and tackifier, etc.), matting, plastic sheeting, and numerous other products designed to provide mechanical or physical protection to exposed soil. Sediment control involves techniques to re-capture transported sediment from runoff. Sediment control measures include sediment traps and basins, sediment fences, check dams, sediment barriers, catch basin filters, etc.

The benefit of erosion prevention is that it seeks to prevent the problem before it starts. It is also often impractical to recover large amounts of sediment after it becomes dislodged and suspended in runoff. On projects where the predominant soil particle size is very small (fine silts and clays, typical of Corvallis), the amount of time required to allow for settling of solids can reach days or even weeks. It is also generally true that erosion prevention measures are more reliable, whereas sediment control measures require continual and costly maintenance. Because successful erosion control requires minimizing disturbed areas, the EPSC plan should emphasize scheduling and phasing. Project scheduling and phasing is often driven by factors other than erosion control, however, so contingency planning is essential. Most importantly, the EPSC plan should be designed and implemented as a living, dynamic plan that can be adapted to address changes in the project as work progresses.

2.2 Five Basic Rules

Erosion control measures are required for construction areas where the ground surface will be disturbed by clearing, grading, fills, excavations and other construction activities. When developing and effective EPSC plan, there are several important concepts to consider:

- Timing - schedule work to minimize overall impacts
- Stage work - identify & process critical areas first
- Minimize disturbance - create buffers & reduce mass grading
- Pre-construction - during preliminary design & prior on site grading activities
- Pictures/Video - documentation throughout life of project

The long-term benefits of an effective erosion and sediment control plan are enormous. An important concept to keep in mind when developing construction and erosion control plans is: **practices which minimize the amount of disturbed land area and avoid or minimize work on steep slopes have the greatest potential to reduce erosion**. There is less chance of soil washing of the site and clogging streets, drainage systems, and entering adjacent properties. The number and size of erosion control measures required will be minimized. The cost of maintaining erosion control facilities is minimized. As much top soil as possible is retained on the site, making re-vegetation and landscaping easier to establish.

It is equally important to note that approval of an erosion and sediment control plan by the City of Corvallis does not relieve the applicant's responsibility to ensure that erosion control measures are constructed and maintained to prevent sediment from leaving construction site. These requirements are upheld throughout the life of the construction project.

2.3 Designer Responsibilities

A designer puts the EPSC plan together in the office based upon information provided from resources obtained from local and regional agencies, and a detailed field site visit. In addition, the designer must, identify potential erosion and sediment problems, develop design objectives, formulate and evaluate alternatives, select best erosion prevention measures, and develop a plan. A determination is made about what best management practices are appropriate. A variety of BMP's should be included on the plan in order to provide adequate tools in the field. By following the step by step process listed below, designers can improve overall success.

The designated person, whether contractor or erosion and sediment control specialist have a defined responsibility to prevent pollution from leaving the site. They must follow a plan, or obtain approval to a revised plan, and insure that the site is stable. Even though the EPSC plan may be followed in detail and appear to have addressed all issues, there will inevitably be obstacles along the way that will change those plans. Therefore, the best scenario includes a good plan, open lines of communication, and defined responsibilities.

2.3.1 Soil Survey Information

Knowing the type of soil found on the project site will help the designer decide upon the degree of erosion protection required. Of prime importance are the predictions of soil behavior for selected land uses. As explained in Chapter 1, the potential for erosion is highly dependent on the type of soil. This will ensure that the EPSC plan is adequate to control soil movement without being overly conservative. The Natural Resource Conservation Service Soil Survey, a mapped inventory with physical properties and characteristics described for each soil type for Benton County is available on the Internet at www.or.nrcs.usda.gov/soil/oregon/or_reports_or.htm

2.3.2 Climate and Precipitation Data

The occurrence and intensity of rainfall is important for the designer when placing and sizing erosion control measures. Additionally, all erosion control measures require inspection after any rain event in excess of 0.5 inches in 24 hours. Rain gauges can be used to assist in determining on-site rainfall. Precipitation and other weather data may be found on the Internet through the West Coast Weather Observation at www.ocs.orst.edu/obs_west Wet weather season extends from October 1 to April 30.

2.3.3 Topography

From the site visit, determine the drainage patterns from the topography. Does runoff flow from offsite through the construction site? If so, measures should be taken to re-route this water around areas that will have ground disturbance.

Will areas of ground distuurbance occur on long slopes that are greater than 2% grade? If so, the lengths of the uninterrupted flows should be broken up so that the rainfall runoff will only flow short distances thereby decreasing flow velocity and the erosive force. In flat areas, runoff is slow and soil particles are not moved far from the point of raindrop impact. If the slopes are steep and short, surface cover may be needed to decrease runoff and promote rainfall infiltration into the soil. On steep slopes, soil movement increases dramatically. Constructing very long slopes and especially, long, steep slopes should be avoided. Those that already exist should not be disturbed.

2.3.4 Revised Universal Soil Loss Equation (RUSLE)

In order to properly design sediment basins and large conveyance structures, a designer must be able to calculate the quantities of water and sediment that will be managed by the structure. The design method for calculating soil loss from disturbed land is the Revised Universal Soil Loss Equation (RUSLE). RUSLE estimates soil loss from a slope caused by raindrop impact and overland flow (collectively referred to as "interrill" erosion), plus rill erosion. It does not estimate gully or stream-channel erosion. RUSLE is a tool to estimate the rate of soil loss based on site-specific environmental conditions and a guide for the selection and design of sediment and erosion control systems for the site. RUSLE does not determine when soil loss is excessive at a site, when erosion control systems have failed, or sediment yield once it has left the site. The RUSLE user makes such decisions based upon numerous criteria, of which soil-loss and sediment-yield estimates are on important compound.

For a complete copy of the guidelines and the public domain RUSLE software visit www.sedlab.olemiss.edu/rusle online or contact:

Joe R. Galetovic, Technical Coordinator
The Office of Technology Transfer
Western Regional Coordinating Center
Office of Surface Mining
1999 Broadway, Suite 3320
Denver, CO 80202-5733
(303) 844-1448
Fax: (303) 844-1546
Email: jgaletov@osmre.gov

2.3.5 Endangered Species

In March of 1999, Chinook were listed as threatened in the Upper Willamette Basin. Erosion of soil from an unstable landscape can dramatically impact the habitat and survival of the Chinook species. The EPSC plan designer needs to determine the potential impacts proposed work may have on endangered species. Under existing planning and permitting requirements, the responsible party must assure its actions do not harm, jeopardize or threaten endangered species. In addition, the responsible party shall implement conservation measures, or reasonable and prudent measures identified by the U.S. Fish and Wildlife Services and the National Marine Fisheries Services, to avoid and minimize potential adverse effects to such species.

2.3.6 Sensitive Areas

Sensitive areas include wetlands, rivers, streams, creeks, lakes, and ponds. Depending on several factors, an undisturbed corridor buffer of varying width is required adjacent to sensitive areas. The responsible party shall be aware of, and adhere to, any limitations in the work area in the proximity of sensitive areas imposed by environmental permits issued by the Division of State Lands (DSL), the U.S. Army Corps of Engineers (USACE) and the Federal Emergency Management Agency (FEMA). This includes work pertaining to, but not limited to:

- work in or over "navigable waters" of the United States, or which affects the course, location, condition or capacity of such waters;
- the removal of material from or placement of fill material into the "waters of the State" and
- work within floodways, as mapped by FEMA.

2.4 Project Scheduling

Following a specified work schedule that coordinates the timing and ground disturbing activities and the installation of control measures is perhaps the most cost-effective way of controlling erosion during construction. The removal of ground cover leaves a site vulnerable to accelerated erosion. Construction procedures that limit land clearing, provide the timely installation of erosion control and sedimentation controls, and restore protective cover quickly can significantly reduce the erosion potential of a site.

Construction projects should be sequenced to reduce the amount and duration of soil exposure to erosion by wind, rain, runoff, and vehicle tracking. The construction schedule is an orderly listing of all major ground disturbing activities together with the necessary erosion and sedimentation control measures planned for a project. This type of schedule guides the contractor on work sequencing so that serious erosion and sedimentation problems can be avoided.

The EPSC plan should indicate in each of the scheduled work, how the proposed erosion/sediment control measures will divert flows, limit runoff from exposed areas, stabilize exposed soil and filter sediment. The following activities should be include in the schedule, if applicable.

- Clearing and grubbing for perimeter controls
- Installation of perimeter controls
- Construction phasing
- Clearing and grubbing, grading and trenching for activities other than perimeter control.
- Grading (including off-site activities) related to the project.
- Final grading, landscaping, and stabilization.
- Work on or at bridges and other water course structures.
- Utility installation and removal.
- Work required in any wetland.
- Monitoring of rainfall.
- Inspection of controls.
- Installation and maintenance of permanent controls.
- Installation, maintenance and removal of temporary controls.
- Disposal of waste materials generated on-site

Note that the construction activities listed above do not usually occur in a specified linear sequence, and schedules will vary due to weather and other unpredictable factors. Schedules for temporary and permanent erosion control work required in any wetlands, as are applicable for clearing and grubbing, grading, trenching, bridges, and other structures at water courses, construction, and paving should be submitted for review by the City. Plans for erosion control on haul roads and borrow pits and plans for disposal of waste materials should also be submitted. The contractor may submit the EPSC plan from the project plans if it is correct for the proposed stage of construction, or prepare a modified version, proposing methods, materials, and procedures, to be used for the weather and site conditions at the time of construction, if applicable.

2.5 Developing an Erosion and Sediment Control Plan

Following are recommended steps and check lists to use in the development and implementation of an acceptable Erosion and Sediment Control plan. This information will provide the necessary tools to gain the City's approval and reduce overall environmental risks. Once the project site has been assessed, the catch points for cuts and fills, drainage areas and drainage patterns, sensitive areas, size and location of drainage structures, and of disturbance should be located on the base map. Approximate final grades and any known problems such as highly erodible soils or unstable slopes should also be noted. A sample ESCP and details can be found in Appendix A.

Step 1: Identify Potential Issues

- Public opinion
- Environmental interest groups
- Public Agencies

- Federal and State Environmental Regulations

Step 2: Goals and Objectives

- Meet all regulations
- Minimize negative public opinion
- Improve aesthetics
- Enhance the environment
- Decrease liability
- Higher emphasis on stabilizing steep slopes (2:1 or greater)
- Reduce short and long term erosion
- Reduce or eliminate irrigation costs
- Maximize use of on-site materials (cost-effective solutions)
- Reduce overall maintenance

Step 3: Erosion Study

- Sediment sources
- Review relative sources
    - Maps and aerial photos
    - Distinctive minerals
    - Alluvial
- Review regional factors
    - Temperature
    - Precipitation
    - Wind
    - Freeze/thaw
    - Snow melt
- Review watershed
    - Watershed size
    - Topography
    - Channel density
    - Soil types
    - Ground cover
    - Land use

Step 4: Selection of Erosion and Sediment Control Materials

- Effectiveness
- Environmental impacts
- Regulatory acceptability
- Material Cost
- Long-term cost (maintenance)
- Public acceptability
- Risk/liability
- Aesthetics

Step 5: Developing the ESCP (where to go?)

- City of Corvallis Community Development Department - Phone: (541) 766-6929
    - Regulations and ordinances
    - Prior land use
    - Adjacent and downstream uses
- NRCS/District Conservationist

- Soils
- Climate
- Vegetation/habitat
- Water management
- Recreational potential
- Aerial surveys

▪ U.S. Geological Survey
  - Topographical maps
  - Major drainage ways

▪ State Environmental Agencies
  - Stream surveys
  - Wildlife habitat
  - ESA
  - Wetlands
  - Sensitive areas

▪ Local Flood Control
  - Rainfall data
  - Storm records
  - Flood plains

Step 6: Developing the ESCP (collecting data)

▪ Photo/video documentation
▪ Field survey and evaluation (existing)
  - Topography & contours
  - Existing drainage upstream & downstream
  - Identify sensitive areas
  - Soil samples
  - Soil survey (NRSC)

▪ Field survey and evaluation (future)
  - Topography & contour design
  - Site drainage system type & location
  - Impervious areas

▪ Climate and rainfall information
  - Onsite rain gauges
  - Meteorologists
  - Airport

▪ Critical habitat
  - Wetlands vegetation profile
  - Mitigation/enhancement

▪ Revised Universal Soil Loss Equation (RUSLE)

  A = R x K x LS x C x P
  A = Average annual rate of erosion in tons/ac/yr
  R = Rainfall factor
  K = Soil erodibility factor
  L = Slope length
  S = Slope gradient
  C = Cover
  P = Conservation practice

Step 7: Lay out Pre-construction Plan & Base Measures

▪ Adapt the plan to the resources available
▪ Fit the development to the existing terrain whenever possible

- Plan must be flexible
- Keep communication lines open at all times
- All reports and instructions must be clear
- Determine construction timing and sequence
- Establish primary access point (s) for construction traffic
- Lay out limits of clearing & construction activities
- Restrict all activities in sensitive areas (mark accordingly)
- Establish base measures including sediment control at toe of disturbed area & stabilized construction entrances
- Establish maintenance procedures for EC Measures

Step 8: Identify Measures During Construction

- Install additional base measures as site clearing/disturbances occur, including stockpiles & slope contours
- Determine if construction may occur during wet weather season (October 1st – April 30th)
- Establish & schedule wet weather measures including cover measures over exposed soils
- Continue to establish maintenance procedures for EC measures

Step 9: Post Construction Measures

- Establish ground cover or permanent landscaping prior to removing base measures

Step 10: Plans and Specifications ***(Sample ESCP-Appendix A)***

- Project description
- Construction notes ***(see Appendix B)***
- BMP's standard symbols ***(see Appendix B)***
- Names of existing roads, waterways, and drainage features
- Boundaries of environmentally sensitive areas such as wetlands
- Right of way and easements
- Statement of existing conditions to include highly erodible areas (steep slopes)
- Existing and proposed contour lines
- Run-off calculations
- Calculations of desired performance standards
- Description of erosion control treatment areas
- Detailed grass establishment instructions
- Detail for each BMP used
- Wind erosion control during/following construction

Step 11: Operations and Maintenance

- Guidelines
- Maintenance instructions
    - Provide operating procedures during/after storm events
- Standards of performance
- Periodic inspection reports w/supported pictures
- Vegetation criteria
- Monitoring
    - Establish procedures for monitoring performance
    - Provide adjustment to mitigation measures as needed
- Monitoring and maintenance plan
- Maps
    - Project boundaries

- Adjacent areas
- Existing and final topographic features
- Drainage areas
- Location of existing problems
- Location of potential problems
- Location and extent of BMP's

2.6 Erosion Prevention and Sediment Control Permit and Plan Submittal Requirements

Submittal requirements for EPSC permits and EPSC plans for various types of construction projects are presented below. This information will provide the necessary tools to gain City approval and reduce overall environmental risks. Once the project site has been assessed, the catch points for cuts and fills, drainage areas and drainage patterns, sensitive areas, size and location of drainage structures, and of disturbance should be located on the base map. Approximate final grades and any known problems such as highly erodible soils or unstable slopes should also be noted. Sample EPSC plans and details can be found in Appendix A.

Approval of an erosion prevention and sediment control plan and permit issuance by the City does not relieve the applicant's responsibility to ensure that erosion control measures are implemented and maintained to contain sediment on the construction site.

2.6.1 Minor Ground Disturbances Including Single Family Homes and Duplexes

This section provides the submittal requirements to obtain an EPSC permit for minor ground disturbances. Sites meeting the following conditions can be characterized as *minor ground disturbances*:

1. Individual single family home and duplex construction on existing lots of record,
2. Manufactured home placement on individual lots or in manufactured home parks,
3. Ground disturbing activities cumulatively affecting less than 1 acre throughout the duration of the project and meeting the following conditions:
   a. Average slopes throughout the disturbed area do not exceed 10% and
   b. Slopes within the disturbed area do not exceed 6 feet in height at slopes greater than 3:1 (horizontal:vertical) and
   c. Concentrated runoff conveyed through the site does not originate from more than 1 acre off-site (outside of disturbed area) and
   d. There are no sensitive areas (wetlands, streams, etc.) located on or adjacent the sitework.

Sites meeting the minor ground disturbance criteria have the following submittal and construction period erosion control requirements.

Table 3-2 designates the minimum erosion control BMPs for minor ground disturbances. Each erosion control BMP presented in the table is presented in further detail with design, construction and maintenance criteria in Chapter 3.

Submit the following information with the application for permit:

1. Plans showing the following:
   a. If there is less than a 4-foot elevation differential across the site, property corner, structure corner and finish floor elevations
   b. If there is more than a 4-foot elevation differential across the site, existing and proposed contour lines with elevations to show slope and/or retaining walls
   c. All areas of ground distuurbance on the site, including areas that will be cleared, graded or excavated
   d. Location for storage and ultimate demise of soils and/or wastes
   e. Gravel construction entrance

f. Property lines and distances to buildings.
g. Placement of erosion control devices (e.g. silt fences).
h. Location and depth of drainage systems during and after construction (e.g. ditches, roof and foundation drains)
i. An Undisturbed Corridor Buffer is required adjacent to sensitive areas (Note: Sensitive areas include wetlands, rivers, streams, creeks, lakes, and ponds) Depending on several factors, the range is from 25 feet to 200 feet wide
j. Location and width of all storm drain and sanitary sewer utilities and easements
k. Location of the 100-year flood plain and 0.2 foot floodway, if applicable

2) Additional requirements for non-single family residences

a. Site restoration plan (permanent landscaping)
b. Water quality facilities (consult City of Corvallis Design Criteria Manual)
c. Detention facilities (consult City of Corvallis Design Criteria Manual)

3) A construction schedule outlining (form provided by City):

a. Expected date by which EP&SC measures will be in place
b. Expected date that ground disturbing activities will commence
c. Expected date that construction will be completed
d. Expected date that permanent ground cover will be in place

4) A signed statement indicating that the applicant will construct and maintain EP&SC measures as required by the City (form provided by City).

2.6.2 Major Ground Disturbing Activities

Construction, other than those sites covered in Section 2.6.1 above which will cause ground surface disturbance, have the following requirements for erosion control.

Tables 3-3 and 3-4 designate the minimum erosion control BMPs for major ground disturbances. Each erosion control BMP presented in the table is presented in further detail with design, construction and maintenance criteria in Chapter 3.

Submit with construction plans for subdivision approval, grading, building, or erosion control permit the following information:

1. Completed Erosion Control Permit Application form from Appendix C.
2. A copy of the completed NPDES 1200-C permit application package submitted to ODEQ
3. Construction schedule with the following information:
    a. Construction start and completion dates.
    b. Dates when erosion control measures will be in place.
    c. Timing of site clearing and grading, placement of fills and excavations.
    d. Projected date of removal of erosion control measures (after landscaping is established or after establishment of a healthy grass stand or other approved vegetation).
4. Submit also with construction plans three (3) sets of erosion control site plan drawings showing:
    a. Vicinity map, property address, and property owner's name and address.
    b. Locations, types and applicable dimensions of erosion control measures.
    c. Applicable details of erosion control measures showing full dimensions and construction information.
    d. Existing and proposed ground contours, including a minimum of the first 50 feet of abutting property.

e. Locations and sizes of existing and proposed channels and drainage pipes (labeled as such and with arrows indicating flow direction) on and immediately upstream and downstream of the site.
f. Site entrances/exits (as approved by the City).
g. Applicable standard erosion control notes from Appendix B, with additions or changes as required.
h. Other notes including references to timing of placement and removal of erosion control measures, and erosion measure specifications such that types and quantities of materials necessary for the installation of the erosion control measures are fully detailed.
i. Stamped or signed by a Certified Professional for projects that disturb 1 acre or more of land surface.

If the site erosion control plan includes sediment traps or ponds, the applicant shall also submit calculations used for determining trap or pond sizing and pipe orifice sizing.

Because of particular site conditions or preferences, the applicant may desire in certain cases to use different erosion control measures than those recommended in Tables 3-2 or 3-3. In such cases, the applicant must submit calculations or other supporting information used to determine the sizing and layout of the measures shown on the submitted erosion control plan.

Cumulative ground disturbing activity, in excess of one acre, requires a NPDES #1200-C storm water general permit issued by the Department of Environmental Quality (DEQ). As indicated above, a copy of the NPDES #1200-C application is required to be submitted to the City of Corvallis.

If the facilities and techniques approved in an EPSC Plan are not effective or sufficient, the applicant shall:

- Take immediate action to stop sediment from leaving the site.
- Immediately implement additional facilities and techniques as approved by the City Inspector.
- Prepare and submit a revised EPSC Plan for City approval.

2.6.3 Construction in Public Rights-of-Way

Private construction in public rights-of-way has the same erosion control plan submittal requirements as noted in Section 2.6.2 above.

An exception is construction of private utilities and similar localized construction or maintenance activities. Such construction must meet noted erosion control measures in Table 3-4 for utilities construction and stock piles as applicable. For such construction, the applicant need only submit the completed Erosion Control Permit Application form in Appendix C as required; unless different erosion measures than those indicated in Table 3-4 are desired, in which case an erosion control site plan drawing must be submitted as required in Section 2.6.2 above. An annual blanket permit may be issued for franchised utilities and City construction activities.

2.7 Internet Access Sites

Oregon Seed Certification Service www.oscs.orst.edu
Natural Resource Conservation Service www.or.nrcs.usda.gov
International Erosion Control Association www.ieca.org
Pacific Northwest Chapter IECA www.pnwieca.org
West Coast Weather Observations www.ocs.orst.noaa.gov
Oregon Coast and Pacific Northwest Weather http://IWIN.nws.noaa.gov/iwin/or/or.html
Oregon Division of State Lands (DSL) http://statelands.dsl.state.or.us/
Oregon Department of Fish and Wildlife (DFW) http://www.dfw.state.or.us/
Oregon Department of Environmental Quality (DEQ) http://www.waterquality.deq.state.or.us
Oregon Department of Agriculture (ODA) http://www.oda.state.or.us

CHAPTER 3
EROSION AND SEDIMENT CONTROL MEASURES AND BMP'S

This chapter presents best management practices for erosion prevention and sediment control. Information such as advantages, disadvantages, design, inspection, and maintenance requirements for each BMP are also included, and should help the designer choose the most appropriate measure or control. In order to maximize the overall benefits of any BMP selection and location, planners and designers must have a thorough understanding of the site characteristics. In addition, preconstruction meetings provide a means of opening lines of communications between ALL individuals affected by the construction, either directly or indirectly.

The details of installation can and should vary in the field depending on the site conditions. Field variations for each type of measure are encouraged. The substitution of other cost-effective products or methods that provide substantially equivalent or superior performance is allowed if approved by the City.

As implied by their name, BMP's are stabilization methods and structural erosion control measures that represent commonly accepted practices. Table 3-1 represents ratings for basic applications of commonly used erosion and sediment control measures. Tables 3-2 through 3-4 are matrices presenting recommended minimum erosion control measures for various site and construction types. Additional measures may be required based on specific site conditions. Table 3-2 is a matrix summarizing recommended erosion controls for single family residential and duplex construction activities on single lots of record. Table 3-3 summarizes recommended erosion control measures for larger construction sites including commercial, industrial and subdivision development and construction. Table 3-4 is a matrix presenting recommended erosion controls for small, linear utilities construction and ditches/swales.

Erosion control measures are divided into two categories:

- Base measures which are required for construction sites at all times while there is disturbed or unstabilized ground surface on the site, and
- Supplementary wet weather measures which are required from October through April in addition to the base measures.

Base measures are indicated on Tables 3-2 through 3-4 with an "X" indicating primary recommended base measures and "A" indicating alternate measures. Wet weather measures are indicated on Tables 3-2 through 3-4 with an "*" for primary recommended measures and with an "O " for alternate measures. In the event of unusual weather patterns, the use of wet weather measures may be required at other times of the year. This is particularly true for the use of plastic sheet coverings.

Each erosion control measure presented in the matrices is presented in further detail with design, construction and maintenance criteria in the following sections of this chapter.

Table 3-1 Matrix of temporary and permanent erosion control measures and estimated effectiveness ratings: E=Excellent, M=Moderate, P=Poor

BMP APPLICATION	TEMPORARY VS PERMANENT	RATING	PAGE
3.1 EROSION PREVENTION			
3.1.1 Preserve Natural Vegetation	P	E	3-7
3.1.2 Buffer Zone	P	E	3-8
3.1.3 Seeding Temporary/Permanent	T/P	E	3-9
3.1.4 Ground Cover	T	E	3-13
3.1.5 Hydraulic Applications	T/P	E	3-15
3.1.6 Sod	P	M	3-17
3.1.7 Matting	T	M	3-18
3.1.8 Plastic Sheeting	T	M	3-24
3.1.9 Dust Control	T	M	3-26
3.2 RUNOFF CONTROL			
3.2.1 Construction Entrance	T	E	3-28
3.2.2 Tire Wash	T	E	3-31
3.2.3 Pipe Slope Drain	T	E	3-34
3.2.4 Outlet Protection	T	E	3-37
3.2.5 Surface Roughening	P	E	3-40
3.2.6 Check Dams	T	M	3-44
3.2.7 Diversion Dikes and Swales	T	M	3-48
3.2.8 Grass-lined Swale	T	M	3-52
3.3 SEDIMENT CONTROL			
3.3.1 Sediment Fence	T	M	3-54
3.3.2 Bio-filter Bags	T	M	3-57
3.3.3 Sand Bags	T	M	3-59
3.3.4 Filter Berm	T	M	3-60
3.3.5 Wattles	T	M	3-62
3.3.6 Sidewalk Subgrade Gravel Barrier	T	M	3-63
3.3.7 Inlet Protection	T	M	3-65
3.3.8 Dewatering	T	E	3-73
3.3.9 Sediment Trap	T	E	3-74
3.3.10 Sediment Basin	P	E	3-77

Table 3-2 Erosion Control Matrix
Single-Family, Duplex Residential, Manufactured Homes

	Construction Site		Stock Piles
Base Measures	Slope<2%	Slope>2%	
1. Gravel construction entrance (BMP 3.2.1)	X	X	
2. Sediment barrier at toe of disturbed area or stockpile (BMP 3.3.1 to 3.3.5)	X	X	X
3. Sidewalk subgrade gravel barrier (site slopes to street at <5%) (BMP 3.3.6)	A	A	
4. Undisturbed buffer at toe of disturbed areas (site slopes <10%) (BMP 3.1.2)	A	A	
5. Storm drain inlet protection barrier (BMP 3.3.7)	X	X	X
Wet Weather Measures			
6. 6-mil plastic sheet cover (BMP 3.1.8)			*
7. 2"-min. Straw mulch cover (BMP 3.1.4)			O
Post Construction			
8. Reestablish permanent ground cover or landscape prior to removing erosion measures (BMP 3.1.3)	X	X	

Key:

X Base measure
A Alternate to Base Measure 2
* Supplemental web weather measures (October - April) (Seeding prior to September 1)
O Alternate supplemental wet weather measures, can be used as applicable

Table 3-3 Erosion Control Matrix
Commercial, Subdivision and Large Site Construction

	Site Slope							Stock Piles
	<2%	<10%	<15%	<20%	<30%	<50%	>50%	
Base Measures								
1. Gravel construction entrance (BMP 3.2.1)	X	X	X	X	X	X	X	
2. Sediment barrier at toe of disturbed area (BMP 3.3.1 to 3.3.5)	X	X	X	X	X	X	X	X
3. Undisturbed buffer at toe of disturbed area (BMP 3.1.2)	A	A						
4. Sediment fence installed on contours (spacing) (BMP 3.3.1)		X (300')	X (150')	X (100')	X (50')	X (25')	X (25')	
5. Temporary interceptor dikes/swales around active work areas (BMP 3.2.7)	#	#	#	#	#	#	#	
6. Storm drain inlet protection barrier (3.3.7)	X	X	X	X	X	X	X	X
Wet Weather Measures								
7. Established grass (BMP 3.1.3)		*	*	*	*	*	*	
8. 2" min. straw mulch cover (BMP 3.1.4)		O	O	O	O	O		O
9. Erosion blankets with anchors (BMP 3.1.7)		O	O	O	O	O	O	
10. 6-mil plastic sheet cover (BMP 3.1.8)		O	O	O	O	O	O	*
11. Sediment traps or ponds (BMP 3.3.9 and 3.3.10)		O	O	O	O	O		
Post Construction								
12. Reestablish permanent ground cover prior to removing erosion measures (BMP 3.1.3)	X	X	X	X	X	X	X	

Key:

X Base measure
A Alternate to Base Measure 2
Optional base measure, can use as applicable
* Supplemental wet weather measures (October - April) (Seeding prior to September 1)
O Alternate supplemental wet weather measures, can be used as applicable

Note: If different areas of the site have considerably different slopes, the site may be divided and erosion measures selected for each area for the appropriate columns in the matrix.

Table 3-4 Erosion Control Matrix
Utilities Construction and Stock Piles/Ditches/Swales Protection

	Utilities Construction		Stock Piles	Ditches/ Swales
	Catch Basin drainage	Ditch Drainage		
Base Measures				
1. Sediment fence or barrier at toe (BMP 3.3.1)				X
2. Check dams (BMP 3.2.6)		X		X
3. Storm drain inlet protection barrier (BMP 3.2.7)	X		X	
Wet Weather Measures				
4. Established grass (BMP 3.1.3)				*
5. 6-mil plastic sheet cover (BMP 3.1.8)			*	
6. 2"-min. straw mulch cover (BMP 3.1.4)			O	O
7. Erosion blanket with anchors (BMP 3.1.7)				O
Post Construction				
8. Reestablish permanent ground cover or landscape prior to removing erosion measures (BMP 3.1.3)	X	X		X

Key:
X Base measure
* Supplemental wet weather measure (October - April) (Seeding prior to September 1)
O Alternate wet weather measure to *

3.1 Erosion Prevention

The designer should keep in mind when laying out an erosion control plan that the purpose of the plan is to maximize erosion prevention and minimize sediment transport from disturbed ground surfaces. Erosion prevention is the most effective and inexpensive method for reducing overall environmental impacts associated with construction activities. With this in mind, Timing, Staging, Minimizing the amount of exposed soil and directing surface water runoff away from exposed soil are all excellent ways to minimize erosion during construction. Erosion control practices primarily involve preserving natural vegetation when possible or stabilizing exposed soils with temporary covers or permanent vegetation. Reducing the erosion associated with construction vehicular traffic is also covered in this section. Many of these techniques can reduce erosion by 80 to 95 percent compared with exposed soils.

1. Preserve Natural Vegetation
2. Buffer Zone
3. Temporary and Permanent Seeding
4. Hydraulic Applications
5. Ground Cover
6. Sod
7. Matting
8. Plastic Sheeting
9. Dust Control

3.1.1 Preserve Natural Vegetation

This BMP involves preserving natural vegetation to the greatest extent possible during the construction process, and after construction where appropriate. Maintaining natural vegetation is the most effective and inexpensive form of erosion prevention control. This method is particularly important in sensitive areas such as wetlands, stream corridors, lakes, and near steep slopes. The project manager, inspector and contractor should address and discuss preserving natural vegetation during the Pre-construction meeting. Although this is a proven BMP, it is imperative that all exposed soils are covered in a timely manner.

<u>Advantages</u>

- Helps reduce soil erosion and runoff while beautifying an area.
- Saves landscaping costs, provides areas for wildlife, and provides visual screening.
- Helps maintain water temperature. Temperature moderation is especially important when detention ponds drain to salmonid-bearing streams.
- Retains existing shade and cover habitat.
- Conserves or increases property values.

<u>Disadvantages</u>

- Retaining older, weak or diseased trees could create a safety hazard.
- May constrict area available for construction activities.

<u>Design Criteria</u>

- Coordinate with the Landscape Architect and Environmental Professionals assigned to the project when determining what to save and how to save it.
- Vegetation can be preserved in natural clumps or as individual trees, shrubs and vines.
- Clearly establish ground disturbance limits outside the dripline of preserved trees, using orange construction safety fence or flagging if approved
- Protect vegetation from:
    - Construction equipment injury above or below the ground level. Injury occurs from scarring, cutting roots, or compaction.
    - Grade changes, which affect the plants' ability to obtain air, water or minerals.
- Placing a layer of gravel and a tile system over the roots before a major fill allows air to circulate and protects the plant from the fill.
- Terracing the area around the plant, or leaving the plants on an undisturbed mound can increase the plants' survival chances.
    - Root exposure can lead to drying, freeze damage and potentially wind-throw.
    - Raising the grade as little as 6 inches can retard the normal exchange of air and gases.
    - Damage caused by excavations for tile, water and sewer lines.

<u>Inspection & Maintenance</u>

- Inspect once per week on active sites, once every two weeks on in-active sites,and within 24 hours following a 0.5 inch rain event
- Repair fencing and/or flagging
- Re-cover and/or seal exposed plant roots.

3.1.2 Buffer Zone

A buffer zone consists of an undisturbed area or strip of natural vegetation or an established suitable planting adjacent to a disturbed area that reduces erosion and runoff. The rooted vegetation holds soils; acts as a wind break and filters runoff that may leave the site.

Advantages

- Filters Sediment.
- Promotes infiltration.
- Provides habitat.
- Reduces velocity and quantity of runoff, dissipates energy.
- Provides visual screening.
- Can be used to stabilize stream banks.
- Low maintenance.

Disadvantages

- Requires keeping all construction equipment, debris and soils out of the natural areas.
- Extensive buffers can cover large areas of land that are not available for project development.
- Are not adequate in areas of concentrated flows

Design Criteria

- Preserve natural vegetation in clumps, blocks or strips.
- Preserve natural vegetation on unstable, steep slopes.
- Clearly establish construction limits with orange construction safety fence and signs spaced 100 feet apart.
- Buffers are best created by or preserved as native, high root mass, dense foliage vegetation. Vegetation should be at least 1 inch in height and provide 80 percent ground coverage. Blackberries do not make good erosion control buffers. Buffers are sized according to the table below:

Site Characteristics	Minimum Buffer Width
Flat sites (<10% slope)	10'
Adjacent waterways and other natural features	Per Land Development Code Chapter 4.5

- Vegetative buffer zones for streams, lakes or other waterways should meet current regulatory standards for width (refer to Land Development Code Chapter 4.5).

Inspection & Maintenance

- Inspect flagging and fencing frequently and repair any rills and replace and/or add additional plants as needed.

3.1.3 Seeding (Temporary/Permanent)

A well-established vegetative cover is one of the most effective methods of reducing erosion. Vegetation should be established on construction sites as the slopes are finished, rather than waiting until all the grading is complete. Equally important and often overlooked is temporary or permanent irrigation. **Temporary or permanent seeding applications must be completed prior to September 1st of each year.**

Advantages

- Eliminates splash erosion
- Traps sediment.
- Promotes infiltration
- Improves appearance of the site.
- Reduces runoff velocities
- Provides excellent stabilization.
- Relatively inexpensive erosion control measure.
- Effective for dust control

Disadvantages

- Needs sufficient time for seed to establish.
- Requires mulch or other cover until vegetation is established.
- May require fertilizer and lime to establish on poor soils.
- Requires irrigation.
- Must be removed prior to applying fill material.

Design Criteria

The following discussion presents general information regarding seeding, bed preparation, mulching and fertilizing.

Selection Criteria

Standard grass and legume seed mixes for erosion control purposes are developed by local or regional distributors, for site specific applications. Often more than one plant species is selected so that at least one species will do well given the extreme seasonal fluctuations that occur in nature. Specific plant characteristics are chosen when developing an erosion control seed mix. Grass species are normally used rather than other plant species because of their fibrous root systems and quick establishment.

Seedling vigor is an important plant characteristic to consider for erosion control seeding because the goal is to have rapid establishment and a dense fibrous root system. This holds the soil in place and provides a thick canopy over the soil to break the raindrop velocity. Some grasses do well early in the season and can act as nurse or cover crops until the slower growing species can establish. Seed mixes are developed for specific climatic zones around the state to match the optimum growing conditions for each species.

One grass seed characteristic that is considered is the season that predominant growth will occur. Grass species are often characterized as being either warm or cool season grasses. A warm season grass, such as bluegrass, will have its predominant growth during the warm months of the year. Conversely, cool-season grasses, like hard fescue, have its predominant growth in the cool weather and produces seeds in the early spring. To obtain optimum establishment, a cool or warm season grass, or both, may be used depending on whether the seed is planted in the spring or fall.

Another plant characteristic of importance in erosion control is the method by which the grass develops, grows and spreads. Grasses can be either rhizomatous, whereas the grass plant will send out runners that will start new growth, a bunch grass, or a sod-forming grass. Rooting depth is important and grasses are characterized as being deep, moderate and shallow rooting for erosion control purposes. The mixture of rooting depths provides optimum support for soils and best enables the removal of water by the roots at the various zones in the soil.

Seed Purity

All seed applied should be those specified in the project plan and should be measured by Pure Live Seed (PLS) weight. Pure live seed refers to the portion of a seed lot that is live seed of the desired kind. The purpose of measuring the application on a PLS basis is so that trash and empty seeds do not confuse seeding rate calculations.

The seed lots should be tested and meet the minimum seed standards. Lots showing Oregon prohibited weeds are not approved. Seed must meet minimum viability standards. Oregon State University Extension Service keeps a listing of seed varieties that are certified in the OSU Extension Certified Seed Handbook. The seed variety must be approved by the OSU Seed Certification Board to be eligible for certification or meet the standards for certification.

- Temporary grass cover measures must be fully established by October 1st or other ground cover measures will have to be implemented. In order to establish an 80% healthy stand of grass, all seeding applications must be completed prior to September 1st.
- Apply permanent seeding when no further disturbances are planned.
- Seed should be applied immediately after seedbed preparation while the soil is loose and moist.
- Apply seed before applying straw mulch or other ground cover applications.
- Hydromulch shall be applied with grass seed at a rate of 2000 lb./acre. On slopes steeper than 10 %, hydroseed and mulch shall be applied with a bonding agent (tackifier). Application rate and methodology to be in accordance with seed supplier recommendations.
- Dry, loose, weed-fee straw used as mulch shall be applied at double the hydromulch application requirement (4000 lb./acre). Anchor straw by working in by hand or with equipment (rollers, cleat tracks, etc).
- Permanent or temporary irrigation shall be supplied especially in abnormally hot or dry weather or on adverse sites. Water application rates should be controlled to provide adequate moisture without causing runoff.

Site Preparation

- Bring the seedbed area to final grade, remove all rocks and debris, and smooth surface undulations larger than 2 inches.
- Divert concentrated flows away from the seeded area.
- For optimum seeding conditions preserve topsoil and stockpile material until final grades are established. Spread topsoil over new grades or:
- Conduct soil test to determine pH and nutrient content.
- Roughen the soil by harrowing, tracking, grooving or furrowing.
- Apply amendments as needed to adjust pH to 6.0-7.5. Incorporate these amendments into the soil.
- The seedbed should be firm but not compact. The top 4-6 inches of soil should be loose, moist and free of large clods and stones.
- If the seedbed has been idle long enough for the soil to become compact, the topsoil should be harrowed with a disk, spring tooth drag, spike tooth drag, or other equipment designed to condition the soil for seeding.
- Harrowing, tracking or furrowing should be done horizontally across the face of the slope, so ridges are along the slope contour.

Seeding

- Seed to soil contact is the key to good germination.
- Apply seed at the rates specified using calibrated seed spreaders, cyclone seeders, mechanical drills, or hydroseeder so the seed is applied uniformly on the site
- Broadcast seed should be incorporated into the soil by raking or chain dragging, and then lightly compacted to provide good seed-soil contact.
- Apply mulch and tackifier or matting, as specified, over the seeded areas.
- To prevent seed from being washed away, confirm installation of all required surface water control measures.
- Double the rate of seed application when mulch and seed is applied in a single application.
- Recommended erosion control grass seed mixes are as follows. Similar mixes designed to achieve erosion control may be substituted with approval
  1. Dwarf Grass Mix (low height, low maintenance)
     Dwarf Perennial Ryegrass, 80% by weight
     Creeping Red Fescue, 20% by weight
     Application rate: 100 pounds minimum per acre
  2. Standard Height Grass Mix
     Annual Ryegrass, 40% by weight
     Turf-type Fescue, 60% by weight
     Application rate: 100 pounds minimum per acre

Fertilizer

- Slow-release fertilizers are more efficient and have fewer environmental impacts.
- Areas being seeded for final landscaping may require soil tests to determine the exact type and quantity of fertilizer needed to prevent the over-application of fertilizer. Use non-phosphorus fertilizer on disturbed areas within 50 feet of water bodies and wetlands.
- The use of stockpiled topsoil or compost reduces the need for fertilizer and improves the overall soil quality.
- Provide project-specific application rates

Mulch

- Refer to Ground Cover and Matting sections of this chapter.
- Straw mulch in loose condition is preferred for seeding during the wet season on slopes 3:1 or flatter.
- Straw mulch may be required during the dry season if:
  - Grass growth is expected to be slow;
  - The soils are highly erodible;
  - There is a water body close to the disturbed area; or
  - Significant precipitation is anticipated before the grass will provide effective cover.
- The straw mulch shall not be moldy, caked, decayed or of otherwise low quality.
- Can be applied on top of the seed or applied with the seed during hydroseeding.
- The application rate of seed per acre should be increased if seed and mulch are applied in a single application.

Hydroseed

- Refer to Hydraulic Application section (BMP 3.1.5) of this chapter
- Hydroseeding requires a mulch or green dye tracer as a visual aid during application.
- On slopes steeper than 2:1, hydroseeding requires an increased rate of tackifier to be applied.
- During the dry season, hydroseeding with wood fiber mulch is adequate.

Inspection & Maintenance

- Inspect once per week on active sites, once every two weeks on in-active sites, and within 24 hours following a 0.5 inch rain event
- Newly seeded areas need to be inspected frequently to ensure the grass is growing.
- If the seeded area is damaged due to runoff, additional BMP's may be needed. Re-seed and mulch damaged areas.
- Spot seeding can be done on small areas to fill in bare spots where grass did not grow properly.
- If spot seeding is ineffective, use an alternate method, such as sod or matting.
- Re-seed and protect with mulch any areas affected by erosion. If the erosion is caused by concentrated runoff, fix the runoff problem and then re-seed and mat the area.

3.1.4 Ground Cover

Ground Cover is a protective layer of straw or other suitable material applied to the soil surface. Straw mulch and/or hydromulch are also used in conjunction with seeding of critical areas for the establishment of temporary or permanent vegetation. Ground cover provides immediate temporary protection from erosion. Mulch also enhances plant establishment by conserving moisture, holding fertilizer, seed, and topsoil in place, and moderating soil temperatures.

Advantages

- Provides immediate protection.
- Conserves moisture
- Acts as a thermal layer for seed
- If used in conjunction with seed, allows seed growth through the mulch
- Protects seeding from direct heat, moisture loss and transport due to runoff
- Used for dust control

Disadvantages

- Thick mulches can delay germination.
- Can be blown or washed away if not adequately tackified.
- Must be removed prior to applying fill material.

Design Criteria

- Divert concentrated runoff from above mulched areas.
- Refer to Table 3-5 outlines mulch type, quality, and application rate.
- The following pages include specific material and application criteria
- Refer to Appendix D for *Mulch Application Rate Worksheet.*

Inspection & Maintenance

- Inspect once per week on active sites, once every two weeks on in-active sites, and within 24 hours following a 0.5 inch rain event
- Maintain specified thickness of the cover.
- Re-mulch and/or protect with a net or blanket any areas that experience erosion.
- If the erosion problem is drainage related, fix the drainage problem and re-mulch the eroded area.
- Hydraulically treated areas shall be inspected and monitored after installation and
- periodically thereafter.
- Hydraulic mulches and tackifiers shall provide the necessary erosion protection until permanent erosion-resistant cover is established. If sheet or rill erosion is evident then prompt re-application of treatments shall be necessary.
- If the hydraulic mulch or tackifiers were applied as stand alone (without vegetation) treatments for erosion and dust control, the product longevity must match the length of time that the soil will remain bare or until revegetation occurs. Periodic inspections will assure the intended purposes will be met.
- Areas that fail to establish cover adequate to prevent erosion shall be re-mulched as soon as such areas are identified.
- If mulched areas are damaged by concentrated runoff, the prompt implementation of additional practices and BMP's may be necessary.

Table: 3-5 Ground Cover Application

Mulch Material	Quality Standards	Application Rate Per acre	Depth of Material	Considerations
Straw	Air dried, free from unwanted seeds & coarse materials	2-2 ½ tons or 90-120 bales	2 inches min. uniform spread	Use where the mulching effects is to be maintained < 3 months. When chopped straw is applied, use a tackifier
Yard Debris Compost	Well composted organic matter free of metals, plastics and other foreign matter	3-6 tons	1 inch 4:1 slopes 2 inch 3:1 slopes 3 inch 2:1 slopes	Excellent soil amendment. Compost size: ¾ x 0 on 3:1 slopes or less. 1 ½ x 0 on 2:1 slopes.
Wood or Cellulose fiber	Dyed green, should not contain growth inhibiting factors	2000 lbs.	N/A	Apply with hydromulcher. May need to double the rate depending on soil and slope. Use tackifier as recommended by manufacturer.
Wood Chips or Grindings	Green or airdried free of objectionable coarse materials	5-6 tons	1-3 inches depending on slope	Very durable. Apply with mulch blower, excavation equipment, or by hand. Not suitable for areas that require close mowing.
Gravel or Crushed Rock	Washed ¾-1.5 inch	9yds/1000 ft2	3 inches	Excellent for short slopes and where subject to foot traffic. Larger pit-run can be used on steep slopes .prone to sub-surface water (springs)

3.1.5 Hydraulic Application

Hydraulic application is a mechanical method of applying erosion control materials to bare soil in order to establish erosion-resistant vegetation on disturbed areas and critical slopes. By using hydraulic equipment, soil amendments, mulch, tackifying agents, Bonded Fiber Matrix (BFM) and liquid co-polymers can be uniformly broadcast, as homogenous slurry, onto the soil. These erosion and dust control materials can often be applied in one operation.

Advantages

- Provides rapid installation with a one step process.
- Generally requires less seedbed preparation, the surface soil may be left irregular with large clods, stones, or rock outcropping exposed.
- Uniformly distributes seed and mulch material.
- Increases favorable conditions for quick germination and growth.
- Can be used effectively on steep slopes and other areas where access is limited.

Disadvantages

- Generally more expensive than broadcast or drilling seed applications.
- Thick mulch applications can delay germination.
- Can be blown or washed away if not adequately tackified.
- Required application rates can vary significantly dependant on site preparation.

Design Criteria

- Divert concentrated runoff from above treated areas.
- Seed, fertilizer, mulch, tackifier, soil amendments, Bonded Fiber Matrix, and chemical stabilization can be applied in a one step procedure.
- Wood fiber mulch or wood/paper mulch should be applied at a rate of 2000 to 2500 lbs per acre.
- Bonded Fiber Matrix (BFM) is considered a liquid blanket and can be applied on steep 1:1 slopes. Application rates between 4000 and 4000 lbs per acre, depending upon soil type and irregularities.
- Use hydraulic applications on slopes steeper than 4:1 that cannot receive adequate seedbed preparation and where mulch would be difficult to otherwise anchor.
- On sites where other soil stabilization, seeding, and mulching practices would result in unacceptable levels of ground disturbance.
- Where site conditions, such as irregular soil surfaces, existing vegetation, and shallow soils preclude the installation of erosion mats.
- When seeding, maintain sufficient moisture level using permanent or temporary irrigation.
- On sites where straw mulch has been applied and the straw needs to be anchored using a liquid tacking agent.
- On sites where dust control is desired.
- If the hydraulic mulch or tackifiers were applied as stand alone (without vegetation) treatments for erosion and dust control, the product longevity must match the length of time that the soil will remain bare or until re-vegetation occurs.
- Refer to Appendix D Hydraulic Application Tables for seed and mulch.

Inspection & Maintenance

- Inspect once per week on active sites, once every two weeks on in-active sites, and within 24 hours following a 0.5 inch rain event
- Re-mulch and/or protect with a erosion control mating any areas that experience erosion. If the erosion problem is drainage related, fix the drainage problem then make necessary repairs.

- Hydraulic mulches and tackifiers shall provide the necessary erosion protection until permanent erosion-resistant cover is established. If sheet or rill erosion is evident then prompt re-application of treatments shall be necessary.
- Areas that fail to establish 80% healthy stand of grass cover to prevent erosion shall be properly covered using one of the selected application.

3.1.6 Sod

Establishes permanent turf for immediate erosion protection and stabilizes drainageways.

Advantages

- Provides immediate, effective protection, and is aesthetically pleasing.
- Provides high-density vegetation, which is superior to a recently seeded area.
- Placement can occur any time that soil moisture is adequate and the ground is not frozen.

Disadvantages

- Expensive.
- Availability is seasonal.
- Irrigation may be required if installed in summer.
- Difficult to mow if installed on slopes steeper than 3:1.
- Installations in grassed waterways may roll up if not anchored or drained properly.
- Time necessary for root establishment may be lengthy.

Design Criteria

- Use sod as a short or long-term cover.
- Around inlets located off roadways
- Use sod that is generally weed free, has uniform thickness (approximately 1 inch thick) and dense root mat for mechanical strength.
- Generally inappropriate for bioswales. Sod can be used for lining ditches or waterways carrying intermittent flows.
- The following steps are general recommendations for sod installation:
    1. Shape and smooth the surface to final grade in accordance with the approved grading plan.
    2. Fertilize as per supplier's recommendations. Non-phosphorous fertilizer is required near water bodies and wetlands.
    3. Work lime and fertilizer into soil 1-2 inches deep and smooth the surface.
    4. Lay sod strips perpendicular to the direction of water flow, beginning at the lowest area to be sodded. Wedge strips securely into place and square the ends of each strip to provide for a close, tight fit. Stagger joints at least 12 inches. Staple sod onto 3:1 and steeper slopes.
        - Roll the sodded area and irrigate.
        - Not for use in high velocity channels/ditches

Inspection & Maintenance

- Inspect once per week on active sites, once every two weeks on in-active sites, and within 24 hours following a 0.5 inch rain event
- Inspect sod area frequently for soil moisture content and root establishment.
- Re-tack, re-sod or re-seed as necessary.
- If it is impossible to establish a healthy ground cover due to frequent saturation, instability, or some other cause; remove the sod, seed the area with an appropriate mix, and protect with matting.

3.1.7 Matting

There are numerous erosion control products available that can be described in various ways, such as matting, blankets, fabric and nets. We will call them all matting. A wide range of materials and combination of materials are used to produce matting including, but not limited to: straw, jute, wood fiber, coir (coconut fiber), plastic netting, and Bonded Fiber Matrix. The selection of matting materials for a site can make a significant difference in the effectiveness of the BMP.

When selecting matting consider these questions:
1. How long will the matting be required to provide protection?
2. How steep is the slope?
3. What is the soil type?
4. What is the shear stress on the channel bottom?

Advantages

- Immediate cushioning against splash erosion from raindrop impact.
- Does not generate high-velocity runoff and, therefore, offers temporary slope protection, which is superior to plastic sheeting.
- Captures a great deal of sediment due to its open, porous structure.
- Usually easy to install.
- Provides long-term protection, based on matting selection.

Disadvantages

- Correct installation is critical to the effectiveness of these products. Good ground contact during installation prevents runoff concentrating under the blanket and causing significant erosion (tenting).
- Soil surface must be graded smooth with no surface irregularities.
- Limited protection capabilities when used as flexible channel liner.

Design Criteria

- Generally used on slopes 3:1 and steeper.
- Surface must be graded smooth.
- Remove all debris and undulations larger than 2 inches in any dimension.
- Apply seed and fertilizer prior to matting.
- Install so that matting is in complete contact with soil surface.
- See Table 3-6 for matting application and staple pattern
- Organic matting materials (excelsior, jute and coir) biodegrade and are useful for applications requiring stabilization for up to three months. Use organic blankets, which retain moisture and provide organic matter to the soil, for slope protection and short-term waterway protection and to improve the speed and success of revegetation.
- Excelsior brand (aspen wood fibre), woven straw, and coir (coconut fiber) blankets may be installed without mulch because they provide complete surface protection.
- Synthetic mats are made from non-biodegradable material and will remain in place for years (some photodegradation does occur). Use purely synthetic blankets for long-term stabilization of waterways.
    - Turf Reinforcement Mats (TRM) are made from polymer netting or monofilaments formed into a Synthetic 3-D mat. TRMs protect seed and increase germination and also acts as part of the root structure; giving the turf higher strength.
    - Erosion Control and Revegetation Mats (ECRM), composed of heat-fused monofilaments or monofilaments stitched between netting act as permanent mulch. ECRM allow growth through the mat.
- Channel or swale applications:
    - Lengthwise overlap: Min. 12 inches

- Crosswise overlap: Min. 6 inches
- Avoid joining material in center of ditch or swale

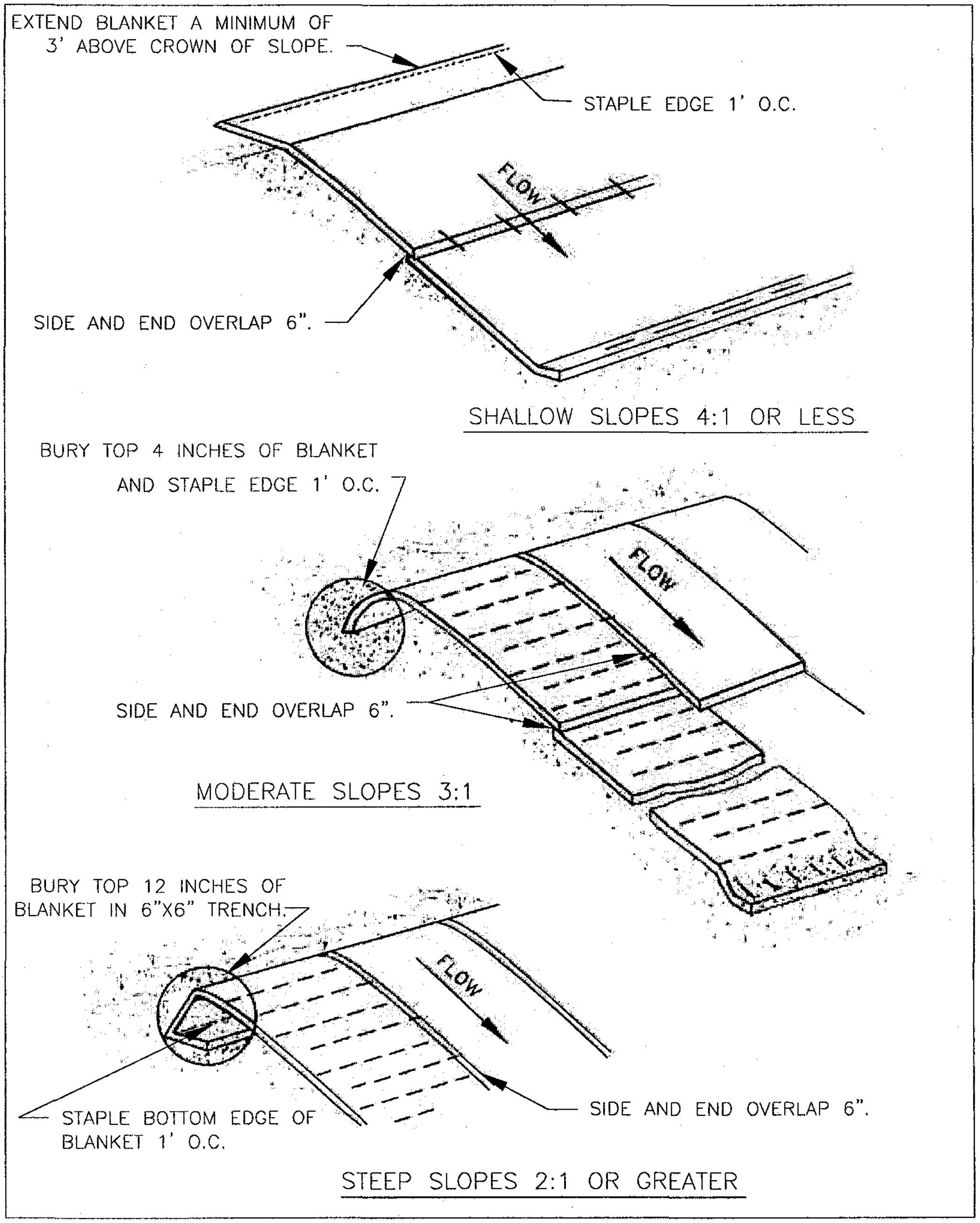
- Slope application:
  - Lengthwise overlap: Min. 6 inches
  - Crosswise overlap: Min. 6 inches
  - At top of slope, entrench material in a 6 inch X 6 inch trench and staple at 12 inch intervals
  - At bottom of slope, extend mat 2 feet beyond the toe of the slope, turn material under 4 inches and staple at 12 inch intervals
  - On 4:1 slopes, rolls can be placed in horizontal strips
  - Mats must be stapled in place as they are installed down the slope face every 4 feet until you reach the bottom. This keeps blanket in relaxed position, eliminating the potential for under-rilling.

<u>Inspection & Maintenance</u>

- Inspect once per week on active sites, once every two weeks on in-active sites, and within 24 hours following a 0.5 inch rain event
- Repair any damaged areas of the net or blanket and staple into the ground any areas not in close contact with the ground surface.
- If erosion occurs, repair and protect the eroded area.

Table 3-6 Matting Specifications

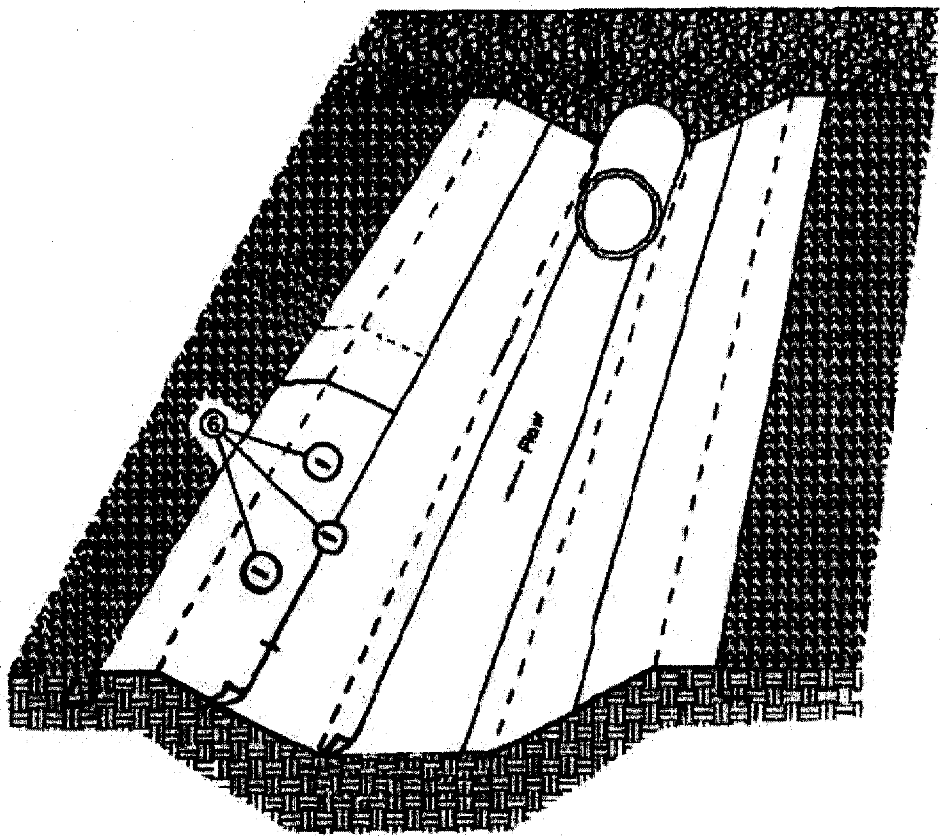
Matting Type	Slope/ Channel Application	Netting Type
Straw	3:1 or less	Type 1 - Photo degradable polypropylene top/bottom Type 2 - 100% Bio degradable (used near sensitive habitat areas)
Straw/Coconut	2:1 or less	Type 1 – Photo degradable polypropylene top/bottom Type 2 – 100% Bio degradable (used near sensitive habitat areas)
Coconut	1:1 or less Low flow channels	Type 1 – Photo degradable polypropylene top/bottom Type 2 – 100% Bio degradable (used near sensitive habitat areas)
Jute	3:1 or less Short, 2:1 slopes	100% Bio degradable
Excelsior	2:1 or less Low flow channel	Photo degradable extruded plastic mesh top/bottom
Coir fabric	1:1 or less 8-10 fps channel	Type 1 – 1 inch grid 100% Bio degradable (4-10 year life) Type 2 – ½ inch grid 100% Bio degradable (4-10 year life) Type 3 – ¼ inch grid 100% Bio degradable (4-10 year life)
TRM	High flow channels 8-20 fps	Three dimensional synthetic polyolefin fibers mechanically bonded between two nets.



NOTES:

1. ON SHALLOW SLOPES BLANKETS MAY BE APPLIED ACROSS THE SLOPE.
2. ALL BLANKET STAPLE REQUIRED AS PER TABLE.

MATTING SLOPE INSTALLATION	Detail Drawing 3.1.7a

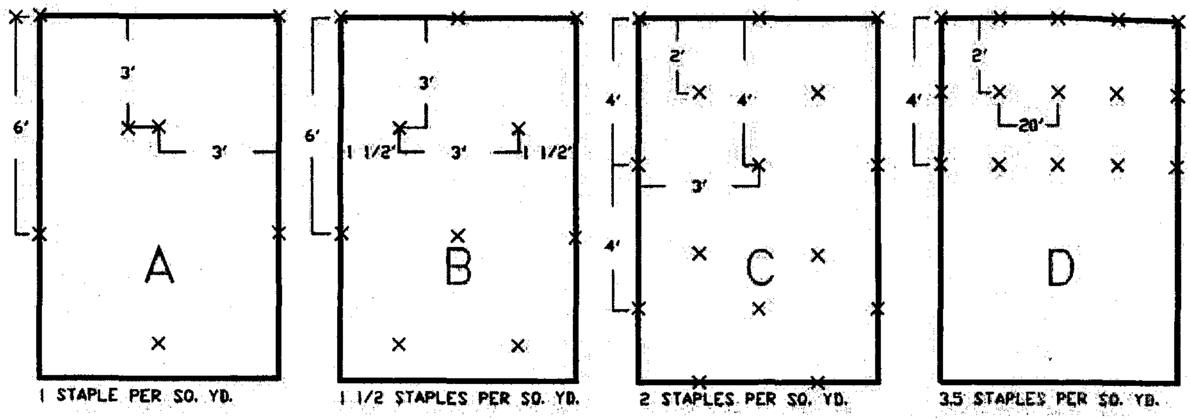


CHANNEL INSTALLATION

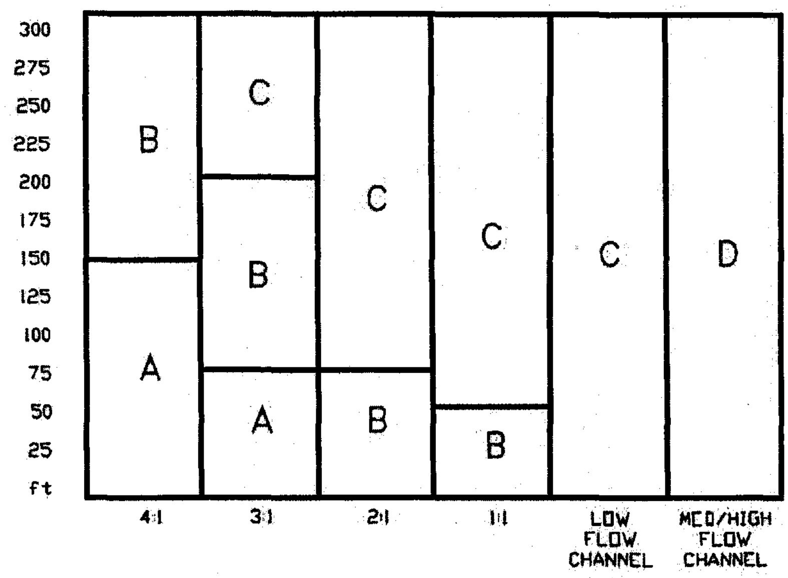
NOTES:
1. INFORMATION PROVIDED IS MINIMUM REQUIREMENTS. MANUFACTURES REQUIREMENTS WHICH ARE MORE STRINGENT SHALL BE USED.
2. INSTALL MAT PARALLEL IN CENTER OF CHANNEL IN THE DIRECTION OF FLOW. FOR CULVERT OUTFALLS, PLACE MAT UNDER CULVERT OR RIP
3. IN CHANNEL BOTTOM, OVERLAP LENGTH ENDS A MINIMUM OF 12 INCHES. WRAP A MINIMUM OF 12 INCHES.
4. REFER TO DETAIL DRAWING 3.1.7a FOR CHANNEL SLOPE APPLICATION.
5. REFER TO DETAIL DRAWING 3.1.7c FOR STAPLE PATTERN.
6. LENGTH OF STAPLES SHALL BE DETERMINDED BY SOIL TYPE– COHESIVE SOIL USE 6 INCH, NON–COHESIVE SOILS 8–12 INCH.

MATTING CHANNEL INSTALLATION	Detail Drawing 3.1.7b

STAPLE PATTERN



LENGTH AND SLOPE TABLE



*MINIMUM STAPLE PATTERN GUIDE AND RECOMMENDATION FOR SLOPE AND CHANNEL APPLICATION.

STAPLE TABLE	Detail Drawing 3.1.7c

3.1.8 Plastic Sheeting

Provides immediate protection to slopes and stockpiles. Plastic sheeting has been known to transfer erosion problems because water will sheet flow off the plastic at high velocity. This is usually attributable to poor application, installation and maintenance. Use alternatives to plastic covering whenever possible.

Advantages

- Provides immediate, short-term erosion protection to slopes that are prone to erosion and stockpiles.
- Fairly quick and easy to install.

Disadvantages

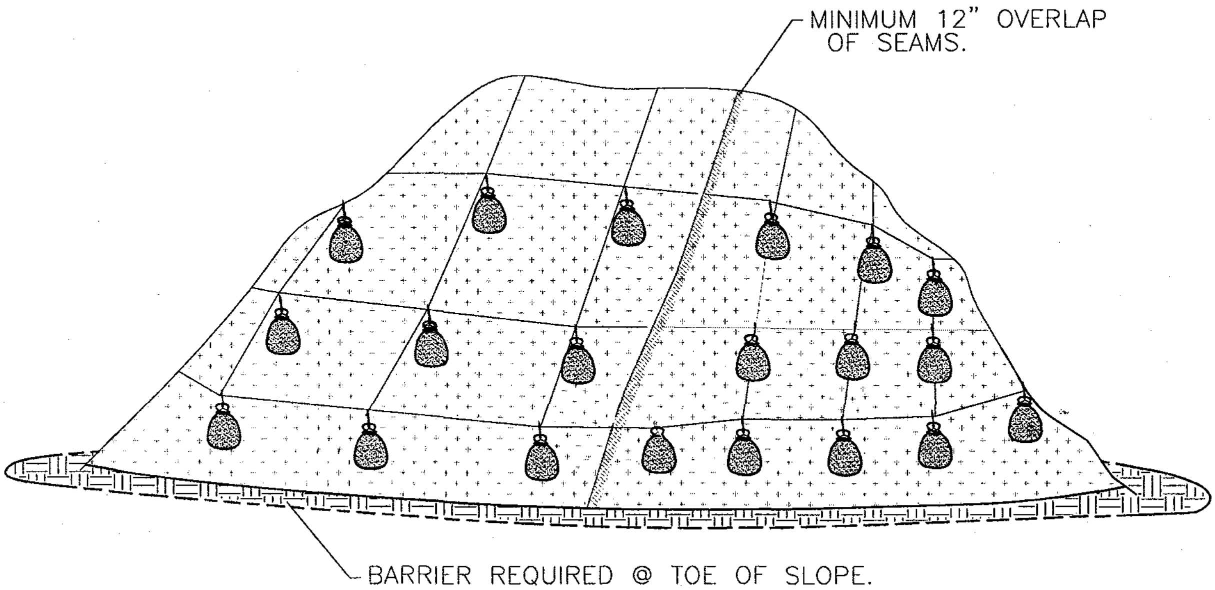
- Plastic sheeting may concentrate sunrays and burn the vegetation beneath it.
- Material generates high velocity runoff.
- Plastic breaks down quickly when exposed to ultraviolet radiation.
- Plastic, when it is not completely removed, can clog drainage system inlets and outlets.
- If not properly anchored, wind may transport plastic onto roadways and create traffic hazard.
- Not effective for preventing illegal discharge

Design Criteria

- Do not use plastic covering upslope of areas such as steep and/or unstable slopes that might be adversely affected by concentrated runoff.
- When possible, install an interceptor dike at the top of the plastic to divert flows away from the plastic.
- Toe-in the top of the sheeting in a 6 inch X 6 inch trench backfilled with compacted native material.
- Install a gravel berm, riprap, or other suitable protection at the toe of slope in order to dissipate runoff velocity.
- Anchor the plastic using sandbags or other suitable tethered anchoring system spaced on a 10 foot grid spacing.
- Overlap seams 1-2 feet, tape, roll and stake the seams and then weigh down the entire length.

Inspection & Maintenance

- Inspect once per week on active sites, once every two weeks on in-active sites, and within 24 hours following a 0.5 inch rain event
- Replace torn sheets and repair open seams.
- Completely remove and replace plastic when it begins to deteriorate.
- Completely remove all plastic once it is no longer needed.
- Check anchoring system and repair or add anchors.



PLASTIC SHEETING

NOTES:
1. MINIMUM 12" OVERLAP OF ALL SEAMS REQUIRED.
2. BARRIER REQUIRED @ TOE OF STOCK PILE.
3. COVERING MAINTAINED TIGHTLY IN PLACE BY USING SANDBAGS OR TIRES ON ROPES WITH A MAXIMUM 10' GRID SPACING IN ALL DIRECTIONS.

PLASTIC SHEETING	Detail Drawing 3.1.8

3.1.9 Dust Control

Preventative measures to minimize the wind transport of soil, prevent traffic hazards and reduce sediment transported by wind and deposited in water resources.

Advantages

- Reduces movement of soil to offsite areas.
- Increases visibility.

Disadvantages

- Over watering may cause erosion.
- Most methods require immediate reapplication if disturbed.
- Too little watering fails to control dust.

Design Criteria

- Installing construction entrances and stabilizing construction haul roads with crushed rock
- Designer can provide project-specific dust control specifications for the contractor to apply. Measures include:
    - Seeding
    - Mulching
    - Matting
    - Water
    - Tackifier
    - Chemical Soil Stabilizers
- Schedule construction operations so that the least amount of project area is disturbed at one time.
- Install temporary or permanent surface stabilization measures immediately after completing land grading.

Inspection & Maintenance

- Maintain dust control measures through dry weather periods until all disturbed areas have been stabilized.
- Immediately re-stabilize areas disturbed by contractor's operations or other activities (wind, water, vandalism, etc.).

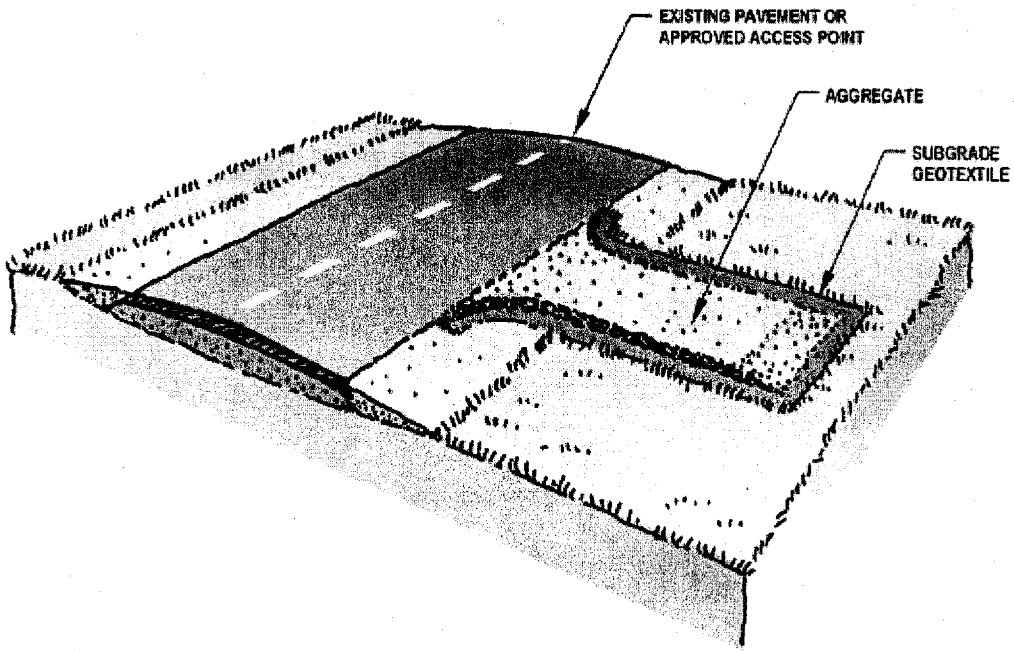
3.2 Runoff Control Practices

The greater the volume and velocity of surface water runoff on construction sites, the more sediment and other pollutants are transported to streams, wetlands, and lakes. Diverting runoff away from exposed soils can greatly reduce the amount of soil eroded from a site. Decreasing runoff velocities reduces erosion and the amount of pollutants carried off-site.

Runoff controls divert runoff from exposed areas and reduce runoff velocities. Runoff control BMP's that divert runoff from exposed areas include pipe slope drains and diversion swales. Runoff control BMP's that reduce runoff velocities include check dams and sediment traps.

1. Construction Entrance
2. Tire Wash Facility
3. Pipe Slope Drain
4. Outlet Protection
5. Surface Roughening
6. Check Dam
7. Diversion Dike/Swale
8. Dewatering

3.2.1 Construction Entrance



A stabilized rock pad, placed at construction site ingress/egress locations, that reduces the amount of sediment transported onto paved roads by vehicles or runoff. The Construction Entrance also includes a curb ramp designed out of wood.

Advantages

- Reduces traffic hazards caused by debris on public roadways.
- Reduces sediment and other debris from entering roadways, which can then be washed into the storm system.

Disadvantages

- Only effective if erosion and sediment control employed elsewhere onsite.
- Only works if installed at every location where significant construction traffic leaves the site.
- Fills with sediment quickly and requires frequent maintenance and/or replacement of rock.

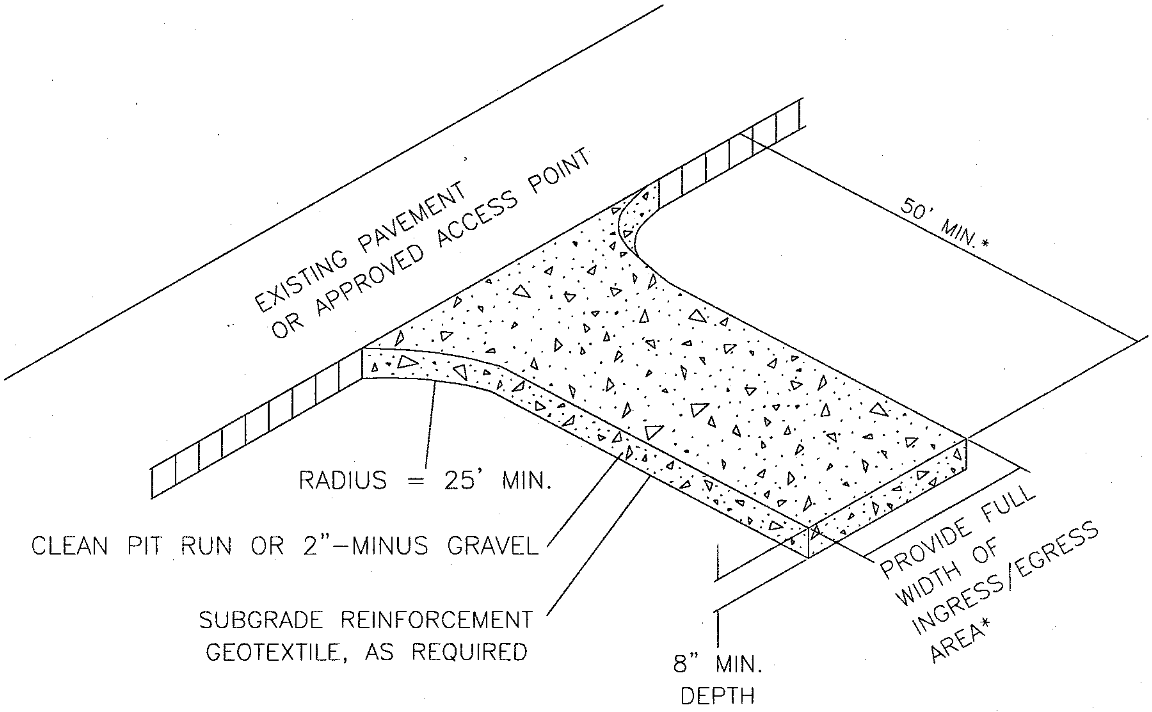
Design Criteria

- Install construction entrance prior to any site work.
- Whenever possible, construct the pad on a firm, compacted subgrade.
- Install geotextile under rock when subgrade is not stable or is "pumping" up into the pad.
- **Minimum length:**
    - 20 ft - all single family sites.
    - 50 ft – all other development sites.
- **Minimum width:**

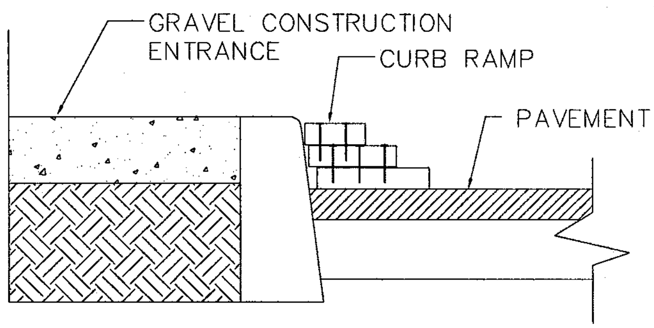
    - 20 ft - all construction sites.
- **Minimum Depth:**
    - 8 in. - all construction sites.
- **Rock Size:**
    - ¾ x 0 - all single family sites
    - 3-6 in. – all other construction sites
- Do not install rock on paved surfaces. (Use wood curb ramps.)
- Wood Curb ramps should be made out of 2x6 material, nailed together.
- Include a tire wash facility if the entrance does not prove effective in retaining sediment onsite.

<u>Inspection & Maintenance</u>

- Requires ongoing inspection
- Immediately sweep up and remove or stabilize onsite any sediment that is tracked onto pavement.
- If the sediment poses a threat to public safety and street sweeping proves ineffective, consider washing the street and collecting the water in a sediment pond or sump before it leaves the site.
- Add or replace rock as needed to maintain the specified dimensions.
- Immediately remove any rock, which gets carried from the pad to the roadway.



*20' MIN. FOR SINGLE FAMILY AND DUPLEX RESIDENTIAL



NOTES:

DIMENSIONS

SINGLE FAMILY

20' LONG BY 20' WIDE

8" DEEP OF $\frac{3}{4}$" MINUS CLEAN ROCK.

COMMERCIAL

50' LONG BY 20' WIDE

3–6" CLEAN ROCK,

GOVERNING AUTHORITY MAY REQUIRE GEOTEXTILE FABRIC TO PREVENT SUB-SOIL PUMPING.

CONSTRUCTION ENTRANCE	Detail Drawing 3.2.1

3.2.2 Tire Wash Facility

Two types of tire wash facilities are available depending on the severity of sediment tracking and the size and duration of project. Type 1 can be retro-fitted in the field, using geotextile fabric and rock. Like a stabilized construction entrance it is graded so that collected wash water is conveyed to a sediment trap, basin or other suitable treatment facility. Type 2 consists of a shallow concrete lined basin partially filled with water, through which exiting vehicles drive.

Advantages

- Reduces traffic hazards caused by debris on public roadways.
- Reduces sediment on roadways, which can wash into the storm sewer system.
- Type 1 is easy to construct and is relatively inexpensive.
- Type 2 is useful for high traffic volumes or large projects of long duration.

Disadvantages

- Only works if installed at every location where construction traffic leaves the site.
- Fills with sediment quickly and requires frequent maintenance.
- Requires a source of wash water.
- Requires a turnout or doublewide exit to avoid entering vehicles having to drive through wash area.
- Type 2 is costly to construct.
- Both facilities will generate large volumes of sediment-laden water, requiring treatment elsewhere on site.

Design Criteria

Type 1 (temporary)

- Minimum length: 40 ft.
- Minimum width: 10 ft.
- Minimum rock depth: 8 in.
- Average tire wash sump: 18 in.
- Install subgrade geotextile fabric as a liner
- Use 4-6 in. rock over geotextile fabric
- **Alternate:** 3 in. asphalt lift over a stable base coarse
- Grade the pad to drain to suitable collection and treatment facility.
- Install fencing as necessary to restrict exiting construction vehicle traffic to the tire wash.

Type 2 (permanent)

- Minimum length: 40 ft. with sloping ingress and egress
- Minimum width: 10 ft.
- Minimum rock depth: 8 in.
- Average tire wash sump: 18 in.
- Run out impervious area should be a minimum of 50 ft, graded back to facility.
- Line bottom of basin with geotextile and 12 in. of rock base coarse.
- Construct basin out of 12 in. concrete with steel reinforcement.
- Provide water supply.
- Provide outlet for sediment-laden water discharge to treatment facility or provide pumps and tanks for water treatment.

Inspection & Maintenance

- Inspect weekly minimum, or more depending upon use.

Type 1

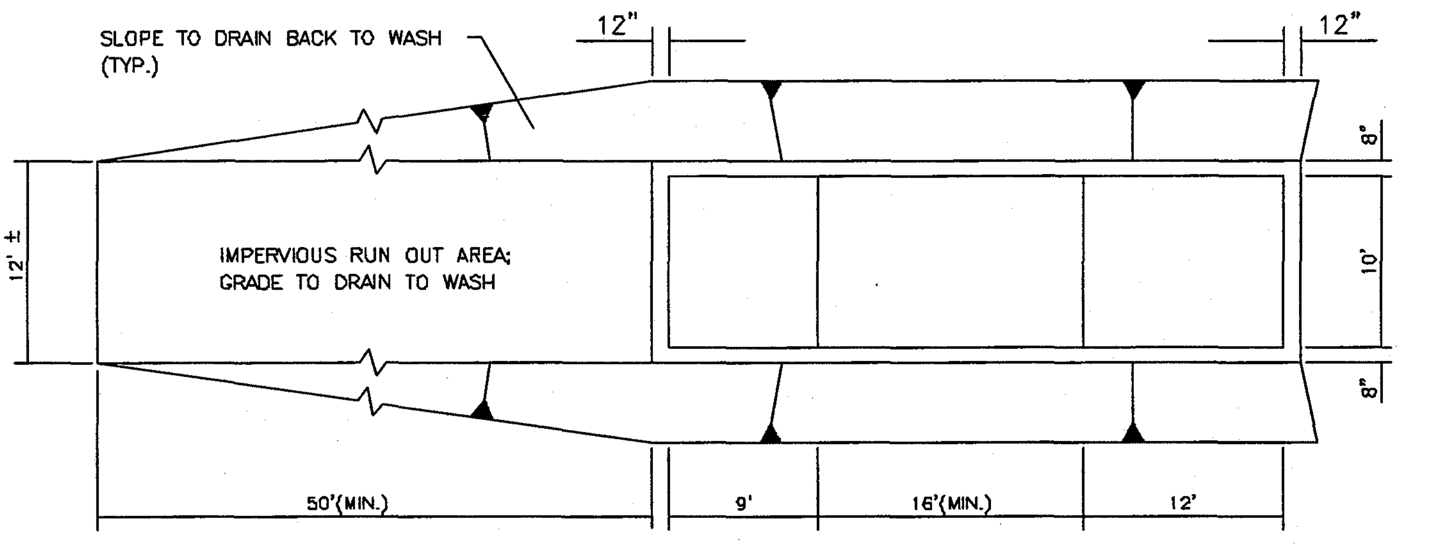
- Clean or replace rock with clogged with sediment.
- Re-grade rock as needed.
- Maintain tire wash sump depth
- Maintain a clean run-out pad
- Immediately remove any rock that gets carried from the pad to the roadway.
- Ensure that wash water drainage, collection and treatment system is functioning.

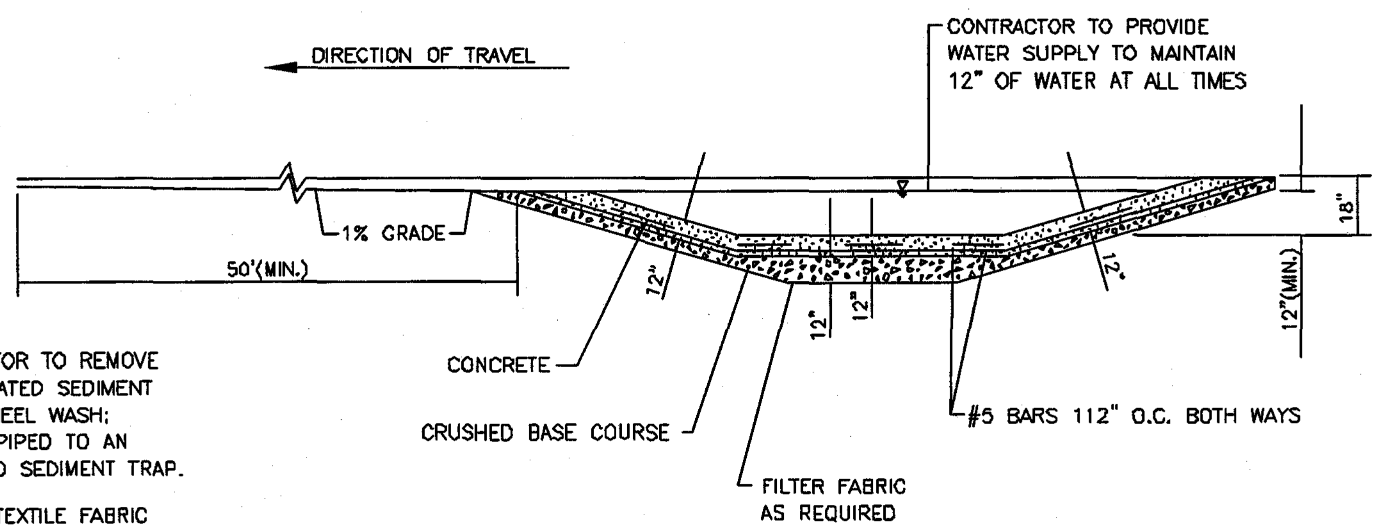
Type 2

- Remove/discharge wash water as needed.
- Remove accumulated sediment from tire wash facility in order to maintain tire wash sump.
- Ensure that wash water collection and treatment system is functioning.

TIRE WASH

Detail Drawing 3.2.2

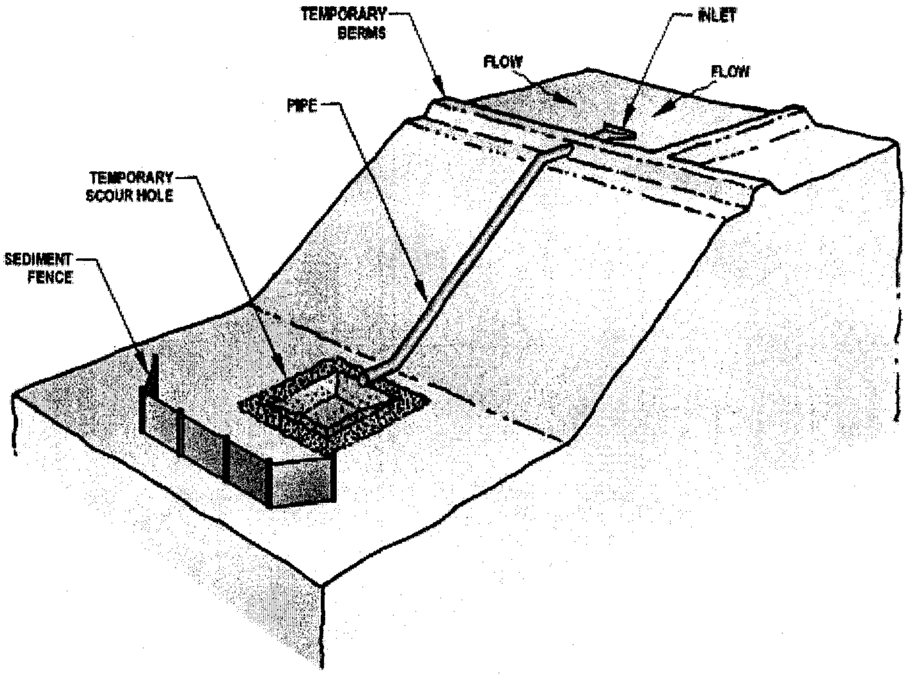




NOTES:

1. CONTRACTOR TO REMOVE ACCUMULATED SEDIMENT FROM WHEEL WASH; MAY BE PIPED TO AN APPROVED SEDIMENT TRAP.
2. USE GEOTEXTILE FABRIC WITH AGGREGATE FOR A TEMPORARY TIRE WASH.

3.2.3 Pipe Slope Drain



A pipe extending from the top to the bottom of a cut or fill and discharging into a stabilized watercourse, sediment trapping device or onto a stabilized area. The pipe slope drain carries concentrated runoff down steep slopes without causing gullies, erosion, or saturation of slide-prone soils.

Advantages

- Effective method of conveying water down steep slopes.
- Reduces or eliminates erosion.
- Easy installation and little maintenance.

Disadvantages

- Drain can be under-designed or incorrectly located.
- Area cleared for drain installation requires stabilization to prevent erosion occurring under the pipe.
- Outfall systems constructed of pipe segments, which are banded and/or gasketed together, could develop leaks causing erosion and failure of the system. Failures on erodible or steep slopes can cause downstream sedimentation or even mudflows.
- Adjustment of pipe lengths is necessary as cut and fill slopes are extended.

Design Criteria

- Capacity – Peak runoff from a 10-yr storm. Inlet control is a critical factor when sizing pipes. Unless they are individually designed, size drains according to Table 3-7.
- On any slope where a large amount of flow must be collected and conveyed to avoid erosion.
- Areas where clean water should be kept separate from sediment-laden water.

- If a permanent measure is needed it should be designed as part of the roadway drainage facilities.

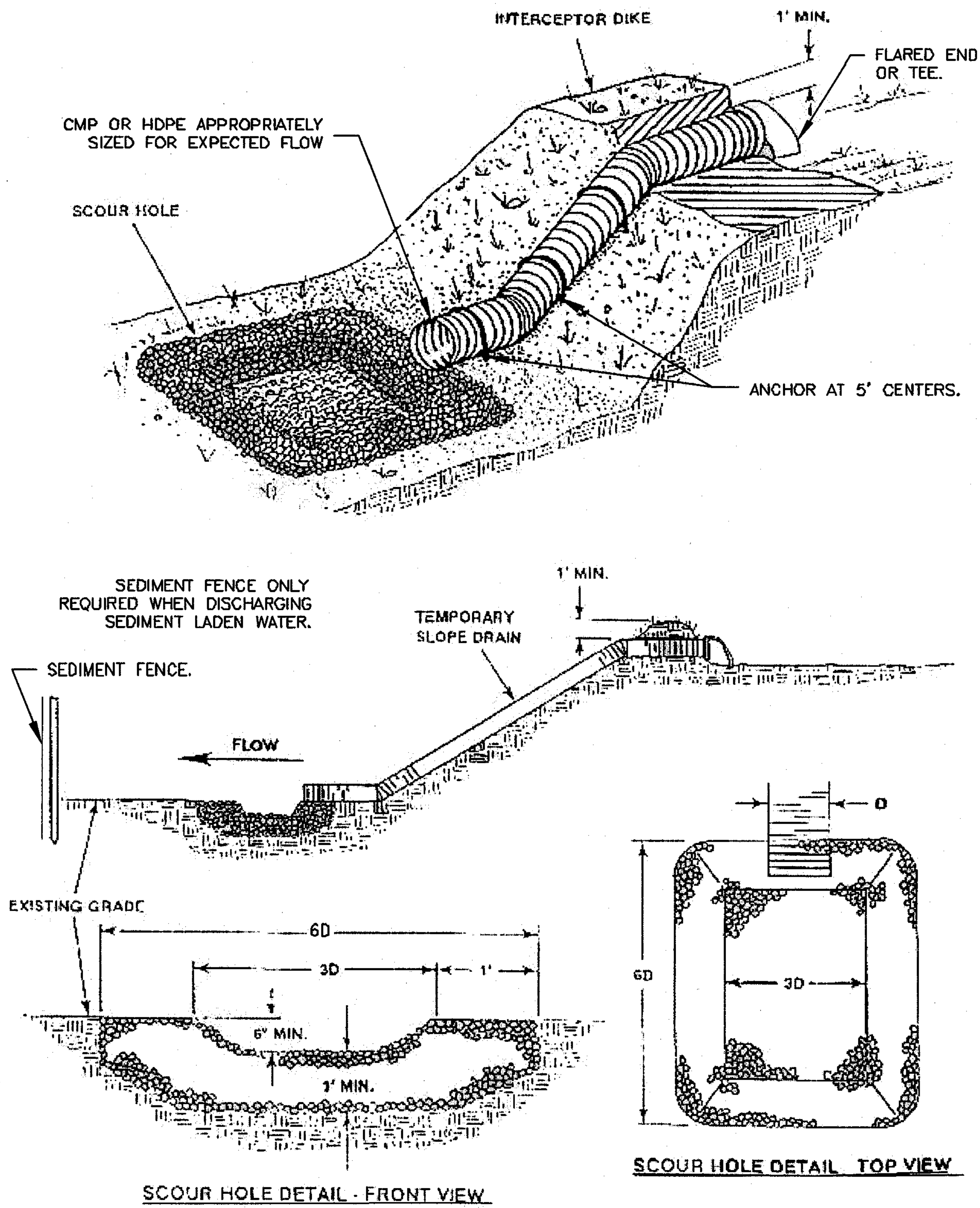
Table 3-7 Slope Drain Sizes

Contributing Drainage Area (Maximum)	Pipe Diameter
0.50 acre	12 inch
0.75 acre	15 inch
1.00 acre	18 inch

- Consider using continuously fused, welded or flange-bolted mechanical joint systems with proper anchoring or HDPP (high-density polyethylene pipe) for outfalls on steep slopes.
- Show the entrance sloped toward the pipe inlet.
- At the inlet, show interceptor dikes that are at least 12 in. higher at all points than the top of the inlet pipe and placed to direct water into the pipe.
- If the pipe slope drain will convey sediment-laden runoff, direct the runoff to a sediment retention facility.
- If the runoff is not from a disturbed area or is conveyed from a sediment trap or pond, convey the runoff to a stabilized discharge point.
- Energy Dissipation – Scour holes or riprap-lined stilling basins prevent most scour problems at outfalls.
- Consider site conditions to determine if a more complex energy dissipater may be required.
- The special provisions and typical notes should include the following installation directions:
    - Minimize disturbance during installation. In some circumstances this requires HDPP installed by hand.
    - Slope anchor details.
    - Immediately stabilize any area disturbed during installation or maintenance.
    - Securely connect the standard flared end section at the entrance to the slope drain, using watertight connecting bands.
- Pipe should be staked securely to prevent movement
    - Securely fasten together the slope drain sections with gasketed watertight fittings, and securely anchor the sections into the soil.
    - Stabilize the area below the outlet following the energy dissipater.

<u>Inspection & Maintenance</u>

- Inspect once per week on active sites, once every two weeks on in-active sites, and within 24 hours following a 0.5 inch rain event
- Adjust lengths of pipe when cut and fill slopes are extended.
- Regularly check the inlet and outlet points, especially following heavy rains. If there are signs of undercutting or water is going around the point of entry, reinforce the head wall with compacted earth or sand bags.
- Regularly check at connection points for signs of erosion. Tighten fittings and repair erosion as needed.
- Immediately repair and install appropriate protection if erosion occurs at the outlet.



PIPE SLOPE DRAIN	Detail Drawing 3.2.3

3.2.4 Outlet Protection

Outlet protection reduces the speed of concentrated flow, thereby preventing scour at conveyance outlets. By dissipating energy, outlet protection lowers the potential for downstream erosion. Outlet protection includes rip-rap-lined basins, concrete aprons, and settling basins. Outlet protection prevents scour at storm water outlets, and minimizes the potential for downstream erosion.

Advantages

- Many techniques are effective and relatively inexpensive and easy to install.
- Removes sediment and reduces velocity.

Disadvantages

- Can be unsightly.
- May be difficult to remove sediment without removing and replacing the structure itself.
- Rock outlets with high velocity flows may require frequent maintenance.

Design Criteria

- At a minimum, all outfalls shall be provided with a rock splash pad (see Figure 3.2.4a, except as specified below and in Table 3-8:
  1. For outfalls with a velocity at design flow greater than 10 fps, gabion dissipater or engineered energy dissipater shall be required. Note the gabion outfall detail shown in Figure3.2.4b is illustrative only; a design engineered to specific site conditions is required.
  2. Engineered energy dissipaters, including stilling basins, drop pools, hydraulic jump basins, baffled aprons, and bucket aprons, are required for outfalls with velocity at design flow greater than 20 fps. These should be designed using published or commonly known techniques found in such references as *Hydraulic Design of Energy Dissipaters for Culverts and Channels,* published by the Federal Highway Administration of the United States Department of Transportation; *Open Channel Flow,* by V. T. Chow; *Hydraulic Design of Stilling Basins and Energy Dissipaters,* EM 25, Bureau of Reclamation (1978); and other publications, such as those prepared by the Soil Conservation Service (now Natural Resource Conservation Service). Alternate mechanisms, such as bubble-up structures (which will eventually drain) and structures fitted with reinforced concrete posts, may require an approved adjustment and must be designed using sound hydraulic principles and considering constructability and ease of maintenance.

Table 3-8 Rock Protection at Outfalls

Discharge Velocity at design Flow (fps)		REQUIRED PROTECTION				
Greater than	Less than or equal to	Minimum Dimensions				
		Type	Thickness	Width	Length	Height
0	5	Rock lining	1 foot	Diameter + 6 feet	Greater of: 8 feet or 4x diameter	Crown + 1 foot
5	10	Riprap(2)	2 feet	Greater of: Diameter + 6 feet or 3x diameter	Greater of: 12 feet or 4x diameter	Crown + 1 foot
10	20	Gabion Outfall	As required	As required	As required	Crown + 1 foot
20	N/A	Engineered energy dissipater required				

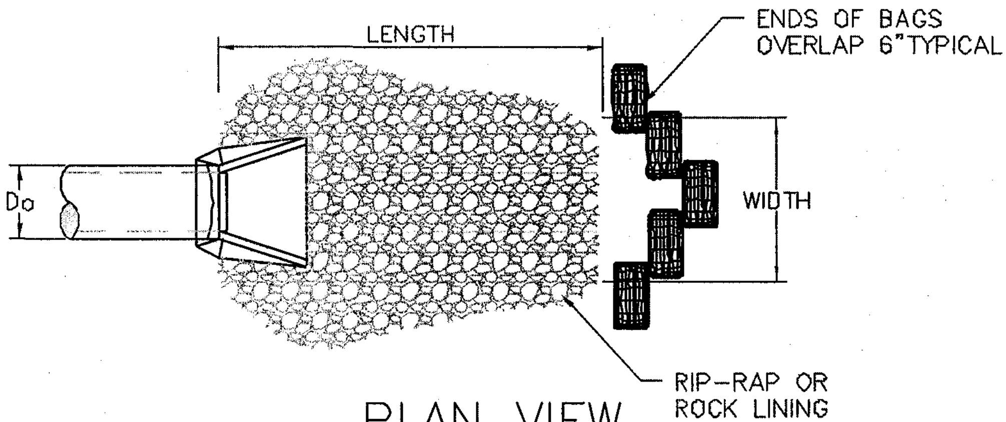
- Rock lining shall be quarry spalls with gradation as follows:
  Passing 8-inch square sieve: 100%
  Passing 3-inch square sieve: 40 to 60% maximum
  Passing 3/4-inch square sieve: 0 to 10% maximum
- Riprap shall be reasonably well graded with gradation as follows:
  Maximum stone size: 24 inches (nominal diameter)
  Median stone size: 16 inches
  Minimum stone size: 4 inches

Note: Riprap sizing governed by side slopes on outlet channel is assumed to be approximately 3: 1.

- **Other Recommended Outfall Features** - Mechanisms which reduce velocity prior to discharge from an outfall are encouraged. Some of these are drop manholes and rapid expansion into pipes of much larger size. New pipe outfalls can provide an opportunity for low-cost fish habitat improvements. For example, an alcove of low-velocity water can be created by constructing the pipe outfall and associated energy dissipater back from the stream edge and digging a channel, over widened to the upstream side, from the outfall to the stream. Overwintering juvenile and migrating adult salmonids may use the alcove as shelter during high flows.

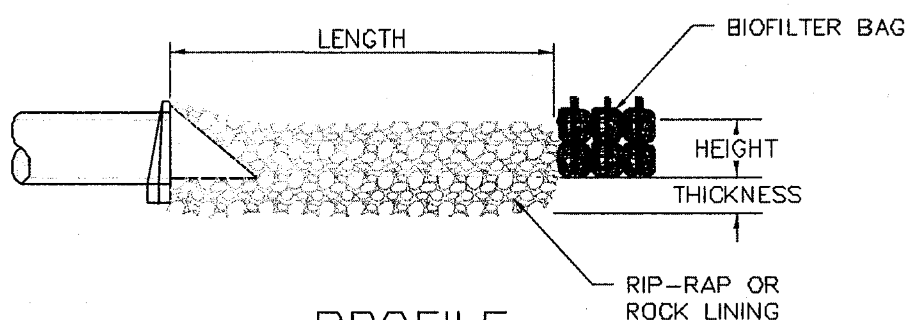
Inspection & Maintenance

- Inspect once per week on active sites, once every two weeks on in-active sites, and within 24 hours following a 0.5 inch rain event
- If there is scour at the outlet, protect the eroded area by increasing the size of the energy dissipater facility.
- Remove accumulated sediment frequently.



PLAN VIEW

NTS

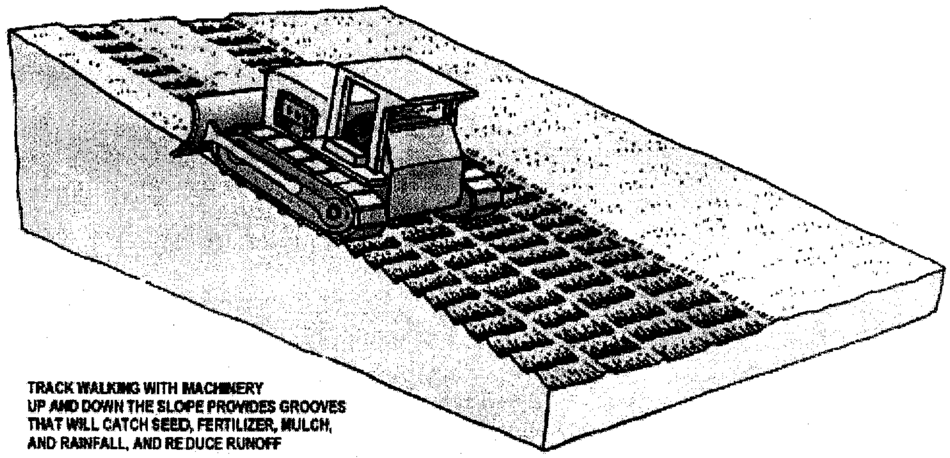


PROFILE

NOTE:
1. BIO BAGS ONLY REQUIRED WHEN DISCHARGING SEDIMENT LADEN WATER.
2. STAKING OF BAGS REQUIRED WITH EITHER METHOD USING (2) 1"x 2" WOOD STAKES OR APPROVED EQUAL PER BAG.

OUTLET PROTECTION	Detail Drawing 3.2.4

3.2.5 Surface Roughening



Leaving the slopes in a roughened condition after clearing or creating a rough soil surface with horizontal depressions or grooves will trap seed and reduce runoff velocity. Roughening can be accomplished by 'track walking' slopes with tracked equipment, by using a serrated wing blade attached to the side of a bulldozer, or by other agricultural equipment.

Advantages

- Grooves trap seed.
- Increased vegetation establishment.
- Reduces runoff velocity, increases infiltration.
- Provides some instant protection from sheet erosion.
- Traps soil eroded from the slopes above.

Disadvantages

- Tracking with a bulldozer/heavy equipment may compact the soil.
- May increase time to finish slopes.
- Should not be relied upon as sole means of erosion control.

Design Criteria

- All slopes to be seeded.
- On slopes 3:1 or less, but can be used on steeper slopes in conjunction with the addition of staging sediment barriers.
- Immediately seed and mulch roughened areas to obtain optimum seed germination and growth.
- Height of track grousers should be 1 ½ inches or greater.
- Tracking should be accomplished by driving equipment **up** and **down** slope to create horizontal depressions/grooves.

Cut Slope Roughening

- Stair-step grade or groove the cut slopes that are steeper than 3:1.

- Use stair-step grading on all erodible material soft enough to be ripped with a bulldozer. Slopes consisting of soft rock with the same subsoil are particularly suited to stair-step grading.
- Make the vertical cut distance less than the horizontal distance, and slightly slope the horizontal position of the "step" in toward the vertical wall.
- Do not make individual vertical cuts more than 2 feet high in soft materials or more than 3 feet in rocky materials.
- Groove the slope using machinery to create a series of ridges and depressions that run across the slope, on the contour.

Fill Slope Roughening

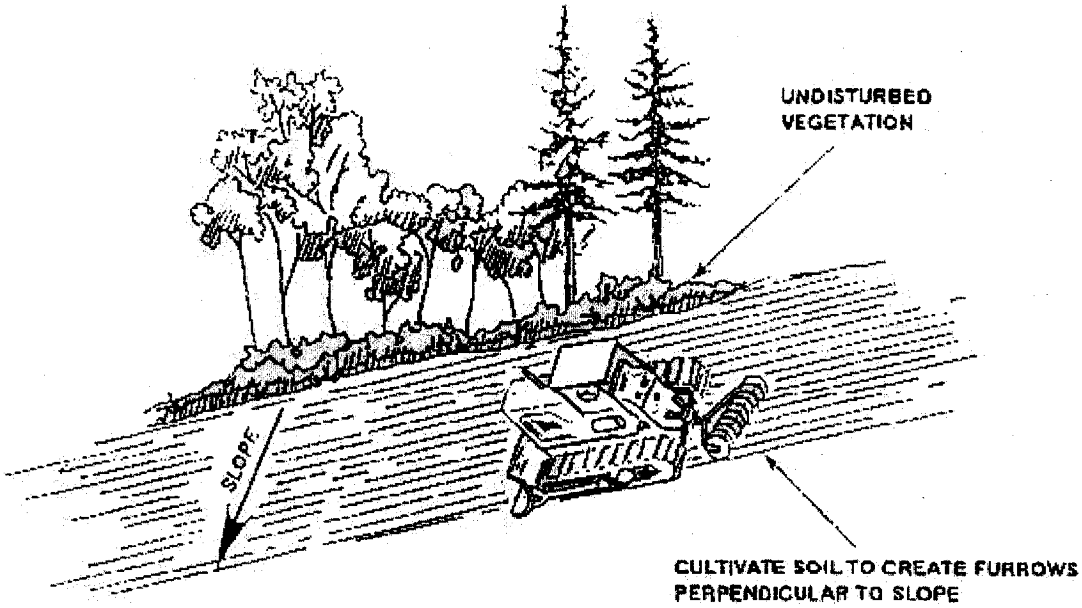
- Place fill slopes with a gradient steeper than 3:1 in lifts not to exceed ½ foot, and make sure each lift is properly compacted.
- Ensure that the face of the slope consists of loose, uncompacted fill 4-6 inches deep.
- Use horizontal grooving along the contour or tracking to roughen the face of the slopes, if necessary.
- Apply seed, fertilizer and straw mulch, and then track or punch the mulch with a bulldozer.
- Do not blade or scrape the final slope face.

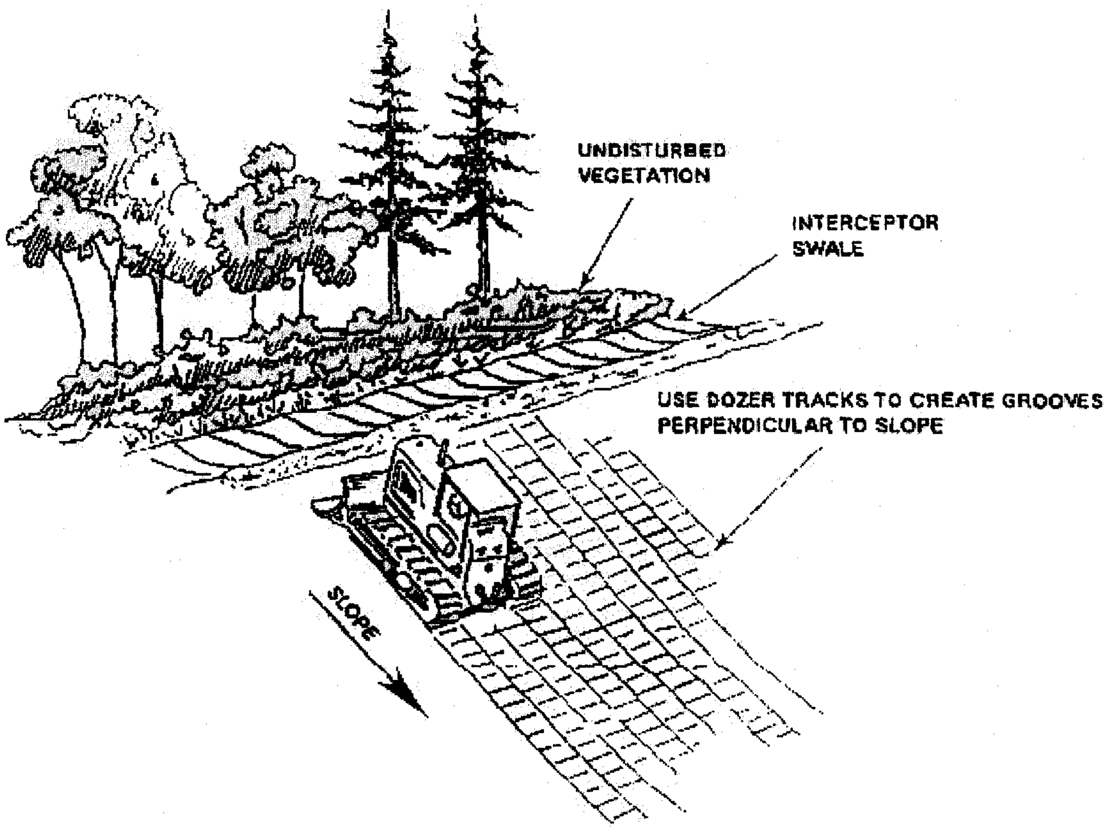
Cuts, Fills, and Graded Areas

- Make mowed slopes no steeper than 3:1.
- Roughen these areas to shallow grooves by normal tilling, disking, harrowing, or use a cultipaker-seeder. Make the final pass of any such tillage on the contour.
- Excessive roughness is undesirable where mowing is planned.

Inspection & Maintenance

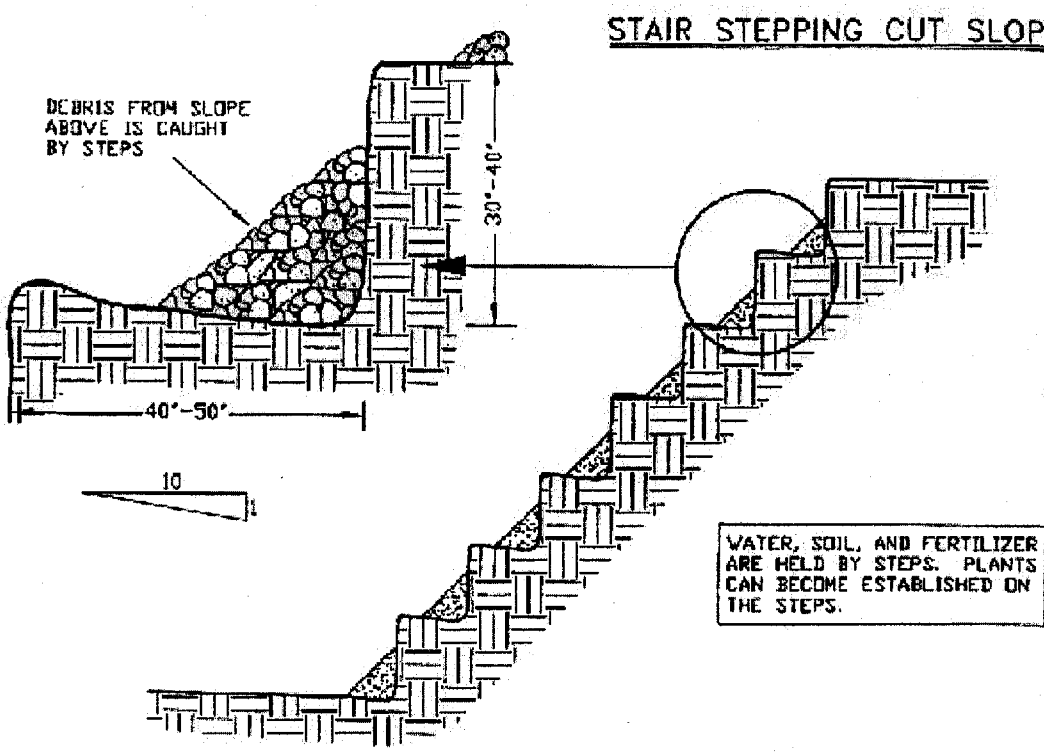
- Inspect once per week on active sites, once every two weeks on in-active sites, and within 24 hours following a 0.5 inch rain event
- Check the seeded slopes for rills and washes. Fill these areas slightly above the original grade, then re-seed, mulch, or mat as soon as possible.



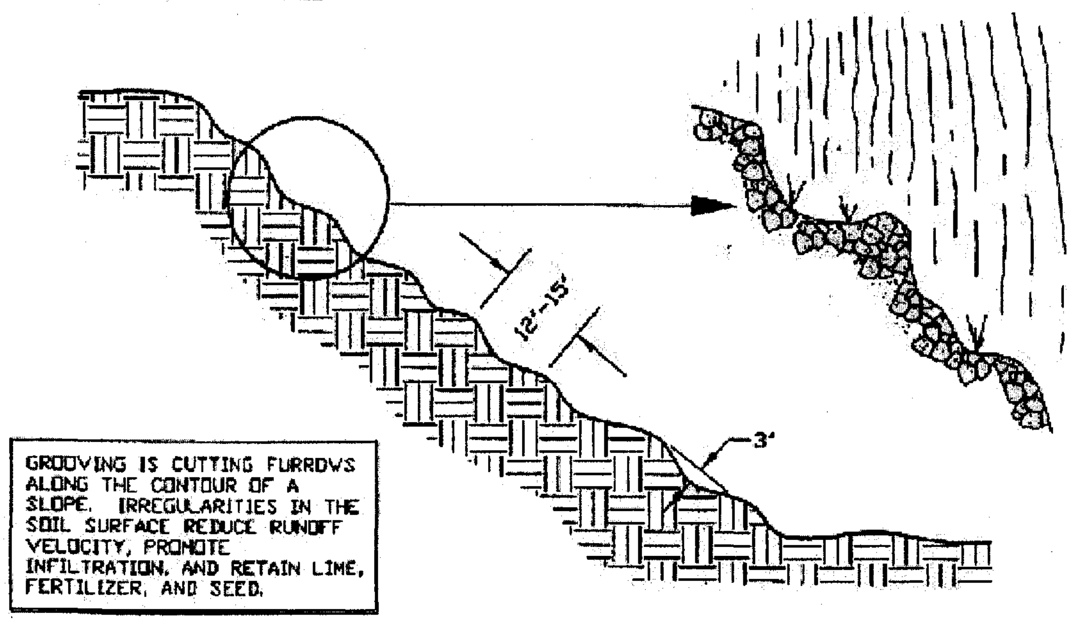


SURFACE ROUGHENING CAT TRACKING	Detail Drawing 3.2.5a

STAIR STEPPING CUT SLOPES



GROOVING SLOPES



SURFACE ROUGHENING STAIR STEPPING/GROOVING SLOPES	Detail Drawing 3.2.5b

3.2.6 Check Dam

Small dams constructed across a swale or ditch to reduce velocities of concentrated flows, thereby reducing erosion in the swale or ditch. Check dams not only prevent gully erosion from occurring before vegetation is established, but also allow a significant amount of suspended sediment to settle out.

- Check Dams can be constructed from a variety of materials.
    - Rock: Rock material only.
    - Bio-filter Bags: Bio-filter bags staked to the ground.
    - Sand Bags
    - Pre-fabricated Check Dam System: A manufactured system specifically designed to slow water so that suspended particles settle out. Field fabricated systems are not allowed.

Advantages

- Prevent erosion and promote settling of sediment in runoff.
- When carefully located and constructed, check dams may function as permanent installations.
- Reduces flow velocity
- Inexpensive and easy to install.
- Rock can be spread into ditch and used as a channel lining when the check dam is no longer necessary.
- Some pre-fabricated check dams are reusable.

Disadvantages

- Removal may be costly for some types of check dams.
- Suitable only for a limited drainage area.
- May reduce hydraulic capacity of the channel.
- May create turbulence downstream, causing erosion of the channel banks.
- Ponded water may kill grass in grass-lined channels.
- May be an obstruction to construction equipment.

Design Criteria

- Space check dams according to the following table.

Table 3-9 Spacing for Check Dams

Ditch Grade	Minimum Weir Depth		
	6 inch	**12 inch**	**18 inch**
6%	**	16 ft O.C.	26 ft O.C.
5%	**	20 ft	30 ft
4%	**	26 ft	40 ft
3%	15 ft	33 ft	50 ft
2%	25 ft	50 ft	80 ft

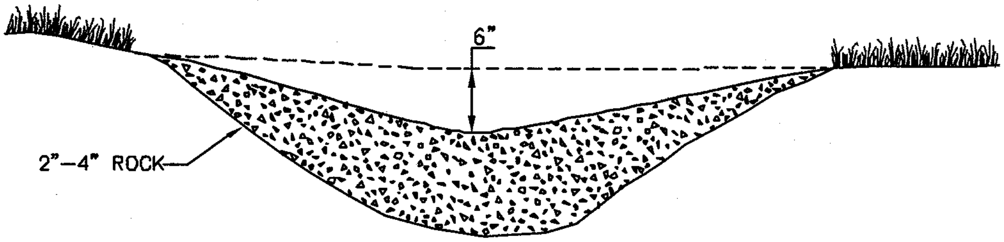
** Not Allowed

- In temporary or permanent channels not yet vegetated when installing channel lining is not feasible.
- In small open channels that drain 10 acres or less.
- Not for use in streams or rivers.

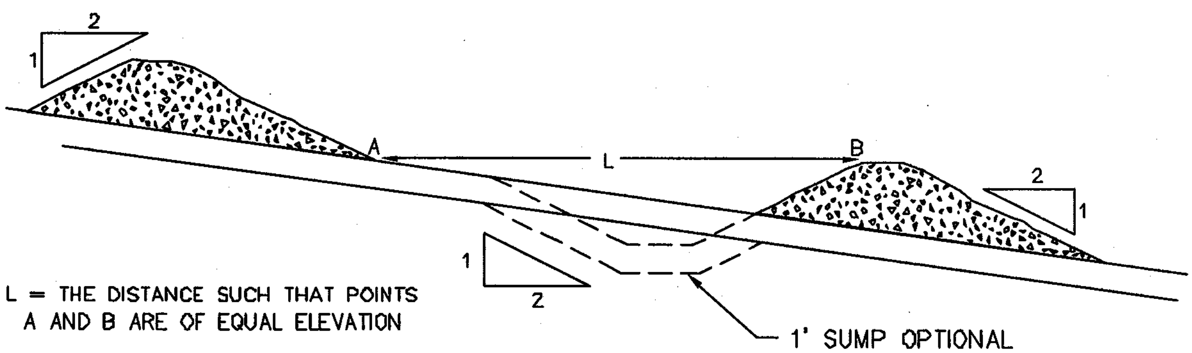
- Construct rock check dams sized to stay in place given the expected design flow velocity. Typical rock size of 3-6 inch. Place rock by hand or by mechanical means rather than dumping the rock.
- Bridge entire ditch or swale width and ensure the center of the dam is 6 inches lower than the outer ends.
- Remove check dams from grass-lined ditches and swales once the grass is established.
- Seed, mulch, or mat the area where the check dams were, immediately following removal.

Inspection & Maintenance

- Inspect once per week on active sites, once every two weeks on in-active sites, and within 24 hours following a 0.5 inch rain event
- Remove sediment once it reaches one-third the depth of the rock weir.
- Replace rock weir when filtering capacity is reduced by one-half.

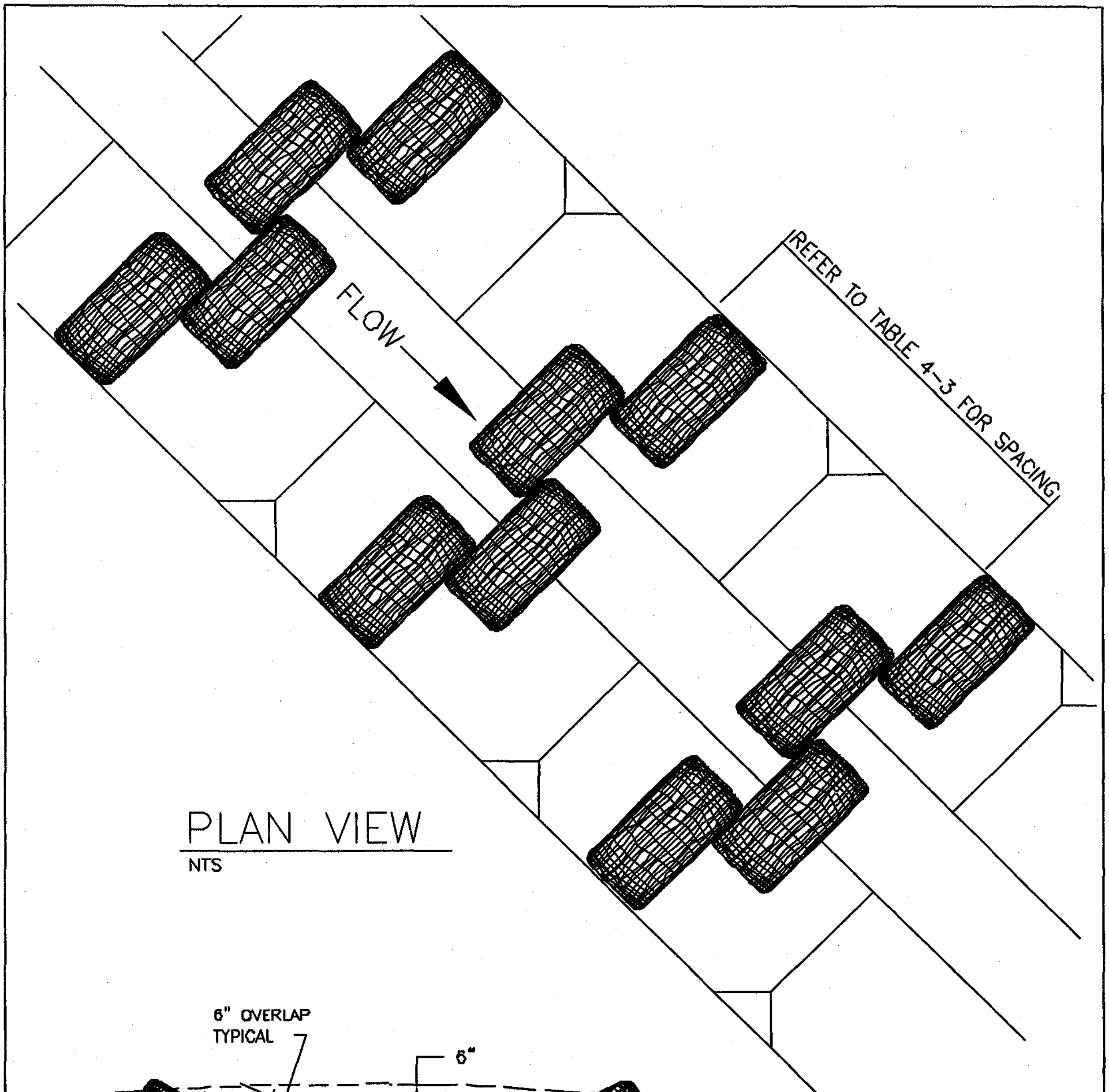


ROCK CHECK DAM

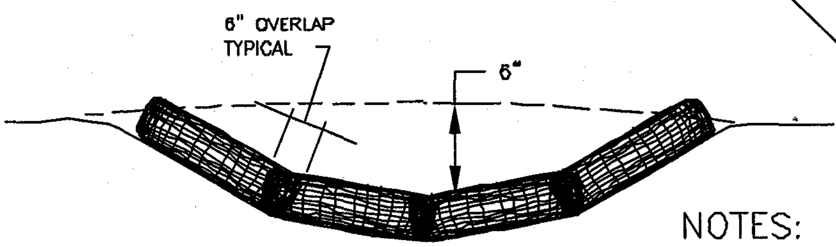


SPACING BETWEEN CHECK DAMS

CHECK DAM ROCK	Detail Drawing 3.2.6a



PLAN VIEW
NTS



PROFILE
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NOTES:

1. STAKING OF BAGS REQUIRED USING (2) 1"X2" WOOD STAKES OR APPROVED EQUAL PER BAG.
2. SURFACE MUST BE SMOOTH BEFORE APPLICATION.

CHECK DAM BIO FILTER BAG	Detail Drawing 3.2.6b

3.2.7 Diversion Dike/ Swale

A ridge of compacted soil or a lined swale with vegetative lining located at the top, base or somewhere along a sloping disturbed area. The dike or swale intercepts and conveys smaller flows along low-gradient drainage ways to larger conveyances such as ditches or pipe slope drains or to a stabilized outlet. Dikes and swales may be used singly or in combination with each other.

Advantages

- Provides a practical, inexpensive method to divert runoff.
- Can handle flows from large drainage areas.
- Use on-site material and equipment to construct.

Disadvantages

- If improperly constructed, can contribute to erosion caused by concentrating the flow.
- High flow velocity can damage vegetation.
- Not effective for preventing illegal discharge.

Design Criteria

- Refer to Table 3-10 Dike Design Criteria and Table 3-11 Swale Design Criteria.
- Install the dike and/or swale horizontally at intervals across a disturbed slope. Space horizontal interceptor dikes and swales according to Tables 3-10 and 3-11.
- For slopes of erodible soils, steeper than 2:1 with more than 10 ft. of vertical relief, construct benches or shorten distance between dikes or swales.
- If the dike or swale intercepts runoff from disturbed areas, discharge the runoff to a stable conveyance that routes the runoff to a sediment trap or basin.
- If the dike or swale intercepts runoff that originates from undisturbed areas, discharge the runoff to a stable conveyance that will route the runoff downslope of any disturbed areas and release the water at a stabilized outlet.
- May need matting to protect seed bed and channel from erosion.

Table 3-10 Diversion Dike Design Criteria

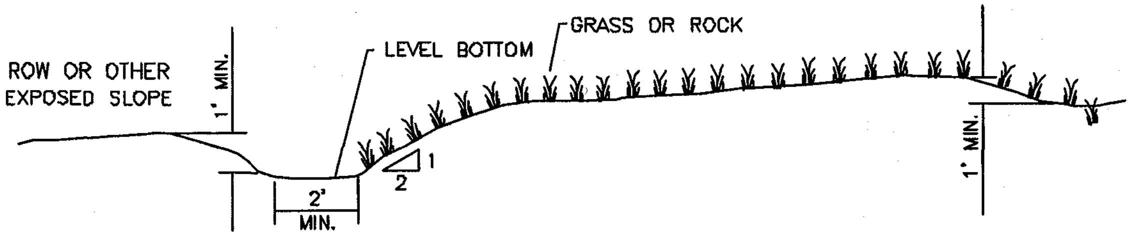
Top Width	24 in. min.	
Height	20 in. min. Measured from upslope toe and at a 90% standard proctor compaction ASTM D698.	
Side Slopes	2:1 or flatter	
Grade	Topography Dependent	
Dike grade	Between 0.5-1%	
Slope of Disturbed Area vs. Horizontal Spacing	<5%	300 ft
	5-10%	200 ft
	10-25%	100 ft
	25-50%	50 ft
Slope Stabilization	<5% Seed and mulch within 5 days following dike construction	
	5-40% Stabilize immediately using either sod or riprap.	
Outlet	Upslope side of dike provides positive drainage to the outlet. Provide energy dissipation as necessary to prevent erosion. Release sediment-laden runoff to a sediment trapping facility.	

Table 3-11 Diversion Swale Design Criteria

Bottom Width	24 in. min. The bottom should be level across the swale.	
Depth	12 in.	
Side Slopes	2:1 or flatter	
Grade	Maximum 5% with positive drainage to a suitable outlet.	
Slope of Disturbed Area vs. Horizontal Spacing	<5%	300 ft.
	5-10%	200 ft.
	10-25%	100 ft.
	25-50%	50 ft.
Slope Stabilization	Temporarily seed or line with riprap 12 in. thick and press into the bank approximately 3-4 in.	
Outlet	Level spreader or riprap to stabilized outlet/sedimentation pond.	

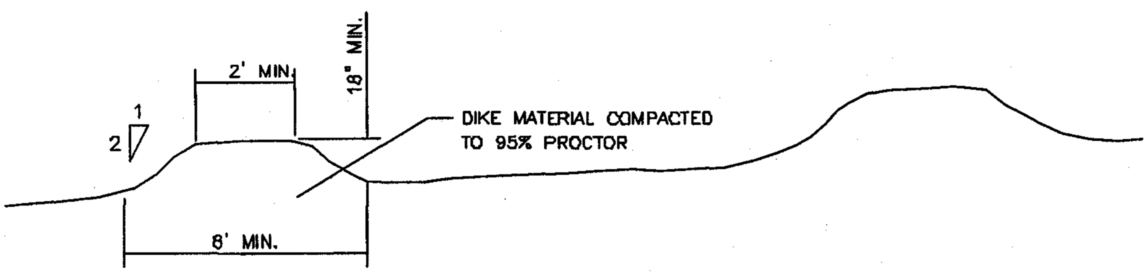
<u>Inspection & Maintenance</u>

- Inspect once per week on active sites, once every two weeks on in-active sites, and within 24 hours following a 0.5 inch rain event
- Immediately repair damage resulting from runoff or construction activity.
- If the dike or swale regularly overflows, increase the capacity and/or frequency of the dikes/swales.
- Inspect and repair as necessary after every major storm.
- Minimize construction traffic over temporary dikes and swales.
- Clean out clogged pipes (as part of the swale system) under roads.



BOTTOM WIDTH	2 FEET MINIMUM; THE BOTTOM WIDTH SHALL BE LEVEL
DEPTH	1 FOOT MINIMUM
SIDE SLOPE	2H:1V OR FLATTER
GRADE	MAXIMUM 5 PERCENT, WITH POSITIVE DRAINAGE TO A SUITABLE OUTLET (SUCH AS SEDIMENTATION POND)

DIVERSION SWALE



TEMPORARY DIVERSION DIKE

Slope	Spacing
<5%	300 feet
5–10%	200 feet
10–40%	100 feet

NOTE:
IMMEDIATELY UPON CONSTRUCTION, ESTABLISHED VEGETATION OR EROSION CONTROL BLANKETS ARE REQUIRED.

DIVERSION DIKE / SWALE	Detail Drawing 3.2.7

3.2.8 Grass-lined Swale

A channel with vegetative lining constructed to convey and dispose of concentrated surface runoff without damage from erosion, deposition, or flooding.

Advantages

- Does not generate high velocity runoff and offers temporary slope protection, which is superior to plastic sheeting.
- Capture a great deal of sediment due to the filtering effect of vegetation.
- Usually easy to install.

Disadvantages

- Requires temporary irrigation to establish vegetation.
- Cannot be used until vegetation is established.

Design Criteria

- As a minimum, grass-lined channels should carry a peak runoff from a 10-year storm event without eroding. Where flood hazards exist, increase the capacity according to the potential damage. The allowable design velocity for grassedlined channels is based on soil conditions, type of vegetation, and the method of establishment. The channel shape may be parabolic, trapezoidal, or v-shaped, depending on the need and site conditions. Small check dams or flow spreaders may be necessary to minimize channelization.

Inspection & Maintenance

- Inspect once per week on active sites, once every two weeks on in-active sites, and within 24 hours following a 0.5 inch rain event
- During the initial establishment, grass-lined channels should be repaired and grass re-established if necessary.
- After grass has become established, the channel should be checked periodically to determine if the channel is withstanding flow velocities without damage.
- Check the channel for debris, scour, or erosion and immediately make repairs. It is particularly important to check the channel outlet and all road crossings for bank stability and evidence of piping or scour holes and make repairs immediately.
- Remove all significant sediment accumulations to maintain the designed carrying capacity.
- Keep the grass in a healthy, vigorous condition at all times, since it is the primary erosion protection for the channel.
- Permanent grassed waterways should be seasonally maintained by mowing and/or irrigating, depending on the type of vegetation selected.
- Newly seeded areas need to be inspected frequently to ensure the grass is growing.
- If the seeded area is damaged due to runoff, additional storm water measures such as check dams or matting may be needed.

3.3 Sediment Control Practices

Once soil erosion occurs, sediment trapping or removal techniques can reduce the amount of sediment and associated pollutants that leave the site, thus protecting nearby streams, wetlands, and lakes. Sediment controls are usually placed around the perimeter of a disturbed area and where concentrated water leaves the site. Sediment control BMP's should be in place before land clearing and grading begins. It is important to note that sediment controls, if poorly maintained, can become sources of sediment and other pollutants during larger storms.

1. Sediment Fence
2. Bio-filter Bags
3. Sand Bags
4. Filter Berm
5. Wattles
6. Sidewalk Subgrade Gravel Barrier
7. Fabricated Barriers
8. Inlet Protection
9. Dewatering
10. Sediment Trap
12. Sediment Basin

3.3.1 Sediment Fence

Temporary sediment trap consisting of an entrenched geotextile stretched across and attached to supporting posts. Sediment fences are adequate to treat flow depths consistent with overland or sheet flow. Standard or heavy duty sediment fence fabric must meet specific ASTM requirements, outlined in Table 3-13.

Advantages

- Reduces runoff velocity.
- Requires minimal ground disturbance to install.
- Relatively inexpensive.

Disadvantages

- Applicable to small drainage areas and overland flow; not applicable to concentrated flows.
- Incorrect geotextile or installation decreases sediment fence performance.
- Requires frequent maintenance and inspection.

Design Criteria

- See Table 3-13 for Sediment Fence Fabric Specifications
- Show sediment fence installed along ground contours according to Table 3-12
- Sediment fence should only be used for sheet and rill erosion
- Standard or heavy-duty sediment fence filter fabric shall have manufactured stitched loops with 2"x 2"x4' posts. Stitched loops shall be installed on the uphill side of the sloped area.
- Sediment fences should be installed a minimum of 3 feet from toe of slope in order to maximize storage.
- A trench should be excavated 6 inches deep along the line of the posts.
- Trench should be backfilled and the soil compacted on both sides of the sediment fence.
- Posts should be spaced a maximum of 6 feet apart and driven securely into the ground a minimum of 12 inches.
- When sediment fence approaches it's termination point, turn fence uphill and extend one full panel (6 ft).
- When joining two or more sediment fences together, join the two end stakes by wrapping the two ends at least one and one half turns and driving the joined stakes into the ground together.
- Height of a sediment fence should not exceed 3 feet. Storage height and ponding height should never exceed 1.5 feet.

Table 3-12 Barrier Spacing for General Application

BARRIER SPACING FOR GENERAL APPLICATION

INSTALL PARALLEL ALONG CONTOURS AS FOLLOWS		
% Slope	Slope	Maximum Spacing on Slope
10 % Flatter	10:1 or Flatter	300 ft
10 > % < 15	10:1 > x < 7.5:1	150 ft
15 > % < 20	7.5:1 > x < 5:1	100 ft
20 > % < 30	5:1 > x < 3.5:1	50 ft
30 > % < 50	3.5:1 > x < 2:1	25 ft

Table 3-13 Sediment Fence Fabric Specifications

WOVEN POLYPROYLENE SEDIMENT FENCE FABRIC

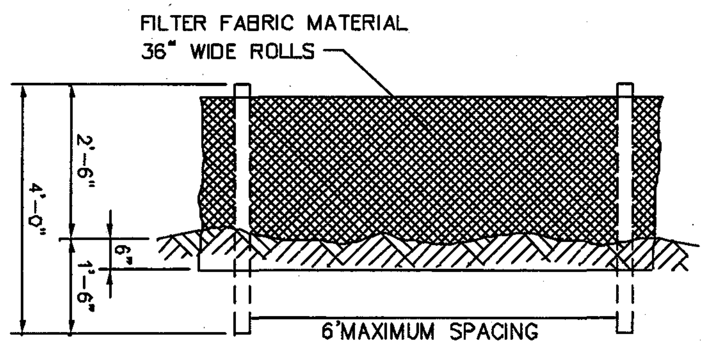
PROPERTY	TEST PROCEDURE	MINIMUM FABRIC VALUE
Grab Tensile Strength	ASTM D-4632	180 lbs.
Grab Elongation	ASTM D-4632	15%
Trapezoid Tear	ASTM D-4533	70 lbs.
Mullen Burst	ASTM D-3786	300 psi
Puncture	ASTM D-4833	80 lbs
Permitivity	ASTM D-4491	.07 sec -1
Permeability	ASTM D-4491	.005 cm/sec
Apparent Opening Size (AOS)	ASTM D-4751	50 U.S. Sieve
UV Resistance (500 hrs)	ASTM D-4355	90%

Inspection & Maintenance

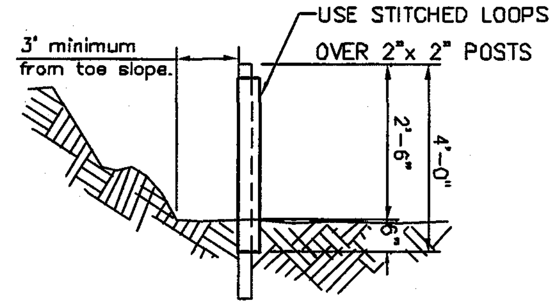
- Inspect once per week on active sites, once every two weeks on in-active sites, and within 24 hours following a 0.5 inch rain event
- Immediately repair any damage.
- Remove accumulated sediment once it has reached 1/3 the height of the sediment fence or 1 ft maximum.
- Inspect for channel formation parallel to the fence, which indicates the geotextile is acting as a flow barrier.
- Replace deteriorated or clogged geotextile.
- Check for under cutting or piping under fence.

SEDIMENT FENCE

Detail Drawing 3.3.1



FRONT VIEW
NTS



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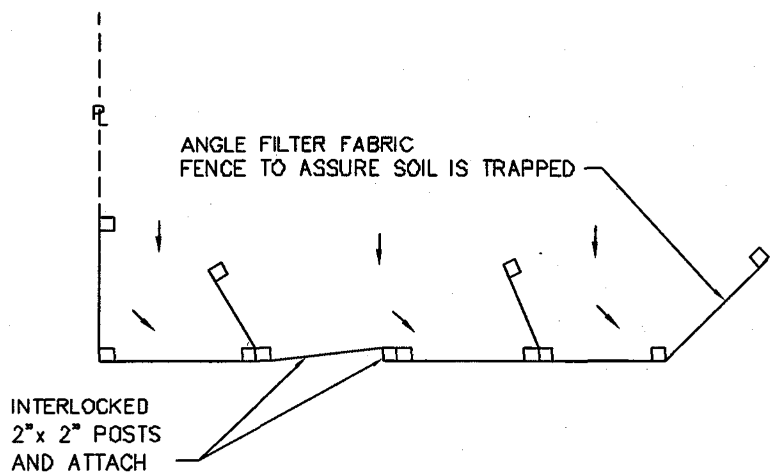


PLAN VIEW
NTS

NOTES:

1. BURY BOTTOM OF FILTER FABRIC 6" VERTICALLY BELOW FINISHED GRADE.
2. 2"x 2" FIR, PINE OR STEEL FENCE POSTS.
3. POSTS TO BE INSTALLED ON UPHILL SIDE OF SLOPE.
4. COMPACT BOTH SIDES OF FILTER FABRIC TRENCH.
5. PANELS MUST BE PLACED ACCORDING TO SPACING TABLE 4-7.

3.3.2 Biofilter Bags

Biofilter bags are manufactured from 100% recycled wood-product waste placed in plastic mesh bags.

Advantages

- Relatively low cost.
- Can be used in place of sediment fences at toe of slope, without trenching in.
- Wood-product can be recycled or used on site when no longer needed.
- Installation is simple, can be done by hand.
- Bags are easy to move, replace and reuse on paved surfaces.
- Are good short-term solution in situations where concentrated flows are causing erosion.

Disadvantages

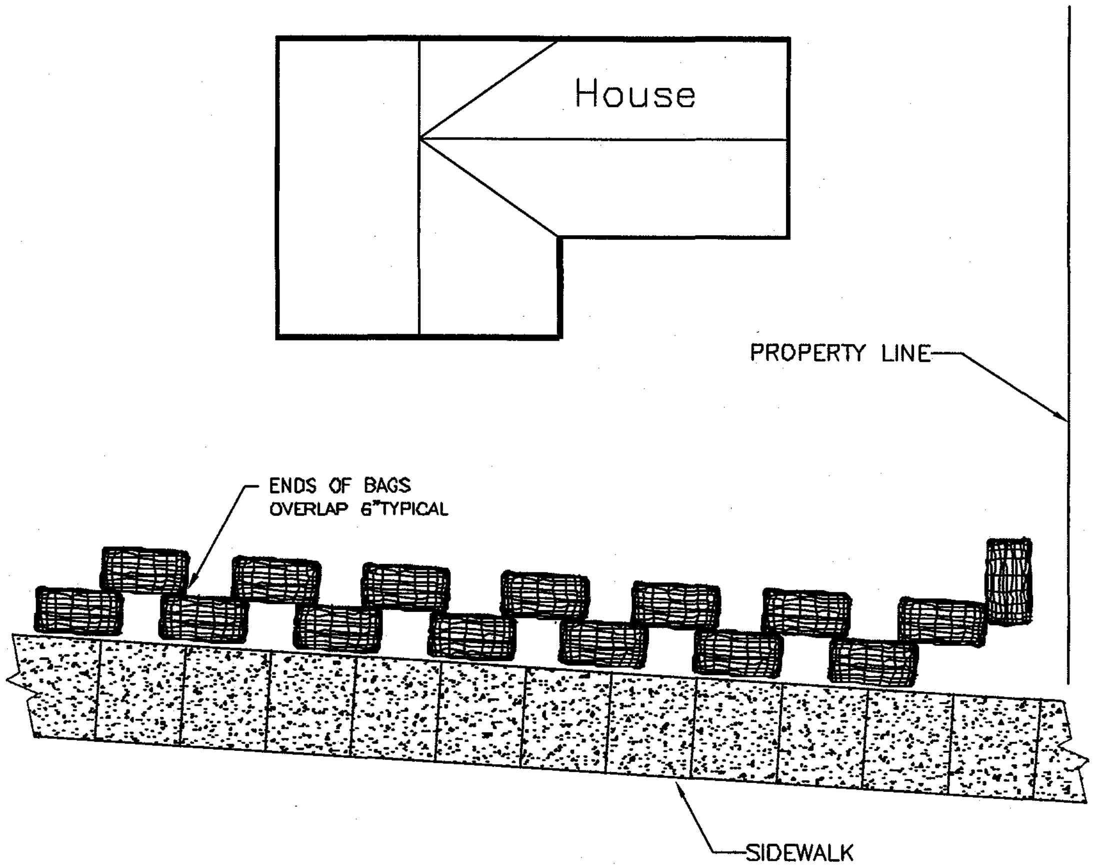
- Generally effective for only a few months.
- Can be easily damaged by construction equipment or by traffic in paved areas.
- Can become clogged with sediment and cease to filter runoff.
- If improperly installed can allow undercutting or end-flow.
- Not effective where water velocities or volumes are high.
- Light weight results in higher buoyancy if not properly installed.
- Low sediment retention capacity may require frequent maintenance.

Design Criteria

- Bio-filter bags should be clean 100 percent recycled wood product waste. Standard size 10x8x30 inches, weight approximately 45 pounds, with ½ inch plastic netting
- May be left in place or used as mulch once they have served their purpose.
- Surface area should be smooth
- Use (2) 1x2 inch stakes per bag, driven 12 inches into ground.
- Ends of bags must be overlapped 6 inches to prevent piping between joints.

Inspection & Maintenance

- Requires routine inspection
- Check that stakes are secure and ends of bags are tightly overlapped. Check that undercutting or end-flow is not occurring.
- Inspect plastic mesh bags for tears.
- Remove sediment when 1/3 height of bag has accumulated.
- Replace damaged bags as needed.



PLAN VIEW
NTS

NOTE:

1. STAKING OF BAGS REQUIRED USING (2) 1"x 2" WOOD STAKES OR APPROVED EQUAL PER BAG.
2. BAGS ARE USED AS ALTERNATE FOR SEDIMENT FENCE FOLLOWING INSTALLATION OF SIDEWALK <u>ON SINGLE FAMILY CONSTRUCTION ONLY.</u>

BIO-FILTER BAGS	Detail Drawing 3.3.2

3.3.3 Sand Bags

Sandbags are manufactured from durable, weather resistant tightly woven Geotextile fabric material sufficient to prohibit leakage of the filler material. The bags should measure 24 x 12 x 6 inches and be filled with firmly packed sand weighing at least 75 lbs.

Advantages

- Relatively low cost.
- Installation is simple, can be done by hand.
- Bags are easy to move, replace and reuse on paved surfaces.
- Are good short-term solution in situations where concentrated flows are causing erosion.
- Can be used to divert and slow velocity of small flows.
- Can be used in concrete lined ditches capture sediment and reduce water velocity.

Disadvantages

- Generally effective for only a few months.
- Can be easily damaged by construction equipment or by traffic in paved areas.
- Can contribute sediment to runoff if bags rupture.
- Cannot be staked and are not appropriate on steep slope applications.
- Not effective in steep swales, channels or ditches.
- If improperly installed can allow undercutting or end-flow.
- Not effective where water velocities or volumes are high, can get washed away.

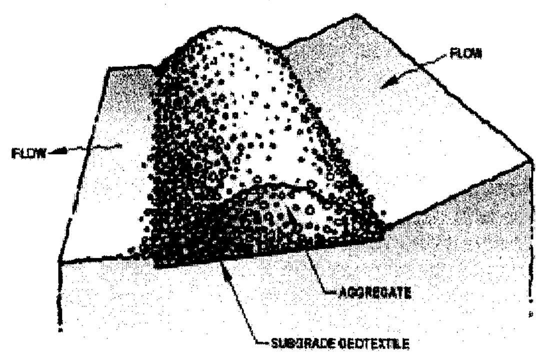
Design Criteria

- Generally used in ditches and/or swales as a check dam.
- Can be used on highway or road projects to divert run-off.
- Ends of bags must be tightly abutted and overlapped to direct flow away from bag joints.

Inspection & Maintenance

- Inspect once per week on active sites, once every two weeks on in-active sites, and within 24 hours following a 0.5 inch rain event
- Check that ends of bags are tightly abutted. Check that undercutting or end-flow is not occurring.
- Remove sediment accumulated behind bags when sediment reaches one-third of the barrier height.
- Replace damaged bags as needed.

3.3.4 Filter Berm



Retains sediment in gravel or crushed rock berm.

Advantages

- Very efficient method for sediment removal.
- Reduces runoff velocity.

Disadvantages

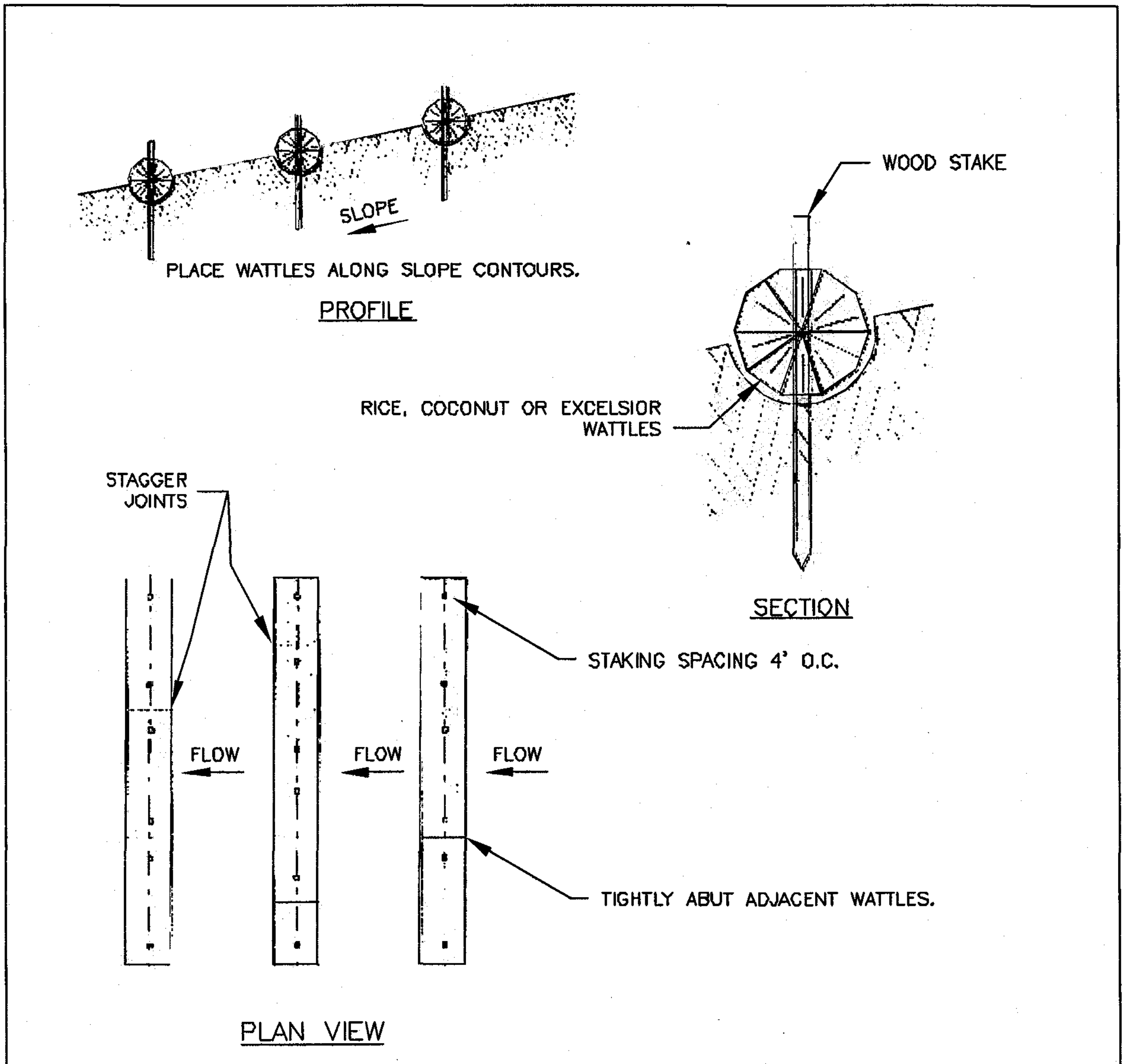
- More expensive than some other measures because requires clean gravel or crushed rock rather than materials found onsite.
- Clogging from mud and soil may make maintenance difficult.
- Has a limited life span.

Design Criteria

- Use 2 in. maximum washed and well-graded gravel or crushed rock with less than 5% fines.
- Berm Dimensions:
  - Height and side slopes: 1 foot high with 3:1 side slopes.
  - Length: 8 foot per 1 cubic foot per second flow, based on the peak flow for the 10-year storm.
  - If used as slope application, use Table 3-12 for spacing.
  - Used primarily as a base measure (toe of slope)

Inspection & Maintenance

- Inspect once per week on active sites, once every two weeks on in-active sites, and within 24 hours following a 0.5 inch rain event
- Remove and replace rock when filtering capacity is reduced by half to maintain performance.
- Removed sediment accumulation when it reaches one-third of the barrier height.

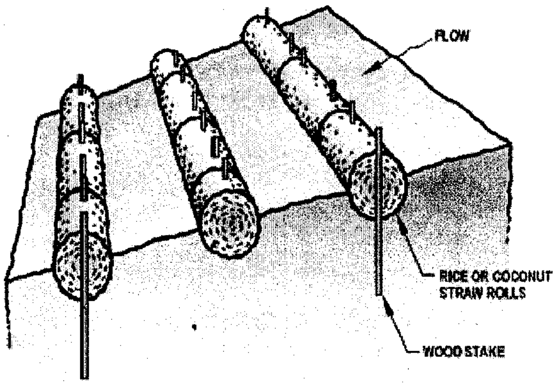


NOTES:

1. STAKING SPECIFICATIONS:
   a. 1"X2" WOODEN STAKES
   b. ADDITIONAL STAKES MAY BE INSTALLED ON DOWNHILL SIDE OF WATTLES, ON STEEP SLOPE OR HIGHLY EROSIVE SOILS.
2. SPACING IN ACCORDANCE WITH TABLE 4-7.

WATTLES	Detail Drawing 3.3.3

3.3.5 Wattles



Wattles are manufactured from straw, coconut, or other material that is wrapped in tubular plastic netting. They are approximately 8-9 in. diameter by 7-25 ft. long. Wattles are placed in shallow trenches and staked along the contour of newly constructed or disturbed slopes.

Advantages

- They can often replace sediment fences on steep slopes.
- Wattles store moisture for vegetation planted immediately upslope.
- May be left in place to biodegrade and/or photodegrade, adding organic material to the soil.
- Reduces runoff velocity.
- Light weight and easy to install.

Disadvantages

- Wattles only function for one or two seasons.
- If not installed properly with sufficient trench, wattles may fail during the first rain event.
- Wattles may require maintenance to ensure that the stakes are holding and the wattles are still in contact with the soil. This is especially true on steep slopes in sandy soil.
- Low sediment retaining capacity may require frequent maintenance.

Design Criteria

- Wattles can be made from straw, coconut, or other approved material.
- Slope requires minor preparation prior to installation.
- Rills and shallow gullies should be smoothed as work progresses.
- Wattles should be installed on contours. Trench should be deep enough to accommodate half the thickness of the wattle.
- Wattles should be installed from the bottom of the slope up.
- Wattle must be tight against the soil with no gaps between the soil and the wattle in the trench.
- If live willow stakes are installed, use a straight bar to drive holes through wattles.
- Stakes must be driven a minimum of 12 inches into undisturbed material.
- Install stakes every 4 ft. Additional stakes may be needed on highly erosive or very steep slopes.

Inspection & Maintenance

- Inspect once per week on active sites, once every two weeks on in-active sites, and within 24 hours following a 0.5 inch rain event
- Make sure the wattles are in contact with the soil.

3.3.6 Sidewalk Sub-grade Gravel Barrier

A sidewalk sub-grade gravel barrier is an application that provides storage and filtration from run-off on sites with mild slopes. It can be used on all types of projects but generally on single family dwellings. Normal installation occurs when excavating for footing and foundation.

Advantages

- Easy to install
- Very economical
- Can retain suspended soils

Disadvantages

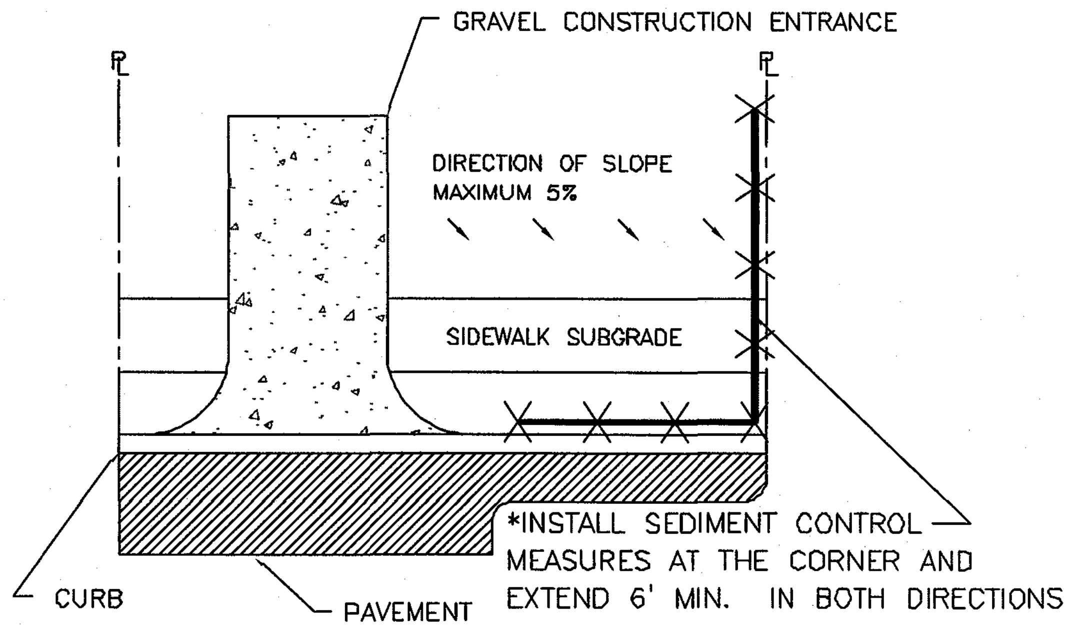
- May require additional measure depending upon soil type
- May need periodic maintenance for removal of suspended materials
- May not be an adequate sediment barrier for steep lots or concentrated flows

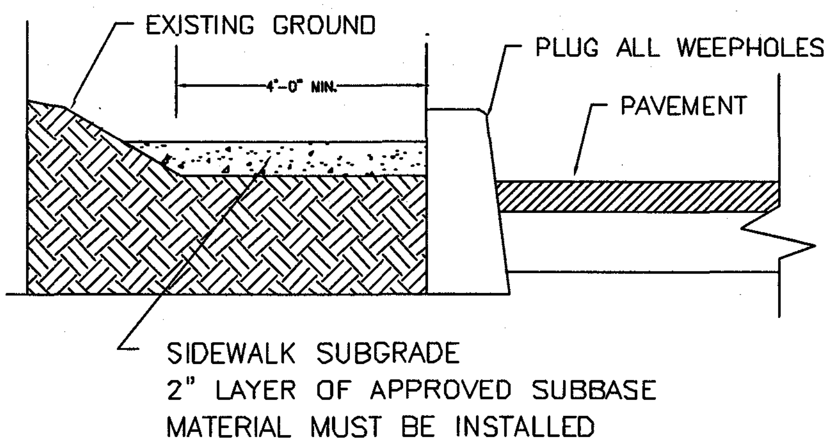
Design Criteria

- Install where the site slopes to a street with curbs and slopes are 5% or less
- Plug all weep holes in curb
- Sidewalk sub-grade must have a minimum 4-inch depth and a 4-foot width.
- A 2 inch layer of approved sub-base material must be installed
- A gravel filter berm may be installed along the inside edge, or toe of slope to increase filtration
- Install sediment barrier on the downhill corner of property to intercept run-off
- On development sites, install sidewalk sub-grade as part of post construction
- On single family sites, install as part of the footing/foundation excavation
- If sidewalk concrete is to be poured prior to establishment of permanent site cover, approved sediment barriers must be installed prior to pouring sidewalk

Inspection & Maintenance

- Inspect once per week on active sites, once every two weeks on in-active sites, and within 24 hours following a 0.5 inch rain event
- Remove and replace gravel when filtering capacity is reduced by half, to maintain performance



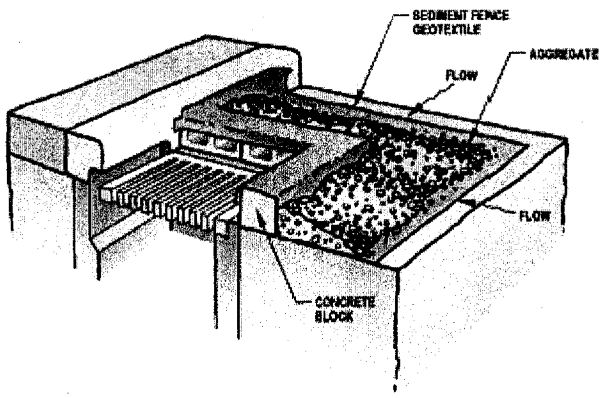


SIDEWALK SUBGRADE	Detail Drawing 3.3.6

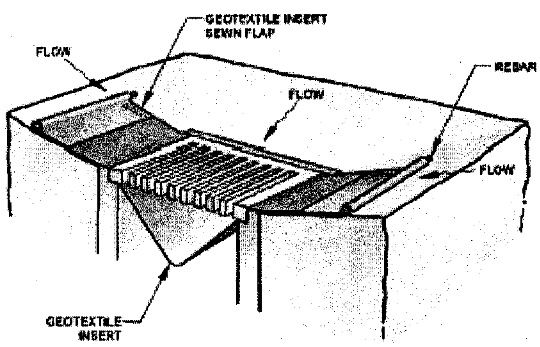
3.3.7 Inlet Protection

Prevents coarse sediment from entering storm drainage systems by filtering runoff and retaining sediment before it reaches a drainage inlet or storm sewer system. There are many options and variations of inlet protection available.

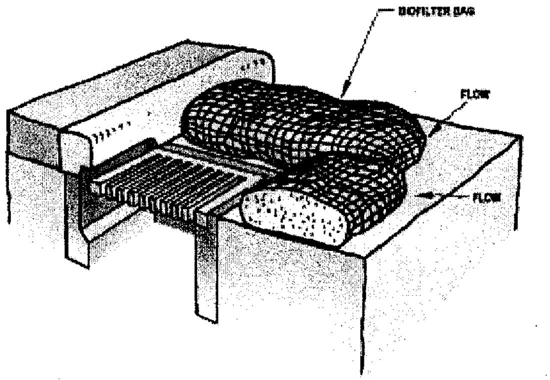
Inlet Protection – Masonry / Aggregate



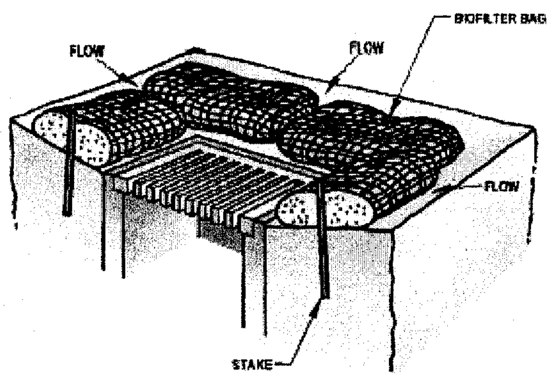
Inlet Protection - Prefabricated Filter Insert



Inlet Protection – Biofilter Bags Around Catch Basin



Inlet Protection – Biofilter Bags Around Area Drain



Advantages

- Prevents sediment from entering the storm drain system.
- Reduces amount of sediment leaving the site.

Disadvantages

- May result in ponding of water above the catch basin.
- Sediment removal may be difficult under high-flow conditions.
- May result in a traffic hazard.
- Short-circuiting of flow may occur if not properly installed.
- Useful only for low flows having low sediment loading.

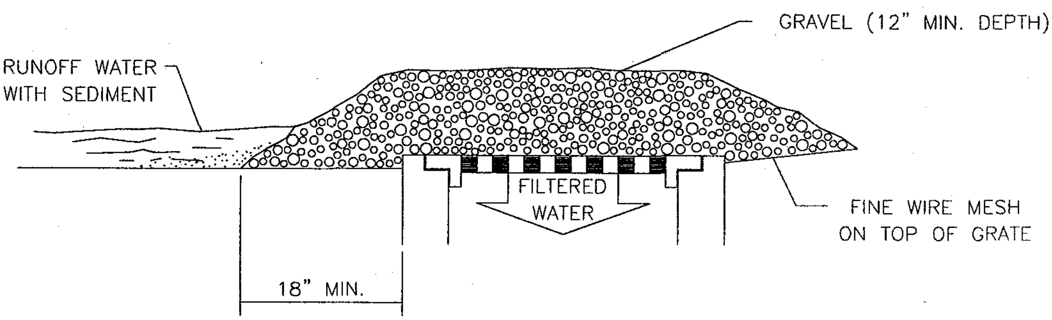
- Improper installation, maintenance or removal may introduce sediment into the storm drain system.

Design Criteria

- Place inlet protection in areas where water can pond, and where ponding will not have adverse impacts.
- Inlet protection must allow for overflow in a severe storm event.
- Addition measures must be considered depending upon soil type
- Inlet protection types include:
- Type 1 - Rock and wire mesh
- Type 2 – Masonry and rock
- Type 3 - Sediment fence
- Type 4 - Biofilter bags
- Type 5 - Catch basin insert

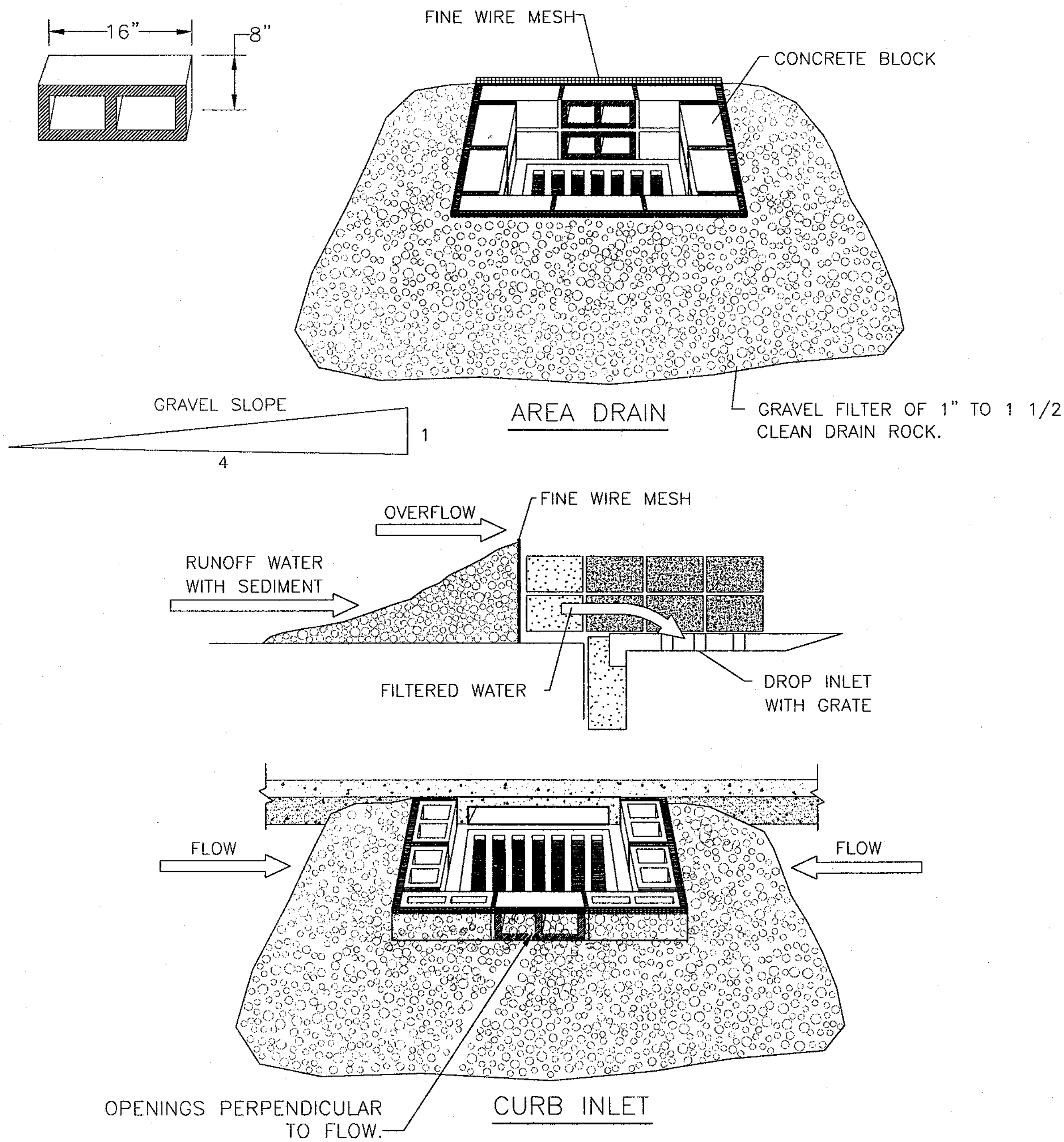
Inspection & Maintenance

- Inspect once per week on active sites, once every two weeks on in-active sites, and within 24 hours following a 0.5 inch rain event
- Clean inlet protection during and after each significant storm and remove sediment from behind structure after every storm.
- If the rock becomes clogged with sediment, it must be carefully removed from the inlet and either cleaned or replaced.
- Assess the impacts of allowing water to pond at the inlet and provide an overflow weir or some other type of relief as needed.
- Consider the effect of placing obstructions at inlets on grade may have on their efficiency.
- Use mechanical means to remove sediment deposits (shovel, broom, sweeper/vactor unit.
- Remove sediment accumulated on or around the protection as needed to maintain intended functions.
- Repair or replace materials as needed to ensure proper functioning.



GRAVEL & WIRE MESH

INLET PROTECTION TYPE 1	Detail Drawing 3.3.7a

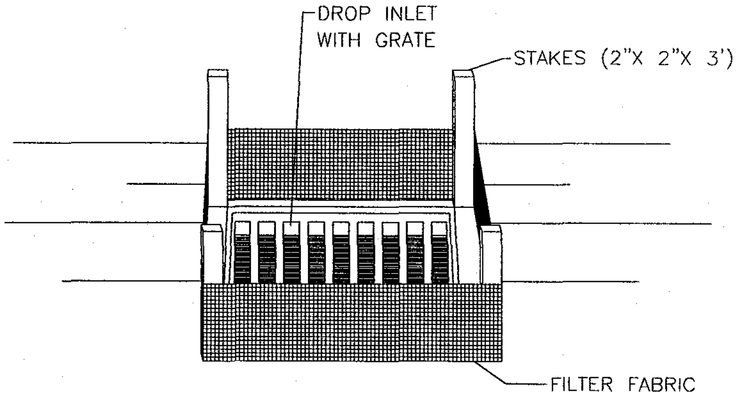


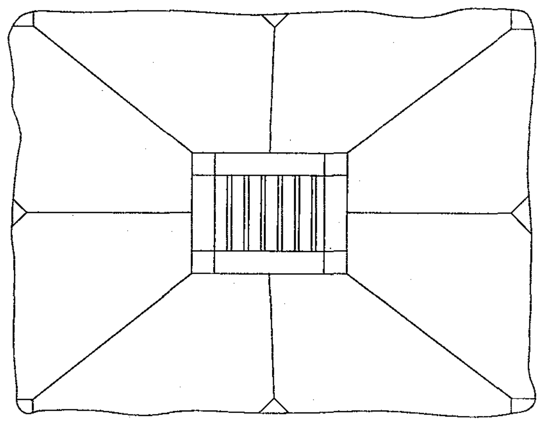
BLOCK AND GRAVEL INLET BARRIERS

NOTE:

1. BLOCKS SHALL BE STACKED WITH THE OPENINGS ON THE TOP AND BOTTOM EXCEPT FOR THE CENTER BLOCKS. CENTER BLOCKS WILL HAVE OPENINGS PERPENDICULAR TO FLOW.

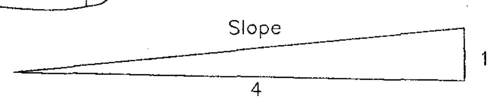
INLET PROTECTION TYPE 2	Detail Drawing 3.3.7b

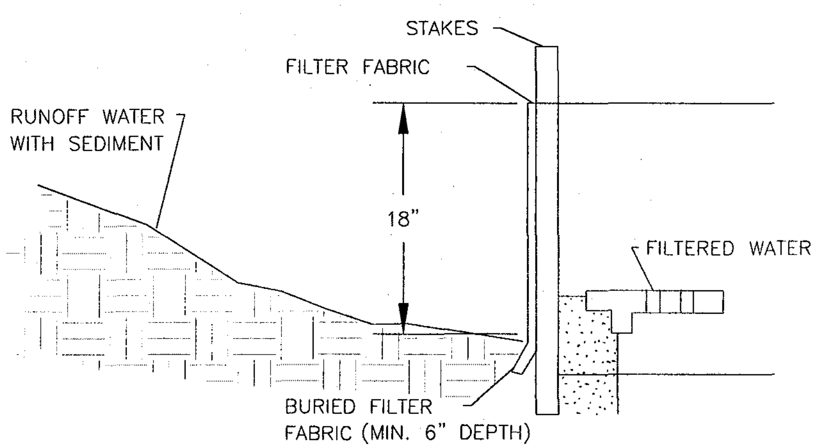




PLAN VIEW

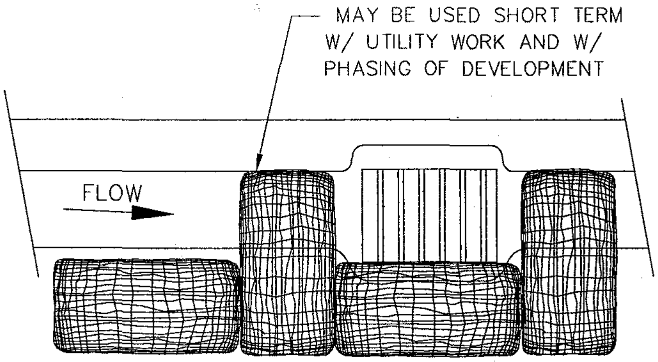
Slope 4:1



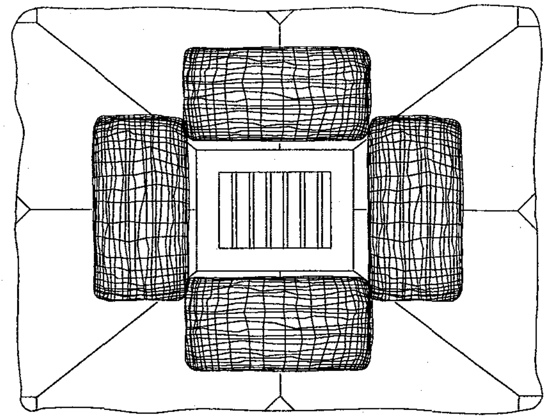


PROFILE

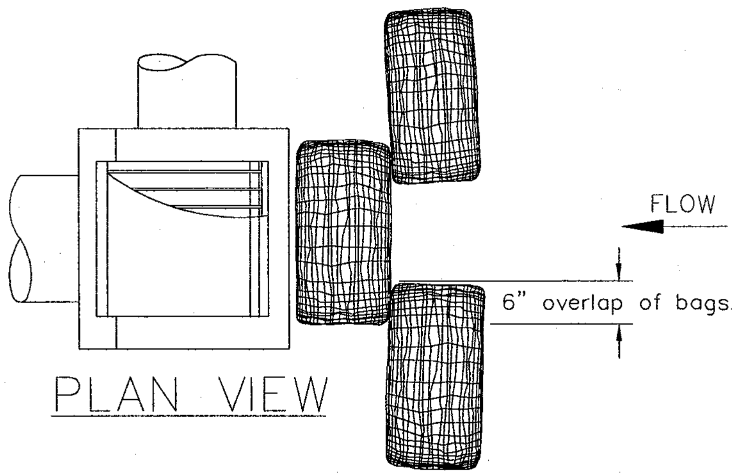
INLET PROTECTION TYPE 3	Detail Drawing 3.3.7c



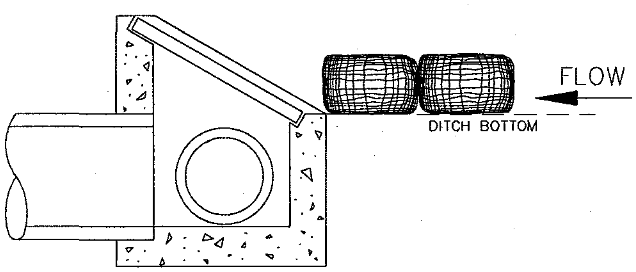
CATCH BASIN



AREA DRAIN



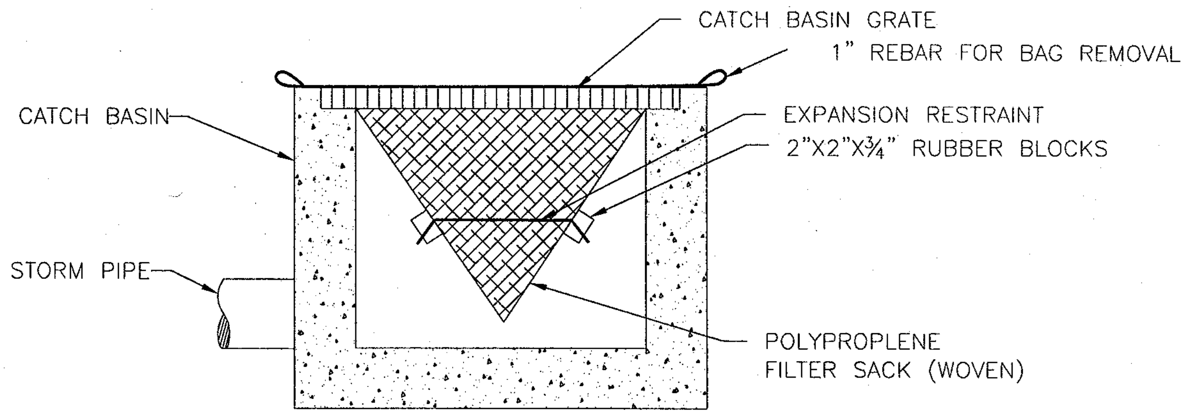
PLAN VIEW



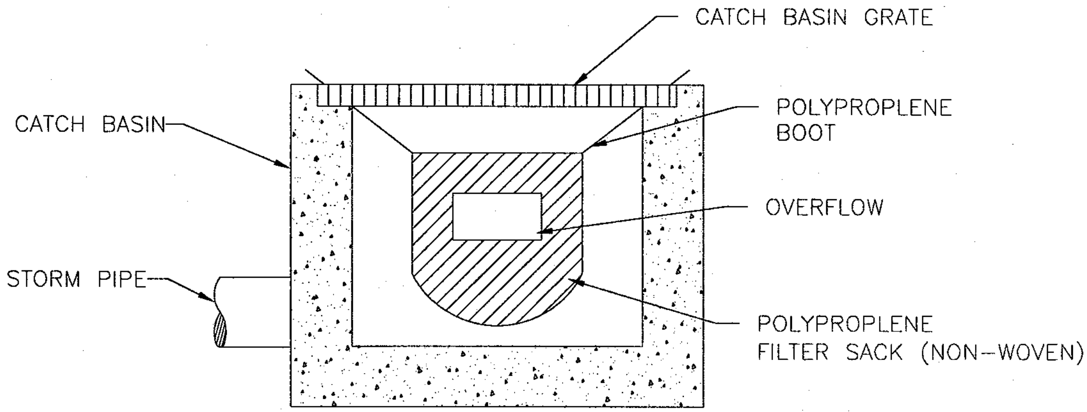
DITCH INLET

NOTES:
1. ADDITIONAL MEASURES MUST BE CONSIDERED DEPENDING ON SOIL TYPES.
2. BIOFILTER BAGS SHOULD BE STAKED WHERE APPLICABLE USING (2) 1"x2" WOODEN STAKES OR APPROVED EQUAL PER BAG.

INLET PROTECTION TYPE 4	Detail Drawing 3.3.7d



WOVEN POLYPROPLENE SACK



NON-WOVEN POLYPROPLENE SACK

NOTE:
1. RECESSED CURB INLET CATCH BASINS MUST BE BLOCKED WHEN USING FILTER FABRIC INLET SACKS. SIZE OF FILTER FABRIC INLET SACKS TO BE DETERMINED BY MANUFACTURER.

INLET PROTECTION TYPE 5	Detail Drawing 3.3.7e

3.3.8 Dewatering

Temporary settling and/or filtering devices for water which is discharged from dewatering operations. Filtration is the separation of sediment from a fluid by passing the fluid through a permeable medium that will trap a high percentage of the particles. This is not a new concept; it has been employed in all types of industries, for various type of liquids, including water. The equipment necessary for filtration applications associated with water containing sediment would be weir tanks, gravity boxes, non-contained sediment bags, sand media filtration, and bag/cartridge chambers. There are two types of filtration systems, gravity and pressure.

Advantages

- Excellent for utility work such as repairs, replacements, or new installations.
- Depending upon the choice of filtration systems, can remove small particles of silt and clays.
- Can be used as an alternate to sediment trap/basin on smaller sites
- Can hold large amounts of sediment which reduces overall maintenance.
- Can be used in conjunction with other types of filters as a pre-filter.
- Can be easily mobilized from site to site.

Disadvantage

- Limited storage capacity depending upon the site.
- Have limitations in removing silts and clays, depending upon selection.
- May require heavy equipment to load and unload system.
- May be cost inhibitive.

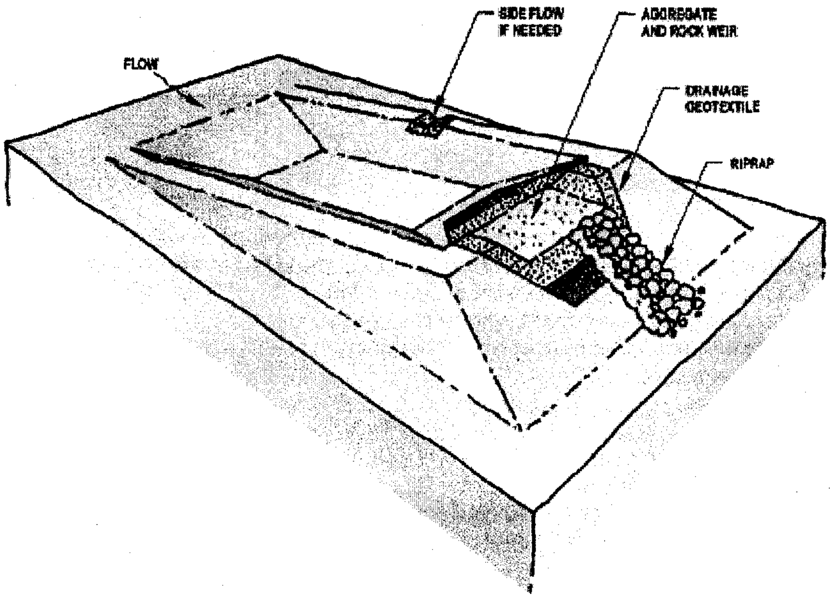
Design Criteria

- Determine soil type prior to selecting type of Dewatering system.
- Select an appropriate location that will reduce overall impacts.
- Weir tanks, Filter Boxes are effective for removal of large particles such as sand
- Sand Media Filters effective for removal of smaller particles such as sand and silt.
- Filter bags can remove large particles until fabric pores start to fill in or cake over then filter capacity increases to smaller sand and silt.
- Filter bags should be placed in a heavily vegetated area to increase there efficiency.
- Cartridge Filter Units will remove smaller particles such as silt and clay
- Rock Berms, Bio-filter Bags, or Sediment Fence shaped in a half circle and stages in a series of three can be installed as an alternate, or in conjunction with other systems.

Inspection & Maintenance

- Ongoing inspection is necessary in order to detect any malfunctions or operation of equipment.
- Periodic inspection of discharge areas.
- Remove sediment when it reaches 1/3 capacity of a sediment barrier.
- Material must be placed in an approved location on site or exported from site.

3.3.9 Sediment Trap



A sediment trap consists of a small, temporary ponding area, with a rock weir or perforated riser pipe at the outlet, formed by excavation or by constructing a weir. The sediment trap serves drainage areas 5 acres and smaller. They are a retention structure designed to remove sediment from runoff by holding a volume of water for a length of time, allowing particles 0.02 mm and large to settle out. Sediment retention should be used as a last line of defense when included in a ESCP and never used by itself.

<u>Combining with Permanent Drainage Facilities</u>

- If a project includes a permanent storm water retention/detention pond, the rough-graded or final-graded facility could function as a trap during construction. Design features of the permanent structure, such as surface area, retention time and outlet control, should meet the design requirements of the temporary facility. Completion of the permanent facility should occur only when all upstream control structures are in place and stabilization of contributing drainage areas is complete.
- If a project includes an infiltration facility, the roughly excavated facility could be used as a trap or basin providing the facility provides the surface area and retention time required by the trap or basin. Excavate the sides and bottom of the facility to a minimum of 3 foot above final grade with a backhoe working at "arms length" to minimize disturbance and compaction of the infiltration surface.
- Additionally, any required pretreatment facilities should be fully constructed prior to any release of sediment-laden water to the facility. Pretreatment and shallow excavations are intended to prevent the clogging of soil with fines.

<u>Advantages</u>

- Protect downstream riparian properties from sediment deposits.
- Prevent reduced downstream capacity due to sediment deposition in a stream channel.
- Prevents clogging of downstream facilities.
- Remove particles up to medium silt size (0.02 mm).

- Surface water conveyances can be connected to the facility as site development proceeds. The designer may want to route surface water collected from disturbed areas of the site through a sediment trap prior to release from the site.

Disadvantages

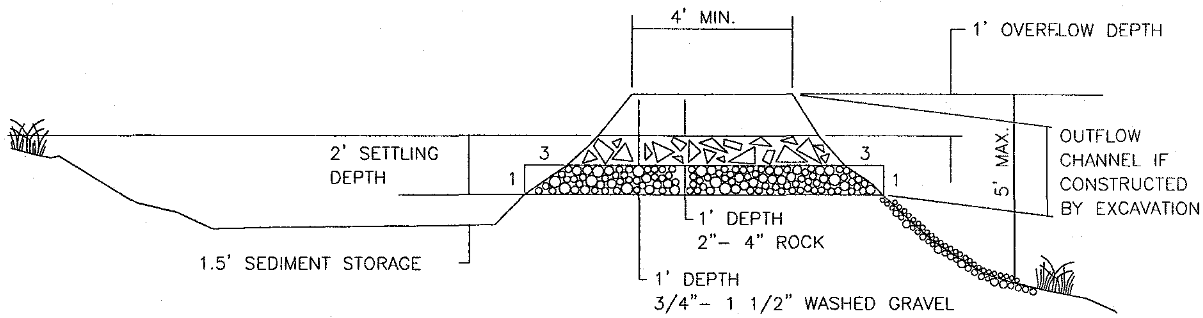
- May become an attractive nuisance. Care must be taken to adhere to all safety practices.
- Maintenance and sediment removal is essential for adequate performance.
- Serves limited areas.
- Does not reduce turbidity resulting from fine silts and clays in runoff. Traps are more effective when used in conjunction with other measures such as seeding and mulching.

Design Criteria

- Construct prior to any upslope clearing and grading.
- Locate in a low area where the trap will intercept all or most of the runoff from the disturbed area before it enters a waterway, considering safety in case structure fails.
- Locate the trap so that it is readily accessible for maintenance.
- Provide for diversion dikes and ditches, as needed, to collect and divert water toward the trap. Sediment storage volume can be calculated using the USLE assuming a minimum one year sediment accumulation period for design purposes. To convert tons of sediment as calculated to cubic feet, multiply 0.05 tons per cubic foot.
- Determine the bottom surface area of the sediment trap using the calculated sediment volume and the maximum 1.5 depth.
- Determine the total trap dimensions by adding an additional 2 feet of depth for settling volume (before overtopping of spillway) above the sediment storage volume, while not exceeding 3:1 side slopes.
- Design the trap with a level bottom, 3:1 or flatter side slopes and a L:W ratio of 3.
- Construct the trap as the first step in the clearing and grading of the site.
- Form the trap by excavation or by construction of compacted embankment. If the trap is formed by embankment, the designer should note that dam safety regulation may apply to heights exceeding 5 foot. The embankment should be stabilized using a cover method such as seeding, mulching or erosion control matting.
- Water temperature in the trap may be too high for direct release. Always moderate the water temperature before it drains into a lake, stream, wetland or waterway. Whenever possible, release the trap discharge onsite onto a relatively level, densely grassed area at least 50 feet from a waterway or wetland.
- Evaluate the release areas on a site-by-site basis in order to determine appropriate locations for and methods of releasing runoff. Do not use vegetated wetlands for this purpose.

Inspection & Maintenance

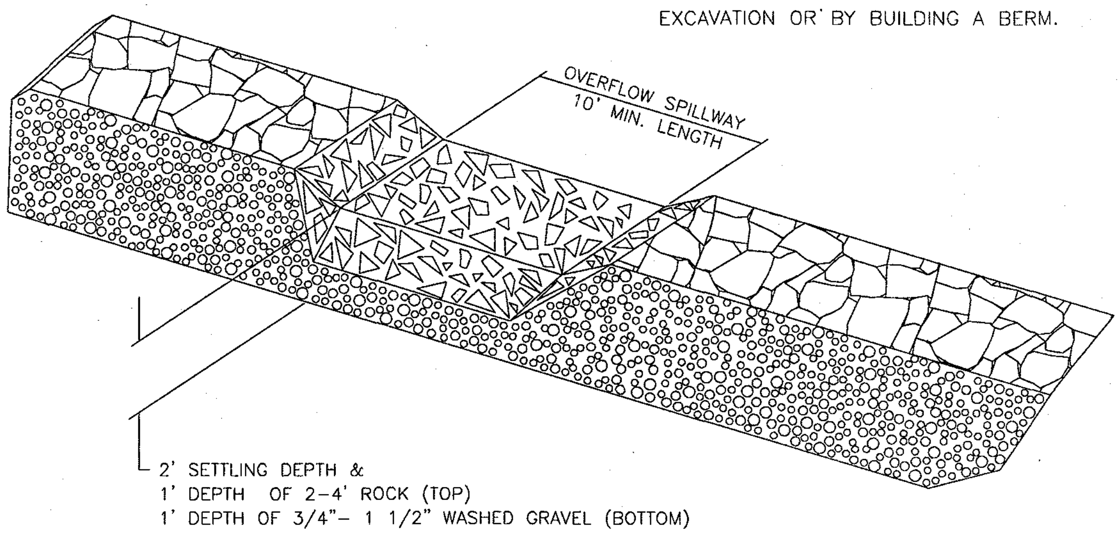
- Inspect once per week on active sites, once every two weeks on in-active sites, and within 24 hours following a 0.5 inch rain event
- Constant maintenance is essential for proper functioning.
- Remove sediment from the trap when it reaches one-third the storage capacity.
- Repair any damage to the trap, the embankments or the slopes.



CROSS SECTION

NTS

NOTE: MAY BE CONSTRUCTED BY EXCAVATION OR BY BUILDING A BERM.



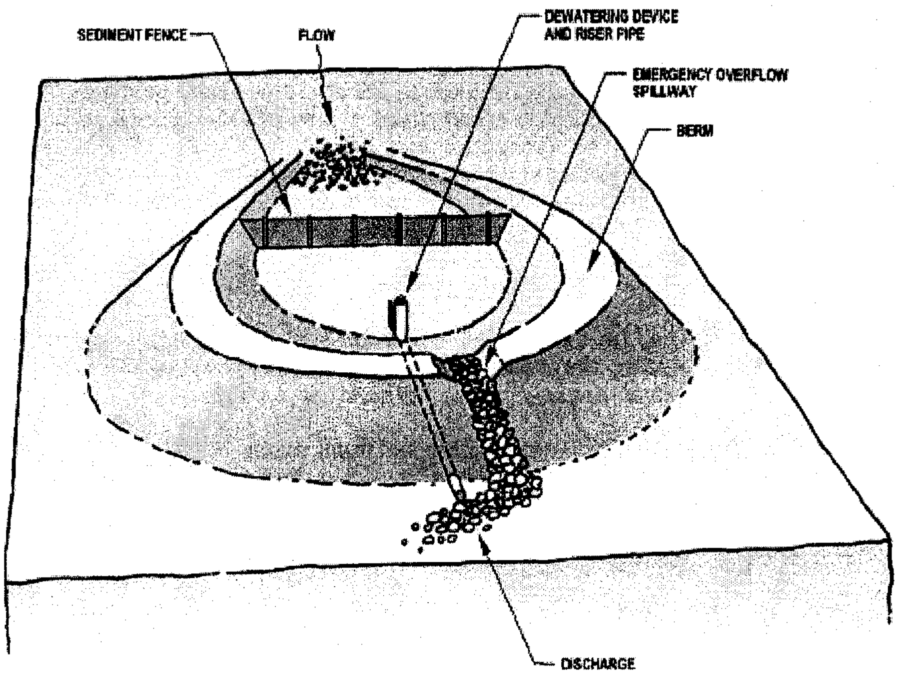
SEDIMENT TRAP OUTLET

NTS

NOTE:
A FILTER FABRIC FENCE OR SIMILAR FILTER MUST BE CONSTRUCTED TO FILTER RUNOFF FROM THE SEDIMENT TRAP PRIOR TO DISCHARGE FROM THE CONSTRUCTION SITE.

SEDIMENT TRAP	Detail Drawing 3.3.9

3.3.10 Sediment Basin



A temporary sediment basin has one or more inflow points and baffles to spread the flow, wet storage and dry storage, a securely anchored riser pipe, a dewatering device and an emergency overflow spillway. The sediment basin serves drainage areas less than 10 acres and has a design life of approximately 1-year.

Basins are large facilities that treat runoff from large drainage areas. Because of this, basins have limited application on linear construction projects. The applications, advantages and disadvantages of basins are included here for the designer's edification.

Combining with Permanent Drainage Facilities

- If a project includes a permanent storm water retention/detention pond, the rough-graded
- or final-graded facility could function as a basin during construction. Design features of the permanent structure, such as surface area, retention time and outlet control, should meet the design requirements of the temporary facility. Completion of the permanent facility should occur only when all upstream control structures are in place and stabilization of contributing drainage areas is complete.
- If a project includes an infiltration facility, the roughly excavated facility could be used as a basin, providing the facility provides the surface area and retention time required by the basin. Excavate the sides and bottom of the facility to a minimum of 2 foot above final grade with a backhoe working at "arms length" to minimize disturbance and compaction of the infiltration surface.
- Any required pretreatment facilities should be fully constructed prior to any release of sediment-laden water to the facility. Pretreatment and shallow excavations are intended to prevent the clogging of soil with fines.

Advantages

- Protect downstream riparian properties from sediment deposits.
- Prevent reduced downstream capacity due to sediment deposition in a stream channel.

- Prevents clogging of downstream facilities.
- Remove particles up to medium silt size 0.02 mm.
- Surface water conveyances can be connected to the facility as site development proceeds.

Disadvantages

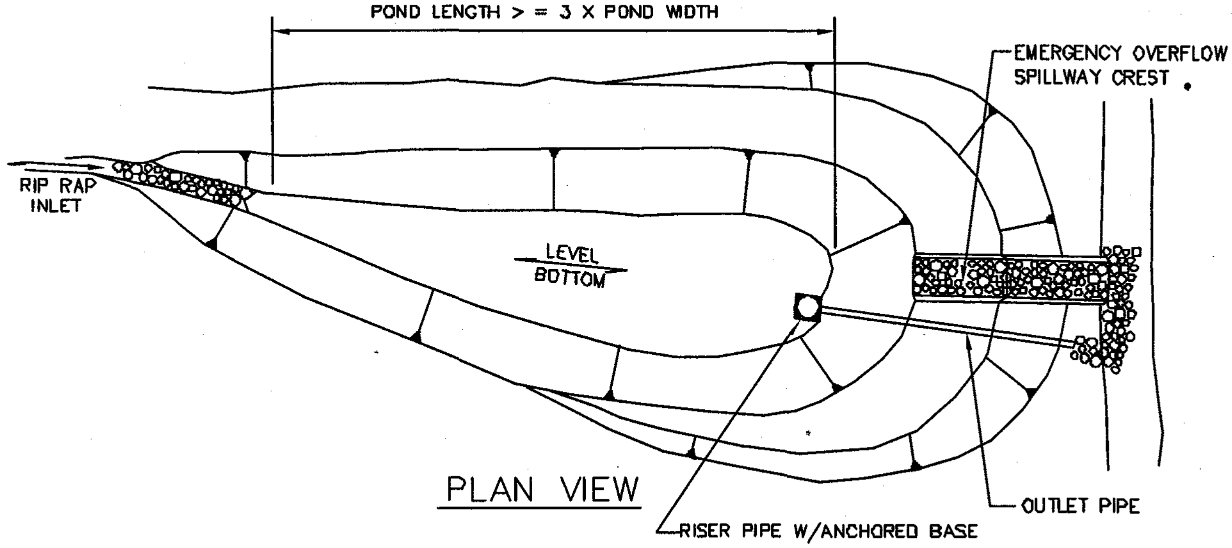
- May become an attractive nuisance. Care must be taken to adhere to all safety practices.
- Failure of a basin which is not properly located could result in loss of life, damage to homes or buildings or interruption of services such as transportation or power.
- Maintenance and sediment removal is essential for adequate performance.
- Does not reduce turbidity resulting from fine silts and clays in runoff. Basins are more effective when used in conjunction with other measures such as seeding and mulching.

Design Criteria

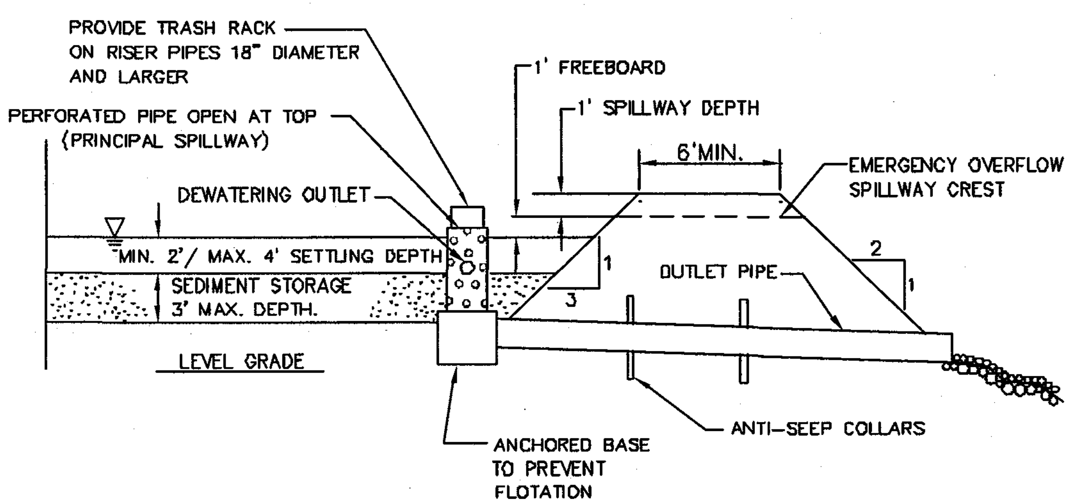
- Water temperature in the basin may be too high for direct release. Always moderate the water temperature before it drains into a lake, stream or waterway. Whenever possible, release the trap discharge onsite onto a relatively level, densely grassed area at least 50 feet from a waterway or wetland.
- Require installation of a staff gauge to aid in determining sediment depth.
- The designer may want to route surface water collected from disturbed areas to a sediment basin prior to release from the site.
- A qualified engineer should design temporary sediment basins.

Inspection & Maintenance

- Inspect once per week on active sites, once every two weeks on in-active sites, and within 24 hours following a 0.5 inch rain event
- All damages caused by soil erosion or construction equipment shall be repaired before the end of each working day.
- Remove sediment when the sediment storage zone is half full. This sediment shall be placed in such a manner that it will not erode from the site. The sediment shall not be deposited downstream from the embankment or in or adjacent to a stream or floodplain.
- When temporary structures have served their intended purpose and the contributing drainage area has been properly stabilized, the embankments and resulting sediment deposit shall be leveled or otherwise disposed of in accordance with the approved erosion and sediment control plan.



PLAN VIEW



PROFILE

NOTE:

1. 50' MINIMUM OF HIGHLY VEGETATED AREA AND OR SEDIMENT FENCE IS REQUIRED PRIOR TO DISCHARGING TO STREAM OR WETLAND.

SEDIMENT BASIN	Detail Drawing 3.3.10

CHAPTER 4:
POLLUTION CONTROL MEASURES AND BMPS

4.1 Management of Other Construction Site Pollutants

There are numerous potential pollutants, other than erosion and sediment, associated with construction activities. Potential pollutants include pollutants associated with the use of concrete and other cement-related mortars and the handling, application, and disposal of construction products and chemicals such as paints, adhesives, and solvents. The improper use and handling of construction materials can result in wash water, spills or wastes being left on the ground. These chemicals can infiltrate into soils causing groundwater contamination or wash-off to surface waters during subsequent storms.

Although this manual is not intended to address all aspects of construction site pollution control, some issues overlap with erosion and sediment control and must be taken into account in the overall planning process.

At a minimum the contractor should provide pollution prevention for:

1. off-site tracking of soils,
2. material management,
3. waste management,
4. vehicle and equipment management.

Each construction project is unique, and understanding the pollution risks for each construction activity is essential to successfully selecting and implementing pollution control BMPs. Defining these risks requires careful review of the site characteristics and the nature of the construction project. Once these risks are defined, BMP objectives can be developed and pollution control BMPs selected. In general the pollution control BMP objectives for construction projects are as follows.

- **Practice Good Housekeeping** – Perform activities in a manner which keeps potential pollutants from either draining or being transported off-site by managing pollutant sources and modifying construction activities.

- **Contain Waste** – Dispose of all construction waste in designated areas and keep storm water from flowing on or off of these areas.

Table 4-1 presents disposal and management alternatives for typical potential pollutants associated with construction activities.

Table 4-1 Quick Reference for Pollution Control

Discharge/Activity	BMP Detail No.	BMP/Pollution Control
Painting & Paint Removal		
Excess paint	7, 3, 4	Oil Based 1. Recycle/reuse. 2. Dispose as hazardous waste. Water Based 1. Recycle/reuse. 2. Dry residue in cans, dispose as trash. 3. If volume is too much to dry, dispose as hazardous waste.
Paint cleanup	3, 8	Wipe paint out of brushes, then: For oil based paints, 1. Filter & reuse thinners, solvents. 2. Dispose as hazardous waste. For water based paints, 1. Rinse to sanitary sewer.
Paint stripping (with solvent)	3	1. Dispose as hazardous waste.
Non-hazardous paint scraping/sand blasting	3	1. Dry sweep, dispose as trash.
HAZARDOUS paint scraping/sand blasting (e.g. marine paints or paints containing lead or tributyl tin)	3, 8	1. Dry sweep, dispose as hazardous waste.
General Construction		
Soil from excavations during wet weather periods	9	1. Should not be placed in street, on paved areas or near waterways. 2. Remove from site or backfill by end of day. 3. Cover with tarpaulin or surround with sediment barrier, or use other runoff controls (see Chapter 3). 4. Place inlet protection over storm drain inlets. Note: Thoroughly sweep following removal of dirt in all four alternatives.
Soil from excavations placed on paved surfaces during dry season	9	1. Keep materials out of storm conveyance systems and thoroughly remove via sweeping. 2. Cover to prevent wind erosion.
Cleaning streets in construction areas	7	1. Dry sweep. 2. Use silt ponds, inlet protection and/or similar sediment control techniques when flushing pavement.

Table 4-1 Quick Reference for Pollution Control

Discharge/Activity	BMP Detail No.	BMP/Pollution Control
Soil erosion, sediments	(see Chapter 3)	1. Cover disturbed soils, use erosion controls, block entry to storm drain. 2. Seed or plant as soon as possible.
Fresh cement, grout, mortar	10	1. Use/reuse excess. 2. Dispose to trash. 3. Do not allow into surface water and/or collection systems.
Washwater from concrete/mortar (etc.) cleanup	10	1. Wash onto dirt area and spade in. 2. Pump and remove to appropriate disposal facility. 3. Settle; pump water to vegetated area at least 150 feet from surface water.
Rinse water from concrete mixing trucks	10	1. Return truck to yard for rinsing into settling pond or dirt area. 2. At construction site, wash into settling pond or dirt area and spade in, never allow into storm sewer or waterways.
Runoff from Foundation Forms & Form Treatment	4, 6	1. Store forms on a pervious surface 2. Place a tarpaulin over the forms when not in use to prevent contact with precipitation. 3. Store form treatment fluids in secondary containment at a designated area.
Non-hazardous construction and demolition debris	7	1. Recycle/reuse (concrete, wood, etc.) 2. Dispose as trash.
Hazardous demolition and construction debris (e.g. asbestos).	8	1. Dispose as hazardous waste.
Concrete saw-cut slurry (wet sawing)	10	1. Use dry cutting technique and sweep up residue. 2. Place a berm on down-slope side of project to collect slurry before it flows off site. 3. Vacuum slurry and dispose off-site. 4. Shovel out gutters; dispose residue to dirt area, construction yard or landfill. 5. Block all storm drains or curb inlets
Construction dewatering (nonturbid, uncontaminated groundwater)	1	1. Recycle/reuse. 2. Discharge to storm drain after receiving City approval. 3. Settle, pump water to sanitary sewer or vegetated area at least 50 yards from surface water. Discharge to sanitary sewer may require a permit from the POTW.

Table 4-1 Quick Reference for Pollution Control

Discharge/Activity	BMP Detail No.	BMP/Pollution Control
Construction dewatering (other than nonturbid, uncontaminated groundwater)	1	1. Recycle/reuse. 2. Discharge to sanitary sewer, may need permit from the POTW. 3. As appropriate, treat prior to discharge to storm drain, requires NPDES permit.
Leaks from garbage dumpsters	6	1. Collect, contain leaking material. Eliminate leak, keep covered, return to leasing company for immediate repair. 2. If dumpster is used for liquid waste, use plastic liner.
Leaks from construction debris bins	6, 4	1. Insure bins are used for dry nonhazardous materials only. (Suggestion: fencing, covering helps prevent misuse).
Dumpster cleaning water	6	1. Clean at dumpster owner's facility and discharge waste through grease interceptor to sanitary sewer. 2. Clean on site and discharge through grease interceptor to sanitary sewer.
Cleaning driveways, paved areas	6	1. Sweep and dispose as trash (dry cleaning only). 2. For vehicle leaks, follow this 3-step process: a. Clean up leaks with rags or absorbents. b. Sweep, using granular absorbent material (cat litter). c. Mop and dispose of mop water to sanitary sewer.
Paving Operations	2	1. Avoid paving during wet weather. 2. Protect drainage systems by diverting runoff or trap/ filter system. 3. Place drip pans or absorbent materials under paving equipment when not in use.
Steam cleaning of sidewalks, plazas	6	1. Collect all water and properly dispose of; do not allow runoff to enter storm sewer. 2. Follow this 3-step process: a. Clean oil leaks with rags or absorbents. b. Sweep (use dry absorbent as needed). c. Use no soap, discharge to storm drain.

Table 4-1 Quick Reference for Pollution Control

Discharge/Activity	BMP Detail No.	BMP/Pollution Control
Aggregate wash from driveway/patio construction	6	1. Wash onto dirt area, spade in. 2. Pour driveway approach last. 3. Collect and remove to appropriate disposal facility. 4. Settle, pump water to vegetated area at least 150 feet from surface water.
Landscape/Garden Maintenance		
Pesticides	5, 8, 15	1. Use all material in container. Rinse containers use rinse water as product. 2. Dispose rinsed containers as trash. 3. Dispose unused pesticide as hazardous waste.
Fertilizer applications	5, 8, 15	1. Sweep any "over spray" material from streets, sidewalks and driveways
Yard & garden clippings	7	1. Compost. 2. Take to landfill.
Tree trimming	7	1. Chip if necessary, before composting or recycling.

Table 4-1 Quick Reference for Pollution Control

Discharge/Activity	BMP Detail No.	BMP/Pollution Control
Vehicle/Equipment Wastes		
Used motor oil & oil filters	14, 6, 4, 8	1. Use secondary containment while storing, send to recycler.
Antifreeze	14, 6, 4, 8	1. Use secondary containment while storing, send to recycler.
Other vehicle fluids and solvents	14, 6, 4, 8	1. Dispose as hazardous waste.
Automobile batteries	14, 4, 8	1. Use secondary containment while storing. 2. Send to auto battery recycler. 3. Take to recycling center.
Vehicle washing	12, 15	1. Wash on pervious surface and use cold water only. 2. Never allow runoff to directly discharge to storm drainage systems.
Mobile vehicle washing	12	1. Collect wash water and discharge to sanitary sewer w/ City approval; never allow wash water to discharge to storm drainage systems.
Rinse water from dust removal at new car fleets	12	1. If rinsing dust from exterior surfaces for appearance purposes, do not use soap (cold water only).
Vehicle leaks & equipment fueling	6, 13, 14	1. Clean up leaks with rags or absorbents. 2. Sweep, using granular absorbent material (cat litter). 3. Fuel only in designated area and place a spill kit in the fueling area.

Table 4-1 Quick Reference for Pollution Control

Other Wastes	
Roof drains	1. If roof is contaminated with industrial waste products, discharge to sanitary sewer with approval from local sanitary authority (may need a discharge permit). 2. If no contamination is present, discharge to pervious surface.
Cooling water Air conditioning condensate	1. Recycle/reuse. 2. Discharge permit may be required, contact local sanitary authority.
Pumped groundwater, infiltration/foundation drainage (contaminated)	1. Recycle/reuse (landscaping, etc.). 2. Discharge permit may be required, contact local sanitary authority.
Fire fighting flows	1. If contamination is present, Fire Department will attempt to prevent flow to stream or storm drainage system.
Clean-up wastewater from sewer back-up	1. Follow this procedure: a. Block storm drain, contain, collect and return spilled material to the sanitary sewer. b. Block storm drain; rinse remaining material to collection point and pump to sanitary sewer. (No rinse water may flow to storm drain.)

4.2 Pollution Control BMPs

This chapter describes specific BMPs for common construction activities that may pollute storm water. The following fact sheets were adapted from the Construction Methods Handbook developed in 1993 by California's Storm Water Quality Task Force and are suitable for inclusion in erosion and sediment control (EPSC) plans or Pollution Control Plans (PCP) for typical contractor activities. The BMPs listed are not an exhaustive list, nor will every BMP be appropriate for every situation. Therefore, suggested BMPs that are inappropriate may be deleted and additional BMPs for specific site conditions should be added. In addition, the selection and implementation of BMPs should be reviewed on a regular basis to match the changing conditions at construction sites.

The following fact sheets have been included.

Target Pollutants and Impact Significance
H = High M = Medium L/U = Low or Unknown

BMP Number and Title	Sediment	Nutrients	Toxic Materials	Oil & Grease	Floatable Materials	Other Const. Waste
1 Dewatering Operations	H	L/U	M	L/U	L/U	L/U
2 Paving Operations	M	L/U	M	M	L/U	L/U
3 Structure Construction and Painting	L/U	L/U	M	L/U	H	H
4 Material Delivery and Storage	M	M	M	M	M	L/U
5 Material Use	L/U	M	M	M	M	L/U
6 Spill Prevention and Control	L/U	L/U	M	M	L/U	L/U
7 Solid Waste Management	M	L/U	L/U	L/U	H	H
8 Hazardous Waste Management	L/U	L/U	M	L/U	L/U	L/U
9 Contaminated Soil Management	M	L/U	M	L/U	L/U	L/U
10 Concrete Waste Management	M	L/U	L/U	L/U	L/U	M
11 Vehicle and Equipment Cleaning	M	L/U	M	M	L/U	L/U
12 Vehicle and Equipment Fueling	L/U	L/U	M	M	L/U	L/U
13 Vehicle and Equipment Maintenance	L/U	L/U	M	M	L/U	L/U
14 Employee and Subcontractor Training						

4.2.1 - BMP 1: Dewatering Operations

<u>Description</u>

Prevent or reduce the discharge of pollutants to storm water from dewatering operations by using sediment controls and by testing the groundwater for pollution.

<u>Approach</u>

There are two general classes of pollutants that may result from dewatering operations: sediment, and toxics and petroleum products. High sediment content in dewatering discharges is common because of the nature of the operation. On the other hand, toxics and petroleum products are not commonly found in dewatering discharges unless the site or surrounding area has been used for light or heavy industrial activities, or the area has a history of groundwater contamination. The following steps will help reduce storm water pollution from dewatering discharges:

Sediment

- Use sediment controls to remove sediment from water generated by dewatering.
- Use filtration to remove sediment from a sediment trap or basin. Filtration can be achieved with:
  - Sump pit and a perforated or slit standpipe with holes and wrapped in filter fabric. The standpipe is surrounded by stones, which filter the water as it collects in the pit before being pumped out. Wrapping the standpipe in filter fabric may require an increased suction inlet area to avoid clogging and unacceptable pump operation.
  - Floating suction hose to allow cleaner surface water to be pumped out.

Toxics and Petroleum Products

- In areas suspected of having groundwater pollution, sample the groundwater near the excavation site and have the water tested for known or suspected pollutants at a certified laboratory. Check with the Department of Environmental Quality (DEQ) and the local wastewater treatment plant for their requirements for dewatering, additional water quality tests, and disposal options.
- With a permit, you may be able to recycle/reuse pumped groundwater for landscape irrigation, or discharge to the storm sewer. With a permit from the DEQ and/or a approval of the City of Corvallis Public Works Environmental Analyst, you may be able to treat pumped groundwater and discharge it to the municipal wastewater treatment plant via the sanitary sewer.
- For a quick reference on disposal alternatives for specific wastes, see Table 4-1, Quick Reference – Disposal Alternatives.

4.2.2 - BMP 2: Paving Operations

Description

Prevent or reduce the discharge of pollutants from paving operations, using measures to prevent run-on and runoff pollution, properly disposing of wastes, and training employees and subcontractors.

Approach

- Avoid paving during wet weather.
- Store materials away from drainage courses to prevent storm water run-on (see BMP 4, Material Delivery and Storage).
- Protect drainage courses, particularly in areas with a grade, by employing BMP's to divert runoff or trap/filter sediment.
- Leaks and spills from paving equipment can contain toxic levels of heavy metals and oil and grease. Place drop pans or absorbent materials under paving equipment when not in use. Clean up spills with absorbent materials rather than burying. See BMP 13 (Vehicle and Equipment Maintenance) and BMP 6 (Spill Prevention and Control) in this chapter.
- Cover catch basins and manhole when applying seal coat, track coat, slurry seal, fog seal, etc.
- Shovel or vacuum saw cut slurry and remove from site. Cover or barricade storm drains during saw cutting to contain slurry.
- If paving involves Portland cement concrete, see BMP 10 (Concrete Waste Management).
- If paving involves asphaltic concrete, the following precautions may help prevent pollutant from entering storm water:
    - Do not allow sand or gravel placed over new asphalt to wash into storm drains, streets, or creeks by sweeping. Properly dispose of this waste by referring to BMP 7 (Solid Waste Management) in this chapter.
    - Old asphalt must be disposed of properly. Collect and remove all broken asphalt from the site and recycle whenever possible.
    - If paving involves on-site mixing plant, follow the storm water permitting requirements for industrial activities.
- Train employees and subcontractors.

4.2.3 - BMP 3: Painting

Description

Prevent or reduce the discharge of pollutants to storm water from structure construction and painting by enclosing or covering or berming building material storage areas, using good housekeeping practices, using safer alternative products and training employees and subcontractors.

Approach

- Keep the work site clean and orderly. Remove debris in a timely fashion. Sweep the area.
- Use soil erosion control techniques if bare ground is exposed.
- Buy recycled or less hazardous products to the maximum extent practicable.
- Conduct painting operations consistent with local air quality and OSHA regulations.
- Properly store paints and solvents. See BMP 4 (Material Delivery and Storage) in this chapter.
- Properly store and dispose waste materials generated from the activity. See the waste management BMPs (BMP 7 to BMP 10) in this chapter.
- Recycle residual paints, solvents, lumber and other materials to the maximum extent practicable.
- Make sure that nearby storm drains are well marked to minimize the chance of inadvertent disposal of residual paints and other liquids.
- Clean the storm drain in the immediate construction area after construction is completed.
- Educate employees who are doing the work.
- Inform subcontractors of company policy on these matters and include appropriate provisions in their contract to make certain proper housekeeping and disposal practices are implemented.
- For a quick reference on disposal alternatives for specific wastes, see Table 4-1.

4.2.4 - BMP 4: Material Delivery and Storage

Description

Prevent or reduce the discharge of pollutants to storm water from material delivery and storage by minimizing the storage of hazardous materials on-site, storing materials in a designated area, installing secondary containment, conducting regular inspection, and training employees and subcontractors.

The best management practice covers only material delivery and storage. For other information on materials, see BMP 5 (Material Use), or BMP 6 (Spill Prevention and Control). For information on wastes, see the waste management BMPs in this chapter.

Approach

The following materials are commonly stored on construction sites:

- Soil
- Pesticides and herbicides
- Fertilizers
- Detergents
- Plaster or other products
- Petroleum products such as fuel, oil, and grease, and
- Other hazardous chemicals such as acids, lime, glues, paints, solvents, and curing compounds

Storage of these materials on-site can pose the following risks:

- Storm water pollution
- Injury to workers or visitors
- Groundwater pollution
- Soil contamination

The following steps should be taken to minimize risk of pollution:

- Designate areas of the construction site for material delivery and storage.
    - Place near the construction entrances, away from waterways
    - Avoid transport near drainage paths or waterways
    - Surround with earth berms
    - Place in an area which will be paved
- Storage of reactive, ignitable, or flammable liquids must comply with the fire codes or your area. Contact the local Fire Marshal to review site materials, quantities, and proposed storage area to determine specific requirements.
- For a quick reference on disposal alternatives for specific wastes, see Table 4-1, Quick Reference – Disposal Alternatives.
- Keep an accurate, up-to-date inventory of materials delivered and stored on-site.
- Keep your inventory down.
- Minimize hazardous materials on-site storage.
- Handle hazardous materials as infrequently as possible.
- During the rainy season, consider storing materials in a covered area. Store materials in secondary containments such as an earthen dike, horse trough, or even a child's wading pool for non-reactive materials such as detergents, oil, grease, and paints. Small amounts of material may be secondarily contained in "bus boy" trays or concrete mixing trays.
- Do not store chemicals, drums, or bagged materials directly on the ground. Place these items on a pallet and, when possible, in secondary containment.
- If drums must be kept uncovered, store them at a slight angle to reduce ponding of rainwater on the lids and to reduce corrosion.
- Try to keep chemicals in their original containers, and keep them well labeled.

- Train employees and subcontractors.
- Employees trained in emergency spill cleanup procedures should be present when dangerous materials or liquid chemicals are unloaded.
- If significant residual materials remain on the ground after construction is complete, properly remove materials and any contaminated soil (See BMP 9). If the area is to be paved, pave as soon as materials are removed to stabilize the soil.

4.2.5 - BMP 5: Material Use

Description

Prevent or reduce the discharge of pollutants to storm water from material use by using alternative products, minimizing hazardous material use on-site, and training employees and subcontractors.

Approach

The following materials are commonly used on construction sites:

- Pesticides and herbicides
- Fertilizers
- Detergents
- Plaster or other products
- Petroleum products such as fuel, oil, and grease, and
- Other hazardous chemicals such as acids, lime, glues, paints, solvents, and curing compounds.

Use of these materials on-site can pose the following risks:

- Storm water pollution
- Injury to workers or visitors
- Groundwater pollution
- Soil contamination

The following steps should be taken to minimize the risk:

- Use less hazardous, alternative materials as much as possible.
- Minimize use of hazardous materials on-site.
- Use materials only where and when needed to complete the construction activity.
- Follow manufacturer's instructions regarding uses, protective equipment, ventilation, flammability, and mixing of chemicals.
- Personnel who use pesticides should be trained in their use.
- Do not over-apply fertilizers, herbicides, and pesticide. Prepare only the amount needed. Follow the recommended usage instructions. Over-application is expensive and environmentally harmful. Unless on steep slopes, till fertilizers into the soil rather than hydroseeding. Apply surface dressings in several smaller applications, as opposed to one large application, to allow time for infiltration and to avoid excess material being carried off-site by runoff. Do not apply these chemicals just before it rains.
- Train employees and subcontractors in proper material use.

4.2.6 - BMP 6: Spill Prevention and Control

Description

Prevent or reduce the discharge of pollutants to storm water from leaks and spills by reducing the chance for spills, stopping the source of spills, containing and cleaning up spills, properly disposing of spill materials, and training employees.

The best management practice covers only spill prevention and control. However, BMP 4 (Material Delivery and Storage) and BMP 5 (Material Use), also contain useful information, particularly on spill prevention. For information on wastes, see the waste management BMPs in this chapter.

Approach

The following steps will help reduce the storm water impacts of leaks and spills:
Define "Significant Spill"

- Different materials pollute in different amounts. Make sure that each employee knows what a "significant spill" is for each material they use, and what is the appropriate response for "significant" and "insignificant" spills.

General Measures

- Hazardous materials and wastes should be stored in covered containers and protected from vandalism.
- Place a stockpile of spill cleanup materials where it will be readily accessible.
- Train employees in spill prevention and cleanup.
- Designate responsible individuals.

Cleanup

- Clean up leaks and spills immediately.
- On paved surfaces, clean up spills with as little water as possible. Use a rag for small spills, a damp mop for general cleanup, and absorbent material for larger spills. If the spilled material is hazardous, then the used cleanup materials are also hazardous and must be sent to either a certified laundry (rags) or disposed of as hazardous waste.
- Never hose down or bury dry material spills. Clean up as much of the material as possible and dispose of properly. See the waste management BMPs in this chapter for specific information.

Reporting

- Report significant spills to local agencies, such as the Fire Department. They can assist in clean up.
- Federal regulation require that any significant oil spill into a water body or onto an adjoining shoreline be reported to the National Response Center (NRC) at 800-424-8802 (24 hour).

Use the following measures related to specific activities:

Vehicle and Equipment Maintenance

- If maintenance must occur on-site, use a designated area and /or a secondary containment, located away from drainage courses, to prevent the run-on of storm water and the runoff of spills.
- Regularly inspect on-site vehicles and equipment for leaks, and repair immediately.
- Check incoming vehicles and equipment (including delivery trucks and employee and subcontractor vehicles) for leaking oil and fluids. Do not allow leaking vehicles or equipment on-site.
- Always use secondary containment, such as a drain pan or drop cloth, to catch spills or leaks when removing or changing fluids.

- Place drip pans or absorbent materials under paving equipment when not in use.
- Use adsorbent materials on small spills rather than hosing down or burying the spill. Remove the adsorbent materials promptly and dispose of properly.
- Promptly transfer used fluids to the proper waste or recycling drums. Do not leave full drip pans or other open containers lying around.
- Oil filters disposed of in trashcans or dumpsters can leak oil and pollute storm water. Place the oil filter in a funnel over a waste oil-recycling drum to drain excess oil before disposal. Oil filters can also be recycled. Ask your oil supplier or recycler about recycling oil filters.
- Store cracked batteries in an on-leaking secondary container. Do this with all cracked batteries, even if you think all the acid has drained out. If you drop a battery, treat it as if it is cracked. Put it into the containment area until you are sure it is not leaking.

Vehicle and Equipment Fueling

- If fueling must occur on-site, use designated areas, located away from drainage courses, to prevent the run-on of storm water and the runoff of spills.
- Discourage "topping-off" of fuel tanks; an increase in temperature can cause fuel to expand and overflow.
- Always use secondary containment such as a drain pan to catch when fuel spills/leaks.

4.2.7 - BMP 7: Solid Waste Management

Description

Prevent or reduce the discharge or pollutants to storm water from solid or construction waste by providing designated waste collection areas and containers, arranging for regular disposal, and training employees and subcontractors.

Approach

Solid waste is one of the major pollutants resulting from construction. Construction debris includes:

- Solid waste generated from trees and shrubs removed during land clearing, demolition or existing structures (rubble), and building construction;
- Packaging materials including wood, paper and plastic;
- Scrap or surplus building materials including scrap metals, rubber, plastic, glass pieces, and masonry products; and
- Domestic wastes including food containers such as beverage cans, coffee cups, paper bags, plastic wrappers, and cigarettes.

The following steps will help keep a clean site and reduce storm water pollution:

- Select designated waste collection areas on-site.
- Inform trash-hauling contractors that you will accept only watertight dumpsters for on-site use. Inspect dumpsters for leaks and repair any dumpster that is not watertight.
- Locate containers in a covered area and/or in a secondary containment.
- Provide an adequate number of containers with lids or covers that can be placed over the container to keep rain out or to prevent loss of wastes when it is windy.
- Plan for additional containers and more frequent pickup during the demolition phase of construction.
- Collect site trash daily, especially during raining and windy conditions.
- Erosion and sediment control devices tend to collect litter. Remove this solid waste promptly.
- Make sure that toxic liquid wastes (used oils, solvents, and paints) and chemicals (acids, pesticides, additives, curing compounds) are not disposed of in dumpsters designated for construction debris.
- Salvage or recycle any useful material. For example, trees and shrubs from land clearing can be used as a brush barrier, or converted into wood chips, then used as mulch on graded areas.
- Do not hose out dumpsters on the construction site. Leave dumpster cleaning to trash hauling contractor.
- Arrange for regular waste collection before containers overflow.
- If a container does spill, clean up immediately.
- Make sure that construction waste is collected, removed, and disposed of only at authorized disposal areas.
- Train employees and subcontractors in proper solid waste management.
- For a quick reference on disposal alternatives for specific wastes, see Table 4-1.

4.2.8 - BMP 8: Hazardous Waste Management

Description

Prevent or reduce the discharge of pollutants to storm water from hazardous waste through proper material use, waste disposal, and training of employees and subcontractors.

Approach

Many of the chemicals used on-site can be hazardous materials that become hazardous waste upon disposal. These wastes may include:

- Paints and solvents
- Petroleum products such as oils, fuels, and grease
- Herbicides and pesticides
- Acids for cleaning masonry
- Concrete curing compounds

In addition, sites with existing structures may contain wastes that must be disposed of in accordance with Federal, State, and local regulations. These wastes include:

- Sandblasting grit mixed with lead-, cadmium-, or chromium-based paints;
- Asbestos; and
- PCBs (particularly in older transformers).

The following steps will help reduce storm water pollution from hazardous wastes:

Material Use

- Use the entire product before disposing of the container.
- Do not remove the original product label, it contains important safety and disposal information.
- Do not over-apply herbicides and pesticides. Prepare only the amount needed. Follow the recommended usage instruction. Over-application is expensive and environmentally harmful. Apply surface dressings in several smaller applications, as opposed to one large application, to allow time for infiltration and to avoid excess material being carried off-site by runoff. Do not apply these chemicals just before it rains. People applying pesticides must be certified in accordance with Federal and State regulations
- Do not clean brushes or rinse paint containers into the dirt, street, gutter, storm drain, or stream. "Paint out" brushes as much as possible. Rinse water-based paints to the sanitary sewer. Filter and re-use thinners and solvents. Dispose of excess oil-based paint and sludge as hazardous waste.

Waste Recycling/Disposal

- Select designated hazardous waste collection areas on-site.
- Hazardous materials and wastes should be stored in covered containers and protected from vandalism.
- Place hazardous waste containers in secondary containment.
- Do not mix wastes. This can cause chemical reactions, make recycling impossible, and complicate disposal.
- Recycle material such as used oil or water-based paint.
- Make sure that toxic liquid wastes (used oils, solvents, and paints) and chemicals (acids, pesticides, additives, curing compounds) are not disposed of in dumpsters designated for construction debris.
- Arrange for regular waste collection before containers overflow.
- Make sure that hazardous waste (e.g. excess oil-based paint and sludge) is collected, removed, and disposed of only at an authorized disposal area.
- For a quick reference on disposal alternatives for specific wastes, see Table 4-1.

Training

- Train employees and subcontractors in proper hazardous waste management.
- Warning signs should be placed in areas recently treated with chemical.
- Place a stockpile of spill cleanup materials where it will be readily accessible.
- If a container does spill, clean up immediately.

4.2.9 - BMP 9: Contaminated Soil Management

Description

Prevent or reduce the discharge of pollutants to storm water from contaminated soil and highly acidic or alkaline soils by conducting pre-construction surveys, inspecting excavations regularly, and remediating contaminated soil promptly.

Approach

Contaminated soils may occur on your site for several reasons including:

- Past site uses and activities;
- Detected or undetected spills and leaks; and
- Acid alkaline solutions from exposed soil or rock formations high in acid or alkaline forming elements.

Most developers conduct pre-construction environmental assessments as a matter of routine. Recent court rulings holding contractors liable for cleanup costs when they unknowingly move contaminated soil highlight the need for contractors to confirm that a site assessment is complete before earth moving begins.

The following steps will help reduce storm water pollution for contaminated soil:

- Conduct thorough site planning including pre-construction geologic surveys.
- Look for contaminated soil as evidenced by discoloration, odors, differences in soil properties, abandoned underground tanks or pipes, or buried debris.
- Prevent leaks and spills to the maximum extent practicable. Contaminated soil can be expensive to treat and/or dispose of properly. However, addressing the problem before construction is much less expensive than after the structures are in place.
- Test suspected soils at a certified laboratory.
- If the soil is contaminated, work with the local regulatory agencies to develop options for treatment and/or disposal.
- For a quick reference on disposal alternatives for specific wastes, see Table 4-1.

4.2.10 - BMP 10: Concrete Waste Management

Description

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

Approach

The following steps will help reduce storm water pollution form concrete wastes:

- Store dry and wet materials under cover, away from drainage areas.
- Avoid mixing excess amount 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.
- Do not allow excess concrete to be dumped on-site, except in designated areas.
- For on-site washout:

  Locate washout area at least 50 feet from storm drains, open ditches, or water bodies. Do not allow runoff from this area by constructing a temporary pit or bermed area large enough for liquid and solid waste;

  Wash out wastes into the temporary pit where the concrete can be set, be broken up, and then disposed of properly.

- When washing concrete to remove fine particles and expose the aggregate, avoid creating runoff by draining the water to a bermed or level area.
- Do not wash 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.
- For a quick reference on disposal alternatives for specific wastes, see Table 4-1.

4.2.11 - BMP 11: Vehicle and Equipment Cleaning

Description

Prevent or reduce the discharge of pollutants to storm water from vehicles and equipment by using off-site facilities, washing in designated, contained areas only, eliminating discharges to the storm drain by infiltrating or recycling the wash water, and/or training employees and subcontractors.

Approach

- Use off-site commercial washing business as much as possible. Washing vehicles and equipment outdoors or in areas where wash water flows onto paved surfaces or into drainage pathways can pollute storm water. If you wash a large number of vehicles or pieces of equipment, consider conducting this work at an off-site commercial business. These businesses are better equipped to handle and dispose of the wash waters properly. Performing this work off-site can also be economical by eliminating the need for a separate washing operation at your site.
- If washing must occur on-site, use designated bermed wash areas to prevent wash water contact with storm water, creeks, rivers, and other water bodies. The wash area can be sloped for wash water collection and subsequent infiltration into the ground.
- Use as little water as possible to avoid having to install erosion and sediment control for the wash area.
- Use phosphate-free, biodegradable soaps.
- Educate employees and subcontractors on pollution prevention measures.
- Do not permit steam cleaning on-site. Steam cleaning can generate significant pollutant concentrations.
- For a quick reference on disposal alternatives for specific wastes, see Table 4-1.

4.2.12 - BMP 12: Vehicle and Equipment Fueling

Description

Prevent fuel spills and leaks, and reduce their impacts to storm water by using off-site facilities, fueling in designated areas only, enclosing or covering stored fuel, implementing spill controls, and training employees and subcontractors.

Approach

- Use off-site fueling stations as much as possible. Fueling vehicles and equipment outdoors or in areas where fuel may spill/leak onto paved surfaces or into drainage pathways can pollute storm water. If you fuel a large number of vehicles or pieces of equipment, consider using an off-site fueling station. These businesses are better equipped to handle fuel and spills properly. Performing this work off-site can also be economical by eliminating the need for a separate fueling area at your site.
- If fueling must occur on-site, use designated areas, located away from drainage.
- Discourage "topping-off" of fuel tanks.
- Always use secondary containment, such as a drain pan or drop cloth, when fueling to catch spills/leaks.
- Place a stockpile of spill cleanup materials where it will be readily accessible.
- Use adsorbent on small spills rather than hosing down or burying the spill. Remove the adsorbent materials promptly and dispose of properly.
- Carry out all Federal and State requirements regarding stationary above-ground storage tanks.
- Avoid mobile fueling of mobile construction equipment around the site; rather, transport the equipment to designated fueling areas. With the exception of tracked equipment such as bulldozers and perhaps forklifts, most vehicles should be able to travel to a designated area with little lost time.
- Train employees and subcontractors in proper fueling and cleanup procedures.
- For a quick reference on disposal alternatives for specific wastes, see Table 4-1.

4.2.13 - BMP 13: Vehicle and Equipment Maintenance

Description

Prevent or reduce the discharge of pollutants to storm water from vehicle and equipment maintenance by running a "dry site". This involves using off-site facilities, performing work in designated areas only, providing cover for materials stored outside, checking for leaks and spills, containing and cleaning up spills immediately, and training employees and subcontractors.

Approach

- Keep vehicles and equipment clean; don't allow excessive build-up of oil and grease.
- Use off-site repair shops as much as possible. Maintaining vehicles and equipment outdoors or in areas where vehicles or equipment fluids may spill or leak into the ground can pollute storm water. If you maintain a large number of vehicles or pieces of equipment, consider using an off-site repair shop. These businesses are better equipped to handle vehicle fluids and spills properly. Performing this work off-site can also be economical by eliminating the need for a separate maintenance area.
- If maintenance must occur on-site, use designated areas, located away from drainage courses, to prevent the run-on of storm water and the runoff of spills.
- Always use secondary containment, such as a drain pan or drop cloth, to catch sills or leaks when removing or changing fluids.
- Place a stockpile of spill cleanup materials where it will be readily accessible.
- Use adsorbent materials on small spills rather than hosing down or burying the spill. Remove the adsorbent materials promptly and dispose of properly.
- Regularly inspect on-site vehicles and equipment for leaks, and repair immediately.
- Check incoming vehicles and equipment (including delivery trucks and employee and subcontractor vehicles) for leaking oil and fluids. Do not allow leaking vehicles or equipment on-site.
- Segregate and recycle wastes, such as greases, used oil or oil filters, antifreeze, cleaning solutions, automotive batteries, hydraulic, and transmissions fluids.
- Train employees and subcontractors in proper maintenance and spill cleanup procedures.
- For a quick reference on disposal alternatives for specific wastes, see Table 4-1.

4.2.14 - BMP 14: Employee and Subcontractor Training

Description

Employee/subcontractor training, like maintenance or a piece of equipment, is not so much a best management practice as it is a method by which to implement BMPs. This fact sheet highlights the importance of training and of integrating the elements of employee/subcontractor training from the individual source controls into a comprehensive training program as part of the Erosion and Sediment Control Plan (ESCP).

The specific employee/subcontractor training aspects of each of the source controls are highlighted in the individual fact sheets. The focus of this fact sheet is more general, and includes the overall objectives and approach for assuring employee/subcontractor training in storm water pollution prevention. Accordingly, the organization of this fact sheet differs from the other fact sheets in the chapter.

Objectives

Employee/subcontractor training should be based on four objectives:

- Promote a clear identification and understanding of the problem, including activities with the potential to pollute storm water;
- Identify solutions (BMPs);
- Promote employee/subcontractor ownership of the problems and the solutions; and
- Integrate employee/subcontractor feedback into training and BMP implementation.

Approach

- Integrate training regarding storm water quality management with existing training programs that may be required by other regulations, the Hazardous Waste Operations and Emergency Response standard (29CFT 1910.120), the Spill Prevention Control and Countermeasure Plan (40CFR 112).
- Train employees/subcontractors in standard operating procedures and spill cleanup techniques described in the Pollution Control Plan. Employee/subcontractors trained in spill containment and cleanup should be present during the loading/unloading and handling of materials.
- Personnel who use pesticides should be trained in their use.
- Educating off-site contractors and subcontractors supports the efforts of well-trained employees.
- Consider posting the quick reference table around the job site or in the on-site office trailer to reinforce training.
- Train employees/subcontractors in standard operating procedures and spill cleanup techniques described in the fact sheets. Employees/subcontractors trained in spill containment and cleanup should be present during the loading/unloading and handling of materials.
- Personnel who use pesticides should be trained in their use. The Oregon Department of Pesticide Regulation and county agricultural commissioner's license pesticide dealers, certify pesticide applicators, and conduct on-site inspections.
- Proper education of off-site contractors is often overlooked. The conscientious efforts of well-trained employee/subcontractors can be lost by unknowing off-site contractors, so make sure they are well informed about what they are expected to do on-site.

REFERENCES

Blueprint for a Clean Bay-Construction-Related Industries: Best Management Practices for Storm Water Pollution Prevention; Santa Clara Valley Nonpoint Source Pollution Control Program, 1992

Storm Water management for Construction Activities, Developing Pollution Prevention Plans and Best Management Practices, EPA 832-R-92005; USEPA, April 1992.

Hot-mix Asphalt Paving Handbook, U.S. Army Corps of Engineers, Ac 150/5370-14, Appendix July 1991

Best Management Practices and Erosion Control Manual for Construction Sites; Flood Control District of Maricopa County, AZ. September 1992

Coastal Nonpoint Pollution Control Program: Program Development and Approval Guidance, Working Group Working Paper; USEPA, April 1992

Processes, Procedures, and Methods to Control Pollution Resulting from all Construction Activity; USEPA, 430/0-73-007,1973.

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CHAPTER 5
MAINTENANCE AND INSPECTION

Erosion prevention and sediment control (EPSC) measures are required on all construction sites where ground disturbing activities are performed because such activities have the potential to impact natural systems that are deemed worthy of protection. An EPSC plan is required to be submitted for all construction sites, within the Corvallis city limits, where ground disturbing activity is performed. Inspection and Maintenance of EPSC measures throughout the life of the project is imperative to ensure their performance. Unless the measures are properly installed and maintained, there is a strong chance of failure during the construction period.

5.1 Erosion and Pollution Control Manager

The City of Corvallis has adopted and implemented a systematic inspection process where initial erosion control inspections must be performed

- prior to footing and foundation inspection for single family, duplex, and mobile home projects, and
- prior to issuance of an excavation and grading permit for multifamily, commercial, and all larger projects requiring a separate excavation and grading permit in accordance with the Oregon Structural Specialty Code Appendix Chapter 33.

Larger more complex construction sites such as: subdivisions, commercial, and street projects require ongoing, very detailed inspection and maintenance for longer periods of time. For that very reason alone, pre-construction meetings are required and should be scheduled prior to any clearing, grading, or utility activities. Equally important is who should attend. Along with the inspector and engineer, the contractors grading and utility superintendent should be present.

The owner of the site shall designate a competent person (EPCM), experienced in all aspects of construction as well as qualified in erosion and sediment control techniques. At a minimum the EPCM should have a thorough knowledge of the content of this manual. It is also recommended that the EPCM should have attended a class on erosion and sediment control materials and installation practices which are outlined in this manual. The EPCM shall be responsible for assuring the implementation of the EPSC plan and have the authority to immediately mobilize necessary personnel and equipment to correct and modify erosion prevention and sediment controls when required.

Duties of the EPCM include:

- Manage and insure proper implementation of the EPSC plan.
- During periods of active construction maintain the EPSC plan at the project site, available for review upon request.
- Accompany the City in a field review of the EPSC plan prior to the beginning of work.
- Inspect erosion and sediment controls on active construction sites weekly.
- Inspect erosion and sediment controls on inactive sites at least biweekly.
- Inspect erosion and sediment controls on both active and inactive sites at least daily during rainy periods where a minimum 0.5 inch of rain has fallen in a 24-hour period.
- Mobilize crews to make immediate repairs to the controls or install controls during working and non-working hours.
- Record measures taken to clean up significant amounts of sediment.
- Complete erosion control monitoring forms after each inspection.
- Maintain up to date EPSC plan throughout the life of the project.
- Prepare a contingency plan in preparation for emergencies and the rainy season.
- Accompany the City on inspections.

5.1.1 Ineffective Controls

The EPCM shall record measures to clean up significant amounts of sediment. Should a control measure not function effectively, one or more of the following tasks should be performed.

- Immediately repair the control.

- Replace the control.
- Provide additional controls.

5.2 Pre-Construction Meeting

The EPCM, contractor and inspector should carefully review the EPSC plan prior to the preconstruction meeting to understand what is required. Implementing the EPSC plan and assuring its performance may involve significant expense. The following preconstruction activities should be required.

- Prior to the pre-construction meeting, review and comment of the EPSC plan.
- During the pre-construction meeting, review all comments and concerns.
- Prohibit clearing and grading operations prior to EPSC plan approval and implementation.
- Tentatively locate construction accesses.
- Delineate clearing limits, drainage courses, easements, setbacks, wetlands, and other sensitive areas and their buffers.

The pre-construction meeting provides an opportunity for the contractor to discuss the plan with the inspector and learn which elements of the EPSC plan deserve the most attention. Adjustments to improve performance or make installation easier and maintenance more reliable may also be discussed.

The pre-construction meeting is also an opportunity to discuss the inspection schedule and procedures. Key points to consider in the pre-construction meeting are:

- Pollution Control Plan for contractor operations.
- Qualifications of individuals designated as competent person for EPSC plan.
- Method to be used to document the up-to-date EPSC plan.
- Adjacent areas that need special protection from sedimentation, particularly environmentally sensitive areas such as wetlands, stream crossings, channel, and water disposal outlets.
- Location of erosion and sediment control practices and their implementation.
- Sequence of installation with respect to the construction schedule.
- Surface stabilization plans, temporary and permanent seeding.
- Construction schedule and any anticipated shutdown periods.
- Maintenance plans and the contractor's procedure for monitoring performance.
- Location of all borrow and disposal areas.
- Emergency or contingency plans.
- Any special requirements identified in permits.
- Monitoring form used and availability.
- Biological Assessment – this report comes from the consultant and cover special needs and concerns for threatened and endangered species on the project, the contractor should be aware of its contents.

5.2.1 Modified EPSC Plan

All projects will include an EPSC plan. This plan is a guide and ideally should have addressed all erosion problems for the project adequately. However, the EPSC plan should not be followed blindly. It is the owner or EPCM responsibility to propose modifications to the plan.

In addition, effective erosion control is closely tied to a contractor's staging, operation methods and construction timing. When the EPSC plan is developed the contractor's staging and operation methods are unknown. Therefore, it is expected that changes to the EPSC plan be updated throughout the life of the project. As modifications to the EPSC plan take place, it is extremely important to secure the interest of all parties. Communications between the contractor, designated person and inspector is vital.

Depending upon the level of modification, the design engineer should be consulted and changes to the EPSC plan should be submitted to the City. Regardless of the magnitude, a contingency plan must be implemented immediately. Minor modifications to the EPSC plan such as installing small sections of sediment control barriers, can be field adjusted and hand written on the plans.

5.2.2 Construction Schedule Review

The implementation of the construction schedule should include the following.

- Timing of activities to limit seasonal and weather impacts.
- Timing of wet season work and temporary work shut down.
- Time of activities to meet "in-water" work restrictions.
- Erosion prevention and sediment controls shown on the plans should be installed before ground-disturbing activities begin.
- Permanent facilities, such as sediment traps and basins, which will be used during construction as temporary measures should be installed.
- Retention of temporary perimeter controls until all upstream areas are finally stabilized.
- Timing of seeding operations.

5.2.3 Monitoring Form

On all development sites inspections are to be recorded on the Erosion Control Monitoring Form (Appendix D). The effectiveness of each BMP at every location on site should be documented on the form, and general observations on site conditions should also be recorded. Information provided on the form is useful for tracking repairs and demonstrating permit compliance. It is noteworthy that in the event of permit violations or subsequent enforcement actions, the information recorded on the form, along with photographs and videos, may be used to evaluate the responsibility of involved parties.

5.3 Materials

The purpose of this manual to provide cost effective, environmentally sensitive management of erosion. This manual illustrates materials that have been approved based on geographical controls such as, climate and soil type. Materials not listed in this manual may be approved based on equal to or greater then criteria. Specific questions regarding materials can be answered by calling (541) 766-6929.

5.4 Installation

It must be understood that installation is equally important to the value and success of the materials. If installed incorrectly, even the best materials will fail causing more damage and additional expense to the project. For this reason alone, installation procedures should be followed very closely.

Installation of all base measures should be inspected and any deficiencies corrected prior to the start of ground disturbing activities. Subsequent inspections of any additional installations should also be made throughout the life of the project as needed.

The inspector, contractor and EPCM should be familiar with installations details for each BMP used on the project. Details for the installation of all specified BMP's should be provided in the EPSC plan. Installation details for BMP's are also provided in Chapter 3 of this manual.

5.5 Inspection Requirements

The owner or designated person (EPCM) shall be required to provide ongoing inspection of erosion and sediment control measures throughout the life of the project. Inspections shall be recorded on an approved monitoring form.
Minimum inspection requirements shall be as follows.

- Once per week on active sites
- Once every two weeks on in-active sites
- Within 24 hours following a 0.5 inch rain event

5.5.1 Inspection of Work Restriction Areas

All construction projects are required to restrict certain types of work, which may contribute to sediment-laden water leaving the project boundaries or entering waterways. The following work restrictions need to be inspected prior to the start of work and throughout the life of the project.

1) Flag Clearing Limits: Construction site clearing limits will be clearly flagged in accordance with the approved plans. No ground disturbance is permitted beyond the flagged boundary. Flagging should be maintained for the duration of construction.
2) Perimeter Controls before Grubbing: all appropriate perimeter controls should be installed prior to any major site grubbing operation. Perimeter controls include interceptor ditches, berms, infill areas, and sediment fences along the banks of existing streams and toes of slopes.
3) Wet Season Plan and Schedule: Prior to wet season construction work and before temporary work suspension for winter, the contractor, or designated person should meet with the City to review and update the EPSC plan and to develop a schedule to assure that appropriate controls are implemented and maintained during the wet season work and suspended periods.
4) Limit Disturbed Areas: If soil erosion and sediment resulting from construction activities is not effectively controlled, the City will limit the amount of disturbed areas that can be effectively controlled.
5) Install BMP's Early: Erosion and sediment control features should be incorporated into the projects at the earliest practicable time. All erosion and sediment control measures should be installed according to the approved implementation schedule and with these specifications.
6) Stop Work: Failure to control erosion and or pollution shall be cause for the City to stop all construction work until measures have been taken to bring all construction into compliance with these specifications.

5.6 Stabilization Requirements

All soils that are exposed and disturbed by construction-related activities should be stabilized according to the following time frames.

- All seeding applications must be completed prior to September 1st
- Wet weather season – October 1st through April 30th
- Soils exposed during wet weather season as a result of construction must be covered at the end of each day

5.7 Erosion Control Contingency Items

It is a requirement that all construction sites have materials on hand as a contingency in the event of a failure or when required to shore up BMP's installed as part of the EPSC plan. The contingency items may also be used at the discretion of the project inspector to strengthen the erosion control measures as needed during construction. At a minimum, the following materials should be kept on the project site for use in emergencies.

Single Family, Duplex, and Mobile Home Projects	Multifamily, Commercial, and Other Large Projects
24 ft of sediment fence	100 ft of sediment fence
250 sq. ft. or plastic sheeting	500 sq. ft. or plastic sheeting
100 ft of rope	1,000 ft of rope
10 empty sand bags (to be filled as needed)	50 empty sand bags (to be filled as needed)
2 bales of straw (used for ground cover)	10 bales of straw (used for ground cover)
4 bio-filter bags with stakes	10 bio-filter bags with stakes

5.8 Maintenance

Erosion and sediment controls must be maintained in good working order at all times in order to function as intended. These controls must be maintained in place until the City issues notification of acceptance of permanent stabilization.

Typical maintenance activities, guidelines and failure modes for BMP's are discussed in Chapter 3 of this manual. The inspector should be familiar with maintenance requirements for each BMP used on the project. It is noteworthy that maintenance activities and frequencies vary among the different BMP's and will depend largely on weather and other site conditions. In general, the more effective erosion prevention measures are, the less maintenance will be required for sediment controls.

5.8.1 Sediment Removal

Sediment shall be removed and the controls upgraded or repaired as outlined in Chapter 3 BMP maintenance, or as directed. In the event of continuous rainfall over a 24-hour period, or other circumstances that preclude equipment operation in that area, additional sediment control shall be hand-carried and installed in accordance with best management practices and as approved by the City. Sediment shall be removed from controls such as sediment fences, sediment barriers, check dams, inlet protection, and sediment traps when the sediment buildup has reached 1/3 the exposed height of the control or storage depth. Rock filters and filter berm material shall be replaced with new rock material when sediment reduces the filtering capacity by 50 percent. Rock or other material specified shall be added or removed as needed to maintain proper function of the entrance areas. All paved areas shall be kept clean (by mechanical means) for the duration of the project.

5.8.2 Sediment Disposal

Removed sediment shall be placed in a non-erodible area within the construction site, or removed and disposed of off site in accordance with all federal, state, and local laws and ordinances. Sediment-laden water shall not be flushed into the storm water system.

5.9 Inspector Checklist

The Inspector Checklist included in Appendix D will be used by City representatives when inspecting erosion and sediment controls on a project site. The checklist is intended to summarize the key elements of a successful erosion and sediment control program. Topics on the checklist include:

- Schedule Review
- Erosion and Sediment Control Plan
- Erosion and Pollution Control Manager
- Sensitive Areas
- Contingency Plans
- Materials On-Hand
- Maintenance
- Monitoring Forms
- Slope Protection and Stabilization
- Plan Revisions and Modifications
- BMP Evaluation
- Additional Items

5.9.1 Winterization

The wet weather period is October 1 through April 30. Prior to wet weather period work and before temporary work suspension for winter, the contractor should meet with the City to review and update the EPSC plan and to develop a schedule to assure that appropriate controls are implemented and maintained during wet season and work suspension periods. Winter preparations should begin in August.

5.9.2 Designer/Inspector Tool Box

Several worksheets are provided in Appendix D to aid designers and inspectors in determining and verifying the quality and quantity of various erosion control items. These are especially useful when verifying the application rates of various mulch and hydraulically applied products. Appendix D includes the following.

- Slope Inclination Conversions
- Metric Conversions Table
- Straw Mulch Application Worksheet
- Hydraulic Application Equations
- Wood Fiber Mulch Hydraulic Application Worksheet
- Seed / Fertilizer Hydraulic Application Worksheet
- Hydraulic Application Example Problems

Appendix A

Sample EPSC Plans

EROSION PREVENTION AND SEDIMENT CONTROL PLAN SUBMITTAL REQUIREMENTS

Submittal requirements for EPSC permits and EPSC plans for various types of construction projects are presented below. This information will provide the necessary tools to gain City approval and reduce overall environmental risks.

Sites meeting the following conditions can be characterized as **minor ground disturbances**:

1) Individual single family home and duplex construction on existing lots of record
2) Manufactured home placement on individual lots or in manufactured home parks
3) Ground disturbing activities cumulatively affecting less than 1 acre throughout the duration of the project and meeting the following conditions:

   (a) Average slopes throughout the disturbed area do not exceed 10% and
   (b) Slopes within the disturbed area do not exceed 6 feet in height at slopes greater than 3:1 (horizontal:vertical) and
   (c) Concentrated runoff conveyed through the site does not originate from more than 1 acre off-site (outside of disturbed area) and
   (d) There are no sensitive areas (wetlands, streams, etc.) located on or adjacent the sitework.

All other construction sites that exceed the above conditions are defined as **major ground disturbances.**

MINOR GROUND DISTURBANCES INCLUDING SINGLE FAMILY HOMES AND DUPLEXES

Sites meeting the minor ground disturbance criteria have the following submittal and construction period erosion control requirements.

Table 3-2 of the City of Corvallis Erosion Preservation and Sediment Control Manual designates the minimum erosion control BMPs for minor ground disturbances. Each erosion control BMP presented in the table is presented in further detail with design, construction and maintenance criteria in Chapter 3.

Submit the following information with the application for permit:

1. Plans, drawn to scale, showing the following:
   a. If there is less than a 4-foot elevation differential across the site, property corner, structure corner and finish floor elevations
   b. If there is more than a 4-foot elevation differential across the site, existing and proposed contour lines with elevations to show slope and/or retaining walls
   c. All areas of ground disturbance on the site, including areas that will be cleared, graded or excavated
   d. Location for storage and ultimate demise of soils and/or wastes
   e. Gravel construction entrance
   f. Property lines and distances to buildings.
   g. Placement of erosion control devices (e.g. silt fences).
   h. Location and depth of drainage systems during and after construction (e.g. ditches, roof and foundation drains)
   i. An Undisturbed Corridor Buffer is required adjacent to sensitive areas (Note: Sensitive areas include wetlands, rivers, streams, creeks, lakes, and ponds) Depending on several factors, the range is from 25 feet to 200 feet wide
   j. Location and width of all storm drain and sanitary sewer utilities and easements
   k. Location of the 100-year flood plain and 0.2 foot floodway, if applicable

2. Additional requirements for non-single family residences

   a. Site restoration plan (permanent landscaping)

b. Water quality facilities (consult City of Corvallis Design Criteria Manual)
c. Detention facilities (consult City of Corvallis Design Criteria Manual)

3. A construction schedule outlining (see form Appendix C):

   a. Expected date by which EP&SC measures will be in place
   b. Expected date that ground disturbing activities will commence
   c. Expected date that construction will be completed
   d. Expected date that permanent ground cover will be in place

4. A signed statement indicating that the applicant will construct and maintain EPSC measures as required by the City (see form Appendix C).

MAJOR GROUND DISTURBING ACTIVITIES

Tables 3-3 and 3-4 of the City of Corvallis Erosion Preservation and Sediment Control Manual designate the minimum erosion control BMPs for major ground disturbances. Each erosion control BMP presented in the table is presented in further detail with design, construction and maintenance criteria in Chapter 3.

Submit with construction plans for subdivision approval, grading, building, or erosion control permit the following information:

1. Completed Erosion Control Permit Application form from Appendix C.
2. A copy of the completed NPDES 1200-C permit application package submitted to ODEQ
3. Construction schedule with the following information:
   1. Construction start and completion dates.
   2. Dates when erosion control measures will be in place.
   3. Timing of site clearing and grading, placement of fills and excavations.
   4. Projected date of removal of erosion control measures (after landscaping is established or after establishment of a healthy grass stand or other approved vegetation).
4. Submit also with construction plans three (3) sets of erosion control site plan drawings, drawn to scale, showing:
   1. Vicinity map, property address, and property owner's name and address.
   2. Locations, types and applicable dimensions of erosion control measures.
   3. Applicable details of erosion control measures showing full dimensions and construction information.
   4. Existing and proposed ground contours, including a minimum of the first 50 feet of abutting property.
   5. Locations and sizes of existing and proposed channels and drainage pipes (labeled as such and with arrows indicating flow direction) on and immediately upstream and downstream of the site.
   6. Site entrances/exits (as approved by the City).
   7. Applicable standard erosion control notes from Appendix B, with additions or changes as required.
   8. Other notes including references to timing of placement and removal of erosion control measures, and erosion measure specifications such that types and quantities of materials necessary for the installation of the erosion control measures are fully detailed.
   9. Stamped or signed by a Certified Professional for projects that disturb 1 acre or more of ground surface.

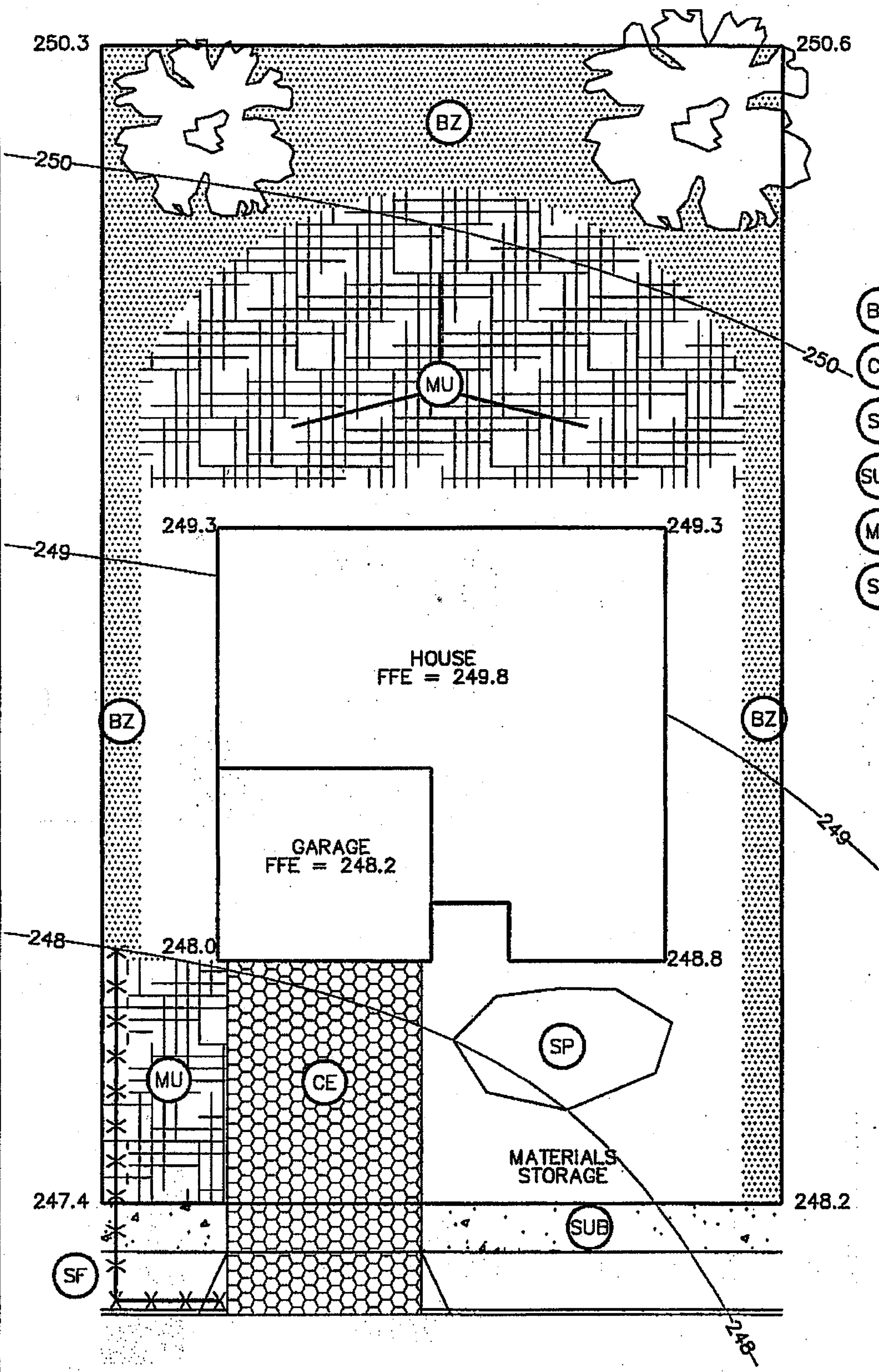
If the site erosion control plan includes sediment traps or ponds, the applicant shall also submit calculations used for determining trap or pond sizing and pipe orifice sizing.

Because of particular site conditions or preferences, the applicant may desire in certain cases to use different erosion control measures than those recommended in Tables 3-2 or 3-3. In such cases, the applicant must submit calculations or other supporting information used to determine the sizing and layout of the measures shown on the submitted erosion control plan.

Cumulative ground disturbing activity, in excess of one acre, requires a NPDES #1200-C storm water general permit issued by the Department of Environmental Quality (DEQ). As indicated above, a copy of the NPDES #1200-C application is required to be submitted to the City of Corvallis.

If the facilities and techniques approved in an EPSC Plan are not effective or sufficient, the applicant shall:

- Take immediate action to stop sediment from leaving the site.
- Immediately implement additional facilities and techniques as approved by the City Inspector.
- Prepare and submit a revised EPSC Plan for City approval.



BZ BUFFER ZONE – DO NOT DISTURB

CE GRAVEL CONSTRUCTION ENTRANCE

SF SEDIMENT FENCE (OR EQUIVALENT)

SUB SIDEWALK SUB–BASE

MU MULCH – ESTABLISH GRASS

SP SOIL STOCKPILE

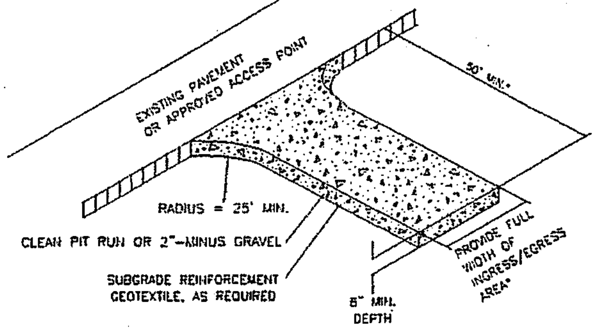
CONSTRUCTION NOTES

STABILIZED CONSTRUCTION ENTRANCE SHALL BE INSTALLED AS THE FIRST SITE ACTIVITY

ALL SOILS EXPOSED FOR MORE THAN 24 HRS. SHALL BE SEEDED AND MULCHED

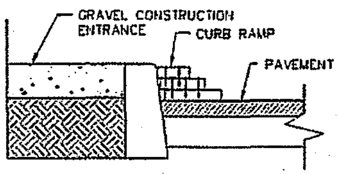
ALL BMPs SHALL BE INSPECTED AND MAINTAINED WEEKLY AND WITHIN 24 HRS. OF A STORM EVENT

SINGLE FAMILY RESIDENCE
TYPICAL EROSION PREVENTION AND SEDIMENT CONTROL PLAN

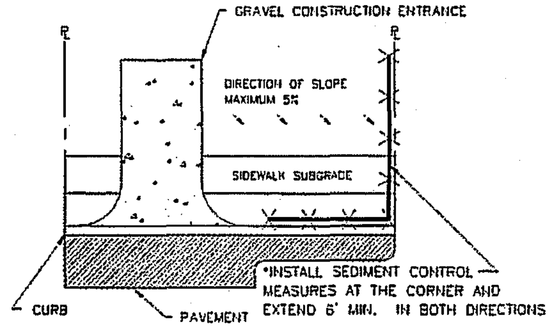


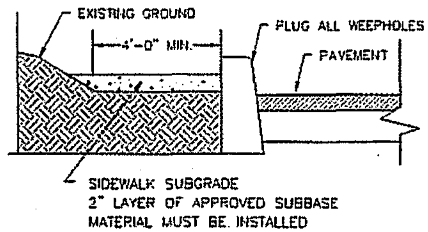
*20' MIN. FOR SINGLE FAMILY AND DUPLEX RESIDENTIAL

NOTES:
DIMENSIONS
SINGLE FAMILY
20' LONG BY 20' WIDE
8" DEEP OF ¾" MINUS CLEAN ROCK.
COMMERCIAL
50' LONG BY 20' WIDE
3-6" CLEAN ROCK.
GOVERNING AUTHORITY MAY REQUIRE GEOTEXTILE FABRIC TO PREVENT SUB-SOIL PUMPING.

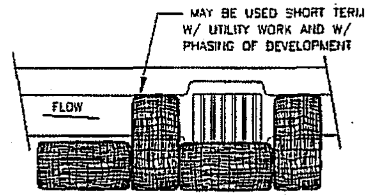


GRAVEL CONSTRUCTION ENTRANCE (BMP 3.2.1)

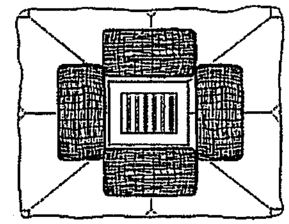




SIDEWALK SUBGRADE (BMP 3.3.7)

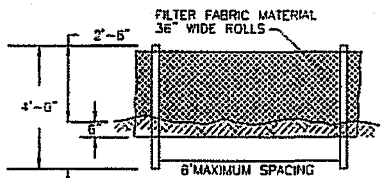


CATCH BASIN

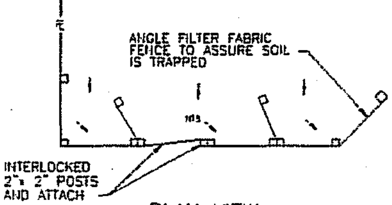


AREA DRAIN

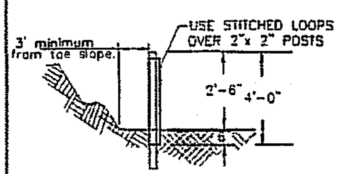
INLET PROTECTION (BMP 3.3.9d)



FRONT VIEW



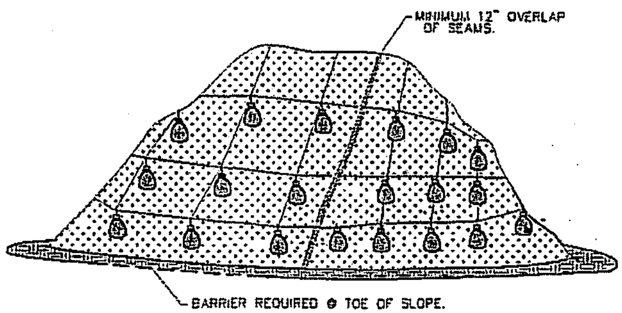
PLAN VIEW



PROFILE

NOTES:
1. BURY BOTTOM OF FILTER FABRIC 6" VERTICALLY BELOW FINISHED GRADE.
2. 2"x 2" FIR, PINE OR STEEL FENCE POSTS.
3. POSTS TO BE INSTALLED ON UPHILL SIDE OF SLOPE.
4. COMPACT BOTH SIDES OF FILTER FABRIC TRENCH.

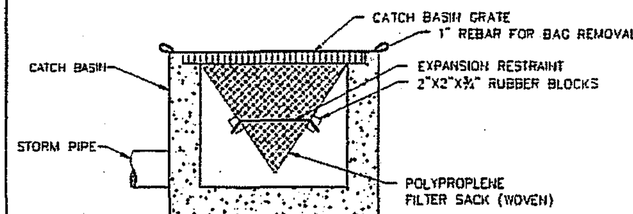
SEDIMENT FENCE (BMP 3.3.1)



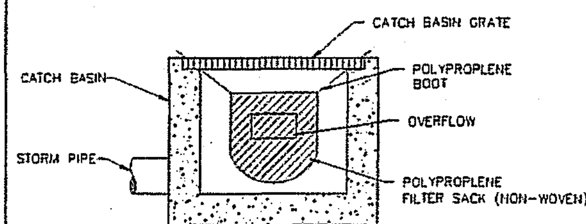
PLASTIC SHEETING

NOTES:
1. MINIMUM 12" OVERLAP OF ALL SEAMS REQUIRED.
2. BARRIER REQUIRED @ TOE OF STOCK PILE.
3. COVERING MAINTAINED TIGHTLY IN PLACE BY USING SANDBAGS OR TIRES ON ROPES WITH A MAXIMUM 10' GRID SPACING IN ALL DIRECTIONS.

PLASTIC SHEETING (BMP 3.18)



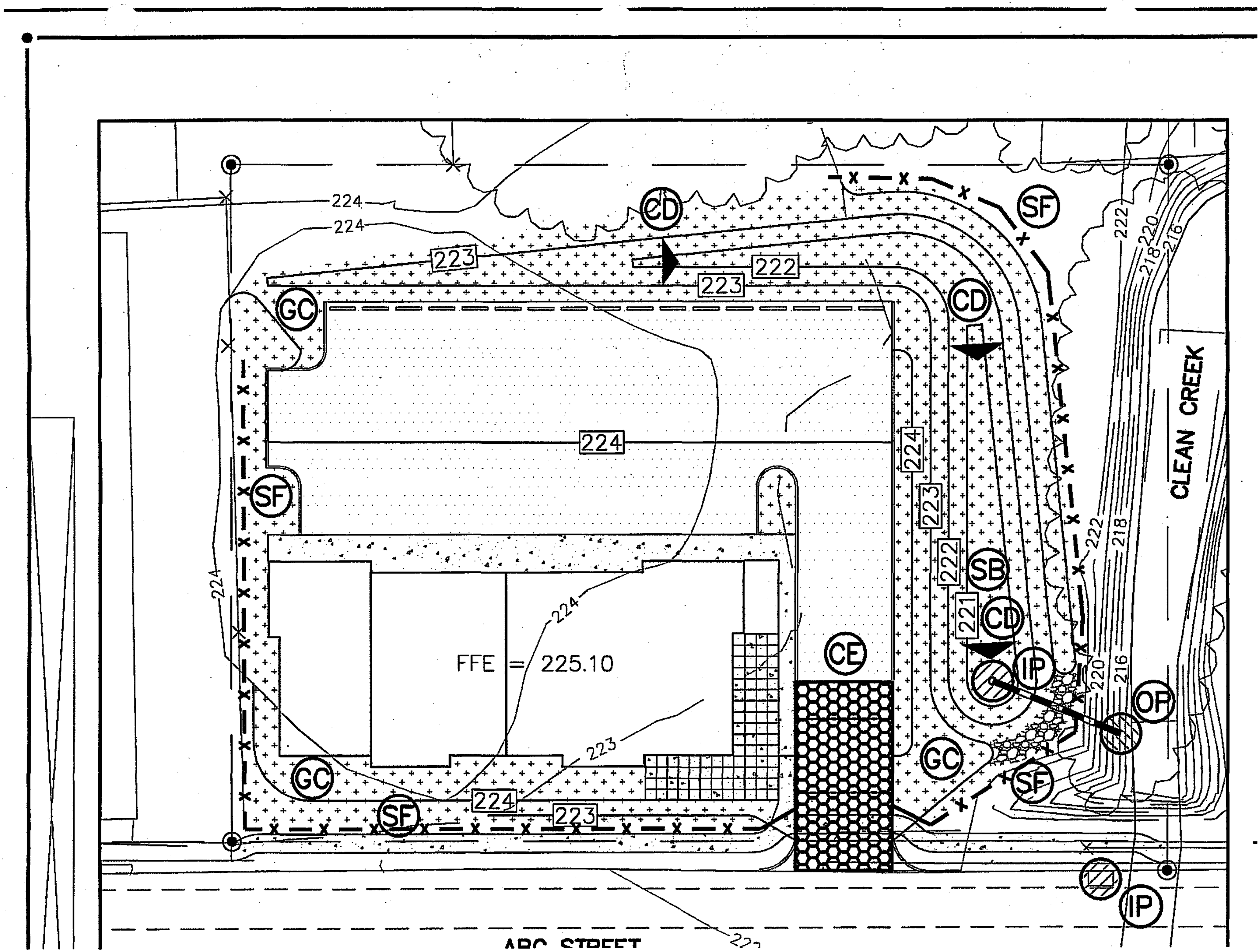
WOVEN POLYPROPLENE SACK

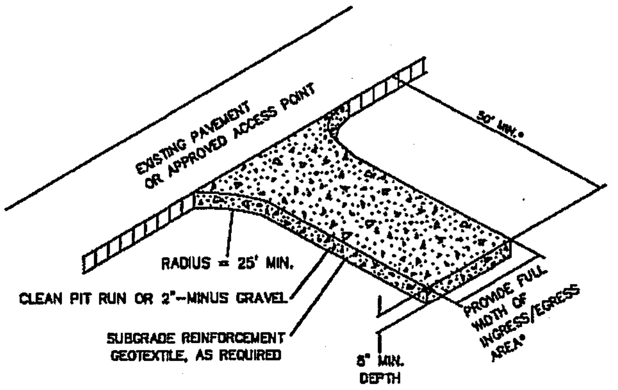


NON-WOVEN POLYPROPLENE SACK

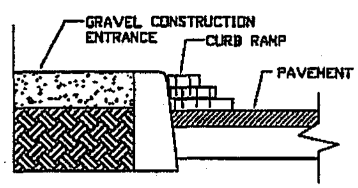
NOTE:
1. RECESSED CURB INLET CATCH BASINS MUST BE BLOCKED WHEN USING FILTER FABRIC INLET SACKS. SIZE OF FILTER FABRIC INLET SACKS TO BE DETERMINED BY MANUFACTURER.

INLET PROTECTION (BMP 3.3.9e)


CLEAN CREEK
FFE = 225.10
CD
SF
GC
SB
IP
OP
CE
224
223
222
221
220
218
216
ABC STREET

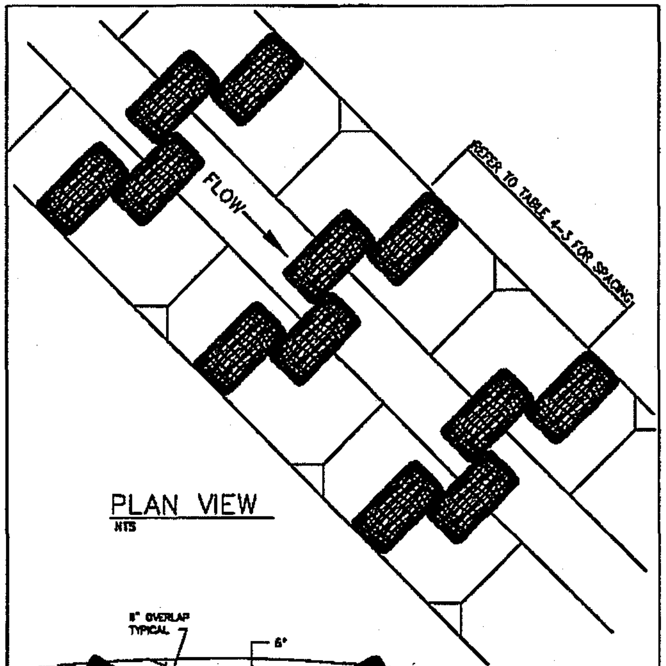


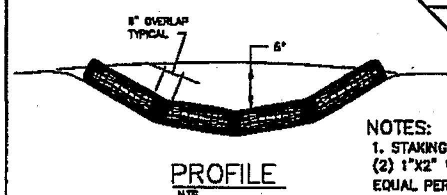
*20' MIN. FOR SINGLE FAMILY AND DUPLEX RESIDENTIAL



NOTES:
DIMENSIONS
SINGLE FAMILY
20' LONG BY 20' WIDE
8" DEEP OF $\frac{3}{4}$" MINUS CLEAN ROCK.
COMMERCIAL
50' LONG BY 20' WIDE
3-6" CLEAN ROCK.
GOVERNING AUTHORITY MAY REQUIRE GEOTEXTILE FABRIC TO PREVENT SUB-SOIL PUMPING.

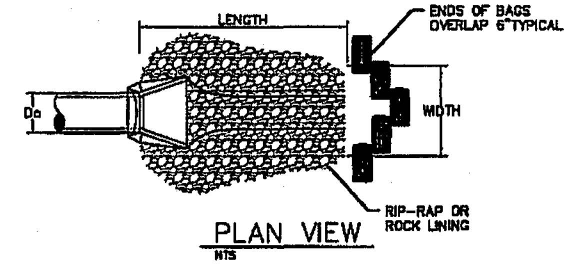
CONSTRUCTION ENTRANCE	Detail Drawing 3.2.1

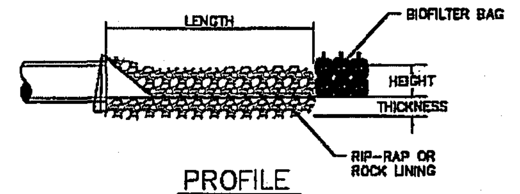




NOTES:
1. STAKING OF BAGS REQUIRED USING (2) 1"X2" WOOD STAKES OR APPROVED EQUAL PER BAG.
2. SURFACE MUST BE SMOOTH BEFORE APPLICATION.

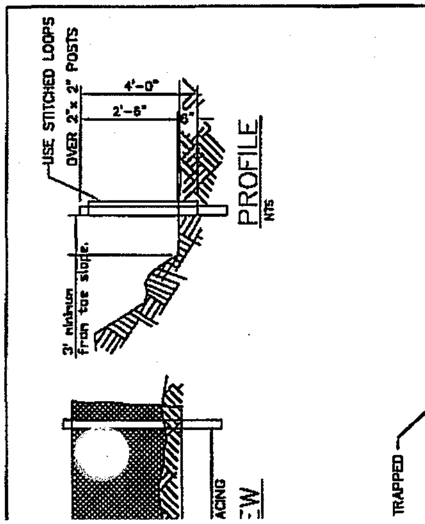
CHECK DAM BIO FILTER BAG	Detail Drawing 3.2.6b



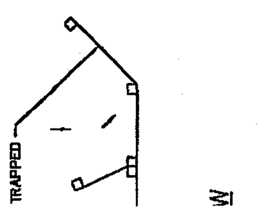


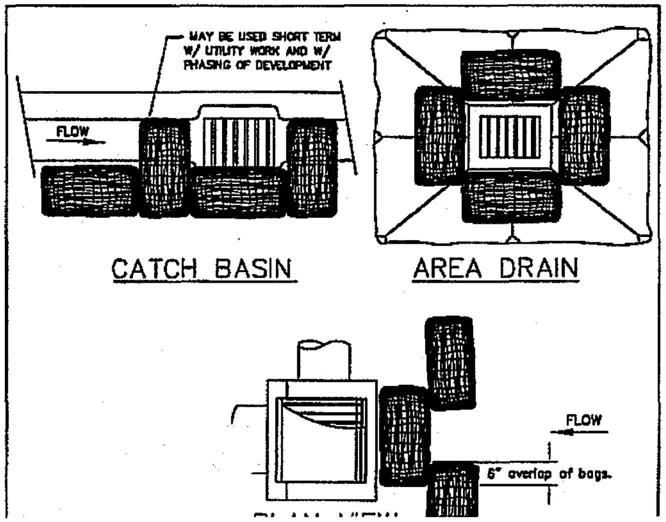
NOTE:
1. BIO BAGS ONLY REQUIRED WHEN DISCHARGING SEDIMENT LADEN WA
2. STAKING OF BAGS REQUIRED WITH EITHER METHOD USING (2) 1"x 2" WOOD STAKES OR APPROV EQUAL PER BAG.

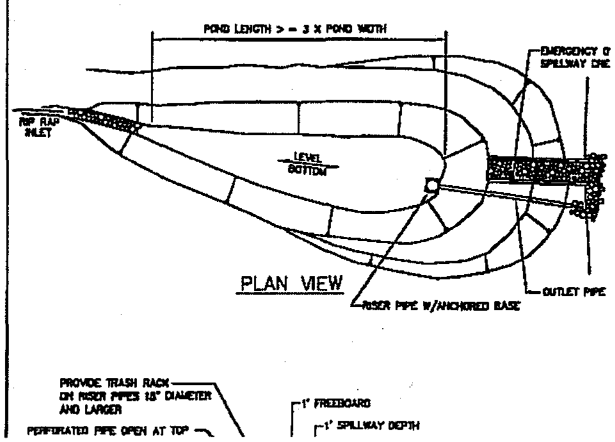
OUTLET PROTECTION	Detail Drawing 3.2.4



NOTES:
1. BURY BOTTOM OF FILTER FABRIC 6" VERTICALLY BELOW FINISHED GRADE.
2. 2"x 2" FIR, PINE OR STEEL FENCE POSTS.
3. POSTS TO BE INSTALLED ON UPHILL SIDE OF SLOPE.
4. COMPACT BOTH SIDES OF FILTER FABRIC TRENCH.
5. PANELS MUST BE PLACED ACCORDING TO SPACING TABLE 3-6.







EROSION CONTROL NOTES

1. Owner or designated person shall be responsible for proper installation and maintenance of all erosion and sediment control measures, in accordance with local, State, and Federal regulations.
2. The implementation of these ESC plans and construction, maintenance, replacement, and upgrading of these ESC facilities is the responsibility of the contractor until all construction is completed and approved by the local jurisdiction, and vegetation/landscaping is established. The developer shall be responsible for maintenance after the project is approved until the lots are sold.
3. The boundaries of the clearing limits shown on this plan shall be clearly marked in the field prior to construction. During the construction period, no disturbance beyond the clearing limits shall be permitted. The markings shall be maintained by the applicant/contractor for the duration of construction.
4. The ESC facilities shown on this plan must be constructed in conjunction with all clearing and grading activities, and in such a manner as to insure that sediment and sediment laden water does not enter the drainage system, roadways, or violate applicable water standards.
5. The ESC facilities shown on this plan are minimum requirements for anticipated site conditions. During construction period, these ESC facilities shall be upgraded as needed for unexpected storm events and to ensure that sediment and sediment laden water does not leave the site.
6. The ESC facilities shall be inspected daily by the applicant/contractor and maintained as necessary to ensure their continued functioning.
7. At no time shall sediment be allowed to accumulate more then 1/3 the barrier height. All catch basins and conveyance lines shall be cleaned prior to paving. The cleaning operations shall not flush sediment-laden water into the downstream system.
8. Stabilized gravel entrances shall be installed at the beginning of construction and maintained for the duration of the project. Additional measures may be required to insure that all paved areas are kept clean for the duration of the project.
9. Storm drain inlets, basins, and area drains shall be protected until pavement surfaces are completed and/or vegetation is re-established.
10. Pavement surfaces and vegetation are to be placed as rapidly as possible.
11. Seeding shall be performed no later than September 1 for each phase of construction.
12. If there are exposed soils or soils not fully established from October 1st through April 30th, the wet weather erosion prevention measures will be in effect. See the Erosion Prevention and Sediment Control Manual (Chapter 3) for requirements.
13. The developer shall remove ESC measures only after vegetation is fully established.

EPSC PLAN SYMBOLS

PS	PERMANENT SEEDING	CE	CONSTRUCTION ENTRANCE
TS	TEMPORARY SEEDING	TW	TIRE WASH
SO	SOD	TSD	TEMP. SLOPE DRAIN
PV	PRESERVE VEGETATION	OP	OUTLET PROTECTION
GC	GROUND COVER	SR	SURFACE ROUGHENING
BZ	BUFFER ZONE	CD	CHECK DAM
M	MATTING	DV	DIVERSION DIKE/SWALE
SDB	SAND BAG BARRIER	GLS	GRASS-LINED SWALE
BB	BIO-FILTER BAGS	SF	SEDIMENT FENCE
BB	BRUSH BARRIER	FB	FILTER BERM
ST	SEDIMENT TRAP	IP	INLET PROTECTION
SB	SEDIMENT BASIN	SS	SOIL STOCKPILE

Appendix C

EPSC Permit Application Form

FOR STAFF USE ONLY

CASE NUMBER____________________ DATE FILED ____________________

FEE ________________ RECEIPT NO.________________ CREDIT CARD ____________

APPLICATION FOR:

EXCAVATION & GRADING/ EROSION PREVENTION AND SEDIMENT CONTROL PERMIT

City of Corvallis
Development Services
501 SW Madison
P.O. Box 1083
Corvallis, OR 97339-1083
Telephone: (541) 766-6929
FAX: (541) 766-6936

CORVALLIS
ENHANCING COMMUNITY LIVABILITY

PLEASE TELL US ABOUT YOURSELF AND YOUR REQUEST:

PROJECT NAME____

PROJECT DESCRIPTION____________________________________

PROJECT ADDRESS OR MAP/TAX LOT NUMBER________________________

APPLICANT/ OWNER: NAME ________________________ PHONE ____________
ADDRESS____

GENERAL CONTRACTOR: NAME ________________________ PHONE ____________
ADDRESS ____

EXCAVATION CONTRACTOR: NAME ________________________ PHONE ____________
ADDRESS ____

24-HR CONTACT: NAME ________________________ PHONE ____________

PLEASE FILL IN ALL INFORMATION:

Total area to be disturbed __________________ square feet

Excavation Volume ________________ CY Fill Volume ________________ CY

Exporting soil? YES or NO If so, address of site____________________________

The project site contains or abuts: ☐ 100-yr. Floodplain ☐ Stream/Riparian Area ☐ Hydric Soils/Wetlands

Name of nearest stream, creek, river: ____________________________________

Dates when erosion control measures will be in place ____________________________

Date site clearing and grading, placement of fills and excavations will commence____________________

Date site clearing and grading, placement of fills and excavations will be completed__________________

Projected date of removal of erosion control measures (after grass or approved vegetation is established).____________

I agree to comply with the "Erosion Prevention and Sediment Control Manual" and will construct and maintain EPSC measures to contain Sediment on the construction site.

____________________________ ________________
Owner/Applicant Signature **Date**

Appendix D

Contractor/Inspector Resources

INSPECTOR CHECKLIST
FOR
EROSION CONTROL

SCHEDULE

- Have you looked at the Contractors Schedule and determined any conflicts?
- Install necessary Best Management Practices (BMF's) prior to any earthwork beginning. Are earthwork operations being performed in October with soils that are highly erosive? Grubbing of areas that will be worked on much later should be delayed Staging of project may require staging of erosion control measures Is seeding scheduled before the end of the seed dates?
- Is there work in sensitive areas that may alter contractor's schedule?
- When will the contractor remove BMP's? Don't remove until seeded slopes are established.

EROSION AND SEDIMENT CONTROL PLAN (ESCP)

- Walk project during preliminary or advanced plan review and look for potential erosion problems
- Have you reviewed the Contractor's Erosion Control Plan to determine if it is adequate or makes sense? The ESCP included in the bid package may need modifications to address site conditions or staging
- Walk project with ESCM prior to any earthwork looking for needed modifications of ESCP Is the ESCP being kept up-to-date? Is the ESCP kept on-site? Where?
- What is contractor's erosion control plan for offsite borrow sources and waste areas?

EROSION AND SEDIMENT CONTROL MANAGER (ESCM)

- Have you met and talked with the person identified as the ESCM?
- Do you believe this person has adequate knowledge to perform this work?
- Does this person understand all the required duties of the ESCM?
- Does this person have the authority to direct resources and make changes in an emergency situation?

SENSITIVE AREAS

- Are there sensitive areas, which require "extra" attention?
- Have they been adequately addressed on the ESCP?
- Will these sensitive areas require more monitoring?

CONTINGENCY PLAN

- Is there a contingency plan for unexpected events?
- What is the plan for stabilization of earthwork perfonned after seeding dates?

MATERIALS ON-HAND

- It may be difficult to get Erosion Control materials in the middle of the wet season. It is easier to deal with erosion before it happens rather than after.
- Does the Contractor have adequate materials on hand to cover each phase of work they plan on performing?
- Are installed erosion and sediment controls in good working order?
- Are catch basins cleaned out when more than 6 inches of sediment depth accumulates?
- Are sediment fences, barriers, check dams, inlet protection cleaned out when sediment reaches 1/3 of the storage depth?
- Are construction entrances maintained with fresh rock to prevent tracking of sediment onto pavement?

MONITORING FORMS

- Are you getting Erosion Control Weekly reports as often as they should be filed from the ESCM?
- Are the forms complete and adequately represent site conditions and work performed?
- Are forms on-site with the "Up-to-Date Plan"?

SLOPE PROTECTION & STABILIZATION

- Permanently finish slopes from top down and seed as you go! Track walk slopes to provide loosened soil and hold seed
- Temporarily stabilize unfinished earthwork scheduled for re-disturbance at a later date (i.e. straw mulch, chemical soil stabilizers, plastic sheeting, matting, etc.)

PLANS ARE ONLY GUIDE

What's best for your project is what works on your project. No designer can sit in an office and determine what works on your project. It may require trial and error. The plans are a toolbox with available tools. You may have to create and modify these tools to satisfy the conditions

IT'S NOT WORKING!!!

- Are the BMP' s working?
- If not, are the facilities attempting to prevent erosion before it starts?

ADDITIONAL ITEMS

- Go back to newly installed BMP's to check their performance
- How will contractor handle dust control or wind erosion?
- Will snow melt change runoff and drainage patterns?

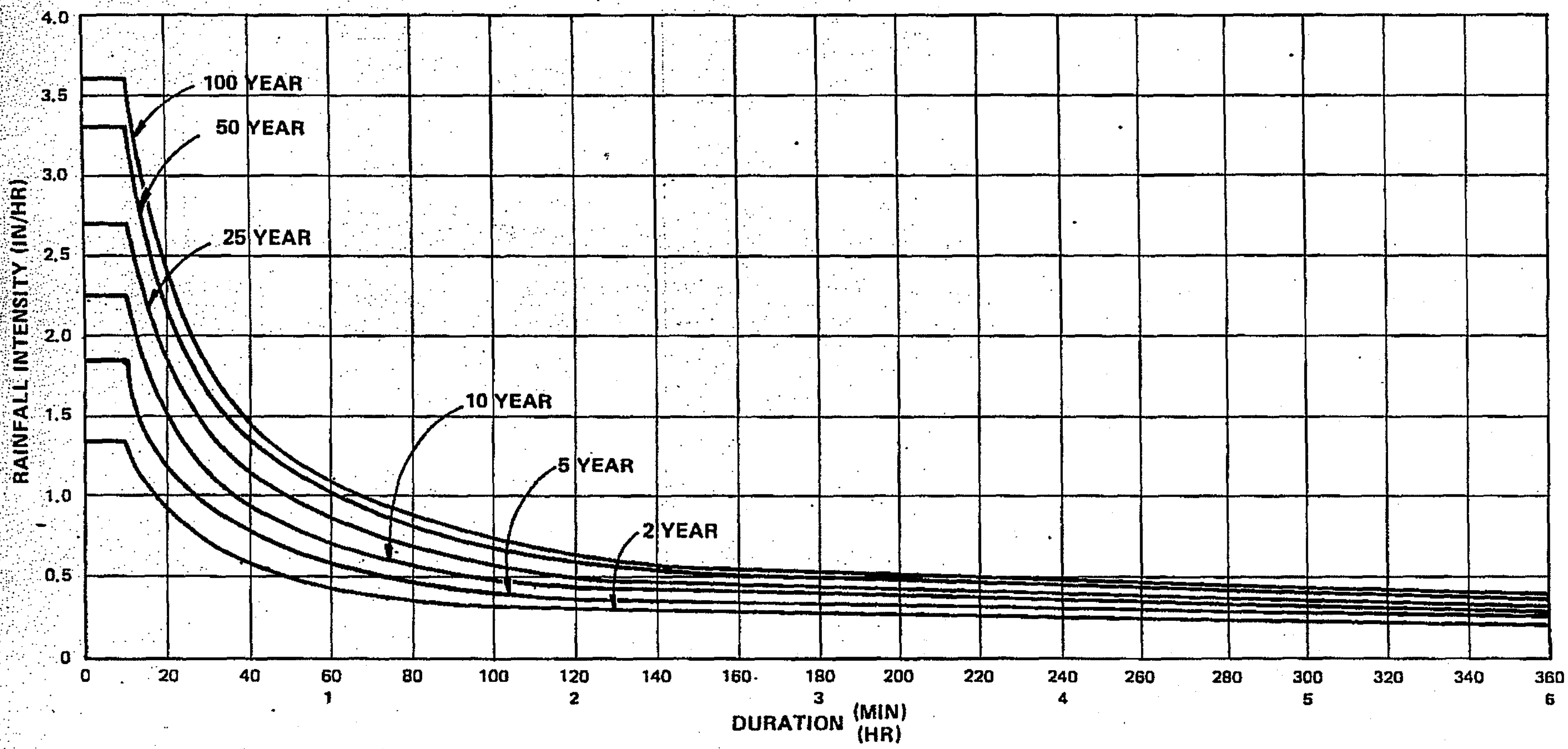


FIGURE 1.3

RAINFALL INTENSITY, DURATION, AND FREQUENCY CURVES

CORVALLIS DRAINAGE MASTER PLAN

CH2M HILL

C13723.A0

SLOPE CONVERSION TABLE

Horizontal:Vertical	% Grade	Angle Degree
100:1	1.0%	0.6
90:1	1.1%	0.6
80:1	1.3%	0.7
70:1	1.4%	0.8
60:1	1.7%	1.0
50:1	2.0%	1.1
40:1	0.2%	1.4
35:1	2.5%	1.6
30:1	3.3%	1.9
25:1	4.0%	2.3
20:1	5.0%	2.9
19:1	5.3%	3.0
18:1	5.6%	3.2
17:1	5.9%	3.4
16:1	6.3%	3.6
15:1	6.7%	3.8
14:1	7.1%	4.1
13:1	7.7%	4.4
12:1	8.3%	4.8
11:1	9.1%	5.2
10:1	10.0%	5.7
9:1	11.1%	6.3
8:1	12.5%	7.1
7:1	14.3%	8.1
6:1	16.7%	9.5
5:1	20.0%	11.3
4:1	25.0%	14.0
3:1	33.3%	18.4
2:1	50.0%	26.6
1:1	100.0%	45.0

HYDRAULIC APPLICATION

Wood Fiber Mulch Hydraulic Application

Average Water Required for Application

V_{wa} (gal) = (W_{wf}) / (40 lbs mulch / 100 gal water)

Maximum Water Required for Application

V_{wm} (gal) = (W_{wf}) / (50 lbs mulch / 100 gal water)

Area of Coverage

A (acre) = (W_{wf} / R_{wf})

A (ft^2) = (W_{wf} / R_{wf}) * (43,560 ft^2/acre)

Wood Fiber Application Rate (lb/acre)	R_{wf}
Weight or Mass of Wood Fiber (lbs)	W_{wf}
Average Water Requirement (gal)	V_{wa}
Maximum Water Requirement (gal)	V_{wm}
Area of Coverage (ft^2) & (acres)	A

Seed or Fertilizer Hydraulic Application

Area of Coverage

A (acre) = (W_{sf} / R_{su})

A (ft^2) = (W_{sf} / R_{su} * (43,560 ft^2/acre)

Seed or Fertilizer Application Rates (lb/acre)	R_{sf}
Weight or Mass of Seed or Fertilizer (lbs)	W_{sf}
Area of Coverage (ft^2) & (acres)	A

HYDRAULIC APPLICATION

Example #1 (Mulch -Area of Coverage)

Given: Required mulch application rate 2,000 lb/acre.
Hydro Seeder with 1,800 gal working capacity.
900 lbs of Wood Fiber to be applied over seeded area.

Find: Range of Area of Coverage.

Answer: Find the 2,000 lb/acre Application Rate Chart, Table D-1.

Using a 50 lbs / 100 gal mulch/water ratio:
Find 1,800 gal in the Maximum Water Required for Application column.
Follow this row over to the area columns.
One tank can cover 0.45 acre (19,602 ft^2).

Using a 40 lbs / 100 gal mulch/water ratio:
Find 1,800 gal in the Average Water Required for Application column, .
There isn't an 1,800 gal row, so interpolate between 1,750 gal and 2,000 gal.
Follow the 1,750 gal and 2,000 gal row over to the area columns.
At 1,750 gal, one tank can cover 0,35 acre (15,246 ft^2).
At 2,000 gal, one tank can cover 0.40 acre (17,424 ft^2).
One tank can cover 1,800 lb * ((0.40 acre -0.35 acre)/(2,000 gal - 1,750 gal))
= *0.36 acre (15,682 ft^2).*

Example #2 (Mulch - Materials Used)

Given: 0.60 acre (26,136 fr) area to be seeded.
Required mulch application rate 1,200 lb/acre.
Hydro Seeder with 2,500 gal working capacity.

Find: A) Amount of Mulch Required in lbs.
B) Range of Water Required in gal.
C) Number of Trips Required.

Answer: Find the 2,000 lb/acre Application Rate Chart, Table D-2.

A) Find 0.60 acre under the Area of Coverage column.
Follow the row over to the Wood Fiber column.
The wood fiber required by the area is *1,200 lb.*

B) Find 0.60 acre under the Area of Coverage column.
Follow the row to the Required Water for Application column.
Using a 50 lbs / 100 gal mulch/water ratio:
The water required for the area is *2,400 gal.*
Using a 40 lbs / 100 gal mulch/water ratio:
The water required for the area is *3,000 gal.*

C) Using a 50 lbs / 100 gal mulch/water ratio:
(2,400 gal / (2,500 gal/trip)) = *1 trip*
Using a 40 lbs / 100 gal mulch/water ratio:
(3,000 gal / (2,500 gal/trip)) = *1.2 trips, so use 2 trips.*

HYDRAULIC APPLICATION

Example #3 (Seed - Area of Coverage)

Given: Seed Application Rate 40 lb/acre.
200 lb of seed is to be applied.

Find: Area of Coverage.

Answer: Use the Seed or Fertilizer Hydraulic Application Chart, Table D-1.
Find the 40 lb/acre application rate column.
Find the 200 lb seed row.
Determine where the column and the row intersect and record the area.
For 40 lb/acre, the area of coverage is *5 acre (217,800 ft²).*
Or
Use the Formula on the Hydraulic Application Equations Sheet.
Find the area of coverage equation under the title Seed or Fertilizer Hydraulic Application.
The area equation is A (acre) = W_{sf} / R_{sf}
Area (acre) = (200 lb) / (40 lb/acre) = *5 acre.*
Area (ft^2 = ((200 lb) / (40 lb/acre)) * (43,560 ft^2/acre) = *217,800 ft^2.*

Example #4 (Seed - Materials Needed)

Given: Required Area of Coverage
0.13 acre (5,662.8 ft^2).
Seed Application Rate 200 lb/acre.

Find: Amount of Seed Required in lbs.

Answer: Use the Seed or Fertilizer Hydraulic Application Chart, Table D-1.
Find the 200 lb/acre application rate column.
Move down the list of areas to 0.13 acre.
0.13 acre is not in this column, so interpolate.
Find the area above and below 0.13 acre.
Follow the row from the area to the Amount of Seed column.
For 0.10 acre (4,356 ft^2), the amount of seed is *20 lbs.*
For 0.15 acre (6,534 ft^2), the amount of seed is *30 lbs.*
At 0.13 acre (5,662.8 ft^2), the amount of seed is

0.13 acre * ((30 lb -20 lb)/(0.15 acre -0.10 acre)) = *26 lbs.*

Or
Use the Formula on the Hydraulic Application Equations Sheet.
Find the area of coverage equation under the title Seed or Fertilizer Hydraulic Application.
The area equation is A (acre) = W_{sf} / R_{sf}
Rearrange the equation so W_{sf} (lb) = (A) * (R_{sf})
W_{sf} (lb) = (0.13 acre) * (200 lb/acre) = *26 lbs.*

Table A-1
Seed or Fertilizer Hydraulic Application

Application Load	Area of Coverage (A)													
	Application Rates of Pure Live Seed (R_{sf})													
(W_{sf})	20 lb/acre		40 lb/acre		60 lb/acre		80 lb/acre		100 lb/acre		200 lb/acre		400 lb/acre	
Pounds	acre	ft^2	acre	ft^2	acre	ft^2	acre	ft^2	acre	ft^2	acre	ft^2	acre	ft^2
10	0.50	21780	0.25	10,890	0.17	7,260	0.13	5,450	0.10	4,360	0.05	2,180	0.03	1,090
20	1.00	43560	0.50	21,780	0.33	14,520	0.25	10,890	0.20	8,710	0.10	4,360	0.05	2,180
30	1.50	65340	0.75	32,670	0.50	21,780	0.38	16,340	0.30	13,070	0.15	6,530	0.08	3,270
40	2.00	87120	1.00	43,560	0.67	29,040	0.50	21,780	0.40	17,420	0.20	8,710	0.10	4,360
50	2.50	108900	1.25	54,450	0.83	36,300	0.63	27,230	0.50	21,780	0.25	10,890	0.13	5,450
60	3.00	130680	1.50	65,340	1.00	43,560	0.75	32,670	0.60	26,140	0.30	13,070	0.15	6,530
70	3.50	152460	1.75	76,230	1.17	50,820	0.88	38,120	0.70	30,490	0.35	15,250	0.18	7,620
80	4.00	174240	2.00	87,120	1.33	58,080	1.00	43,560	0.80	34,850	0.40	17,420	0.20	8,710
90	4.50	196020	2.25	98,010	1.50	65,340	1.13	49,010	0.90	39,200	0.45	19,600	0.23	9,800
100	5.00	217800	2.50	108,900	1.67	72,600	1.25	54,450	1.00	43,560	0.50	21,780	0.25	10,890
120	6.00	261360	3.00	130,680	2.00	87,120	1.38	59,900	1.20	52,270	0.60	26,140	0.30	13,070
140	7.00	304920	3.50	152,460	2.33	101,640	1.50	65,340	1.40	60,980	0.70	30,490	0.35	15,250
160	8.00	348480	4.00	174,240	2.67	116,160	1.75	76,230	1.60	69,700	0.80	34,850	0.40	17,420
180	9.00	392040	4.50	196,020	3.00	130,680	2.00	87,120	1.80	78,410	0.90	39,200	0.45	19,600
200	10.00	435600	5.00	217,800	3.33	145,200	2.25	98,010	2.00	87,120	1.00	43,560	0.50	21,780
220	11.00	479160	5.50	239,580	3.67	159,720	2.50	108,900	2.20	95,830	1.10	47,920	0.55	23,960
240	12.00	522720	6.00	261,360	4.00	174,240	2.75	119,790	2.40	104,540	1.20	52,270	0.60	26,140
260	13.00	566280	6.50	283,140	4.33	188,760	3.00	130,680	2.60	113,260	1.30	56,630	0.65	28,310
280	14.00	609840	7.00	304,920	4.67	203,280	3.25	141,570	2.80	121,970	1.40	60,980	0.70	30,490
300	15.00	653400	7.50	326,700	5.00	217,800	3.50	152,460	3.00	130,680	1.50	65,340	0.75	32,670

Table A-1
Seed or Fertilizer Hydraulic Application

Application Load	Area of Coverage (A)													
	Application Rates of Pure Live Seed (R_{sf})													
(W_{sf})	20 lb/acre		40 lb/acre		60 lb/acre		80 lb/acre		100 lb/acre		200 lb/acre		400 lb/acre	
Pounds	acre	ft^2	acre	ft^2	acre	ft^2	acre	ft^2	acre	ft^2	acre	ft^2	acre	ft^2
10	0.50	21780	0.25	10,890	0.17	7,260	0.13	5,450	0.10	4,360	0.05	2,180	0.03	1,090
20	1.00	43560	0.50	21,780	0.33	14,520	0.25	10,890	0.20	8,710	0.10	4,360	0.05	2,180
30	1.50	65340	0.75	32,670	0.50	21,780	0.38	16,340	0.30	13,070	0.15	6,530	0.08	3,270
40	2.00	87120	1.00	43,560	0.67	29,040	0.50	21,780	0.40	17,420	0.20	8,710	0.10	4,360
50	2.50	108900	1.25	54,450	0.83	36,300	0.63	27,230	0.50	21,780	0.25	10,890	0.13	5,450
60	3.00	130680	1.50	65,340	1.00	43,560	0.75	32,670	0.60	26,140	0.30	13,070	0.15	6,530
70	3.50	152460	1.75	76,230	1.17	50,820	0.88	38,120	0.70	30,490	0.35	15,250	0.18	7,620
80	4.00	174240	2.00	87,120	1.33	58,080	1.00	43,560	0.80	34,850	0.40	17,420	0.20	8,710
90	4.50	196020	2.25	98,010	1.50	65,340	1.13	49,010	0.90	39,200	0.45	19,600	0.23	9,800
100	5.00	217800	2.50	108,900	1.67	72,600	1.25	54,450	1.00	43,560	0.50	21,780	0.25	10,890
120	6.00	261360	3.00	130,680	2.00	87,120	1.38	59,900	1.20	52,270	0.60	26,140	0.30	13,070
140	7.00	304920	3.50	152,460	2.33	101,640	1.50	65,340	1.40	60,980	0.70	30,490	0.35	15,250
160	8.00	348480	4.00	174,240	2.67	116,160	1.75	76,230	1.60	69,700	0.80	34,850	0.40	17,420
180	9.00	392040	4.50	196,020	3.00	130,680	2.00	87,120	1.80	78,410	0.90	39,200	0.45	19,600
200	10.00	435600	5.00	217,800	3.33	145,200	2.25	98,010	2.00	87,120	1.00	43,560	0.50	21,780
220	11.00	479160	5.50	239,580	3.67	159,720	2.50	108,900	2.20	95,830	1.10	47,920	0.55	23,960
240	12.00	522720	6.00	261,360	4.00	174,240	2.75	119,790	2.40	104,540	1.20	52,270	0.60	26,140
260	13.00	566280	6.50	283,140	4.33	188,760	3.00	130,680	2.60	113,260	1.30	56,630	0.65	28,310
280	14.00	609840	7.00	304,920	4.67	203,280	3.25	141,570	2.80	121,970	1.40	60,980	0.70	30,490
300	15.00	653400	7.50	326,700	5.00	217,800	3.50	152,460	3.00	130,680	1.50	65,340	0.75	32,670

Wood Fiber Mulch Hydraulic Application

Table C-1	500 lb/acre Application Rate (R_{wf})			
Wood Fiber (W_{wf})	Water Required for Application		Area of Coverage (A)	
	Average (V_{wa}) 40 lbs mulch / 100 gal water	Maximum (V_{wm}) 50 lbs mulch / 100 gal water		
Pounds	*Gallons	*Gallons	ft^2	Acres
500	1,250	1,000	43,560	1.00
600	1,500	1,200	52,272	1.20
700	1,750	1,400	60,984	1.40
800	2,000	1,600	69,696	1.60
900	2,250	1,800	78,408	1.80
1,000	2,500	2,000	87,120	2.00
1,100	2,750	2,200	95,832	2.20
1,200	3,000	2,400	104,544	2.40
1,300	—	2,600	113,256	2.60
1,400	—	2,800	121,968	2.80
1,500	—	3,000	130,680	3.00

Table C-2	1,500 lb/acre Application Rate (Rwf)			
Wood Fiber (Wwf)	Water Required for Application		Area of Coverage (A)	
	Average (Vwa) 40 lbs mulch / 100 gal water	Maximum (Vwm) 50 lbs mulch / 100 gal water		
Pounds	*Gallons	*Gallons	ft^2	Acres
500	1,250	1,000	14,520	0.33
600	1,500	1,200	17,424	0.40
700	1,750	1,400	20,328	0.47
800	2,000	1,600	23,232	0.53
900	2,250	1,800	26,136	0.60
1,000	2,500	2,000	29,041	0.67
1,100	2,750	2,200	31,945	0.73
1,200	3,000	2,400	34,849	0.80
1,300	—	2,600	37,753	0.87
1,400	—	2,800	40,657	0.93
1,500	—	3,000	43,561	1.00

Wood Fiber Mulch Hydraulic Application

Table C-3	2,000 lb/acre Application Rate (Rwf)			
Wood Fiber (Wwf)	Water Required for Application		Area of Coverage (A)	
	Average (Vwa) 40 lbs mulch / 100 gal water	Maximum (Vwm) 50 lbs mulch / 100 gal water		
Pounds	*Gallons	*Gallons	ft^2	Acres
500	1,250	1,000	10,890	0.25
600	1,500	1,200	13,068	0.30
700	1,750	1,400	15,246	0.35
800	2,000	1,600	17,424	0.40
900	2,250	1,800	19,602	0.45
1,000	2,500	2,000	21,780	0.50
1,100	2,750	2,200	23,958	0.55
1,200	3,000	2,400	26,136	0.60
1,300	—	2,600	28,314	0.65
1,400	—	2,800	30,492	0.70
1,500	—	3,000	32,670	0.75

Table C-4	2,500 lb/acre Application Rate (Rwf)			
Wood Fiber (Wwf)	Water Required for Application		Area of Coverage (A)	
	Average (Vwa) 40 lbs mulch / 100 gal water	Maximum (Vwm) 50 lbs mulch / 100 gal water		
Pounds	*Gallons	*Gallons	ft^2	Acres
500	1,250	1,000	8,712	0.20
600	1,500	1,200	10,454	0.24
700	1,750	1,400	12,197	0.28
800	2,000	1,600	13,939	0.32
900	2,250	1,800	15,682	0.36
1,000	2,500	2,000	17,424	0.40
1,100	2,750	2,200	19,166	0.44
1,200	3,000	2,400	20,909	0.48
1,300	—	2,600	22,651	0.52
1,400	—	2,800	24,394	0.56
1,500	—	3,000	26,136	0.60

Wood Fiber Mulc 'ydraulic Application

Table C-1	500 lb/acre Application Rate (R_{wf})			
Wood Fiber (W_{wf}) Pounds	Water Required for Application: Average (V_{wa}) 40 lbs mulch / 100 gal water *Gallons	Water Required for Application: Maximum (V_{wm}) 50 lbs mulch / 100 gal water *Gallons	Area of Coverage (A): ft^2	Area of Coverage (A): Acres
500	1,250	1,000	43,560	1.00
600	1,500	1,200	52,272	1.20
700	1,750	1,400	60,984	1.40
800	2,000	1,600	69,696	1.60
900	2,250	1,800	78,408	1.80
1,000	2,500	2,000	87,120	2.00
1,100	2,750	2,200	95,832	2.20
1,200	3,000	2,400	104,544	2.40
1,300	—	2,600	113,256	2.60
1,400	—	2,800	121,968	2.80
1,500	—	3,000	130,680	3.00

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Wood Fiber (Wwf) Pounds	Water Required for Application: Average (Vwa) 40 lbs mulch / 100 gal water *Gallons	Water Required for Application: Maximum (Vwm) 50 lbs mulch / 100 gal water *Gallons	Area of Coverage (A): ft^2	Area of Coverage (A): Acres
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600	1,500	1,200	17,424	0.40
700	1,750	1,400	20,328	0.47
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Wood Fiber Mulch Hydraulic Application

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600	1,500	1,200	13,068	0.30
700	1,750	1,400	15,246	0.35
800	2,000	1,600	17,424	0.40
900	2,250	1,800	19,602	0.45
1,000	2,500	2,000	21,780	0.50
1,100	2,750	2,200	23,958	0.55
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Table C-4	2,500 lb/acre Application Rate (Rwf)			
Wood Fiber (Wwf)	Water Required for Application		Area of Coverage (A)	
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Pounds	*Gallons	*Gallons	ft^2	Acres
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700	1,750	1,400	12,197	0.28
800	2,000	1,600	13,939	0.32
900	2,250	1,800	15,682	0.36
1,000	2,500	2,000	17,424	0.40
1,100	2,750	2,200	19,166	0.44
1,200	3,000	2,400	20,909	0.48
1,300	—	2,600	22,651	0.52
1,400	—	2,800	24,394	0.56
1,500	—	3,000	26,136	0.60

Appendix E

Glossary

GLOSSARY OF TERMS

AASHTO Classification The official classification of soil materials and soil aggregate mixtures for highway construction used by the American Association of State Highway and Transportation Officials.

Adsorption The adhesion of a substance to the surface of a solid or liquid. Heavy metals such as zinc and lead often adsorb onto particles.

Alluvial Soils Soils developed from transported and relatively recently deposited material (alluvium) characterized by a weak modification (or none) of the original material by soil-forming processes.

Alluvium A general term for all detrital material deposited or in transit by streams, including gravel, sand, silt, clay, and all variations and 0"--, mixtures of these. Unless otherwise noted, alluvium is unconsolidated.

Anadromous Fishes which ascend rivers from the sea for breeding.

Annual Storm The highest peak storm discharge that is expected in any given year.

Apron A pad of non-erosive material designed to prevent scour holes developing at the outlet ends of culverts, outlet pipes, grade stabilization structures, and other water control devices.

Aquifer An underground porous, water-bearing geological formation. The term is generally restricted to materials capable of yielding an appreciable supply of water.

Barrel A conduit placed through a dam, levee, or a dike to control the release of water.

Base Flow Stream discharge derived from groundwater sources as .differentiated from surface runoff. Sometimes considered to include flows from regulated lakes or reservoirs.

Bearing Capacity The maximum load that a material can support before failing.

Bedrock The more or less solid rock in place either on or beneath the surface of the earth. It may be soft, medium or hard and have a smooth or irregular surface.

Berm A constructed barrier of compacted earth.

Best Management Practices Physical, structural and/or managerial practices employed to (BMP's) avoid or mitigate damage or potential damage from the contamination or pollution of surface waters or wetlands. Structural BMP's are actual physical installations rather than procedural/managerial BMP's, such as good housekeeping and employee training.

GLOSSARY OF TERMS
(continued)

Capillary Action The tendency of drier soil particles to attract moisture from wetter portions of soil.

Catch Basin A grated inlet, curb opening or combination inlet with or without a sump which admits storm water to a sewer or subdrain.

CD Cross machine direction; direction perpendicular to the machine or manufacture direction.

Channel A natural stream or excavated ditch that conveys water.

Channel Stabilization Protecting the sides and bed of a channel from erosion by controlling flow velocities and flow directions using jetties, drops or other structures and/or by lining the channel with a suitable liner such as vegetation, riprap, concrete or other similar material.

Channelization Alteration of a stream channel by widening, deepening, straightening, or paving certain areas to improve flow characteristics.

Check Dam A small dam constructed in a gully or other small watercourse to decrease flow velocity , minimize channel scour and promote sediment deposition.

Chute A high-velocity, open channel for conveying water down a steep slope without erosion, usually paved.

Clay (1) Soil fraction consisting of particles less than 0.002 mm in diameter. (2) A soil texture class which is dominated by clay or at least has a larger proportion of clay than either silt or sand.

Cohesion The capacity of a soil to resist shearing stress, exclusive of functional resistance.

Cohesive Soil A soil that, when unconfined, has considerable strength when air- dried and significant strength when saturated.

Coir Fiber made from coconut husks.

Compost Organic residue or a mixture of organic residues and soil, that has undergone biological decomposition until it has become relatively stable humus-

Conventional Pollutants Contaminants (other than nutrients) such as sediment, oil, and vehicle fluids.

Contour An imaginary line on the surface of the earth connecting points of the same elevation.

GLOSSARY OF TERMS
(continued)

Cut	Portion of ground surface or area from which earth has been removed or will be removed by excavating; the depth below the original ground surface to the excavated surface.
Cut-and-Fill	Process of earth grading by excavating part of a higher area and using the excavated material for fill to raise the surface of an adjacent lower area.
Cutoff Trench	A long, narrow excavation (keyway) constructed along the center line of a dam, dike, levee or embankment and filled with relatively impervious material intended to reduce seepage of water through porous strata.
Cutting	A leaf, stem or branch cut form a plant to establish a new plant.
Design Highwater	The elevation of the water surface at peak flow conditions of the design flood.
Design Life	The period of time for which a facility is expected to perform its intended function.
Design Storm	Selected storm of a given frequency used for designing a design storm system. Hypothetical storm derived from intensity- duration-frequency curves. A prescribed hydrograph and total precipitation amount (for a specific duration recurrence frequency) used to estimate runoff in order to analyze existing drainage, design new drainage facilities or assess impacts of a proposed project on surface water flow.
Desilting Area	An area of grass, shrubs, or other vegetation used for including deposition of silt and other debris from flowing water; located above a stock tank, pond, field, or other area needing protection from sediment accumulation.
Detention	Storage and subsequent release of excess storm water runoff.
Detention Facility	An above or below ground facility, such as a pond or tank, which temporarily stores storm water runoff and releases it at a controlled rate. There is little or no infiltration of the stored storm water.
Detention Time	The theoretical time required to displace the contents of a tank or unit at a given rate of discharge (volume divided by rate of discharge).
Dewatering	The removal of water temporarily impounded in a holding basin.
Dike	An embankment to confine or control water, often built along the banks of a river to prevent overflow of lowlands; a levee.
Discharge	Usually the rate of water flow; a volume of fluid passing a point per unit time

commonly expressed as cubic feet per second, cubic meters per second, gallons per minute, or millions of gallons per day.

Dispersion, Soil — The breaking down of fine soil aggregates into individual particles, resulting in single-grain structure. Ease of dispersion influences the erodibility of soils. Generally speaking, the more easily dispersed the soil, the more erodible it is.

Diversion — A channel with a supporting ridge on the lower side constructed at the top, across, or at the bottom of a slope for the purpose of controlling surface runoff.

Diversion Dike — A barrier built to divert surface runoff.

Drain — A buried slotted or perforated pipe or other conduit (subsurface drain) or a ditch (open drain) for carrying off surplus groundwater or surface water.

Drainage — The removal of excess surface water or groundwater from land by means of ditches or subsurface drains.

Drainageway — A natural or artificial depression that carries surface water to a larger watercourse or outlet such as a river, lake, or bay.

Drop Inlet — Overall structure in which the water drops through a vertical riser .r connected a discharge conduit or storm sewer.

Drop Spillway — Overall structure in which the water drops over a vertical wall onto an apron at a lower elevation.

Dry Pond — A facility which provides storm water quantity control by detaining runoff in a detention basin, then releasing the runoff at allowable rates.

Elongation — The increase in length produced in the gage length produced by a tensile load.

Embankment — A man-made deposit of soil, rock, or other material often used to form an impoundment.

Emergency Spillway — Usually a vegetated earth channel used to safely convey flood discharges around an impoundment structure.

Energy Dissipater — A device used to reduce the energy of flowing water to prevent erosion.

Environment — The sum total of all the external conditions that may act upon a living organism or community to influence its development or existence.

Erodibility — Susceptibility to erosion.

GLOSSARY OF TERMS
(continued)

Erosion The wearing away of the land surface by water, wind, ice, gravity, or other geological agents. The following terms are used to describe different types of water erosion:

1. **Accelerated erosion** -Erosion much more rapid than normal or geologic erosion, primarily as a result of the activities of man.
2. **Channel erosion** -The erosion process whereby the volume and velocity of flow wears away the bed and/or banks of a well-defined channel.
3. **Gully erosion** -The erosion process whereby runoff water accumulates in narrow channels and, over relatively short periods, removes the soil to considerable depths, ranging from 1 to 2 feet to as much as 75 to 100 feet.
4. **Rill erosion** -An erosion process in which numerous small channels only several inches deep are formed; occurs mainly on recently disturbed and exposed soils. See Rill.
5. **Splash erosion** -The spattering of small soil particles caused by the impact of raindrops on wet soils. The loosened and spattered particles mayor may not be subsequently removed by surface runoff.
6. **Sheet erosion** -The gradual removal of a fairly uniform layer of soil from the land surface by runoff water.

Erosion Prevention and Sediment Control Any temporary or permanent measures taken to reduce erosion, control siltation and sedimentation, and ensure that sediment- laden water does not leave a site.

Erosion Prevention and Sediment Control Plan (EPSC plan) Plans, specification and BMP details intended to prevent and control erosion and sediment related to the project construction activities.

Estuary Area where fresh water meets salt water, (e.g. bays, mouths of rivers, salt marshes and lagoons). Estuaries serve as spawning and feeding grounds for large numbers of marine organisms and provide shelter and food for birds and wildlife.

Evapotranspiration The combined loss of water from an area by evaporation from the soil surface and by transpiration of plants.

Excess Rainfall The amount of rainfall that runs directly off an area.

Filter Blanket A layer of sand and/or gravel designed to prevent the movement .1 of finegrained soils

Filter Fabric A woven or non-woven, water penl1eable material generally made of synthetic products such a polypropylene and used in erosion and sediment control applications to trap sediment or prevent the movement of fine soil particles. Often used instead of a filter blanket.

Flood Peak The highest stage or greatest discharge attained by a flood event. Thus, peak stage or peak discharge.

Floodplain The lowland that borders a stream and is subject to flooding when the stream overflows its banks.

Flood Stage The stage at which overflow of the natural banks of a stream begins.

Floodway A channel, either natural, excavated, or bounded by dikes and levees, used to carry flood flows.

Flume A constructed channel lined with erosion-resistant materials used to convey water on steep grades without erosion.

Fluvial Sediment Those deposits produced by stream or river action.

Foundation Drain A pipe or series of pipes which collects groundwater from the foundation or footing of structures to improve stability.

Freeboard Vertical clearance between the nonl1al operating level and the top side of an open conduit or channel. Vertical distance between the design water surface elevation and the elevation of the barrier retaining the water.

Frequency of Storm (design storm frequency) The anticipated period in years that will elapse before another storm of equal intensity and/or total volume will recur: a 10-year storm can be expected to occur on the average once every 10 years.

Gabion A wire mesh cage, usually rectangular, filled with rock and used to protect channel banks and other sloping areas from erosion.

Gauge Device for measuring precipitation, water level., discharge, velocity, pressure, temperature, etc., e.g., a rain gauge. A measure of the thickness of metal, e.g., diameter of wire or wall thickness of steel pipe.

Geotextile Any permeable textile used with foundation, rock, earth or any other geotechnical engineering-related material as an integral part of a human-made project, structure or system.

GLOSSARY OF TERMS
(continued)

Grade (1) The slope of a road, a channel, or natural. ground. (2) The finished surface of canal, bed, roadbed, top of embankment, or bottom of excavation; any surface prepared to a design elevation for the support of construction such as paving or the laying of a conduit. (3) To finish the surface of a canal bed, roadbed, top of embankment, or bottom of excavation, or other land area to a smooth, even condition.

Grade Stabilization Structure A structure for the purpose of stabilizing the grade of a gu1.1y or other watercourse, thereby preventing further head-cutting or lowering of the channel bottom.

Gradient Change of elevation, velocity , pressure, or other characteristics per unit length; slope.

Grading The cutting and/or filling of the land surface to a desired slope or elevation.

Grass A member of the botanical family Gramineae, characterized by blade-like leaves that originate as a sheath wrapped around the stem.

Grassed Waterway A natural or constructed waterway, usua1.1y broad and shallow, covered with erosion-resistant grasses and used to safely conduct surface water from an area.

Ground Cover (Horticulture) Low-growing, spreading plants useful for low- maintenance landscape areas.

Habitat The environment in which the life needs of a plant or animal are c supplied.

Harmful Pollutant A substance which has adverse effects on an organism. Adverse effects include immediate death, chronic poisoning, impaired reproduction and other conditions.

Head The height of water above any plain of reference. The energy, either kinetic or potential, possessed by each unit weight of a liquid, expressed as the vertical height through which a unit weight would have to fall to release the average energy possessed. Used in various compound terms such as pressure head of velocity head.

Head loss Energy loss due to friction, eddies, changes in velocity, elevation or direction of flow.

Headwater The source of a stream. The water upstream from a structure or point a stream.

Heavy Metals Metals having a high specific gravity , present in municipal and industrial wastes, that pose long-tem environmental hazards. Such metals include cadmium, chromium, cobalt, copper, lead, mercury, nickel and zinc.

GLOSSARY OF TERMS
(continued)

Hydrologic cycle The circuit of water movement from the atmosphere to the earth and back to the atmosphere through various stages or processes such as precipitation, interception, runoff, infiltration, percolation, storage, evaporation, and transpiration.

Hydrology The science of the behavior of water in the atmosphere; on the surface of the earth, and underground.

Hyetograph A graph of runoff rate, inflow rate or discharge rate past a specific point in time. A graph of flow versus time.

Impact basin A device used to dissipate the energy of flowing water to reduce erosion. Generally constructed of concrete partially submerged with baffles to dissipate velocities.

Impervious A surface which water can not easily penetrate. Can include graveled surface as well as paved surfaces.

Material Safety Data Sheets Data sheets which come with materials. The sheets contain (MSDS) information such as pH, flashpoint, reactivity, first aid recommendations and indicate material classification and handling requirements.

MD Machine direction; in textiles, the direction in a machine-made fabric parallel to the direction the fabric followed in the manufacturing machine.

Mean Depth Average depth; cross-sectional area of stream or channel divided by its surface or top width.

Mean Velocity The average velocity of a stream flowing in a channel or conduit at a given cross-section or in a given reach. It is equal to the discharge divided by the cross-section area of the reach.

Microclimate The climate specifically associated with a very small area such as a crevice in a rock outcropping. V

Mitigation Means, in the following order of importance:

1. A voiding the impact altogether by not taking a certain action or part of an action

2. Minimizing impacts by limiting the degree or magnitude of the action and its implementation, by using appropriate technology, or by taking affirmative steps to avoid or reduce impacts.

GLOSSARY OF TERMS
(continued)

3. Rectifying the impact by repairing, rehabilitating or restoring the affected environment.

4. Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action and

5. Compensation for the impact by replacing, enhancing, or providing substitute resources or environments.

Mulch A natural or artificial layer of plant residue or other materials covering the land surface which conserves moisture, holds soil in place. aids in establishing plant cover, and minimizes temperature fluctuations.

National Pollutant Discharge Elimination System (NPDES) The part of the Federal Clean Water Act which requires permits (NPDES permits) for point and nonpoint source discharges.

Natural Drainage The flow patterns of storm water runoff over the land in its pre- development state.

Nitrogen Fixation The conversion of atmospheric nitrogen into stable compounds usable by plants. Carried out by bacteria that colonize the roots of most legumes.

Nonpoint Source Pollution Pollution that enters a waterbody from diffuse origins on the watershed and does not result from discernible, confined, or discrete conveyances.

Normal Depth Depth of flow in an open conduit during uniform flow for the given conditions.

Nutrients Essential chemicals for plant and animal growth. Excessive amounts can lead to water quality degradation and algae blooms. '-..I Some nutrients are toxic at high concentrations.

Open Drain Natural watercourse or constructed open channel that conveys drainage water .

Orifice An opening with closed perimeter, usually of regular form, through which water may flow, generally to control outlet flow.

Outfall The point, location, or structure where wastewater or drainage discharge from a sewer to a receiving body of water.

Outlet Point of water disposal from a stream, river, lake, tidewater, or artificial drain.

Outlet channel A waterway constructed or altered primarily to carry water from man-made structures, such as smaller channels, tiles, lines, and diversions.

GLOSSARY OF TERMS
(continued)

Peak Discharge The maximum, instantaneous flow rate during a storm, usually in ~ reference to a specific design storm event.

Permeability A generic term for the ability of a material to conduct a fluid.

Permeable Soils Soil materials with filtration rate of 10 minutes per inch or better . Such soils allow infiltration and reduce or eliminate surface and storm water runoff. Classified as SCS (Soil Conservation Services) Type A.

Permeability Rate The rate at which water will move through a saturated soil. Permeability rates are classified as follows:

- Very slow - Less than 0.06 inches per hour.
- Slow - 0.06 to 0.20 inches per hour.
- Moderately slow - 0.20 to 0.63 inches per hour.
- Moderate - 0.63 to 2.0 inches per hour.
- Rapid - 6.3 to 20.0 inches per hour.
- Very rapid - More than 20.0 inches per hour.

Permittivity For a geotextile, the volumetric flow rate if water per unit cross- y section area, per unit head, under laminar flow conditions, in the normal direction through the fabric.

Plasticity Index The numerical difference between the liquid limit and the plastic limit of soil; the range of moisture content within which the soil remains plastic.

Plastic Limit The moisture content at which a soil changes from a semi-solid to a plastic state.

Point Source Any discernible, confined an discrete conveyance, including but not limited to any pipe ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation. or vessel or other floating craft. from which pollutants are or may be discharged.

Point Source Pollutants Pollution which enters a water body resulting from discernible confined or discrete conveyances.

Pollution Control Plan (PCP) Consists of Pollution Control Plan form, narrative, site map and details

GLOSSARY OF TERMS
(continued)

describing measures to prevent pollution related to contractor activities.

Pervious Allowing movement of water.

Porosity The volume of pore space in soil or rock.

pH A numerical measures of hydrogen ion activity .The neutral point is pH 7.0. All pH values below 7.0 are acid and all above 7.0 are alkaline.

Rainfall Intensity The rate at which rain is falling at any given instant, usually expressed in inches per hour .

Rational Method A means of computing storm drainage flow rates, Q, by use of the formula Q=CIA, where C is a coefficient describing the physical drainage area, I is the rainfall intensity and A is the area.

Receiving Stream The body of water into which runoff or effluent is discharged.

Recharge Basin A basin provided to increase infiltration for the purpose of replenishing groundwater supply.

Retention The process of collecting and holding surface and storm water runoff with no surface overflow.

Retention/Detention Facility A type of drainage facility designed either to hold water for a considerable length of time and then release it by evaporation, plant transpiration, and/or infiltration into the ground, or to hold surface and storm water runoff for a short period of time and then release it to the surface and storm water management system.

Retention Structure A natural or artificial basin that functions similar to a detention structure except that it maintains a permanent water supply.

Riparian Pertaining to banks of streams, wetlands, lakes or tide waters.

Riparian Rights A principle of common law which requires that any user of waters adjoining or flowing through his lands must so use and protect them that he will enable his neighbor to utilize the same waters undiminished in quantity and undefiled in quality.

Riser The inlet portions of a drop inlet spillway that extends vertically from the pipe conduit barrel to the water surface.

Runoff That portion or precipitation that flows from a drainage area on the land surface, in open channels or in storm water conveyance systems.

GLOSSARY OF TERMS
(continued)

Salmonid	A member of the fish family salmonidae. Includes Chinook, coho, chum, sockeye and pink salmon, cutthroat, steelhead, rainbow, Dolly varden, brook, kokanee and whitefish.
Sand	(1) Soil particles between 0.05 and 2.0 mm in diameter. (2) A soil textural class inclusive of all soils which are at least 70% sand and 15% or less clay.
Saturation	In soils, the point at which a soil or an aquifer will no longer absorb any amount of water without losing an equal amount.
Scour	The clearing and digging action of flowing water, especially the downward erosion caused by stream water in sweeping away mud and silt from the stream bed and outside bank of a curved channel.
Sediment	Fragmented material originated from weathering and erosion of rocks and unconsolidated deposits. The material is transported by, suspended in, or deposited by water .
Sedimentation	Deposition or formation of sediment.
Sediment Delivery Ratio	The fraction of the soil eroded from upland sources that actually reaches a stream channel or storage reservoir.
Sediment Discharge	The quality of sediment, measured in dry weight or by volume, transported through a stream cross-section in a given time. Sediment discharge consists of both suspended load and bed.load.
Sediment Pool	The reservoir space allotted to the accumulation of sediment during the life of the structure.
Seedbed	The soil prepared by natural or artificial means to promote the germination of seed and the growth of seedlings.
Seedling	A young plant grown from seed.
Settling Basin	An enlargement in the channel of a stream to permit the settling of debris carried in suspension.
Sheet Erosion	Relatively uniform removal of soil from an area without the development of conspicuous water channels.
Sheet Flow	Relatively uniform flow over a plane surface without concentration of water into conspicuous channels.

GLOSSARY OF TERMS
(continued)

Silt (1) Soil fraction consisting of particles between 0.002 and 0.05 mm in diameter. (2) A soil textural class indicating more than 80% silt.

Siltation Process by which a river. lake or other water body becomes clogged with sediment. Siltation can clog gravel beds and prevent successful salmon spawning.

Slope Degree of deviation of a surface from the horizontal; measured as a numerical ratio or percent. Expressed as a ratio, the first number is the horizontal distance (run) and the second is the vertical distance (rise), e.g., 2:1. Slope can also be expressed as the rise over the run. For instance, a 2:1 slope is a 50 percent slope.

Soil The unconsolidated mineral and organic material on the immediate surface of the earth that serves as a natural medium for the growth of land plants.

Soil Horizon A horizontal layer of soil that, through processes of soil formation, has developed characteristics distinct from the layers above and below.

Soil Profile A vertical section of the soil from the surface through all horizons.

Soil Stabilization Use of rock-lining, vegetation or other methods to prevent soil movement when loads are applied to the soil.

Soil Structure The relation of particles or groups of particles which impart to the whole soil a characteristic manner of breaking; some types are crumb structure, block structure, platy structure, and columnar structure.

Soil Texture The physical structure or character of soil determined by the relative proportions of the soil separates (sand, silt and clay) of which it is composed.

Spillway A passage such as a paved apron or channel for surplus water over or around or through a dam or similar structure. An open or closed channel, or both, used to convey excess water from a reservoir. It may contain gates, whether manually or automatically controlled, to regulate the discharge of excess water.

Storm Frequency The statistical time interval between major storms of predetermined intensity and runoff volumes for which storm sewers and other structures are designed and constructed to handle hydraulically without surcharge or backflood.

Storm Sewer A sewer that carries storm water, surface drainage, street wash and other wash waters, but excludes sewage and industrial wastes. Also called a storm drain.

Storm Water That portion of precipitation that does not percolate into the ground or

GLOSSARY OF TERMS
(continued)

evaporate, but flows via overland flow, interflow, channels or pipes into a defined surface water channel, or a constructed infiltration facility .

Storm Water Facility	A constructed component of a storm water drainage system, designed or constructed to perform a particular function, or multiple functions. Storm water facilities include pipes, swales, ditches, culverts, street gutters, detention basins, retention basins, constructed wetlands and other.
Streambanks	The usual boundaries, not the flood boundaries, of a stream channel. Right and left banks are named facing downstream.
Stream Gauging	The quantitative determination of stream flow using gauges, current meters, weirs, or other measure instruments at selected locations. See Gauging station.
Subcritical Flow	Flow at relatively low velocity where the wave from a disturbance can move upstream. Froude No. less than 1.
Subsoil	The B horizons of soils with distinct profiles. In soils with weak profile development, the subsoil can be defined as the soil below which roots do not normally grow.
Subsurface Drain	A pervious backfilled trench usually containing stone and perforated pipe for intercepting groundwater or seepage.
Subwatershed	A watershed subdivision of unspecified size that forms a convenient natural unit.
Surface Runoff	Precipitation that falls onto the surfaces of roofs, streets, the ground, etc., and is not absorbed or retained by that surface, but collects and runs off.
Suspended Solids	Organic or inorganic particles suspended in and carried by water: sand, mud, clay as well as solids.
Swale	An elongated depression in the land surface that is at least seasonally wet, is usually heavily vegetated, and is normally without flowing water. Swales conduct storm water into primary drainage channels and may provide some groundwater recharge.
Tile	Drain Pipe made of perforated plastic, burned clay, concrete, or similar material, laid to a designed grade and depth, to collect and carry excess water from the soil.
Tile Drainage	Land drainage by means of a series of tile lines laid at a specified depth, grade and spacing.

GLOSSARY OF TERMS
(continued)

Time of Concentration The time period necessary for surface water runoff to reach the outlet of a sub-basin from the hydraulically most remote point in the tributary drainage area.

Toe of Slope The base or bottom of a slope at the point where the ground surface abruptly changes to a significantly flatter grade.

Topography General term to include characteristics of the ground surface such as plains, hills, mountains, degree of relief, steepness of slopes and other physiographic features.

Topsoil The dark-colored surface layer of A horizon of a soil. When present it ranges in depth from a fraction of an inch to 2 or 3 feet; equivalent to the plow layer of cultivated soils. Commonly used to refer to the surface soil layer(s), enriched in organic matter and haying textural and structural characteristics favorable for plant growth.

Total Solids Solids in water, sewage or other liquids including dissolved, filterable and nonfilterable solids. The residue left when moisture evaporates and the remainder is dried at a specified temperature.

Total Suspended Solids (TSS) The entire amount of organic and inorganic particles dispersed in water. TSS are the larger particles in the water which are more easily removed by sedimentation than smaller particles which cause turbidity.

Toxicity The characteristic of being poisonous or harmful to plant animal life; the relative degree or severity of this characteristic.

Trash Rack A structural device used to prevent debris from entering a pipe spillway or other hydraulic structure.

Transmissivity The volumetric flow rate per unit thickness under laminar flow conditions, in the in-plane direction of the fabric.

Turbidity Is caused by silt and clay particles, particles smaller than 0.02 mm, suspended in water. Measurement of turbidity can be done by turbidimeter which measures light-beam scatter caused by small suspended particles and converts it to NTU (national turbidity units).

Turf Surface soil supporting a dense growth of grass and associated root mat.

Unified Soil Classification A classification system based on the identification of soils System according to their particle size, gradation, plasticity index, and liquid limit.

Vactor Waste The waste material in the bottom of a catch basin.

Vegetative Stabilization Protection of erodible or sediment-producing areas with:

- Permanent seeding, producing long-term vegetative cover,
- Short-term seeding, producing temporary vegetative cover, or
- Sodding, producing areas covered with a turf of perennial sod-forming grass.

Watercourse A definite channel with bed and banks within which concentrated water flows, either continuously or intennittently.

Water Quality A term used to describe the chemical, physical, and biological characteristics of water, usually in respect to its suitability for a particular purpose.

Water Resources The supply of groundwater and surface water in a given area.

Watershed Area All land and water within the confines of a drainage divide.

Water Table The free surface of the groundwater. That surface subject to atmospheric pressure under the ground, generally rising and falling with the season, or from other conditions such as water withdrawal.

Weir Device for measure or regulating the flow of water . Weir Notch The opening in a weir for the passage of water.

Wet Pond A facility treating storm water by utilizing a permanent pool of water to remove conventional pollutants from runoff. Treatment mechanisms include sedimentation, biological uptake and plant filtration.

Wet Season October 1 to April 30.

Appendix G

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City of Corvallis Stormwater Phase II
Post-Construction Stormwater Management
in New Development and Redevelopment Program

The Post-Construction Stormwater Management in New Development and Redevelopment Measure is one of six measures the City of Corvallis, as an operator of a Phase II regulated municipal separate storm sewer system (MS4), is required to include in its stormwater management program to meet the conditions of its stormwater permit. The following document outlines the City's Post-Construction Stormwater Management in New Development and Redevelopment plan that will be implemented as part of its stormwater management program.

I. INTRODUCTION

Post-construction stormwater managememt in areas undergoing development or redevelopment is necessary because runoff from these areas has the potential to negatively affect receiving water bodies. Many studies indicate that planning and design for the minimization of pollutants in post construction storm water discharges is a cost effective approach to stormwater quality management.

There are generally two types of substantial impacts of post-construction runoff. The first type is caused by an increase in the type and quantity of pollutants in stormwater runoff. As runoff flows over areas altered by development, it can pick up harmful sediment and substances such as oil and grease, pesticides, heavy metals, and nutrients (e.g. nitrogen and phosphorous). These pollutants often become suspended in runoff and are carried to receiving waters such as streams, wetlands and rivers. These pollutants can harm aquatic life that inhabit these waters, and threaten human uses as well.

The second type of post-construction runoff impact occurs by increasing the quantity of water delivered to the waterbody during and following storms. Increased impervious surfaces interrupt the natural cycle of gradual percolation of water through vegetation and soil. Instead, water is collected from surfaces such as asphalt and concrete and routed to drainage systems where large volumes of runoff quickly flow to the nearest receiving water. The effects of this process can include streambank scouring, channel incising, and downstream flooding, which can lead to a loss of aquatic life and damage to property.

II. ELEMENTS OF THE POST-CONSTRUCTION STORMWATER MANAGEMENT PROGRAM

The City of Corvallis will develop a Post-Construction Stormwater Management Program generally based on the following EPA guidelines. The text below is taken from the Phase II rule for the Post-Construction Stormwater Management component described in federal code. The rule states :

> The permittee must develop, implement and enforce a program to address stormwater runoff from new development and redevelopment projects that disturb greater than or equal to one acre, including projects less than one acre that are part of a larger common plan of development or sale, that discharge into the permittee's small municipal separate storm sewer system. The permittee's program must ensure that controls are in place that would prevent or minimize water quality impacts.
>
> The permittee must:
>
> A. Develop and implement strategies which include a combination of structural and/or non-structural best management practices (BMPs) appropriate for the permitted community;

B. Use and ordinance or other regulatory mechanism to address post-construction runoff from new development and redevelopment projects to the extent allowable under State, Tribal or local law;

C. Ensure adequate long-term operation and maintenance of BMPs; and

D. Determine the appropriate measurable goals for this minimum control measure.

A. Post-Construction Runoff Control Management and BMPS

1. Stormwater Best Management Practices

Stormwater BMPs are the primary tool used to improve the quality of urban streams and meet the requirements of NPDES permits. BMPs are devices or design considerations that are used to reduce the impacts of development or human activities on water quality. They can include schedules of activities, prohibitions of practices, maintenance procedures, the use of pollution control devices and other management practices or policies used to prevent or reduce the amount of pollution introduced to receiving waters through stormwater runoff. Used individually or in combination, BMPs are intended to be a cost effective, practicable means to reduce pollutants and/or the amount of runoff that reaches receiving waters.

The EPA regulations refer to two categories of BMPs; structural and non-structural. Structural BMPs are physical devices (i.e. "structures") or landscape features that remove pollutants from stormwater runoff through filtration, infiltration, or detention. These controls generally work by capturing and holding a portion of the runoff and releasing it slowly over a sufficient period of time to promote removal of pollutants, resulting in improved water quality. Structural BMPs such as detention ponds, water quality wetlands, and sand filters are traditional techniques that have been used to treat stormwater runoff from developments.

The EPA has compiled a series of structural BMP fact sheets; these are included in Appendix A. The list includes BMPs that the City will consider including in the Post-Construction Stormwater Management Program. BMP suggested by EPA include:

- Dry Extended Detention Ponds
- Wet Ponds
- Stormwater Wetlands
- Infiltration Basin
- Infiltration Trench
- Porous Pavement
- Bioretention
- Sand and Organic Filters

- Grassed Swales
- Grassed Filter Strip
- Catch Basin Insert
- In-line Storage
- Manufactured Products for Stormwater Inlets

Non-structural BMPs are more difficult to define. They are proactive, preventative actions that reduce post-construction impacts on the landscape. They involve re-thinking the way urban environments are planned and designed. Examples include policies and ordinances that maintain or increase open space, protection of sensitive areas such as wetlands, provision of buffers along riparian areas, and minimization of impervious surfaces. These BMPs can include policies or ordinances that encourage infill development in higher density urban areas to reduce overall impacts of development within a landscape, and education programs for developers and the public about project designs that minimize water quality impacts.

EPA fact sheets for non-structural BMPs that the City will consider implementing are also included in Appendix SM-A. The non-structural BMPs include:

- Buffer Zones
- Open Space Design
- Urban Forestry
- Conservation Easements
- Infrastructure Planning
- Narrower Residential Streets
- Eliminating Curbs and Gutters
- Green Parking Alternatives
- Alternative Pavers
- Zoning

2. City of Corvallis Stormwater Master Plan

An effective program for managing post-construction runoff includes options for implementation of BMPs within the context of a comprehensive stormwater management program that addresses multiple impacts of post-construction stormwater runoff.

The City of Corvallis completed a Stormwater Master Plan in September 2002 that provides this context, and represents an integrated approach to managing stormwater quality and quantity. This document is included for reference in Appendix SM-B. The plan addresses post-construction runoff control, and includes a variety of structural and non-structural BMPs. The Stormwater Master Plan addresses stormwater quality issues including pollutants in surface water and the measures to reduce them. It also addresses water quantity management in pre- and post- development scenarios, and how stormwater volume is managed within the Corvallis urban landscape. Recommendations include specific projects, BMPs, operations and maintenance requirements, and policy development that support a unified stormwater management strategy. An implementation plan is also included that establishes two levels of short term and long term programs for stormwater related improvements.

For the purpose of meeting the City's NPDES Phase II permit requirements, post-construction stormwater management BMPs will be implemented when feasible and as resources allow.

B. Post-Construction Runoff Control Regulatory Mechanism

The City will be developing a stormwater regulatory mechanism that will require:

- New and redevelopment projects (where feasible) to implement a combination of BMPs (non-structural and/or structural) designed to reduce stormwater pollution from the respective site or area; and

- New and redevelopment projects (where feasible) to control the peak runoff for a specified range of design storm events from the respective site or area.

The goal of the regulatory mechanism will be to minimize runoff pollution loadings and reduce hydrologic impacts within the landscape as development occurs. The City will consider using elements of an EPA model post-construction stormwater management ordinance when developing the local regulatory mechanism. The EPA model ordinance is included for reference in Appendix SM-C.

C. Stormwater BMP Operation and Maintenance Considerations

The City will include structural BMP operation and maintenance considerations in the Post-Construction Stormwater Management Program. Inspection and enforcement procedures will also be integrated into the program. Potential components include:

- Development submittals to include a plan for operation and maintenance for structural BMPs;

- Plans that contain inspection, operation, and maintenance requirements, and address access and safety issues;

- Vegetation maintenance, sediment removal, floatables removal, mosquito control, and outlet structure maintenance (as applicable per BMP type);

- Operation and maintenance of structural storm water controls following sale or transfer of properties;

- Appropriate frequencies for inspection during construction of stormwater BMPs to ensure proper installation;

- Establishment of procedures for issuance of notices of violation if requirements are not met; and

- Establishment of provisions for correction of violations.

D. Measurable Goals

Measurable goals, which are required for each minimum control measure or Phase II Stormwater Program component, are meant to gauge permit compliance and program effectiveness. Table SM-1, on the following page, includes these measurable goals and an implementation schedule for the first five years of the Post-Construction Stormwater Management in New Development and Redevelopment Program.

Table SM-1. Stormwater Phase II Measurable Goals for Post-Construction Stormwater Management in New Development and Redevelopment Program Implementation Schedule for Five Years

Activities	Year 1	Year 2	Year 3	Year 4	Year 5
Post-Construction Runoff Criteria and Standards	Review existing development criteria and standards.	Gather technical information on post-construction stormwater management.	Initiate review and development of draft criteria and standards for post-construction stormwater management structural BMPs	Complete review and development of draft criteria and standards for post-construction stormwater management structural BMPs.	Implement applicable post-construction stormwater management criteria and standards. Evaluate.
Post-Construction Runoff Regulatory Mechanisms					Develop and implement a regulatory mechanism for maintenance of post-construction stormwater management structural BMPs.
Post-Construction Runoff Control & BMP Education					Create educational materials on post-construction runoff controls, BMPs and regulatory mechanism. Make available to municipal staff and the development/construction community.

Activities	Year 1	Year 2	Year 3	Year 4	Year 5
Permitting and Inspection Program				Conduct an inventory of structural BMPs located within the City.	Create draft operations and maintenance inspection criteria for structural BMPs
Record Keeping					Develop and implement a post-construction project and BMP record keeping procedure.
Post Construction Runoff Management Through Non-Structural BMPs				Coordinate with Community Development Department to review post-construction stormwater management through non-structural BMPs.	Coordinate with Community Development Department to design methods to incorporate post-construction stormwater management non-structural BMPs into development process.

City of Corvallis Stormwater Phase II
Post-Construction Stormwater Management
in New Development and Redevelopment

Appendix SM-A

Post-Construction Stormwater Management in New Development and Redevelopment BMP Fact Sheets

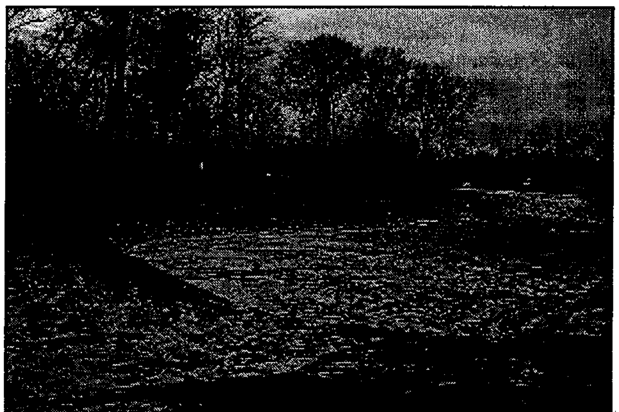
U.S. Environmental Protection Agency

National Pollutant Discharge Elimination System (NPDES)

Post-Construction Storm Water Management in New Development & Redevelopment

Dry Extended Detention Pond

Description



A dry extended detention pond is designed to temporarily detain runoff during storm events

Dry extended detention ponds (a.k.a. dry ponds, extended detention basins, detention ponds, extended detention ponds) are basins whose outlets have been designed to detain the storm water runoff from a water quality design storm for some minimum time (e.g., 24 hours) to allow particles and associated pollutants to settle. Unlike wet ponds, these facilities do not have a large permanent pool. However, they are often designed with small pools at the inlet and outlet of the basin. They can also be used to provide flood control by including additional flood detention storage.

Applicability

Dry extended detention ponds are among the most widely applicable storm water management practices. Although they have limited applicability in highly urbanized settings, they have few other restrictions.

Regional Applicability

Dry extended detention ponds can be applied in all regions of the United States. Some minor design modifications might be needed, however, in cold or arid climates or in regions with karst (i.e. limestone) topography.

Ultra-Urban Areas

Ultra-urban areas are densely developed urban areas in which little pervious surface is present. It is difficult to use dry extended detention ponds in the ultra-urban environment because of the land area each pond consumes. They can, however, be used in an ultra-urban environment if a relatively large area is available downstream of the pond.

Storm Water Hot Spots

Storm water hot spots are areas where land use or activities generate highly contaminated runoff, with concentrations of pollutants in excess of those typically found in storm water. Dry extended detention ponds can accept runoff from storm water hot spots, but they need significant separation from ground water if they will be used for this purpose.

Storm Water Retrofit

A storm water retrofit is a storm water management practice (usually structural) put into place after development has occurred to improve water quality, protect downstream channels, reduce flooding, or meet other specific objectives. Dry extended detention ponds are very useful storm water retrofits, and they have two primary applications as a retrofit design. In many communities in the past, detention basins have been designed for flood control. It is possible to modify these facilities to incorporate features that encourage water quality control and/or channel protection. It is also possible to construct new dry ponds in open areas of a watershed to capture existing drainage.

Cold Water (Trout) Streams

A study in Prince George's County, Maryland, found that storm water management practices can increase stream temperatures (Galli, 1990). Overall, dry extended detention ponds increased temperature by about 5°F. In cold water streams, dry ponds should be designed to detain storm water for a relatively short time (i.e., less than 12 hours) to minimize the amount of warming that occurs in the practice.

Siting and Design Considerations

Siting Considerations

Although dry extended detention ponds can be applied rather broadly, designers need to ensure that they are feasible at the site in question. This section provides basic guidelines for siting dry extended detention ponds.

<u>Drainage Area</u>

In general, dry extended detention ponds should be used on sites with a minimum area of 10 acres. On smaller sites, it can be challenging to provide channel or water quality control because the orifice diameter at the outlet needed to control relatively small storms becomes very small and thus prone to clogging. In addition, it is generally more cost-effective to control larger drainage areas due to the economies of scale (see Cost Considerations).

<u>Slope</u>

Dry extended detention basins can be used on sites with slopes up to about 15 percent. The local slope needs to be relatively flat, however, to maintain reasonably flat side slopes in the practice. There is no minimum slope requirement, but there does need to be enough elevation drop from the pond inlet to the pond outlet to ensure that flow can move through the system.

<u>Soils / Topography</u>

Extended detention basins can be used with almost all soils and geology, with minor design adjustments for regions of karst topography or in rapidly percolating soils such as sand. In these areas, extended detention ponds should be designed with an impermeable liner to prevent ground water contamination or sinkhole formation.

Ground Water

Except for the case of hot spot runoff, the only consideration regarding ground water is that the base of the extended detention facility should not intersect the ground water table. A permanently wet bottom may become a mosquito breeding ground. Research in Southwest Florida (Santana et al., 1994) demonstrated that intermittently flooded systems, such as dry extended detention ponds, produce more mosquitoes than other pond systems, particularly when the facilities remained wet for more than 3 days following heavy rainfall.

Design Considerations

Specific designs may vary considerably, depending on site constraints or preferences of the designer or community. Some features, however, should be incorporated into most dry extended detention pond designs. These design features can be divided into five basic categories: pretreatment, treatment, conveyance, maintenance reduction, and landscaping.

Pretreatment

Pretreatment incorporates design features that help to settle out coarse sediment particles. By removing these particles from runoff before they reach the large permanent pool, the maintenance burden of the pond is reduced. In ponds, pretreatment is achieved with a sediment forebay, which is a small pool (typically about 10 percent of the volume of water to be treated for pollutant removal).

Treatment

Treatment design features help enhance the ability of a storm water management practice to remove pollutants. Designing dry ponds with a high length-to-width ratio (i.e., at least 1.5:1) and incorporating other design features to maximize the flow path effectively increases the detention time in the system by eliminating the potential of flow to short-circuit the pond. Designing ponds with relatively flat side slopes can also help to lengthen the effective flow path. Finally, the pond should be sized to detain the volume of runoff to be treated for between 12 and 48 hours.

Conveyance

Conveyance of storm water runoff into and through a storm water management practice is a critical component of any such practice. Storm water should be conveyed to and from practices safely in a manner that minimizes erosion potential. The outfall of pond systems should always be stabilized to prevent scour. To convey low flows through the system, designers should provide a pilot channel. A pilot channel is a surface channel that should be used to convey low flows through the pond. In addition, an emergency spillway should be provided to safely convey large flood events. To help mitigate warming at the outlet channel, designers should provide shade around the channel at the pond outlet.

Maintenance Reduction

In addition to regular maintenance activities needed to maintain the function of storm water practices, some design features can be incorporated to ease the maintenance burden of each practice. In dry extended detention ponds, a "micropool" at the outlet can prevent resuspension of sediment and outlet clogging. A good design includes maintenance access to the forebay and micropool.

Another design feature that can reduce maintenance needs is a non-clogging outlet. Typical examples include a reverse-slope pipe or a weir outlet with a trash rack. A reverse slope pipe draws from below the permanent pool extending in a reverse angle up to the riser and determines the water elevation of the micropool. Because these outlets draw water from below the level of the permanent pool, they are less likely to be clogged by floating debris.

Landscaping

Designers should maintain a vegetated buffer around the pond and should select plants within the extended detention zone (i.e., the portion of the pond up to the elevation where storm water is detained) that can withstand both wet and dry periods. The side slopes of dry ponds should be relatively flat to reduce safety risks.

Design Variations

Dry Detention Ponds

Dry detention ponds are similar in design to extended detention ponds, except that they do not incorporate features to improve water quality. In particular, these practices do not detain storm water from small-flow events. Therefore, detention ponds provide almost no pollutant removal. However, dry ponds can help to meet flood control, and sometimes channel protection, objectives in a watershed.

Tank Storage

Another variation of the dry detention pond design is the use of tank storage. In these designs, storm water runoff is conveyed to large storage tanks or vaults underground. This practice is most often used in the ultra-urban environment, on small sites where no other opportunity is available to provide flood control. Tank storage is provided on small areas because providing underground storage for a large drainage area would generally be cost-prohibitive. Because the drainage area contributing to tank storage is typically small, the outlet diameter needed to reduce the flow from very small storms would very small. A very small outlet diameter, along with the underground location of the tanks, creates the potential for debris being caught in the outlet and resulting maintenance problems. Since it is necessary to control small runoff events (such as the runoff from a 1-inch storm) to improve water quality, it is generally infeasible to use tank storage for water quality and generally impractical to use it to protect stream channels.

Regional Variations

Arid or Semi-Arid Climates

In arid and semi-arid regions, some modifications might be needed to conserve scarce water resources. Any landscaping plans should prescribe drought-tolerant vegetation wherever possible. In addition, the wet forebay can be replaced with an alternative dry pretreatment, such as a detention cell. One opportunity in regions with a distinct wet and dry season, as in many arid regions, is to use regional extended detention ponds as a recreation area such as a ball field during the dry season.

Cold Climates

In cold climates, some additional design features can help to treat the spring snowmelt. One such modification is to increase the volume available for detention to help treat this relatively large runoff event. In some cases, dry facilities may be an option as a snow storage facility to promote some treatment of plowed snow. If a pond is used to treat road runoff or is used for snow storage, landscaping should incorporate salt-tolerant species. Finally, sediment might need to be removed from the forebay more frequently than in warmer climates (see Maintenance Considerations for guidelines) to account for sediment deposited as a result of road sanding.

Limitations

Although dry extended detention ponds are widely applicable, they have some limitations that might make other storm water management options preferable:

- Dry extended detention ponds have only moderate pollutant removal when compared to other structural storm water practices, and they are ineffective at removing soluble pollutants (See Effectiveness).
- Dry extended detention ponds may become a nuisance due to mosquito breeding.
- Habitat destruction may occur during construction if the practice is designed in-stream or within the stream buffer.
- Although wet ponds can increase property values, dry ponds can actually detract from the value of a home (see Cost Considerations).

Dry extended detention ponds on their own only provide peak flow reduction and do little to control overall runoff volume, which could result in adverse downstream impacts.

Maintenance Considerations

In addition to incorporating features into the pond design to minimize maintenance, some regular maintenance and inspection practices are needed. Table 1 outlines some of these practices.

Table 1. Typical maintenance activities for dry ponds (Source: Modified from WMI, 1997)

Activity	Schedule
• Note erosion of pond banks or bottom	Semiannual inspection
• Inspect for damage to the embankment • Monitor for sediment accumulation in the facility and forebay • Examine to ensure that inlet and outlet devices are free of debris and operational	Annual inspection
• Repair undercut or eroded areas • Mow side slopes • Manage pesticide and nutrients • Remove litter and debris	Standard maintenance
• Seed or sod to restore dead or damaged ground cover	Annual maintenance (as needed)
• Remove sediment from the forebay	5- to 7-year maintenance
• Monitor sediment accumulations, and remove sediment when the pond volume has been	25- to 50-year maintenance

reduced by 25 percent	

Effectiveness

Structural management practices can be used to achieve four broad resource protection goals: flood control, channel protection, ground water recharge, and pollutant removal. Dry extended detention basins can provide flood control and channel protection, as well as some pollutant removal.

Flood Control

One objective of storm water management practices can be to reduce the flood hazard associated with large storm events by reducing the peak flow associated with these storms. Dry extended detention basins can easily be designed for flood control, and this is actually the primary purpose of most extended detention ponds.

Channel Protection

One result of urbanization is the geomorphic changes that occur in response to modified hydrology. Traditionally, dry extended detention basins have provided control of the 2-year storm (i.e., the storm that occurs, on average, once every 2 years) for channel protection. It appears that this control has been relatively ineffective, and recent research suggests that control of a smaller storm might be more appropriate (MacRae, 1996). Slightly modifying the design of dry extended detention basins to reduce the flow of smaller storm events might make them effective tools in reducing downstream erosion.

Pollutant Removal

Dry extended detention basins provide moderate pollutant removal, provided that the design features described in the Siting and Design Considerations section are incorporated. Although they can be effective at removing some pollutants through settling, they are less effective at removing soluble pollutants because of the absence of a permanent pool. A few studies are available on the effectiveness of dry extended detention ponds. Typical removal rates, as reported by Schueler (1997), are as follows:

Total suspended solids: 61%

Total phosphorus: 19%

Total nitrogen: 31%

Nitrate nitrogen: 9%

Metals: 26%–54%

There is considerable variability in the effectiveness of ponds, and it is believed that properly designing and maintaining ponds may help to improve their performance. The siting and design criteria presented in this sheet reflect the best current information and experience to improve the performance of wet ponds. A recent joint project of the American Society of Civil Engineers (ASCE) and the USEPA Office of Water might help to isolate specific design features that can improve performance. The National Storm Water Best Management Practice (BMP) database is a compilation of storm water practices that includes both design information and performance data for various practices. As the database expands, inferences about the extent to which specific design criteria influence pollutant removal may be made. For more information on this database, access the BMP database web page at http://www.bmpdatabase.org EXIT disclaimer.

Cost Considerations

Dry extended detention ponds are the least expensive storm water management practice, on the basis of cost per unit area treated. The construction costs associated with these facilities range considerably. One recent study evaluated the cost of all pond systems (Brown and Schueler, 1997). Adjusting for inflation, the cost of dry extended detention ponds can be estimated with the equation

$C = 12.4V^{0.760}$

where:

C = Construction, design, and permitting cost, and

V = Volume needed to control the 10-year storm (ft^3).

Using this equation, typical construction costs are

$ 41,600 for a 1 acre-foot pond

$ 239,000 for a 10 acre-foot pond

$ 1,380,000 for a 100 acre-foot pond

Interestingly, these costs are generally slightly higher than the cost of wet ponds on a cost per total volume basis. Dry extended detention ponds are generally less expensive on a given site, however, because they are usually smaller than a wet pond design for the same site.

Ponds do not consume a large area compared to the total area treated (typically 2 to 3 percent of the contributing drainage area). It is important to note, however, that each pond is generally large. Other practices, such as filters or swales, may be "squeezed in" on relatively unusable land, but ponds need a relatively large continuous area.

For ponds, the annual cost of routine maintenance is typically estimated at about 3 to 5 percent of the construction cost. Alternatively, a community can estimate the cost of the maintenance activities outlined in the maintenance section. Finally, ponds are long-lived facilities (typically longer than 20 years). Thus, the initial investment into pond systems can be spread over a relatively long time period.

Another economic concern associated with dry ponds is that they might detract slightly from the value of adjacent properties. One study found that dry ponds can actually detract from the perceived value of homes adjacent to a dry pond by between 3 and 10 percent (Emmerling-Dinovo, 1995).

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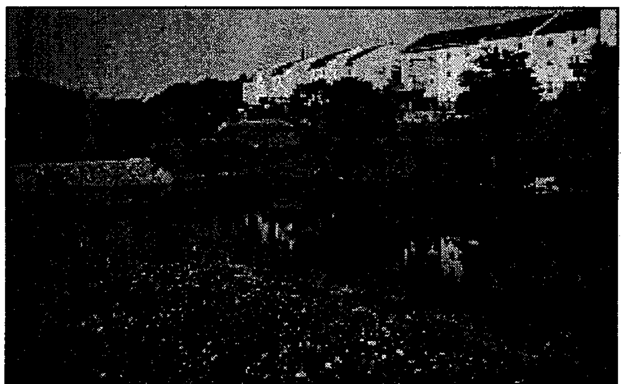
Post-Construction Storm Water Management in New Development & Redevelopment

Wet Ponds

Description



The primary functions of a wet pond are to detain storm water and facilitate pollutant removal through settling and biological uptake

Wet ponds (a.k.a. storm water ponds, retention ponds, wet extended detention ponds) are constructed basins that have a permanent pool of water throughout the year (or at least throughout the wet season). Ponds treat incoming storm water runoff by settling and algal uptake. The primary removal mechanism is settling as storm water runoff resides in this pool, and pollutant uptake, particularly of nutrients, also occurs through biological activity in the pond. Wet ponds are among the most cost-effective and widely used storm water practices. While there are several different versions of the wet pond design, the most common modification is the extended detention wet pond, where storage is provided above the permanent pool in order to detain storm water runoff in order to provide settling.

Applicability

Wet ponds are widely applicable storm water management practices. Although they have limited applicability in highly urbanized settings and in arid climates, they have few other restrictions.

Regional Applicability

Wet extended detention ponds can be applied in most regions of the United States, with the exception of arid climates. In arid regions, it is difficult to justify the supplemental water needed to maintain a permanent pool because of the scarcity of water. Even in semi-arid Austin, Texas, one study found that 2.6 acre-feet per year of supplemental water was needed to maintain a permanent pool of only 0.29 acre-feet (Saunders and Gilroy, 1997). Other modifications and design variations are needed in semi-arid and cold climates, and karst (i.e., limestone) topography.

Ultra-Urban Areas

Ultra-urban areas are densely developed urban areas in which little pervious surface exists. It is difficult to use wet ponds in the ultra-urban environment because of the land area each pond consumes. They can, however, be used in an ultra-urban environment if a relatively large area is available downstream of the site.

Storm Water Hot Spots

Storm water hot spots are areas where land use or activities generate highly contaminated runoff, with concentrations of pollutants in excess of those typically found in storm water. A typical example is a gas station. Wet ponds can accept runoff from storm water hot spots, but need significant separation from ground water if they will be used for this purpose.

Storm Water Retrofit

A storm water retrofit is a storm water management practice (usually structural) put into place after development has occurred, to improve water quality, protect downstream channels, reduce flooding, or meet other specific objectives. Wet ponds are very useful storm water retrofits and have two primary applications as a retrofit design. In many communities, detention ponds have been designed for flood control in the past. It is possible to modify these facilities to develop a permanent wet pool to provide water quality control (see Treatment under Design Considerations), and modify the outlet structure to provide channel protection. Alternatively, wet ponds may be designed in-stream, or in open areas as a part of a retrofit study.

Cold Water (Trout) Streams

Wet ponds pose a risk to cold water systems because of their potential for stream warming. When water remains in the permanent pool, it is heated by the sun. A study in Prince George's County, Maryland, found that storm water wet ponds heat storm water by about 9°F from the inlet to the outlet (Galli, 1990).

Siting and Design Considerations

Siting Considerations

In addition to the restrictions and modifications to adapting wet ponds to different regions and land uses, designers need to ensure that this management practice is feasible at the site in question. The following section provides basic guidelines for siting wet ponds.

<u>Drainage Area</u>

Wet ponds need sufficient drainage area to maintain the permanent pool. In humid regions, this is typically about 25 acres, but a greater area may be needed in regions with less rainfall.

<u>Slope</u>

Wet ponds can be used on sites with an upstream slope up to about 15 percent. The local slope should be relatively shallow, however. Although there is no minimum slope requirement, there does need to be enough elevation drop from the pond inlet to the pond outlet to ensure that water can flow through the system.

Soils / Topography

Wet ponds can be used in almost all soils and geology, with minor design adjustments for regions of karst topography (see Design Considerations).

Ground Water

Unless they receive hot spot runoff, ponds can often intersect the ground water table. However, some research suggests that pollutant removal is reduced when ground water contributes substantially to the pool volume (Schueler, 1997b).

Design Considerations

Specific designs may vary considerably, depending on site constraints or preferences of the designer or community. There are some features, however, that should be incorporated into most wet pond designs. These design features can be divided into five basic categories: pretreatment, treatment, conveyance, maintenance reduction, and landscaping.

Pretreatment

Pretreatment incorporates design features that help to settle out coarse sediment particles. By removing these particles from runoff before they reach the large permanent pool, the maintenance burden of the pond is reduced. In ponds, pretreatment is achieved with a sediment forebay. A sediment forebay is a small pool (typically about 10 percent of the volume of the permanent pool). Coarse particles remain trapped in the forebay, and maintenance is performed on this smaller pool, eliminating the need to dredge the entire pond.

Treatment

Treatment design features help enhance the ability of a storm water management practice to remove pollutants. The purpose of most of these features is to increase the amount of time that storm water remains in the pond.

One technique of increasing the pollutant removal of a pond is to increase the volume of the permanent pool. Typically, ponds are sized to be equal to the water quality volume (i.e., the volume of water treated for pollutant removal). Designers may consider using a larger volume to meet specific watershed objectives, such as phosphorous removal in a lake system. Regardless of the pool size, designers need to conduct a water balance analysis to ensure that sufficient inflow is available to maintain the permanent pool.

Other design features do not increase the volume of a pond, but can increase the amount of time storm water remains in the practice and eliminate short-circuiting. Ponds should always be designed with a length-to-width ratio of at least 1.5:1. In addition, the design should incorporate features to lengthen the flow path through the pond, such as underwater berms designed to create a longer route through the pond. Combining these two measures helps ensure that the entire pond volume is used to treat storm water. Another feature that can improve treatment is to use multiple ponds in series as part of a "treatment train" approach to pollutant removal. This redundant treatment can also help slow the rate of flow through the system.

Conveyance

Storm water should be conveyed to and from all storm water management practices safely and to minimize erosion potential. The outfall of pond systems should always be stabilized to prevent scour. In addition, an emergency spillway should be provided to safely convey large flood events. To help mitigate warming at the outlet channel, designers should provide shade around the channel at the pond outlet.

Maintenance Reduction

In addition to regular maintenance activities needed to maintain the function of storm water practices, some design features can be incorporated to ease the maintenance burden of each practice. In wet ponds, maintenance reduction features include techniques to reduce the amount of maintenance needed, as well as techniques to make regular maintenance activities easier.

One potential maintenance concern in wet ponds is clogging of the outlet. Ponds should be designed with a non-clogging outlet such as a reverse-slope pipe, or a weir outlet with a trash rack. A reverse-slope pipe draws from below the permanent pool extending in a reverse angle up to the riser and establishes the water elevation of the permanent pool. Because these outlets draw water from below the level of the permanent pool, they are less likely to be clogged by floating debris. Another general rule is that no orifice should be less than 3 inches in diameter. (Smaller orifices are more susceptible to clogging).

Design features are also incorporated to ease maintenance of both the forebay and the main pool of ponds. Ponds should be designed with a maintenance access to the forebay to ease this relatively routine (5–7 year) maintenance activity. In addition, ponds should generally have a pond drain to draw down the pond for the more infrequent dredging of the main cell of the pond.

Landscaping

Landscaping of wet ponds can make them an asset to a community and can also enhance the pollutant removal of the practice. A vegetated buffer should be preserved around the pond to protect the banks from erosion and provide some pollutant removal before runoff enters the pond by overland flow. In addition, ponds should incorporate an aquatic bench (i.e., a shallow shelf with wetland plants) around the edge of the pond. This feature may provide some pollutant uptake, and it also helps to stabilize the soil at the edge of the pond and enhance habitat and aesthetic value.

Design Variations

There are several variations of the wet pond design. Some of these design alternatives are intended to make the practice adaptable to various sites and to account for regional constraints and opportunities.

Wet Extended Detention Pond

The wet extended detention pond combines the treatment concepts of the dry extended detention pond and the wet pond. In this design, the water quality volume is split between the permanent pool and detention storage provided above the permanent pool. During storm events, water is detained above the permanent pool and released over 12 to 48 hours. This design has similar pollutant removal to a traditional wet pond and consumes less space. Wet extended detention ponds should be designed to maintain at least half the treatment volume of the permanent pool. In addition, designers need to carefully select vegetation to be planted in the extended detention zone to ensure that the selected vegetation can withstand both wet and dry periods.

Pocket Pond

In this design alternative, a pond drains a smaller area than a traditional wet pond, and the permanent pool is maintained by intercepting the ground water. While this design achieves less pollutant removal than a traditional wet pond, it may be an acceptable alternative on sites where space is at a premium, or in a retrofit situation.

Water Reuse Pond

Some designers have used wet ponds to act as a water source, usually for irrigation. In this case, the water balance should account for the water that will be taken from the pond. One study conducted in Florida estimated that a water reuse pond could provide irrigation for a 100-acre golf course at about one-seventh the cost of the market rate of the equivalent amount of water ($40,000 versus $300,000).

Regional Adaptations

Semi-Arid Climates

In arid climates, wet ponds are not a feasible option (see Applicability), but they may possibly be used in semi-arid climates if the permanent pool is maintained with a supplemental water source, or if the pool is allowed to vary seasonally. This choice needs to be seriously evaluated, however. Saunders and Gilroy (1997) reported that 2.6 acre-feet per year of supplemental water were needed to maintain a permanent pool of only 0.29 acre-feet in Austin, Texas.

Cold Climates

Cold climates present many challenges to designers of wet ponds. The spring snowmelt may have a high pollutant load and a large volume to be treated. In addition, cold winters may cause freezing of the permanent pool or freezing at inlets and outlets. Finally, high salt concentrations in runoff resulting from road salting, and sediment loads from road sanding, may impact pond vegetation as well as reduce the storage and treatment capacity of the pond.

One option to deal with high pollutant loads and runoff volumes during the spring snowmelt is the use of a seasonally operated pond to capture snowmelt during the winter, and retain the permanent pool during warmer seasons. In this option, proposed by Oberts (1994), the pond has two water quality outlets, both equipped with gate valves. In the summer, the lower outlet is closed. During the fall and throughout the winter, the lower outlet is opened to draw down the permanent pool. As the spring melt begins, the lower outlet is closed to provide detention for the melt event. This method can act as a substitute for using a minimum extended detention storage volume. When wetlands preservation is a downstream objective, seasonal manipulation of pond levels may not be desired. An analysis of the effects on downstream hydrology should be conducted before considering this option. In addition, the manipulation of this system requires some labor and vigilance; a careful maintenance agreement should be confirmed.

Several other modifications may help to improve the performance of ponds in cold climates. Designers should consider planting the pond with salt-tolerant vegetation if the facility receives road runoff. In order to counteract the effects of freezing on inlet and outlet structures, the use of inlet and outlet structures that are resistant to frost, including weirs and larger diameter pipes, may be useful. Designing structures on-line, with a continuous flow of water through the pond, will also help prevent freezing of these structures. Finally, since freezing of the permanent pool can reduce the effectiveness of pond systems, it may be useful to incorporate extended detention into the design to retain usable treatment area above the permanent pool when it is frozen.

Karst Topography

In karst (i.e., limestone) topography, wet ponds should be designed with an impermeable liner to prevent ground water contamination or sinkhole formation, and to help maintain the permanent pool.

Limitations

Limitations of wet ponds include:

- If improperly located, wet pond construction may cause loss of wetlands or forest.
- Although wet ponds consume a small amount of space relative to their drainage areas, they are often inappropriate in dense urban areas because each pond is generally quite large.
- Their use is restricted in arid and semi-arid regions due to the need to supplement the permanent pool.
- In cold water streams, wet ponds are not a feasible option due to the potential for stream warming.
- Wet ponds may pose safety hazards.

Maintenance Considerations

In addition to incorporating features into the pond design to minimize maintenance, some regular maintenance and inspection practices are needed. The table below outlines these practices.

Table 1. Typical maintenance activities for wet ponds (Source: WMI, 1997)

Activity	Schedule
• If wetland components are included, inspect for invasive vegetation.	Semi-annual inspection
• Inspect for damage. • Note signs of hydrocarbon build-up, and deal with appropriately. • Monitor for sediment accumulation in the facility and forebay. • Examine to ensure that inlet and outlet devices are free of debris and operational.	Annual inspection
• Repair undercut or eroded areas.	As needed maintenance
• Clean and remove debris from inlet and outlet structures. • Mow side slopes.	Monthly maintenance
• Manage and harvest wetland plants.	Annual maintenance (if needed)
• Remove sediment from the forebay.	5- to 7-year maintenance
• Monitor sediment accumulations, and remove sediment when the pool volume has become reduced significantly or the pond becomes eutrophic.	20-to 50-year maintenance

Effectiveness

Structural storm water management practices can be used to achieve four broad resource protection goals. These include flood control, channel protection, ground water recharge, and pollutant removal. Wet ponds can provide flood control, channel protection, and pollutant removal.

Flood Control

One objective of storm water management practices can be to reduce the flood hazard associated with large storm events by reducing the peak flow associated with these storms. Wet ponds can easily be designed for flood control by providing flood storage above the level of the permanent pool.

Channel Protection

When used for channel protection, wet ponds have traditionally controlled the 2-year storm. It appears that this control has been relatively ineffective, and recent research suggests that control of a smaller storm may be more appropriate (MacRae, 1996).

Ground Water Recharge

Wet ponds cannot provide ground water recharge. Infiltration is impeded by the accumulation of debris on the bottom of the pond.

Pollutant Removal

Wet ponds are among the most effective storm water management practices at removing storm water pollutants. A wide range of research is available to estimate the effectiveness of wet ponds. Table 2 summarizes some of the research completed on wet pond removal efficiency. Typical removal rates, as reported by Schueler (1997a) are:

Total Suspended Solids: 67%

Total Phosphorous: 48%

Total Nitrogen: 31%

Nitrate Nitrogen: 24%

Metals: 24–73%

Bacteria: 65%

Table 2. Wet pond percent removal efficiency data

Wet Pond Removal Efficiencies							
Study	TSS	TP	TN	NO_3	Metals	Bacteria	Practice Type
City of Austin, TX 1991. Woodhollow, TX	54	46	39	45	69–76	46	wet pond
Driscoll 1983. Westleigh, MD	81	54	37	-	26–82	-	wet pond

Dorman et al., 1989. West Pond, MN	65	25	-	61	44–66	-	wet pond
Driscoll, 1983. Waverly Hills, MI	91	79	62	66	57–95	-	wet pond
Driscoll, 1983. Unqua, NY	60	45	-	-	80	86	wet pond
Cullum, 1985. Timber Creek, FL	64	60	15	80	-	-	wet pond
City of Austin, TX 1996. St. Elmo, TX.	92	80	19	-17	2–58	89-91	wet pond
Horner, Guedry, and Kortenhoff, 1990. SR 204, WA	99	91	-	-	88–90	-	wet pond
Horner, Guedry, and Kortenhoff, 1990. Seattle, WA	86.7	78.4	-	-	65–67	-	wet pond
Kantrowitz and Woodham, 1995. Saint Joe's Creek, FL	45	45	-	36	38–82	-	wet pond
Wu, 1989. Runaway Bay, NC	62	36	-	-	32–52	-	wet pond
Driscoll 1983. Pitt-AA, MI	32	18	-	7	13–62	-	wet pond
Bannerman and Dodds, 1992. Monroe Street, WI	90	65	-	-	65–75	70	wet pond
Horner, Guedry, and Kortenhoff, 1990. Mercer, WA	75	67	-	-	23–51	-	wet pond
Oberts, Wotzka, and Hartsoe 1989. McKnight, MN	85	48	30	24	67	-	wet pond
Yousef, Wanielista, and Harper 1986. Maitland, FL	-	-	-	87	77–96	-	wet pond
Wu, 1989. Lakeside Pond, NC	93	45	-	-	80–87	-	wet pond
Oberts, Wotzka, and Hartsoe, 1989. Lake Ridge, MN	90	61	41	10	73	-	wet pond
Driscoll, 1983. Lake Ellyn, IL	84	34	-	-	71-78	-	wet pond
Dorman et al., 1989. I-4, FL	54	69	-	97	47–74	-	wet pond
Martin, 1988. Highway Site, FL	83	37	30	28	50–77	-	wet pond
Driscoll, 1983. Grace Street, MI	32	12	6	-1	26	-	wet pond
Occoquan Watershed Monitoring Laboratory, 1983. Farm Pond, VA	85	86	34	-	-	-	wet pond
Occoquan Watershed Monitoring Laboratory, 1983. Burke, VA	-33.3	39	32	-	38–84	-	wet pond
Dorman et al., 1989. Buckland, CT	61	45	-	22	-25 to -51	-	wet pond
Holler, 1989. Boynton	91	76	-	87	-	-	wet pond

Beach Mall, FL							
Urbonas, Carlson, and Vang 1994. Shop Creek, CO	78	49	-12	-85	51–57	-	wet pond
Oberts and Wotzka, 1988. McCarrons, MN	91	78	85	-	90	-	wet pond
Gain, 1996. FL	54	30	16	24	42–73	-	wet pond
Ontario Ministry of the Environment, 1991. Uplands, Ontario	82	69	-	-	-	97	wet extended detention pond
Borden et al., 1996. Piedmont, NC	19.6	36.5	35.1	65.9	-4 to-97	-6	wet extended detention pond
Holler, 1990. Lake Tohopekaliga District, FL	-	85	-	-	-	-	wet extended detention pond
Ontario Ministry of the Environment 1991. Kennedy-Burnett, Ontario	98	79	54	-	21–39	99	wet extended detention pond
Ontario Ministry of the Environment 1991. East Barrhaven, Ontario	52	47	-	-	-	56	wet extended detention pond
Borden et al., 1996. Davis, NC	60.4	46.2	16	18.2	15–51	48	wet extended detention pond

There is considerable variability in the effectiveness of ponds, and it is believed that properly designing and maintaining ponds may help to improve their performance. The siting and design criteria presented in this sheet reflect the best current information and experience to improve the performance of wet ponds. A recent joint project of the American Society of Civil Engineers (ASCE) and the USEPA Office of Water may help to isolate specific design features that can improve performance. The National Stormwater Best Management Practice (BMP) database is a compilation of storm water practices which includes both design information and performance data for various practices. As the database expands, inferences about the extent to which specific design criteria influence pollutant removal may be made. More information on this database is available from the BMP database web page at www.bmpdatabase.org EXIT disclaimer.

Cost Considerations

Wet ponds are relatively inexpensive storm water practices. The construction costs associated with these facilities range considerably. A recent study (Brown and Schueler, 1997) estimated the cost of a variety of storm water management practices. The study resulted in the following cost equation, adjusting for inflation:

$C = 24.5V^{0.705}$

where:

C = Construction, design and permitting cost;

V = Volume in the pond to include the 10-year storm (ft^3).

Using this equation, typical construction costs are:

$45,700 for a 1 acre-foot facility

$232,000 for a 10 acre-foot facility

$1,170,000 for a 100 acre-foot facility

Ponds do not consume a large area (typically 2–3 percent of the contributing drainage area). Therefore, the land consumed to design the pond will not be very large. It is important to note, however, that these facilities are generally large. Other practices, such as filters or swales, may be "squeezed" into relatively unusable land, but ponds need a relatively large continuous area.

For ponds, the annual cost of routine maintenance is typically estimated at about 3 to 5 percent of the construction cost. Alternatively, a community can estimate the cost of the maintenance activities outlined in the maintenance section. Ponds are long-lived facilities (typically longer than 20 years). Thus, the initial investment into pond systems may be spread over a relatively long time period.

In addition to the water resource protection benefits of wet ponds, there is some evidence to suggest that they may provide an economic benefit by increasing property values. The results of one study suggest that "pond front" property can increase the selling price of new properties by about 10 percent (USEPA, 1995). Another study reported that the perceived value (i.e., the value estimated by residents of a community) of homes was increased by about 15 to 25 percent when located near a wet pond (Emmerling-Dinovo, 1995).

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Post-Construction Storm Water Management in New Development & Redevelopment

Storm Water Wetland

Description


A storm water wetland detains storm water, removes pollutants, and provides habitat and aesthetic benefits (Source: The Bioengineering Group, Inc., no date)

Storm water wetlands (a.k.a. constructed wetlands) are structural practices similar to wet ponds (see Wet Pond fact sheet) that incorporate wetland plants into the design. As storm water runoff flows through the wetland, pollutant removal is achieved through settling and biological uptake within the practice. Wetlands are among the most effective storm water practices in terms of pollutant removal and they also offer aesthetic value. Although natural wetlands can sometimes be used to treat storm water runoff that has been properly pretreated, storm water wetlands are fundamentally different from natural wetland systems. Storm water wetlands are designed specifically for the purpose of treating storm water runoff, and typically have less biodiversity than natural wetlands in terms of both plant and animal life. Several design variations of the storm water wetland exist, each design differing in the relative amounts of shallow and deep water, and dry storage above the wetland.

A distinction should be made between using a constructed wetland for storm water management and diverting storm water into a natural wetland. The latter practice is not recommended because altering the hydrology of the existing wetland with additional storm water can degrade the resource and result in plant die-off and the destruction of wildlife habitat. In all circumstances, natural wetlands should be protected from the adverse effects of development, including impacts from increased storm water runoff. This is especially important because natural wetlands provide storm water and flood control benefits on a regional scale.

Applicability

Constructed wetlands are widely applicable storm water management practices. While they have limited applicability in highly urbanized settings and in arid climates, wetlands have few other restrictions.

Regional Applicability

Storm water wetlands can be applied in most regions of the United States, with the exception of arid climates. In arid and semi-arid climates, it is difficult to design any storm water practice that has a permanent pool. Because storm water wetlands are shallow, a relatively large area is subject to evaporation relative, to the volume of the practice. This makes maintaining the permanent pool in wetlands both more challenging and more important than maintaining the pool of a wet pond (see Wet Pond fact sheet).

Ultra-Urban Areas

Ultra-urban areas are densely developed urban areas in which little pervious surface exists. It is difficult to use wet ponds in the ultra-urban environment because of the land area each wetland consumes. They can, however, be used in an ultra-urban environment if a relatively large area is available downstream of the site.

Storm Water Hot Spots

Storm water hot spots are areas where land use or activities generate highly contaminated runoff, with concentrations of pollutants in excess of those typically found in storm water. A typical example is a gas station. Wetlands can accept runoff from storm water hot spots, but need significant separation from ground water if they will be used for this purpose. Caution also needs to be exercised, if these practices are designed to encourage wildlife use, to ensure that pollutants in storm water runoff do not work their way through the food chain of organisms living in or near the wetland.

Storm Water Retrofit

A storm water retrofit is a storm water management practice (usually structural) put into place after development has occurred, to improve water quality, protect downstream channels, reduce flooding, or meet other specific objectives. When retrofitting an entire watershed, storm water wetlands have the advantage of providing both educational and habitat value. One disadvantage to wetlands, however, is the difficulty of storing large amounts of runoff without consuming a large amount of land. It is also possible to incorporate wetland elements into existing practices, such as wetland plantings (see Wet Pond and Dry Extended Detention Pond fact sheets)

Cold Water (Trout) Streams

Wetlands pose a risk to cold water systems because of their potential for stream warming. When water remains in the permanent pool, it is heated by the sun. A study in Prince George's County, Maryland, investigated the thermal impacts of a wide range of storm water management practices (Galli, 1990). In this study, only one wetland was investigated, which was an extended detention wetland (see Design Variations). The practice increased the average temperature of storm water runoff that flowed through the practice by about 3°F. As a result, it is likely that wetlands increase water temperature.

Siting and Design Considerations

In addition to the broad applicability concerns described above, designers need to consider conditions at the site level. In addition, they need to incorporate design features to improve the longevity and performance of the practice, while minimizing the maintenance burden.

Siting Considerations

In addition to the restrictions and modifications to adapting storm water wetlands to different regions and land uses, designers need to ensure that this management practice is feasible at the site in question. The following section provides basic guidelines for siting wetlands.

Drainage Area

Wetlands need sufficient drainage area to maintain the permanent pool. In humid regions, this is typically about 25 acres, but a greater area may be needed in regions with less rainfall.

Slope

Wetlands can be used on sites with an upstream slope of up to about 15 percent. The local slope should be relatively shallow, however. While there is no minimum slope requirement, there does need to be enough elevation drop from the inlet to the outlet to ensure that hydraulic conveyance by gravity is feasible (generally about 3 to 5 feet).

Soils/Topography

Wetlands can be used in almost all soils and geology, with minor design adjustments for regions of karst (i.e. limestone) topography (see Design Considerations).

Ground Water

Unless they receive hot spot runoff, wetlands can often intersect the ground water table. Some research suggests that pollutant removal is reduced when ground water contributes substantially to the pool volume (Schueler, 1997b). It is assumed that wetlands would have a similar response.

Design Considerations

Specific designs may vary considerably, depending on site constraints or preferences of the designer or community. There are some features, however, that should be incorporated into most wetland designs. These design features can be divided into five basic categories: pretreatment, treatment, conveyance, maintenance reduction, and landscaping.

Pretreatment

Pretreatment incorporates design features that help to settle out coarse sediment particles. By removing these particles from runoff before they reach the large permanent pool, the maintenance burden of the pond is reduced. In wetlands, pretreatment is achieved with a sediment forebay. A sediment forebay is a small pool (typically about 10 percent of the volume of the permanent pool). Coarse particles remain trapped in the forebay, and maintenance is performed on this smaller pool, eliminating the need to dredge the entire pond.

Treatment

Treatment design features help enhance the ability of a storm water management practice to remove pollutants. The purpose of most of these features is to increase the amount of time and flowpath by which storm water remains in the wetland. Some typical design features include

- The surface area of wetlands should be at least 1 percent of the drainage area to the practice.
- Wetlands should have a length-to-width ratio of at least 1.5:1. Making the wetland longer than it is wide helps prevent "short circuiting" of the practice.
- Effective wetland design displays "complex microtopography." In other words, wetlands should have zones of both very shallow (<6 inches) and moderately shallow (<18 inches) wetlands incorporated, using underwater earth berms to create the zones. This design will provide a longer flow path through the wetland to encourage settling, and it provides two depth zones to encourage plant diversity.

Conveyance

Conveyance of storm water runoff into and through a storm water management practice is a critical component of any practice. Storm water should be conveyed to and from practices safely and to minimize erosion potential. The outfall of pond systems should always be stabilized to prevent scour. In addition, an emergency spillway should be provided to safely convey large flood events. To help mitigate warming at the outlet channel, designers should provide shade around the channel at the pond outlet.

Maintenance Reduction

In addition to regular maintenance activities needed to maintain the function of storm water practices, some design features can be incorporated to ease the maintenance burden of each practice. In wetlands, maintenance reduction features include techniques to reduce the amount of maintenance needed, as well as techniques to make regular maintenance activities easier.

One potential maintenance concern in wet ponds is clogging of the outlet. Wetlands should be designed with a nonclogging outlet such as a reverse-slope pipe or a weir outlet with a trash rack. A reverse-slope pipe draws from below the permanent pool extending in a reverse angle up to the riser and establishes the water elevation of the permanent pool. Because these outlets draw water from below the level of the permanent pool, they are less likely to be clogged by floating debris. Another general rule is that no orifice should be less than 3 inches in diameter. Smaller orifices are generally more susceptible to clogging, without specific design considerations to reduce this problem. Another feature that can help reduce the potential for clogging of the outlet is to incorporate a small pool, or "micropool" at the outlet.

Design features are also incorporated to ease maintenance of both the forebay and the main pool of wetlands. Wetlands should be designed with a maintenance access to the forebay to ease this relatively routine (5- to 7-year) maintenance activity. In addition, the permanent pool should have a pond drain to draw down the pond for the more infrequent dredging of the main cell of the wetland.

Landscaping

Landscaping of wetlands can make them an asset to a community and can also enhance the pollutant removal of the practice. In wetland systems, landscaping is an integral part of the design. To ensure the establishment and survival of wetland plants, a landscaping plan should provide detailed information about the plants selected, when they will be planted, and a strategy for maintaining them. The plan should detail wetland plants, as well as vegetation to be established adjacent to the wetland.

A variety of techniques can be used to establish wetland plants. The most effective techniques are the use of nursery stock as dormant rhizomes, live potted plants, and bare rootstock. A "wetland mulch," soil from a natural wetland or a designed "wetland mix," can be used to supplement wetland plantings or alone to establish wetland vegetation. Wetland mulch carries with it the seed bank from the original wetland, and can help to enhance diversity in the wetland. The least expensive option to establish wetlands is to allow the wetland to colonize itself. One disadvantage to this last technique is that invasive species such as cattails or Phragmites may dominate the wetland.

When developing a plan for wetland planting, care needs to be taken to ensure that plants are established in the proper depth and within the planting season. This season varies regionally, and is generally between 2 and 3 months long in the spring to early summer. Plant lists are available for various regions of the United States through wetland nurseries, extension services, and conservation districts.

Design Variations

There are several variations of the wetland design. The designs are characterized by the volume of the wetland in deep pool, high marsh, and low marsh, and whether the design allows for detention of small storms above the wetland surface. Other design variations help to make wetland designs practical in cold climates.

Shallow Marsh

In the shallow marsh design, most of the wetland volume is in the relatively shallow high marsh or low marsh depths. The only deep portions of the shallow wetland design are the forebay at the inlet to the wetland and the micropool at the outlet. One disadvantage to this design is that, since the pool is very shallow, a large amount of land is typically needed to store the water quality volume (i.e., the volume of runoff to be treated in the wetland).

Extended Detention Wetland

This design is the same as the shallow marsh, with additional storage above the surface of the marsh. Storm water is temporarily ponded above the surface in the extended detention zone for between 12 and 24 hours. This design can treat a greater volume of storm water in a smaller space than the shallow wetland design. In the extended detention wetland option, plants that can tolerate wet and dry periods should be specified in the extended detention zone.

Pond/Wetland System

The pond/wetland system combines the wet pond (see Wet Pond fact sheet) design with a shallow marsh. Storm water runoff flows through the wet pond and into the shallow marsh. Like the extended detention wetland, this design requires less surface area than the shallow marsh because some of the volume of the practice is in the relatively deep (i.e., 6–8 feet) pond.

Pocket Wetland

This design is very similar to the pocket pond (see Wet Pond fact sheet). In this design, the bottom of the wetland intersects the ground water, which helps to maintain the permanent pool. Some evidence suggests that ground water flows may reduce the overall effectiveness of storm water management practices (Schueler, 1997b). This option may be used when there is not significant drainage area to maintain a permanent pool.

Gravel-Based Wetlands

In this design, runoff flows through a rock filter with wetland plants at the surface. Pollutants are removed through biological activity on the surface of the rocks, as well as by pollutant uptake of the plants. This practice is fundamentally different from other wetland designs because, while most wetland designs behave like wet ponds with differences in grading and landscaping, gravel-based wetlands are more similar to a filtering system.

Regional Variations

Cold Climates

Cold climates present many challenges to designers of wetlands. During the spring snowmelt, a large volume of water runs off in a short time, carrying a relatively high pollutant load. In addition, cold winter temperatures may cause freezing of the permanent pool or freezing at inlets and outlets. Finally, high salt concentrations in runoff resulting from road salting, as well as sediment loads from road sanding, may impact wetland vegetation.

One of the greatest challenges of storm water wetlands, particularly shallow marshes, is that much of the practice is very shallow. Therefore, much of the volume in the wetland can be lost as the surface of the practice freezes. One study found that the performance of a wetland system was diminished during the spring snowmelt because the outlet and surface of the wetland had frozen. Sediment and pollutants in snowmelt and rainfall events "skated" over the surface of the wetland, depositing at the outlet of the wetland. When the ice melted, this sediment was washed away by storm events (Oberts, 1994). Several design features can help minimize this problem, including:

- "On-line" designs allowing flow to move continuously can help prevent outlets from freezing.
- Wetlands should be designed with multiple cells, with a berm or weir separating each cell. This modification will help to retain storage for treatment above the ice layer during the winter season.
- Outlets that are resistant to freezing should be used. Some examples include weirs or pipes with large diameters.

The salt and sand used to remove ice from roads and parking lots may also create a challenge to designing wetlands in cold climates. When wetlands drain highway runoff, or parking lots, salt-tolerant vegetation, such as pickle weed or cord grass should be used. (Contact a local nursery or extension agency for more information in your region). In addition, designers should consider using a large forebay to capture the sediment from road sanding.

Karst Topography

In karst (i.e., limestone) topography, wetlands should be designed with an impermeable liner to prevent ground water contamination or sinkhole formation, and to help maintain the permanent pool.

Limitations

Some features of storm water wetlands that may make the design challenging include the following:

- Each wetland consumes a relatively large amount of space, making it an impractical option on many sites.
- Improperly designed wetlands can become a breeding area for mosquitoes.
- Wetlands require careful design and planning to ensure that wetland plants are sustained after the practice is in place.
- It is possible that storm water wetlands may release nutrients during the nongrowing season.
- Designers need to ensure that wetlands do not negatively impact natural wetlands or forest during the design phase.
- Wetlands consume a large amount of land. This characteristic may limit their use in areas where land values are high.

Maintenance Considerations

In addition to incorporating features into the wetland design to minimize maintenance, some regular maintenance and inspection practices are needed. Table 1 outlines these practices.

Table 1. Regular maintenance activities for wetlands (Source: Adapted from WMI, 1997, and CWP, 1998)

Activity	Schedule
• Replace wetland vegetation to maintain at least 50% surface area coverage in wetland plants after the second growing season.	One-time
• Inspect for invasive vegetation and remove where possible.	Semi-annual inspection
• Inspect for damage to the embankment and inlet/outlet structures. Repair as necessary. • Note signs of hydrocarbon build-up, and deal with appropriately. • Monitor for sediment accumulation in the facility and forebay. • Examine to ensure that inlet and outlet devices are free of debris and are operational.	Annual inspection
• Repair undercut or eroded areas.	As needed maintenance
• Clean and remove debris from inlet and outlet structures. • Mow side slopes.	Frequent (3–4 times/year) maintenance
• Supplement wetland plants if a significant portion have not established (at least 50% of the surface area). • Harvest wetland plants that have been "choked out" by sediment build-up.	Annual maintenance (if needed)
• Remove sediment from the forebay.	5- to 7-year maintenance
• Monitor sediment accumulations, and remove sediment when the pool volume has become reduced significantly, plants are "choked" with sediment, or the wetland becomes eutrophic.	20- to 50-year maintenance

Effectiveness

Structural storm water management practices can be used to achieve four broad resource protection goals. These include flood control, channel protection, ground water recharge, and pollutant removal. Wetlands can provide flood control, channel protection, and pollutant removal.

Flood Control

One objective of storm water management practices can be to reduce the flood hazard associated with large storm events by reducing the peak flow associated with these storms. Wetlands can easily be designed for flood control by providing flood storage above the level of the permanent pool.

Channel Protection

When used for channel protection, wetlands have traditionally controlled the 2-year storm. It appears that this control has been relatively ineffective, and recent research suggests that control of a smaller storm may be more appropriate (MacRae, 1996).

Ground Water Recharge

Wetlands cannot provide ground water recharge. The build-up of debris at the bottom of the wetland prevents the movement of water into the subsoil.

Pollutant Removal

Wetlands are among the most effective storm water management practices at removing storm water pollutants. A wide range of research is available to estimate the effectiveness of wetlands. Wetlands have high pollutant removal rates, and are more effective than any other practice at removing nitrate and bacteria. Table 2 provides pollutant removal data derived from the Center for Watershed Protections's National Pollutant Removal Database for Stormwater Treatment Practices (Winer, 2000).

Table 2. Typical Pollutant Removal Rates of Wetlands (%) (Winer, 2000)

Pollutant	Stormwater Treatment Practice Design Variation			
	Shallow Marsh	ED Wetland[1]	Pond/Wetland System	Submerged Gravel Wetland[1]
TSS	83±51	69	71±35	83
TP	43±40	39	56±35	64
TN	26±49	56	19±29	19
NOx	73±49	35	40±68	81
Metals	36–85	(-80)–63	0–57	21–83
Bacteria	76[1]	NA	NA	78

[1]Data based on fewer than five data points

The effectiveness of wetlands varies considerably, but many believe that proper design and maintenance might help to improve their performance. The siting and design criteria presented in this sheet reflect the best current information and experience to improve the performance of wetlands. A recent joint project of the American Society of Civil Engineers (ASCE) and the U.S. EPA Office of Water may help to isolate specific design features that can improve performance. The National Stormwater Best Management Practice (BMP) database is a compilation of storm water practices which includes both design information and performance data for various practices. As the database expands, inferences about the extent to which specific design criteria influence pollutant removal may be made. More information on this database is available on the BMP database web page at http://www.bmpdatabase.org EXIT disclaimer.

Cost Considerations

Wetlands are relatively inexpensive storm water practices. Construction cost data for wetlands are rare, but one simplifying assumption is that they are typically about 25 percent more expensive than storm water ponds of an equivalent volume. Using this assumption, an equation developed by Brown and Schueler (1997) to estimate the cost of wet ponds can be modified to estimate the cost of storm water wetlands using the equation:

$C = 30.6V^{0.705}$

where:

C = Construction, design, and permitting cost;

V = Wetland volume needed to control the 10-year storm (ft^3).

Using this equation, typical construction costs are the following:

$ 57,100 for a 1 acre-foot facility

$ 289,000 for a 10 acre-foot facility

$ 1,470,000 for a 100 acre-foot facility

Wetlands consume about 3 to 5 percent of the land that drains to them, which is relatively high compared with other storm water management practices. In areas where land value is high, this may make wetlands an infeasible option.

For wetlands, the annual cost of routine maintenance is typically estimated at about 3 percent to 5 percent of the construction cost. Alternatively, a community can estimate the cost of the maintenance activities outlined in the maintenance section. Wetlands are long-lived facilities (typically longer than 20 years). Thus, the initial investment into these systems may be spread over a relatively long time period.

Although no studies are available on wetlands in particular, there is some evidence to suggest that wet ponds may provide an economic benefit by increasing property values. The results of one study suggest that "pond frontage" property can increase the selling price of new properties by about 10 percent (USEPA, 1995). Another study reported that the perceived value (i.e., the value estimated by residents of a community) of homes was increased by about 15 to 25 percent when located near a wet pond (Emmerling-Dinovo, 1995). It is anticipated that well-designed wetlands, which incorporate additional aesthetic features, would have the same benefit.

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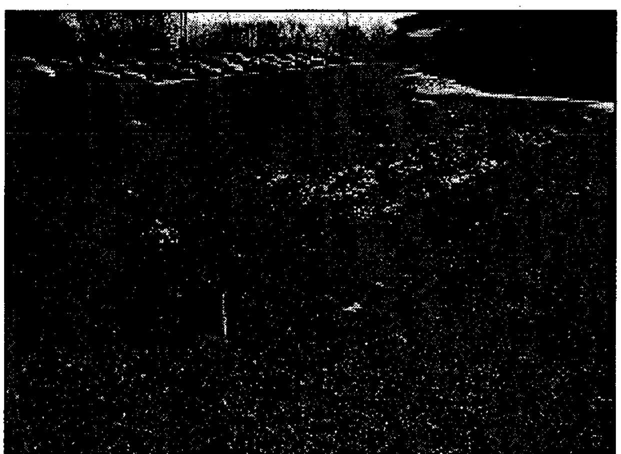
Post-Construction Storm Water Management in New Development & Redevelopment

Infiltration Basin

Description

An infiltration basin is a shallow impoundment which is designed to infiltrate storm water into the ground water. This practice is believed to have a high pollutant removal efficiency and can also help recharge the ground water, thus restoring low flows to stream systems. Infiltration basins can be challenging to apply on many sites, however, because of soils requirements. In addition, some studies have shown relatively high failure rates compared with other management practices.


Infiltration basins are designed to collect storm water from impervious areas and provide pollutant removal benefits through detention and filtration

Applicability

Infiltration basins have select applications. Their use is often sharply restricted by concerns over ground water contamination, soils, and clogging at the site.

Regional Applicability

Infiltration basins can be utilized in most regions of the country, with some design modifications in cold and arid climates. In regions of karst (i.e., limestone) topography, these storm water management practices may not be applied due to concerns of sink hole formation and ground water contamination.

Ultra-Urban Areas

Ultra-urban areas are densely developed urban areas in which little pervious surface exists. In these areas, few storm water practices can be easily applied due to space limitations. Infiltration basins can rarely be applied in the ultra-urban environment.

Two features that can restrict their use are the potential of infiltrated water to interfere with existing infrastructure, and the relatively poor infiltration capacity of most urban soils. In addition, while they consume only the space of the infiltration basin site itself, they need a continuous, relatively flat area. Thus, it is more difficult to fit them into small unusable areas on a site.

Storm Water Hot Spots

A storm water hot spot is an area where land use or activities generate highly contaminated runoff, with concentrations of pollutants in excess of those typically found in storm water. Infiltration basins should never receive runoff from storm water hot spots, unless the storm water has already been treated by another practice. This caution is due to potential ground water contamination.

Storm Water Retrofit

A storm water retrofit is a storm water practice (usually structural) put into place after development has occurred, to improve water quality, protect downstream channels, reduce flooding, or meet other specific objectives. Infiltration basins have limited applications as a storm water retrofit. Their use is restricted by three factors. First, infiltration basins should be used to treat small sites (less than 5 acres). Practices that are applied to small sites, such as infiltration basins, are generally a high-cost retrofit option in terms of construction cost and the maintenance burden associated with the large number of practices needed to retrofit a watershed. Second, it is often difficult to find areas where soils are appropriate for infiltration in an already urban or suburban environment. Finally, infiltration basins are best applied to small sites, yet need a flat, relatively continuous area. It is often difficult to find sites with this type of area available.

Cold Water (Trout) Streams

Infiltration basins are an excellent option for cold water streams because they encourage infiltration of storm water and maintain dry weather flow. Because storm water travels underground to the stream, it has little opportunity to increase in temperature.

Siting and Design Considerations

When designing infiltration basins, designers need to carefully consider both the restrictions on the site and design features to improve the long-term performance of the practice.

Siting Considerations

Infiltration practices need to be located extremely carefully. In particular, designers need to ensure that the soils on the site are appropriate for infiltration, and that designs minimize the potential for ground water contamination and long-term maintenance problems.

<u>Drainage Area</u>

Infiltration basins have historically been used as regional facilities, serving for both quantity and quality control. In some regions of the country, this practice is feasible, particularly if the soils are particularly sandy. In most areas, however, infiltration basins experience high rates of failure when used in this manner. In general, the practice is best applied to relatively small drainage areas (i.e., less than 10 acres).

Slope

The bottom of infiltration basins needs to be completely flat to allow infiltration throughout the entire basin bottom.

Soils/Topography

Soils and topography are strongly limiting factors when locating infiltration practices. Soils must be significantly permeable to ensure that the practice can infiltrate quickly enough to reduce the potential for clogging, and soils that infiltrate too rapidly may not provide sufficient treatment, creating the potential for ground water contamination. The infiltration rate should range between 0.5 and 3 inches per hour. In addition, the soils should have no greater than 20 percent clay content, and less than 40 percent silt/clay content (MDE, 2000). Finally, infiltration basins may not be used in regions of karst topography, due to the potential for sinkhole formation or ground water contamination.

Ground Water

Designers always need to provide significant separation distance (2 to 5 feet) from the bottom of the infiltration basin and the seasonally high ground water table, to reduce the risk of contamination. Infiltration practices should also be separated from drinking water wells.

Design Considerations

Specific designs may vary considerably, depending on site constraints or preferences of the designer or community. There are some features, however, that should be incorporated into most infiltration basin designs. These design features can be divided into five basic categories: pretreatment, treatment, conveyance, maintenance reduction, and landscaping.

Pretreatment

Pretreatment refers to design features that provide settling of large particles before runoff reaches a management practice, easing the long-term maintenance burden. Pretreatment is important for all structural management practices, but it is particularly important for infiltration practices. In order to ensure that pretreatment mechanisms are effective, designers should incorporate "multiple pretreatment," using practices such as grassed swales, sediment basins, and vegetated filter strips in series.

Treatment

Treatment design features enhance the pollutant removal of a practice. For infiltration practices, designers need to stabilize upland soils to ensure that the basin does not become clogged with sediment. In addition, the facility needs to be sized so that the volume of water to be treated infiltrates through the bottom in a given amount of time. Because infiltration basins are designed in this manner, infiltration basins designed on less permeable soils should be significantly larger than those designed on more permeable soils.

Conveyance

Storm water needs to be conveyed through storm water management practices safely and in a way that minimizes erosion. Designers need to be particularly careful in ensuring that channels leading to an infiltration practice are designed to minimize erosion. In general, infiltration basins should be designed to treat only small storms (i.e., only for water quality). Thus, these practices should be designed "off-line," using a flow separator to divert only small flows to the practice.

Maintenance Reduction

In addition to regular maintenance activities, designers also need to incorporate features into the design to ensure that the maintenance burden of a practice is reduced. These features can make regular maintenance activities easier or reduce the need to perform maintenance. In infiltration basins, designers need to provide access to the basin for regular maintenance activities. Where possible, a means to drain the basin, such as an underdrain, should be provided in case the bottom becomes clogged. This feature allows the basin to be drained and accessed for maintenance in the event that the water has ponded in the basin bottom or the soil is saturated.

Landscaping

Landscaping can enhance the aesthetic value of storm water practices or improve their function. In infiltration basins, the most important purpose of vegetation is to reduce the tendency of the practice to clog. Upland drainage needs to be properly stabilized with a thick layer of vegetation, particularly immediately following construction. In addition, providing a thick turf at the basin bottom helps encourage infiltration and prevent the formation of rills in the basin bottom.

Design Variations

Some modifications may be needed to ensure the performance of infiltration basins in arid and cold climates.

Arid or Semi-Arid Climates

In arid regions, infiltration practices are often highly recommended because of the need to recharge the ground water. In arid regions, designers need to emphasize pretreatment even more strongly to ensure that the practice does not clog, because of the high sediment concentrations associated with storm water runoff in areas such as the Southwest. In addition, the basin bottom may be planted with drought-tolerant species and/or covered with an alternative material such as sand or gravel.

Cold Climates

In extremely cold climates (i.e., regions that experience permafrost), infiltration basins may be an infeasible option. In most cold climates, infiltration basins can be a feasible practice, but there are some challenges to its use. First, the practice may become inoperable during some portions of the year when the surface of the basin becomes frozen. Other design features also may be incorporated to deal with the challenges of cold climates. One such challenge is the volume of runoff associated with the spring snowmelt event. The capacity of the infiltration basin might be increased to account for snowmelt volume.

Another option is the use of a seasonably operated facility (Oberts, 1994). A seasonally operated infiltration/detention basin combines several techniques to improve the performance of infiltration practices in cold climates. Two features, the underdrain system and level control valves, are useful in cold climates. These features are used as follows: At the beginning of the winter season, the level control valve is opened and the soil is drained. As the snow begins to melt in the spring, the underdrain and the level control valves are closed. The snowmelt is infiltrated until the capacity of the soil is reached. Then, the facility acts as a detention facility, providing storage for particles to settle.

Other design features can help to minimize problems associated with winter conditions, particularly concerns that chlorides from road salting may contaminate ground water. The basin may be disconnected during the winter to ensure that chlorides do not enter the ground water in areas where this is a problem, or if the basin is used to treat roadside runoff. Designers may also want to reconsider application of infiltration practices on parking lots or roads where deicing is used, unless it is confirmed that the practice will not cause elevated chloride levels in the ground water. If the basin is used for snow storage, or to treat roadside or parking lot runoff, the basin bottom should be planted with salt-tolerant vegetation.

Limitations

Although infiltration basins can be useful practices, they have several limitations. Infiltration basins are not generally aesthetic practices, particularly if they clog. If they clog, the soils become saturated, and the practice can be a source of mosquitoes. In addition, these practices are challenging to apply because of concerns over ground water contamination and sufficient soil infiltration. Finally, maintenance of infiltration practices can be burdensome, and they have a relatively high rate of failure.

Maintenance Considerations

Regular maintenance is critical to the successful operation of infiltration basins (see Table 1). Historically, infiltration basins have had a poor track record. In one study conducted in Prince George's County, Maryland (Galli, 1992), all of the infiltration basins investigated clogged within 2 years. This trend may not be the same in soils with high infiltration rates, however. A study of 23 infiltration basins in the Pacific Northwest showed better long-term performance in an area with highly permeable soils (Hilding, 1996). In this study, few of the infiltration basins had failed after 10 years.

Table 1. Typical maintenance activities for infiltration basins (Source: Modified from WMI, 1997)

Activity	Schedule
• Inspect facility for signs of wetness or damage to structures • Note eroded areas. • If dead or dying grass on the bottom is observed, check to ensure that water percolates 2–3 days following storms. • Note signs of petroleum hydrocarbon contamination and handle properly.	Semi-annual inspection
• Mow and remove litter and debris. • Stabilize of eroded banks. • Repair undercut and eroded areas at inflow and outflow structures.	Standard maintenance (as needed)
• Disc or otherwise aerate bottom. • Dethatch basin bottom.	Annual maintenance
• Scrape bottom and remove sediment. Restore original cross-section and infiltration rate. • Seed or sod to restore ground cover.	5-year maintenance

Effectiveness

Structural management practices can be used to achieve four broad resource protection goals. These include flood control, channel protection, ground water recharge, and pollutant removal. Infiltration basins can provide ground water recharge and pollutant removal.

Ground Water Recharge

Infiltration basins recharge the ground water because runoff is treated for water quality by filtering through the soil and discharging to ground water.

Pollutant Removal

Very little data are available regarding the pollutant removal associated with infiltration basins. It is generally assumed that they have very high pollutant removal because none of the storm water entering the practice remains on the surface. Schueler (1987) estimated pollutant removal for infiltration basins based on data from land disposal of wastewater. The average pollutant removal, assuming the infiltration basin is sized to treat the runoff from a 1-inch storm, is:

TSS 75%

Phosphorous 60–70%

Nitrogen 55–60%

Metals 85–90%

Bacteria 90%

These removal efficiencies assume that the infiltration basin is well designed and maintained. The information in the Siting and Design Considerations and Maintenance Considerations sections represent the best available information on how to properly design these practices. The design references below also provide additional information.

Cost Considerations

Infiltration basins are relatively cost-effective practices because little infrastructure is needed when constructing them. One study estimated the total construction cost at about $2 per ft^3 (adjusted for inflation) of storage for a 0.25-acre basin (SWRPC, 1991). Infiltration basins typically consume about 2 to 3 percent of the site draining to them, which is relatively small. Maintenance costs are estimated at 5 to 10 percent of construction costs.

One cost concern associated with infiltration practices is the maintenance burden and longevity. If improperly maintained, infiltration basins have a high failure rate (see Maintenance Considerations). Thus, it may be necessary to replace the basin after a relatively short period of time.

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Post-Construction Storm Water Management in New Development & Redevelopment

Infiltration Trench

Description

An infiltration trench (a.k.a. infiltration galley) is a rock-filled trench with no outlet that receives storm water runoff. Storm water runoff passes through some combination of pretreatment measures, such as a swale and detention basin, and into the trench. There, runoff is stored in the void space between the stones and infiltrates through the bottom and into the soil matrix. The primary pollutant removal mechanism of this practice is filtering through the soil.

Applicability

Infiltration trenches have select applications. While they can be applied in most regions of the country, their use is sharply restricted by concerns due to common site factors, such as potential ground water contamination, soils, and clogging.

Regional Applicability

Infiltration trenches can be utilized in most regions of the country, with some design modifications in cold and arid climates. In regions of karst (i.e., limestone) topography, these storm water management practices may not be applied due to concerns of sink hole formation and ground water contamination.

Ultra-Urban Areas

Ultra-urban areas are densely developed urban areas in which little pervious surface exists. Infiltration trenches can sometimes be applied in the ultra-urban environment. Two features that can restrict their use are the potential of infiltrated water to interfere with existing infrastructure, and the relatively poor infiltration of most urban soils.

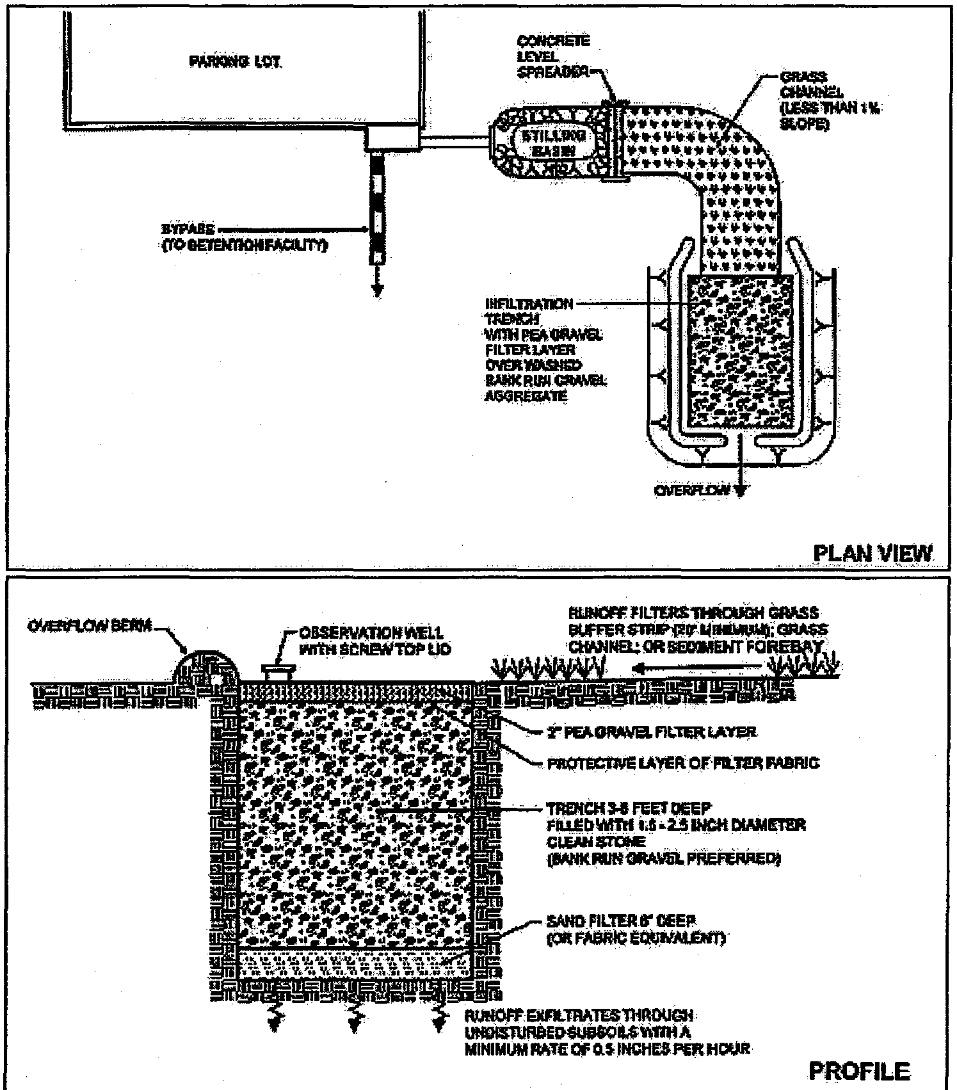
Storm Water Hot Spots

Storm water hot spots are areas where land use or activities generate highly contaminated runoff, with concentrations of pollutants in excess of those typically found in storm water. Infiltration trenches should not receive runoff from storm water hot spots, unless the storm water has already been treated by another storm water management practice, because of potential ground water contamination.

The documents on this site are best viewed with Acrobat 5.0

Siting and Design Considerations

Infiltration trenches have select applications. Although they can be applied in a variety of situations, the use of infiltration trenches is restricted by concerns over ground water contamination, soils, and clogging.



A schematic of an infiltration trench (Source: MDE, 2000)

Siting Considerations

Infiltration practices need to be sited extremely carefully. In particular, designers need to ensure that the soils on site are appropriate for infiltration and that designs minimize the potential for ground water contamination and long-term maintenance.

Drainage Area

Infiltration trenches generally can be applied to relatively small sites (less than 5 acres), with relatively high impervious cover. Application to larger sites generally causes clogging, resulting in a high maintenance burden.

Slope

Infiltration trenches should be placed on flat ground, but the slopes of the site draining to the practice can be as steep as 15 percent.

Soils/Topography

Soils and topography are strongly limiting factors when locating infiltration practices. Soils must be significantly permeable to ensure that the storm water can infiltrate quickly enough to reduce the potential for clogging. In addition, soils that infiltrate too rapidly may not provide sufficient treatment, creating the potential for ground water contamination. The infiltration rate should range between 0.5 and 3 inches per hour. In addition, the soils should have no greater than 20-percent clay content, and less than 40-percent silt/clay content (MDE, 2000). The infiltration rate and textural class of the soil need to be confirmed in the field; designers should not rely on more generic information such as a soil survey. Finally, infiltration trenches may not be used in regions of karst topography, due to the potential for sinkhole formation or ground water contamination.

Ground Water

Designers always need to provide significant separation (2 to 5 feet) from the bottom of the infiltration trench and the seasonally high ground water table, to reduce the risk of contamination. In addition, infiltration practices should be separated from drinking water wells.

Design Considerations

Specific designs may vary considerably, depending on site constraints or preferences of the designer or community. There are some features, however, that should be incorporated into most infiltration trench designs. These design features can be divided into five basic categories: pretreatment, treatment, conveyance, maintenance reduction, and landscaping.

Pretreatment

Pretreatment refers to design features that provide settling of large particles before runoff reaches a management practice, easing the long-term maintenance burden. Pretreatment is important for all structural storm water management practices, but it is particularly important for infiltration practices. To ensure that pretreatment mechanisms are effective, designers should incorporate "multiple pretreatment," using practices such as grassed swales, vegetated filter strips, detention, or a plunge pool in series.

Treatment

Treatment design features enhance the pollutant removal of a practice. During the construction process, the upland soils of infiltration trenches need to be stabilized to ensure that the trench does not become clogged with sediment. Furthermore, the practice should be filled with large clean stones that can retain the volume of water to be treated in their voids. Like infiltration basins, this practice should be sized so that the volume to be treated can infiltrate out of the trench bottom in 24 hours.

Conveyance

Storm water needs to be conveyed through storm water management practices safely, and in a way that minimizes erosion. Designers need to be particularly careful in ensuring that channels leading to an infiltration practice are designed to minimize erosion. Infiltration trenches should be designed to treat only small storms, (i.e., only for water quality). Thus, these practices should be designed "off-line," using a structure to divert only small flows to the practice. Finally, the sides of an infiltration trench should be lined with a geotextile fabric to prevent flow from causing rills along the edge of the practice.

Maintenance Reduction

In addition to regular maintenance activities, designers also need to incorporate features into the design to ensure that the maintenance burden of a practice is reduced. These features can make regular maintenance activities easier or reduce the need to perform maintenance. As with all management practices, infiltration trenches should have an access path for maintenance activities. An observation well (i.e., a perforated PVC pipe that leads to the bottom of the trench) can enable inspectors to monitor the drawdown rate. Where possible, trenches should have a means to drain the practice if it becomes clogged, such as an underdrain. An underdrain is a perforated pipe system in a gravel bed, installed on the bottom of filtering practices to collect and remove filtered runoff. An underdrain pipe with a shutoff valve can be used in an infiltration system to act as an overflow in case of clogging.

Landscaping

In infiltration trenches, there is no landscaping on the practice itself, but it is important to ensure that the upland drainage is properly stabilized with thick vegetation, particularly following construction.

Regional Variations

Arid or Semi-Arid Climates

In arid regions, infiltration practices are often highly recommended because of the need to recharge the ground water. One concern in these regions is the potential of these practices to clog, due to relatively high sediment concentrations in these environments. Pretreatment needs to be more heavily emphasized in these dryer climates.

Cold Climates

In extremely cold climates (i.e., regions that experience permafrost), infiltration trenches may be an infeasible option. In most cold climates, infiltration trenches can be a feasible management practice, but there are some challenges to their use. The volume may need to be increased in order to treat snowmelt. In addition, if the practice is used to treat roadside runoff, it may be desirable to divert flow around the trench in the winter to prevent infiltration of chlorides from road salting, where this is a problem. Finally, a minimum setback from roads is needed to ensure that the practice does not cause frost heaving.

Limitations

Although infiltration trenches can be a useful management practice, they have several limitations. While they do not detract visually from a site, infiltration trenches provide no visual enhancements. Their application is limited due to concerns over ground water contamination and other soils requirements. Finally, maintenance can be burdensome, and infiltration practices have a relatively high rate of failure.

Maintenance Considerations

In addition to incorporating features into the design to minimize maintenance, some regular maintenance and inspection practices are needed. Table 1 outlines some of these practices.

Table 1. Typical maintenance activities for infiltration trenches (Source: Modified from WMI, 1997)

Activity	Schedule
• Check observation wells following 3 days of dry weather. Failure to percolate within this time period indicates clogging. • Inspect pretreatment devices and diversion structures for sediment build-up and structural damage.	Semi-annual inspection
• Remove sediment and oil/grease from pretreatment devices and overflow structures.	Standard maintenance
• If bypass capability is available, it may be possible to regain the infiltration rate in the short term by using measures such as providing an extended dry period.	5-year maintenance
• Total rehabilitation of the trench should be conducted to maintain storage capacity within 2/3 of the design treatment volume and 72-hour exfiltration rate limit. • Trench walls should be excavated to expose clean soil.	Upon failure

Infiltration practices have historically had a high rate of failure compared to other storm water management practices. One study conducted in Prince George's County, Maryland (Galli, 1992), revealed that less than half of the infiltration trenches investigated (of about 50) were still functioning properly, and less than one-third still functioned properly after 5 years. Many of these practices, however, did not incorporate advanced pretreatment. By carefully selecting the location and improving the design features of infiltration practices, their performance should improve.

Effectiveness

Structural storm water management practices can be used to achieve four broad resource protection goals. These include flood control, channel protection, ground water recharge, and pollutant removal. Infiltration trenches can provide ground water recharge, pollutant control, and can help somewhat to provide channel protection.

Ground Water Recharge

Infiltration trenches recharge the ground water because runoff is treated for water quality by filtering through the soil and discharging to ground water.

Pollutant Removal

Very little data are available regarding the pollutant removal associated with infiltration trenches. It is generally assumed that they have very high pollutant removal, because none of the storm water entering the practice remains on the surface. Schueler (1987) estimated pollutant removal for infiltration trenches based on data from land disposal of wastewater. The average pollutant removal, assuming the infiltration trench is sized to treat the runoff from a 1-inch storm, is:

TSS 75%

Phosphorous 60–70%

Nitrogen 55–60%

Metals 85–90%

Bacteria 90%

These removal efficiencies assume that the infiltration trench is well designed and maintained. The information in the Siting and Design Considerations and Maintenance Considerations sections represent the best available information on how to properly design these practices. The design references below provide additional information.

Cost Considerations

Infiltration trenches are somewhat expensive, when compared to other storm water practices, in terms of cost per area treated. Typical construction costs, including contingency and design costs, are about $5 per ft^3 of storm water treated (SWRPC, 1991; Brown and Schueler, 1997).

Infiltration trenches typically consume about 2 to 3 percent of the site draining to them, which is relatively small. In addition, infiltration trenches can fit into thin, linear areas. Thus, they can generally fit into relatively unusable portions of a site.

One cost concern associated with infiltration practices is the maintenance burden and longevity. If improperly maintained, infiltration trenches have a high failure rate (see Maintenance Considerations). In general, maintenance costs for infiltration trenches are estimated at between 5 percent and 20 percent of the construction cost. More realistic values are probably closer to the 20-percent range, to ensure long-term functionality of the practice.

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U.S. Environmental Protection Agency
National Pollutant Discharge Elimination System (NPDES)

Post-Construction Storm Water Management in New Development & Redevelopment

Porous Pavement

Description


A porous pavement parking lot (Source: Invisible Structures, no date)

Porous pavement is a permeable pavement surface with an underlying stone reservoir to temporarily store surface runoff before it infiltrates into the subsoil. This porous surface replaces traditional pavement, allowing parking lot storm water to infiltrate directly and receive water quality treatment. There are a few porous pavement options, including porous asphalt, pervious concrete, and grass pavers. Porous asphalt and pervious concrete appear to be 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 gridded systems with open areas designed to allow grass to grow within the void areas. Other alternative paving surfaces can help reduce the runoff from paved areas but do not incorporate the stone trench for temporary storage below the pavement (see Green Parking fact sheet). While porous pavement has the potential to be a highly effective treatment practice, maintenance has been a concern in past applications of the practice.

Application

The ideal application for porous pavement is to treat low-traffic or overflow parking areas. Porous pavement may also have some application on highways, where it is currently used as a surface material to reduce hydroplaning.

Regional Applicability

Porous pavement can be applied in most regions of the country, but the practice has

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unique challenges in cold climates. 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 as chlorides from road salt may migrate into the ground water. For block pavers, plowing may be challenging because the edge of the snow plow blade can catch the edge of the blocks, damaging the surface. This difficulty does not imply that it is impossible to use porous pavement in cold climates. Another concern in cold climates is that infiltrating runoff below pavement may cause frost heave, although design modifications can reduce this risk. Porous pavement has been used successfully in Norway (Stenmark, 1995), incorporating design features to reduce frost heave. Furthermore, some experience suggests that snow melts faster on a porous surface because of rapid drainage below the snow surface (Cahill Associates, 1993).

Ultra-Urban Areas

Ultra-urban areas are densely developed urban areas in which little pervious surface exists. Porous pavements are a good option in these areas because they consume no space. They are not ideal for high-traffic areas, however, because of the potential for failure due to clogging (Galli, 1992).

Storm Water Hot Spots

Storm water hot spots are areas where land use or activities generate highly contaminated runoff, with concentrations of pollutants in excess of those typically found in storm water. These areas include commercial nurseries, auto recycle facilities, commercial parking lots, fueling stations, storage areas, industrial rooftops, marinas, outdoor container storage of liquids, outdoor loading/unloading facilities, public works storage areas, hazardous materials generators (if containers are exposed to rainfall), vehicle service and maintenance areas, and vehicle and equipment washing/steam cleaning facilities. Since porous pavement is an infiltration practice, it should not be applied on storm water hot spots due to the potential for ground water contamination.

Storm Water Retrofit

A storm water retrofit is a storm water management practice (usually structural) put into place after development has occurred, to improve water quality, protect downstream channels, reduce flooding, or meet other specific objectives. Since porous pavement can only be applied to relatively small sites, using porous pavement as a primary tool for watershed retrofitting would be expensive. The best application of porous pavement for retrofits is on individual sites where a parking lot is being resurfaced.

Cold Water (Trout) Streams

Porous pavement can help to reduce the increased temperature commonly associated with increased impervious cover. Storm water ponds on the surface of conventional pavement, and is subsequently heated by the sun and hot pavement surface. By rapidly infiltrating rainfall, porous pavement reduces the time that storm water is exposed to the sun and heat.

Siting and Design Considerations

Siting Considerations

Porous pavement has the same siting considerations as other infiltration practices (see Infiltration Trench fact sheet). The site needs to meet the following criteria:

- Soils need to have a 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 sited 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 sited on low-traffic or overflow parking areas, which are not sanded for snow removal.

Design Considerations

Some basic features should be incorporated into all porous pavement practices. These design features can be divided into five basic categories: pretreatment, treatment, conveyance, maintenance reduction, and landscaping.

1. *Pretreatment.* In porous pavement designs, the pavement itself acts as pretreatment to the stone reservoir below. Because the surface serves this purpose, frequent maintenance of the surface is critical to prevent clogging. Another pretreatment item can be the incorporation of a fine gravel layer above the coarse gravel treatment reservoir. Both of these pretreatment measures are marginal, which is one reason that these systems have a high failure rate.

2. *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 a water quality storm (i.e., the storm that will be treated for pollutant removal), which can range from 0.5 to 1.5 inches. As in infiltration trenches, water can be stored only in the void spaces of the stone reservoir.

3. *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 use storm drain inlets set slightly above the elevation of the pavement. This would allow for some ponding above the surface, but would bypass flows that are too large to be treated by the system or when the surface clogs.

4. *Maintenance Reduction.* One nonstructural component that can help ensure proper maintenance of porous pavement is the use of a carefully worded maintenance agreement that provides specific guidance, 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.

   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, storm water will flow over the surface and into the trench, where some infiltration and treatment will occur.

5. *Landscaping.* For porous pavement, the most important landscaping feature is a fully stabilized upland drainage. Reducing sediment loads entering the pavement can help to prevent clogging.

Design Variations

In one design variation, the stone reservoir below the filter can also treat runoff from other sources such as rooftop runoff. In this design, pipes are connected to the stone reservoir to direct flow throughout the bottom of the storage reservoir (Cahill Associates, 1993; Schueler, 1987). If used to treat off-site runoff, porous pavement should incorporate pretreatment, as with all structural management practices.

Regional Adaptations

In cold climates, the base of the stone reservoir should be below the frost line. This modification will help to reduce the risk of frost heave.

Limitations

In addition to the relatively strict siting requirements of porous pavement, a major limitation to the practice is the poor success rate it has experienced in the field. Several studies indicate that, with proper maintenance, porous pavement can retain its permeability (e.g., Goforth et al., 1983; Gburek and Urban, 1980; Hossain and Scofield, 1991). When porous pavement has been implemented in communities, however, the failure rate has been as high as 75 percent over 2 years (Galli, 1992).

Maintenance Considerations

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 are shown in Table 1.

Table 1. Typical maintenance activities for porous pavement (Source: WMI, 1997)

Activity	Schedule
• Avoid sealing or repaving with non-porous materials.	N/A
• Ensure that paving area is clean of debris. • Ensure that paving dewaters between storms. • Ensure that the area is clean of sediments.	Monthly
• Mow upland and adjacent areas, and seed bare areas. • Vacuum sweep frequently to keep the surface free of sediment.	As needed (typically three to four times per year).
• Inspect the surface for deterioration or spalling.	Annual

Effectiveness

Porous pavement can be used to provide ground water recharge and to reduce pollutants in storm water runoff. Some data suggest that as much as 70 to 80 percent of annual rainfall will go toward ground water recharge (Gburek and Urban, 1980). These data will vary depending on design characteristics and underlying soils. Two studies have been conducted on the long-term pollutant removal of porous pavement, both in the Washington, DC, area. They suggest high pollutant removal, although it is difficult to extrapolate these results to all applications of the practice. The results of the studies are presented in Table 2.

Table 2. Effectiveness of porous pavement pollutant removal (Schueler, 1987)

	Pollutant Removal (%)				
Study	TSS	TP	TN	COD	Metals
Prince William, VA	82	65	80	-	-

Rockville, MD	95	65	85	82	98–99

Cost Considerations

Porous pavement is significantly more expensive than traditional asphalt. While traditional asphalt is approximately \$0.50 to \$1.00 per ft^2, porous pavement can range from \$2 to \$3 per ft^2, depending on the design (CWP, 1998; Schueler, 1987). Subtracting the cost of traditional pavement, this amounts to approximately \$45,000 and \$100,000 per impervious acre treated, which would be quite expensive. In addition, the cost of vacuum sweeping may be substantial if a community does not already perform vacuum sweeping operations. Finally, the practice life may be very short because the risk of clogging is high.

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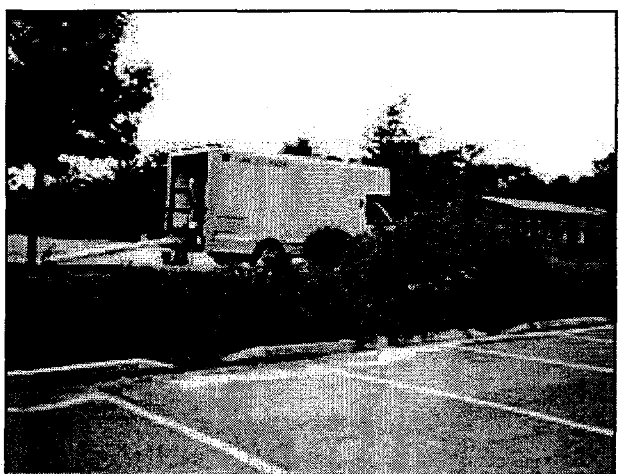
Post-Construction Storm Water Management in New Development & Redevelopment

Bioretention

Description



Bioretention areas can be used in parking areas to collect and treat storm water (Source: University of Maryland, 2000)

Bioretention areas are landscaping features adapted to provide on-site treatment of storm water runoff. They are commonly located in parking lot islands or within small pockets of residential land uses. Surface runoff is directed into shallow, landscaped depressions. These depressions are designed to incorporate many of the pollutant removal mechanisms that operate in forested ecosystems. During storms, runoff ponds above the mulch and soil in the system. Runoff from larger storms is generally diverted past the facility to the storm drain system. The remaining runoff filters through the mulch and prepared soil mix. Typically, the filtered runoff is collected in a perforated underdrain and returned to the storm drain system.

Applicability

Bioretention systems are generally applied to small sites and in a highly urbanized setting. Bioretention can be applied in many climatological and geologic situations, with some minor design modifications.

Regional Applicability

Bioretention systems are applicable almost everywhere in the United States. In arid or cold climates, however, some minor design modifications may be needed.

Ultra-Urban Areas

Ultra-urban areas are densely developed urban areas in which little pervious surface

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exists. Bioretention facilities are ideally suited to many ultra-urban areas, such as parking lots. While they consume a fairly large amount of space (approximately 5 percent of the area that drains to them), they can be fit into existing parking lot islands or other landscaped areas.

Storm Water Hot Spots

Storm water hot spots are areas where land use or activities generate highly contaminated runoff, with concentrations of pollutants in excess of those typically found in storm water. A typical example is a gas station or convenience store parking lot. Bioretention areas can be used to treat storm water hot spots as long as an impermeable liner is used at the bottom of the filter bed.

Storm Water Retrofit

A storm water retrofit is a storm water management practice (usually structural) put into place after development has occurred, to improve water quality, protect downstream channels, reduce flooding, or meet other specific objectives. Bioretention can be used as a storm water retrofit, by modifying existing landscaped areas, or if a parking lot is being resurfaced. In highly urbanized areas, this is one of the few retrofit options that can be employed. However, it is very expensive to retrofit an entire watershed or subwatershed using storm water management practices designed to treat small sites.

Cold Water (Trout) Streams

Some species in cold water streams, notably trout, are extremely sensitive to changes in temperature. In order to protect these resources, designers should avoid treatment practices that increase the temperature of the storm water runoff they treat. Bioretention is a good option in cold water streams because water ponds in them for only a short time, decreasing the potential for stream warming.

Siting and Design Considerations

In addition to the broad applicability concerns described above, designers need to consider conditions at the site level. In addition, they need to incorporate design features to improve the longevity and performance of the practice, while minimizing the maintenance burden.

Siting

Some considerations for selecting a storm water management practice are the drainage area the practice will need to treat, the slopes both at the location of the practice and the drainage area, soil and subsurface conditions, and the depth of the seasonably high ground water table. Bioretention can be applied on many sites, with its primary restriction being the need to apply the practice on small sites.

<u>Drainage Area</u>

Bioretention areas should usually be used on small sites (i.e., 5 acres or less). When used to treat larger areas, they tend to clog. In addition, it is difficult to convey flow from a large area to a bioretention area.

<u>Slope</u>

Bioretention areas are best applied to relatively shallow slopes (usually about 5 percent). However, sufficient slope is needed at the site to ensure that water that enters the bioretention area can be connected with the storm drain system. These storm water management practices are most often applied to parking lots or residential landscaped areas, which generally have shallow slopes.

Soils/Topography

Bioretention areas can be applied in almost any soils or topography, since runoff percolates through a man-made soil bed and is returned to the storm water system.

Ground Water

Bioretention should be separated somewhat from the ground water to ensure that the ground water table never intersects with the bed of the bioretention facility. This design consideration prevents possible ground water contamination.

Design Considerations

Specific designs may vary considerably, depending on site constraints or preferences of the designer or community. There are some features, however, that should be incorporated into most bioretention area designs. These design features can be divided into five basic categories: pretreatment, treatment, conveyance, maintenance reduction, and landscaping.

Pretreatment

Pretreatment refers to features of a management practice that cause coarse sediment particles and their associated pollutants to settle. Incorporating pretreatment helps to reduce the maintenance burden of bioretention and reduces the likelihood that the soil bed will clog over time. Several different mechanisms can be used to provide pretreatment in bioretention facilities. Often, runoff is directed to a grass channel or filter strip to filter out coarse materials before the runoff flows into the filter bed of the bioretention area. Other features may include a pea gravel diaphragm, which acts to spread flow evenly and drop out larger particles.

Treatment

Treatment design features help enhance the ability of a storm water management practice to remove pollutants. Several basic features should be incorporated into bioretention designs to enhance their pollutant removal. The bioretention system should be sized between 5 and 10 percent of the impervious area draining to it. The practice should be designed with a soil bed that is a sand/soil matrix, with a mulch layer above the soil bed. The bioretention area should be designed to pond a small amount of water (6–9 inches) above the filter bed.

Conveyance

Conveyance of storm water runoff into and through a storm water practice is a critical component of any storm water management practice. Storm water should be conveyed to and from practices safely and to minimize erosion potential. Ideally, some storm water treatment can be achieved during conveyance to and from the practice.

Bioretention practices are designed with an underdrain system to collect filtered runoff at the bottom of the filter bed and direct it to the storm drain system. An underdrain is a perforated pipe system in a gravel bed, installed on the bottom of the filter bed. Designers should provide an overflow structure to convey flow from storms that are not treated by the bioretention facility to the storm drain.

Maintenance Reduction

In addition to regular maintenance activities needed to maintain the function of storm water practices, some design features can be incorporated to reduce the required maintenance of a practice. Designers should ensure that the bioretention area is easily accessible for maintenance.

Landscaping

Landscaping is critical to the function and aesthetic value of bioretention areas. It is preferable to plant the area with native vegetation, or plants that provide habitat value, where possible. Another important design feature is to select species that can withstand the hydrologic regime they will experience. At the bottom of the bioretention facility, plants that tolerate both wet and dry conditions are preferable. At the edges, which will remain primarily dry, upland species will be the most resilient. Finally, it is best to select a combination of trees, shrubs, and herbaceous materials.

Design Variations

One design alternative to the traditional bioretention practice is the use of a "partial exfiltration" system, used to promote ground water recharge. Other design modifications may make this practice more effective in arid or cold climates.

Partial Exfiltration

In one design variation of the bioretention system, the underdrain is only installed on part of the bottom of the bioretention system. This design alternative allows for some infiltration, with the underdrain acting as more of an overflow. This system can be applied only when the soils and other characteristics are appropriate for infiltration (see Infiltration Trench and Infiltration Basin).

Arid Climates

In arid climates, bioretention areas should be landscaped with drought-tolerant species.

Cold Climates

In cold climates, bioretention areas can be used as snow storage areas. If used for this purpose, or if used to treat runoff from a parking lot where salt is used as a deicer, the bioretention area should be planted with salt-tolerant, nonwoody plant species.

Limitations

Bioretention areas have a few limitations. Bioretention areas cannot be used to treat a large drainage area, limiting their usefulness for some sites. In addition, although the practice does not consume a large amount of space, incorporating bioretention into a parking lot design may reduce the number of parking spaces available. Finally, the construction cost of bioretention areas is relatively high compared with many other management practices (see Cost Considerations).

Maintenance Considerations

Bioretention requires frequent landscaping maintenance, including measures to ensure that the area is functioning properly, as well as maintenance of the landscaping on the practice. In many cases, bioretention areas initially require intense maintenance, but less maintenance is needed over time. In many cases, maintenance tasks can be completed by a landscaping contractor, who may already be hired at the site.

Table 1. Typical maintenance activities for bioretention areas (Source: ETA and Biohabitats, 1993)

Activity	Schedule
• Remulch void areas • Treat diseased trees and shrubs • Mow turf areas	As needed
• Water plants daily for 2 weeks	At project completion
• Inspect soil and repair eroded areas • Remove litter and debris	Monthly
• Remove and replace dead and diseased vegetation	Twice per year
• Add mulch • Replace tree stakes and wires	Once per year

Effectiveness

Structural storm water management practices can be used to achieve four broad resource protection goals. These include flood control, channel protection, ground water recharge, and pollutant removal. In general, bioretention areas can provide only pollutant removal.

Flood Control

Bioretention areas are not designed to provide flood control. These larger flows must be diverted to a detention pond that can provide flood peak reduction.

Channel Protection

Bioretention areas are generally not designed to provide channel protection because at the scale at which they are typically installed they are not able to infiltrate large volumes. (They are typically designed to treat and infiltrate the first inch of runoff and are bypassed by larger flows that can erode channels.) Channel protection must be provided by other means, such as ponds or other volume control practices.

Ground Water Recharge

Bioretention areas do not usually recharge the ground water, except in the case of the partial exfiltration design (see Design Variations).

Pollutant Removal

Little pollutant removal data have been collected on the pollutant removal effectiveness of bioretention areas. A field and laboratory analysis of bioretention facilities conducted by Davis et al. (1997), showed very high removal rates (roughly 95 percent for copper, 98 percent for phosphorus, 20 percent for nitrate, and 50 percent for total Kjeldhal nitrogen (TKN). Table 2 shows data from two other studies of field bioretention sites in Maryland.

Table 2. Pollutant removal effectiveness of two bioretention areas in Maryland (USEPA, 2000).

Pollutant	Pollutant Removal
Copper	43%–97%
Lead	70%–95%
Zinc	64%–95%
Phosphorus	65%–87%
TKN	52–67%
NH_4^+	92%
NO_3^-	15%–16%
Total nitrogen (TN)	49%
Calcium	27%

Assuming that bioretention systems behave similarly to swales, their removal rates are relatively high. The negative removal rate for bacteria may reflect sampling errors, such as failure to account for bacterial sources in the practice. Alternatively, these data may be the result of bacteria reproduction in the moist soils of swale systems.

There is considerable variability in the effectiveness of bioretention areas, and it is believed that properly designing and maintaining these areas may help to improve their performance. The siting and design criteria presented in this sheet reflect the best current information and experience to improve the performance of bioretention areas. A recent joint project of the American Society of Civil Engineers (ASCE) and the EPA Office of Water may help to isolate specific design features that can improve performance. The National Stormwater Best Management Practice (BMP) database is a compilation of storm water practices which includes both design information and performance data for various practices. As the database expands, inferences about the extent to which specific design criteria influence pollutant removal might be made. More information on this database is accessible on the BMP database web page at http://www.bmpdatabase.org EXIT disclaimer.

Cost Considerations

Bioretention areas are relatively expensive. A recent study (Brown and Schueler, 1997) estimated the cost of a variety of storm water management practices. The study resulted in the following cost equation for bioretention areas, adjusting for inflation:

$C = 7.30\ V^{0.99}$

where:

C = Construction, design, and permitting cost ($); and

V = Volume of water treated by the facility (ft^3).

An important consideration when evaluating the costs of bioretention is that this practice replaces an area that most likely would have been landscaped. Thus, the true cost of the practice is less than the construction cost reported. Similarly, maintenance activities conducted on bioretention areas are not very different from maintenance of a landscaped area. The land consumed by bioretention areas is relatively high compared with other practices (about 5 percent of the drainage area). Again, this area should not necessarily be considered lost, since the practice may only be slightly larger than a traditional landscaped area. Finally, bioretention areas can improve upon existing landscaping and can therefore be an aesthetic benefit.

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Post-Construction Storm Water Management in New Development & Redevelopment

Sand and Organic Filters

Description

Sand filters are usually two-chambered storm water practices; the first is a settling chamber, and the second is a filter bed filled with sand or another filtering media. As storm water flows into the first chamber, large particles settle out, and then finer particles and other pollutants are removed as storm water flows through the filtering medium. There are several modifications of the basic sand filter design, including the surface sand filter, underground sand filter, perimeter sand filter, organic media filter, and Multi-Chamber Treatment Train. All of these filtering practices operate on the same basic principle. Modifications to the traditional surface sand filter were made primarily to fit sand filters into more challenging design sites (e.g., underground and perimeter filters) or to improve pollutant removal (e.g., organic media filter).

Applicability

Sand filters can be applied in most regions of the country and on most types of sites. Some restrictions at the site level, however, might restrict the use of sand filters as a storm water management practice (see Siting and Design Considerations).

Regional Applicability

Although sand filters can be used in both cold and arid climates, some design modifications might be necessary (See Siting and Design Considerations).

Ultra-Urban Areas

Ultra-urban areas are densely developed urban areas in which little pervious surface is present. Sand filters in general are good options in these areas because they consume little space. Underground and perimeter sand filters in particular are well suited to the ultra-urban setting because they consume no surface space.

Storm Water Hot Spots

Storm water hot spots are areas where land use or activities generate highly contaminated runoff, with concentrations of pollutants in excess of those typically found in storm water. These areas include commercial nurseries, auto recycle facilities, commercial parking lots, fueling stations, storage areas, industrial rooftops, marinas, outdoor container storage of liquids, outdoor loading/unloading facilities, public works storage areas, hazardous materials generators (if containers are exposed to rainfall), vehicle service and maintenance areas, and vehicle and equipment washing/steam cleaning facilities. Sand filters are an excellent option to treat runoff from storm water hot spots because storm water treated by sand filters has no interaction with, and thus no potential to contaminate, the groundwater.

Storm Water Retrofit

A storm water retrofit is a storm water management practice (usually structural) put into place after development has occurred to improve water quality, protect downstream channels, reduce flooding, or meet other specific objectives. Sand filters are a good option to achieve water quality goals in retrofit studies where space is limited because they consume very little surface space and have few site restrictions. It is important to note, however, that sand filters cannot treat a very large drainage area. Using small-site BMPs in a retrofit may be the only option for a retrofit study in a highly urbanized area, but it is expensive to treat the drainage area of an entire watershed using many small-site practices, as opposed to one larger facility such as a pond.

Cold Water (Trout) Streams

Some species in cold water streams, notably trout, are extremely sensitive to changes in temperature. To protect these resources, designers should avoid treatment practices that increase the temperature of the storm water runoff they treat. Sand filters can be a good treatment option for cold water streams. In some storm water treatment practices, particularly wet ponds, runoff is warmed by the sun as it resides in the permanent pool. Surface sand filters are typically not designed with a permanent pool, although there is ponding in the sedimentation chamber and above the sand filter. Designers may consider shortening the detention time in cold water watersheds. Underground and perimeter sand filter designs have little potential for warming because these practices are not exposed to the sun.

Siting and Design Considerations

In addition to the broad applicability issues described above, designers need to consider conditions at the site level and need to incorporate design features to improve the longevity and performance of the practice, while minimizing the maintenance burden.

Siting Considerations

Some considerations when selecting a storm water management practice are the drainage area the practice will need to treat, the slopes both at the location of the practice and draining to it, soil and subsurface conditions, and the depth of the seasonably high ground water table. Although sand filters are relatively versatile, some site restrictions such as available head might limit their use.

<u>Drainage Area</u>

Sand filters are best applied on relatively small sites (up to 10 acres for surface sand filters and closer to 2 acres for perimeter or underground filters [MDE, 2000]). Filters have been used on larger drainage areas, of up to 100 acres, but these systems can clog when they treat larger drainage areas unless adequate measures are provided to prevent clogging, such as a larger sedimentation chamber or more intensive regular maintenance.

Slope

Sand filters can be used on sites with slopes up to about 6 percent. It is challenging to use most sand filters in very flat terrain because they require a significant amount of elevation drop, or head (about 5 to 8 feet), to allow flow through the system. One exception is the perimeter sand filter, which can be applied with as little as 2 feet of head.

Soils/Topography

When sand filters are designed as a stand-alone practice, they can be used on almost any soil because they can be designed so that storm water never infiltrates into the soil or interacts with the ground water. Alternatively, sand filters can be designed as pretreatment for an infiltration practice, where soils do play a role.

Ground Water

Designers should provide at least 2 feet of separation between the bottom of the filter and the seasonally high ground water table. This design feature prevents both structural damage to the filter and possibly, though unlikely, ground water contamination.

Design Considerations

Specific designs may vary considerably, depending on site constraints or preferences of the designer or community. Some features, however, should be incorporated into most designs. These design features can be divided into five basic categories: pretreatment, treatment, conveyance, maintenance reduction, and landscaping.

Pretreatment

Pretreatment is a critical component of any storm water management practice. In sand filters, pretreatment is achieved in the sedimentation chamber that precedes the filter bed. In this chamber, the coarsest particles settle out and thus do not reach the filter bed. Pretreatment reduces the maintenance burden of sand filters by reducing the potential of these sediments to clog the filter. Designers should provide at least 25 percent of the water quality volume in a dry or wet sedimentation chamber as pretreatment to the filter system. The water quality volume is the amount of runoff that will be treated for pollutant removal in the practice. Typical water quality volumes are the runoff from a 1-inch storm or ½ inch of runoff over the entire drainage area to the practice.

The area of the sedimentation chamber may be determined based on the Camp-Hazen equation, as adapted by the Washington State Department of Ecology (Washington State DOE, 1992). This equation can be expressed as:

$A_s = (Q_o/W) \mathit{ln}(1-E)$

where:

A_s = surface area (ft^2);

Q_o = discharge rate from basin (water quality volume/detention time);

W = particle settling velocity (ft/s);

[CWP (1996) used a settling of 0.0004 ft/s for drainage areas greater than 75% impervious and 0.0033 ft/s for drainage areas less than or equal to 75% impervious to account for the finer particles that erode from pervious surfaces.]

E = removal efficiency fraction (usually assumed to be about 0.9(90%)).

Using the simplifying assumption of a 24-hour detention time, CWP (1996) reduced the above equation to

A_s = 0.066WTV (>75%)

A_s = 0.0081WTV (< or = 75%)

where

WTV = water quality volume (ft^3), or the volume of storm water to be treated by the practice.

Treatment

Treatment design features help enhance the ability of a storm water management practice to remove pollutants. In filtering systems, designers should provide at least 75 percent of the water quality volume in the practice (including both the sand chamber and the sediment chamber). In sand filters, designers should select a medium sand as the filtering medium.

The filter bed should be sized using Darcy's Law, which relates the velocity of fluids to the hydraulic head and the coefficient of permeability of a medium. The resulting equation, as derived by the city of Austin, Texas, (1996), is

AF = WTV d/[k t (h+d)]

where

AF = area of the filter bed (ft^2);

d = depth of the filter bed (ft; usually about 1.5 feet, depending on the design);

k = coefficient of permeability of the filtering medium (ft/day);

t = time for the water quality volume to filter through the system (days; usually assumed to be 1.67 days); and

h = average water height above the sand bed (ft; assumed to be one-half of the maximum head).

Typical values for k, as assembled by CWP (1996), are shown in Table 1.

Table 1: Coefficient of permeability values for storm water filtering practices (CWP, 1996)

Filter Medium	Coefficient of Permeability (ft/day)
Sand	3.5

Peat/Sand	2.75
Compost	8.7

Conveyance

Conveyance of storm water runoff into and through a storm water practice is a critical component of any storm water management practice. Storm water should be conveyed to and from practices safely and in a manner that minimizes erosion potential. Ideally, some storm water treatment can be achieved during conveyance to and from the practice.

Typically, filtering practices are designed as "off-line" systems, meaning that they have the smaller water quality volume diverted to them only during larger storms, using a flow splitter, which is a structure that bypasses larger flows to the storm drain system or to a stabilized channel. One exception is the perimeter filter; in this design, all flows enter the system, but larger flows overflow to an outlet chamber and are not treated by the practice.

All filtering practices, with the exception of exfilter designs (see Design Variations) are designed with an under drain below the filtering bed. An under drain is a perforated pipe system in a gravel bed, installed on the bottom of filtering practices and used to collect and remove filtered runoff.

Maintenance Reduction

In addition to regular maintenance activities needed to maintain the function of storm water practices, some design features can be incorporated to ease the maintenance burden of each practice. Designers should provide maintenance access to filtering systems. In underground sand filters, confined space rules defined by the Occupational Safety and Health Administration (OSHA) need to be addressed.

Landscaping

Landscaping can add to both the aesthetic value and the treatment ability of storm water practices. In sand filters, little landscaping is generally used on the practice, although surface sand filters and organic media filters may be designed with a grass cover on the surface of the filter. In all filters, designers need to ensure that the contributing drainage has dense vegetation to reduce sediment loads to the practice.

Design Variations

As mentioned earlier in this fact sheet, there are five basic storm water filter designs--surface sand filter, underground filter, perimeter filter (also known as the "Delaware" filter), organic media filter, and Multi-Chamber Treatment Train. Other design variations can incorporate design features to recharge ground water or to meet the design challenges of cold or arid climates.

Surface Sand Filter

The surface sand filter is the original sand filter design. In this practice both the filter bed and the sediment chamber are aboveground. The surface sand filter is designed as an off-line practice, where only the water quality volume is directed to the filter. The surface sand filter is the least expensive filter option and has been the most widely used.

Underground Sand Filter

The underground sand filter is a modification of the surface sand filter, where all of the filter components are underground. Like the surface sand filter, this practice is an off-line system that receives only the smaller water quality events. Underground sand filters are expensive to construct but consume very little space. They are well suited to highly urbanized areas.

Perimeter Sand Filter

The perimeter sand filter also includes the basic design elements of a sediment chamber and a filter bed. In this design, however, flow enters the system through grates, usually at the edge of a parking lot. The perimeter sand filter is the only filtering option that is on-line, with all flows entering the system but larger events bypassing treatment by entering an overflow chamber. One major advantage to the perimeter sand filter design is that it requires little hydraulic head and thus is a good option in areas of low relief.

Organic Media Filter

Organic media filters are essentially the same as surface filters, with the sand medium replaced with or supplemented by another medium. Two examples are the peat/sand filter (Galli, 1990) and the compost filter system (CSF, 1996). The assumption is that these systems will have enhanced pollutant removal for many compounds because of the increased cation exchange capacity achieved by increasing the organic matter.

Multi-Chamber Treatment Train

The Multi-Chamber Treatment Train (Robertson et al., 1995) is essentially a "deluxe sand filter." This underground system consists of three chambers. Storm water enters into the first chamber, where screening occurs, trapping large sediments and releasing highly volatile materials. The second chamber provides settling of fine sediments and further removal of volatile compounds and also floatable hydrocarbons through the use of fine bubble diffusers and sorbent pads. The final chamber provides filtration by using a sand and peat mixed medium for reduction of the remaining pollutants. The top of the filter is covered by a filter fabric that evenly distributes the water volume and prevents channelization. Although this practice can achieve very high pollutant removal rates, it might be prohibitively expensive in many areas and has been implemented only on an experimental basis.

Exfiltration/Partial Exfiltration

In exfilter designs, all or part of the under drain system is replaced with an open bottom that allows infiltration to the ground water. When the under drain is present, it is used as an overflow device in case the filter becomes clogged. These designs are best applied in the same soils where infiltration practices are used (see Infiltration Basin and Infiltration Trench fact sheets).

Regional Variations

Arid Climates

Filters have not been widely used in arid climates. In these climates, however, it is probably necessary to increase storage in the sediment chamber to account for high sediment loads. Designers should consider increasing the volume of the sediment chamber to up to 40 percent of the water quality volume.

Cold Climates

In cold climates, filters can be used, but surface or perimeter filters will not be effective during the winter months, and unintended consequences might result from a frozen filter bed. Using alternative conveyance measures such as a weir system between the sediment chamber and filter bed may avoid freezing associated with the traditional standpipe. Where possible, the filter bed should be below the frost line. Some filters, such as the peat/sand filter, should be shut down during the winter. These media will become completely impervious during freezing conditions. Using a larger under drain system to encourage rapid draining during the winter months may prevent freezing of the filter bed. Finally, the sediment chamber should be larger in cold climates to account for road sanding (up to 40 percent of the water quality volume).

Limitations

Sand filters can be used in unique conditions where many other storm water management practices are inappropriate, such as in karst (i.e., limestone) topography or in highly urbanized settings. There are several limitations to these practices, however. Sand filters cannot control floods and generally are not designed to protect stream channels from erosion or to recharge the ground water. In addition, sand filters require frequent maintenance, and underground and perimeter versions of these practices are easily forgotten because they are out of sight. Perhaps one of the greatest limitations to sand filters is that they cannot be used to treat large drainage areas. Finally, surface sand filters are generally not aesthetically pleasing management practices. Underground and perimeter sand filters are not visible, and thus do not add or detract from the aesthetic value of a site.

Maintenance Considerations

Intense and frequent maintenance and inspection practices are needed for filter systems. Table 2 outlines some of these requirements.

Table 2: Typical maintenance/inspection activities for filtration systems (Adapted from WMI, 1997; CWP, 1997)

Activity	Schedule
• Ensure that contributing area, filtering practice, inlets, and outlets are clear of debris. • Ensure that the contributing area is stabilized and mowed, with clippings removed. • Check to ensure that the filter surface is not clogging (also after moderate and major storms). • Ensure that activities in the drainage area minimize oil/grease and sediment entry to the system. • If a permanent pool is present, ensure that the chamber does not leak and that normal pool level is retained.	Monthly
• Replace sorbent pillows (Multi-Chamber Treatment Train only).	Biannual
• Check to see that the filter bed is clean of sediments, and the sediment chamber is no more than one-half full of sediment. Remove sediment if necessary. • Make sure that there is no evidence of deterioration, sailing, or cracking of concrete. • Inspect grates (if used). • Inspect inlets, outlets, and overflow spillway to ensure good condition and no evidence of erosion.	Annual

• Repair or replace any damaged structural parts. • Stabilize any eroded areas. • Ensure that flow is not bypassing the facility. • Ensure that no noticeable odors are detected outside the facility.	

Effectiveness

Structural storm water management practices can be used to achieve four broad resource protection goals: flood control, channel protection, ground water recharge, and pollutant removal. Filtering practices are for the most part adapted only to provide pollutant removal.

Ground Water Recharge

In exfilter designs, some ground water recharge can be provided; however, none of the other sand filter designs can provide recharge.

Pollutant Removal

Sand filters are effective storm water management practices for pollutant removal. Removal rates for all sand filters and organic filters are presented in Table 3. With the exception of nitrates, which appear to be exported from filtering systems, they perform relatively well at removing pollutants. The export of nitrates from filters may be caused by mineralization of organic nitrogen in the filter bed. Table 3 shows typical removal efficiencies for sand filters.

Table 3: Sand filter removal efficiencies (percent)

	Sand Filters (Schueler, 1997)	Peat/Sand Filter (Curran, 1996)	Compost Filter System		Multi-Chamber Treatment Train		
			Stewart, 1992	Leif, 1999	Pitt et al., 1997	Pitt, 1996	Greb et al., 1998
TSS	87	66	95	85	85	83	98
TP	51	51	41	4	80	-	84
TN	44	47	-	-	-	-	-
Nitrate	-13	22	-34	-95	-	14	-
Metals	34-80	26-75	61-88	44-75	65-90	91-100	83-89
Bacteria	55	-	-	-	-	-	-

From the few studies available, it is difficult to determine if organic filters necessarily have higher removal efficiencies than sand filters. The Multi-Chamber Treatment Train appears to have high pollutant removal for some constituents, although these data are based on only a handful of studies. The siting and design criteria presented in this fact sheet reflect the best current information and experience to improve the performance of sand filters. A recent joint project of the American Society of Civil Engineers (ASCE) and the U.S. EPA Office of Water may help to isolate specific design features that can improve performance. The National Stormwater Best Management Practice (BMP) database is a compilation of storm water practices that includes both design information and performance data for various practices. As the database expands, inferences about the extent to which specific design criteria influence pollutant removal may be made. For more information on this database, access the BMP database web page at http://www.bmpdatabase.org

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Cost Considerations

There are few consistent data on the cost of sand filters, largely because, with the exception of Austin, Texas, Alexandria, Virginia, and Washington, D.C., they have not been widely used. Furthermore, filters have such varied designs that it is difficult to assign a cost to filters in general. A study by Brown and Schueler (1997) was unable to find a statistically valid relationship between the volume of water treated in a filter and the cost of the practice, but typical total cost of installation ranged between \$2.50 and \$7.50 per cubic foot of storm water treated, with an average cost of about \$5 per cubic foot. (This estimate includes approximately 25 percent contingency costs beyond the construction costs reported). The cost per impervious acre treated varies considerably depending on the region and design used (see Table 4). It is important to note that, although underground and perimeter sand filters can be more expensive than surface sand filters, they consume no surface space, making them a relatively cost-effective practice in ultra-urban areas where land is at a premium.

Table 4: Construction costs for various sand filters (Source: Schueler, 1994)

Region (Design)	Cost/Impervious Acre
Delaware (Perimeter)	\$10,000
Alexandria, VA (Perimeter)	\$23,500
Austin, TX (<2 acres) (Surface)	\$16,000
Austin, TX (>5 acres) (Surface)	\$3,400
Washington, DC (underground)	\$14,000
Denver, CO	\$30,000–\$50,000
Multi-Chamber Treatment Train	\$40,000–\$80,000

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Appendix I. Filter removal efficiency data

Filter Removal Efficiencies

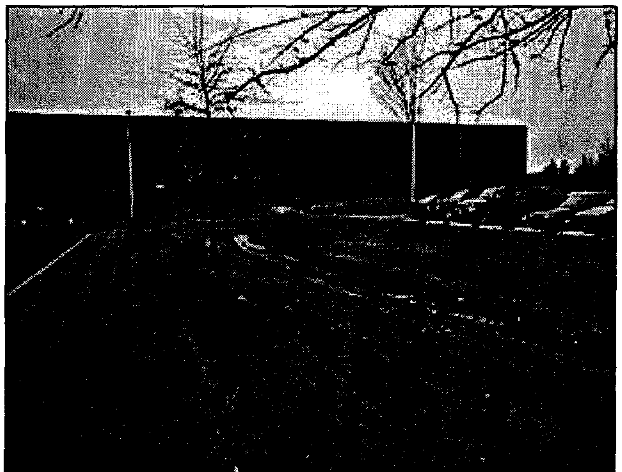
Study	TSS	TP	TN	NO_3	Metals	Bacteria	Practice Type
Bell et al., 1995	79	65.5	47	-53.3	25–91	-	perimeter sand filter
Horner and Horner, 1995	83	46.3	-	-	22–33	-	perimeter sand filter
Horner and Horner, 1995	8	20	-	-	31–69	-	perimeter sand filter
Harper and Herr, 1993	98	61	-	27	37–89	-	surface sand filter
Welborn and Veenhuis, 1987	78	27	27	-100	33–60	81	surface sand filter
City of Austin, TX, 1990	75	59	44	-13	34–67	36	surface sand filter

City of Austin, TX, 1990	92	80	71	23	84–91	83	surface sand filter
City of Austin, TX, 1990	86	19	31	-5	33–71	37	surface sand filter
City of Austin, TX, 1990	87	61	32	-79	60-86	37	surface sand filter
Barton Springs/Edwards Aquifer Conservation District, 1996	81	39	13	-11	58–79	-	vertical sand filter
Barton Springs/Edwards Aquifer Conservation District, 1996	55	45	15	-87	58–60	-	vertical sand filter
Stewart, 1992	95	41	-	-34	61–87	-	organic filter
Curran, 1996	66	51	47	22	26–75	-	organic filter

Post-Construction Storm Water Management in New Development & Redevelopment

Grassed Swales

Description



Grassed swales can be used along roadsides and parking lots to collect and treat storm water runoff

The term swale (a.k.a. grassed channel, dry swale, wet swale, biofilter) refers to a series of vegetated, open channel management practices designed specifically to treat and attenuate storm water runoff for a specified water quality volume. As storm water runoff flows through these channels, it is treated through filtering by the vegetation in the channel, filtering through a subsoil matrix, and/or infiltration into the underlying soils. Variations of the grassed swale include the grassed channel, dry swale, and wet swale. The specific design features and methods of treatment differ in each of these designs, but all are improvements on the traditional drainage ditch. These designs incorporate modified geometry and other features for use of the swale as a treatment and conveyance practice.

Applicability

Grassed swales can be applied in most situations with some restrictions. Swales are very well suited for treating highway or residential road runoff because they are linear practices.

Regional Applicability

Grassed swales can be applied in most regions of the country. In arid and semi-arid climates, however, the value of these practices needs to be weighed against the water needed to irrigate them.

Ultra-Urban Areas

Ultra-urban areas are densely developed urban areas in which little pervious surface exists. Grassed swales are generally not well suited to ultra-urban areas because they require a relatively large area of pervious surfaces.

Storm Water Hot Spots

Storm water hot spots are areas where land use or activities generate highly contaminated runoff, with concentrations of pollutants in excess of those typically found in storm water. A typical example is a gas station or convenience store. With the exception of the dry swale design (see Design Variations), hot spot runoff should not be directed toward grassed channels. These practices either infiltrate storm water or intersect the ground water, making use of the practices for hot spot runoff a threat to ground water quality.

Storm Water Retrofit

A storm water retrofit is a storm water management practice (usually structural) put into place after development has occurred, to improve water quality, protect downstream channels, reduce flooding, or meet other specific objectives. One retrofit opportunity using grassed swales modifies existing drainage ditches. Ditches have traditionally been designed only to convey storm water away from roads. In some cases, it may be possible to incorporate features to enhance pollutant removal or infiltration such as check dams (i.e., small dams along the ditch that trap sediment, slow runoff, and reduce the longitudinal slope). Since grassed swales cannot treat a large area, using this practice to retrofit an entire watershed would be expensive because of the number of practices needed to manage runoff from a significant amount of the watershed's land area.

Cold Water (Trout) Streams

Grassed channels are a good treatment option within watersheds that drain to cold water streams. These practices do not pond water for a long period of time and often induce infiltration. As a result, standing water will not typically be subjected to warming by the sun in these practices.

Siting and Design Considerations

In addition to the broad applicability concerns described above, designers need to consider conditions at the site level. In addition, they need to incorporate design features to improve the longevity and performance of the practice, while minimizing the maintenance burden.

Siting Considerations

In addition to considering the restrictions and adaptations of grassed swales to different regions and land uses, designers need to ensure that this management practice is feasible at the site in question because some site conditions (i.e., steep slopes, highly impermeable soils) might restrict the effectiveness of grassed channels.

Drainage Area

Grassed swales should generally treat small drainage areas of less than 5 acres. If the practices are used to treat larger areas, the flows and volumes through the swale become too large to design the practice to treat storm water runoff through infiltration and filtering.

Slope

Grassed swales should be used on sites with relatively flat slopes of less than 4 percent slope; 1 to 2 percent slope is recommended. Runoff velocities within the channel become too high on steeper slopes. This can cause erosion and does not allow for infiltration or filtering in the swale.

Soils / Topography

Grassed swales can be used on most soils, with some restrictions on the most impermeable soils. In the dry swale (see Design Variations) a fabricated soil bed replaces on-site soils in order to ensure that runoff is filtered as it travels through the soils of the swale.

Ground Water

The depth to ground water depends on the type of swale used. In the dry swale and grassed channel options, designers should separate the bottom of the swale from the ground water by at least 2 ft to prevent a moist swale bottom, or contamination of the ground water. In the wet swale option, treatment is enhanced by a wet pool in the practice, which is maintained by intersecting the ground water.

Design Considerations

Although there are different design variations of the grassed swale (see Design Variations), there are some design considerations common to all three. One overriding similarity is the cross-sectional geometry of all three options. Swales should generally have a trapezoidal or parabolic cross section with relatively flat side slopes (flatter than 3:1). Designing the channel with flat side slopes maximizes the wetted perimeter. The wetted perimeter is the length along the edge of the swale cross section where runoff flowing through the swale is in contact with the vegetated sides and bottom of the swale. Increasing the wetted perimeter slows runoff velocities and provides more contact with vegetation to encourage filtering and infiltration. Another advantage to flat side slopes is that runoff entering the grassed swale from the side receives some pretreatment along the side slope. The flat bottom of all three should be between 2–8 ft wide. The minimum width ensures a minimum filtering surface for water quality treatment, and the maximum width prevents braiding, the formation of small channels within the swale bottom.

Another similarity among all three designs is the type of pretreatment needed. In all three design options, a small forebay should be used at the front of the swale to trap incoming sediments. A pea gravel diaphragm, a small trench filled with river run gravel, should be used as pretreatment for runoff entering the sides of the swale.

Two other features designed to enhance the treatment ability of grassed swales are a flat longitudinal slope (generally between 1 percent and 2 percent) and a dense vegetative cover in the channel. The flat slope helps to reduce the velocity of flow in the channel. The dense vegetation also helps reduce velocities, protect the channel from erosion, and act as a filter to treat storm water runoff. During construction, it is important to stabilize the channel before the turf has been established, either with a temporary grass cover or with the use of natural or synthetic erosion control products.

In addition to treating runoff for water quality, grassed swales need to convey larger storms safely. Typical designs allow the runoff from the 2-year storm (i.e., the storm that occurs, on average, once every two years) to flow through the swale without causing erosion. Swales should also have the capacity to pass larger storms (typically a 10-year storm) safely.

Design Variations

The following discussion identifies three different variations of open channel practices, including the grassed channel, the dry swale, and the wet swale.

Grassed Channel

Of the three grassed swale designs, grassed channels are the most similar to a conventional drainage ditch, with the major differences being flatter side slopes and longitudinal slopes, and a slower design velocity for water quality treatment of small storm events. Of all of the grassed swale options, grassed channels are the least expensive but also provide the least reliable pollutant removal. The best application of a grassed channel is as pretreatment to other structural storm water practices.

One major difference between the grassed channel and most of the other structural practices is the method used to size the practice. Most storm water management water quality practices are sized by volume. This method sets the volume available in the practice equal to the water quality volume, or the volume of water to be treated in the practice. The grassed channel, on the other hand, is a flow-rate-based design. Based on the peak flow from the water quality storm (this varies from region to region, but a typical value is the 1-inch storm), the channel should be designed so that runoff takes, on average, 10 minutes to flow from the top to the bottom of the channel. A procedure for this design can be found in *Design of Storm Water Filtering Systems* (CWP, 1996).

Dry Swales

Dry swales are similar in design to bioretention areas (see Bioretention fact sheet). These designs incorporate a fabricated soil bed into their design. The existing soil is replaced with a sand/soil mix that meets minimum permeability requirements. An underdrain system is used under the soil bed. This system is a gravel layer that encases a perforated pipe. Storm water treated in the soil bed flows through the bottom into the underdrain, which conveys this treated storm water to the storm drain system. Dry swales are a relatively new design, but studies of swales with a native soil similar to the man-made soil bed of dry swales suggest high pollutant removal.

Wet Swales

Wet swales intersect the ground water and behave almost like a linear wetland cell (see Storm Water Wetland fact sheet). This design variation incorporates a shallow permanent pool and wetland vegetation to provide storm water treatment. This design also has potentially high pollutant removal. One disadvantage to the wet swale is that it cannot be used in residential or commercial settings because the shallow standing water in the swale is often viewed as a potential nuisance by homeowners and also breeds mosquitos.

Regional Variations

Cold Climates

In cold or snowy climates, swales may serve a dual purpose by acting as both a snow storage/treatment and a storm water management practice. This dual purpose is particularly relevant when swales are used to treat road runoff. If used for this purpose, swales should incorporate salt-tolerant vegetation, such as creeping bentgrass.

Arid Climates

In arid or semi-arid climates, swales should be designed with drought-tolerant vegetation, such as buffalo grass. As pointed out in the Applicability section, the value of vegetated practices for water quality needs to be weighed against the cost of water needed to maintain them in arid and semi-arid regions.

Limitations

Grassed swales have some limitations, including the following:

- Grassed swales cannot treat a very large drainage area.
- Wet swales may become a nuisance due to mosquito breeding.
- If designed improperly (e.g., if proper slope is not achieved), grassed channels will have very little pollutant removal.
- A thick vegetative cover is needed for these practices to function properly.

Maintenance Considerations

Maintenance of grassed swales mostly involves maintenance of the grass or wetland plant cover. Typical maintenance activities are included in Table 1.

Table 1. Typical maintenance activities for grassed swales (Source: Adapted from CWP, 1996)

Activity	Schedule
• Inspect pea gravel diaphragm for clogging and correct the problem. • Inspect grass along side slopes for erosion and formation of rills or gullies and correct. • Remove trash and debris accumulated in the inflow forebay. • Inspect and correct erosion problems in the sand/soil bed of dry swales. • Based on inspection, plant an alternative grass species if the original grass cover has not been successfully established. • Replant wetland species (for wet swale) if not sufficiently established.	Annual (semi-annual the first year)
• Rototill or cultivate the surface of the sand/soil bed of dry swales if the swale does not draw down within 48 hours. • Remove sediment build-up within the bottom of the swale once it has accumulated to 25 percent of the original design volume.	As needed (infrequent)
• Mow grass to maintain a height of 3–4 inches	As needed (frequent seasonally)

Effectiveness

Structural storm water management practices can be used to achieve four broad resource protection goals. These include flood control, channel protection, ground water recharge, and pollutant removal. Grassed swales can be used to meet ground water recharge and pollutant removal goals.

Ground Water Recharge

Grassed channels and dry swales can provide some ground water recharge as infiltration is achieved within the practice. Wet swales, however, generally do not contribute to ground water recharge. Infiltration is impeded by the accumulation of debris on the bottom of the swale.

Pollutant Removal

Few studies are available regarding the effectiveness of grassed channels. In fact, only 9 studies have been conducted on all grassed channels designed for water quality (Table 2). The data suggest relatively high removal rates for some pollutants, but negative removals for some bacteria, and fair performance for phosphorous. One study of available performance data (Schueler, 1997) estimates the removal rates for grassed channels as:

Total Suspended Solids: 81%

Total Phosphorous: 29%

Nitrate Nitrogen: 38%

Metals: 14% to 55%

Bacteria: -50%

Table 2. Grassed swale pollutant removal efficiency data

Removal Efficiencies (% Removal)							
Study	**TSS**	**TP**	**TN**	**NO_3**	**Metals**	**Bacteria**	**Type**
Goldberg 1993	67.8	4.5	-	31.4	42–62	-100	grassed channel
Seattle Metro and Washington Department of Ecology 1992	60	45	-	-25	2–16	-25	grassed channel
Seattle Metro and Washington Department of Ecology, 1992	83	29	-	-25	46–73	-25	grassed channel
Wang et al., 1981	80	-	-	-	70–80	-	dry swale
Dorman et al., 1989	98	18	-	45	37–81	-	dry swale
Harper, 1988	87	83	84	80	88–90	-	dry swale
Kercher et al., 1983	99	99	99	99	99	-	dry swale
Harper, 1988.	81	17	40	52	37–69	-	wet swale
Koon, 1995	67	39	-	9	-35 to 6	-	wet swale
Occoquan Watershed Monitoring Lab, 1983	-100	-100	-100	-	-100	-	drainage channel
Yousef et al., 1985	-	8	13	11	14–29	-	drainage channel
Occoquan Watershed Monitoring Lab, 1983	-50	-9.1	-18.2	-	-100	-	drainage channel
		-					drainage

Yousef et al., 1985	-	19.5	8	2	41–90	-	channel
Occoquan Watershed Monitoring Lab, 1983	31	-23	36.5	-	-100 to 33	-	drainage channel
Welborn and Veenhuis, 1987	0	-25	-25	-25	0	-	drainage channel
Yu et al., 1993	68	60	-	-	74	-	drainage channel
Dorman et al., 1989	65	41	-	11	14-55	-	drainage channel
Pitt and McLean, 1986	0	-	0	-	0	0	drainage channel
Oakland, 1983	33	-25	-	-	20–58	0	drainage channel
Dorman et al., 1989	-85	12	-	-100	14–88	-	drainage channel

While it is difficult to distinguish between different designs based on the small amount of available data, grassed channels generally have poorer removal rates than wet and dry swales, although wet swales appear to export soluble phosphorous (Harper, 1988; Koon, 1995). It is not clear why swales export bacteria. One explanation is that bacteria thrive in the warm swale soils. Another is that studies have not accounted for some sources of bacteria, such as local residents walking dogs within the grassed swale area.

Cost Considerations

Little data are available to estimate the difference in cost between various swale designs. One study (SWRPC, 1991) estimated the construction cost of grassed channels at approximately \$0.25 per ft^2. This price does not include design costs or contingencies. Brown and Schueler (1997) estimate these costs at approximately 32 percent of construction costs for most storm water management practices. For swales, however, these costs would probably be significantly higher since the construction costs are so low compared with other practices. A more realistic estimate would be a total cost of approximately \$0.50 per ft^2, which compares favorably with other storm water management practices.

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Post-Construction Storm Water Management in New Development & Redevelopment

Grassed Filter Strip

Description

Grassed filter strips (vegetated filter strips, filter strips, and grassed filters) are vegetated surfaces that are designed to treat sheet flow from adjacent surfaces. Filter strips function by slowing runoff velocities and filtering out sediment and other pollutants, and by providing some infiltration into underlying soils. Filter strips were originally used as an agricultural treatment practice, and have more recently evolved into an urban practice. With proper design and maintenance, filter strips can provide relatively high pollutant removal. One challenge associated with filter strips, however, is that it is difficult to maintain sheet flow, so the practice may be "short circuited" by concentrated flows, receiving little or no treatment.

Applicability

Filter strips are applicable in most regions, but are restricted in some situations because they consume a large amount of space relative to other practices. Filter strips are best suited to treating runoff from roads and highways, roof downspouts, very small parking lots, and pervious surfaces. They are also ideal components of the "outer zone" of a stream buffer (see Buffer Zones fact sheet), or as pretreatment to a structural practice. This recommendation is consistent with recommendations in the agricultural setting that filter strips are most effective when combined with another practice (Magette et al., 1989). In fact, the most recent storm water manual for Maryland does not consider the filter strip as a treatment practice, but does offer storm water volume reductions in exchange for using filter strips to treat some of a site.

Regional Applicability

Filter strips can be applied in most regions of the country. In arid areas, however, the cost of irrigating the grass on the practice will most likely outweigh its water quality benefits.

Ultra-Urban Areas

Ultra-urban areas are densely developed urban areas in which little pervious surface exists. Filter strips are impractical in ultra-urban areas because they consume a large amount of space.

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Storm Water Hot Spots

Storm water hot spots are areas where land use or activities generate highly contaminated runoff, with concentrations of pollutants in excess of those typically found in storm water. A typical example is a gas station. Filter strips should not receive hot spot runoff, because the practice encourages infiltration. In addition, it is questionable whether this practice can reliably remove pollutants, so it should definitely not be used as the sole treatment of hot spot runoff.

Storm Water Retrofit

A storm water retrofit is a storm water management practice (usually structural), put into place after development has occurred, to improve water quality, protect downstream channels, reduce flooding, or meet other specific objectives. Filter strips are generally a poor retrofit option because they consume a relatively large amount of space and cannot treat large drainage areas.

Cold Water (Trout) Streams

Some cold water species, such as trout, are sensitive to changes in temperature. While some treatment practices, such as wet ponds (see Wet Ponds fact sheet), can warm storm water substantially, filter strips do not warm pond water on the surface for long periods of time and are not expected to increase storm water temperatures. Thus, these practices are good for protection of cold-water streams.

Siting and Design Considerations

Siting Considerations

In addition to the restrictions and modifications to adapting filter strips to different regions and land uses, designers need to ensure that this management practice is feasible at the site in question. The following section provides basic guidelines for siting filter strips.

Drainage Area

Typically, filter strips are used to treat very small drainage areas. The limiting design factor, however, is not the drainage area the practice treats but the length of flow leading to it. As storm water runoff flows over the ground's surface, it changes from sheet flow to concentrated flow. Rather than moving uniformly over the surface, the concentrated flow forms rivulets which are slightly deeper and cover less area than the sheet flow. When flow concentrates, it moves too rapidly to be effectively treated by a grassed filter strip. As a rule, flow concentrates within a maximum of 75 feet for impervious surfaces, and 150 feet for pervious surfaces (CWP, 1996). Using this rule, a filter strip can treat one acre of impervious surface per 580-foot length.

Slope

Filter strips should be designed on slopes between 2 and 6 percent. Greater slopes than this would encourage the formation of concentrated flow. Except in the case of very sandy or gravelly soil, runoff would pond on the surface on slopes flatter than 2 percent, creating potential mosquito breeding habitat.

Soils /Topography

Filter strips should not be used on soils with a high clay content, because they require some infiltration for proper treatment. Very poor soils that cannot sustain a grass cover crop are also a limiting factor.

Ground Water

Filter strips should be separated from the ground water by between 2 and 4 ft to prevent contamination and to ensure that the filter strip does not remain wet between storms.

Design Considerations

Filter strips appear to be a minimal design practice because they are basically no more than a grassed slope. However, some design features are critical to ensure that the filter strip provides some minimum amount of water quality treatment.

- A pea gravel diaphragm should be used at the top of the slope. The pea gravel diaphragm (a small trench running along the top of the filter strip) serves two purposes. First, it acts as a pretreatment device, settling out sediment particles before they reach the practice. Second, it acts as a level spreader, maintaining sheet flow as runoff flows over the filter strip.
- The filter strip should be designed with a pervious berm of sand and gravel at the toe of the slope. This feature provides an area for shallow ponding at the bottom of the filter strip. Runoff ponds behind the berm and gradually flows through outlet pipes in the berm. The volume ponded behind the berm should be equal to the water quality volume. The water quality volume is the amount of runoff that will be treated for pollutant removal in the practice. Typical water quality volumes are the runoff from a 1-inch storm or ½-inch of runoff over the entire drainage area to the practice.
- The filter strip should be at least 25 feet long to provide water quality treatment.
- Designers should choose a grass that can withstand relatively high velocity flows and both wet and dry periods.
- Both the top and toe of the slope should be as flat as possible to encourage sheet flow and prevent erosion.

Regional Variations

In cold climates, filter strips provide a convenient area for snow storage and treatment. If used for this purpose, vegetation in the filter strip should be salt-tolerant, (e.g., creeping bentgrass), and a maintenance schedule should include the removal of sand built up at the bottom of the slope. In arid or semi-arid climates, designers should specify drought-tolerant grasses (e.g., buffalo grass) to minimize irrigation requirements.

Limitations

Filter strips have several limitations related to their performance and space consumption:

- The practice has not been shown to achieve high pollutant removal.
- Filter strips require a large amount of space, typically equal to the impervious area they treat, making them often infeasible in urban environments where land prices are high.
- If improperly designed, filter strips can become a mosquito breeding ground.
- Proper design requires a great deal of finesse, and slight problems in the design, such as improper grading, can render the practice ineffective in terms of pollutant removal.

Maintenance Considerations

Filter strips require similar maintenance to other vegetative practices (see Grassed Swales fact sheet). These maintenance needs are outlined below. Maintenance is very important for filter strips, particularly in terms of ensuring that flow does not short circuit the practice.

Table 1. Typical maintenance activities for grassed filter strips (Source: CWP, 1996)

Activity	Schedule
• Inspect pea gravel diaphragm for clogging and remove built-up sediment. • Inspect vegetation for rills and gullies and correct. Seed or sod bare areas. • Inspect to ensure that grass has established. If not, replace with an alternative species.	Annual inspection (semi-annual the first year)
• Mow grass to maintain a 3–4 inch height	Regular (frequent)
• Remove sediment build-up within the bottom when it has accumulated to 25% of the original capacity.	Regular (infrequent)

Effectiveness

Structural storm water management practices can be used to achieve four broad resource protection goals. These include flood control, channel protection, ground water recharge, and pollutant removal. The first two goals, flood control and channel protection, require that a storm water practice be able to reduce the peak flows of relatively large storm events (at least 1- to 2-year storms for channel protection and at least 10- to 50-year storms for flood control). Filter strips do not have the capacity to detain these events, but can be designed with a bypass system that routes these flows around the practice entirely.

Filter strips can provide a small amount of ground water recharge as runoff flows over the vegetated surface and ponds at the toe of the slope. In addition, it is believed that filter strips can provide modest pollutant removal. Studies from agricultural settings suggest that a 15-foot-wide grass buffer can achieve a 50 percent removal rate of nitrogen, phosphorus, and sediment, and that a 100-foot buffer can reach closer to 70 percent removal of these constituents (Desbonette et al., 1994). It is unclear how these results can be translated to the urban environment, however. The characteristics of the incoming flows are radically different both in terms of pollutant concentration and the peak flows associated with similar storm events. To date, only one study (Yu et al., 1992) has investigated the effectiveness of a grassed filter strip to treat runoff from a large parking lot. The study found that the pollutant removal varied depending on the length of flow in the filter strip. The narrower (75-foot) filter strip had moderate removal for some pollutants and actually appeared to export lead, phosphorus, and nutrients (See Table 2).

Table 2. Pollutant removal of an urban vegetated filter strip (Source: Yu et al., 1993)

	Pollutant Removal (%)	
	75-Ft Filter Strip	150-Ft Filter Strip
Total suspended solids	54	84
Nitrate+nitrite	-27	20
Total phosphorus	-25	40
Extractable lead	-16	50
Extractable zinc	47	55

Cost Considerations

Little data are available on the actual construction costs of filter strips. One rough estimate can be the cost of seed or sod, which is approximately 30¢ per ft^2 for seed or 70¢ per ft^2 for sod. This amounts to between $13,000 and $30,000 per acre for a filter strip, or the same amount per impervious acre treated. This cost is relatively high compared with other treatment practices. However, the grassed area used as a filter strip may have been seeded or sodded even if it were not used for treatment. In these cases, the only additional costs are the design, which is minimal, and the installation of a berm and gravel diaphragm. Typical maintenance costs are about $350/acre/year (adapted from SWRPC, 1991). This cost is relatively inexpensive and, again, might overlap with regular landscape maintenance costs.

The true cost of filter strips is the land they consume, which is higher than for any other treatment practice. In some situations this land is available as wasted space beyond back yards or adjacent to roadsides, but this practice is cost-prohibitive when land prices are high and land could be used for other purposes.

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Post-Construction Storm Water Management in New Development & Redevelopment

Catch Basins/Catch Basin Insert

Description

A worker inserts a catch basin insert for oil and grease, trash, debris, and sediment removal from storm water as it enters the storm drainage system (Source: AbTech Industries, 2001)

A catch basin (a.k.a. storm drain inlet, curb inlet) is an inlet to the storm drain system that typically includes a grate or curb inlet and a sump to capture sediment, debris, and associated pollutants. They are also used in combined sewer overflow (CSO) watersheds to capture floatables and settle some solids. Catch basins act as pretreatment for other treatment practices by capturing large sediments. The performance of catch basins at removing sediment and other pollutants depends on the design of the catch basin (e.g., the size of the sump) and maintenance procedures to retain the storage available in the sump to capture sediment.

Catch basin efficiency can be improved using inserts, which can be designed to remove oil and grease, trash, debris, and sediment. Some inserts are designed to drop directly into existing catch basins, while others may require extensive retrofit construction.

Applicability

Catch basins are used in drainage systems throughout the United States. However, many catch basins are not ideally designed for sediment and pollutant capture. Ideal application of catch basins is as pretreatment to another storm water management practice. Retrofitting existing catch basins may help to improve their performance substantially. A simple retrofit option is to ensure that all catch basins have a hooded outlet to prevent floatable materials, such as trash and debris, from entering the storm drain system. Catch basin inserts for both new development and retrofits at existing sites may be preferred when available land is limited, as in urbanized areas.

Limitations

Catch basins have three major limitations, including:

- Even ideally designed catch basins cannot remove pollutants as well as structural storm water management practices, such as wet ponds, sand filters, and storm water wetlands.
- Unless frequently maintained, catch basins can become a source of pollutants through resuspension.
- Catch basins cannot effectively remove soluble pollutants or fine particles.

Siting and Design Considerations

The performance of catch basins is related to the volume in the sump (i.e., the storage in the catch basin below the outlet). Lager et al. (1997) described an "optimal" catch basin sizing criterion, which relates all catch basin dimensions to the diameter of the outlet pipe (D):

- The diameter of the catch basin should be equal to 4D.
- The sump depth should be at least 4D. This depth should be increased if cleaning is infrequent or if the area draining to the catch basin has high sediment loads.
- The top of the outlet pipe should be 1.5 D from the bottom of the inlet to the catch basin.

Catch basins can also be sized to accommodate the volume of sediment that enters the system. Pitt et al. (1997) propose a sizing criterion based on the concentration of sediment in storm water runoff. The catch basin is sized, with a factor of safety, to accommodate the annual sediment load in the catch basin sump. This method is preferable where high sediment loads are anticipated, and where the optimal design described above is suspected to provide little treatment.

The basic design should also incorporate a hooded outlet to prevent floatable materials and trash from entering the storm drain system. Adding a screen to the top of the catch basin would not likely improve the performance of catch basins for pollutant removal, but would help capture trash entering the catch basin (Pitt et al., 1997).

Several varieties of catch basin inserts exist for filtering runoff. There are two basic catch basin insert varieties. One insert option consists of a series of trays, with the top tray serving as an initial sediment trap, and the underlying trays composed of media filters. Another option uses filter fabric to remove pollutants from storm water runoff. Yet another option is a plastic box that fits directly into the catch basin. The box construction is the filtering medium. Hydrocarbons are removed as the storm water passes through the box while trash, rubbish, and sediment remain in the box itself as storm water exits. These devices have a very small volume, compared to the volume of the catch basin sump, and would typically require very frequent sediment removal. Bench test studies found that a variety of options showed little removal of total suspended solids, partially due to scouring from relatively small (6-month) storm events (ICBIC, 1995).

One design adaptation of the standard catch basin is to incorporate infiltration through the catch basin bottom. Two challenges are associated with this design. The first is potential ground water impacts, and the second is potential clogging, preventing infiltration. Infiltrating catch basins should not be used in commercial or industrial areas, because of possible ground water contamination. While it is difficult to prevent clogging at the bottom of the catch basin, it might be possible to incorporate some pretreatment into the design.

Maintenance Considerations

Typical maintenance of catch basins includes trash removal if a screen or other debris capturing device is used, and removal of sediment using a vactor truck. Operators need to be properly trained in catch basin maintenance. Maintenance should include keeping a log of the amount of sediment collected and the date of removal. Some cities have incorporated the use of GIS systems to track sediment collection and to optimize future catch basin cleaning efforts.

One study (Pitt, 1985) concluded that catch basins can capture sediments up to approximately 60 percent of the sump volume. When sediment fills greater than 60 percent of their volume, catch basins reach steady state. Storm flows can then resuspend sediments trapped in the catch basin, and will bypass treatment. Frequent clean-out can retain the volume in the catch basin sump available for treatment of storm water flows.

At a minimum, catch basins should be cleaned once or twice per year (Aronson et al., 1993). Two studies suggest that increasing the frequency of maintenance can improve the performance of catch basins, particularly in industrial or commercial areas. One study of 60 catch basins in Alameda County, California, found that increasing the maintenance frequency from once per year to twice per year could increase the total sediment removed by catch basins on an annual basis (Mineart and Singh, 1994). Annual sediment removed per inlet was 54 pounds for annual cleaning, 70 pounds for semi-annual and quarterly cleaning, and 160 pounds for monthly cleaning. For catch basins draining industrial uses, monthly cleaning increased total annual sediment collected to six times the amount collected by annual cleaning (180 pounds versus 30 pounds). These results suggest that, at least for industrial uses, more frequent cleaning of catch basins may improve efficiency. However, the cost of increased operation and maintenance costs needs to be weighed against the improved pollutant removal.

In some regions, it may be difficult to find environmentally acceptable disposal methods for collected sediments. The sediments may not always be land-filled, land-applied, or introduced into the sanitary sewer system due to hazardous waste, pretreatment, or ground water regulations. This is particularly true when catch basins drain runoff from hot spot areas.

Effectiveness

What is known about the effectiveness of catch basins is limited to a few studies. Table 1 outlines the results of some of these studies.

Table 1. Pollutant removal of catch basins (percent).

Study	Notes	TSS[a]	COD[a]	BOD[a]	TN[a]	TP[a]	Metals
Pitt et al., 1997	–	32	–		–	–	–
Aronson et al., 1983	Only very small storms were monitored in this study.	60–97	10–56	54–88	–	–	–
Mineart and Singh, 1994	Annual load reduction estimated based on concentrations and mass of catch basin sediment.	–	–	–	–	–	For Copper: 3–4% (Annual cleaning) 15% (Monthly

								cleaning)

[a] TSS=total suspended solids; COD=chemical oxygen demand; BOD=biological oxygen demand; TN=total nitrogen; TP=total phosphorus

Cost Considerations

A typical pre-cast catch basin costs between $2,000 and $3,000. The true pollutant removal cost associated with catch basins, however, is the long-term maintenance cost. A vactor truck, the most common method of catch basin cleaning, costs between $125,000 and $150,000. This initial cost may be high for smaller Phase II communities. However, it may be possible to share a vactor truck with another community. Typical vactor trucks can store between 10 and 15 cubic yards of material, which is enough storage for three to five catch basins with the "optimal" design and an 18-inch inflow pipe. Assuming semi-annual cleaning, and that the vactor truck could be filled and material disposed of twice in one day, one truck would be sufficient to clean between 750 and 1,000 catch basins. Another maintenance cost is the staff time needed to operate the truck. Depending on the regulations within a community, disposal costs of the sediment captured in catch basins may be significant.

Retrofit catch basin inserts range from as little as $400 for a "drop-in" type to as much as $10,000 or more for more elaborate designs.

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Post-Construction Storm Water Management in New Development & Redevelopment

In-Line Storage

Description

In-line storage refers to a number of practices designed to use the storage within the storm drain system to detain flows. While these practices can reduce storm peak flows, they are unable to improve water quality or protect downstream channels. Storage is achieved by placing devices in the storm drain system to restrict the rate of flow. Devices can slow the rate of flow by backing up flow, as in the case of a dam or weir, or through the use of vortex valves, devices that reduce flow rates by creating a helical flow path in the structure. A description of various flow regulators is included in Urbonas and Stahre (1990).

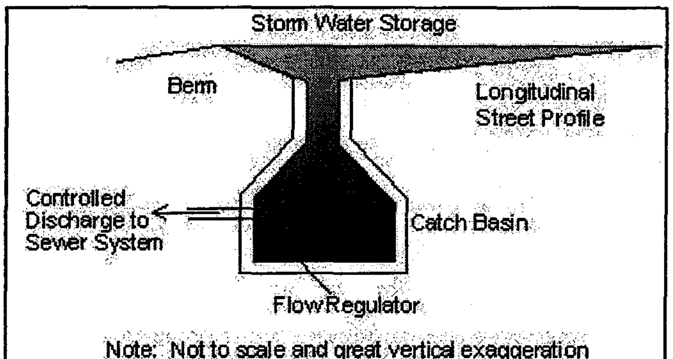
Applicability

In-line storage practices serve the same purpose as traditional detention basins (see Dry Extended Detention Pond). These practices can act as a surrogate for aboveground storage when little space is available for aboveground storage facilities.

Limitations

In-line storage has several limitations, including:

- In-line storage practices only control flow, and thus are not able to improve the water quality of storm water runoff.
- If improperly designed, these practices may cause upstream flooding.



Catch basins can be equipped with flow restrictors to temporarily detain storm water in the conveyance system

Siting and Design Considerations

Flow regulators cannot be applied to all storm drain systems. In older cities, the storm drainpipes may not be oversized, and detaining storm water within them would cause upstream flooding. Another important issue in siting these practices is the slope of the pipes in the system. In areas with very flat slopes, restricting flow within the system is likely to cause upstream flooding because introducing a regulator into the system will cause flows to back up a long distance before the regulator. In steep pipes, on the other hand, a storage flow regulator cannot utilize much of the storage available in the storm drain system.

Maintenance Considerations

Flow regulators require very little maintenance, because they are designed to be "self cleaning," much like the storm drain system. In some cases, flow regulators may be modified based on downstream flows, new connections to the storm drain, or the application of other flow regulators within the system. For some designs, such as check dams, regulations will require only moderate construction in order to modify the structure's design.

Effectiveness

The effectiveness of in-line storage practices is site-specific and depends on the storage available in the storm drain system. In one study, a single application was able to reduce peak flows by approximately 50 percent (VDCR, 1999).

Cost Considerations

Flow regulators are relatively low cost options, particularly since they require little maintenance and consume little surface area.

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Post-Construction Storm Water Management in New Development & Redevelopment

Manufactured Products for Storm Water Inlets

Description

A variety of products for storm water inlets known as swirl separators, or hydrodynamic structures, have been widely applied in recent years. Swirl separators are modifications of the traditional oil-grit separator and include an internal component that creates a swirling motion as storm water flows through a cylindrical chamber. The concept behind these designs is that sediments settle out as storm water moves in this swirling path. Additional compartments or chambers are sometimes present to trap oil and other floatables. There are several different types of proprietary separators, each of which incorporates slightly different design variations, such as off-line application. Another common manufactured product is the catch basin insert. These products are discussed briefly in the Catch Basin fact sheet.

Applicability

Swirl separators are best installed on highly impervious sites. Because little data are available on their performance, and independently conducted studies suggest marginal pollutant removal, swirl separators should not be used as a stand-alone practice for new development. The best application of these products is as pretreatment to another storm water device, or in a retrofit situation where space is limited.

Limitations

Limitations to swirl separators include:

- Very little data are available on the performance of these practices, and independent studies suggest only moderate pollutant removal. In particular, these practices are ineffective at removing fine particles and soluble pollutants.
  - The practice has a high maintenance burden (i.e., frequent cleanout).
  - Swirl concentrators are restricted to small and highly impervious sites.

Siting and Design Considerations

The specific design of swirl concentrators is specified by product literature available

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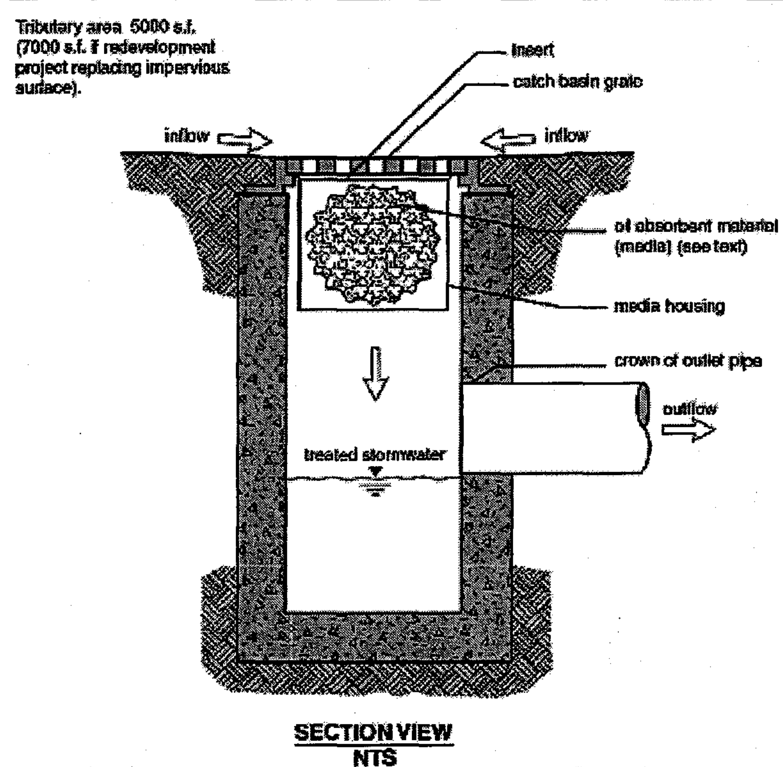
from each manufacturer. For the most part, swirl concentrators are a rate-based design. That is, they are sized based on the peak flow of a specific storm event. This design contrasts with most other storm water management practices, which are sized based on capturing and storing or treating a specific volume. Sizing based on flow rate allows the practice to provide treatment within a much smaller area than other storm water management practices.



The typical design of a catch basin insert is a set of filters that are specifically chosen to address the pollutants expected at that site (Source: King County, Washington, 2000)

Maintenance Considerations

Swirl concentrators require frequent maintenance (typically quarterly). Maintenance is performed using a vactor truck, as is used for catch basins (see Catch Basin). In some regions, it may be difficult to find environmentally acceptable disposal methods. The sediments may not always be land-filled, land-applied, or introduced into the sanitary sewer system due to hazardous waste, pretreatment, or groundwater regulations. This is particularly true when catch basins drain runoff from hot spot areas.

Effectiveness

While manufacturers' literature typically reports removal rates for swirl separator design, there is actually very little independent data to evaluate the effectiveness of these products. Two studies investigated one of these products. Both studies reported moderate pollutant removal. While the product outperforms oil/grit separators, which have virtually no pollutant removal (Schueler, 1997), the removal rates are not substantially different from the standard catch basin. One long-term advantage of these products over catch basins is that, if they incorporate an off-line design, trapped sediment will not become resuspended. Data from two studies are presented below. Both of these studies are summarized in a Claytor (1999).

Table 1. Effectiveness of manufactured products for storm water inlets

Study	Greb et al., 1998	Labatiuk et al., 1997
Notes	Investigated 45 precipitation events over a 9-month period. Percent removal rates reflect overall efficiency, accounting for pollutants in bypassed flows.	Data represent the mean percent removal rate for four storm events.
TSS[a]	21	51.5
TDS[a]	-21	-
TP[a]	17	-
DP[a]	17	-
Pb[a]	24	51.2
Zn[a]	17	39.1
Cu[a]	-	21.5
PAH[a]	32	-
NO_2+NO_3[a]	5	-

[a] TSS=total suspended solids; TDS=total dissolved solids; TP=total phosphorus; DP=dissolved phosphorus; Pb=lead; Zn=zinc; Cu=copper; PAH=polynuclear aromatic hydrocarbons; NO_2+NO_3=nitrite+nitrate-nitrogen

Cost Considerations

A typical swirl separator costs between $5,000 and $35,000, or between $5,000 and $10,000 per impervious acre. This cost is within the range of some sand filters, which also treat highly urbanized runoff (see Sand Filters). Swirl separators consume very little land, making them attractive in highly urbanized areas.

The maintenance of these practices is relatively expensive. Swirl concentrators typically require quarterly maintenance, and a vactor truck, the most common method of cleaning these practices, costs between $125,000 and $150,000. This initial cost may be high for smaller Phase II communities. However, it may be possible to share a vactor truck with another community. Depending on the rules within a community, disposal costs of the sediment captured in swirl separators may be significant.

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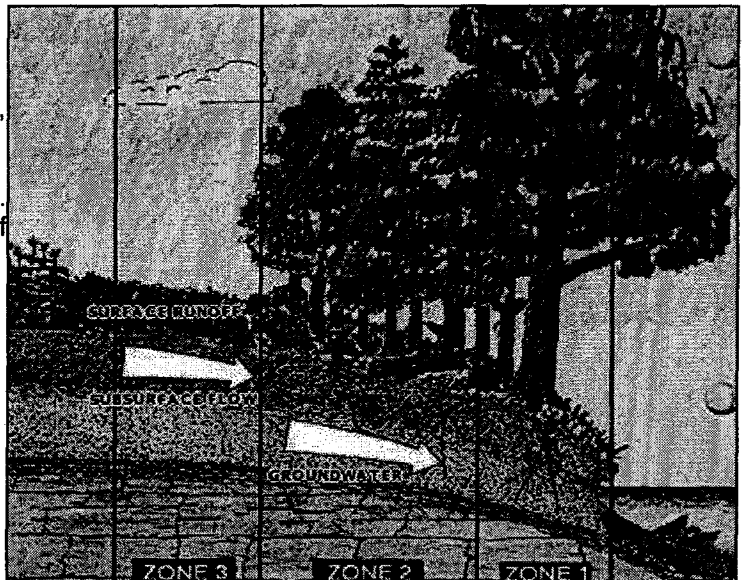
Post-Construction Storm Water Management in New Development & Redevelopment

Buffer Zones

Description



Sketch of a typical riparian forest buffer (Source: Chesapeake Bay Program, 2000)

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. If properly designed, a buffer can provide storm water 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 that 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, vegetated buffers, and engineered buffers. Water pollution hazard setbacks are areas that separate a potential pollution hazard from a waterway. By providing setbacks from these areas in the form of a buffer, the potential for pollution can be reduced. Vegetated buffers are any number of natural areas that exist to divide land uses or provide landscape relief. Engineered buffers are areas specifically designed to treat storm water before it enters into a stream, lake, or wetland.

Applicability

Buffers can be applied to new development by establishing specific preservation

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areas and sustaining management through easements or community associations. For existing developed areas, an easement may be needed from adjoining landowners. A local ordinance can help set specific criteria for buffers to achieve storm water management goals.

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In many regions of the country, the benefits of buffers are amplified if they are managed in a forested condition. In some settings, buffers can remove pollutants traveling in storm water or ground water. Shoreline and stream buffers situated in flat soils have been found to be effective in removing sediment, nutrients, and bacteria from storm water runoff and septic system effluent in a wide variety of rural and agricultural settings along the East Coast and with some limited capability in urban settings. Buffers can also provide wildlife habitat and recreation, and can be reestablished in urban areas as part of an urban forest.

Siting and Design Considerations

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, turfgrass 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.

For optimal storm water treatment, the following buffer designs are recommended. The buffer should be composed of three lateral zones: a storm water depression area that leads to a grass filter strip that in turn leads to a forested buffer. The storm water depression is designed to capture and store storm water during smaller storm events and bypass larger stormflows directly into a channel. The captured runoff within the storm water depression can then be spread across a grass filter designed for sheetflow conditions for the water quality storm. The grass filter then discharges into a wider forest buffer designed to have zero discharge of surface runoff to the stream (i.e., full infiltration of sheetflow).

Stream buffers must be highly engineered in order to satisfy these demanding hydrologic and hydraulic conditions. In particular, simple structures are needed to store, split, and spread surface runoff within the storm water depression area. Although past efforts to engineer urban stream buffers were plagued by hydraulic failures and maintenance problems, recent experience with similar bioretention areas has been much more positive (Claytor and Schueler, 1996). Consequently, it may be useful to consider elements of bioretention design for the first zone of an urban stream buffer (shallow ponding depths, partial underdrains, drop inlet bypass, etc).

Limitations

Only a handful of studies have measured the ability of stream buffers to remove pollutants from storm water. One limitation is that urban runoff concentrates rapidly on paved and hard-packed turf surfaces and often crosses the buffer as channel flow, effectively shortcutting through the buffer. To achieve optimal pollutant removal, the engineered buffer should be carefully designed with a storm water depression area, grass filter, and forested strip.

Maintenance Considerations

An effective buffer management plan should include establishment, management, and distinctions of allowable and unallowable uses in the buffer zones. Buffer boundaries should be well defined and visible before, during, and after construction. Without clear signs or markers defining the buffer, boundaries become invisible to local governments, contractors, and residents. Buffers designed to capture storm water runoff from urban areas will require more maintenance if the first zone is designated as a bioretention or other engineered depression area.

Effectiveness

The pollutant removal effectiveness of buffers depends on the design of the buffer; while water pollution hazard setbacks are designed to prevent possible contamination from neighboring land uses, they are not designed for pollutant removal during a storm. With vegetated buffers, some pollutant removal studies have shown that they range widely in effectiveness (Table 1). Proper design of buffers can help increase the pollutant removal from storm water runoff (Table 2).

Table 1: Pollutant removal rates in buffer zones

Reference	Buffer Vegetation	Buffer Width (meters)	Total % TSS Removal	Total % Phosphorous Removal	Total % Nitrogen Removal
Dillaha et al., 1989	Grass	4.6–9.1	63–78	57–74	50–67
Magette et al., 1987	Grass	4.6–9.2	72–86	41–53	17–51
Schwer and Clausen, 1989	Grass	26	89	78	76
Lowrance et al., 1983	Native hardwood forest	20–40	–	23	–
Doyle et al., 1977	Grass	1.5	–	8	57
Barker and Young,	Grass	79	–	–	99

1984					
Lowrance et al., 1984	Forested	–	–	30–42	85
Overman and Schanze, 1985	Grass	–	81	39	67

Table 2: Factors that enhance/reduce buffer pollutant removal performance

Factors that Enhance Performance	Factors that Reduce Performance
Slopes less than 5%	Slopes greater than 5%
Contributing flow lengths <150 feet.	Overland flow paths over 300 feet
Water table close to surface	Ground water far below surface
Check dams/level spreaders	Contact times less than 5 minutes
Permeable but not sandy soils	Compacted soils
Growing season	Nongrowing season
Long length of buffer or swale	Buffers less than 10 feet
Organic matter, humus, or mulch layer	Snowmelt conditions, ice cover
Small runoff events	Runoff events >2 year event.
Entry runoff velocity less than 1.5 feet/sec	Entry runoff velocity more than 5 feet/sec
Swales that are routinely mowed	Sediment buildup at top of swale
Poorly drained soils, deep roots	Trees with shallow root systems
Dense grass cover, 6 inches tall	Tall grass, sparse vegetative cover

Cost Considerations

Several studies have documented the increase of property values in areas adjacent to buffers. At the same time, the real costs of instituting a buffer program for local government involve the extra staff and training time to conduct plan reviews, and to provide technical assistance, field delineation, construction, and ongoing buffer education programs. To implement a stream buffer program, a community will need to adopt an ordinance, develop technical criteria, and invest in additional staff resources and training. The adoption of a buffer program also requires an investment in training for the plan reviewer and the consultant alike. Manuals, workshops, seminars, and direct technical assistance are needed to explain the new requirements to all the players in the land development business. Lastly, buffers need to be maintained, and resources should include systematic inspection of the buffer network before and after construction and work to increase resident awareness about buffers.

One way to relieve some of the significant financial hardships for developers is to provide flexibility through buffer averaging. Buffer averaging allows developers to narrow the buffer width at some points if the average width of the buffer and the overall buffer area meet the minimum criteria. Variances can also be granted if the developer or landowner can demonstrate severe economic hardship or unique circumstances that make compliance with the buffer ordinance difficult.

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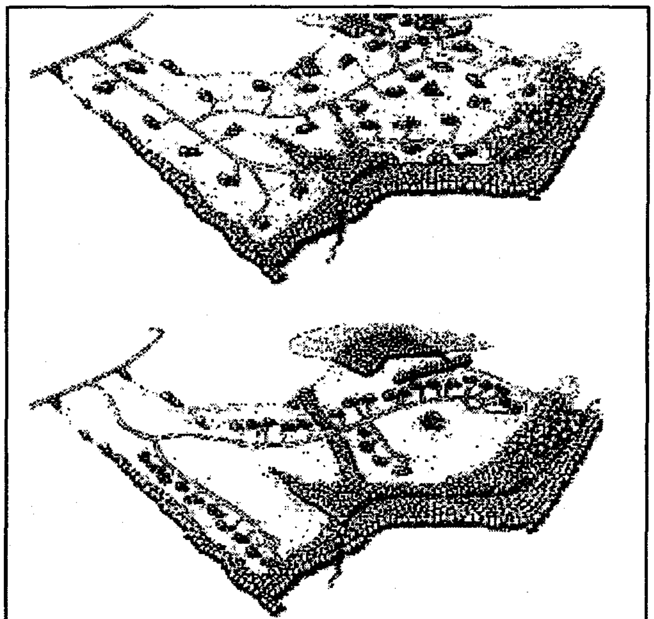
Post-Construction Storm Water Management in New Development & Redevelopment

Open Space Design

Description



A site developed using open space design principles (bottom) maintains more undeveloped common space than the conventional development plan (top) (Source: Arendt, 1996)

Open space design, also known as conservation development or cluster development, is a better site design technique that concentrates dwelling units in a compact area in one portion of the development site in exchange for providing open space and natural areas elsewhere on the site. The minimum lot sizes, setbacks and frontage distances for the residential zone are relaxed in order to create the open space at the site. Open space designs have many benefits in comparison to the conventional subdivisions that they replace: they can reduce impervious cover, storm water pollutants, construction costs, grading, and the loss of natural areas. However, many communities lack zoning ordinances to permit open space development, and even those that have enacted ordinances might need to revise them to achieve greater water quality and environmental benefits.

The benefits of open space design can be amplified when it is combined with other better site design techniques such as narrow streets, open channels, and alternative turnarounds (see Narrower Residential Streets, Eliminating Curbs and Gutters, and Alternative Turnarounds).

Applicability

The documents on this site are best viewed with Acrobat 5.0

The codes and ordinances that govern residential development in many communities do not allow developers to build anything other than conventional subdivisions. Consequently, it may be necessary to enact a new ordinance or revise current development regulations to enable developers to pursue this design option. Model ordinances and regulations for open space design can be found on http://www.cwp.org EXIT disclaimer and in *Better Site Design: A Handbook for Changing Development Rules in Your Community* (CWP, 1998).

Open space design is widely applicable to most forms of residential development. The greatest storm water and pollutant reduction benefits typically occur when open space design is applied to residential zones that have larger lots (less than two dwelling units per acre). In these types of large lot zones, a great deal of natural or community open space can be created by shrinking lot sizes. However, open space design may not always be a viable option for high-density residential zones, redevelopment, or infill development, where lots are small to begin with and clustering will yield little open space. In rural areas, open space design may need to be adapted, especially in communities where shared septic fields are not currently allowed by public health authorities.

Open space design can be employed in nearly all geographic regions of the country, with the result of different types of open space being conserved (forest, prairie, farmland, chaparral, or desert).

Siting and Design Conditions

Several site planning techniques have been proposed for designing effective open space developments (Arendt, 1996, and DE DNREC, 1997). Often, a necessary first step is adoption of a local ordinance that allows open space design within conventional residential zones. Such ordinances specify more flexible and smaller lot sizes, setbacks, and frontage distances for the residential zone, as well as minimum requirements for open space and natural area conservation. Other key elements of effective open space ordinances include requirements for the consolidation and use of open space, as well as enforceable provisions for managing the open space on a common basis.

Limitations

A number of real and perceived barriers hinder wider acceptance of open space designs by developers, local governments, and the general public. For example, despite strong evidence to the contrary, some developers still feel that open space designs are less marketable than conventional residential subdivisions. In other cases, developers contend that the review process for open space design is more lengthy, costly, and potentially controversial than that required for conventional subdivisions, and thus, not worth the trouble.

Local governments may be concerned that homeowner associations lack the financial resources, liability insurance, or technical competence to maintain open space adequately. Finally, the general public is often suspicious of cluster or open space development proposals, feeling that they are a "Trojan Horse" for more intense development, traffic, and other local concerns. At the regional level, open space design policies and ordinances need to be carefully constructed and implemented so as not to lead to "leap-frogging," which is the creation of additional development in already built-up areas. An open space development that requires new infrastructure, such as roads, water and sewer lines, and commercial areas, can actually create more imperviousness at the regional level than it saves at the site level.

In reality, many of these misconceptions can be directly addressed through a clear open space ordinance and by providing training and incentives to the development and engineering community. The Natural Resources Defense Council presents several examples of successful conservation-oriented developments in *Stormwater Strategies: Community Responses to Runoff Pollution* (1999).

Maintenance Considerations

Once established, common open space and natural conservation areas must be managed by a responsible party able to maintain the areas in a natural state in perpetuity. Typically, the open space is protected by legally enforceable deed restrictions, conservation easements, and maintenance agreements. In most communities, the authority for managing open space falls to a homeowner or community association or a land trust. Annual maintenance tasks for open space managed as natural areas are almost non-existent, and the annual maintenance cost for managing an acre of natural area is less than $75 (CWP, 1998). It may be useful to develop a habitat plan for natural areas that may require periodic management actions.

Effectiveness

Recent redesign research indicates that open space design can provide impressive pollutant reduction benefits compared to the conventional subdivisions they replace. For example, the Center for Watershed Protection (1998) reported that nutrient export declined by 45 percent to 60 percent when two conventional subdivisions were redesigned as open space subdivisions. Other researchers have reported similar levels of pollutant reductions when conventional subdivisions were replaced by open space subdivisions (Maurer, 1996; DE DNREC, 1997; Dreher and Price, 1994; and SCCCL, 1995). In all cases, the reduction in pollutants was due primarily to the sharp drop in runoff caused by the lower impervious cover associated with open space subdivisions. In the redesign studies cited above, impervious cover declined by an average of 34 percent when open space designs were utilized.

Along with reduced imperviousness, open space designs provide a host of other environmental benefits lacking in most conventional designs. These developments reduce potential pressure to encroach on resource and buffer areas because enough open space is usually reserved to accommodate resource protection areas. As less land is cleared during the construction process, the potential for soil erosion is also greatly diminished. Perhaps most importantly, open space design reserves 25 to 50 percent of the development site in green space that would not otherwise be protected, preserving a greater range of landscapes and habitat "islands" that can support considerable diversity in mammals, songbirds, and other wildlife.

Cost Considerations

Open space developments can be significantly less expensive to build than conventional subdivisions. Most of the cost savings are due to savings in road building and storm water management conveyance costs. In fact, the use of open space design techniques at a residential development in Davis, California, provided an estimated infrastructure construction costs savings of $800 per home (Liptan and Brown, 1996). Other examples demonstrate infrastructure costs savings ranging from 11 to 66 percent. Table 1 lists some of the projected construction cost savings generated by the use of open space redesign at several residential sites.

Table 1. Projected construction cost savings for open space designs from redesign analyses

Residential Development	Construction Savings	Notes
		Includes costs for engineering, road

Remlik Hall [1]	52%	construction, and obtaining water and sewer permits
Duck Crossing [2]	12%	Includes roads, storm water management, and reforestation
Tharpe Knoll [3]	56%	Includes roads and storm water management
Chapel Run [3]	64%	Includes roads, storm water management, and reforestation
Pleasant Hill [3]	43%	Includes roads, storm water management, and reforestation
Rapahannock [2]	20%	Includes roads, storm water management, and reforestation
Buckingham Greene [3]	63%	Includes roads and storm water management
Canton, Ohio[4]	66%	Includes roads and storm water management

Sources: [1] Maurer, 1996; [2] CWP, 1998; [3] DE DNREC, 1997; [4] NAHB, 1986

While open space developments are frequently less expensive to build, developers find that these properties often command higher prices than homes in more conventional developments. Several regional studies estimate that residential properties in open space developments garner premiums that are 5 to 32 percent higher than conventional subdivisions and moreover, sell or lease at an increased rate. In Massachusetts, cluster developments were found to appreciate 12 percent faster than conventional subdivisions over a 20-year period (Lacey and Arendt, 1990). In Atlanta, Georgia, the presence of trees and natural areas measurably increased the residential property tax base (Anderson and Cordell, 1982).

In addition to being aesthetically pleasing, the reduced impervious cover and increased tree canopy associated with open space development reduce the size and cost of downstream storm water treatment facilities. The resulting cost savings can be considerable, as the cost to treat the quality and quantity of storm water from a single impervious acre can range from $2,000 to a staggering $50,000. The increased open space within a cluster development also provides a greater range of locations for more cost-effective storm water practices. Clearly, open space developments are valuable from an economic as well as an environmental standpoint.

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Post-Construction Storm Water Management in New Development & Redevelopment

Urban Forestry

Description

Trees can be incorporated into urban landscapes for water quality benefits in addition to aesthetic and shade benefits (Source: Tree City USA, no date)

Urban forestry is the study of trees and forests in and around towns and cities. Since trees absorb water, 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.

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.

Applicability

From a stream preservation perspective, it is ideal to retain as much contiguous forest as possible. At the same time, this may not be an option in many urban areas. If forested areas are fragmented, it is ideal to retain the closest fragments together.

In rapidly urbanizing areas, where clearing and grading are important, tree preservation areas should be clearly marked. Delineating lines along a critical root zone (CRZ) rather than a straight line is essential to preserving trees and can help reduce homeowner complaints about tree root interference into sewer or septic lines.

Implementation

The concept of the CRZ is essential to a proper management plan. The CRZ is the

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area around a tree required for the tree's survival. Determined by the tree size and species, as well as soil conditions, for isolated specimen trees, the CRZ can be estimated as 1-1/2 feet of radial distance for every inch of tree diameter. In larger areas of trees, the CRZ of forests can be estimated at 1 foot of radial distance for every inch of tree diameter, or a minimum of 8 feet.

An urban forestry plan should include measures to establish, conserve, and/or reestablish preservation areas. A forest preservation ordinance is one way to set design standards outlining how a forest should be preserved and managed. The ordinance should outline some basic management techniques and should contain some essential elements. The following is a list of some typical elements of a forest conservation plan:

- A map and narrative description of the forest and the surrounding area that includes topography, soils, streams, current forested and unforested areas, tree lines, critical habitats, and 100-year flood plain.
- An assessment that establishes preservation, reforestation, and afforestation areas.
- A forest conservation map that outlines forest retention areas, reforestation, afforestation, protective devices, limits of disturbance, and stockpile areas.
- A schedule of any additional construction in and around the forest area.
- A specific management plan, including tree and forest protection measures.
- A reforestation and afforestation plan.

An ordinance can also be developed that addresses tree preservation at the site level both during construction and after construction is complete. This type of ordinance can be implemented on a smaller scale and can be integrated with a proposed development's erosion and sediment control and storm water pollution prevention plans, which many communities require of new developments.

American Forests, a non-profit organization dedicated to preserving and restoring forests in the United States, adopted an ecosystem restoration and maintenance agenda in 1999 to assist communities in planning and implementing tree and forest actions to restore and maintain healthy ecosystems and communities (American Forests, 2000). The agenda presents the organization's core values and policy goals as the basis for policy statements and as information to help community-based partners to prepare their own policy statements. Key policy goals include

- Increasing public and private sector investment in ecosystem restoration and maintenance activities
- Promoting an ecosystem workforce through training and apprenticeship programs and new job opportunities
- Building support for innovative monitoring systems to ensure collaborative learning and adaptive management
- Encouraging a "civic science" approach to ecosystem research that respects local knowledge, seeks community participation, and provides accessible information for communities.

Limitations

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. The size of the land may also limit the ability to protect individual trees. In these areas, a tree ordinance may be a more practical approach.

Forests may also harbor undesirable wildlife elements including insects and other pests. If forests border houses, this may be a concern for residents.

Maintenance Considerations

Maintenance considerations for urban forests may require fringe landscaping and trash pick-up. By using native vegetation and keeping the area as natural as possible, maintenance efforts can be minimized.

Effectiveness

There are numerous environmental and storm water benefits to urban forestry. 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 particulate matter (pollutants, some nutrients, and sediment) and by absorption of water. Urban forestry also reduces noise levels, provides recreational benefits, and increases property values.

Urban forests and trees are known to have numerous environmental benefits, including pollutant removal. Trees can absorb water, pollutant gases, airborne particulates, sediment, nitrogen, phosphorous, and pesticides.

There are numerous economic benefits to urban forests, including proven increases in property values. In addition, by preserving trees and forests, clearing and grading as well as erosion and sediment costs are saved during construction. Maintenance costs are also minimized by keeping areas as natural as possible (Table 1).

Table 1: Annual maintenance costs of different types of green spaces (Adapted from Brown et al., 1998)

Land Use	Approximate Annual Maintenance Costs	Source
Natural Open Space: Only minimum maintenance, trash/debris cleanup	$75/acre/year	NPS, 1995
Lawns: Regular mowing	$270 to $240/acre/year	WHEC, 1992
Passive Recreation	$200/acre/year	NPS, 1995

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U.S. Environmental Protection Agency

National Pollutant Discharge Elimination System (NPDES)

Post-Construction Storm Water Management in New Development & Redevelopment

Conservation Easements

Description

Conservation easements are voluntary agreements that allow an individual or group to set aside private property to limit the type or amount of development on their property. The conservation easement can cover all or a portion of a property and can either be permanent or last for a specified time. The easement is typically described in terms of the resource it is designed to protect (e.g., agricultural, forest, historic, or open space easements) and explains and mandates the restrictions on the uses of the particular property. Easements relieve property owners of the burden of managing these areas by shifting responsibility to a private organization (land trust) or government agency better equipped to handle maintenance and monitoring issues.

Conservation easements are thought to make a contribution to protecting water quality, mostly in an indirect way. Land set aside in a permanent conservation easement is land that will have a prescribed set of uses or activities, generally restricting future development.

The location of the land held in a conservation easement may also determine if it will provide water quality benefits. Property along stream corridors and shorelines can act as a vegetated buffer that may filter out pollutants from storm water runoff. The ability of a conservation easement to function as a stream buffer is related to the width of the easement and in what vegetated state the easement is maintained (see Buffer Zones fact sheet).

Applicability

Conservation easements are typically done to preserve agricultural lands and natural areas that are facing development pressure on the suburban-rural fringe. For rapidly urbanizing areas, conservation easements may be a way to preserve open space before land prices make the purchase of land containing important cultural and natural features impractical for governmental agencies with limited budgets. Conservation easements are not often used in ultra-urban areas, due to both the lack of available open space for purchase and the high cost of undeveloped land. In addition, private land trusts may limit the size and type of the land that they are willing to manage as conservation easements.

Implementation

Conservation easements are designed to assure that the land is preserved in its current state long after the original owners no longer control the property. By agreeing to give up or restrict the development rights for a parcel of land, a landowner can guarantee that their property will remain in a prescribed state for perpetuity while receiving tax benefits. Often, state agencies and private land trusts have specific qualifications for a property before they will enter into an easement agreement with land owners. Table 1 contains examples of criteria that are used by private land trusts to determine if a property is worth managing in a conservation easement.

Table 1: Typical criteria that land trusts use to determine feasibility of entering into conservation easement agreement

Criteria	Details
Natural resource value	Does the property provide a critical habitat or important environmental aspects worth preserving?
Uniqueness of the property	Does the property have unique traits worth preserving?
Size of land	Is the land large enough to have a natural resource or conservation value?
Financial considerations	Are funds available to meet all financial obligations?
Perpetuity	Is the conservation agreement a perpetual one?
Land trust's mission	Does the property align with the land trust's mission and the organization's specific criteria?

Conservation easements have been used in all parts of the country, and many private groups, both nationally and locally, exist to preserve natural lands and manage conservation easements. States also use conservation easements and land purchase programs to protect significant environmental features and tracts of open space. Maryland is one state that has been nationally recognized for its programs that provide funding for state and local parks and conservation areas. The state is one of the first to use real estate transfer taxes to pay for land conservation programs. Several programs are funded through this transfer tax of one-half of one percent ($5 per thousand) of the purchase price of a home or land, or other state funding programs. Conservation programs include:

- *Program Open Space*. This program is responsible for acquiring 150,000 acres of open space for state parks and natural resource areas and more than 25,000 acres of local park land. Every county must create a Land Preservation and Recreation Plan that outlines acquisition and development goals in order to receive a portion of the 50 percent that is granted to local governments (MDNR, no date).
- *Maryland Environmental Trust*. This trust is a state-funded agency that helps citizen groups form and operate local land trusts and offers the land trusts technical assistance, training, grants for land protection projects and administrative expenses, and participation in the Maryland Land Trust Alliance (MDNR, 2001a).
- *Rural Legacy Program*. This program is a Smart Growth Initiative that redirects existing state funds into a focused and dedicated land preservation program specifically designed to limit the adverse impacts of sprawl on agricultural lands and natural resources. The program purchases conservation easements for large contiguous tracts of agricultural, forest, and natural areas subject to development pressure, and purchases fee interests in open space where public access and use is needed (MDNR, 2001b).

Regardless of whether a conservation easement is held by a government agency or a private land trust, certain management responsibilities must be addressed by the easement holder. The following is a list of some of these management duties:

- Ensure that the language of the easement is clear and enforceable.
- Develop maps, descriptions and baseline documentation of the property's characteristics.
- Monitor the use of the land on a regular basis.
- Provide information regarding the easement to new or prospective property owners.
- Establish a review and approval process for land activities stipulated in the easement.
- Enforce the restrictions of the easement through the legal system if necessary.
- Maintain property/easement-related records.

Limitations

A number of limitations exist for using conservation easements as a storm water management tool. One is that there is no hard evidence that conservation easements actually do protect water quality. Another is that conservation easements are often not an option in more urbanized areas, where the size, quality, and cost of land can restrict the use of easements. Easements might also not be held in perpetuity, which means that land could still face development pressure in the future. Easements also may not provide for the filtering of pollutants from concentrated flows. More information on the filtering potential of stream buffers can be found in the Buffer Zones fact sheet.

Maintenance Considerations

The responsibility for maintenance of property in a conservation easement depends on the individual agreement with a land trust or agency. While many organizations assume the responsibility for managing and monitoring a property, some land trusts leave maintenance responsibilities to the landowner and act only to monitor that the terms of the easement are met.

Effectiveness

The pollutant removal efficiency of a conservation area will depend on how much is conserved, the techniques used to conserve it, and the specific nature of the easement. Conservation easements are assumed to contribute water quality benefits, but no national studies proving this have been released.

Cost Considerations

Table 2 summarizes the costs of maintaining green spaces with different types of uses.

Table 2: Annual maintenance costs of different types of green space uses (Adapted from CWP, 1998)

Land Use	Approximate Annual Maintenance Costs
Natural open space Only minimum maintenance, trash/debris cleanup	$75/acre/year
Lawns Regular mowing	$270 to $240/acre/year

Passive recreation	$200/acre/year

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Post-Construction Storm Water Management in New Development & Redevelopment

Infrastructure Planning

Description

Developers can design streets and pedestrian paths to maximize convenience and safety while at the same time minimizing impervious surface area (Source: The Rouse Company, no date)

This practice requires changes in the regional growth planning process to contain sprawl development. Sprawl development is the expansion of low-density development into previously undeveloped land. The American Farmland Trust has estimated that the United States is losing about 50 acres an hour to suburban and exurban development (Longman, 1998). This sprawl development requires local governments to extend public services to new residential communities whose tax payments often do not cover the cost of providing those services. For example, in Prince William County, Virginia, officials have estimated that the costs of providing services to new residential homes exceeds what is brought in from taxes and other fees by $1,600 per home (Shear and Casey, 1996).

Infrastructure planning makes wise decisions to locate public services—water, sewer, roads, schools, and emergency services—in the suburban fringe and direct new growth into previously developed areas, discouraging low-density development. Generally, this is done by drawing a boundary or envelope around a community, beyond which major public infrastructure investments are discouraged or not subsidized. Meanwhile, economic and other incentives are provided within the boundary to encourage growth in existing neighborhoods. By encouraging housing growth in areas that are already provided with public services—water, sewer, roads, schools, and emergency services—communities not only save infrastructure development costs, but reduce the impacts of sprawl development on urban streams and water quality.

Sprawl development negatively impacts water quality in several ways. The most significant impact comes from the increase in impervious cover that is associated with sprawl growth. In addition to rooftop impervious area from new development, extension of road systems and additions of paved surface from driveways create an overall increase in imperviousness. This increase in the impervious cover level of an

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area directly influences local streams and water quality by increasing the volume of storm water runoff. These elevated runoff levels impact urban streams in several ways, including enlarging stream channels, increasing sediment and pollutant loads, degrading stream habitat, and reducing aquatic diversity (Schueler, 1995). Sprawl has been reported to generate 43 percent more runoff that contains three times greater sediment loads than traditional development (SCCCL, 1995).

Sprawl development influences water quality in other ways. This type of development typically occurs in areas not served by centralized sewer or water services. For example, over 80 percent of the land developed in the state of Maryland in the last decade has been outside the sewer and water "envelope." This requires new housing developments to use septic systems or another form of on-site wastewater disposal to treat household sewage. These on-site treatment systems can represent a significant source of nutrients and bacteria that affect both surface waters and groundwater. More information about septic systems is contained in the fact sheets in both the Illicit Discharge Detection and Elimination Category and the Pollution Prevention Category.

Applicability

Sprawl development occurs in all regions of the country and has recently become the subject of many new programs to counteract its impacts. These programs seldom focus on the water quality implications of sprawl growth, instead concentrating on economic and transportation issues. Even so, methods such as infrastructure planning can reduce the impact of new development. Promoting the infill and redevelopment of existing urban areas in combination with other better site design techniques (see the other fact sheets in this category) will decrease impervious cover levels and lessen the amount of pollution discharged to urban streams.

Siting and Design Conditions

Various techniques have been used to manage urban growth while conserving resources. Although none of these techniques specifically concentrates on infrastructure planning, each of the techniques recognizes that directing growth to areas that have been previously developed or promoting higher density development in areas where services exist prevents sprawl development and helps communities to mitigate the water quality impacts of economic growth. Among the techniques that have been used are:

- *Urban Growth Boundaries.* This planning tool establishes a dividing line that defines where a growth limit is to occur and where agricultural or rural land is to be preserved. Often, an urban services area is included in this boundary that creates a zone where public services will not be extended.

- *Infill/Community Redevelopment.* This practice encourages new development in unused or underutilized land in existing urban areas. Communities may offer tax breaks or other economic incentives to developers to promote the redevelopment of properties that are vacant or damaged.

The State of Maryland has been one of the states that has recently passed legislation to control growth. This "Smart Growth" legislation allows the State to direct its programs and funding to support locally-designated growth areas and protect rural and natural areas. The central component of this legislative package is the "Priority Funding Areas" legislation that limits most state infrastructure funding and economic development program monies to areas that local governments designate for growth and that meet guidelines for intended use, availability of plans for sewer and water systems, and permitted residential density (MOP, no date).

The other bills in the legislative package also support development of existing areas and preservation of undeveloped land. A brownfields program encourages revitalization of existing neighborhoods and industrial areas and establishes a brownfield revitalization incentive program that provides grants and low-interest loans to fund brownfield redevelopment. A new "Live Near Your Work" pilot program supports this effort by providing cash contributions to workers buying homes in certain older neighborhoods. The "Rural Legacy Program" spurs preservation of undeveloped land by providing financial resources for the protection of farm and forest lands from development and for the conservation of these essential rural resources from development.

Limitations

Intense development of existing areas can create a new set of challenges for storm water program managers. Storm water management solutions are often more difficult and complex in ultra-urban areas than in suburban areas. The lack of space for structural storm water controls and the high cost of available land where structural controls could be installed are just two problems that program managers will face in managing storm water in intensely developed areas.

Infrastructure planning is often done on a regional scale and requires a cooperative effort between all the communities within a given region in order to be successful. Phase II program managers will need to develop lines of communication with other state and local agencies and community leaders to ensure that infrastructure plans direct growth to those areas that will have the least impacts on watersheds and water quality.

Effectiveness

The effectiveness of infrastructure planning at protecting water quality is currently unknown. Although studies exist detailing the economic benefits of infrastructure planning, how this translates to storm water pollutant reductions is difficult if not impossible to calculate. However, a relationship does exist between impervious cover levels and urban stream characteristics, and one can assume that tools such as infrastructure planning that help control imperviousness have a positive impact on water quality.

Compact development benefits program managers in numerous ways. One benefit is that compact development can preserve prime agricultural land and sensitive areas while reducing costly construction of new infrastructure (Pelley, 1997). Less new land developed translates into less need for new infrastructure and public services.

Cost Considerations

The economic benefits of reducing costly construction of new infrastructure and providing new services can be quite substantial. The following is a list of examples of the projected savings of limiting sprawl through managed growth (APA, no date):

- New Jersey's plan for managed growth will save the state $700 million in road costs, $562 million in sewer and water costs, $178 million in school costs, and up to $380 million in operating costs per year.
- Fifteen years of continued sprawl would cost Maryland $10 billion more than a more compact pattern of growth.
- A 1989 Florida study demonstrated that planned, concentrated growth would cost the taxpayer 50 percent to 75 percent less than continued sprawl.

- The Cities of Minneapolis-St. Paul will spend $3.1 billion by the year 2020 for new water and sewer services to accommodate sprawl.
- Since 1980 the City of Fresno, California, has added $56 million in yearly revenues but has added $123 million in service costs.

Other studies have found that planned development consumes about 45 percent less land and costs 25 percent less for roads, 15 percent less for utilities, 5 percent less for housing, and 2 percent less for other fiscal impacts (Burchell and Listokin, 1995, as cited in Pelley, 1997).

The control of sprawl development through legislation and "Smart Growth" programs is currently being implemented in a number of states and counties across the U.S. As these programs mature and begin to influence development patterns in urban areas, local governments should begin to see the positive impacts of condensed growth on the aquatic environment and water quality of local streams.

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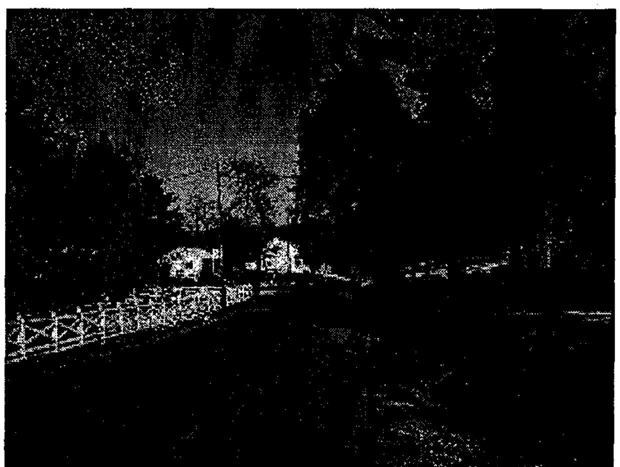
Post-Construction Storm Water Management in New Development & Redevelopment

Narrower Residential Streets

Description


A narrow street in a residential neighborhood. Cars can be parked in driveways or along the road shoulder

This better site design practice promotes the use of narrower streets to reduce the amount of impervious cover created by new residential development and, in turn, reduce the storm water runoff and associated pollutant loads. Currently, many communities require wide residential streets that are 32, 36, and even 40 feet wide. These wide streets provide two parking lanes and two moving lanes, but provide much more parking than is actually necessary. In many residential settings, streets can be as narrow as 22 to 26 feet wide without sacrificing emergency access, on-street parking or vehicular and pedestrian safety. Even narrower access streets or shared driveways can be used when only a handful of homes need to be served. However, developers often have little flexibility to design narrower streets, as most communities require wide residential streets as a standard element of their local road and zoning standards. Revisions to current local road standards are often needed to promote more widespread use of narrower residential streets.

Applicability

Narrower streets can be used in residential development settings that generate 500 or fewer average daily trips (ADT), which is generally about 50 single family homes, and may sometimes also be feasible for streets that are projected to have 500 to 1,000 ADT. However, narrower streets are not feasible for arterials, collectors, and other street types that carry greater traffic volumes or are not expected to have a constant traffic volume over time.

In most communities, existing local road standards will need to be modified to permit the use of narrower streets. Several communities have successfully implemented narrower streets, including Portland, OR; Bucks County, PA; Boulder, CO; and throughout New Jersey. In addition, there are numerous examples of communities where developers have successfully narrowed private streets within innovative subdivisions.

Siting and Design Conditions

Residential street design requires a careful balancing of many competing objectives: design, speed, traffic volume, emergency access, parking, and safety. Communities that want to change their road standards to permit narrower streets need to involve all the stakeholders who influence street design in the revision process. Several excellent references on narrow street design are provided at the end of this fact sheet.

Limitations

A number of real and perceived barriers hinder wider acceptance of narrower streets at the local level. Advocates for narrower streets will need to respond to the concerns of many local agencies and the general public. Some of the more frequent concerns about narrower streets are listed below.

- *Inadequate On-Street Parking.* Recent research and local experience have demonstrated that narrow streets can easily accommodate residential parking demand. A single family home typically requires 2 to 2.5 parking spaces. In most residential zones, this parking demand can be easily satisfied by one parking lane on the street and driveways.
- *Car and Pedestrian Safety.* Recent research indicates that narrow streets have lower accident rates than wide streets. Narrow streets tend to lower the speed of vehicles and act as traffic calming devices.
- *Emergency Access.* When designed properly, narrower streets can easily accommodate fire trucks, ambulances and other emergency vehicles.
- *Large Vehicles.* Field tests have shown that school buses, garbage trucks, moving vans, and other large vehicles can generally safely negotiate narrower streets, even when cars are parked on both sides of the street. In regions with high snowfall, streets may need to be slightly wider to accommodate snowplows and other equipment.
- *Utility Corridors.* It is often necessary to place utilities underneath the street rather than in the right of way.

In addition, local communities may lack the authority to change road standards when the review of public roads is retained by state agencies. In these cases, street narrowing can be accomplished only on private streets (i.e., maintained by residents rather than a local or state agency).

Maintenance Considerations

Narrower streets should slightly reduce road maintenance costs for local communities, since they present a smaller surface area to maintain and repair.

Effectiveness

Since streets constitute the largest share of impervious cover in residential developments (about 40 to 50 percent), a shift to narrower streets can result in a 5-

to 20-percent overall reduction in impervious area for a typical residential subdivision (Schueler, 1995). As nearly all the pollutants deposited on street surfaces or trapped along curbs are delivered to the storm drain system during storm events, this reduced imperviousness translates directly into less storm water runoff and pollutant loadings from the development. From the standpoint of storm water quality, residential streets rank as a major source area for many storm water pollutants, including sediment, bacteria, nutrients, hydrocarbons, and metals (Bannerman, 1994).

Cost Considerations

Narrower streets cost less to build than wider streets. Considering that the cost of paving a road averages $15 per square yard, shaving even a mere four feet from existing street widths can yield cost savings of more than $35,000 per mile of residential street. In addition, since narrower streets produce less impervious cover and runoff, additional savings can be realized in the reduced size and cost of downstream storm water management facilities.

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Post-Construction Storm Water Management in New Development & Redevelopment

Eliminating Curbs and Gutters

Description

Developers can eliminate curbs and gutters to disconnect impervious surfaces and promote infiltration of storm water on vegetated areas (such as this grass-lined channel in a residential neighborhood)

This better site design practice involves promoting the use of grass swales as an alternative to curbs and gutters along residential streets. Curbs and gutters are designed to quickly convey runoff from the street to the storm drain and, ultimately, to the local receiving water. Consequently, curbs and gutters provide little or no removal of storm water pollutants. Indeed, curbs often act as a pollutant trap where deposited pollutants are stored until they are washed out in the next storm. Many communities require curb and gutters as a standard element of their road sections, and discourage the use of grass swales. Revisions to current local road and drainage regulations are needed to promote greater use of grass swales along residential streets, in the appropriate setting. The storm water management and pollutant removal benefits of grass swales are documented in detail in the Grassed Swales fact sheet.

Applicability

The use of engineered swales in place of curbs and gutters should be encouraged in low- and medium-density residential zones where soils, slope and housing density permit. However, eliminating curbs and gutters is generally not feasible for streets with high traffic volume or extensive on-street parking demand (i.e., commercial and industrial roads), nor is it a viable option in arid and semi-arid climates where grass cannot grow without irrigation. Moreover, the use of grass swales may not be permitted by current local or state street and drainage standards.

Siting and Design Conditions

A series of site factors must be evaluated to determine whether a grass swale is a viable replacement for curbs and gutters at a particular site.

Contributing drainage area. Most individual swales cannot accept runoff from more than 5 acres of contributing drainage area, and typically serve 1–2 acres each.

Slope. Swales generally require a minimum slope of 1 percent and a maximum slope of 5 percent.

Soils. The effectiveness of swales is greatest when the underlying soils are permeable (hydrologic soil groups A and B). The swale may need more engineering if soils are less permeable.

Water Table. Swales should be avoided if the seasonally high water table is within 2 feet of the proposed bottom of the swale.

Development Density. The use of swales is often difficult when development density becomes more intense than four dwelling units per acre, simply because the number of driveway culverts increases to the point where the swale essentially becomes a broken-pipe system. Typically, grass swales are designed with a capacity to handle the peak flow rate from a 10-year storm, and fall below erosive velocities for a 2-year storm.

Limitations

A number of real and perceived limitations hinder the use of grass swales as an alternative to curb and gutters:

- *Snowplow operation can be more difficult without a defined road edge*. However, on the plus side, roadside swales increase snow storage at the road edge, and smaller snowplows may be adequate.
- *The pavement edge along the swale can experience more cracking and structural failure, increasing maintenance costs*. The potential for pavement failure at the road/grass interface can be alleviated by "hardening" the interface with grass pavers or geo-synthetics placed beneath the grass. Other options include placing a low-rising concrete strip along the pavement edge.
- *The shoulder and open channel will require more maintenance*. In reality, maintenance requirements for grass channels are generally comparable to those of curb and gutter systems. The major requirements involve turf mowing, debris removal, and periodic inspections.
- *Some grass swales can have standing water, which make them difficult to mow, and can cause nuisance problems such as odors, discoloration, and mosquitoes*. In reality, grass channels are not designed to retain water for any appreciable period of time, and the potential for snakes and other vermin can be minimized by frequent mowing.

Other concerns involve fears about utility installation and worries that the grass edge along the pavement will be torn up by traffic and parking. While utilities will need to be installed below the paved road surface instead of the right of way, most other concerns can frequently be alleviated through the careful design and integration of the open channels along the residential street. (Consult the Grassed Swales fact sheet for details on design variations that can reduce these problems.)

Maintenance Considerations

The major maintenance requirement for grass swales involves mowing during the growing season, a task usually performed by homeowners. In addition, sediment deposits may need to be removed from the bottom of the swale every ten years or so, and the swale may need to be tilled and re-seeded periodically. Occasionally, erosion of swale side slopes may need to be stabilized. The overall maintenance burden of grass swales is low in relation to other storm water practices, and is usually within the competence of the individual homeowner. The only major maintenance problem that might arise pertains to "problem" swales that have standing water and are too wet to mow. This particular problem is often alleviated by the installation of an underground storm drain system.

Effectiveness

Under the proper design conditions, grass swales can be effective in removing pollutants from urban storm water (Schueler, 1996). More information on the pollutant removal capability of various grass swale designs can be found in the Grassed Swales fact sheet.

Cost Considerations

Engineered swales are a much less expensive option for storm water conveyance than the curb and gutter systems they replace. Curbs and gutters and the associated underground storm sewers frequently cost as much as $36 per linear foot, which is roughly twice the cost of a grass swale (Schueler, 1995, and CWP, 1998). Consequently, when curbs and gutters can be eliminated, the cost savings can be considerable.

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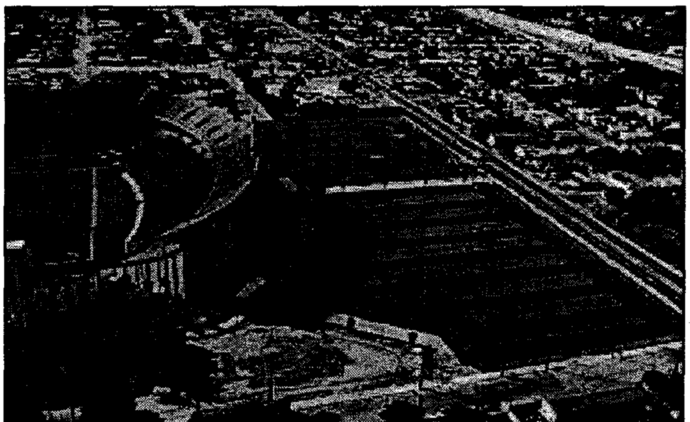
Post-Construction Storm Water Management in New Development & Redevelopment

Green Parking

Description



A green parking lot at the Orange Bowl in Miami, Florida (Source: Invisible Structures, no date)

Green parking refers to several techniques applied together to reduce the contribution of parking lots to the total impervious cover in a lot. From a storm water perspective, application of green parking techniques in the right combination can dramatically reduce impervious cover and, consequently, the amount of storm water runoff. Green parking lot techniques include setting maximums for the number of parking lots created, minimizing the dimensions of parking lot spaces, utilizing alternative pavers in overflow parking areas, using bioretention areas to treat storm water, encouraging shared parking, and providing economic incentives for structured parking.

Applicability

All of the green parking techniques can be applied in new developments and some can be applied in redevelopment projects, depending on the extent and parameters of the project. In urban areas, application of some techniques, like encouraging shared parking and providing economic incentives for structured parking, can be very practical and necessary. Commercial areas can have excessively high parking ratios, and application of green parking techniques in various combinations can dramatically reduce the impervious cover of a site.

Implementation

Many parking lot designs result in far more spaces than actually required. This problem is exacerbated by a common practice of setting parking ratios to accommodate the highest hourly parking during the peak season. By determining

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average parking demand instead, a lower maximum number of parking spaces can be set to accommodate most of the demand.

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Table 1 provides examples of conventional parking requirements and compares them to average parking demand.

Table 1: Conventional minimum parking ratios (Source: ITE, 1987; Smith, 1984; Wells, 1994)

Land Use	Parking Requirement		Actual Average Parking Demand
	Parking Ratio	Typical Range	
Single family homes	2 spaces per dwelling unit	1.5–2.5	1.11 spaces per dwelling unit
Shopping center	5 spaces per 1000 ft^2 GFA	4.0–6.5	3.97 per 1000 ft^2 GFA
Convenience store	3.3 spaces per 1000 ft^2 GFA	2.0–10.0	–
Industrial	1 space per 1000 ft^2 GFA	0.5–2.0	1.48 per 1000 ft^2 GFA
Medical/ dental office	5.7 spaces per 1000 ft^2 GFA	4.5–10.0	4.11 per 1000 ft^2 GFA
GFA = Gross floor area of a building without storage or utility spaces.			

Another green parking lot technique is to minimize the dimensions of the parking spaces. This can be accomplished by reducing both the length and width of the parking stall. Parking stall dimensions can be further reduced if compact spaces are provided. While the trend toward larger sport utility vehicles (SUVs) is often cited as a barrier to implementing stall minimization technique, stall width requirements in most local parking codes are much larger than the widest SUVs (CWP, 1998).

Utilizing alternative pavers is also an effective green parking technique. They can replace conventional asphalt or concrete in both new developments and redevelopment projects. Alternative pavers can range from medium to relatively high effectiveness in meeting storm water quality goals. The different types of alternative pavers include gravel, cobbles, wood mulch, brick, grass pavers, turf blocks, natural stone, pervious concrete, and porous asphalt. In general, alternate pavers require proper installation and more maintenance than conventional asphalt or concrete. For more specific information on alternate pavers, refer to the Alternative Pavers fact sheet.

Bioretention areas can effectively treat storm water leaving a parking lot. Storm water is directed into a shallow, landscaped area and temporarily detained. The runoff then filters down through the bed of the facility and is infiltrated into the subsurface or collected into an underdrain pipe for discharge into a stream or another storm water facility. Bioretention facilities can be attractively integrated into landscaped areas and can be maintained by commercial landscaping firms. For detailed design specifications of bioretention areas, refer to the Bioretention fact sheet.

Shared parking in mixed-use areas and structured parking also are green parking techniques that can further reduce the conversion of land to impervious cover. A shared parking arrangement could include usage of the same parking lot by an office space that experiences peak parking demand during the weekday with a church that experiences parking demands during the weekends and evenings. Costs may dictate the usage of structured parking, but building upward or downward can help minimize surface parking.

Limitations

Some limitations to applying green parking techniques include applicability, cost, and maintenance. For example, shared parking is only practical in mixed use areas, and structured parking may be limited by the cost of land versus construction. Alternative pavers are currently only recommended for overflow parking because of the considerable cost of maintenance. Bioretention areas increase construction costs.

The pressure to provide excessive parking spaces can come from fear of complaints as well as requirements of bank loans. These factors can pressure developers to construct more parking than necessary and present possible barriers to providing the greenest parking lot possible.

Effectiveness

Applied together, green parking techniques can effectively reduce the amount of impervious cover, help to protect local streams, result in storm water management cost savings, and visually enhance a site. Proper design of bioretention areas can help meet storm water management and landscaping requirements while keeping maintenance costs at a minimum.

Utilizing green parking lots can dramatically reduce the amount of impervious cover created. The level of the effectiveness depends on how much impervious cover is reduced as well as the combination of techniques utilized to provide the greenest parking lot. While the pollutant removal rates of bioretention areas have not been directly measured, their capability is considered comparable to a dry swale, which removes 91 percent of total suspended solids, 67 percent of total phosphorous, 92 percent of total nitrogen, and 80–90 percent of metals (Claytor and Schueler, 1996).

An excellent example of the multiple benefits of rethinking parking lot design is the Fort Bragg vehicle maintenance facility parking lot in North Carolina (NRDC, 1999). This redesign reduced impervious cover by 40 percent, increased parking by 20 percent, and saved $1.6 million (20 percent) on construction costs over the original, conventional design. Stormwater management features, such as detention basins located within grassed islands and an onsite drainage system that took advantage of existing sandy soils, were incorporated into the parking lot design as well.

Cost Considerations

Setting maximums for parking spaces, minimizing stall dimensions, and encouraging shared parking can result in considerable construction cost savings. At the same time, implementing green parking techniques can also reduce storm water management costs.

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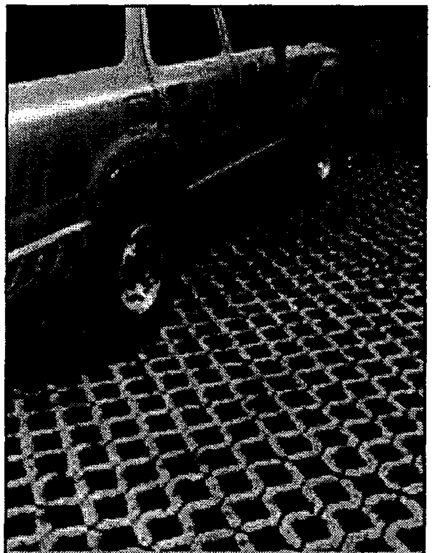
Post-Construction Storm Water Management in New Development & Redevelopment

Alternative Pavers

Description

Alternative pavers are permeable surfaces that can replace asphalt and concrete and can be used for driveways, parking lots, and walkways. From a storm water perspective, this is important because alternative pavers can replace impervious surfaces, creating less storm water runoff. The two broad categories of alternative pavers are paving blocks and other surfaces, including gravel, cobbles, wood, mulch, brick, and natural stone. While porous pavement is an alternative paver, as an engineered storm water management practice it is discussed in detail in the Porous Pavement fact sheet.



One type of alternative paver consists of a concrete lattice structure for support with grass growing in the void spaces (Source: Lo Gioco Landscaping, Inc., no date)

Paving Blocks

Paving blocks are concrete or plastic grids with gaps between them. Paving blocks make the surface more rigid and gravel or grass planted inside the holes allows for infiltration. Depending on the use and soil types, a gravel layer can be added underneath to prevent settling and allow further infiltration.

Other Alternative Surfaces

Gravel, cobbles, wood, and mulch also allow varying degrees of infiltration. Brick and natural stone arranged in a loose configuration allow for some infiltration through the gaps. Gravel and cobbles can be used as driveway material, and wood and mulch can be used to provide walking trails.

Applicability

Alternative pavers can replace conventional asphalt or concrete in parking lots,

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driveways, and walkways. At the same time, traffic volume and type can limit application. For this reason, alternative pavers for parking are recommended only for overflow areas. In residential areas, alternative surfaces can be used for driveways and walkways, but are not ideal for areas that require handicap accessibility.

Siting and Design Criteria

Accessibility, climate, soil type, traffic volume, and long-term performance should be considered, along with costs and storm water quality controls, when choosing paving materials. Use of alternative pavers in cold climates will require special consideration, as snow shovels are not practical for many of these surfaces. Sand is particularly troublesome if used with paving blocks, as the sand that ends up between the blocks cannot effectively wash away or be removed. In addition, salt used to de-ice can also infiltrate directly into the soil and cause potential ground water pollution.

Soil types will affect the infiltration rates and should be considered when using alternative pavers. Clayey soils (D soils) will limit the infiltration on a site. If ground water pollution is a concern, use of alternative pavers with porous soils should be carefully considered.

The durability and maintenance cost of alternative pavers also limits use to low-traffic-volume areas. At the same time, alternative pavers can abate storm water management costs. Used in combination with other better-site-design techniques, the cumulative effect on storm water can be dramatic.

Limitations

Alternative pavers are not recommended for high-traffic volumes for durability reasons. Access for wheelchairs is limited with alternative pavers. In addition, snow removal is difficult since plows cannot be used, sand can cause the system to clog, and salt can be a potential pollutant.

Maintenance Considerations

Alternative pavers require periodic maintenance, and costs increase when the permeable surface must be restored.

Effectiveness

The most obvious benefit of utilizing alternative pavers includes reduction or elimination of other storm water management techniques. Applied in combination with other techniques such as bioretention and green parking, pollutant removal and storm water management can be further improved. (see Bioretention and Green Parking fact sheets for more information.)

Alternative pavers all provide better water quality improvement than conventional asphalt or concrete, and the range of improvement depends on the type of paver used. Table 1 provides a list of pavers and the range of water quality improvement achievable by different types of alternative pavers.

Table 1. Water quality improvement of various pavers (Source: BASMAA, 1997)

Material	Water Quality Effectiveness
Conventional Asphalt/ Concrete	Low
Brick (in a loose configuration)	Medium

Natural Stone	Medium
Gravel	High
Wood Mulch	High
Cobbles	Medium

Cost Considerations

The range of installation and maintenance costs of various pavers is provided in Table 2. Depending on the material used, installation costs can be higher or lower for alternative pavers than for conventional asphalt or concrete, but maintenance costs are almost always higher.

Table 2. Installation and maintenance costs for various pavers (Source: BASMAA, 1997)

Material	Installation Cost	Maintenance Cost
Conventional Asphalt/Concrete	Medium	Low
Brick (in a loose configuration)	High	Medium
Natural Stone	High	Medium
Gravel	Low	Medium
Wood Mulch	Low	Medium
Cobbles	Low	Medium

Reference

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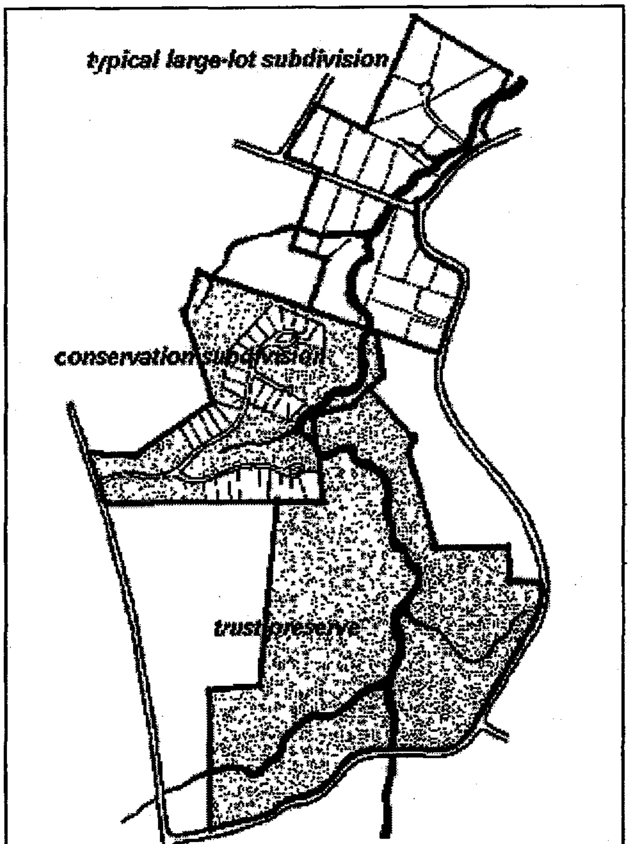
National Pollutant Discharge Elimination System (NPDES)

Post-Construction Storm Water Management in New Development & Redevelopment

Zoning



Property boundaries differ widely between traditional large-lot zoning, which maximizes the acreage of individual properties, and conservation zoning, which maximizes the amount of shared open space (Source: Arendt, 1996)

Description

Zoning is a classification scheme for land use planning. Zoning can serve numerous functions and can help mitigate storm water runoff problems by facilitating better site designs. By correctly applying the right zoning technique, development can be targeted into specific areas, limiting development in other areas and providing protection for the most important land conservation areas.

There are numerous types of zoning techniques for better site design, including watershed-based zoning, overlay zoning, floating zones, incentive zoning, performance zoning, urban growth boundaries, large lot zoning, infill/community redevelopment, transfer of development rights, and limiting infrastructure extensions. Table 1 describes each of these zoning techniques and its utility.

Table 1. Zoning techniques (Source: Caraco et al., 1998)

Land Use Planning Technique	Description	Utility as a Watershed Protection Technique
Watershed-Based Zoning	Watershed and subwatershed boundaries are the foundation for land use planning.	Protects receiving water quality on the subwatershed scale by relocating development out of particular subwatersheds.
Overlay Zoning	Superimposes additional regulations or specific development criteria within specific mapped districts.	Requires development restrictions or allows alternative site design techniques in specific areas.
Impervious Overlay Zoning	Specific overlay zoning that limits total impervious cover within mapped districts.	Protects receiving water quality at both the subwatershed and site level.
Floating Zones	Applies a special zoning district without identifying the exact location until land owner specifically requests the zone.	Obtains proffers or other watershed protective measures that accompany specific land uses within the district.
Incentive Zoning	Applies bonuses or incentives to encourage creation of amenities or environmental protection.	Encourages development within a particular subwatershed or to obtain open space in exchange for a density bonus at the site level.
Performance Zoning	Specifies a performance requirement that accompanies a zoning district.	Requires additional levels of performance within a subwatershed or at the site level.
Urban Growth Boundaries	Establishes a dividing line that defines where a growth limit is to occur and where agricultural or rural land is to be preserved.	Used in conjunction with natural watershed or subwatershed boundaries to protect specific water bodies.
Large Lot Zoning	Zones land at very low densities.	Decreases impervious cover at the site or subwatershed level, but may have an adverse impact on regional or

		watershed imperviousness.
Infill/Community Redevelopment	Encourages new development and redevelopment within existing developed areas.	Used in conjunction with watershed-based zoning or other zoning tools to restrict development in sensitive areas and foster development in areas with existing infrastructure.
Transfer of Development Rights (TDRs)	Transfers potential development from a designated "sending area" to a designated "receiving area."	Used in conjunction with watershed-based zoning to restrict development in sensitive areas and encourage development in areas capable of accommodating increased densities.
Limiting Infrastructure Extensions	A conscious decision is made to limit or deny extending infrastructure (such as public sewer, water, or roads) to designated areas to avoid increased development in these areas.	A temporary method to control growth in a targeted watershed or subwatershed. Usually delays development until the economic or political climate changes.

Applicability

The type of zoning to apply will depend on management goals. If water or land quality is a primary goal of the zoning technique, then watershed-based zoning can provide a comprehensive approach. At the same time, incentive zoning, performance zoning, and transfer of development rights can be used as protection measures for specific conservation areas.

Implementation

Watershed-Based Zoning: Watershed-based zoning can employ a mixture of land use and zoning options to achieve desired results. A watershed-based zoning approach should include the following nine steps:

- Conduct a comprehensive stream inventory.
- Measure current levels of impervious cover.
- Verify impervious cover/stream quality relationships.
- Project future levels of impervious cover.
- Classify subwatersheds-based on stream management "templates" and current impervious cover.
- Modify master plans/zoning to correspond to subwatershed impervious cover targets and other management strategies identified in Subwatershed Management Templates.
- Incorporate management priorities from larger watershed management units such as river basins or larger watersheds (see discussion later in this fact

sheet).

- Adopt specific watershed protection strategies for each subwatershed.
- Conduct long-term monitoring over a prescribed cycle to assess watershed status.

Overlay Zoning: The advantage of overlay zones is that specific criteria can be applied to isolated areas without the threat of being considered spot zoning. Overlay districts are not necessarily restricted by the limits of the underlying base zoning. An overlay zone may take up only a part of an underlying zone or may even encompass several underlying zones. Often the utilization of an overlay zone is optional.

Impervious Overlay Zoning: This type of overlay zoning limits future impervious areas. The environmental impacts of future impervious cover are estimated and a limit is set on the maximum imperviousness within a given planning area. Site development proposals are then reviewed in the context of an imperviousness cap. Subdivision layout options must then conform to the total impervious limit of the planning area.

Floating Zones: Normally, a parcel of land will not qualify for the application of the floating zone district unless it is large enough to allow the buffering of its development from the surrounding area. It is important to note that the existence of a floating zone district does not automatically grant rezoning to each landowner whose property complies with the prescribed conditions. Each property owner must have his or her application for rezoning reviewed and approved by the local governing body to determine if it is consistent with a comprehensive development plan.

Incentive Zoning: This planning technique relies on bonuses or incentives for developers to encourage the creation of certain amenities or land use designs. A developer is granted the right to build more intensively on a property or given some other bonus in exchange for an amenity or a design that the community considers beneficial. Developers stand to gain an increase in profits from the more intensive use of the property, while a community might use incentive zoning to promote more compact development, encourage open space designs, or generate other desired amenities such as trails, parks, or totlots.

Performance Zoning: Performance zoning is a flexible approach that has been employed in a variety of fashions in several different communities across the country. Some performance factors include traffic or noise generation limits, lighting requirements, storm water runoff quality and quantity criteria, protection of wildlife and vegetation, and even architectural style criteria.

Urban Growth Boundaries: Urban growth boundaries are sometimes called development service districts and include areas where public services are already provided (e.g., sewer, water, roads, police, fire, and schools). The delineation of the boundary is very important. Several important issues to consider in establishing an urban growth boundary include the following:

- Public facilities and services must be nearby and/or can be provided at reasonable cost and in a specific time frame.
- A sufficient amount of land to meet projected growth over the planning period must be provided.
- A mix of land uses must be provided.
- The potential impact of growth within the boundary on existing natural

resources should be analyzed.

- The criteria for defining the boundary needs to be fair and should consider natural features (versus man-made features) wherever possible. The use of watershed boundaries as the urban growth boundary is one such natural feature.

Large Lot Zoning: Although large lot zoning does tend to reduce the impervious cover and therefore the amount of storm water runoff at a particular location, it also spreads development over vast areas. The road networks required to connect these large lots can actually increase the total amount of imperviousness created for each dwelling unit (Schueler, 1995). In addition, large lot zoning contributes to regional sprawl. Sprawl-like development increases the expense of providing community services such as fire protection, water and sewer systems, and school transportation.

Infill/Community Redevelopment: Infill and redevelopment can be employed in either large or small projects. Some of the existing impediments to more widespread implementation of these types of projects include the existing condition of a potential redevelopment site in terms of environmental constraints, the restrictive nature of many land use regulations, and pressing social and economic issues. Local governments may need to modify local zoning or building codes to make infill and redevelopment a more inviting attraction to developers. In addition, citizen involvement has been demonstrated to be a vital catalyst for leveraging funding or revising codes. Furthermore, lending institutions must be progressive in their view of funding infill and redevelopment projects. One possibility is to partner with local governments or community organizations.

Transfer of Development Rights (TDRs): The principle of TDRs is based on the premise that ownership of land entails certain property rights. While some of these rights may be restricted by zoning, building codes, and environmental constraints, landowners are "entitled" to use their land for the "highest and best use." TDRs are based on a market-driven incentive program where it is possible to sell development potential (zoned density) without buying or selling land. Landowners in preservation areas are compensated for lost development potential , while conventional down-zoning deprives landowners of this potential value.

Limitations

Some zoning techniques may be limited by economic and political acceptance and should be evaluated on these criteria as well as storm water management goals.

Maintenance Considerations

Some maintenance issues to consider for the long term are the following:

- What are the most economically and politically acceptable zoning technique (s) that can be used to shift or reduce impervious cover among the subwatersheds?
- How accurate are the estimates of the amount and location of future impervious cover in the watershed? Are better projections needed?
- Will future increases in impervious cover create unacceptable changes to a watershed and/or subwatershed?
- Which subwatersheds appear capable of absorbing future growth in impervious cover?

Effectiveness

There are numerous case studies of performance-based zoning used in different communities. Some of these examples are summarized in Table 2.

Table 2. Case examples of performance-based zoning (Source: Porter et al., 1991)

Location	Performance Zoning Provisions	Notes
Fort Collins, Colorado	Planned Unit Development (PUD) options are applied to all parcels in city. Developers may choose conventional zoning or the optional PUD. PUD proposals must meet a point value for an absolute criterion and a relative criterion.	Applications are discussed at a conceptual stage where suggestions are made to improve scores. The local planning board has quite a bit of latitude to use discretion to require special conditions.
Largo, Florida	The Land Use Plan defines uses and densities. Four overlay "policy"districts (environmental conservation, management, redevelopment, and downtown) define general standards and prohibited uses. Each land use within a policy district falls into a one of three classes (allowable, allowable with special mitigating measures, or prohibited).	A variety of uses are permitted within the 4 policy districts when applying the special mitigating measures. The city also has a five-tiered system of review and approval that facilitates fast reviews for many common applications and a more involved process for projects that require mitigation.
Hardin County, Kentucky	The land development ordinance allows agricultural and single family uses by right. All other uses must be evaluated by a three-step process. At the first step, the agricultural and development potential is evaluated using a point system. If the site scores a minimum threshold value, than it moves onto the second step, a compatibility assessment. The final step involves typical review of subdivision standards and requirements.	The program places a special emphasis on preserving agricultural uses. The process involves a unique feature that calls on citizen consensus for each step. This decision making process might be considered highly discretionary, but with a widespread interest by most Hardin County citizens in seeing development proceed, there have been few complaints.
	The township's ordinance provides five	

Bath Charter Township, Michigan	zoning districts: two traditional districts for rural, low-density residential; and three applied to existing settlements/expected development corridor. These three districts allow a range of uses either "by right" or with special permits for certain uses.	The ordinance is a compromise between complex, inflexible zoning and no zoning at all. The process allows for extensive review and individual decisions for individual controversial cases.
Buckingham Township, Pennsylvania	The ordinance contains typical zoning districts but provides cluster and performance standard development provisions. It aims to preserve natural resources by clustering housing on the least environmentally sensitive areas.	Development of cluster and performance standards are "by rights," and as such, do not require public hearings. The sensitivity of natural areas makes the zoning more flexible in unrestricted areas but less flexible than most conventional zoning in placing restrictions for protecting natural areas.
Duxbury, Massachusetts	Two new categories of development (planned developments and cluster) were created in addition to existing traditional zoning. Both types are allowed in different portions of the town under a special permit process.	Termed "impact zoning," the ordinance aimed to create incentives for developers to build more diverse and environmentally sensitive housing. Developers are choosing standard subdivisions over the optional techniques to avoid lengthy and complex reviews.

Cost Considerations

Subwatershed planning for better site design zoning involves many costs. Mapping, photography, delineations, and involving the public are some of the items typically in such a budget (Table 3).

Table 3. Unit prices for subwatershed planning (Adapted from CWP, 1998)

Budget Item	Estimated Unit Cost	Assumptions
Aerial Photography	$500 per photo	Includes aerial flyover and developing of one color photograph.
Base Mapping	$500	For Subwatershed Management Map using USGS 7.5 minute Quad. Sheet. Includes, subwatershed delineation, overlaying land use, monitoring

		stations, and transportation routes.
Base Mapping	$5,000	For Aquatic Corridor Management Map, using aerial topography at 2' contour interval. Includes, aerial topography at 1" = 200', locating existing utilities, floodplain, wetlands, and riparian cover from existing maps (no field walk and no topo. survey control).
Floodplain Delineation	$5,000	Detailed analysis beyond FEMA, cross-sections plotted at 1000 ft on-center, topo spot-checked, road crossings evaluated, includes report, assumes flow data are available.
Geographic Information System (GIS)—start-up	$15,000	High end work station and software (e.g., ARC/INFO), includes approx. 2 weeks of training for operator. Does not include data layers
GIS—Obtain or Digitize Data Layers	–	Data layers include impervious cover, topography (5' C.I.), zoning, utilities, vegetative cover (broad categories)
Impervious Cover Measurement—Actual	$3,000	Uses digital orthophotography, impervious layer clipped at subwatershed boundary, algorithm to calculate impervious area
Impervious Cover Estimation—Land Use	$600	Uses land use designations or zoning and measured areas compared against tables, requires review of aerial photo (not included) to estimate build-out.
Impervious Cover Projection—Based on Future Land Use	$800	Uses zoning or master plan and measured areas compared against tables, requires assessment of future build-out
		1000 homes contacted

Public Attitude Survey	$15,000 per survey	by telephone, includes survey questionnaire preparation and data analysis.
Stakeholder Involvement Program	$15,000	Plan and hold four public and four community meetings, direct mail to 20,000 people, staff time and direct expenses included.

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City of Corvallis Stormwater Phase II
Post-Construction Stormwater Management
in New Development and Redevelopment

Appendix SM-B

City of Corvallis
Stormwater Master Plan

Please see separate document for Appendix SM-B.

City of Corvallis Stormwater Phase II
Post-Construction Stormwater Management
in New Development and Redevelopment

Appendix SM-C

EPA Model
Post-Construction Runoff Control Ordinance

Model Ordinance for the Control of Post Construction Stormwater Runoff

Table of Contents

Section 1. General Provisions

1.1. Findings of Fact

It is hereby determined that:

Land development projects and associated increases in impervious cover alter the hydrologic response of local watersheds and increase stormwater runoff rates and volumes, flooding, stream channel erosion, and sediment transport and deposition;

This stormwater runoff contributes to increased quantities of water-borne pollutants, and;

Stormwater runoff, soil erosion and nonpoint source pollution can be controlled and minimized through the regulation of stormwater runoff from development sites.

Therefore, the **(jurisdictional stormwater authority)** establishes this set of water quality and quantity policies applicable to all surface waters to provide reasonable guidance for the regulation of stormwater runoff for the purpose of protecting local water resources from degradation. It is determined that the regulation of stormwater runoff discharges from land development projects and other construction activities in order to control and minimize increases in stormwater runoff rates and volumes, soil erosion, stream channel erosion, and nonpoint source pollution associated with stormwater runoff is in the public interest and will prevent threats to public health and safety.

1.2. Purpose

The purpose of this ordinance is to establish minimum stormwater management requirements and controls to protect and safeguard the general health, safety, and welfare of the public residing in watersheds within this jurisdiction. This ordinance seeks to meet that purpose through the following objectives:

(1). minimize increases in stormwater runoff from any development in order to reduce flooding, siltation, increases in stream temperature, and streambank erosion and maintain the integrity of stream channels;

(2). minimize increases in nonpoint source pollution caused by stormwater runoff from development which would otherwise degrade local water quality

(3). minimize the total annual volume of surface water runoff which flows from any specific site during and following development to not exceed the pre-development hydrologic regime to the maximum extent practicable.

(4). reduce stormwater runoff rates and volumes, soil erosion and nonpoint source pollution, wherever possible, through stormwater management controls and to ensure that these management controls are properly maintained and pose no threat to public safety.

➲ *The above list is a general set of objectives to reduce the impact of stormwater on receiving waters. The local stormwater authority may wish to set some more specific objectives, based on priority water quality and habitat problems (e.g., to reduce phosphorus loads being delivered to recreational lakes, to sustain a class X trout fishery)*

1.3. Applicability

This ordinance shall be applicable to all subdivision or site plan applications, unless eligible for an exemption or granted a waiver by the **(jurisdictional stormwater authority)** under the specifications of Section 4 of this ordinance. The ordinance also applies to land development activities that are smaller than the minimum applicability criteria if such activities are part of a larger common plan of development that meets the following applicability criteria, even though multiple separate and distinct land development activities may take place at different times on different schedules. In addition, all plans must also be reviewed by local environmental protection officials to ensure that established water quality standards will be maintained during and after development of the site and that post construction runoff levels are consistent with any local and regional watershed plans.

➲ *The size of the site development to which post-construction stormwater management runoff control applies varies but many communities opt for a size limit of 5000 square feet or more. For sites less than 5000 square feet, local officials may wish to grant an exemption as long as the amount of impervious cover created does not exceed 1000 square feet.*

To prevent the adverse impacts of stormwater runoff, the **(jurisdictional stormwater authority)** has developed a set of performance standards that must be met at new development sites. These standards apply to any construction activity disturbing ____ or more square feet of land. The following activities may be exempt from these stormwater performance criteria:

1. Any logging and agricultural activity which is consistent with an approved soil conservation plan or a timber management plan prepared or approved by the

(appropriate agency), as applicable.

2. Additions or modifications to existing single family structures
3. Developments that do not disturb more than ____ square feet of land, provided they are not part of a larger common development plan;
4. Repairs to any stormwater treatment practice deemed necessary by **(jurisdictional stormwater authority)**.

When a site development plan is submitted that qualifies as a redevelopment project as defined in Section 2 of this ordinance, decisions on permitting and on-site stormwater requirements shall be governed by special stormwater sizing criteria found in the current stormwater design manual. This criteria is dependent on the amount of impervious area created by the redevelopment and its impact on water quality. Final authorization of all redevelopment projects will be determined after a review by **(jurisdictional stormwater authority)**.

➲ *There are a number of decisions to be made by local communities when addressing the issue of redevelopment and stormwater treatment. The first is defining exactly what qualifies as redevelopment. The definition in Section 2 is from the current Maryland Stormwater Management regulations, and uses the square foot size of the project and its land use classification to establish the definition of a redevelopment project. The second decision involves to what level of stormwater management standards redevelopment projects will be held. Providing cost effective stormwater treatment at redevelopment sites is often a difficult task, and these projects may be given reduced criteria to meet to allow for site constraints. The State of Maryland currently requires that proposed redevelopment project designs include either at least a 20 percent reduction in existing site impervious area, management of at least 20 % of the water quality volume, or some combination of both.*

1.4. Compatibility with Other Permit and Ordinance Requirements

This ordinance is not intended to interfere with, abrogate, or annul any other ordinance, rule or regulation, stature, or other provision of law. The requirements of this ordinance should be considered minimum requirements, and where any provision of this ordinance imposes restrictions different from those imposed by any other ordinance, rule or regulation, or other provision of law, whichever provisions are more restrictive or impose higher protective standards for human health or the environment shall be considered to take precedence.

1.5. Severability

If the provisions of any article, section, subsection, paragraph, subdivision or clause of this ordinance shall be judged invalid by a court of competent jurisdiction, such order of judgment shall not affect or invalidate the remainder of any article, section, subsection, paragraph, subdivision or clause of this ordinance.

1.6. Development of a Stormwater Design Manual

The **(jurisdictional stormwater authority)** may furnish additional policy, criteria and information including specifications and standards, for the proper implementation of the requirements of this ordinance and may provide such information in the form of a Stormwater Design Manual.

This manual will include a list of acceptable stormwater treatment practices, including the specific design criteria and operation and maintenance requirements for each stormwater practice. The manual may be updated and expanded from time to time, at the discretion of the local review authority, based on improvements in engineering, science, monitoring and local maintenance experience. Stormwater treatment practices that are designed and constructed in accordance with these design and sizing criteria will be presumed to meet the minimum water quality performance standards.

➲ *Local communities will need to select the minimum water quality performance standards (e.g., 80% TSS, 40% P) they will require for stormwater treatment practices and place these in their design manual. The 80% removal goal for total suspended solids (TSS) is a management measure developed by EPA as part of the Coastal Zone Act Reauthorization Amendments of 1990. It was selected by EPA for the following factors: (1) removal of 80% is assumed to control heavy metals, phosphorus, and other pollutants; (2) a number of states including DE, FL, TX, MD, and MA require/recommend TSS removal of 80% or greater for new development; and (3) data show that certain structural controls, when properly designed and maintained, can meet this performance level. Further discussion of water quality standards for stormwater management measures can be found in the CZARA Coastal Zone 6217(g) management measures document entitled "Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters" (US EPA, 1993).*

➲ *There are a number of good stormwater design manuals available around the country that communities may wish to refer to in creating their own local manual. Two examples are the new Maryland Department of the Environment 2000 Maryland Stormwater Design Manual Volumes I & II available online at http://www.mde.state.md.us/environment/wma/stormwatermanual/ and the Stormwater Management Manual for Western Washington, Volumes 1-5 available online at http://www.ecy.wa.gov/programs/wq/stormwater/manual.html.*

➲ *Local communities may also wish to consult a new resource available on the Internet called the* ***Stormwater Managers Resource Center (SMRC)****. This site is dedicated to providing information to stormwater management program managers in Phase II communities to assist in meeting the requirements of the new National Pollutant Discharge Elimination System Phase II regulations. Among the resources available at the website will be a section devoted to supplying guidance on how to build a stormwater manual, including sizing and design criteria. The SMRC website and the manual-builder resources are located at www.stormwatercenter.net.*

Section 2. Definitions

"Accelerated Erosion" means erosion caused by development activities that exceeds the natural processes by which the surface of the land is worn away by the action of water, wind, or chemical action.

"Applicant" means a property owner or agent of a property owner who has filed an application for a stormwater management permit.

"Building" means any structure, either temporary or permanent, having walls and a roof, designed for the shelter of any person, animal, or property, and occupying more than 100 square feet of area.

"Channel" means a natural or artificial watercourse with a definite bed and banks that conducts continuously or periodically flowing water.

"Dedication" means the deliberate appropriation of property by its owner for general public use.

"Detention" means the temporary storage of storm runoff in a stormwater management practice with the goals of controlling peak discharge rates and providing gravity settling of pollutants.

"Detention Facility" means a detention basin or alternative structure designed for the purpose of temporary storage of stream flow or surface runoff and gradual release of stored water at controlled rates.

"Developer" means a person who undertakes land disturbance activities.

"Drainage Easement" means a legal right granted by a landowner to a grantee allowing the use of private land for stormwater management purposes.

"Erosion and Sediment Control Plan" means a plan that is designed to minimize the accelerated erosion and sediment runoff at a site during construction activities.

"Fee in Lieu" means a payment of money in place of meeting all or part of the storm water performance standards required by this ordinance.

"Hotspot" means an area where land use or activities generate highly contaminated runoff, with concentrations of pollutants in excess of those typically found in stormwater.

"Hydrologic Soil Group (HSG)" means a Natural Resource Conservation Service classification system in which soils are categorized into four runoff potential groups. The groups range from A soils, with high permeability and little runoff production, to D soils, which have low permeability rates and produce much more runoff.

"Impervious Cover" means those surfaces that cannot effectively infiltrate rainfall (e.g., building rooftops, pavement, sidewalks, driveways, etc).

"Industrial Stormwater Permit" means an National Pollutant Discharge Elimination System permit issued to a commercial industry or group of industries which regulates the pollutant levels associated with industrial stormwater discharges or specifies on-site pollution control strategies.

"Infiltration" means the process of percolating stormwater into the subsoil.

"Infiltration Facility" means any structure or device designed to infiltrate retained water to the subsurface. These facilities may be above grade or below grade.

"Jurisdictional Wetland" means an area that is inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support a prevalence of vegetation typically adapted for life in saturated soil conditions, commonly known as hydrophytic vegetation.

"Land Disturbance Activity" means any activity which changes the volume or peak flow discharge rate of rainfall runoff from the land surface. This may include the grading, digging, cutting, scraping, or excavating of soil, placement of fill materials, paving, construction, substantial removal of vegetation,, or any activity which bares soil or rock or involves the diversion or piping of any natural or man-made watercourse.

"Landowner" means the legal or beneficial owner of land, including those holding the right to purchase or lease the land, or any other person holding proprietary rights in the land.

"Maintenance Agreement" means a legally recorded document that acts as a property deed restriction, and which provides for long-term maintenance of storm water management practices.

"Nonpoint Source Pollution" means pollution from any source other than from any discernible, confined, and discrete conveyances, and shall include, but not be limited to, pollutants from agricultural, silvicultural, mining, construction, subsurface disposal and urban runoff sources.

"Offset Fee" means a monetary compensation paid to a local government for failure to meet pollutant load reduction targets.

"Off-Site Facility" means a stormwater management measure located outside the subject property boundary described in the permit application for land development activity.

"On-Site Facility" means a stormwater management measure located within the subject property boundary described in the permit application for land development activity.

"Recharge" means the replenishment of underground water reserves.

"Redevelopment" means any construction, alteration or improvement exceeding ___ square feet in areas where existing land use is high density commercial, industrial, institutional or multi-family residential.

"Stop Work Order" means an order issued which requires that all construction activity on a site be stopped.

"Storm Water Management" means the use of structural or non-structural practices that are designed to reduce storm water runoff pollutant loads, discharge volumes, peak flow discharge rates and detrimental changes in stream temperature that affect water quality and habitat.

"Storm Water Retrofit" means a stormwater management practice designed for an existing development site that previously had either no stormwater management practice in place or a practice inadequate to meet the stormwater management requirements of the site.

"Stormwater Runoff" means flow on the surface of the ground, resulting from precipitation.

"Stormwater Treatment Practices (STPs)" means measures, either structural or nonstructural, that are determined to be the most effective, practical means of preventing or reducing point source or nonpoint source pollution inputs to stormwater runoff and water bodies.

"Water Quality Volume (WQ_v)" means the storage needed to capture and treat 90% of the average annual stormwater runoff volume. Numerically **(WQ_v)** will vary as a function of long term rainfall statistical data.

"Watercourse" means a permanent or intermittent stream or other body of water, either natural or man-made, which gathers or carries surface water.

Section 3. Permit Procedures and Requirements

3.1. Permit Required.

No land owner or land operator shall receive any of the building, grading or other land development permits required for land disturbance activities without first meeting the requirements of this ordinance prior to commencing the proposed activity.

➲ *The intent is to ensure that no activities that disturb the land are issued permits prior to review and approval of the stormwater management plan. Communities may elect to issue a stormwater management permit separate of any other land development permits required, or, as in this ordinance, tie the issuing of construction permits to the approval of a final stormwater management plan.*

3.2. Application Requirements

Unless specifically excluded by this ordinance, any land owner or operator desiring a permit for a land disturbance activity shall submit to the **(jurisdictional stormwater authority)** a permit application on a form provided for that purpose.

Unless otherwise excepted by this ordinance, a permit application must be accompanied by the following in order that the permit application be considered: a stormwater management concept plan; a maintenance agreement; and a non-refundable permit review fee.

The stormwater management plan shall be prepared to meet the requirements of Sec. 5 of this ordinance, the maintenance agreement shall be prepared to meet the requirements of Sec. 9 of this ordinance, and fees shall be those established by the **(jurisdictional stormwater authority)**.

3.3. Application Review Fees

The fee for review of any land development application shall be based on the amount of land to be disturbed at the site, and the fee structure shall be established by the **(jurisdictional stormwater authority)**. All of the monetary contributions shall be credited to a local budgetary category to support local plan review, inspection and program administration, and shall be made prior to the issuance of any building permit for the development.

➲ *Local communities can use these review fees to raise funds for staff and resources to further their stormwater management programs.*

3.4. Application Procedure

1. Applications for land disturbance activity permits must be filed with the **(appropriate review agency)** on any regular business day.
2. A copy of this permit application shall be forwarded to **(jurisdictional stormwater authority)** for review
3. Permit applications shall include the following: two copies of the stormwater management concept plan, two copies of the maintenance agreement, and any required review fees.
4. Within __ business days of the receipt of a complete permit application, including all documents as required by this ordinance, the **(jurisdictional stormwater authority)** shall inform the applicant whether the application, plan and maintenance agreement are approved or disapproved.

➲ *Local officials will need to decide the appropriate time frame for review of an application. This will often be determined by the staff available for permit review and for an inspection of sites undergoing construction.*

5. If the permit application, stormwater management plan or maintenance agreement are disapproved, the applicant may revise the stormwater management plan or agreement. If additional information is submitted, the **(jurisdictional stormwater authority)** shall have __ business days from the date the additional information is received to inform the applicant that the plan and maintenance agreement are either approved or disapproved.
6. If the permit application, final stormwater management plan and maintenance agreement are approved by the **(jurisdictional stormwater authority)**, all appropriate land disturbance activity permits shall be issued.

3.5. Permit Duration

Permits issued under this section shall be valid from the date of issuance through the date the **(jurisdictional stormwater authority)** notifies the permitholder that all stormwater management practices have passed the final inspection required under permit condition.

Section 4. Waivers to Stormwater Management Requirements

4.1. Waivers for Providing Stormwater Management

Every applicant shall provide for stormwater management as required by this ordinance, unless a written request is filed to waive this requirement. Requests to waive the stormwater management plan requirements shall be submitted to the **(jurisdictional stormwater authority)** for approval.

The minimum requirements for stormwater management may be waived in whole or in part upon written request of the applicant, provided that at least one of the following conditions applies:

1. It can be demonstrated that the proposed development is not likely to impair attainment of the objectives of this ordinance.
2. Alternative minimum requirements for on-site management of stormwater discharges have been established in a stormwater management plan that has been approved by the **(jurisdictional stormwater authority)** and the implementation of the plan is required by local ordinance.
3. Provisions are made to manage stormwater by an off-site facility. The off-site facility is required to be in place, to be designed and adequately sized to provide a level of stormwater control that is equal to or greater than that which would be afforded by on-site practices and there is a legally obligated entity responsible for long-term operation and maintenance of the stormwater practice.
4. The **(jurisdictional stormwater authority)** finds that meeting the minimum on-site management requirements is not feasible due to the natural or existing physical characteristics of a site.

5. Non-structural practices will be used on the site that reduce: a) the generation of stormwater from the site, b) the size and cost of stormwater storage and c) the pollutants generated at the site. These non-structural practices are explained in detail in the current design manual and the amount of credit available for using such practices shall be determined by the **(jurisdictional stormwater authority)**.

In instances where one of the conditions above applies, the **(jurisdictional stormwater authority)** may grant a waiver from strict compliance with these stormwater management provisions, as long as acceptable mitigation measures are provided. However, to be eligible for a variance, the applicant must demonstrate to the satisfaction of the **(jurisdictional stormwater authority)** that the variance will not result in the following impacts to downstream waterways:

Deterioration of existing culverts, bridges, dams, and other structures;
Degradation of biological functions or habitat;
Accelerated streambank or streambed erosion or siltation;
Increased threat of flood damage to public health, life, property .

Furthermore, where compliance with minimum requirements for stormwater management is waived, the applicant will satisfy the minimum requirements by meeting one of the mitigation measures selected by the jurisdictional stormwater authority. Mitigation measures may include, but are not limited to, the following:

- The purchase and donation of privately owned lands, or the grant of an easement to be dedicated for preservation and/or reforestation. These lands should be located adjacent to the stream corridor in order to provide permanent buffer areas to protect water quality and aquatic habitat,
- The creation of a stormwater management facility or other drainage improvements on previously developed properties, public or private, that currently lack stormwater management facilities designed and constructed in accordance with the purposes and standards of this ordinance,
- Monetary contributions (Fee-in-Lieu) to fund stormwater management activities such as research and studies (e.g., regional wetland delineation studies, stream monitoring studies for water quality and macroinvertebrates, stream flow monitoring, threatened and endangered species studies, hydrologic studies, and monitoring of stormwater management practices.

4.2. Fee in Lieu of Stormwater Management Practices.

Where the **(jurisdictional stormwater authority)** waives all or part of the minimum stormwater management requirements, or where the waiver is based on the provision of adequate stormwater facilities provided downstream of the proposed development, the applicant shall be required to pay a fee in an amount as determined by the **(jurisdictional stormwater authority)**.

When an applicant obtains a waiver of the required stormwater management, the monetary contribution required shall be in accordance with a fee schedule (unless the developer and the stormwater authority agree on a greater alternate contribution) established by the **(jurisdictional stormwater authority)**, and based on the cubic feet of storage required for stormwater management of the development in question. All of the monetary contributions shall be credited to an appropriate capital improvements program project, and shall be made by the developer prior to the issuance of any building permit for the development.

4.3. Dedication of land

In lieu of a monetary contribution, an applicant may obtain a waiver of the required stormwater management by entering into an agreement with the **(jurisdictional stormwater authority)** for the granting of an easement or the dedication of land by the applicant, to be used for the construction of an off-site stormwater management facility. The agreement shall be entered into by the applicant and the **(jurisdictional stormwater authority)** prior to the recording of plats or, if no record plat is required, prior to the issuance of the building permit.

Section 5. General Performance Criteria for Stormwater Management

Unless judged by the **(jurisdictional stormwater authority)** to be exempt or granted a waiver, the following performance criteria shall be addressed for stormwater management at all sites:

(A). All site designs shall establish stormwater management practices to control the peak flow rates of stormwater discharge associated with specified design storms and reduce the generation of stormwater. These practices should seek to utilize pervious areas for stormwater treatment and to infiltrate stormwater runoff from driveways, sidewalks, rooftops, parking lots, and landscaped areas to the maximum extent practical to provide treatment for both water quality and quantity.

➲ *There are several sources of climatological references that can be consulted to find the rainfall depths for the appropriate design storm intervals (1, 10, 25, and 100 year). The NOAA National Climatological Data Center has a "Summary of the Day" database that can provide rainfall numbers for most major cities and airports in the country. Another possible source is the Urban Hydrology for Small Watersheds, TR-55 (Technical Release 55) published by the Engineering Division, United States Natural Resource Conservation Service (formerly known as the Soil Conservation Service) United States Department of Agriculture, June 1986.*

(B). All stormwater runoff generated from new development shall not discharge untreated stormwater directly into a jurisdictional wetland or local water body without adequate treatment. Where such discharges are proposed, the impact of the proposal on wetland functional values shall be assessed using a method acceptable to the **(jurisdictional stormwater authority)**. In no case shall the impact on functional values be any less than allowed by the Army Corp of Engineers (ACE) or the **(Appropriate State Agency)** responsible for natural resources.

(C). Annual groundwater recharge rates shall be maintained, by promoting infiltration through the use of structural and non-structural methods. At a minimum, annual recharge from the post development site shall mimic the annual recharge from pre-development site conditions.

➲ *Recharge is a relatively new stormwater criteria, and has been implemented so far in the Massachusetts coastal zone and in Maryland. The recharge criteria requires considerable effort to use existing pervious areas for stormwater treatment and infiltration, which means that it must be considered very early in the site design process when basic decisions about layout and vegetative cover are made. For additional discussion of recharge criteria, consult the manual builder on the Stormwater Managers Resource Center (SMRC) at www.stormwatercenter.net.*

(D). For new development, structural stormwater treatment practices shall be designed to remove _% of the average annual post development total suspended solids load (TSS). It is presumed that a STP complies with this performance standard if it is:

- sized to capture the prescribed water quality volume (WQ_v).
- designed according to the specific performance criteria outlined in the local stormwater design manual,
- constructed properly, and
- maintained regularly.

➲ *For post construction stormwater runoff, the ability of stormwater management programs to meet federal guidelines under the NPDES regulations will become increasingly important. A local government seeking to manage runoff to achieve water quality standards has a number of options for reaching their goal. The options are listed below, from the most typical standard stormwater quality practice to more advanced program options. Each option has an associated level of effort for the management of stormwater, and the likelihood of realizing water quality treatment goals depends on the option a local government selects. Local governments should assess the option they wish to select in light of new Phase II regulations and the current ability of their stormwater management staff to meet more extensive local/state staff review and inspection requirements.*

Option 1. Require Stormwater Treatment Practices for Stormwater Quality

Many current stormwater programs simply require that the developer install stormwater treatment practices, but do not specify a target for specific pollutant reduction performance. These programs simply require that a standard volume of stormwater be treated (e.g., a half-inch of runoff). Many of these programs also have generous waiver and exemption provisions, so that as much as 25% of all new development can avoid criteria for water quality. Unless the target removal goals are very low, these communities cannot expect their current programs to eliminate net additional pollutants associated with future development.
(See City of Knoxville, TN Stormwater and Street Ordinance, at http://www.ci.knoxville.tn.us/)

Option 2. Institute More Rigorous Design Standards for Stormwater Practices.

A number of communities have improved their stormwater programs by strengthening their design standards for stormwater practices. This has involved narrowing the list of acceptable practices to those with a proven ability to remove particular pollutants, increasing the volume of runoff that is treated by each practice (e.g, treat first 1" of stormwater runoff), clamping down on waivers and exemptions (or requiring a fee-in-lieu), and requiring design features that reduce maintenance problems.

The advantage of this program option is that compliance can be presumed as long as designers follow the design rules. It does require a good stormwater manual and more extensive local/state staff review and training. It can achieve significant reduction for some pollutants, such as sediment and nutrients. The disadvantage of the program option is that current stormwater technology may not be effective enough for some pollutants (e.g., bacteria), or capable of reducing the net additional load for high levels from future development.

(For an example see Maryland Department of the Environment 2000 Maryland Stormwater Design Manual available at http://www.mde.state.md.us/environment/wma/stormwatermanual/. The states of New York and Vermont are in the process of adopting similar design standards for their manuals).

Option 3. Require On-Site Load Calculation

A handful of communities have adopted an approach whereby the design engineer must calculate pre- and post- development loads for a particular pollutant, and then design a system of practices to meet a load reduction target, based on STP removal rates. Phosphorus has been used in most cases, and the load reduction target varies. This option results in more directed design geared more specifically to the pollutant of concern.

The on-site load calculation option has several disadvantages. First, designers can select to use math modeling to their advantage to reduce costs and come into compliance. Second, technical data to support the program option are limited to just a few parameters, such as phosphorus, nitrogen and sediment. Third, the removal rates for the stormwater practices seldom account for factors where pollutant load removal is compromised, and tend to be optimistic. Lastly, this program option is very intensive in terms of local review and compliance, and requires more staffing to implement.

(For an example of on-site load calculation see the publication Phosphorus Control in Lake Watersheds: A Technical Guide to Evaluating New Development by the Maine Department of Environmental Protection. Another example where this option has been applied is for New York City water supply areas).

Option 4. Load Calculation w/ Stormwater Offset Fee to Provide Retrofits on Existing Development

In this program option, a community requires the on-site load calculation described in Option 3, but is very conservative in the assumptions it allows on loading and removal efficiency. Consequently, designers at most sites cannot fully comply with the load reduction for the requirement at their site. To fully comply, they must pay an offset fee to the local government which is used to support design and construction of stormwater retrofits at existing development in the watershed. The fee is set at the cost of providing an equivalent amount of pollutant removal elsewhere (dollars/pound).

The advantage of this approach is that it provides a means of financing the stormwater retrofits needed to reduce pollutant loads from existing development. It does require greater local staffing to find, design and build the retrofits which offset the loads from new development. If administered properly, this program option can potentially eliminate the net additional load from new development. Several communities currently provide this option for developers, but it is not clear how much revenue has been collected so far.

(This option has been applied in Maryland Critical Areas and Virginia Chesapeake Bay resource management areas. For more information, see the website regarding the Maryland Critical Area Act at http://www.dnr.state.md.us/criticalarea/ and the Virginia Chesapeake Bay Preservation Area Regulation at http://www.cblad.state.va.us/regs.htm)

(E). To protect stream channels from degradation, a specific channel protection criteria shall be provided as prescribed in the current stormwater manual.

➲ *Channel protection is a relatively new criteria, but is increasingly viewed as a critical one due to the mounting evidence that stream channels enlarge in response to watershed development. Studies have found higher bank erosion rates and increased instream sediment loads for urban streams when compared to the 5-20% estimate for the annual sediment budget attributable to bank erosion in rural streams (Walling and Woodward, 1995; Collins et al., 1997). Research also indicates that channel enlargement can begin at a relatively low level of watershed development, as indicated by the amount of impervious cover. One study estimated that channel erosion rates were three to six times higher in a moderately urbanized watershed (14% impervious cover) than in a comparable rural one, with less than 2% impervious cover (Neller, 1988).*

The basic methodology to calculate channel enlargement relies on obtaining historical cross-sectional data from past surveys (often obtained from transportation agencies or public works departments that conducted surveys at the time of road construction or improvement projects) and comparing these with current cross-sectional data obtained from field surveys conducted at the time of the study. The approach also utilizes predictive (i.e., empirical) equations to estimate an ultimate channel enlargement ratio once the channel has enlarged sufficiently to be in balance with its hydrological forces.

Basic Options for Stream Channel Protection

Many different design criteria have been suggested to protect downstream channels from erosion. It should be clearly noted that none of these criteria have yet been monitored in the field to demonstrate their effectiveness, and most are based on hydrologic or hydraulic modeling of streams. The three options that appear to hold some promise are:

24 hour detention of the one year storm event. *This criteria would result in up to 24 hours of detention for runoff generated by a rainfall depth based on annual rainfall for a region. Smaller storms events would also experience some detention, but probably much less than 24 hours. The premise of this criteria is that runoff would be stored and released in such a gradual manner that critical erosive velocities would seldom be exceeded in downstream channels. The required volume needed for 1 year extended detention is significant; it is roughly equivalent to about 90 to 95% of the required volume needed for ten year peak discharge control. Consequently, the need for two year peak discharge management would be eliminated when the 1 year ED is provided, as long as the ten year peak discharge control is achieved.*
(For an example, see Maryland Department of the Environment 2000 Maryland Stormwater Design Manual available at http://www.mde.state.md.us/environment/wma/stormwatermanual/. The states of New York and Virginia also use this design criteria for stream channel protection in their stormwater design manuals).

Distributed runoff control (DRC): *This criteria has been developed by MaCrae (1993) and involves complex field assessments and modeling to determine the hydraulic stress and erosion potential of bank materials. The criteria states that channel erosion is minimized if the alteration in the transverse distribution of erosion potential about a channel parameter is maintained constant with predevelopment values, over the range of available flows, such that the channel is just able to move the dominant particle size of the bed load. This Canadian method holds promise, but has not been tested extensively in the United States and requires significantly greater data collection and modeling then any of the other methods.*
(For a discussion of this criteria, see the Vermont Stormwater Management Handbook Technical Support Document- Appendix B, November 2000).

Bankfull capacity/duration criteria: *This criteria has been advanced by Tapley et al 1996, and states that the post-development, bankfull flow frequency, duration and depth must be controlled to predevelopment values at a designated control point(s) in the channel. The Rule of thumb for selecting control point(s) is to use a 10: 1 ratio of peak discharge from the one year storm for the developed site to the discharge from the stream for the same frequency storm (Tapley et al, 1996). In theory, this criteria should result in a high level of downstream protection. The practical problem is in defining how the criteria is to be interpreted; whether sub-bankfull events (that typically erode the toe of the streambank) should also be considered; and precisely where the "bankfull" should be measured. For example, the channel of many streams have been modified in the past by prior land uses and channelization, and may not represent the "true" channel. In other cases, the stormwater outfall discharge laterally to a stream, and it is therefore difficult to assign which flows the developer is actually responsible for controlling.*

Pros and Cons of Channel Protection Sizing Criteria.

Each of the three options has some limitations. For example, both the DRC and bankfull capacity sizing criteria options lack widely accepted or universal design methodologies. In each case, local stream cross-section and/or soil measurements are needed, and considerable contention between the designer and the reviewer can be expected on how and where the analysis should be performed. Given the many operational problems currently associated with either option, and the lack of a tested design methodology at present, the two options probably deserve further study, but are not ready for wide application.

This leaves only one remaining option-- the one-year 24 hour detention criteria. It, too, has some limitations:

- *results in unacceptably small diameter orifices for sites less than ten acres in size.*
- *requires a storage volume roughly equivalent to that needed for two year control.*
- *has not been "tested" by continuous simulation modeling to determine if acceptable detention times can be achieved for smaller storms can be achieved (1.0 to 1.5 inches).*
- *is only needed in streams that are susceptible to bank erosion.*

Based on the foregoing, it appears that the best option to provide channel protection (Cp_v) is 12 to 24 hour extended detention of the one-year 24 hour storm event. This Cp_v requirement only applies to sites greater than ten acres in size. Local governments may wish to retain the option of employing the DRC or bankfull capacity/duration criteria as an alternative, should their analytical and design requirements become more simplified and refined in the future

There are some basic exemptions to where the channel protection criteria should be applied (small drainage areas, direct discharge to tidal waters or a lake, flat terrain etc), and communities must decide how and when this criteria will be required.

(F). Stormwater discharges to critical areas with sensitive resources (i.e., cold water fisheries, shellfish beds, swimming beaches, recharge areas, water supply reservoirs) may be subject to additional performance criteria, or may need to utilize or restrict certain stormwater management practices.

(G). Certain industrial sites are required to prepare and implement a stormwater pollution prevention plan, and shall file a notice of intent (NOI) under the provisions of the National Pollutant Discharge Elimination System (NPDES) general permit. The stormwater pollution prevention plan requirement applies to both existing and new industrial sites.

➲ *Applicants and local communities may wish to consult the Environmental Protection Agency website at http://www.epa.gov/owm/swm/phase2 for more information on Phase II requirements.*

(H). Stormwater discharges from land uses or activities with higher potential pollutant loadings, known as "hotspots", may require the use of specific structural STPs and pollution prevention practices.

(I). Prior to design, applicants are required to consult with the **(jurisdictional stormwater authority)** to determine if they are subject to additional stormwater design requirements.

(J). The calculations for determining peak flows as found in the Stormwater Design Manual shall be used for sizing all stormwater management practices.

Section 6. Basic Stormwater Management Design Criteria

➲ *Rather than place specific stormwater design criteria into an ordinance, it is often preferable to fully detail these requirements in a stormwater design manual. This allows specific design information to change over time as new information or techniques become available without requiring the formal process needed to change ordinance language. The ordinance can then require those submitting any development application to consult the current stormwater design manual for the exact design criteria for the stormwater management practices appropriate for their site.*

In the Maryland Stormwater Design Manual, for example, there are a set of specified performance criteria for each stormwater management practice, based on six factors:

- *Site Design Feasibility -*
- *Conveyance Issues -*
- *Pretreatment Requirements -*
- *Treatment/Geometry Conditions*
- *Environmental/Landscaping Standards*
- *Maintenance Needs*

Each community will need to decide the specific design and sizing criteria for the stormwater management practices they allow, and select a storm event frequency(1, 2, 10, 100 year) that they believe will meet their stormwater quality and quantity control requirements.

6.1. Minimum Control Requirements

All stormwater management practices will be designed so that the specific storm frequency storage volumes (e.g., recharge, water quality, channel protection, 10 year, 100 year) as identified in the current stormwater design manual are met, unless the **(jurisdictional stormwater authority)** grants the applicant a waiver or the applicant is exempt from such requirements.

In addition, if hydrologic or topographic conditions warrant greater control than that provided by the minimum control requirements, the **(jurisdictional stormwater authority)** reserves the right to impose any and all additional requirements deemed necessary to control the volume, timing, and rate of runoff.

6.2 Site Design Feasibility

Stormwater management practices for a site shall be chosen based on the physical conditions of the site. Among the factors that should be considered:

1. Topography
2. Maximum Drainage Area
3. Depth to Water Table
4. Soils
5. Slopes
6. Terrain
7. Head
8. Location in relation to environmentally sensitive features or ultra-urban areas

Applicants shall consult the Stormwater Design Manual for guidance on the factors that determine site design feasibility when selecting a stormwater management practice.

6.3. Conveyance Issues

All stormwater management practices shall be designed to convey stormwater to allow for the maximum removal of pollutants and reduction in flow velocities. This shall include, but not be limited to:

1. Maximizing of flowpaths from inflow points to outflow points
2. Protection of inlet and outfall structures
3. Elimination of erosive flow velocities
4. Providing of underdrain systems, where applicable

The Stormwater Design Manual shall provide detailed guidance on the requirements for conveyance for each of the approved stormwater management practices.

6.4. Pretreatment Requirements

Every stormwater treatment practice shall have an acceptable form of water quality pretreatment, in accordance with the pretreatment requirements found in the current stormwater design manual. Certain stormwater treatment practices, as specified in the Stormwater Design Manual, are prohibited even with pretreatment in the following circumstances:

A. Stormwater is generated from highly contaminated source areas known as "hotspots"

B. Stormwater is carried in a conveyance system that also carries contaminated, non-stormwater discharges

C. Stormwater is being managed in a designated groundwater recharge area.

D. Certain geologic conditions exist (e.g., karst) that prohibit the proper pretreatment of stormwater.

6.5. Treatment/Geometry Conditions

All stormwater management practices shall be designed to capture and treat stormwater runoff according to the specifications outlined in the Stormwater Design Manual. These specifications will designate the water quantity and quality treatment criteria that apply to an approved stormwater management practice.

6.6. Landscaping Plans Required

All stormwater management practices must have a landscaping plan detailing both the vegetation to be in the practice and how and who will manage and maintain this vegetation. This plan must be prepared by a registered landscape architect or soil conservation district.

6.7. Maintenance Agreements

All stormwater treatment practices shall have an enforceable operation and maintenance agreement to ensure the system functions as designed. This agreement will include any and all maintenance easements required to access and inspect the stormwater treatment practices, and to perform routine maintenance as necessary to ensure proper functioning of the stormwater treatment practice. In addition, a legally binding covenant specifying the parties responsible for the proper maintenance of all stormwater treatment practices shall be secured prior to issuance of any permits for land disturbance activities.

6.8. Non-Structural Stormwater Practices

The use of non-structural stormwater treatment practices is encouraged in order to minimize the reliance on structural practices. Credit in the form of reductions in the amount of stormwater that must be managed can be earned through the use of non-structural practices that reduce the generation of stormwater from the site. These non-structural practices are explained in detail in the current design manual and applicants wishing to obtain credit for use of non-structural practices must ensure that these practices are documented and remain unaltered by subsequent property owners.

Section 7. Requirements for Stormwater Management Plan Approval

7.1. Stormwater Management Plan Required for All Developments.

No application for development will be approved unless it includes a stormwater management plan detailing in concept how runoff and associated water quality impacts resulting from the development will be controlled or managed. This plan must be prepared by an individual approved by the **(jurisdictional stormwater authority)** and must indicate whether stormwater will be managed on-site or off-site and, if on-site, the general location and type of practices. The stormwater management plan(s) shall be referred for comment to all other interested agencies, and any comments must be addressed in a final stormwater management plan. This final plan must be signed by a licensed professional engineer (PE), who will verify that the design of all stormwater management practices meet the submittal requirements outlined in the Submittal Checklist found in the stormwater design manual. No building, grading, or sediment control permit shall be issued until a satisfactory final stormwater management plan, or a waiver thereof, shall have undergone a review and been approved by the **(jurisdictional stormwater authority)** after determining that the plan or waiver is consistent with the requirements of this ordinance.

➲ *One way to handle the submittal requirements for both the concept plan and the final design plan is to place Submittal Checklists in the stormwater design manual and require that they are used for submission of any plan. The benefit of this is that changes in submittal requirements can be made as needed without needing to revisit and alter the original ordinance. Three model checklists can be found on the Stormwater Managers Resource Center (SMRC) website at www.stormwatercenter.net.*

7.2. Stormwater Management Concept Plan Requirements

A stormwater management concept plan shall be required with all permit applications and will include sufficient information (e.g., maps, hydrologic calculations, etc) to evaluate the environmental characteristics of the project site, the potential impacts of all proposed development of the site, both present and future, on the water resources, and the effectiveness and acceptability of the measures proposed for managing stormwater generated at the project site. The intent of this conceptual planning process is to determine the type of stormwater management measures necessary for the proposed project, and ensure adequate planning for management of stormwater runoff from future development. To accomplish this goal the following information shall be included in the concept plan:

1. A map (or maps) indicating the location of existing and proposed buildings, roads, parking areas, utilities, structural stormwater management and sediment control facilities. The map(s) will also clearly show proposed land use with tabulation of the percentage of surface area to be adapted to various uses; drainage patterns; locations of utilities, roads and easements; the limits of clearing and grading; A written description of the site plan and justification of proposed changes in natural conditions may also be required.

➲ *This project description and site plan requirement includes information normally found in an Erosion and Sediment Control plan. For local governments that do not currently have ESC plan requirements or are looking to upgrade their ESC ordinance language, there is a model Erosion and Sediment Control ordinance located at the SMRC website.*

2. Sufficient engineering analysis to show that the proposed stormwater management measures are capable of controlling runoff from the site in compliance with this ordinance and the specifications of the Stormwater Design Manual.

3. A written or graphic inventory of the natural resources at the site and surrounding area as it exists prior to the commencement of the project and a description of the watershed and its relation to the project site. This description should include a discussion of soil conditions, forest cover, topography, wetlands, and other native vegetative areas on the site. Particular attention should be paid to environmentally sensitive features that provide particular opportunities or constraints for development.
4. A written description of the required maintenance burden for any proposed stormwater management facility.
5. The **(jurisdictional stormwater authority)** may also require a concept plan to consider the maximum development potential of a site under existing zoning, regardless of whether the applicant presently intends to develop the site to its maximum potential.

For development or redevelopment occurring on a previously developed site, an applicant shall be required to include within the stormwater concept plan measures for controlling existing stormwater runoff discharges from the site in accordance with the standards of this Ordinance to the maximum extent practicable.

7.3. Final Stormwater Management Plan Requirements

After review of the stormwater management concept plan, and modifications to that plan as deemed necessary by the **(jurisdictional stormwater authority)**, a final stormwater management plan must be submitted for approval. The final stormwater management plan, in addition to the information from the concept plan, shall include all of the information required in the Final Stormwater Management Plan checklist found in the Stormwater Design Manual. This includes:

1. Contact Information

   The name, address, and telephone number of all persons having a legal interest in the property and the tax reference number and parcel number of the property or properties affected.

2. Topographic Base Map

   A 1" = 200' topographic base map of the site which extends a minimum of___ feet beyond the limits of the proposed development and indicates existing surface water drainage including streams, ponds, culverts, ditches, and wetlands; current land use including all existing structures; locations of utilities, roads, and easements; and significant natural and manmade features not otherwise shown.

3. Calculations

   Hydrologic and hydraulic design calculations for the pre-development and post-development conditions for the design storms specified in this ordinance. Such calculations shall include (i) description of the design storm frequency, intensity and duration, (ii) time of concentration, (iii) Soil Curve Numbers or runoff coefficients, (iv) peak runoff rates and total runoff volumes for each watershed area, (v) infiltration rates, where applicable, (vi) culvert capacities, (vii) flow velocities, (viii) data on the increase in rate and volume of runoff for the design storms referenced in the Stormwater Design Manual, and (ix) documentation of sources for all computation methods and field test results.

4. Soils Information

If a stormwater management control measure depends on the hydrologic properties of soils (e.g., infiltration basins), then a soils report shall be submitted. The soils report shall be based on on-site boring logs or soil pit profiles. The number and location of required soil borings or soil sits shall be determined based on what is needed to determine the suitability and distribution of soil types present at the location of the control measure.

5. Maintenance and Repair Plan

The design and planning of all stormwater management facilities shall include detailed maintenance and repair procedures to ensure their continued function. These plans will identify the parts or components of a stormwater management facility that need to be maintained and the equipment and skills or training necessary. Provisions for the periodic review and evaluation of the effectiveness of the maintenance program and the need for revisions or additional maintenance procedures shall be included in the plan.

6. Landscaping plan

The applicant must present a detailed plan for management of vegetation at the site after construction is finished, including who will be responsible for the maintenance of vegetation at the site and what practices will be employed to ensure that adequate vegetative cover is preserved. This plan must be prepared by a registered landscape architect or by the soil conservation district.

7. Maintenance Easements

The applicant must ensure access to all stormwater treatment practices at the site for the purpose of inspection and repair by securing all the maintenance easements needed on a permanent basis. These easements will be recorded with the plan and will remain in effect even with transfer of title to the property.

8. Maintenance Agreement

The applicant must execute an easement and an inspection and maintenance agreement binding on all subsequent owners of land served by na on-site stormwater management measure in accordance with the specifications of this ordinance.

9. Erosion and Sediment Control Plans for Construction of Stormwater Management Measures

The applicant must prepare an erosion and sediment control plan for all construction activities related to implementing any on-site stormwater management practices.

10. Other Environmental Permits

The applicant shall assure that all other applicable environmental permits have been acquired for the site prior to approval of the final stormwater design plan.

7.4. Performance Bond/Security

The **(jurisdictional stormwater authority)** may, at its discretion, require the submittal of a performance security or bond prior to issuance of a permit in order to insure that the stormwater practices are installed by the permit holder as required by the approved stormwater management plan. The amount of the installation performance security shall be the total estimated construction cost of the stormwater management practices approved under the permit, plus 25%. The performance security shall contain forfeiture provisions for failure to complete work specified in the stormwater management plan.

The installation performance security shall be released in full only upon submission of "as built plans" and written certification by a registered professional engineer that the stormwater practice has been installed in accordance with the approved plan and other applicable provisions of this ordinance. The **(jurisdictional stormwater authority)** will make a final inspection of the stormwater practice to ensure that it is in compliance with the approved plan and the provisions of this ordinance. Provisions for a partial pro-rata release of the performance security based on the completion of various development stages can be done at the discretion of the **(jurisdictional stormwater authority).**

➲ *Some communities elect to also require a maintenance performance security. This bond typically is set at the maintenance costs estimated in the stormwater plan for the period during which the permit holder has maintenance responsibility and is released when the responsibility for practice maintenance is passed on to another party, via an approved maintenance agreement.*

Section 8. Construction Inspection

8.1. Notice of Construction Commencement

The applicant must notify the **(jurisdictional stormwater authority)** in advance before the commencement of construction. Regular inspections of the stormwater management system construction shall be conducted by the staff of the **(jurisdictional stormwater authority)** or certified by a professional engineer or their designee who has been approved by the jurisdictional stormwater authority. All inspections shall be documented and written reports prepared that contain the following information:

1. The date and location of the inspection;
2. Whether construction is in compliance with the approved stormwater management plan
3. Variations from the approved construction specifications
4. Any violations that exist

If any violations are found, the property owner shall be notified in writing of the nature of the violation and the required corrective actions. No added work shall proceed until any violations are corrected and all work previously completed has received approval by the **(jurisdictional stormwater authority).**

8.2. As Built Plans

All applicants are required to submit actual "as built" plans for any stormwater management practices located on-site after final construction is completed. The plan must show the final design specifications for all stormwater management facilities and must be certified by a professional engineer. A final inspection by the **(jurisdictional stormwater authority)** is required before the release of any performance securities can occur.

8.3. Landscaping and Stabilization Requirements

Any area of land from which the natural vegetative cover has been either partially or wholly cleared or removed by development activities shall be revegetated within ten (10) days from the substantial completion of such clearing and construction. The following criteria shall apply to revegetation efforts:

Reseeding must be done with an annual or perennial cover crop accompanied by placement of straw mulch or its equivalent of sufficient coverage to control erosion until such time as the cover crop is established over ninety percent (90%) of the seeded area.

Replanting with native woody and herbaceous vegetation must be accompanied by placement of straw mulch or its equivalent of sufficient coverage to control erosion until the plantings are established and are capable of controlling erosion.

Any area of revegetation must exhibit survival of a minimum of seventy-five percent (75%) of the cover crop throughout the year immediately following revegetation. Revegetation must be repeated in successive years until the minimum seventy-five percent (75%) survival for one (1) year is achieved.

In addition to the above requirements, a landscaping plan must be submitted with the final design describing the vegetative stabilization and management techniques to be used at a site after construction is completed. This plan will explain not only how the site will be stabilized after construction, but who will be responsible for the maintenance of vegetation at the site and what practices will be employed to ensure that adequate vegetative cover is preserved. This plan must be prepared by a registered landscape architect or by the soil conservation district, and must be approved prior to receiving a permit.

Section 9. Maintenance and Repair of Stormwater Facilities

➲ *A model operation and maintenance ordinance for stormwater facilities is also available at the SMRC website. This ordinance goes into greater detail on the elements needed to create an effective stormwater maintenance ordinance. Requirements for inspection are also included in the model.*

9.1. Maintenance Easement

Prior to the issuance of any permit that has an stormwater management facility as one of the requirements of the permit, the applicant or owner of the site must execute a maintenance easement agreement that shall be binding on all subsequent owners of land served by the stormwater management facility. The agreement shall provide for access to the facility at reasonable times for periodic inspection by the **(jurisdictional stormwater authority)**, or their contractor or agent, and for regular or special assessments of property owners to ensure that the facility is maintained in proper working condition to meet design standards and any other provisions established by this ordinance. The easement agreement shall be recorded by the **(jurisdictional stormwater authority)** in the land records.

9.2. Maintenance Covenants

Maintenance of all stormwater management facilities shall be ensured through the creation of a formal maintenance covenant that must be approved by the **(jurisdictional stormwater authority)** and recorded into the land record prior to final plan approval. As part of the covenant, a schedule shall be developed for when and how often maintenance will occur to ensure proper function of the stormwater management facility. The covenant shall also include plans for periodic inspections to ensure proper performance of the facility between scheduled cleanouts.

The **(jurisdictional stormwater authority)**, in lieu of an maintenance covenant, may accept dedication of any existing or future stormwater management facility for maintenance, provided such facility meets all the requirements of this chapter and includes adequate and perpetual access and sufficient area, by easement or otherwise, for inspection and regular maintenance.

9.3. Requirements for Maintenance Covenants

All stormwater management facilities must undergo, at the minimum, an annual inspection to document maintenance and repair needs and ensure compliance with the requirements of this ordinance and accomplishment of its purposes. These needs may include; removal of silt, litter and other debris from all catch basins, inlets and drainage pipes, grass cutting and vegetation removal, and necessary replacement of landscape vegetation. Any maintenance needs found must be addressed in a timely manner, as determined by the **(jurisdictional stormwater authority)**, and the inspection and maintenance requirement may be increased as deemed necessary to ensure proper functioning of the stormwater management facility.

9.4. Inspection of Stormwater Facilities

Inspection programs may be established on any reasonable basis, including but not limited to: routine inspections; random inspections; inspections based upon complaints or other notice of possible violations; inspection of drainage basins or areas identified as higher than typical sources of sediment or other contaminants or pollutants; inspections of businesses or industries of a type associated with higher than usual discharges of contaminants or pollutants or with discharges of a type which are more likely than the typical discharge to cause violations of state or federal water or sediment quality standards or the NPDES stormwater permit; and joint inspections with other agencies inspecting under environmental or safety laws. Inspections may include, but are not limited to: reviewing maintenance and repair records; sampling discharges, surface water, groundwater, and material or water in drainage control facilities; and evaluating the condition of drainage control facilities and other stormwater treatment practices.

9.5. Right-of-Entry for Inspection

When any new drainage control facility is installed on private property, or when any new connection is made between private property and a public drainage control system, sanitary sewer or combined sewer, the property owner shall grant to the **(jurisdictional stormwater authority)** the right to enter the property at reasonable times and in a reasonable manner for the purpose of inspection. This includes the right to enter a property when it has a reasonable basis to believe that a violation of this ordinance is occurring or has occurred, and to enter when necessary for abatement of a public nuisance or correction of a violation of this ordinance.

9.6. Records of Installation and Maintenance Activities.

Parties responsible for the operation and maintenance of a stormwater management facility shall make records of the installation and of all maintenance and repairs, and shall retain the records for at least___ years. These records shall be made available to the (jurisdictional stormwater authority) during inspection of the facility and at other reasonable times upon request.

9.7 Failure to Maintain Practices

If a responsible party fails or refuses to meet the requirements of the maintenance covenant, the **(jurisdictional stormwater authority)**, after reasonable notice, may correct a violation of the design standards or maintenance needs by performing all necessary work to place the facility in proper working condition. In the event that the stormwater management facility becomes a danger to public safety or public health, the **(jurisdictional stormwater authority)** shall notify the party responsible for maintenance of the stormwater management facility in writing. Upon receipt of that notice, the responsible person shall have___ days to effect maintenance and repair of the facility in an approved manner. After proper notice, the **(jurisdictional stormwater authority)** may assess the owner(s) of the facility for the cost of repair work and any penalties; and the cost of the work shall be a lien on the property, or prorated against the beneficial users of the property, and may be placed on the tax bill and collected as ordinary taxes by the county.

Section 10. Enforcement and Penalties.

10.1. Violations

Any development activity that is commenced or is conducted contrary to this Ordinance, may be restrained by injunction or otherwise abated in a manner provided by law.

10.2. Notice of Violation.

When the **(jurisdictional stormwater authority)** determines that an activity is not being carried out in accordance with the requirements of this Ordinance, it shall issue a written notice of violation to the owner of the property. The notice of violation shall contain :

(1) the name and address of the owner or applicant;

(2) the address when available or a description of the building, structure or land upon which the violation is occurring;
(3) a statement specifying the nature of the violation;
(4) a description of the remedial measures necessary to bring the development activity into compliance with this Ordinance and a time schedule for the completion of such remedial action;
(5) a statement of the penalty or penalties that shall or may be assessed against the person to whom the notice of violation is directed;
(6) a statement that the determination of violation may be appealed to the municipality by filing a written notice of appeal within fifteen (15) days of service of notice of violation.

10.3. Stop Work Orders

Persons receiving a notice of violation will be required to halt all construction activities. This "stop work order" will be in effect until the **(jurisdictional stormwater authority)** confirms that the development activity is in compliance and the violation has been satisfactorily addressed. Failure to address a notice of violation in a timely manner can result in civil, criminal, or monetary penalties in accordance with the enforcement measures authorized in this ordinance.

10.4. Civil and Criminal Penalties

In addition to or as an alternative to any penalty provided herein or by law, any person who violates the provisions of this Ordinance shall be punished by a fine of not less than __________ Dollars ($xx) or by imprisonment for a period not to exceed____ (xx) days, or both such fine and imprisonment. Such person shall be guilty of a separate offense for each day during which the violation occurs or continues.

10.4. Restoration of lands

Any violator may be required to restore land to its undisturbed condition. In the event that restoration is not undertaken within a reasonable time after notice, the **(jurisdictional stormwater authority)** may take necessary corrective action, the cost of which shall become a lien upon the property until paid.

10.5. Holds on Occupation Permits

Occupation permits will not be granted until a corrections to all stormwater practices have been made and accepted by the **(jurisdictional stormwater authority)**.

Approved by: ________________________________ Date ___________________

<u>References</u>

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City of Corvallis Stormwater Phase II
Pollution Prevention/Good Housekeeping for Municipal Operations Program

This document outlines the Pollution Prevention/Good Housekeeping for Municipal Operations plan that the City of Corvallis will implement to meet the conditions of its NPDES Phase II Stormwater permit. The Pollution Prevention/Good Housekeeping for Municipal Operations component is one of six measures the operator of a Phase II regulated small municipal separate storm sewer system (MS4) is required to include in its stormwater management program.

I. INTRODUCTION

Municipal operations include a wide variety of activities conducted to maintain City owned property and facilities such as parks, public streets and the storm drain system. These activities may potentially contribute pollutants to stormwater runoff. For example, pesticide and herbicide use are concerns associated with vegetation management and maintenance of parks, street medians, and other landscaped areas. Minimizing use of these chemicals reduces the likelihood that they will enter storm inlets. Street repairs that involve asphalt or concrete removal/addition may create materials such as saw-cut slurry and asphalt waste; these materials must be properly contained to avoid discharge to the storm sewer system. These and other municipal activities must be addressed through the implementation of Best Management Practices (BMPs) to minimize pollutants from entering the City's drainage system and local waterbodies.

II. ELEMENTS OF THE POLLUTION PREVENTION/GOOD HOUSEKEEPING FOR MUNICIPAL OPERATIONS PROGRAM

The EPA Phase II regulations include Pollution Prevention/Good Housekeeping for Municipal Operations guidelines. According to federal code, the permittee must develop and implement an operations and maintenance program that has the ultimate goal of reducing or preventing pollutant runoff from municipal operations and the risk of related water quality problems. The program must include implementation of BMPs and training to reduce stormwater pollution from activities such as park and open space maintenance, fleet and building operations, new construction and land disturbance, and stormwater system maintenance.

The City of Corvallis will develop a Pollution Prevention/Good Housekeeping for Municipal Operations plan based on these guidelines. The planning process will include the following key components:

A. An inventory will be developed of municipal facilities and activities that may be a source of pollutants in stormwater;

B. Municipal facilities and activities will be assessed for their potential to discharge pollutants to storm drains and/or receiving waters;

C. Best management practices (BMPs) will be selected to mitigate the potential water quality impacts from the identified sources of stormwater pollution;

D. BMPs will be implemented. Record keeping and/or inspection will be included to evaluate BMP performance and program effectiveness; and

E. Appropriate measurable goals for this minimum control measure will be determined.

A. Inventory of Municipal Facilities and Activities

Inventories of the pollution generating activities associated with municipal operations will be conducted as part of the pollution prevention planning activities. These activities will be categorized as associated with either fixed facilities or field programs that are within the City of Corvallis' jurisdiction.

1. Fixed facilities are specific locations that the City owns and at which municipal activities occur. Examples of fixed facility types include municipal parks, public buildings, parking facilities, and waste storage or recovery facilities.

2. Field programs are a set of related municipal activities that take place throughout the City. Examples of municipal field programs include street maintenance and drainage system operation and maintenance.

1. Fixed Facility Program Inventory Procedures

Inventory procedures for fixed facilities will begin with collecting baseline information on City-owned facilities. This information will include the name, location, type of facility, watershed, and a general site map. The site map will include stormwater collection and conveyance systems, associated points of discharge, and the flow direction occurring within facility grounds. Examples of fixed facility types include water and wastewater treatment facilities, materials storage yards, airfields, parks, solid waste storage and/or transfer facilities, public buildings, streets and medians, and public parking facilities.

Following the identification of the fixed facility types, the potential pollutant generating activities and potential pollutants for each fixed facility will be identified and included in the inventory. A list of fixed facility activities that have the potential to generate pollutant discharges and the potential pollutants that are associated with those activities is included in Table MO-1. This list includes examples of typical fixed facility activities found in municipalities, and will be modified as appropriate for Corvallis as the municipal pollution prevention program is developed.

Table MO-1. Potential Pollutants Likely Associated with Fixed Facility Activities

Fixed Facility Activity	Sediment	Nutrients	Trash	Metals	Bacteria	Oil	Organics	Pesticides	BOD Substances
Building and Grounds Maintenance and Repair	X	X	X	X	X	X	X	X	X
Parking/Storage Area Maintenance	X	X	X	X	X	X	X		X
Waste Handling and Disposal	X	X	X	X	X	X	X	X	X

Fixed Facility Activity	Sediment	Nutrients	Trash	Metals	Bacteria	Oil	Organics	Pesticides	BOD Substances
Vehicle and Equipment Fueling			X	X		X	X		
Vehicle and Equipment Maintenance and Repair				X		X	X		
Vehicle and Equipment Washing	X	X	X	X		X	X		
Outdoor Loading and Unloading of Materials	X	X	X	X		X	X	X	X
Outdoor Container Storage of Liquids		X		X		X	X	X	X
Outdoor Storage of Raw Materials	X	X	X			X	X	X	X
Outdoor Process Equipment	X		X	X		X	X		
Landscape Maintenance	X	X	X		X			X	X

2. Field Program Inventory Procedures

Field program inventory procedures will begin with collection of baseline information on each of the field activities conducted by the City. Baseline information collected will include the type of activity, approximate area of coverage, and which watersheds the action occurs in. Mapping the field program infrastructure according to watershed and drainage patterns will be also be included as part of the inventory procedure. Examples of field program activities that have the potential for pollutant discharges are inspection and cleaning of stormwater conveyance facilities, landscape maintenance, and street repair and maintenance. A more comprehensive list of field program activities that have the potential to generate pollutant discharges and the potential pollutants that are associated with those activities is presented in Table MO-2. This list will serve as a starting point for developing an inventory of City field activities, and will be modified as Corvallis' Municipal Pollution Prevention program is developed.

Table MO-2. Field Program Activities and Associated Potential Pollutants

Field Programs	Activities	Sediment	Nutrients	Trash	Metals	Bacteria	Oil	Organics	Pesticides	BOD
Street Operations and Maintenance	Sweeping and Cleaning	X		X	X		X	X		X

Field Programs	Activities	Sediment	Nutrients	Trash	Metals	Bacteria	Oil	Organics	Pesticides	BOD
Streets Operation and Maintenance Cont.	Street Repair, Maintenance, and Striping/Painting	X		X	X		X	X		
	Bridge and Structure Maintenance	X		X	X		X	X		
Parking Lot and Multi-Purpose Path Maintenance	Surface Cleaning	X	X			X	X			X
	Graffiti Cleaning	X	X		X			X		
	Multi-Purpose Path Repair	X		X						
	Controlling Litter	X		X		X	X			X
Landscape Maintenance	Mowing/Trimming/Planting	X	X	X		X			X	X
	Fertilizer and Pesticide Management	X	X						X	
	Managing Landscape Wastes		X	X		X		X	X	X
	Erosion Control	X	X							
Drainage System Operation and Maintenance	Inspection and Cleaning of Stormwater Conveyance Structures	X	X	X		X		X		X
	Controlling Illicit Connections and Discharges	X	X	X	X	X	X	X	X	X
	Controlling Illegal Dumping	X	X	X	X	X	X	X	X	X
	Maintenance of Inlet and Outlet Structures	X	X	X	X		X			X
Waste Handling and Disposal	Solid Waste Collection		X	X	X	X	X	X		X
	Waste Reduction and Recycling		X	X	X		X		X	X
	"Household" Hazardous Waste Collection			X	X		X	X	X	
	Controlling Litter			X	X	X		X		X
	Controlling Illegal Dumping	X	X	X	X	X	X	X	X	X

Field Programs	Activities	Sediment	Nutrients	Trash	Metals	Bacteria	Oil	Organics	Pesticides	BOD
Water and Wastewater Utility Operation and Maintenance	Water Line Maintenance	X				X	X			
	Sanitary Sewer Maintenance	X				X	X			X
	Spill/Leak/Overflow Control, Response and Containment	X	X			X		X		X

B. Assessment of Municipal Facilities and Activities

This section outlines the procedures for assessing fixed facilities and field programs for BMP selection and implementation. Data gathered during the inventory process will be used to support the assessment process described below.

1. Fixed Facilities Assessment

The first step in the assessment will be to identify BMPs already in place at a facility. These may include BMPs in place for pavement sweeping, storm drain inlet cleaning, covered waste storage bins, and spill prevention and cleanup procedures. This information will be considered when determining which BMPs will be selected and implemented at a site.

Once the existing BMPs have been identified and the inventory completed, an assessment of municipal activities and potential pollutant sources will be conducted at each fixed facility to determine which areas are likely sources of pollutants in stormwater, and which pollutants are likely to be present in stormwater discharges.

Next, City staff will determine whether additional BMPs should be implemented to reduce or eliminate the potential for stormwater pollutants discharged from a site. City staff will consider and evaluate various factors when performing this assessment:

- Types of activities;
- Types and quantities of materials handled, produced, stored or disposed of;
- History of spills or leaks;
- Size of facility and stormwater flow generated by the site;
- Effectiveness of current BMPs; and
- Destination of discharges (stormwater system or treatment facility).

Appendix MO-A includes an example of a method that may be used as a model for assessing a fixed facility.

2. Field Programs Assessment

Assessing field activities with the potential for discharging pollutants will be similar to the effort at a fixed facility. The process will include identifying BMPs that are already in place and their effectiveness. Using this information and the inventory data, the City will identify the activities with the potential for discharging pollutants, the type of pollutants discharged, and the extent that the pollutants are being addressed with current procedures or BMPs. The City will then assess whether additional BMPs are necessary. In considering the need for additional BMPs the City will consider:

- Type of field program and pollutants being discharged;
- Exposure of activities to stormwater;
- Effectiveness of current BMPs; and
- Destination of discharges (stormwater system or treatment facility).

C. BMP Selection

Selection of BMPs will focus first on source control BMPs and second on treatment control BMPs. Typically source control BMPs will serve to reduce pollutants from activities to the maximum extent practicable. Treatment control BMPs will be considered when source control BMPs are impracticable or have been shown to be ineffective, or when environmental or site conditions warrant a different approach.

The suite of BMPs listed below are measures that may be used to control the discharge of pollutants to the stormwater drainage system for the activities identified during the assessment process. The list includes source and treatment control BMPs for fixed facilities and field programs. These BMPs are described in full in Appendix MO-B as fact sheets, and will be used to identify recommended BMPs for municipal operations. Not all BMPs listed in the fact sheets may be applicable to a given facility. This set of BMP fact sheets was developed through the California Stormwater Quality Association (California Stormwater Quality Association Stormwater Best Management Practice Handbook: Municipal, California Stormwater Quality Association, 2003) and will be used as a model for the Corvallis Pollution Prevention for Municipal Operations Program. The BMPs in Appendix MO-B will be modified and implemented as applicable to local conditions within Corvallis.

1. Source Control BMPs

a. Municipal fixed facility categories for BMP application

Vehicle and equipment management

- Vehicle and equipment fueling
- Vehicle and equipment cleaning
- Vehicle and equipment repair

Material and waste management

- Outdoor loading/unloading
- Outdoor container storage
- Outdoor equipment maintenance
- Outdoor storage of raw materials
- Waste handling and disposal
- Spill prevention, control and cleanup

Building and grounds management

- Building and grounds maintenance
- Parking/storage area maintenance

General stormwater management

- Housekeeping practices
- Alternative products

b. Municipal field program categories for BMP application

- Road and street maintenance
- Plaza and sidewalk cleaning
- Landscape maintenance
- Stormwater system maintenance
- Waste handling and disposal
- Water and wastewater utility maintenance

2. *Treatment Control BMPs*

- Infiltration trench
- Infiltration basin
- Retention facility
- Wet pond

- Extended detention basin
- Vegetated swale
- Vegetated buffer strip
- Bioretention
- Media filter
- Water quality inlet
- Wetland
- Media filter
- Wet vault
- Vortex separator

D. BMP Implementation and Record Keeping

City staff perform numerous municipal activities that have the potential to discharge pollutants. By consistently implementing BMPs or procedures applicable to these activities, the amount of pollutants discharged to the stormwater system will be minimized or eliminated.

Successful implementation of the Pollution Prevention for Municipal Operations Program will be based on:

- Effective training of municipal employees working in both fixed facilities and field programs;
- Application of source and treatment control BMPs;
- Regular inspection of fixed facilities, field programs and treatment controls;
- Maintenance of treatment controls as needed to ensure proper function;
- Periodic evaluation/monitoring of BMP performance; and
- Follow-up action to correct deficiencies in BMP implementation noted during inspections.

Record keeping will be a component of BMP implementation. Records will be kept on training, site inspection, and BMP maintenance.

Records of training sessions provided to staff will be maintained for the following purposes:

- Determining appropriate training for applicable staff;
- Determining training schedule; and

- Documenting training activities for compliance purposes.

BMP inspection reports/records will be kept to:

- Track frequency and results of inspections;
- Verify BMPs implemented;
- Record condition of BMPs inspected; and
- Monitor follow up actions taken.

E. Measurable Goals

Measurable goals are required for each minimum control measure or Phase II Stormwater Program component and are meant to gage permit compliance and program effectiveness. Table MO-3 includes measurable goals and an implementation schedule for the first five years of the City's Pollution Prevention/Good Housekeeping for Municipal Operations Program.

Table MO-3. Stormwater Phase II Measurable Goals for Pollution Prevention/Good Housekeeping for Municipal Operations Program Implementation Schedule for Five Years

Activities	Year 1	Year 2	Year 3	Year 4	Year 5
Municipal Operations Stormwater Pollution Prevention Training			Initiate stormwater pollution prevention program for municipal operations. Identify key components of planning process including inventory, assessment, BMP selection and implementation.	Update and continue.	Update and continue. Evaluate.
Inventory Fixed Facilities and Field Program Activities				Develop inventory collection forms for fixed facilities and field program activities.	Update and continue. Evaluate.
				Inventory fixed facilities and field programs for pollution generating activities.	Update and continue. Evaluate.
BMP Fact Sheets				Create fact sheets that describe source control and treatment control BMPs.	Update and continue. Evaluate.
Inspection of Fixed Facilities, Field Programs and Treatment Controls				Create inspection forms for fixed facilities, field programs and treatment controls. Develop and initiate inspection schedule.	Update and continue. Evaluate.

Activities	Year 1	Year 2	Year 3	Year 4	Year 5
Fixed Facility and Field Program Assessment				Create evaluation forms for assessing fixed facility and field program pollutant discharge potential. Identify BMPs already in place and additional BMPs needed.	Update and continue. Evaluate.
Municipal Operation Stormwater Pollution Prevention BMP Implementation				Continue to implement stormwater pollution prevention BMPs already in place. Implement additional BMPs as resources allow. Train municipal staff on how to identify and report illegal discharges of pollutants into the stormwater system when they are on the job and/or driving around the City.	Update and continue.
Record Keeping				Develop and implement BMP record keeping procedure for both staff training and BMP inspections.	Update and continue. Evaluate.

City of Corvallis Stormwater Phase II
Pollution Prevention/Good Housekeeping for Municipal Operations Program

Appendix MO-A

Example Method for Fixed Facility Assessment

WORKSHEET 1

Facility Name: County yard
Contact Name: Ron Jones

Site Address: 1200 Pine Rd., Anaheim, CA 92933
Phone: (111) 222-3333

1. ACTIVITIES – In the table below check each activity present at the site and evaluate its **potential for pollutant discharge (PPD):** 1 = high potential, 2= medium potential, 3= low potential

2. BMP EFFECTIVENESS – In the table below provide an effectiveness rating using the provided scale.

ACTIVITY AND BMP CHECKLIST	APPLICABLE ACTIVITY Yes	No	PPD	EFFECTIVENESS RATING *
A. VEHICLE AND EQUIPMENT FUELING BMPs employed: ▪ Employees trained in proper fueling and cleanup procedures. ▪ "Shut-off" valves installed on nozzles. ▪ "Topping off" of fuel tanks is discouraged. ▪ Adsorbent materials used on spills as opposed to hosing down. ▪ Drains labeled within the facility boundary, by stencil to indicate whether they flow to an oil/water separator, directly to the sewer, or to a storm drain. ▪ Fueling area designed to prevent storm water runoff and spills. ▪ Fueling area covered with an overhanging roof structure.	[x]	[ ]	[1]	① ② ❸ ④ ⑤
B. VEHICLE AND EQUIPMENT WASHING/STEAM CLEANING BMPs employed: ▪ Vehicles and equipment are washed at an off-site commercial washing location whenever possible. ▪ On-site washing area is clearly marked as a wash area. ▪ Signs are posted stating that only washing is allowed in wash area and that discharges to the storm drain are prohibited. ▪ Trash containers are provided in wash area. ▪ A map of on-site storm drain locations exists to avoid discharges to the storm drain system.	[x]	[ ]	[2]	① ② ③ ❹ ⑤
C. VEHICLE AND EQUIPMENT MAINTENANCE AND REPAIR BMPs employed: ▪ Idle equipment is stored under cover. ▪ Drip pans are used for leaking vehicle/equipment. ▪ Vehicle maintenance area is designed to prevent storm water pollution (area contains berming and appropriate drainage routing). ▪ Signs are painted on storm drain inlets to indicate that they are not to receive liquid or solid wastes. ▪ The work area is covered to limit exposure to the rain.	[x]	[ ]	[1]	① ② ❸ ④ ⑤
D. OUTDOOR LOADING/UNLOADING OF MATERIALS BMPs employed:	[ ]	[x]	[ ]	① ② ③ ④ ⑤
E. OUTDOOR CONTAINER STORAGE OF LIQUIDS BMPs employed:	[ ]	[x]	[ ]	① ② ③ ④ ⑤
F. OUTDOOR PROCESS EQUIPMENT OPERATIONS AND MAINTENANCE BMPs employed:	[ ]	[x]	[ ]	① ② ③ ④ ⑤
G. OUTDOOR STORAGE OF RAW MATERIALS BMPs employed: ▪ Materials are stored inside when feasible. ▪ All outside storage areas are covered with a roof or enclosed to prevent stormwater contact. ▪ Outdoor storage containers are kept in good condition. ▪ Lids are secured on waste barrels and containers. ▪ Drums are stored in a secure area where unauthorized persons cannot gain access.	[x]	[ ]	[2]	① ② ③ ❹ ⑤
H. WASTE HANDLING AND DISPOSAL BMPs employed:	[ ]	[x]	[-]	① ② ③ ④ ⑤
I BUILDING AND GROUNDS MAINTENANCE BMPs employed:	[ ]	[x]	[-]	① ② ③ ④ ⑤
J PARKING/STORAGE AREA MAINTENANCE BMPs employed: ▪ Parking and storage areas are kept clean and orderly. ▪ Site is designed to allow sheet runoff to flow into biofilters (vegetated strip and swale) and/or infiltration devices. ▪ Rooftop drains are arranged to prevent drainage directly onto paved surfaces. ▪ Lot is designed to include semi-permeable hardscape.	[ ]	[x]	[-]	① ② ❸ ④ ⑤
K. OVER WATER ACTIVITIES BMPs employed:	[ ]	[x]	[-]	① ② ③ ④ ⑤
L. OTHER (describe):	[ ]	[x]	[-]	① ② ③ ④ ⑤

***① No BMPs used and stormwater pollution likely** **② Some BMPs used but not effective** **③ Some BMPs used and moderately effective**
④ Source control BMPs used and very effective/structural BMPs needed **⑤ All necessary BMPs used and very effective**

3. **TYPE AND QUANTITY OF MATERIALS USED**

Material	Typical Quantity/Frequency	Is Stored Material Likely to Generate Pollutants
Gasoline	250 gal/day	yes
Motor oil	90 gal/wk	yes
Detergents	40 lb/wk	no

4. **HISTORY OF SPILLS AND LEAKS**
   a) Is there a chronic history of spills and leaks? *no*
   b) Is there no evidence of leaks and drips from equipment and machinery? *drip pans in place*
   c) Is there a spill prevention and response team? *yes*
   d) Are appropriate spill containment and cleanup materials kept on-site and in convenient locations? *materials present, but need to be placed near fueling areas.*
   e) Are cleanup procedures for spills followed regularly and correctly? *yes*
   f) Are used absorbent materials removed and disposed of in a timely manner? *stored spill clean up materials observed on-site, proper disposal required.*
   g) Are personnel regularly trained in the use of spill control materials? *yes*

5. **NON-STORMWATER DISCHARGES**
   a) Outfall directly observed during assessment *no*
   b) Are BMPs implemented to prevent, treat, or control non-stormwater discharges? *yes, but could use improvement (see BMP selection recommendations)*.
   c) Is there a potential for non-stormwater discharges (i.e. non-stormwater sources observed without BMPs implemented) *yes, (see BMP selection recommendations)*

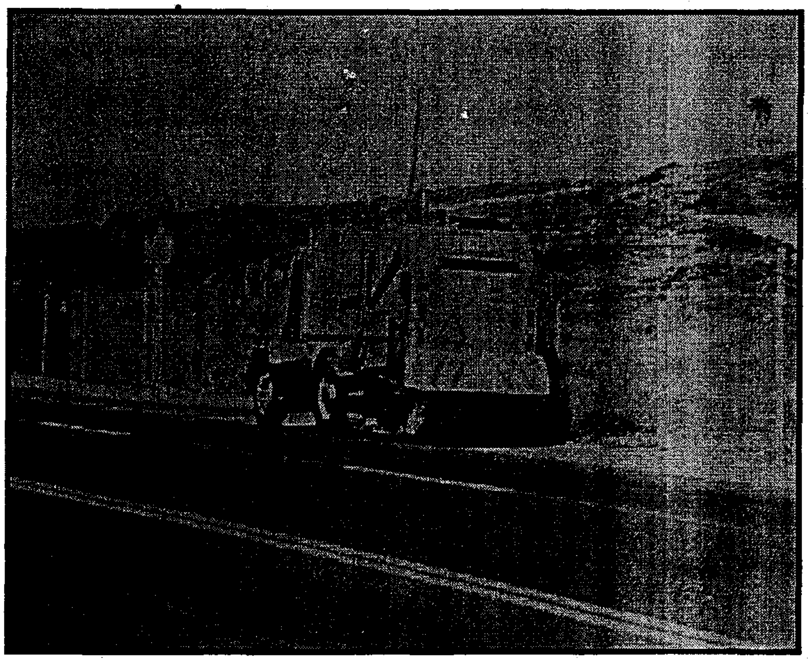
6. **SIZE OF FACILTIY** (incorporating the size of a facility serves as a surrogate measure for flow)
   a) Total area *400,000 square feet.*
   b) The impervious area (including parking lot) is *320,000 square feet (80% impervious)*

7. **PROXIMITY TO RECEIVING WATER**
   Does the facility discharge directly or adjacent to a 303(d) water body or other environmentally sensitive area? *no*

City of Corvallis Stormwater Phase II
Pollution Prevention/Good Housekeeping for Municipal Operations Program

Appendix MO-B

Pollution Prevention for Municipal Operations BMP Fact Sheets



Objectives

- Cover
- Contain
- Educate
- Reduce/Minimize

Targeted Constituents

Sediment	
Nutrients	
Trash	✓
Metals	✓
Bacteria	
Oil and Grease	✓
Organics	✓
Oxygen Demanding	

CASQA California Stormwater Quality Association

Description

Spills and leaks that occur during vehicle and equipment fueling can contribute hydrocarbons, oil and grease, as well as heavy metals to stormwater runoff. Implementing the following management practices can help prevent fuel spills and leaks.

Approach

Reduce potential for pollutant discharge through source control pollution prevention and BMP implementation. Successful implementation depends on effective training of employees on applicable BMPs and general pollution prevention strategies and objectives.

Pollution Prevention

- Use properly maintained offsite fueling stations whenever possible. These businesses are better equipped to handle fuel and spills properly.
- Educate employees about pollution prevention measures and goals
- Focus pollution prevention activities on containment of spills and leaks, most of which may occur during liquid transfers.

Suggested Protocols

General

- "Spot clean" leaks and drips routinely. Leaks are not cleaned up until the absorbent is picked up and disposed of properly.

- Label drains within the facility boundary, by paint/stencil (or equivalent), to indicate whether they flow to an oil/water separator, directly to the sewer, or to a storm drain. Labels are not necessary for plumbing fixtures directly connected to the sanitary sewer but may be useful to help eliminate confusion about where the drain leads.

- Post signs to remind employees not to top-off the fuel tank when filling and signs that ban employees from changing engine oil or other fluids at that location.

- Report leaking vehicles to fleet maintenance.

- Install inlet catch basin equipped with a small sedimentation basin or grit chamber to remove large particles from stormwater in highly impervious areas. Proper maintenance of these devices is necessary.

- Accumulated non-contaminated stormwater (e.g., in a secondary containment) should be released prior to next storm.

- Ensure the following safeguards are in place:
  - Overflow protection devices on tank systems to warn the operator to automatically shutdown transfer pumps when the tank reaches full capacity.
  - Protective guards around tanks and piping to prevent vehicle or forklift damage.
  - Clearly tagging or labeling all valves to reduce human error.
  - Automatic shut off for severed fuel hoses.

Fuel Dispensing Areas

- Maintain clean fuel-dispensing areas using dry cleanup methods such as sweeping for removal of litter and debris, or use of rags and absorbents for leaks and spills. Do not wash down areas with water.

- Fit underground storage tanks with spill containment and overfill prevention systems meeting the requirements of Section 2635(b) of Title 23 of the California Code of Regulations.

- Fit fuel dispensing nozzles with "hold-open latches" (automatic shutoffs) except where prohibited by local fire departments.

- Post signs at the fuel dispenser or fuel island warning vehicle owners/operators against "topping off" of vehicle fuel tanks.

- Design fueling area to prevent stormwater runoff and spills.

- Cover fueling area with an overhanging roof structure or canopy so that precipitation cannot come in contact with the fueling area and if possible use a perimeter drain or slope pavement inward with drainage to a blind sump (must be properly maintained and water properly disposed of); pave area with concrete rather than asphalt.

- Apply a suitable sealant that protects the asphalt from spilled fuels in areas where covering is infeasible and the fuel island is surrounded by pavement.
- Install vapor recovery nozzles to help control drips as well as air pollution.
- Use secondary containment when transferring fuel from the tank truck to the fuel tank.
- Cover storm drains in the vicinity during transfer.

Outdoor Waste Receptacle Area

- Spot clean leaks and drips routinely to prevent runoff of spillage.
- Minimize the possibility of stormwater pollution from outside waste receptacles by using an effective combination of the following:
  - use only watertight waste receptacle(s) and keep the lid(s) closed, or
  - grade and pave the waste receptacle area to prevent runon of stormwater, or
  - install a roof over the waste receptacle area, or
  - install a low containment berm around the waste receptacle area, or
  - use and maintain drip pans under waste receptacles. Containment areas and drip pans must be properly maintained and collected water disposed of properly (e.g., to sanitary sewer). Several drip pans should be stored in a covered location near outdoor waste receptacle area so that they are always available, yet protected from precipitation when not in use.
- Post "no littering" signs.

Air/Water Supply Area

- Minimize the possibility of stormwater pollution from air/water supply areas by implementing an effective combination of the following:
  - spot clean leaks and drips routinely to prevent runoff of spillage, or
  - grade and pave the air/water supply area to prevent runon of stormwater, or
  - install a roof over the air/water supply area, or
  - install a low containment berm around the air/water supply area. Maintain containment areas and dispose of contaminated water properly (e.g., to sanitary sewer).

Inspection

- Aboveground Tank Leak and Spill Control:
  - Check for external corrosion and structural failure.

- Check for spills and overfills due to operator error.
- Check for failure of piping system.
- Check for leaks or spills during pumping of liquids or gases from truck or rail car to a storage facility or vice versa.
- Visually 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.
- Periodically, integrity testing should be conducted by a qualified professional.

■ Inspect and clean, if necessary, storm drain inlets and catch basins within the facility boundary before October 1 each year.

Training

■ Train all employees upon hiring and annually thereafter on proper methods for handling and disposing of waste. Make sure that all employees understand stormwater discharge prohibitions, wastewater discharge requirements, and these best management practices.

■ Train employees on proper fueling and cleanup procedures.

■ Use a training log or similar method to document training.

■ Ensure that employees are familiar with the site's spill control plan and/or proper spill cleanup procedures.

Spill Response and Prevention

■ Keep your Spill Prevention Control and Countermeasure (SPCC) Plan up-to-date.

■ Place stockpiles of spill cleanup materials where they are readily accessible.

■ Use adsorbent materials on small spills and general cleaning rather than hosing down the area. Remove the adsorbent materials promptly and dispose properly.

■ Store portable absorbent booms (long flexible shafts or barriers made of absorbent material) in unbermed fueling areas.

■ Report spills promptly.

■ Install an oil/water separator and connect to the sanitary sewer (if allowed), if a dead-end sump is not used to collect spills.

Other Considerations

■ Carry out all federal and state requirements regarding underground storage tanks, or install above ground tanks.

Requirements

Costs

- The retrofitting of existing fueling areas to minimize stormwater exposure or spill runoff can be expensive. Good design must occur during the initial installation.
- Extruded curb along the "upstream" side of the fueling area to prevent stormwater runon is of modest cost.

Maintenance

- Clean oil/water separators at appropriate intervals.
- Keep ample supplies of spill cleanup materials onsite.
- Inspect fueling areas, storage tanks, catch basin inserts, containment areas, and drip pans on a regular schedule.

Supplemental Information

Design Considerations

Designing New Installations

The elements listed below should be included in the design and construction of new or substantially remodeled facilities.

Fuel Dispensing Areas

- Fuel dispensing areas must be paved with Portland cement concrete (or, equivalent smooth impervious surface), with a 2% to 4% slope to prevent ponding, and must be separated from the rest of the site by a grade break that prevents runon of stormwater to the extent practicable. The fuel dispensing area is defined as extending 6.5 feet from the corner of each fuel dispenser or the length at which the hose and nozzle assembly may be operated plus 1 foot, whichever is less. The paving around the fuel dispensing area may exceed the minimum dimensions of the "fuel dispensing area" stated above.
- The fuel dispensing area must be covered, and the cover's minimum dimensions must be equal to or greater than the area within the grade break or the fuel dispensing area, as defined above. The cover must not drain onto the fuel dispensing area.
- If necessary install and maintain an oil control device in the appropriate catch basin(s) to treat runoff from the fueling area.

Outdoor Waste Receptacle Area

- Grade and pave the outdoor waste receptacle area to prevent runon of stormwater to the extent practicable.

Air/Water Supply Area

- Grade and pave the air/water supply area to prevent runon of stormwater to the extent practicable.

Designated Fueling Area

- If your facility has large numbers of mobile equipment working throughout the site and you currently fuel them with a mobile fuel truck, consider establishing a designated fueling area. With the exception of tracked equipment such as bulldozers and perhaps small forklifts, most vehicles should be able to travel to a designated area with little lost time. Place temporary "caps" over nearby catch basins or manhole covers so that if a spill occurs it is prevented from entering the storm drain.

Examples

The Spill Prevention Control and Countermeasure (SPCC) Plan, which is required by law for some facilities, is an effective program to reduce the number of accidental spills and minimize contamination of stormwater runoff.

The City of Palo Alto has an effective program for commercial vehicle service facilities. Many of the program's elements, including specific BMP guidance and lists of equipment suppliers, are also applicable to industrial facilities.

References and Resources

Best Management Practice Guide for Retail Gasoline Outlets, California Stormwater Quality Task Force. 1997.

King County Stormwater Pollution Control Manual – http//www.dnr.metrokc.gov/wlr/dss/spcm.htm

Orange County Stormwater Program http://www.ocwatersheds.com/StormWater/swp_introduction.asp

San Diego Stormwater Co-permittees Jurisdictional Urban Runoff Management Program (URMP)

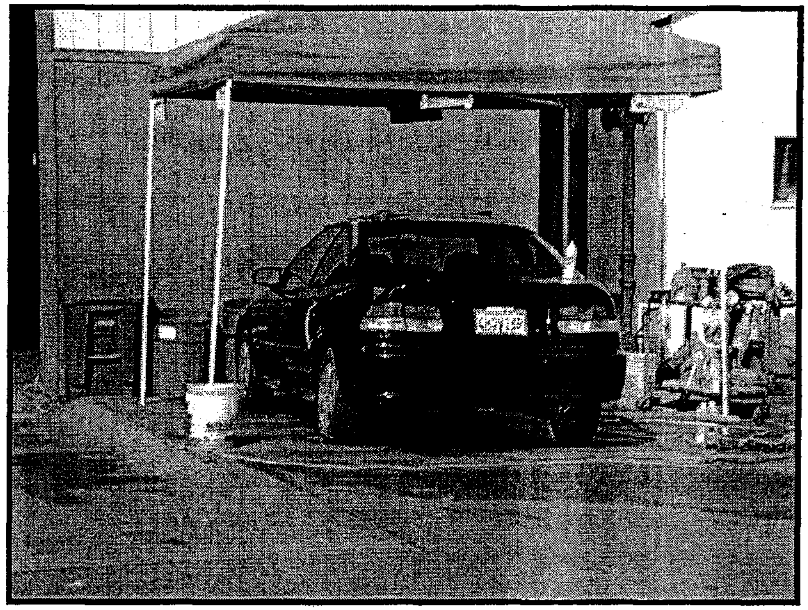


Photo Credit: Geoff Brosseau

Objectives

- Cover
- Contain
- Educate
- Reduce/Minimize
- Product Substitution

Targeted Constituents

Sediment	✓
Nutrients	✓
Trash	✓
Metals	✓
Bacteria	
Oil and Grease	✓
Organics	✓
Oxygen Demanding	

Description

Wash water from vehicle and equipment cleaning activities performed outdoors or in areas where wash water flows onto the ground can contribute toxic hydrocarbons and other organic compounds, oils and greases, nutrients, phosphates, heavy metals, and suspended solids to stormwater runoff. Use of the procedures outlined below can prevent or reduce the discharge of pollutants to stormwater during vehicle and equipment cleaning.

Approach

Reduce potential for pollutant discharge through source control pollution prevention and BMP implementation. Successful implementation depends on effective training of employees on applicable BMPs and general pollution prevention strategies and objectives

Pollution Prevention

- If possible, use properly maintained off-site commercial washing and steam cleaning businesses whenever possible. These businesses are better equipped to handle and properly dispose of the wash waters.
- Good housekeeping practices can minimize the risk of contamination from wash water discharges.

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Suggested Protocols

General

- Use biodegradable, phosphate-free detergents for washing vehicles as appropriate.
- Mark the area clearly as a wash area.
- Post signs stating that only washing is allowed in wash area and that discharges to the storm drain are prohibited.
- Provide a trash container in wash area.
- Map on-site storm drain locations to avoid discharges to the storm drain system.
- Emphasize the connection between the storm drain system and runoff and help reinforce that car washing activities can have an affect on local water quality. This can be accomplished through storm drain stenciling programs.

Vehicle and Equipment Cleaning

- Design wash areas to properly collect and dispose of wash water when engine cleaning is conducted and when chemical additives, solvents, or degreasers are used. This may include installation of sumps or drain lines to collect wash water or construction of a berm around the designated area and grading of the area to collect wash water as well as prevent stormwater run-on.
- Consider washing vehicles and equipment inside the building if washing/cleaning must occur on-site. This will help to control the targeted constituents by directing them to the sanitary sewer.
- If washing must occur on-site and outdoor:
  - Use designated paved wash areas. Designated wash areas must be well marked with signs indicating where and how washing must be done. This area must be covered or bermed to collect the wash water and graded to direct the wash water to a treatment or disposal facility.
  - Oil changes and other engine maintenance cannot be conducted in the designated washing area. Perform these activities in a place designated for such activities.
  - Cover the wash area when not in use to prevent contact with rain water.
- Use hoses with nozzles that automatically turn off when left unattended.
- Perform pressure cleaning and steam cleaning off-site to avoid generating runoff with high pollutant concentrations. If done on-site, no pressure cleaning and steam cleaning should be done in areas designated as wellhead protection areas for public water supply.

Disposal

- Consider filtering and recycling wash water.

- Discharge equipment wash water to the sanitary sewer, a holding tank, or a process treatment system, regardless of the washing method used.
- Discharge vehicle wash water to (1) the sanitary sewer, a holding tank, or process treatment system or (2) an enclosed recycling system.
- Discharge wash water to sanitary sewer only after contacting the local sewer authority to find out if pretreatment is required.

Training

- Train employees on proper cleaning and wash water disposal procedures and conduct "refresher" courses on a regular basis.
- Train staff on proper maintenance measures for the wash area.
- Train employees and contractors on proper spill containment and cleanup. The employee should have the tools and knowledge to immediately begin cleaning up a spill if one should occur.

Spill Response and Prevention

- Refer to SC-11, Spill Prevention, Control and Cleanup.
- Keep your Spill Prevention Control and Counter Measure (SPCC) Plan up-to-date, and implement accordingly.
- Have spill cleanup materials readily available and in a known location.
- Clean up spills immediately and use dry methods if possible.
- Properly dispose of spill cleanup material.

Other Considerations (Limitations and Regulations)

- Some municipalities may require pretreatment and monitoring of wash water discharges to the sanitary sewer.
- Steam cleaning can generate significant pollutant concentrations requiring that careful consideration be given to the environmental impacts and compliance issues related to steam cleaning.
- Most car washing best management practices are inexpensive, and rely more on good housekeeping practices (where vehicles are washed, planning for the collection of wash water) than on expensive technology. However, the construction of a specialized area for vehicle washing can be expensive for municipal facilities. Also, for facilities that cannot recycle their wash water the cost of pre-treating wash water through either structural practices or planning for collection and hauling of contaminated water to sewage treatment plants can represent a cost limitation.

Requirements

Costs

- Capital costs vary depending on measures implemented

- Low cost ($500-1,000) for berm construction,
- Medium cost ($5,000-20,000) for plumbing modifications (including re-routing discharge to sanitary sewer and installing simple sump).
- High cost ($30,000-150,000) for on-site treatment and recycling.

- O&M costs increase with increasing capital investment.

Maintenance

- Berm repair and patching.
- Sweep washing areas frequently to remove solid debris.
- Inspect and maintain sumps, oil/water separators, and on-site treatment/recycling units.

Supplemental Information

Design Considerations

Designated Cleaning Areas

- Washing operations outside should be conducted in a designated wash area having the following characteristics:
  - Paved with Portland cement concrete,
  - Covered and bermed to prevent contact with stormwater and contain wash water,
  - Sloped for wash water collection,
  - Equipped with an oil/water separator, if necessary.

Examples

The City of Palo Alto has an effective program for commercial vehicle service facilities. Many of the program's elements, including specific BMP guidance and lists of equipment suppliers, are applicable to industrial vehicle service facilities.

The U.S. Postal Service in West Sacramento has a new vehicle wash system that collects, filters, and recycles the wash water.

References and Resources

http://www.stormwatercenter.net/

King County - ftp://dnr.metrokc.gov/wlr/dss/spcm/Chapter%203.PDF

Orange County Stormwater Program
http://www.ocwatersheds.com/StormWater/swp_introduction.asp

San Diego Stormwater Co-permittees Jurisdictional Urban Runoff Management Program (URMP)
http://www.projectcleanwater.org/pdf/Model%20Program%20Municipal%20Facilities.pdf

Vehicle and Equipment Repair SC-22

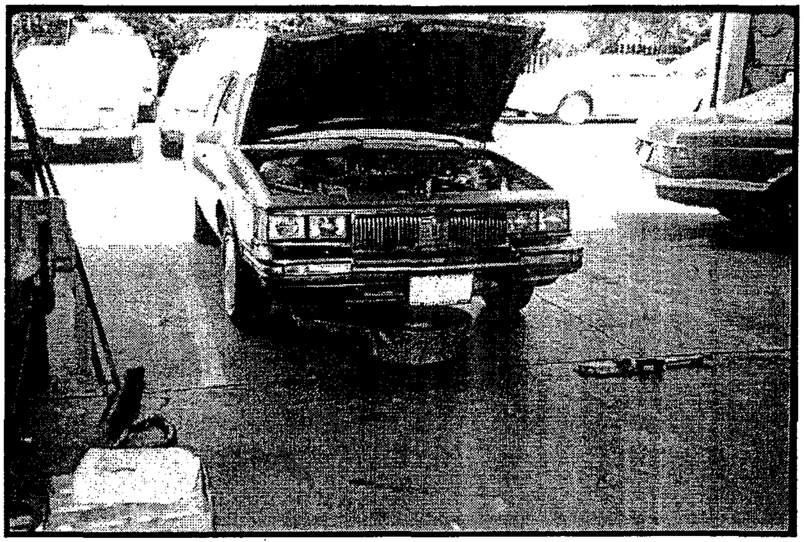

Photo Credit: Geoff Brosseau

Objectives

- Cover
- Contain
- Educate
- Reduce/Minimize
- Product Substitution

Targeted Constituents

Sediment	
Nutrients	
Trash	
Metals	✓
Bacteria	
Oil and Grease	✓
Organics	✓
Oxygen Demanding	

Description

Vehicle or equipment maintenance and repair is potentially a significant source of stormwater pollution, due to the use of materials and wastes created that are harmful to humans and the environment. Engine repair and service (e.g. parts cleaning), replacement of fluids (e.g. oil change), and outdoor equipment storage and parking (dripping engines) can impact water quality if stormwater runoff from areas with these activities occurring on them becomes polluted by a variety of contaminants. Implementation of the following activities will prevent or reduce the discharge of pollutants to stormwater from vehicle and equipment maintenance and repair activities.

Approach

Pollution Prevention

- Keep accurate maintenance logs to evaluate materials use.
- Switch to non-toxic chemicals for maintenance when possible.
- Choose cleaning agents that can be recycled.
- Minimize use of solvents. Clean parts without using solvents whenever possible.
- Keep an accurate, up-to-date inventory of materials.
- Recycle used motor oil, diesel oil, and other vehicle fluids and parts whenever possible.

Suggested Protocols

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General

- Move maintenance and repair activities indoors whenever feasible.
- Store idle equipment containing fluids under cover.
- Use a vehicle maintenance area designed to prevent stormwater pollution - minimize contact of stormwater with outside operations through berming and appropriate drainage routing.
- Avoid hosing down your work areas. If work areas are washed, collect and direct wash water to sanitary sewer.
- Paint signs on storm drain inlets to indicate that they are not to receive liquid or solid wastes.
- Post signs at sinks to remind employees, not to pour hazardous wastes down drains.
- Clean yard storm drain inlets(s) regularly.
- Do not pour materials down drains or hose down work areas; use dry sweeping.
- Cover the work area so as to limit exposure to the rain
- Place curbs around the immediate boundaries of the process equipment.
- Build a shed or temporary roof over areas where you park cars awaiting repair or salvage, especially if you handle wrecked vehicles. Build a roof over vehicles you keep for parts.

Material and Waste Handling

- Store materials and wastes under cover whenever possible.
- Designate a special area to drain and replace motor oil, coolant, and other fluids. This area should not have any connections to the storm drain or the sanitary sewer and should allow for easy clean up of drips and spills.
- Drain all fluids from wrecked vehicles immediately. Ensure that the drain pan or drip pan is large enough to contain drained fluids (e.g. larger pans are needed to contain antifreeze, which may gush from some vehicles).
- Do not pour liquid waste to floor drains, sinks, outdoor storm drain inlets, or other storm drains or sewer connections.
- Do not dispose of used or leftover cleaning solutions, solvents, and automotive fluids and oil in the sanitary sewer.
- Dispose of all waste materials according to applicable laws and regulations.
- Collect leaking or dripping fluids in drip pans or containers. Fluids are easier to recycle if kept separate.

- Promptly transfer used fluids to the proper waste or recycling drums and store in an appropriately designed area that can contain spills. Don't leave drip pans or other open containers lying around.

- Do not dispose of oil filters in trash cans or dumpsters, which may leak oil and contaminate stormwater. Place the oil filter in a funnel over a waste oil recycling drum to drain excess oil before disposal. Most municipalities prohibit or discourage disposal of these items in solid waste facilities. Oil filters can also be recycled. Ask your oil supplier or recycler about recycling oil filters.

- Store cracked and/or dead batteries in a non-leaking covered secondary container and dispose of properly at recycling or household hazardous waste facilities..

Maintenance and Repair Activities

- Provide a designated area for vehicle maintenance.

- Keep equipment clean, don't allow excessive build-up of oil and grease.

- If temporary work is being conducted outside: Use a tarp, ground cloth, or drip pans beneath the vehicle or equipment to capture all spills and drips., The collected drips and spills must be disposed, reused, or recycled properly.

- If possible, perform all vehicle fluid removal or changing inside or under cover to prevent the runon of stormwater and the runoff of spills:

  - 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. Don't leave drip pans or other open containers lying around.

  - Keep drip pans or containers under vehicles or equipment that might drip during repairs.

  - Do not change motor oil or perform equipment maintenance in non-appropriate areas.

- If equipment (e.g., radiators, axles) is to be stored outdoors, oil and other fluids should be drained first. This is also applicable to vehicles being stored and not used on a regular basis.

- Monitor parked vehicles closely for leaks and place pans under any leaks to collect the fluids for proper disposal or recycling.

Parts Cleaning

- Clean vehicle parts without using liquid cleaners wherever possible to reduce waste.

- Do all liquid cleaning at a centralized station so the solvents and residues stay in one area.

- Discharge wastewater generated from steam cleaning and pressure washing to an appropriate treatment control that is connected to a blind sump. Non-caustic detergents should be used instead of caustic cleaning agents, detergent-based or water-based cleaning systems in place of organic solvent degreasers, and non-chlorinated solvent in place of chlorinated organic solvents for parts cleaning. Refer to SC-21 for more information on steam cleaning.

- Locate drip pans, drain boards, and drying racks to direct drips back into a solvent sink or fluid holding tank for reuse.

Inspection

- Regularly inspect vehicles and equipment for leaks, and repair immediately.

- Make sure incoming vehicles are checked for leaking oil and fluids. Apply controls accordingly.

Training

- Train employees and contractors in the proper handling and disposal of engine fluids and waste materials.

- Ensure that employees are familiar with the site's spill control plan and/or proper spill cleanup procedures (You can use reusable cloth rags to clean up small drips and spills instead of disposables; these can be washed by a permitted industrial laundry. Do not clean them at home or at a coin-operated laundry business). The employee should have the tools and knowledge to immediately begin cleaning up a spill if one should occur.

- Use a training log or similar method to document training.

Spill Response and Prevention

- Refer to SC-11 Spill Prevention, Control & Cleanup for more information.

- Keep your Spill Prevention Control and Countermeasure (SPCC) Plan up-to-date, and implement accordingly.

- Place adequate stockpiles of spill cleanup materials where they are readily accessible.

- Clean leaks, drips, and other spills with as little water as possible. Use rags for small spills, a damp mop for general cleanup, and dry absorbent material for larger spills. Use the following three-step method for cleaning floors:

  - Clean spills with rags or other absorbent materials

  - Sweep floor using dry absorbent material

  - Mop the floor. Mop water may be discharged to the sanitary sewer via a toilet or sink.

- Remove absorbent materials used for cleaning small spills promptly and properly.

- Do not saturate rags or absorbent material to eliminate need for disposal of spilled material as hazardous waste.

Other Considerations
- Space and time limitations may preclude all work being conducted indoors.
- It may not be possible to contain and clean up spills from vehicles/equipment brought onsite 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.
- Identification of engine leaks may require some use of solvents, which may require disposal as hazardous waste.
- Installation of structural treatment practices for pretreatment controls of wastewater discharges can be expensive.
- Prices for recycled materials and fluids may be higher than those of non-recycled materials.
- Some facilities can be limited by a lack of providers of recycled materials, and by the absence of businesses to provide services such as hazardous waste removal, structural treatment practice maintenance or solvent equipment and solvent recycling.

Requirements
Costs
- Should be low, but will vary depending on the size of the facility.

Maintenance
- Sweep the maintenance area weekly, if it is paved, to collect loose particles, and wipe up spills with rags and other absorbent material immediately, do not hose down the area to a storm drain.

Supplemental Information
Further Detail of the BMP
Recycling

Separating wastes allows for easier recycling and may reduce treatment costs. Keep hazardous and non-hazardous wastes separate, do not mix used oil and solvents, and keep chlorinated solvents (e.g., 1,1,1-trichloroethane) separate from non-chlorinated solvents (e.g., kerosene and mineral spirits).

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.

- Recycling is always preferable to disposal of unwanted materials.
- Separate wastes for easier recycling. Keep hazardous and non-hazardous wastes separate, do not mix used oil and solvents, and keep chlorinated solvents separate from non-chlorinated solvents.
- Label and track the recycling of waste material (e.g. used oil, spent solvents, batteries).

- Purchase recycled products to support the market for recycled materials.

Safer Alternatives

If possible, eliminate or reduce the amount of hazardous materials and waste by substituting non-hazardous or less hazardous material:

- Use non-caustic detergents instead of caustic cleaning for parts cleaning.
- Use detergent-based or water-based cleaning systems in place of organic solvent degreasers. Wash water may require treatment before it can be discharged to the sewer.
- Replace chlorinated organic solvents with non-chlorinated solvents. Non-chlorinated solvents like kerosene or mineral spirits are less toxic and less expensive to dispose of properly. Check list of active ingredients to see whether it contains chlorinated solvents.
- Choose cleaning agents that can be recycled.
- Refer to SC-61 Safer Alternative Products fact sheet for more information.

References and Resources

DTSC Doc. No. 619a Switching to Water Based Cleaners

DTSC Doc. No. 621 http://www.stormwatercenter.net/

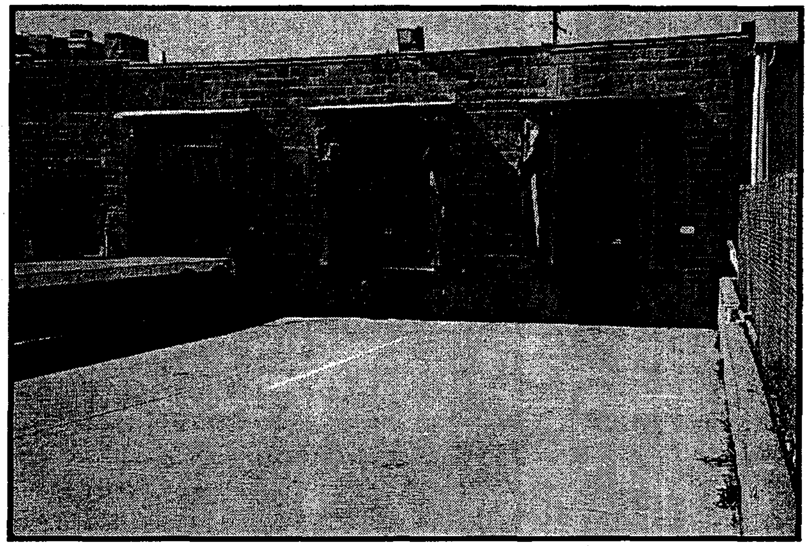
King County - ftp://dnr.metrokc.gov/wlr/dss/spcm/Chapter%203.PDF

Model Urban Runoff Program: A How-To-Guide for Developing Urban Runoff Programs for Small Municipalities. Prepared by City of Monterey, City of Santa Cruz, California Coastal Commission, Monterey Bay National Marine Sanctuary, Association of Monterey Bay Area Governments, Woodward-Clyde, Central Coast Regional Water Quality Control Board. July 1998 (Revised February 2002 by the California Coastal Commission).

Orange County Stormwater Program
http://www.ocwatersheds.com/StormWater/swp_introduction.asp

San Diego Stormwater Co-permittees Jurisdictional Urban Runoff Management Program (URMP) -
http://www.projectcleanwater.org/pdf/Model%20Program%20Municipal%20Facilities.pdf

Outdoor Loading/Unloading SC-30



Objectives

- Cover
- Contain
- Educate
- Reduce/Minimize
- Product Substitution

Description

The loading/unloading of materials usually takes place outside on docks or terminals; therefore, materials spilled, leaked, or lost during loading/unloading may collect in the soil or on other surfaces and have the potential to be carried away by stormwater runoff or when the area is cleaned. Additionally, rainfall may wash pollutants from machinery used to unload or move materials. Loading and unloading of material may include package products, barrels, and bulk products. Implementation of the following protocols will prevent or reduce the discharge of pollutants to stormwater from outdoor loading/unloading of materials.

Targeted Constituents

Sediment	✓
Nutrients	✓
Trash	
Metals	✓
Bacteria	
Oil and Grease	✓
Organics	✓
Oxygen Demanding	✓

Approach

Pollution Prevention

- Keep accurate maintenance logs to evaluate materials removed and improvements made.
- Park tank trucks or delivery vehicles in designated areas so that spills or leaks can be contained.
- Limit exposure of materials with the potential to contaminate stormwater.
- Prevent stormwater runon.
- Regularly check equipment for leaks.

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Suggested Protocols

Loading and Unloading – General Guidelines

- Develop an operations plan that describes procedures for loading and/or unloading.
- Do not conduct loading and unloading during wet weather, whenever possible.
- Cover designated loading/unloading areas to reduce exposure of materials to rain.
- A seal or door skirt between delivery vehicles and building can reduce or prevent exposure to rain.
- Design loading/unloading area to prevent stormwater runon which would include grading or berming the area, and positioning roof downspouts so they direct stormwater away from the loading/unloading areas.
- If feasible, load and unload all materials and equipment in covered areas such as building overhangs at loading docks.
- Load/unload only at designated loading areas.
- Use drip pans underneath hose and pipe connections and other leak-prone spots during liquid transfer operations, and when making and breaking connections. Several drip pans should be stored in a covered location near the liquid transfer area so that they are always available, yet protected from precipitation when not in use. Drip pans can be made specifically for railroad tracks. Drip pans must be cleaned periodically, and drip collected materials must be disposed of properly.
- Pave loading areas with concrete instead of asphalt.
- Avoid placing storm drains in the area.
- Grade and/or berm he loading/ unloading area to a drain that is connected to a dead-end sump.

Inspection

- Check loading and unloading equipment regularly for leaks, including valves, pumps, flanges and connections.
- Look for dust or fumes during loading or unloading operations.

Training

- Train employees (e.g. fork lift operators) and contractors on proper spill containment and cleanup.
- Employees trained in spill containment and cleanup should be present during the loading/unloading.
- Train employees in proper handling techniques during liquid transfers to avoid spills.

- Make sure forklift operators are properly trained on loading and unloading procedures.

Spill Response and Prevention

- Refer to SC-11, Spill Prevention, Control & Cleanup
- Keep your spill prevention Control and countermeasure (SPCC) Plan up-to-date, and implement accordingly.
- Have spill cleanup materials readily available and in a known location.
- Cleanup spills immediately and use dry methods if possible.
- Properly dispose of spill cleanup material.

Other Considerations

- Space, material characteristics and/or time limitations may preclude all transfers from being performed indoors or under cover.

Requirements

Costs

- Should be low except when covering a large loading/unloading area.

Maintenance

- Conduct regular 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.
- Regular broom dry-sweeping of area.
- Conduct major clean-out of loading and unloading area and sump prior to October 1 of each year.

Supplemental Information

Further Detail of the BMP

Special Circumstances for Indoor Loading/Unloading of Materials

As appropriate loading or unloading of liquids should occur indoors so that any spills that are not completely retained can be discharged to the sanitary sewer, treatment plant, or treated in a manner consistent with local sewer authorities and permit requirements.

- For loading and unloading tank trucks to above and below ground storage tanks, the following procedures should be used:
  - The area where the transfer takes place should be paved. If the liquid is reactive with the asphalt, Portland cement should be used to pave the area.
  - Transfer area should be designed to prevent runon 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.

- Transfer area should be designed to prevent runoff of spilled liquids from the area. Sloping the area to a drain should prevent runoff. The drain should be connected to a dead-end sump or to the sanitary sewer (if allowed). A positive control valve should be installed on the drain.

- For transfer from rail cars to storage tanks that must occur outside, use the following procedures:

  - Drip pans should be placed at locations where spillage may occur, such as hose connections, hose reels, and filler nozzles, Use drip pans when making and breaking connections.

  - Drip pan systems should be installed between the rails to collect spillage from tank cars.

References and Resources

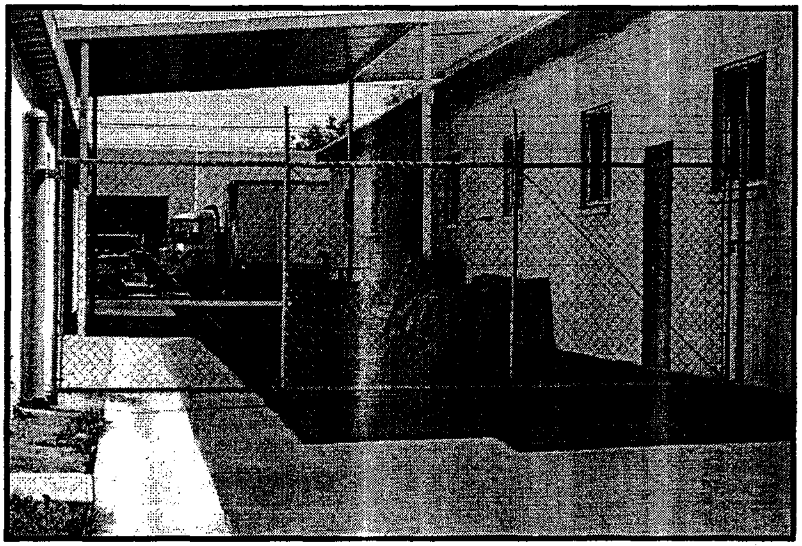
http://www.stormwatercenter.net/

King County - ftp://dnr.metrokc.gov/wlr/dss/spcm/Chapter%203.PDF

Orange County Stormwater Program
http://www.ocwatersheds.com/StormWater/swp_introduction.asp

San Diego Stormwater Co-permittees Jurisdictional Urban Runoff Management Program (URMP) -
http://www.projectcleanwater.org/pdf/Model%20Program%20Municipal%20Facilities.pdf

Outdoor Container Storage SC-31



Objectives

- Cover
- Contain
- Educate
- Reduce/Minimize
- Product Substitution

Description

Accidental releases of materials from above ground liquid storage tanks, drums, and dumpsters present the potential for contaminating stormwaters with many different pollutants. Tanks may store many potential stormwater runoff pollutants, such as gasoline, aviation gas, diesel fuel, ammonia, solvents, syrups, etc. Materials spilled, leaked, or lost from storage tanks may accumulate in soils or on other surfaces and be carried away by rainfall runoff. These source controls apply to containers located outside of a building used to temporarily store liquid materials and include installing safeguards against accidental releases, installing secondary containment, conducting regular inspections, and training employees in standard operating procedures and spill cleanup techniques.

Targeted Constituents

Sediment	
Nutrients	✓
Trash	
Metals	✓
Bacteria	
Oil and Grease	✓
Organics	✓
Oxygen Demanding	✓

Approach

Pollution Prevention

- Educate employees about pollution prevention measures and goals

- Keep an accurate, up-to-date inventory of the materials delivered and stored on-site. Re-evaluate inventory needs and consider purchasing alternative products. Properly dispose of outdated products.

- Try to keep chemicals in their original containers, and keep them well labeled.

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Suggested Protocols

General

- Develop an operations plan that describes procedures for loading and/or unloading. Refer to SC-30 Outdoor Loading/Unloading for more detailed BMP information pertaining to loading and unloading of liquids.
- Protect materials from rainfall, runon, runoff, and wind dispersal:
  - Cover the storage area with a roof.
  - Minimize stormwater runon by enclosing the area or building a berm around it.
  - Use a "doghouse" structure for storage of liquid containers.
  - Use covered dumpsters for waste product containers.
- Employ safeguards against accidental releases:
  - Provide overflow protection devices to warn operator or automatic shut down transfer pumps.
  - Provide protection guards (bollards) around tanks and piping to prevent vehicle or forklift damage, and
  - Provide clear tagging or labeling, and restricting access to valves to reduce human error.
- Berm or surround tank or container with secondary containment system using dikes, liners, vaults, or double walled tanks.
- Contact the appropriate regulatory agency regarding environmental compliance for facilities with "spill ponds" designed to intercept, treat, and/or divert spills.
- Have registered and specifically trained professional engineers can identify and correct potential problems such as loose fittings, poor welding, and improper or poorly fitted gaskets for newly installed tank systems.

Storage Areas

- Provide storage tank piping located below product level with a shut-off valve at the tank; ideally this valve should be an automatic shear valve with the shut-off located inside the tank.
- Provide barriers such as posts or guard rails, where tanks are exposed, to prevent collision damage with vehicles.
- Provide secure storage to prevent vandalism.
- Place tight-fitting lids on all containers.
- Enclose or cover the containers where they are stored.

- Raise the containers off the ground by use of pallet or similar method, with provisions for spill control and secondary containment.
- Contain the material in such a manner that if the container leaks or spills, the contents will not discharge, flow, or be washed into the storm drainage system, surface waters or groundwater.
- Place drip pans or absorbent materials beneath all mounted container taps, and at all potential drip and spill locations during filling and unloading of containers. Drip pans must be cleaned periodically, and all collected liquids and soiled absorbent materials must be reused/recycled or properly disposed.
- Ensure that any underground or aboveground storage tanks shall be designed and managed in accordance with applicable regulations, be identified as a potential pollution source, have secondary containment, such as a berm or dike with an impervious surface.
- Rainfall collected in secondary containment system must not contain pollutants for discharge to storm drain system.

Container Management

- Keep containers in good condition without corrosion or leaky seams.
- Place containers in a lean-to structure or otherwise covered to keep rainfall from reaching the drums.
- Replace containers if they are deteriorating to the point where leakage is occurring. Keep all containers undercover to prevent the entry of stormwater. Employees should be made aware of the importance of keeping the containers free from leaks.
- Keep waste container drums in an area such as a service bay. Drums stored outside must be stored in a lean-to type structure, shed or walk-in container.

Storage of Hazardous Materials

- Storage of reactive, ignitable, or flammable liquids must comply with the fire and hazardous waste codes.
- Place containers in a designated area that is paved, free of cracks and gaps, and impervious in order to contain leaks and spills. The area should also be covered.
- Surround stored hazardous materials and waste with a curb or dike to provide the volume to contain 10 percent of the volume of all of the containers or 110 percent of the volume of the largest container, whichever is greater. The area inside the curb should slope to a drain and a dead-end sump should be installed in the drain.

Inspection

- Provide regular inspections:
  - Inspect storage areas regularly for leaks or spills.

- Conduct routine inspections and check for external corrosion of material containers. Also check for structural failure, spills and overfills due to operator error, failure of piping system.

- Check for leaks or spills during pumping of liquids or gases from truck or rail car to a storage facility or vice versa.

- Visually inspect new tank or container installations 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.

- Replace containers that are leaking, corroded, or otherwise deteriorating with ones in good condition. If the liquid chemicals are corrosive, containers made of compatible materials must be used instead of metal drums.

- Label new or secondary containers with the product name and hazards.

Training

- Train employees (e.g. fork lift operators) and contractors in proper spill containment and cleanup. The employee should have the tools and knowledge to immediately begin cleaning up a spill if one should occur.

- Train employees in proper storage measures.

- Use a training log or similar method to document training.

Spill Response and Prevention

- Keep your Spill Prevention Control and Countermeasure (SPCC) Plan up-to-date, and implement accordingly.

- Have an emergency plan, equipment and trained personnel ready at all times to deal immediately with major spills.

- Collect all spilled liquids and properly dispose of them.

- Employees trained in emergency spill cleanup procedures should be present when dangerous waste, liquid chemicals, or other wastes are delivered.

- Operator errors can be prevented by using engineering safe guards and thus reducing accidental releases of pollutant.

- Store and maintain appropriate spill cleanup materials in a location known to all near the tank storage area.

- See Aboveground Tank Leak and Spill Control section of the Spill Prevention, Control & Cleanup fact sheet (SC-11) for additional information.

Other Considerations

- Storage sheds often must meet building and fire code requirements.
- The local fire district must be consulted for limitations on clearance of roof covers over containers used to store flammable materials.
- All specific standards set by federal and state laws concerning the storage of oil and hazardous materials must be met.
- Storage of reactive, ignitable, or flammable liquids should comply with the Uniform Fire Code and the National Electric Code.
- Storage of oil and hazardous materials must meet specific federal and state standards including:
  - Spill Prevention Control and Countermeasure Plan (SPCC) Plan
  - Secondary containment
  - Integrity and leak detection monitoring
  - Emergency preparedness plans

Requirements

Costs

- Will vary depending on the size of the facility and the necessary controls, such as berms or safeguards against accidental controls.

Maintenance

- Conduct weekly inspection.
- Sweep and clean the storage area regularly if it is paved, do not hose down the area to a storm drain.

Supplemental Information

- The most common causes of unintentional releases are:
  - Installation problems,
  - Failure of piping systems (pipes, pumps, flanges, couplings, hoses, and valves),
  - External corrosion and structural failure,
  - Spills and overfills due to operator error, and
  - Leaks during pumping of liquids or gases from truck or rail car to a storage tank or vice versa

Further Detail of the BMP

Dikes

One of the best protective measures against contamination of stormwater is diking. Containment dikes are berms or retaining walls that are designed to hold spills. Diking is an effective pollution prevention measure for above ground storage tanks and railcar or tank truck loading and unloading areas. The dike surrounds the area of concern and holds the spill, keeping spill materials separated from the stormwater side of the dike area. Diking can be used in any industrial or municipal facility, but it is most commonly used for controlling large spills or releases from liquid storage areas and liquid transfer areas.

- For single-wall tanks, containment dikes should be large enough to hold the contents of the storage tank for the facility plus rain water.
- For trucks, diked areas should be capable of holding an amount equal to the volume of the tank truck compartment. Diked 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.
- Strong acids or bases may react with metal containers, concrete, and some plastics.
- Where strong acids or bases or stored, alternative dike materials should be considered. More active organic chemicals may need certain special liners for dikes.
- Dikes may also be designed with impermeable materials to increase containment capabilities.
- Dikes should be inspected during or after significant storms or spills to check for washouts or overflows.
- Regular checks of containment dikes to insure the dikes are capable of holding spills should be conducted.
- Inability of a structure to retain stormwater, dike erosion, soggy areas, or changes in vegetation indicate problems with dike structures. Damaged areas should be patched and stabilized immediately.
- Accumulated stormwater in the containment are should be analyzed for pollutants before it is released to surface waters. If pollutants are found or if stormwater quality is not determined, then methods other than discharging to surface waters should be employed (e.g., discharge to sanitary sewer if allowed).
- Earthen dikes may require special maintenance of vegetation such as mulching and irrigation.

Curbing

Curbing is a barrier that surrounds an area of concern. Curbing is similar to containment diking in the way that it prevents spills and leaks from being released into the environment. The curbing is usually small scaled and does not contain large spills like diking. Curbing is common at many facilities in small areas where handling and transfer liquid materials occur. Curbing can redirect stormwater away from the storage area. It is useful in areas where liquid materials are transferred from one container to another. Asphalt is a common material used for curbing; however, curbing materials include earth, concrete, synthetic materials, metal, or other impenetrable materials.

- Spilled materials should be removed immediately from curbed areas to allow space for future spills.
- 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 clogging debris.
- Maintenance should also be conducted frequently to prevent overflow of any spilled materials as curbed areas are designed only for smaller spills.
- Curbing has the following advantages:
  - Excellent runon control,
  - Inexpensive,
  - Ease of installment,
  - Provides option to recycle materials spilled in curb areas, and
  - Common industry practice.

Examples

The "doghouse" design has been used to store small liquid containers. The roof and flooring design prevent contact with direct rain or runoff. The doghouse has two solid structural walls and two canvas covered walls. The flooring is wire mesh about secondary containment. The unit has been used successfully at Lockheed Missile and Space Company in Sunnyvale.

References and Resources

British Columbia Lake Stewardship Society. Best Management Practices to Protect Water Quality from Non-Point Source Pollution. March 2000
http://www.nalms.org/bclss/storage.html

King County Stormwater Pollution Control Manual –
http://dnr.metrokc.gov/wlr/dss/spcm.htm

San Diego Stormwater Co-permittees Jurisdictional Urban Runoff Management Program (URMP) -
http://www.projectcleanwater.org/pdf/Model%20Program%20Municipal%20Facilities.pdf

Outdoor Equipment Maintenance SC-32

Objectives

- Cover
- Contain
- Educate
- Reduce/Minimize
- Product Substitution

Targeted Constituents

Sediment	✓
Nutrients	
Trash	✓
Metals	✓
Bacteria	
Oil and Grease	✓
Organics	✓
Oxygen Demanding	

Description

Outside process equipment operations and maintenance can contaminate stormwater runoff. Activities, such as grinding, painting, coating, sanding, degreasing or parts cleaning, landfills and waste piles, solid waste treatment and disposal, are examples of process operations that can lead to contamination of stormwater runoff. Source controls for outdoor process equipment operations and maintenance include reducing the amount of waste created, enclosing or covering all or some of the equipment, installing secondary containment, and training employees.

Approach

Pollution Prevention

- Perform the activity during dry periods.
- Use non-toxic chemicals for maintenance and minimize or eliminate the use of solvents.

Suggested Protocols

- Consider enclosing the activity in a building and connecting the floor drains to the sanitary sewer.
- Cover the work area with a permanent roof.
- Minimize contact of stormwater with outside process equipment operations through berming and drainage routing (runon prevention). If allowed, connect process equipment area to public sewer.
- Dry clean the work area regularly.

Training

- Train employees to perform the activity during dry periods only and to use less or non-toxic materials.
- Train employee and contractors in proper techniques for spill containment and cleanup. The employee should have the tools and knowledge to immediately begin cleaning up a spill if one should occur.

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Spill Response and Prevention

- Refer to SC-11, Spill Prevention, Control & Cleanup
- Keep your spill prevention control and countermeasure (SPCC) plan up-date, and implement accordingly.
- Have spill cleanup materials readily available and in a known location.
- Cleanup spills immediately and use dry methods if possible.
- Properly dispose of spill cleanup material.

Other Considerations

- Space limitations may preclude enclosing some equipment.
- Storage sheds often must meet building and fire code requirements.

Requirements

Costs

- Costs vary depending on the complexity of the operation and the amount of control necessary for stormwater pollution control.
- Providing cover may be expensive.

Maintenance

- Conduct routine preventive maintenance, including checking process equipment for leaks.
- Clean the storm drain system regularly.

Supplemental Information

Further Detail of the BMP

Hydraulic/Treatment Modifications

In some cases it may be necessary to capture and treat polluted stormwater. If the municipality does not have its own process wastewater treatment system, consider discharging to the public sewer system. Use of the public sewer might be allowed under the following conditions:

- If the activity area is very small (less than a few hundred square feet), the local sewer authority may be willing to allow the area to remain uncovered with the drain connected to the public sewer.
- It may be possible under unusual circumstances to connect a much larger area to the public sewer, as long as the rate of stormwater discharges does not exceed the capacity of the wastewater treatment plant. The stormwater could be stored during the storm and then transferred to the public sewer when the normal flow is low, such as at night.

References and Resources

California's Nonpoint Source Program Plan http://www.swrcb.ca.gov/nps/index.html

Clark County Stormwater Pollution Control Manual
http://www.co.clark.wa.us/pubworks/bmpman.pdf

King County Stormwater Pollution Control Manual http://dnr.metrokc.gov/wlr/dss/spcm.htm

Santa Clara Valley Urban Runoff Pollution Prevention Program http://www.scvurppp.org

The Stormwater Managers Resource Center http://www.stormwatercenter.net/

Outdoor Storage of Raw Materials SC-33

Objectives

- Cover
- Contain
- Educate
- Reduce/Minimize

Description

Raw materials, by-products, finished products, containers, and material storage areas exposed to rain and/or runoff can pollute stormwater. Stormwater can become contaminated when materials wash off or dissolve into water or are added to runoff by spills and leaks. Improper storage of these materials can result in accidental spills and the release of materials. To prevent or reduce the discharge of pollutants to stormwater from material delivery and storage, pollution prevention and source control measures, such as minimizing the storage of hazardous materials on-site, enclosing or covering materials, storing materials in a designated area, installing secondary containment, conducting regular inspections, preventing stormwater runon and runoff, and training employees and subcontractors must be implemented.

Targeted Constituents

Sediment	✓
Nutrients	✓
Trash	✓
Metals	
Bacteria	
Oil and Grease	✓
Organics	✓
Oxygen Demanding	✓

Approach

Pollution Prevention

- Employee education is paramount for successful BMP implementation.
- Minimize inventory of raw materials.
- Keep an accurate, up-to-date inventory of the materials delivered and stored on-site.
- Try to keep chemicals in their original containers, and keep them well labeled.

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SC-33 Outdoor Storage of Raw Materials

Suggested Protocols

General

- Store all materials inside. If this is not feasible, then all outside storage areas should be covered with a roof, and bermed, or enclosed to prevent stormwater contact. At the very minimum, a temporary waterproof covering made of polyethylene, polypropylene or hypalon should be used over all materials stored outside.
- Cover and contain the stockpiles of raw materials to prevent stormwater from running into the covered piles. The covers must be in place at all times when work with the stockpiles is not occurring. (applicable to small stockpiles only).
- If the stockpiles are so large that they cannot feasibly be covered and contained, implement erosion control practices at the perimeter of your site and at any catch basins to prevent erosion of the stockpiled material off site,
- Keep liquids in a designated area on a paved impervious surface within a secondary containment.
- Keep outdoor storage containers in good condition.
- Keep storage areas clean and dry.
- Design paved areas to be sloped in a manner that minimizes the pooling of water on the site, particularly with materials that may leach pollutants into stormwater and/or groundwater, such as compost, logs, and wood chips. A minimum slope of 1.5 percent is recommended.
- Secure drums stored in an area where unauthorized persons may gain access to prevent accidental spillage, pilferage, or any unauthorized use.
- Cover wood products treated with chromated copper arsenate, ammonical copper zinc arsenate, creosote, or pentachlorophenol with tarps or store indoors.

Raw Material Containment

- Do not store chemicals, drums, or bagged materials directly on the ground. Place these items in secondary containers if applicable.
- Prevent the run-on of uncontaminated stormwater from adjacent areas as well as runoff of stormwater from the stockpile areas, by placing a curb along the perimeter of the area. The area inside the curb should slope to a drain. Liquids should be drained to the sanitary sewer if allowed. The drain must have a positive control such as a lock, valve, or plug to prevent release of contaminated liquids.
- Tanks should be bermed or surrounded by a secondary containment system.
- Release accumulated stormwater in petroleum storage areas prior to the next storm. At a minimum, water should pass through an oil/water separator and, if allowed, discharged to a sanitary sewer.

Inspection

- Conduct regular inspections of storage areas so that leaks and spills are detected as soon as possible.
- Conduct routine inspections and check for external corrosion of material containers. Also check for structural failure, spills and overfills due to operator error, failure of piping system.
- Check for leaks or spills during pumping of liquids or gases from truck or rail car to a storage facility or vice versa.
- Visually inspect new tank or container installations 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.

Training

- Employees should be well trained in proper material storage.
- Train employees and contractors in proper techniques for spill containment and cleanup.

Spill Response and Prevention

- Refer to SC-11, Spill Prevention, Control & Cleanup.
- Keep your Spill Prevention Control and countermeasure (SPCC) plan up-to-date, and implement accordingly.
- Have spill cleanup materials readily available and in a known location.
- Cleanup spills immediately and use dry methods if possible.
- Properly dispose of spill cleanup material.
- Have employees trained in spill containment and cleanup present during loading/unloading of dangerous waste, liquid chemicals and other potentially hazardous materials.

Other Considerations

- Storage sheds often must meet building and fire code requirements. Storage of reactive, ignitable, or flammable liquids must comply with the Uniform Fire Code and the National Electric Code.
- Space limitations may preclude storing some materials indoors.
- Some municipalities require that secondary containment areas (regardless of size) be connected to the sanitary sewer, prohibiting any hard connections to the storm drain. Storage sheds often must meet building and fire code requirements.
- The local fire district must be consulted for limitations on clearance of roof covers over containers used to store flammable materials.

SC-33 Outdoor Storage of Raw Materials

Requirements

Costs

- Costs will vary depending on the size of the facility and the necessary controls. They should be low except where large areas may have to be covered.

Maintenance

- Accurate and up-to-date inventories should be kept of all stored materials.
- Berms and curbs may require periodic repair and patching.
- Parking lots or other surfaces near bulk materials storage areas should be swept periodically to remove debris blown or washed from storage area.
- Sweep paved storage areas regularly for collection and disposal of loose solid materials, do not hose down the area to a storm drain or conveyance ditch.
- Keep outdoor storage areas in good condition (e.g. repair roofs, floors, etc. to limit releases to runoff).

Supplemental Information

Further Detail of the BMP

Raw Material Containment

Paved areas should be sloped in a manner that minimize the pooling of water on the site, particularly with materials that may leach pollutants into stormwater and/or groundwater, such as compost, logs, and wood chips. A minimum slope of 1.5 percent is recommended.

- Curbing should be placed along the perimeter of the area to prevent the runon of uncontaminated stormwater from adjacent areas as well as runoff of stormwater from the stockpile areas.
- The storm drainage system should be designed to minimize the use of catch basins in the interior of the area as they tend to rapidly fill with manufacturing material.
- The area should be sloped 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, more information for outside storage of liquids can be found under SC-31, Outdoor Container Storage.

Examples

The "doghouse" design has been used to store small liquid containers. The roof and flooring design prevent contact with direct rain or runoff. The doghouse has two solid structural walls and two canvas covered walls. The flooring is wire mesh about secondary containment. The unit has been used successively at Lockheed Missile and Space Company in Sunnyvale.

References and Resources

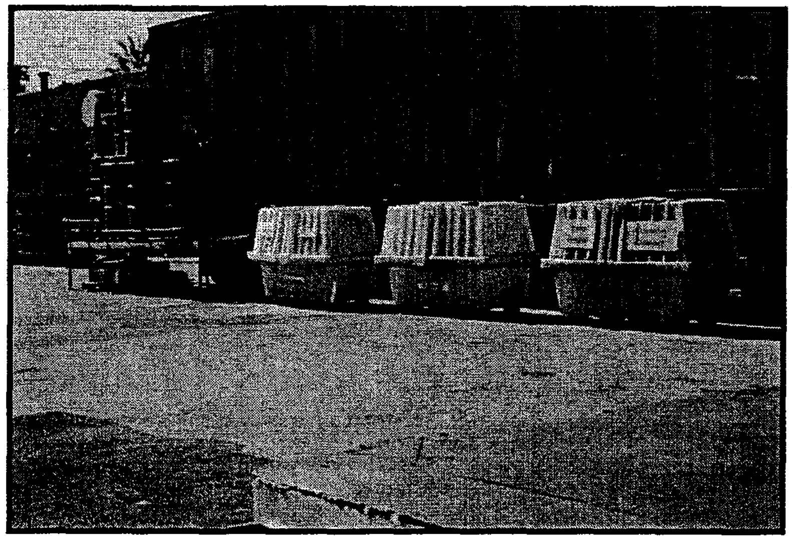
King County Stormwater Pollution Control Manual - http://dnr.metrokc.gov/wlr/dss/spcm.htm

Model Urban Runoff Program: A How-To-Guide for Developing Urban Runoff Programs for Small Municipalities. Prepared by City of Monterey, City of Santa Cruz, California Coastal Commission, Monterey Bay National Marine Sanctuary, Association of Monterey Bay Area Governments, Woodward-Clyde, Central Coast Regional Water Quality Control Board. July 1998 (Revised February 2002 by the California Coastal Commission).

Orange County Stormwater Program
http://www.ocwatersheds.com/StormWater/swp_introduction.asp

San Diego Stormwater Co-permittees Jurisdictional Urban Runoff Management Program (URMP)
http://www.projectcleanwater.org/pdf/Model%20Program%20Municipal%20Facilities.pdf

Waste Handling & Disposal SC-34



Objectives

- Cover
- Contain
- Educate
- Reduce/Minimize
- Product Substitution

Targeted Constituents

Sediment	✓
Nutrients	✓
Trash	✓
Metals	✓
Bacteria	✓
Oil and Grease	✓
Organics	✓
Oxygen Demanding	✓

Description

Improper storage and handling of solid wastes can allow toxic compounds, oils and greases, heavy metals, nutrients, suspended solids, and other pollutants to enter stormwater runoff. The discharge of pollutants to stormwater from waste handling and disposal can be prevented and reduced by tracking waste generation, storage, and disposal; reducing waste generation and disposal through source reduction, re-use, and recycling; and preventing runon and runoff.

Approach

Pollution Prevention

- Reduction in the amount of waste generated can be accomplished using the following source controls such as:
  - Production planning and sequencing
  - Process or equipment modification
  - Raw material substitution or elimination
  - Loss prevention and housekeeping
  - Waste segregation and separation
  - Close loop recycling
- Establish a material tracking system to increase awareness about material usage. This may reduce spills and minimize contamination, thus reducing the amount of waste produced.
- Recycle materials whenever possible.

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Suggested Protocols

General

- Cover storage containers with leak proof lids or some other means. If waste is not in containers, cover all waste piles (plastic tarps are acceptable coverage) and prevent stormwater runon and runoff with a berm. The waste containers or piles must be covered except when in use.
- Use drip pans or absorbent materials whenever grease containers are emptied by vacuum trucks or other means. Grease cannot be left on the ground. Collected grease must be properly disposed of as garbage.
- Check storage containers weekly for leaks and to ensure that lids are on tightly. Replace any that are leaking, corroded, or otherwise deteriorating.
- Sweep and clean the storage area regularly. If it is paved, do not hose down the area to a storm drain.
- Dispose of rinse and wash water from cleaning waste containers into a sanitary sewer if allowed by the local sewer authority. Do not discharge wash water to the street or storm drain.
- Transfer waste from damaged containers into safe containers.
- Take special care when loading or unloading wastes to minimize losses. Loading systems can be used to minimize spills and fugitive emission losses such as dust or mist. Vacuum transfer systems can minimize waste loss.

Controlling Litter

- Post "No Littering" signs and enforce anti-litter laws.
- Provide a sufficient number of litter receptacles for the facility.
- Clean out and cover litter receptacles frequently to prevent spillage.

Waste Collection

- Keep waste collection areas clean.
- Inspect solid waste containers for structural damage or leaks regularly. Repair or replace damaged containers as necessary.
- Secure solid waste containers; containers must be closed tightly when not in use.
- Place waste containers under cover if possible.
- Do not fill waste containers with washout water or any other liquid.
- Ensure that only appropriate solid wastes are added to the solid waste container. Certain wastes such as hazardous wastes, appliances, fluorescent lamps, pesticides, etc. may not be

disposed of in solid waste containers (see chemical/ hazardous waste collection section below).

- Do not mix wastes; this can cause chemical reactions, make recycling impossible, and complicate disposal.

Good Housekeeping

- Use all of the product before disposing of the container.
- Keep the waste management area clean at all times by sweeping and cleaning up spills immediately.
- Use dry methods when possible (e.g. sweeping, use of absorbents) when cleaning around restaurant/food handling dumpster areas. If water must be used after sweeping/using absorbents, collect water and discharge through grease interceptor to the sewer.
- Stencil storm drains on the facility's property with prohibitive message regarding waste disposal.

Chemical/Hazardous Wastes

- Select designated hazardous waste collection areas on-site.
- Store hazardous materials and wastes in covered containers protected from vandalism, and in compliance with fire and hazardous waste codes.
- Place hazardous waste containers in secondary containment.
- Make sure that hazardous waste is collected, removed, and disposed of only at authorized disposal areas.

Runon/Runoff Prevention

- Prevent stormwater runon from entering the waste management area by enclosing the area or building a berm around the area.
- Prevent the waste materials from directly contacting rain.
- Cover waste piles with temporary covering material such as reinforced tarpaulin, polyethylene, polyurethane, polypropyleneor hypalon.
- Cover the area with a permanent roof if feasible.
- Cover dumpsters to prevent rain from washing waste out of holes or cracks in the bottom of the dumpster.
- Move the activity indoor after ensuring all safety concerns such as fire hazard and ventilation are addressed.

Inspection

- Inspect and replace faulty pumps or hoses regularly to minimize the potential of releases and spills.
- Check waste management areas for leaking containers or spills.
- Repair leaking equipment including valves, lines, seals, or pumps promptly.

Training
- Train staff pollution prevention measures and proper disposal methods.
- Train employees and contractors proper spill containment and cleanup. The employee should have the tools and knowledge to immediately begin cleaning up a spill if one should occur.
- Train employees and subcontractors in proper hazardous waste management.

Spill Response and Prevention
- Refer to SC-11, Spill Prevention, Control & Cleanup.
- Keep your Spill Prevention Control and countermeasure (SPCC) plan up-to-date, and implement accordingly.
- Have spill cleanup materials readily available and in a known location.
- Cleanup spills immediately and use dry methods if possible.
- Properly dispose of spill cleanup material.
- Vehicles transporting waste should have spill prevention equipment that can prevent spills during transport. The spill prevention equipment includes:
  - Vehicles equipped with baffles for liquid waste
  - Trucks with sealed gates and spill guards for solid waste

Other Considerations
- Hazardous waste cannot be re-used or recycled; it must be disposed of by a licensed hazardous waste hauler.

Requirements
Costs
- Capital and operation and maintenance costs will vary substantially depending on the size of the facility and the types of waste handled. Costs should be low if there is an inventory program in place.

Maintenance
- None except for maintaining equipment for material tracking program.

Supplemental Information

Further Detail of the BMP

Land Treatment System

- Minimize the runoff of polluted stormwater from land application of municipal waste on-site by:
  - Choosing a site where slopes are under 6%, the soil is permeable, there is a low water table, it is located away from wetlands or marshes, there is a closed drainage system.
  - Avoiding application of waste to the site when it is raining or when the ground is saturated with water.
  - Growing vegetation on land disposal areas to stabilize soils and reduce the volume of surface water runoff from the site.
  - Maintaining adequate barriers between the land application site and the receiving waters. Planted strips are particularly good.
  - Using erosion control techniques such as mulching and matting, filter fences, straw bales, diversion terracing, and sediment basins.
  - Performing routine maintenance to ensure the erosion control or site stabilization measures are working.

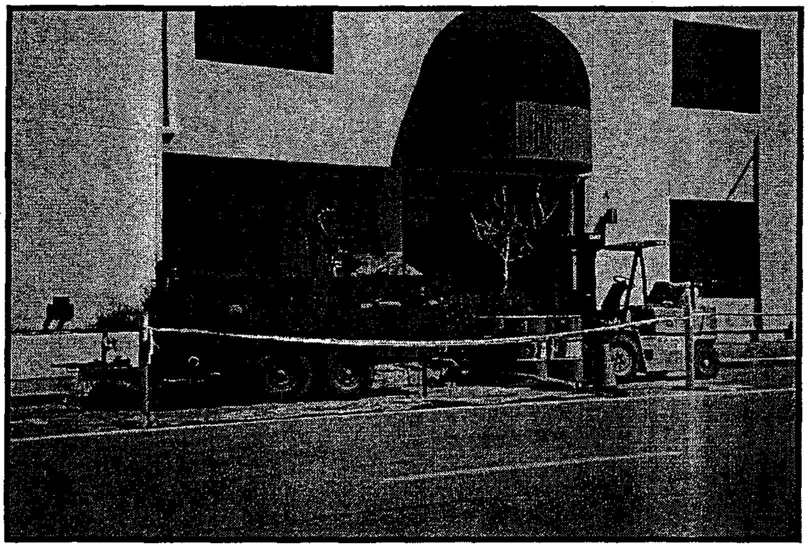
References and Resources

King County Stormwater Pollution Control Manual - http://dnr.metrokc.gov/wlr/dss/spcm.htm

Orange County Stormwater Program
http://www.ocwatersheds.com/StormWater/swp_introduction.asp

Pollution from Surface Cleaning Folder. 1996. Bay Area Stormwater Management Agencies Associations (BASMAA). On-line: http://www.basmaa.org

Spill Prevention, Control & Cleanup SC-11



Objectives

- Cover
- Contain
- Educate
- Reduce/Minimize
- Product Substitution

Targeted Constituents

Sediment	
Nutrients	✓
Trash	
Metals	✓
Bacteria	
Oil and Grease	✓
Organics	✓
Oxygen Demanding	✓

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Description

Spills and leaks, if not properly controlled, can adversely impact the storm drain system and receiving waters. Due to the type of work or the materials involved, many activities that occur either at a municipal facility or as a part of municipal field programs have the potential for accidental spills and leaks. Proper spill response planning and preparation can enable municipal employees to effectively respond to problems when they occur and minimize the discharge of pollutants to the environment.

Approach

- An effective spill response and control plan should include:
  - Spill/leak prevention measures;
  - Spill response procedures;
  - Spill cleanup procedures;
  - Reporting; and
  - Training
- A well thought out and implemented plan can prevent pollutants from entering the storm drainage system and can be used as a tool for training personnel to prevent and control future spills as well.

Pollution Prevention

- Develop and implement a Spill Prevention Control and Response Plan. The plan should include:

- A description of the facility, the address, activities and materials involved
- Identification of key spill response personnel
- Identification of the potential spill areas or operations prone to spills/leaks
- Identification of which areas should be or are bermed to contain spills/leaks
- Facility map identifying the key locations of areas, activities, materials, structural BMPs, etc.
- Material handling procedures
- Spill response procedures including:
    - Assessment of the site and potential impacts
    - Containment of the material
    - Notification of the proper personnel and evacuation procedures
    - Clean up of the site
    - Disposal of the waste material and
    - Proper record keeping

- Product substitution – use less toxic materials (i.e. use water based paints instead of oil based paints)
- Recycle, reclaim, or reuse materials whenever possible. This will reduce the amount of materials that are brought into the facility or into the field.

Suggested Protocols

Spill/Leak Prevention Measures

- If possible, move material handling indoors, under cover, or away from storm drains or sensitive water bodies.
- Properly label all containers so that the contents are easily identifiable.
- Berm storage areas so that if a spill or leak occurs, the material is contained.
- Cover outside storage areas either with a permanent structure or with a seasonal one such as a tarp so that rain can not come into contact with the materials.
- Check containers (and any containment sumps) often for leaks and spills. Replace containers that are leaking, corroded, or otherwise deteriorating with containers in good condition. Collect all spilled liquids and properly dispose of them.

- Store, contain and transfer liquid materials in such a manner that if the container is ruptured or the contents spilled, they will not discharge, flow or be washed into the storm drainage system, surface waters, or groundwater.

- Place drip pans or absorbent materials beneath all mounted taps and at all potential drip and spill locations during the filling and unloading of containers. Any collected liquids or soiled absorbent materials should be reused/recycled or properly disposed of.

- For field programs, only transport the minimum amount of material needed for the daily activities and transfer materials between containers at a municipal yard where leaks and spill are easier to control.

- If paved, sweep and clean storage areas monthly, do not use water to hose down the area unless all of the water will be collected and disposed of properly.

- Install a spill control device (such as a tee section) in any catch basins that collect runoff from any storage areas if the materials stored are oil, gas, or other materials that separate from and float on water. This will allow for easier cleanup if a spill occurs.

- If necessary, protect catch basins while conducting field activities so that if a spill occurs, the material will be contained.

Training

- Educate employees about spill prevention, spill response and cleanup on a routine basis.

- Well-trained employees can reduce human errors that lead to accidental releases or spills:

  - The employees should have the tools and knowledge to immediately begin cleaning up a spill if one should occur.

  - Employees should be familiar with the Spill Prevention Control and Countermeasure Plan if one is available.

- Training of staff from all municipal departments should focus on recognizing and reporting potential or current spills/leaks and who they should contact.

- Employees responsible for aboveground storage tanks and liquid transfers for large bulk containers should be thoroughly familiar with the Spill Prevention Control and Countermeasure Plan and the plan should be readily available.

Spill Response and Prevention

- Identify key spill response personnel and train employees on who they are.

- Store and maintain appropriate spill cleanup materials in a clearly marked location near storage areas; and train employees to ensure familiarity with the site's spill control plan and/or proper spill cleanup procedures.

- Locate spill cleanup materials, such as absorbents, where they will be readily accessible (e.g. near storage and maintenance areas, on field trucks).

SC-11 Spill Prevention, Control & Cleanup

- Follow the Spill Prevention Control and Countermeasure Plan if one is available.
- If a spill occurs, notify the key spill response personnel immediately. If the material is unknown or hazardous, the local fire department may also need to be contacted.
- If safe to do so, attempt to contain the material and block the nearby storm drains so that the area impacted is minimized. If the material is unknown or hazardous wait for properly trained personnel to contain the materials.
- Perform an assessment of the area where the spill occurred and the downstream area that it could impact. Relay this information to the key spill response and clean up personnel.

Spill Cleanup Procedures

- Small non-hazardous spills
  - Use a rag, damp cloth or absorbent materials for general clean up of liquids
  - Use brooms or shovels for the general clean up of dry materials
  - If water is used, it must be collected and properly disposed of. The wash water can not be allowed to enter the storm drain.
  - Dispose of any waste materials properly
  - Clean or dispose of any equipment used to clean up the spill properly
- Large non-hazardous spills
  - Use absorbent materials for general clean up of liquids
  - Use brooms, shovels or street sweepers for the general clean up of dry materials
  - If water is used, it must be collected and properly disposed of. The wash water can not be allowed to enter the storm drain.
  - Dispose of any waste materials properly
  - Clean or dispose of any equipment used to clean up the spill properly
- For hazardous or very large spills, a private cleanup company or Hazmat team may need to be contacted to assess the situation and conduct the cleanup and disposal of the materials.
- Chemical cleanups of material can be achieved with the use of absorbents, gels, and foams. Remove the adsorbent materials promptly and dispose of according to regulations.
- If the spilled material is hazardous, then the used cleanup materials are also hazardous and must be sent to a certified laundry (rags) or disposed of as hazardous waste.

Reporting

- Report any spills immediately to the identified key municipal spill response personnel.

- Report spills in accordance with applicable reporting laws. Spills that pose an immediate threat to human health or the environment must be reported immediately to the Office of Emergency Service (OES)

- Spills that pose an immediate threat to human health or the environment may also need to be reported within 24 hours to the Regional Water Quality Control Board.

- Federal regulations require that any oil spill into a water body or onto an adjoining shoreline be reported to the National Response Center (NRC) at 800-424-8802 (24 hour)

- After the spill has been contained and cleaned up, a detailed report about the incident should be generated and kept on file (see the section on Reporting below). The incident may also be used in briefing staff about proper procedures

Other Considerations

- State regulations exist for facilities with a storage capacity of 10,000 gallons or more of petroleum to prepare a Spill Prevention Control and Countermeasure Plan (SPCC) Plan (Health & Safety Code Chapter 6.67).

- State regulations also exist for storage of hazardous materials (Health & Safety Code Chapter 6.95), including the preparation of area and business plans for emergency response to the releases or threatened releases.

- Consider requiring smaller secondary containment areas (less than 200 sq. ft.) to be connected to the sanitary sewer, if permitted to do so, prohibiting any hard connections to the storm drain.

Requirements

Costs

- Will vary depending on the size of the facility and the necessary controls.

- Prevention of leaks and spills is inexpensive. Treatment and/or disposal of wastes, contaminated soil and water is very expensive

Maintenance

- This BMP has no major administrative or staffing requirements. However, extra time is needed to properly handle and dispose of spills, which results in increased labor costs

Supplemental Information

Further Detail of the BMP

Reporting

Record keeping and internal reporting represent good operating practices because they can increase the efficiency of the response and containment of a spill. A good record keeping system helps the municipality minimize incident recurrence, correctly respond with appropriate containment and cleanup activities, and comply with legal requirements.

SC-11 Spill Prevention, Control & Cleanup

A record keeping and reporting system should be set up for documenting spills, leaks, and other discharges, including discharges of hazardous substances in reportable quantities. Incident records describe the quality and quantity of non-stormwater discharges to the storm drain.

These records should contain the following information:

- Date and time of the incident
- Weather conditions
- Duration of the spill/leak/discharge
- Cause of the spill/leak/discharge
- Response procedures implemented
- Persons notified
- Environmental problems associated with the spill/leak/discharge

Separate record keeping systems should be established to document housekeeping and preventive maintenance inspections, and training activities. All housekeeping and preventive maintenance inspections should be documented. Inspection documentation should contain the following information:

- The date and time the inspection was performed
- Name of the inspector
- Items inspected
- Problems noted
- Corrective action required
- Date corrective action was taken

Other means to document and record inspection results are field notes, timed and dated photographs, videotapes, and drawings and maps.

Examples

The City of Palo Alto includes spill prevention and control as a major element of its highly effective program for municipal vehicle maintenance shops.

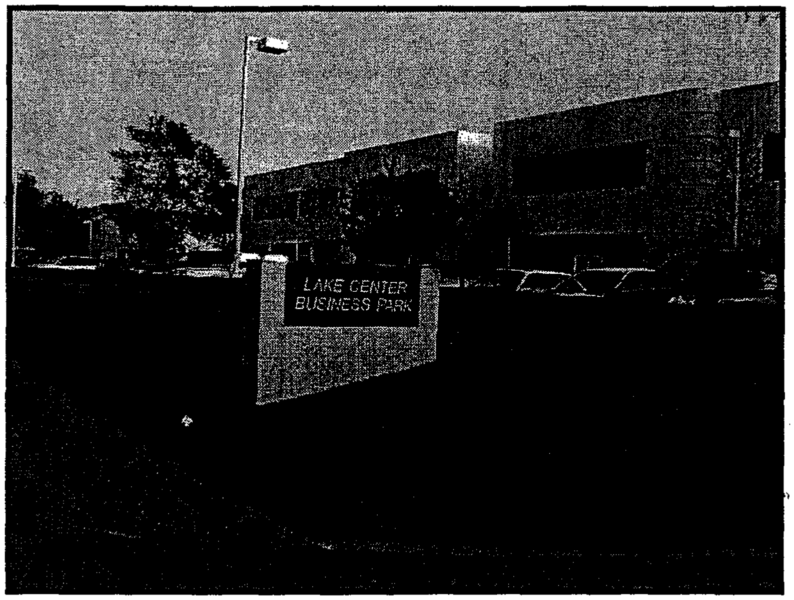
References and Resources

King County Stormwater Pollution Control Manual - http://dnr.metrokc.gov/wlr/dss/spcm.htm

Orange County Stormwater Program
http://www.ocwatersheds.com/stormwater/swp_introduction.asp

San Diego Stormwater Co-permittees Jurisdictional Urban Runoff Management Program (URMP)
http://www.projectcleanwater.org/pdf/Model%20Program%20Municipal%20Facilities.pdf

Building & Grounds Maintenance SC-41



Objectives

- Cover
- Contain
- Educate
- Reduce/Minimize
- Product Substitution

Targeted Constituents

Sediment	✓
Nutrients	✓
Trash	✓
Metals	✓
Bacteria	✓
Oil and Grease	✓
Organics	✓
Oxygen Demanding	✓

Description

Stormwater runoff from building and grounds maintenance activities can be contaminated with toxic hydrocarbons in solvents, fertilizers and pesticides, suspended solids, heavy metals, and abnormal pH. Utilizing the following protocols will prevent or reduce the discharge of pollutants to stormwater from building and grounds maintenance activities by washing and cleaning up with as little water as possible, following good landscape management practices, preventing and cleaning up spills immediately, keeping debris from entering the storm drains, and maintaining the stormwater collection system.

Approach

Pollution Prevention

- Switch to non-toxic chemicals for maintenance when possible.
- Choose cleaning agents that can be recycled.
- Encourage proper lawn management and landscaping, including use of native vegetation.
- Encourage use of Integrated Pest Management techniques for pest control.
- Encourage proper onsite recycling of yard trimmings.
- Recycle residual paints, solvents, lumber, and other material as much as possible.

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Suggested Protocols

Pressure Washing of Buildings, Rooftops, and Other Large Objects

- In situations where soaps or detergents are used and the surrounding area is paved, pressure washers must use a waste water collection device that enables collection of wash water and associated solids. A sump pump, wet vacuum or similarly effective device must be used to collect the runoff and loose materials. The collected runoff and solids must be disposed of properly.

- If soaps or detergents are not used, and the surrounding area is paved, wash water runoff does not have to be collected but must be screened. Pressure washers must use filter fabric or some other type of screen on the ground and/or in he catch basin to trap the particles in wash water runoff.

- If you are pressure washing on a grassed area (with or without soap), runoff must be dispersed as sheet flow as much as possible, rather than as a concentrated stream. The wash runoff must remain on the grass and not drain to pavement. Ensure that this practice does not kill grass.

Landscaping Activities

- Do not apply any chemicals (insecticide, herbicide, or fertilizer) directly to surface waters, unless the application is approved and permitted by the state.

- Dispose of grass clippings, leaves, sticks, or other collected vegetation as garbage, or by composting. Do not dispose of collected vegetation into waterways or storm drainage systems.

- Use mulch or other erosion control measures on exposed soils.

- Check irrigation schedules so pesticides will not be washed away and to minimize non-stormwater discharge.

Building Repair, Remodeling, and Construction

- Do not dump any toxic substance or liquid waste on the pavement, the ground, or toward a storm drain.

- Use ground or drop cloths underneath outdoor painting, scraping, and sandblasting work, and properly dispose of collected material daily.

- Use a ground cloth or oversized tub for activities such as paint mixing and tool cleaning.

- Clean paint brushes and tools covered with water-based paints in sinks connected to sanitary sewers or in portable containers that can be dumped into a sanitary sewer drain. Brushes and tools covered with non-water-based paints, finishes, or other materials must be cleaned in a manner that enables collection of used solvents (e.g., paint thinner, turpentine, etc.) for recycling or proper disposal.

- Use a storm drain cover, filter fabric, or similarly effective runoff control mechanism if dust, grit, wash water, or other pollutants may escape the work area and enter a catch basin. The containment device(s) must be in place at the beginning of the work day, and accumulated dirty runoff and solids must be collected and disposed of before removing the containment device(s) at the end of the work day.

- If you need to de-water an excavation site, you may need to filter the water before discharging to a catch basin or off-site. In which case you should direct the water through hay bales and filter fabric or use other sediment filters or traps.

- Store toxic material under cover with secondary containment during precipitation events and when not in use. A cover would include tarps or other temporary cover material.

Mowing, Trimming, and Planting

- Dispose of leaves, sticks, or other collected vegetation as garbage, by composting or at a permitted landfill. Do not dispose of collected vegetation into waterways or storm drainage systems.

- Use mulch or other erosion control measures when soils are exposed.

- Place temporarily stockpiled material away from watercourses and drain inlets, and berm or cover stockpiles to prevent material releases to the storm drain system.

- Consider an alternative approach when bailing out muddy water; do not put it in the storm drain, pour over landscaped areas.

- Use hand or mechanical weeding where practical.

Fertilizer and Pesticide Management

- Follow all federal, state, and local laws and regulations governing the use, storage, and disposal of fertilizers and pesticides and training of applicators and pest control advisors.

- Follow manufacturers' recommendations and label directions. Pesticides must never be applied if precipitation is occuring or predicted. Do not apply insecticides within 100 feet of surface waters such as lakes, ponds, wetlands, and streams.

- Use less toxic pesticides that will do the job, whenever possible. Avoid use of copper-based pesticides if possible.

- Do not use pesticides if rain is expected.

- Do not mix or prepare pesticides for application near storm drains.

- Use the minimum amount needed for the job.

- Calibrate fertilizer distributors to avoid excessive application.

- Employ techniques to minimize off-target application (e.g. spray drift) of pesticides, including consideration of alternative application techniques.

- Apply pesticides only when wind speeds are low.
- Work fertilizers into the soil rather than dumping or broadcasting them onto the surface.
- Irrigate slowly to prevent runoff and then only as much as is needed.
- Clean pavement and sidewalk if fertilizer is spilled on these surfaces before applying irrigation water.
- Dispose of empty pesticide containers according to the instructions on the container label.
- Use up the pesticides. Rinse containers, and use rinse water as product. Dispose of unused pesticide as hazardous waste.
- Implement storage requirements for pesticide products with guidance from the local fire department and County Agricultural Commissioner. Provide secondary containment for pesticides.

Inspection

- Inspect irrigation system periodically to ensure that the right amount of water is being applied and that excessive runoff is not occurring. Minimize excess watering, and repair leaks in the irrigation system as soon as they are observed.

Training

- Educate and train employees on use of pesticides and in pesticide application techniques to prevent pollution.
- Train employees and contractors in proper techniques for spill containment and cleanup.
- Be sure the frequency of training takes into account the complexity of the operations and the nature of the staff.

Spill Response and Prevention

- Refer to SC-11, Spill Prevention, Control & Cleanup
- Keep your Spill Prevention Control and countermeasure (SPCC) plan up-to-date, and implement accordingly.
- Have spill cleanup materials readily available and in a known location.
- Cleanup spills immediately and use dry methods if possible.
- Properly dispose of spill cleanup material.

Other Considerations

- Alternative pest/weed controls may not be available, suitable, or effective in many cases.

Requirements

Costs

- Overall costs should be low in comparison to other BMPs.

Maintenance

- Sweep paved areas regularly to collect loose particles, and wipe up spills with rags and other absorbent material immediately, do not hose down the area to a storm drain.

Supplemental Information

Further Detail of the BMP

Fire Sprinkler Line Flushing

Building fire sprinkler line flushing may be a source of non-stormwater runoff pollution. The water entering the system is usually potable water though in some areas it may be non-potable reclaimed wastewater. There are subsequent factors that may drastically reduce the quality of the water in such systems. Black iron pipe is usually used since it is cheaper than potable piping but it is subject to rusting and results in lower quality water. Initially the black iron pipe has an oil coating to protect it from rusting between manufacture and installation; this will contaminate the water from the first flush but not from subsequent flushes. Nitrates, poly-phosphates and other corrosion inhibitors, as well as fire suppressants and antifreeze may be added to the sprinkler water system. Water generally remains in the sprinkler system a long time, typically a year, between flushes and may accumulate iron, manganese, lead, copper, nickel and zinc. The water generally becomes anoxic and contains living and dead bacteria and breakdown products from chlorination. This may result in a significant BOD problem and the water often smells. Consequently dispose fire sprinkler line flush water into the sanitary sewer. Do not allow discharge to storm drain or infiltration due to potential high levels of pollutants in fire sprinkler line water.

References and Resources

California's Nonpoint Source Program Plan http://www.swrcb.ca.gov/nps/index.html

King County - ftp://dnr.metrokc.gov/wlr/dss/spcm/Chapter%203.PDF

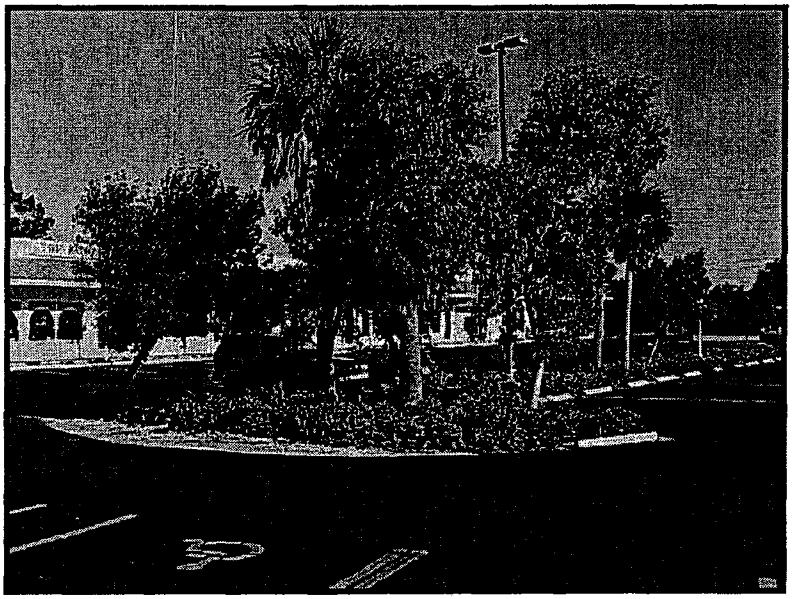
Orange County Stormwater Program
http://www.ocwatersheds.com/StormWater/swp_introduction.asp

Mobile Cleaners Pilot Program: Final Report. 1997. Bay Area Stormwater Management Agencies Association (BASSMA) http://www.basmaa.org/

Pollution from Surface Cleaning Folder. 1996. Bay Area Stormwater Management Agencies Association (BASMAA) http://www.basmaa.org/

San Diego Stormwater Co-permittees Jurisdictional Urban Runoff Management Program (URMP) -
http://www.projectcleanwater.org/pdf/Model%20Program%20Municipal%20Facilities.pdf

Parking/Storage Area Maintenance SC-43



Objectives

- Cover
- Contain
- Educate
- Reduce/Minimize
- Product Substitution

Targeted Constituents

Sediment	✓
Nutrients	✓
Trash	✓
Metals	✓
Bacteria	✓
Oil and Grease	✓
Organics	✓
Oxygen Demanding	✓

Description

Parking lots and storage areas can contribute a number of substances, such as trash, suspended solids, hydrocarbons, oil and grease, and heavy metals that can enter receiving waters through stormwater runoff or non-stormwater discharges. The following protocols are intended to prevent or reduce the discharge of pollutants from parking/storage areas and include using good housekeeping practices, following appropriate cleaning BMPs, and training employees.

Approach

Pollution Prevention

- Encourage alternative designs and maintenance strategies for impervious parking lots. (See New Development and Redevelopment BMP Handbook).
- Keep accurate maintenance logs to evaluate BMP implementation.

Suggested Protocols

General

- Keep the parking and storage areas clean and orderly. Remove debris in a timely fashion.
- Allow sheet runoff to flow into biofilters (vegetated strip and swale) and/or infiltration devices.
- Utilize sand filters or oleophilic collectors for oily waste in low concentrations.

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- Arrange rooftop drains to prevent drainage directly onto paved surfaces.
- Design lot to include semi-permeable hardscape.

Controlling Litter

- Post "No Littering" signs and enforce anti-litter laws.
- Provide an adequate number of litter receptacles.
- Clean out and cover litter receptacles frequently to prevent spillage.
- Provide trash receptacles in parking lots to discourage litter.
- Routinely sweep, shovel and dispose of litter in the trash.

Surface cleaning

- Use dry cleaning methods (e.g. sweeping or vacuuming) to prevent the discharge of pollutants into the stormwater conveyance system.
- Establish frequency of public parking lot sweeping based on usage and field observations of waste accumulation.
- Sweep all parking lots at least once before the onset of the wet season.
- If water is used follow the procedures below:
  - Block the storm drain or contain runoff.
  - Wash water should be collected and pumped to the sanitary sewer or discharged to a pervious surface, do not allow wash water to enter storm drains.
  - Dispose of parking lot sweeping debris and dirt at a landfill.
- When cleaning heavy oily deposits:
  - Use absorbent materials on oily spots prior to sweeping or washing.
  - Dispose of used absorbents appropriately.

Surface Repair

- Pre-heat, transfer or load hot bituminous material away from storm drain inlets.
- Apply concrete, asphalt, and seal coat during dry weather to prevent contamination form contacting stormwater runoff.
- Cover and seal nearby storm drain inlets (with waterproof material or mesh) and manholes before applying seal coat, slurry seal, etc., where applicable. Leave covers in place until job is complete and until all water from emulsified oil sealants has drained or evaporated. Clean any debris from these covered manholes and drains for proper disposal.

- Use only as much water as necessary for dust control, to avoid runoff.
- Catch drips from paving equipment that is not in use with pans or absorbent material placed under the machines. Dispose of collected material and absorbents properly.

Inspection

- Have designated personnel conduct inspections of the parking facilities and stormwater conveyance systems associated with them on a regular basis.
- Inspect cleaning equipment/sweepers for leaks on a regular basis.

Training

- Provide regular training to field employees and/or contractors regarding cleaning of paved areas and proper operation of equipment.
- Train employees and contractors in proper techniques for spill containment and cleanup.

Spill Response and Prevention

- Refer to SC-11, Spill Prevention, Control & Cleanup.
- Keep your Spill Prevention Control and countermeasure (SPCC) plan up-to-date, nad implement accordingly.
- Have spill cleanup materials readily available and in a known location.
- Cleanup spills immediately and use dry methods if possible.
- Properly dispose of spill cleanup material.

Other Considerations

- Limitations related to sweeping activities at large parking facilities may include high equipment costs, the need for sweeper operator training, and the inability of current sweeper technology to remove oil and grease.

Requirements

Costs

Cleaning/sweeping costs can be quite large, construction and maintenance of stormwater structural controls can be quite expensive as well.

Maintenance

- Sweep parking lot to minimize cleaning with water.
- Clean out oil/water/sand separators regularly, especially after heavy storms.
- Clean parking facilities on a regular basis to prevent accumulated wastes and pollutants from being discharged into conveyance systems during rainy conditions.

Supplemental Information

Further Detail of the BMP

Surface Repair

Apply concrete, asphalt, and seal coat during dry weather to prevent contamination form contacting stormwater runoff. Where applicable, cover and seal nearby storm drain inlets (with waterproof material or mesh) and manholes before applying seal coat, slurry seal, etc. Leave covers in place until job is complete and until all water from emulsified oil sealants has drained or evaporated. Clean any debris from these covered manholes and drains for proper disposal. Use only as much water as necessary for dust control, to avoid runoff.

References and Resources

http://www.stormwatercenter.net/

California's Nonpoint Source Program Plan http://www.swrcb.ca.gov/nps/index.html

Model Urban Runoff Program: A How-To Guide for Developing Urban Runoff Programs for Small Municipalities. Prepared by City of Monterey, City of Santa Cruz, California Coastal Commission, Monterey Bay National Marine Sanctuary, Association of Monterey Bay Area Governments, Woodward-Clyde, Central Coast Regional Water Quality control Board. July 1998 (Revised February 2002 by the California Coastal Commission).

Orange County Stormwater Program
http://www.ocwatersheds.com/StormWater/swp_introduction.asp

Oregon Association of Clean Water Agencies. Oregon Municipal Stormwater Toolbox for Maintenance Practices. June 1998.

Pollution from Surface Cleaning Folder. 1996. Bay Area Stormwater Management Agencies Association (BASMAA) http://www.basma.org

San Diego Stormwater Co-permittees Jurisdictional Urban Runoff Management Program (URMP)
http://www.projectcleanwater.org/pdf/Model%20Program%20Municipal%20Facilities.pdf

Housekeeping Practices SC-60

Objectives

- Cover
- Contain
- Educate
- Reduce/Minimize
- Product Substitution

Targeted Constituents

Sediment	✓
Nutrients	✓
Trash	✓
Metals	✓
Bacteria	✓
Oil and Grease	✓
Organics	✓
Oxygen Demanding	✓

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Description

Promote efficient and safe housekeeping practices (storage, use, and cleanup) when handling potentially harmful materials such as fertilizers, pesticides, cleaning solutions, paint products, automotive products, and swimming pool chemicals. Related information is provided in BMP fact sheets SC-11 Spill Prevention, Control & Cleanup and SC-34 Waste Handling & Disposal.

Approach

Pollution Prevention

- Purchase only the amount of material that will be needed for foreseeable use. In most cases this will result in cost savings in both purchasing and disposal. See SC-61 Safer Alternative Products for additional information.

- Be aware of new products that may do the same job with less environmental risk and for less or the equivalent cost. Total cost must be used here; this includes purchase price, transportation costs, storage costs, use related costs, clean up costs and disposal costs.

Suggested Protocols

General

- Keep work sites clean and orderly. Remove debris in a timely fashion. Sweep the area.

- Dispose of wash water, sweepings, and sediments, properly.

- Recycle or dispose of fluids properly.

- Establish a daily checklist of office, yard and plant areas to confirm cleanliness and adherence to proper storage and security. Specific employees should be assigned specific inspection responsibilities and given the authority to remedy any problems found.

- Post waste disposal charts in appropriate locations detailing for each waste its hazardous nature (poison, corrosive, flammable), prohibitions on its disposal (dumpster, drain, sewer) and the recommended disposal method (recycle, sewer, burn, storage, landfill).

- Summarize the chosen BMPs applicable to your operation and post them in appropriate conspicuous places.

- Require a signed checklist from every user of any hazardous material detailing amount taken, amount used, amount returned and disposal of spent material.
- Do a before audit of your site to establish baseline conditions and regular subsequent audits to note any changes and whether conditions are improving or deteriorating.
- Keep records of water, air and solid waste quantities and quality tests and their disposition.
- Maintain a mass balance of incoming, outgoing and on hand materials so you know when there are unknown losses that need to be tracked down and accounted for.
- Use and reward employee suggestions related to BMPs, hazards, pollution reduction, work place safety, cost reduction, alternative materials and procedures, recycling and disposal.
- Have, and review regularly, a contingency plan for spills, leaks, weather extremes etc. Make sure all employees know about it and what their role is so that it comes into force automatically.

Training

- Train all employees, management, office, yard, manufacturing, field and clerical in BMPs and pollution prevention and make them accountable.
- Train municipal employees who handle potentially harmful materials in good housekeeping practices.
- Train personnel who use pesticides in the proper use of the pesticides. The California Department of Pesticide Regulation license pesticide dealers, certify pesticide applicators and conduct onsite inspections.
- Train employees and contractors in proper techniques for spill containment and cleanup. The employee should have the tools and knowledge to immediately begin cleaning up a spill if one should occur.

Spill Response and Prevention

- Refer to SC-11, Spill Prevention, Control & Cleanup.
- Keep your Spill Prevention Control and Countermeasure (SPCC) plant up-to-date, and implement accordingly.
- Have spill cleanup materials readily available and in a known location.
- Cleanup spills immediately and use dry methods if possible.
- Properly dispose of spill cleanup material.

Other Considerations

- There are no major limitations to this best management practice.
- There are no regulatory requirements to this BMP. Existing regulations already require municipalities to properly store, use, and dispose of hazardous materials

Requirements

Costs

- Minimal cost associated with this BMP. Implementation of good housekeeping practices may result in cost savings as these procedures may reduce the need for more costly BMPs.

Maintenance

- Ongoing maintenance required to keep a clean site. Level of effort is a function of site size and type of activities.

Supplemental Information

Further Detail of the BMP

- The California Integrated Waste Management Board's Recycling Hotline, 1-800-553-2962, provides information on household hazardous waste collection programs and facilities.

Examples

There are a number of communities with effective programs. The most pro-active include Santa Clara County and the City of Palo Alto, the City and County of San Francisco, and the Municipality of Metropolitan Seattle (Metro).

References and Resources

British Columbia Lake Stewardship Society. Best Management Practices to Protect Water Quality from Non-Point Source Pollution. March 2000. http://www.nalms.org/bclss/bmphome.html#bmp

King County Stormwater Pollution Control Manual - http://dnr.metrokc.gov/wlr/dss/spcm.htm

Model Urban Runoff Program: A How-To Guide for Developing Urban Runoff Programs for Small Municipalities, Prepared by City of Monterey, City of Santa Cruz, California Coastal Commission, Monterey Bay National Marine Sanctuary, Association of Monterey Bay Area Governments, Woodward-Clyde, Central Coast Regional Water Quality Control Board. July, 1998, Revised by California Coastal Commission, February 2002.

Orange County Stormwater Program http://www.ocwatersheds.com/stormwater/swp_introduction.asp

San Mateo STOPPP - (http://stoppp.tripod.com/bmp.html)

Safer Alternative Products SC-61

Objectives

- Educate
- Reduce/Minimize
- Product Substitution

Descriptions

Promote the use of less harmful products. Alternatives exist for most product classes including chemical fertilizers, pesticides, cleaning solutions, janitorial chemicals, automotive and paint products, and consumables (batteries, fluorescent lamps).

Approach

Develop a comprehensive program based on:

- The "Precautionary Principle," which is an alternative to the "Risk Assessment" model that says it's acceptable to use a potentially harmful product until physical evidence of its harmful effects are established and deemed too costly from an environmental or public health perspective. For instance, a risk assessment approach might say it's acceptable to use a pesticide until there is direct proof of an environmental impact. The Precautionary Principle approach is used to evaluate whether a given product is safe, whether it is really necessary, and whether alternative products would perform just as well.

- Environmentally Preferable Purchasing Program to minimize the purchase of products containing hazardous ingredients used in the facility's custodial services, fleet maintenance, and facility maintenance in favor of using alternate products that pose less risk to employees and to the environment.

- Integrated Pest Management (IPM) or Less-Toxic Pesticide Program, which uses a pest management approach that minimizes the use of toxic chemicals and gets rid of pests by methods that pose a lower risk to employees, the public, and the environment.

- Energy Efficiency Program including no-cost and low-cost energy conservation and efficiency actions that can reduce both energy consumption and electricity bills, along with long-term energy efficiency investments.

Consider the following mechanisms for developing and implementing a comprehensive program:

- Policies
- Procedures
  - Standard operating procedures (SOPs)
  - Purchasing guidelines and procedures

Targeted Constituents

Sediment	
Nutrients	✓
Trash	
Metals	✓
Bacteria	
Oil and Grease	✓
Organics	✓
Oxygen Demanding	

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  - Bid packages (services and supplies)
- Materials
  - Preferred or approved product and supplier lists
  - Product and supplier evaluation criteria
  - Training sessions and manuals
  - Fact sheets for employees

Training

- Employees who handle potentially harmful materials in the use of safer alternatives.
- Purchasing departments should be encouraged to procure less hazardous materials and products that contain little or no harmful substances or TMDL pollutants.

Regulations

This BMP has no regulatory requirements. Existing regulations already encourage facilities to reduce the use of hazardous materials through incentives such as reduced:

- Specialized equipment storage and handling requirements,
- Stormwater runoff sampling requirements,
- Training and licensing requirements, and
- Record keeping and reporting requirements.

Equipment

- There are no major equipment requirements to this BMP.

Limitations

- Alternative products may not be available, suitable, or effective in every case.

Requirements

Costs

- The primary cost is for staff time to: 1) develop new policies and procedures and 2) educate purchasing departments and employees who handle potentially harmful materials about the availability, procurement, and use of safer alternatives.
- Some alternative products may be slightly more expensive than conventional products.

Supplemental Information

Employees and contractors / service providers can both be educated about safer alternatives by using information developed by a number of organizations including the references and resources listed below.

The following discussion provides some general information on safer alternatives. More specific information on particular hazardous materials and the available alternatives may be found in the references and resources listed below.

- Automotive products – Less toxic alternatives are not available for many automotive products, especially engine fluids. But there are alternatives to grease lubricants, car polishes, degreasers, and windshield washer solution. Rerefined motor oil is also available.
- Vehicle/Trailer lubrication – Fifth wheel bearings on trucks require routine lubrication. Adhesive lubricants are available to replace typical chassis grease.
- Cleaners – Vegetables-based or citrus-based soaps are available to replace petroleum-based soaps/detergents.
- Paint products – Water-based paints, wood preservatives, stains, and finishes are available.
- Pesticides – Specific alternative products or methods exist to control most insects, fungi, and weeds.
- Chemical Fertilizers – Compost and soil amendments are natural alternatives.
- Consumables – Manufacturers have either reduced or are in the process of reducing the amount of heavy metals in consumables such as batteries and fluorescent lamps. All fluorescent lamps contain mercury, however low-mercury containing lamps are now available from most hardware and lighting stores. Fluorescent lamps are also more energy efficient than the average incandescent lamp.
- Janitorial chemicals – Even biodegradable soap can harm fish and wildlife before it biodegrades. Biodegradable does not mean non-toxic. Safer products and procedures are available for floor stripping and cleaning, as well as carpet, glass, metal, and restroom cleaning and disinfecting.

Examples
There are a number of business and trade associations, and communities with effective programs. Some of the more prominent are listed below in the references and resources section.

References and Resources
Note: Many of these references provide alternative products for materials that typically are used inside and disposed to the sanitary sewer as well as alternatives to products that usually end up in the storm drain.

General Sustainable Practices and Pollution Prevention Including Pollutant-Specific Information
California Department of Toxic Substances Control (www.dtsc.ca.gov)

California Integrated Waste Management Board (www.ciwmb.ca.gov)

City of Santa Monica (www.santa-monica.org/environment)

City of Palo Alto (www.city.palo-alto.ca.us/cleanbay)

City and County of San Francisco, Department of the Environment (www.ci.sf.ca.us/sfenvironment)

Earth 911 (www.earth911.org/master.asp)

Environmental Finance Center Region IX (www.greenstart.org/efc9)

Flex Your Power (www.flexyourpower.ca.gov)

GreenBiz.com (www.greenbiz.com)

Green Business Program (www.abag.org/bayarea/enviro/gbus/gb.html)

Pacific Industrial and Business Association (www.piba.org)

Sacramento Clean Water Business Partners (www.sacstormwater.org)

USEPA BMP fact sheet – Alternative products (http://cfpub.epa.gov/npdes/stormwater/menuofbmps/poll_2.cfm)

USEPA Region IX Pollution Prevention Program (www.epa.gov/region09/p2)

Western Regional Pollution Prevention Network (www.westp2net.org)

Metals (mercury, copper)

National Electrical Manufacturers Association - Environment, Health and Safety (www.nema.org)

Sustainable Conservation (www.suscon.org)

Auto Recycling Project

Brake Pad Partnership

Pesticides and Chemical Fertilizers

Bio-Integral Resource Center (www.birc.org)

California Department of Pesticide Regulation (www.cdpr.ca.gov)

University of California Statewide IPM Program (www.ipm.ucdavis.edu/default.html)

Dioxins

Bay Area Dioxins Project (http://dioxin.abag.ca.gov/)

Road and Street Maintenance SC-70

Objectives

- Cover
- Contain
- Educate
- Reduce/Minimize
- Product Substitution

Targeted Constituents

Sediment	✓
Nutrients	
Trash	✓
Metals	✓
Bacteria	
Oil and Grease	✓
Organics	✓
Oxygen Demanding	✓

Description

Streets, roads, and highways are significant sources of pollutants in stormwater discharges, and operation and maintenance (O&M) practices, if not conducted properly, can contribute to the problem. Stormwater pollution from roadway and bridge maintenance should be addressed on a site-specific basis. Use of the procedures outlined below, that address street sweeping and repair, bridge and structure maintenance, and unpaved roads will reduce pollutants in stormwater.

Approach

Pollution Prevention

- Use the least toxic materials available (e.g. water based paints, gels or sprays for graffiti removal)
- Recycle paint and other materials whenever possible.
- Enlist the help of citizens to keep yard waste, used oil, and other wastes out of the gutter.

Suggested Protocols

Street Sweeping and Cleaning

- Maintain a consistent sweeping schedule. Provide minimum monthly sweeping of curbed streets.
- Perform street cleaning during dry weather if possible.

CASQA
California Stormwater Quality Association

- Avoid wet cleaning or flushing of street, and utilize dry methods where possible.
- Consider increasing sweeping frequency based on factors such as traffic volume, land use, field observations of sediment and trash accumulation, proximity to water courses, etc. For example:
  - Increase the sweeping frequency for streets with high pollutant loadings, especially in high traffic and industrial areas.
  - Increase the sweeping frequency just before the wet season to remove sediments accumulated during the summer.
  - Increase the sweeping frequency for streets in special problem areas such as special events, high litter or erosion zones.
- Maintain cleaning equipment in good working condition and purchase replacement equipment as needed. Old sweepers should be replaced with new technologically advanced sweepers (preferably regenerative air sweepers) that maximize pollutant removal.
- Operate sweepers at manufacturer requested optimal speed levels to increase effectiveness.
- To increase sweeping effectiveness consider the following:
  - Institute a parking policy to restrict parking in problematic areas during periods of street sweeping.
  - Post permanent street sweeping signs in problematic areas; use temporary signs if installation of permanent signs is not possible.
  - Develop and distribute flyers notifying residents of street sweeping schedules.
- Regularly inspect vehicles and equipment for leaks, and repair immediately.
- If available use vacuum or regenerative air sweepers in the high sediment and trash areas (typically industrial/commercial).
- Keep accurate logs of the number of curb-miles swept and the amount of waste collected.
- Dispose of street sweeping debris and dirt at a landfill.
- Do not store swept material along the side of the street or near a storm drain inlet.
- Keep debris storage to a minimum during the wet season or make sure debris piles are contained (e.g. by berming the area) or covered (e.g. with tarps or permanent covers).

Street Repair and Maintenance

Pavement marking

- Schedule pavement marking activities for dry weather.

- Develop paint handling procedures for proper use, storage, and disposal of paints.
- Transfer and load paint and hot thermoplastic away from storm drain inlets.
- Provide drop cloths and drip pans in paint mixing areas.
- Properly maintain application equipment.
- Street sweep thermoplastic grindings. Yellow thermoplastic grindings may require special handling as they may contain lead.
- Paints containing lead or tributyltin are considered a hazardous waste and must be disposed of properly.
- Use water based paints whenever possible. If using water based paints, clean the application equipment in a sink that is connected to the sanitary sewer.
- Properly store leftover paints if they are to be kept for the next job, or dispose of properly.

Concrete installation and repair

- Schedule asphalt and concrete activities for dry weather.
- Take measures to protect any nearby storm drain inlets and adjacent watercourses, prior to breaking up asphalt or concrete (e.g. place san bags around inlets or work areas).
- Limit the amount of fresh concrete or cement mortar mixed, mix only what is needed for the job.
- Store concrete materials under cover, away from drainage areas. Secure bags of cement after they are open. Be sure to keep wind-blown cement powder away from streets, gutters, storm drains, rainfall, and runoff.
- Return leftover materials to the transit mixer. Dispose of small amounts of hardened excess concrete, grout, and mortar in the trash.
- Do not wash sweepings from exposed aggregate concrete into the street or storm drain. Collect and return sweepings to aggregate base stockpile, or dispose in the trash.
- When making saw cuts in pavement, use as little water as possible and perform during dry weather. Cover each storm drain inlet completely with filter fabric or plastic during the sawing operation and contain the slurry by placing straw bales, sandbags, or gravel dams around the inlets. After the liquid drains or evaporates, shovel or vacuum the slurry residue from the pavement or gutter and remove from site. Alternatively, a small onsite vacuum may be used to pick up the slurry as this will prohibit slurry from reaching storm drain inlets.
- Wash concrete trucks off site or in designated areas on site designed to preclude discharge of wash water to drainage system.

Patching, resurfacing, and surface sealing

- Schedule patching, resurfacing and surface sealing for dry weather.
- Stockpile materials away from streets, gutter areas, storm drain inlets or watercourses. During wet weather, cover stockpiles with plastic tarps or berm around them if necessary to prevent transport of materials in runoff.
- Pre-heat, transfer or load hot bituminous material away from drainage systems or watercourses.
- Where applicable, cover and seal nearby storm drain inlets (with waterproof material or mesh) and maintenance holes before applying seal coat, slurry seal, etc. Leave covers in place until job is complete and until all water from emulsified oil sealants has drained or evaporated. Clean any debris from covered maintenance holes and storm drain inlets when the job is complete.
- Prevent excess material from exposed aggregate concrete or similar treatments from entering streets or storm drain inlets. Designate an area for clean up and proper disposal of excess materials.
- Use only as much water as necessary for dust control, to avoid runoff.
- Sweep, never hose down streets to clean up tracked dirt. Use a street sweeper or vacuum truck. Do not dump vacuumed liquid in storm drains.
- Catch drips from paving equipment that is not in use with pans or absorbent material placed under the machines. Dispose of collected material and absorbents properly.

Equipment cleaning maintenance and storage

- Inspect equipment daily and repair any leaks. Place drip pans or absorbent materials under heavy equipment when not in use.
- Perform major equipment repairs at the corporation yard, when practical.
- If refueling or repairing vehicles and equipment must be done onsite, use a location away from storm drain inlets and watercourses.
- Clean equipment including sprayers, sprayer paint supply lines, patch and paving equipment, and mud jacking equipment at the end of each day. Clean in a sink or other area (e.g. vehicle wash area) that is connected to the sanitary sewer.

Bridge and Structure Maintenance

Paint and Paint Removal

- Transport paint and materials to and from job sites in containers with secure lids and tied down to the transport vehicle.
- Do not transfer or load paint near storm drain inlets or watercourses.

- Test and inspect spray equipment prior to starting to paint. Tighten all hoses and connections and do not overfill paint container.
- Plug nearby storm drain inlets prior to starting painting where there is significant risk of a spill reaching storm drains. Remove plugs when job is completed.
- If sand blasting is used to remove paint, cover nearby storm drain inlets prior to starting work.
- Perform work on a maintenance traveler or platform, or use suspended netting or tarps to capture paint, rust, paint removing agents, or other materials, to prevent discharge of materials to surface waters if the bridge crosses a watercourse. If sanding, use a sander with a vacuum filter bag.
- Capture all clean-up water, and dispose of properly.
- Recycle paint when possible (e.g. paint may be used for graffiti removal activities). Dispose of unused paint at an appropriate household hazardous waste facility.

Graffiti Removal

- Schedule graffiti removal activities for dry weather.
- Protect nearby storm drain inlets prior to removing graffiti from walls, signs, sidewalks, or other structures needing graffiti abatement. Clean up afterwards by sweeping or vacuuming thoroughly, and/or by using absorbent and properly disposing of the absorbent.
- When graffiti is removed by painting over, implement the procedures under Painting and Paint Removal above.
- Direct runoff from sand blasting and high pressure washing (with no cleaning agents) into a landscaped or dirt area. If such an area is not available, filter runoff through an appropriate filtering device (e.g. filter fabric) to keep sand, particles, and debris out of storm drains.
- If a graffiti abatement method generates wash water containing a cleaning compound (such as high pressure washing with a cleaning compound), plug nearby storm drains and vacuum/pump wash water to the sanitary sewer.
- Consider using a waterless and non-toxic chemical cleaning method for graffiti removal (e.g. gels or spray compounds).

Repair Work

- Prevent concrete, steel, wood, metal parts, tools, or other work materials from entering storm drains or watercourses.
- Thoroughly clean up the job site when the repair work is completed.
- When cleaning guardrails or fences follow the appropriate surface cleaning methods (depending on the type of surface) outlined in SC-71 Plaza & Sidewalk Cleaning fact sheet.

- If painting is conducted, follow the painting and paint removal procedures above.
- If graffiti removal is conducted, follow the graffiti removal procedures above.
- If construction takes place, see the Construction Activity BMP Handbook.
- Recycle materials whenever possible.

Unpaved Roads and Trails

- Stabilize exposed soil areas to prevent soil from eroding during rain events. This is particularly important on steep slopes.
- For roadside areas with exposed soils, the most cost-effective choice is to vegetate the area, preferably with a mulch or binder that will hold the soils in place while the vegetation is establishing. Native vegetation should be used if possible.
- If vegetation cannot be established immediately, apply temporary erosion control mats/blankets; a comma straw, or gravel as appropriate.
- If sediment is already eroded and mobilized in roadside areas, temporary controls should be installed. These may include: sediment control fences, fabric-covered triangular dikes, gravel-filled burlap bags, biobags, or hay bales staked in place.

Non-Stormwater Discharges

Field crews should be aware of non-stormwater discharges as part of their ongoing street maintenance efforts.

- Refer to SC-10 Non-Stormwater Discharges
- Identify location, time and estimated quantity of discharges.
- Notify appropriate personnel.

Training

- Train employees regarding proper street sweeping operation and street repair and maintenance.
- Instruct employees and subcontractors to ensure that measures to reduce the stormwater impacts of roadway/bridge maintenance are being followed.
- Require engineering staff and/or consulting A/E firms to address stormwater quality in new bridge designs or existing bridge retrofits.
- Use a training log or similar method to document training.
- Train employees on proper spill containment and clean up, and in identifying non-stormwater discharges.

Spill Response and Prevention

- Refer to SC-11, Spill Prevention, Control & Cleanup.
- Keep your Spill Prevention Control and countermeasure (SPCC) plan up-to-date, and implement accordingly.
- Have spill cleanup materials readily available and in a known location.
- Cleanup spills immediately and use dry methods if possible.
- Properly dispose of spill cleanup material.

Other Considerations

- Densely populated areas or heavily used streets may require parking regulations to clear streets for cleaning.
- No currently available conventional sweeper is effective at removing oil and grease. Mechanical sweepers are not effective at removing finer sediments.
- Limitations may arise in the location of new bridges. The availability and cost of land and other economic and political factors may dictate where the placement of a new bridge will occur. Better design of the bridge to control runoff is required if it is being placed near sensitive waters.

Requirements

Costs

- The maintenance of local roads and bridges is already a consideration of most community public works or transportation departments. Therefore, the cost of pollutant reducing management practices will involve the training and equipment required to implement these new practices.
- The largest expenditures for street sweeping programs are in staffing and equipment. The capital cost for a conventional street sweeper is between $60,000 and $120,000. Newer technologies might have prices approaching $180,000. The average useful life of a conventional sweeper is about four years, and programs must budget for equipment replacement. Sweeping frequencies will determine equipment life, so programs that sweep more often should expect to have a higher cost of replacement.
- A street sweeping program may require the following.
  - Sweeper operators, maintenance, supervisory, and administrative personnel are required.
  - Traffic control officers may be required to enforce parking restrictions.
  - Skillful design of cleaning routes is required for program to be productive.
  - Arrangements must be made for disposal of collected wastes.

- If investing in newer technologies, training for operators must be included in operation and maintenance budgets. Costs for public education are small, and mostly deal with the need to obey parking restrictions and litter control. Parking tickets are an effective reminder to obey parking rules, as well as being a source of revenue.

Maintenance
- Not applicable

Supplemental Information
Further Detail of the BMP
Street sweeping

There are advantages and disadvantages to the two common types of sweepers. The best choice depends on your specific conditions. Many communities find it useful to have a compliment of both types in their fleet.

Mechanical Broom Sweepers - More effective at picking up large debris and cleaning wet streets. Less costly to purchase and operate. Create more airborne dust.

Vacuum Sweepers - More effective at removing fine particles and associated heavy metals. Ineffective at cleaning wet streets. Noisier than mechanical broom sweepers which may restrict areas or times of operation. May require an advance vehicle to remove large debris.

Street Flushers - Not affected by biggest interference to cleaning, parked cars. May remove finer sediments, moving them toward the gutter and stormwater inlets. For this reason, flushing fell out of favor and is now used primarily after sweeping. Flushing may be effective for combined sewer systems. Presently street flushing is not allowed under most NPDES permits.

Cross-Media Transfer of Pollutants

The California Air Resources Board (ARB) has established state ambient air quality standards including a standard for respirable particulate matter (less than or equal to 10 microns in diameter, symbolized as PM10). In the effort to sweep up finer sediments to remove attached heavy metals, municipalities should be aware that fine dust, that cannot be captured by the sweeping equipment and becomes airborne, could lead to issues of worker and public safety.

Bridges

Bridges that carry vehicular traffic generate some of the more direct discharges of runoff to surface waters. Bridge scupper drains cause a direct discharge of stormwater into receiving waters and have been shown to carry relatively high concentrations of pollutants. Bridge maintenance also generates wastes that may be either directly deposited to the water below or carried to the receiving water by stormwater. The following steps will help reduce the stormwater impacts of bridge maintenance:

- Site new bridges so that significant adverse impacts to wetlands, sensitive areas, critical habitat, and riparian vegetation are minimized.

- Design new bridges to avoid the use of scupper drains and route runoff to land for treatment control. Existing scupper drains should be cleaned on a regular basis to avoid sediment/debris accumulation.
- Reduce the discharge of pollutants to surface waters during maintenance by using suspended traps, vacuums, or booms in the water to capture paint, rust, and paint removing agents. Many of these wastes may be hazardous. Properly dispose of this waste by referring to CA21 (Hazardous Waste Management) in the Construction Handbook.
- Train employees and subcontractors to reduce the discharge of wastes during bridge maintenance.

De-icing

- Do not over-apply deicing salt and sand, and routinely calibrate spreaders.
- Near reservoirs, restrict the application of deicing salt and redirect any runoff away from reservoirs.
- Consider using alternative deicing agents (less toxic, biodegradable, etc.).

References and Resources

Model Urban Runoff Program: A How-To Guide for Developing Urban Runoff Programs for Small Municipalities. Prepared by City of Monterey, City of Santa Cruz, California Coastal Commission, Monterey Bay National Marine Sanctuary, Association of Monterey Bay Area Governments, Woodward-Clyde, Central Coast Regional Water Quality Control Board. July. 1998.

Orange County Stormwater Program
http://www.ocwatersheds.com/stormwater/swp_introduction.asp

Oregon Association of Clean Water Agencies. Oregon Municipal Stormwater Toolbox for Maintenance Practices. June 1998.

Santa Clara Valley Urban Runoff Pollution Prevention Program. 1997 Urban Runoff Management Plan. September 1997, updated October 2000.

Santa Clara Valley Urban Runoff Pollution Prevention Program. 2001. Fresh Concrete and Mortar Application Best Management Practices for the Construction Industry. June.

Santa Clara Valley Urban Runoff Pollution Prevention Program. 2001. Roadwork and Paving Best Management Practices for the Construction Industry. June.

United States Environmental Protection Agency (USEPA). 2002. Pollution Prevention/Good Housekeeping for Municipal Operations Roadway and Bridge Maintenance. On-line http://www.epa.gov/npdes/menuofbmps/poll_13.htm

Plaza and Sidewalk Cleaning SC-71

Objectives

- Cover
- Contain
- Educate
- Reduce/Minimize
- Product Substitution

Targeted Constituents

Sediment	✓
Nutrients	✓
Trash	✓
Metals	✓
Bacteria	✓
Oil and Grease	✓
Organics	✓
Oxygen Demanding	✓

CASQA California Stormwater Quality Association

Description

Pollutants on sidewalks and other pedestrian traffic areas and plazas are typically due to littering and vehicle use. This fact sheet describes good housekeeping practices that can be incorporated into the municipality's existing cleaning and maintenance program.

Approach

Pollution Prevention

- Use dry cleaning methods whenever practical for surface cleaning activities.
- Use the least toxic materials available (e.g. water based paints, gels or sprays for graffiti removal).

Suggested Protocols

Surface Cleaning

- Regularly broom (dry) sweep sidewalk, plaza and parking lot areas to minimize cleaning with water.
- Dry cleanup first (sweep, collect, and dispose of debris and trash) when cleaning sidewalks or plazas, then wash with or without soap.
- Block the storm drain or contain runoff when cleaning with water. Discharge wash water to landscaping or collect water and pump to a tank or discharge to sanitary sewer if allowed. (Permission may be required from local sanitation district.)

- Block the storm drain or contain runoff when washing parking areas, driveways or drive-throughs. Use absorbents to pick up oil; then dry sweep. Clean with or without soap. Collect water and pump to a tank or discharge to sanitary sewer if allowed. Street Repair and Maintenance.

Graffiti Removal

- Avoid graffiti abatement activities during rain events.
- Implement the procedures under Painting and Paint Removal in SC-70 Roads, Streets, and Highway Operation and Maintenance fact sheet when graffiti is removed by painting over.
- Direct runoff from sand blasting and high pressure washing (with no cleaning agents) into a dirt or landscaped area after treating with an appropriate filtering device.
- Plug nearby storm drain inlets and vacuum/pump wash water to the sanitary sewer if authorized to do so if a graffiti abatement method generates wash water containing a cleaning compound (such as high pressure washing with a cleaning compound). Ensure that a non-hazardous cleaning compound is used or dispose as hazardous waste, as appropriate.

Surface Removal and Repair

- Schedule surface removal activities for dry weather if possible.
- Avoid creating excess dust when breaking asphalt or concrete.
- Take measures to protect nearby storm drain inlets prior to breaking up asphalt or concrete (e.g. place hay bales or sand bags around inlets). Clean afterwards by sweeping up as much material as possible.
- Designate an area for clean up and proper disposal of excess materials.
- Remove and recycle as much of the broken pavement as possible to avoid contact with rainfall and stormwater runoff.
- When making saw cuts in pavement, use as little water as possible. Cover each storm drain inlet completely with filter fabric during the sawing operation and contain the slurry by placing straw bales, sandbags, or gravel dams around the inlets. After the liquid drains or evaporates, shovel or vacuum the slurry residue from the pavement or gutter and remove from site.
- Always dry sweep first to clean up tracked dirt. Use a street sweeper or vacuum truck. Do not dump vacuumed liquid in storm drains. Once dry sweeping is complete, the area may be hosed down if needed. Wash water should be directed to landscaping or collected and pumped to the sanitary sewer if allowed.

Concrete Installation and Repair

- Schedule asphalt and concrete activities for dry weather.

- Take measures to protect any nearby storm drain inlets and adjacent watercourses, prior to breaking up asphalt or concrete (e.g. place san bags around inlets or work areas).
- Limit the amount of fresh concrete or cement mortar mixed, mix only what is needed for the job.
- Store concrete materials under cover, away from drainage areas. Secure bags of cement after they are open. Be sure to keep wind-blown cement powder away from streets, gutters, storm drains, rainfall, and runoff.
- Return leftover materials to the transit mixer. Dispose of small amounts of hardened excess concrete, grout, and mortar in the trash.
- Do not wash sweepings from exposed aggregate concrete into the street or storm drain. Collect and return sweepings to aggregate base stockpile, or dispose in the trash.
- Protect applications of fresh concrete from rainfall and runoff until the material has dried.
- Do not allow excess concrete to be dumped onsite, except in designated areas.
- Wash concrete trucks off site or in designated areas on site designed to preclude discharge of wash water to drainage system.

Controlling Litter

- Post "No Littering" signs and enforce anti-litter laws.
- Provide litter receptacles in busy, high pedestrian traffic areas of the community, at recreational facilities, and at community events.
- Cover litter receptacles and clean out frequently to prevent leaking/spillage or overflow.
- Clean parking lots on a regular basis with a street sweeper.

Training

- Provide regular training to field employees and/or contractors regarding surface cleaning and proper operation of equipment.
- Train employee and contractors in proper techniques for spill containment and cleanup.
- Use a training log or similar method to document training.

Spill Response and Prevention

- Refer to SC-11, Spill Prevention, Control & Cleanup.
- Have spill cleanup materials readily available and in a known location.
- Cleanup spills immediately and use dry methods if possible.
- Properly dispose of spill cleanup material.

Other Considerations

- Limitations related to sweeping activities at large parking facilities may include current sweeper technology to remove oil and grease.
- Surface cleaning activities that require discharges to the local sewering agency will require coordination with the agency.
- Arrangements for disposal of the swept material collected must be made, as well as accurate tracking of the areas swept and the frequency of sweeping.

Requirements

Costs

- The largest expenditures for sweeping and cleaning of sidewalks, plazas, and parking lots are in staffing and equipment. Sweeping of these areas should be incorporated into street sweeping programs to reduce costs.

Maintenance

Not applicable

Supplemental Information

Further Detail of the BMP

Community education, such as informing residents about their options for recycling and waste disposal, as well as the consequences of littering, can instill a sense of citizen responsibility and potentially reduce the amount of maintenance required by the municipality.

Additional BMPs that should be considered for parking lot areas include:

- Allow sheet runoff to flow into biofilters (vegetated strip and swale) and infiltration devices.
- Utilize sand filters or oleophilic collectors for oily waste in low concentrations.
- Arrange rooftop drains to prevent drainage directly onto paved surfaces.
- Design lot to include semi-permeable hardscape.
- Structural BMPs such as storm drain inlet filters can be very effective in reducing the amount of pollutants discharged from parking facilities during periods of rain.

References and Resources

Bay Area Stormwater Management Agencies Association (BASMAA). 1996. Pollution From Surface Cleaning Folder http://www.basmaa.org

Model Urban Runoff Program: A How-To Guide for Developing Urban Runoff Programs for Small Municipalities. Prepared by City of Monterey, City of Santa Cruz, California Coastal Commission, Monterey Bay National Marine Sanctuary, Association of Monterey Bay Area Governments, Woodward-Clyde, Central Coast Regional Water Quality Control Board. July. 1998.

Oregon Association of Clean Water Agencies. Oregon Municipal Stormwater Toolbox for Maintenance Practices. June 1998.

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Santa Clara Valley Urban Runoff Pollution Prevention Program. Maintenance Best Management Practices for the Construction Industry. Brochures: Landscaping, Gardening, and Pool; Roadwork and Paving; and Fresh Concrete and Mortar Application. June 2001.

San Diego Stormwater Co-permittees Jurisdictional Urban Runoff Management Plan. 2001. Municipal Activities Model Program Guidance. November.

Fountain & Pool Maintenance SC-72

Objectives

- Contain
- Educate
- Reduce/Minimize
- Product Substitution

Targeted Constituents

Sediment	✓
Nutrients	✓
Trash	✓
Metals	
Bacteria	✓
Oil and Grease	
Organics	✓
Oxygen Demanding	✓

CASQA California Stormwater Quality Association

Description

The primary pollutant of concern in municipal swimming pool water is chlorine or chloramine used as a disinfectant. This water, if discharged to the storm drain system, can be toxic to aquatic life. In lakes, lagoons, and fountains, the pollutants of concern are chemical algaecides that are added to control algae mainly for aesthetic reasons (visual and odor). Following the procedures noted in this fact sheet will reduce the pollutants in this discharge.

Approach

Pollution Prevention

- Prevent algae problems with regular cleaning, consistent adequate chlorine levels, and well-maintained water filtration and circulation systems.
- Manage pH and water hardness to minimize corrosion of copper pipes.

Suggested Protocols

Pools and Fountains

- Do not use copper-based algaecides. Control algae with chlorine or other alternatives, such as sodium bromide.
- Do not discharge water to a street or storm drain when draining pools or fountains; discharge to the sanitary sewer if permitted to do so. If water is dechlorinated with a neutralizing chemical or by allowing chlorine to dissipate for a few days (do not use the facility during this time), the water may be recycled/reused by draining it gradually onto a landscaped area. Water must be tested prior to discharge to ensure that chlorine is not present.
- Prevent backflow if draining a pool to the sanitary sewer by maintaining an "air gap" between the discharge line and the sewer line (do not seal the connection between the hose and sewer line). Be sure to call the local wastewater treatment plant for further guidance on flow rate restrictions, backflow prevention, and handling special cleaning waste (such as acid wash). Discharge flows should be kept to the low levels typically possible through a garden hose. Higher flow rates may be prohibited by local ordinance.
- Provide drip pans or buckets beneath drain pipe connections to catch leaks. This will be especially pertinent if pool or spa water that has not been dechlorinated is pumped through piping to a discharge location.

- Never clean a filter in the street or near a storm drain.

- Rinse cartridge filters onto a dirt area, and spade filter residue into soil.

- Backwash diatomaceous earth filters onto dirt. Dispose of spent diatomaceous earth in the garbage. Spent diatomaceous earth cannot be discharged to surface waters, storm drainage systems, septic systems, or on the ground.

- If there is not a suitable dirt area discharge filter backwash or rinsewater to the sanitary sewer if permitted to do so by the local sewering agency.

Lakes and Lagoons

- Reduce fertilizer use in areas around the water body. High nitrogen fertilizers can produce excess growth requiring more frequent mowing or trimming, and may contribute to excessive algae growth.

- To control bacteria, discourage the public from feeding birds and fish (i.e. place signs that prohibit feeding of waterfowl).

- Consider introducing fish species that consume algae. Contact the California Department of Fish and Game for more information on this issue.

- Mechanically remove pond scum (blue-green algae) using a 60 micron net.

- Educate the public on algae and that no controls are necessary for certain types of algae that are beneficial to the water body.

- Control erosion by doing the following:

  - Maintain vegetative cover on banks to prevent soil erosion. Apply mulch or leave clippings to serve as additional cover for soil stabilization and to reduce the velocity of stormwater runoff.

  - Areas should be designed (sloped) to prevent runoff and erosion and to promote better irrigation practices.

  - Provide energy dissipaters (e.g. riprap) along banks to minimize potential for erosion.

  - Confine excavated materials to surfaces away from lakes. Material must be covered if rain is expected.

- Conduct inspections to detect illegal dumping of clippings/cuttings in or near a lake. Materials found should be picked up and properly disposed of.

- Avoid landscape wastes in and around lakes should be avoided by either using bagging equipment or by manually picking up the material. Collect trash and debris from within water bodies where feasible

- Provide and maintain trash receptacles near recreational water bodies to hold refuse generated by the public.

- Increase trash collection during peak visitation months (generally June, July and August).

Training

- Train maintenance personnel to test chlorine levels and to apply neutralizing chemicals.
- Train personnel regarding proper maintenance of pools, ponds and lakes.

Spill Response and Prevention

- Refer to SC-11, Spill Prevention, Control & Cleanup
- Have spill cleanup materials readily available and in a known location.
- Cleanup spills immediately and use dry methods if possible.
- Properly dispose of spill cleanup material.

Other Considerations

- Managers of pools located in sensitive areas or adjacent to shorelines should check with the appropriate authorities to determine if code requirements apply.
- Cleanup activities at lakes and lagoons may create a slight disturbance for local aquatic species. If the lake is recognized as a wetland, many activities, including maintenance, may be subject to regulation and permitting.

Requirements

Costs

- The maintenance of pools and lakes is already a consideration of most municipal public works departments. Therefore the cost associated with this BMP is minimal and only reflects an increase in employee training and public outreach.

Maintenance

Not applicable

Supplemental Information

Further Detail of the BMP

When dredging is conducted, adhere to the following:

- Dredge with shovels when laying/maintaining pipes.
- To determine amount to dredge, determine rate of volume loss due to sediments.
- For large lakes, dredge every 10 years.
- When dredging small lakes, drain lake.
- When dredging large lakes, use vacuum equipment.
- After dredging test sediment piles for proper disposal. Dredged sediment can be used as fill, or may have to be land filled.

References and Resources

King County Stormwater Pollution Control Manual. Best Management Practices for Businesses. 1995. King County Surface Water Management. July. On-line: http://dnr.metrokc.gov/wlr/dss/spcm.htm

Los Angeles County Stormwater Quality. Public Agency Activities Model Program. On-line: http://ladpw.org/wmd/npdes/public_TC.cfm

Model Urban Runoff Program: A How-To Guide for Developing Urban Runoff Programs for Small Municipalities. Prepared by City of Monterey, City of Santa Cruz, California Coastal Commission, Monterey Bay National Marine Sanctuary, Association of Monterey Bay Area Governments, Woodward-Clyde, Central Coast Regional Water Quality Control Board. July. 1998.

Orange County Stormwater Program
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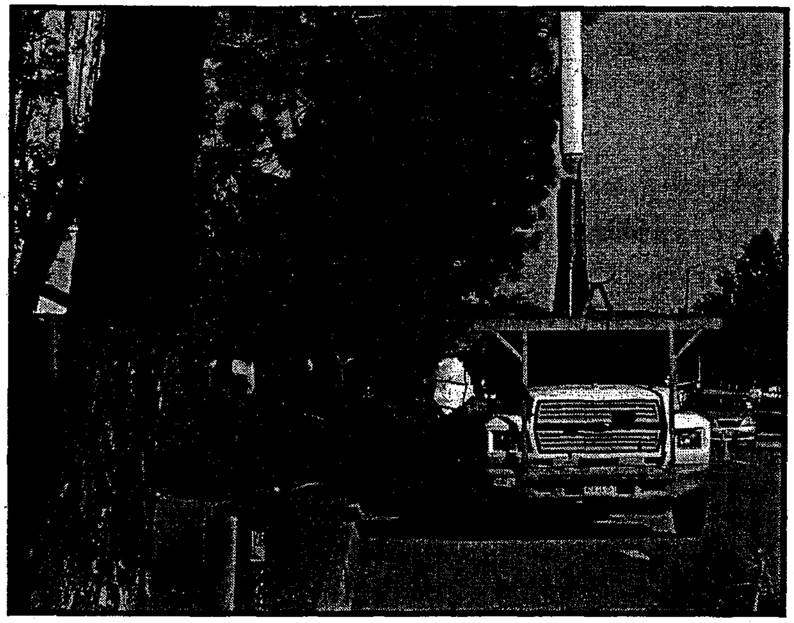
Landscape Maintenance SC-73



Objectives

- Contain
- Educate
- Reduce/Minimize
- Product Substitution

Targeted Constituents

Sediment	✓
Nutrients	✓
Trash	✓
Metals	
Bacteria	
Oil and Grease	
Organics	
Oxygen Demanding	✓

Description

Landscape maintenance activities include vegetation removal; herbicide and insecticide application; fertilizer application; watering; and other gardening and lawn care practices. Vegetation control typically involves a combination of chemical (herbicide) application and mechanical methods. All of these maintenance practices have the potential to contribute pollutants to the storm drain system. The major objectives of this BMP are to minimize the discharge of pesticides, herbicides and fertilizers to the storm drain system and receiving waters; prevent the disposal of landscape waste into the storm drain system by collecting and properly disposing of clippings and cuttings, and educating employees and the public.

Approach

Pollution Prevention

- Implement an integrated pest management (IPM) program. IPM is a sustainable approach to managing pests by combining biological, cultural, physical, and chemical tools.
- Choose low water using flowers, trees, shrubs, and groundcover.
- Consider alternative landscaping techniques such as naturescaping and xeriscaping.
- Conduct appropriate maintenance (i.e. properly timed fertilizing, weeding, pest control, and pruning) to help preserve the landscapes water efficiency.

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- Consider grass cycling (grass cycling is the natural recycling of grass by leaving the clippings on the lawn when mowing. Grass clippings decompose quickly and release valuable nutrients back into the lawn).

Suggested Protocols

Mowing, Trimming, and Weeding

- Whenever possible use mechanical methods of vegetation removal (e.g mowing with tractor-type or push mowers, hand cutting with gas or electric powered weed trimmers) rather than applying herbicides. Use hand weeding where practical.
- Avoid loosening the soil when conducting mechanical or manual weed control, this could lead to erosion. Use mulch or other erosion control measures when soils are exposed.
- Performing mowing at optimal times. Mowing should not be performed if significant rain events are predicted.
- Mulching mowers may be recommended for certain flat areas. Other techniques may be employed to minimize mowing such as selective vegetative planting using low maintenance grasses and shrubs.
- Collect lawn and garden clippings, pruning waste, tree trimmings, and weeds. Chip if necessary, and compost or dispose of at a landfill (see waste management section of this fact sheet).
- Place temporarily stockpiled material away from watercourses, and berm or cover stockpiles to prevent material releases to storm drains.

Planting

- Determine existing native vegetation features (location, species, size, function, importance) and consider the feasibility of protecting them. Consider elements such as their effect on drainage and erosion, hardiness, maintenance requirements, and possible conflicts between preserving vegetation and the resulting maintenance needs.
- Retain and/or plant selected native vegetation whose features are determined to be beneficial, where feasible. Native vegetation usually requires less maintenance (e.g., irrigation, fertilizer) than planting new vegetation.
- Consider using low water use groundcovers when planting or replanting.

Waste Management

- Compost leaves, sticks, or other collected vegetation or dispose of at a permitted landfill. Do not dispose of collected vegetation into waterways or storm drainage systems.
- Place temporarily stockpiled material away from watercourses and storm drain inlets, and berm or cover stockpiles to prevent material releases to the storm drain system.
- Reduce the use of high nitrogen fertilizers that produce excess growth requiring more frequent mowing or trimming.

- Avoid landscape wastes in and around storm drain inlets by either using bagging equipment or by manually picking up the material.

Irrigation

- Where practical, use automatic timers to minimize runoff.

- Use popup sprinkler heads in areas with a lot of activity or where there is a chance the pipes may be broken. Consider the use of mechanisms that reduce water flow to sprinkler heads if broken.

- Ensure that there is no runoff from the landscaped area(s) if re-claimed water is used for irrigation.

- If bailing of muddy water is required (e.g. when repairing a water line leak), do not put it in the storm drain; pour over landscaped areas.

- Irrigate slowly or pulse irrigate to prevent runoff and then only irrigate as much as is needed.

- Apply water at rates that do not exceed the infiltration rate of the soil.

Fertilizer and Pesticide Management

- Utilize a comprehensive management system that incorporates integrated pest management (IPM) techniques. There are many methods and types of IPM, including the following:

  - Mulching can be used to prevent weeds where turf is absent, fencing installed to keep rodents out, and netting used to keep birds and insects away from leaves and fruit.

  - Visible insects can be removed by hand (with gloves or tweezers) and placed in soapy water or vegetable oil. Alternatively, insects can be sprayed off the plant with water or in some cases vacuumed off of larger plants.

  - Store-bought traps, such as species-specific, pheromone-based traps or colored sticky cards, can be used.

  - Slugs can be trapped in small cups filled with beer that are set in the ground so the slugs can get in easily.

  - In cases where microscopic parasites, such as bacteria and fungi, are causing damage to plants, the affected plant material can be removed and disposed of (pruning equipment should be disinfected with bleach to prevent spreading the disease organism).

  - Small mammals and birds can be excluded using fences, netting, tree trunk guards.

  - Beneficial organisms, such as bats, birds, green lacewings, ladybugs, praying mantis, ground beetles, parasitic nematodes, trichogramma wasps, seed head weevils, and spiders that prey on detrimental pest species can be promoted.

- Follow all federal, state, and local laws and regulations governing the use, storage, and disposal of fertilizers and pesticides and training of applicators and pest control advisors.

- Use pesticides only if there is an actual pest problem (not on a regular preventative schedule).
- Do not use pesticides if rain is expected. Apply pesticides only when wind speeds are low (less than 5 mph).
- Do not mix or prepare pesticides for application near storm drains.
- Prepare the minimum amount of pesticide needed for the job and use the lowest rate that will effectively control the pest.
- Employ techniques to minimize off-target application (e.g. spray drift) of pesticides, including consideration of alternative application techniques.
- Fertilizers should be worked into the soil rather than dumped or broadcast onto the surface.
- Calibrate fertilizer and pesticide application equipment to avoid excessive application.
- Periodically test soils for determining proper fertilizer use.
- Sweep pavement and sidewalk if fertilizer is spilled on these surfaces before applying irrigation water.
- Purchase only the amount of pesticide that you can reasonably use in a given time period (month or year depending on the product).
- Triple rinse containers, and use rinse water as product. Dispose of unused pesticide as hazardous waste.
- Dispose of empty pesticide containers according to the instructions on the container label.

Inspection

- Inspect irrigation system periodically to ensure that the right amount of water is being applied and that excessive runoff is not occurring. Minimize excess watering, and repair leaks in the irrigation system as soon as they are observed.
- Inspect pesticide/fertilizer equipment and transportation vehicles daily.

Training

- Educate and train employees on use of pesticides and in pesticide application techniques to prevent pollution. Pesticide application must be under the supervision of a California qualified pesticide applicator.
- Train/encourage municipal maintenance crews to use IPM techniques for managing public green areas.
- Annually train employees within departments responsible for pesticide application on the appropriate portions of the agency's IPM Policy, SOPs, and BMPs, and the latest IPM techniques.

- Employees who are not authorized and trained to apply pesticides should be periodically (at least annually) informed that they cannot use over-the-counter pesticides in or around the workplace.

- Use a training log or similar method to document training.

Spill Response and Prevention
- Refer to SC-11, Spill Prevention, Control & Cleanup

- Have spill cleanup materials readily available and in a know in location

- Cleanup spills immediately and use dry methods if possible.

- Properly dispose of spill cleanup material.

Other Considerations
- The Federal Pesticide, Fungicide, and Rodenticide Act and California Title 3, Division 6, Pesticides and Pest Control Operations place strict controls over pesticide application and handling and specify training, annual refresher, and testing requirements. The regulations generally cover: a list of approved pesticides and selected uses, updated regularly; general application information; equipment use and maintenance procedures; and record keeping. The California Department of Pesticide Regulations and the County Agricultural Commission coordinate and maintain the licensing and certification programs. All public agency employees who apply pesticides and herbicides in "agricultural use" areas such as parks, golf courses, rights-of-way and recreation areas should be properly certified in accordance with state regulations. Contracts for landscape maintenance should include similar requirements.

- All employees who handle pesticides should be familiar with the most recent material safety data sheet (MSDS) files.

- Municipalities do not have the authority to regulate the use of pesticides by school districts, however the California Healthy Schools Act of 2000 (AB 2260) has imposed requirements on California school districts regarding pesticide use in schools. Posting of notification prior to the application of pesticides is now required, and IPM is stated as the preferred approach to pest management in schools.

Requirements
Costs
Additional training of municipal employees will be required to address IPM techniques and BMPs. IPM methods will likely increase labor cost for pest control which may be offset by lower chemical costs.

Maintenance
Not applicable

Supplemental Information

Further Detail of the BMP

Waste Management

Composting is one of the better disposal alternatives if locally available. Most municipalities either have or are planning yard waste composting facilities as a means of reducing the amount of waste going to the landfill. Lawn clippings from municipal maintenance programs as well as private sources would probably be compatible with most composting facilities

Contractors and Other Pesticide Users

Municipal agencies should develop and implement a process to ensure that any contractor employed to conduct pest control and pesticide application on municipal property engages in pest control methods consistent with the IPM Policy adopted by the agency. Specifically, municipalities should require contractors to follow the agency's IPM policy, SOPs, and BMPs; provide evidence to the agency of having received training on current IPM techniques when feasible; provide documentation of pesticide use on agency property to the agency in a timely manner.

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Drainage System Maintenance SC-74

Photo Credit: Geoff Brosseau

Objectives

- Contain
- Educate
- Reduce/Minimize

Targeted Constituents

Sediment	✓
Nutrients	✓
Trash	✓
Metals	✓
Bacteria	✓
Oil and Grease	✓
Organics	✓
Oxygen Demanding	✓

Description

As a consequence of its function, the stormwater conveyance system collects and transports urban runoff that may contain certain pollutants. Maintaining catch basins, stormwater inlets, and other stormwater conveyance structures on a regular basis will remove pollutants, prevent clogging of the downstream conveyance system, restore catch basins' sediment trapping capacity, and ensure the system functions properly hydraulically to avoid flooding.

Approach

Suggested Protocols

Catch Basins/Inlet Structures

- Municipal staff should regularly inspect facilities to ensure the following:
  - Immediate repair of any deterioration threatening structural integrity.
  - Cleaning before the sump is 40% full. Catch basins should be cleaned as frequently as needed to meet this standard.
  - Stenciling of catch basins and inlets (see SC-75 Waste Handling and Disposal).
- Clean catch basins, storm drain inlets, and other conveyance structures in high pollutant load areas just before the wet season to remove sediments and debris accumulated during the summer.

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- Conduct inspections more frequently during the wet season for problem areas where sediment or trash accumulates more often. Clean and repair as needed.
- Keep accurate logs of the number of catch basins cleaned.
- Record the amount of waste collected.
- Store wastes collected from cleaning activities of the drainage system in appropriate containers or temporary storage sites in a manner that prevents discharge to the storm drain.
- Dewater the wastes with outflow into the sanitary sewer if permitted. Water should be treated with an appropriate filtering device prior to discharge to the sanitary sewer. If discharge to the sanitary sewer is not allowed, water should be pumped or vacuumed to a tank and properly disposed of. Do not dewater near a storm drain or stream.
- Except for small communities with relatively few catch basins that may be cleaned manually, most municipalities will require mechanical cleaners such as eductors, vacuums, or bucket loaders.

Storm Drain Conveyance System

- Locate reaches of storm drain with deposit problems and develop a flushing schedule that keeps the pipe clear of excessive buildup.
- Collect flushed effluent and pump to the sanitary sewer for treatment.

Pump Stations

- Clean all storm drain pump stations prior to the wet season to remove silt and trash.
- Do not allow discharge from cleaning a storm drain pump station or other facility to reach the storm drain system.
- Conduct quarterly routine maintenance at each pump station.
- Inspect, clean, and repair as necessary all outlet structures prior to the wet season.
- Sample collected sediments to determine if landfill disposal is possible, or illegal discharges in the watershed are occurring.

Open Channel

- Consider modification of storm channel characteristics to improve channel hydraulics, to increase pollutant removals, and to enhance channel/creek aesthetic and habitat value.
- Conduct channel modification/improvement in accordance with existing laws. Any person, government agency, or public utility proposing an activity that will change the natural (emphasis added) state of any river, stream, or lake in California, must enter into a steam or Lake Alteration Agreement with the Department of Fish and Game. The developer-applicant should also contact local governments (city, county, special districts), other state agencies

(SWRCB, RWQCB, Department of Forestry, Department of Water Resources), and Federal Corps of Engineers and USFWS

Illicit Connections and Discharges

- During routine maintenance of conveyance system and drainage structures field staff should look for evidence of illegal discharges or illicit connections:
  - Is there evidence of spills such as paints, discoloring, etc.
  - Are there any odors associated with the drainage system
  - Record locations of apparent illegal discharges/illicit connections
  - Track flows back to potential dischargers and conduct aboveground inspections. This can be done through visual inspection of up gradient manholes or alternate techniques including zinc chloride smoke testing, fluorometric dye testing, physical inspection testing, or television camera inspection.
  - Once the origin of flow is established, require illicit discharger to eliminate the discharge.
- Stencil storm drains, where applicable, to prevent illegal disposal of pollutants. Storm drain inlets should have messages such as "Dump No Waste Drains to Stream" stenciled next to them to warn against ignorant or intentional dumping of pollutants into the storm drainage system.
- Refer to fact sheet SC-10 Non-Stormwater Discharges.

Illegal Dumping

- Regularly inspect and clean up hot spots and other storm drainage areas where illegal dumping and disposal occurs.
- Establish a system for tracking incidents. The system should be designed to identify the following:
  - Illegal dumping hot spots
  - Types and quantities (in some cases) of wastes
  - Patterns in time of occurrence (time of day/night, month, or year)
  - Mode of dumping (abandoned containers, "midnight dumping" from moving vehicles, direct dumping of materials, accidents/spills)
  - Responsible parties
- Post "No Dumping" signs in problem areas with a phone number for reporting dumping and disposal. Signs should also indicate fines and penalties for illegal dumping.
- Refer to fact sheet SC-10 Non-Stormwater Discharges.

- The State Department of Fish and Game has a hotline for reporting violations called Cal TIP (1-800-952-5400). The phone number may be used to report any violation of a Fish and Game code (illegal dumping, poaching, etc.).

- The California Department of Toxic Substances Control's Waste Alert Hotline, 1-800-69TOXIC, can be used to report hazardous waste violations.

Training

- Train crews in proper maintenance activities, including record keeping and disposal.

- Only properly trained individuals are allowed to handle hazardous materials/wastes.

- Train municipal employees from all departments (public works, utilities, street cleaning, parks and recreation, industrial waste inspection, hazardous waste inspection, sewer maintenance) to recognize and report illegal dumping.

- Train municipal employees and educate businesses, contractors, and the general public in proper and consistent methods for disposal.

- Train municipal staff regarding non-stormwater discharges (See SC-10 Non-Stormwater Discharges).

Spill Response and Prevention

- Refer to SC-11, Prevention, Control & Cleanup

- Have spill cleanup materials readily available and in a known location.

- Cleanup spills immediately and use dry methods if possible.

- Properly dispose of spill cleanup material.

Other Considerations

- Cleanup activities may create a slight disturbance for local aquatic species. Access to items and material on private property may be limited. Trade-offs may exist between channel hydraulics and water quality/riparian habitat. If storm channels or basins are recognized as wetlands, many activities, including maintenance, may be subject to regulation and permitting.

- Storm drain flushing is most effective in small diameter pipes (36-inch diameter pipe or less, depending on water supply and sediment collection capacity). Other considerations associated with storm drain flushing may include the availability of a water source, finding a downstream area to collect sediments, liquid/sediment disposal, and disposal of flushed effluent to sanitary sewer may be prohibited in some areas.

- Regulations may include adoption of substantial penalties for illegal dumping and disposal.

- Municipal codes should include sections prohibiting the discharge of soil, debris, refuse, hazardous wastes, and other pollutants into the storm drain system.

- Private property access rights may be needed to track illegal discharges up gradient.

- Requirements of municipal ordinance authority for suspected source verification testing for illicit connections necessary for guaranteed rights of entry.

Requirements

Costs

- An aggressive catch basin cleaning program could require a significant capital and O&M budget. A careful study of cleaning effectiveness should be undertaken before increased cleaning is implemented. Catch basin cleaning costs are less expensive if vacuum street sweepers are available; cleaning catch basins manually can cost approximately twice as much as cleaning the basins with a vacuum attached to a sweeper.

- Methods used for illicit connection detection (smoke testing, dye testing, visual inspection, and flow monitoring) can be costly and time-consuming. Site-specific factors, such as the level of impervious area, the density and ages of buildings, and type of land use will determine the level of investigation necessary. Encouraging reporting of illicit discharges by employees can offset costs by saving expense on inspectors and directing resources more efficiently. Some programs have used funds available from "environmental fees" or special assessment districts to fund their illicit connection elimination programs.

Maintenance

- Two-person teams may be required to clean catch basins with vactor trucks.

- Identifying illicit discharges requires teams of at least two people (volunteers can be used), plus administrative personnel, depending on the complexity of the storm sewer system.

- Arrangements must be made for proper disposal of collected wastes.

- Requires technical staff to detect and investigate illegal dumping violations, and to coordinate public education.

Supplemental Information

Further Detail of the BMP

Storm Drain flushing

Sanitary sewer flushing is a common maintenance activity used to improve pipe hydraulics and to remove pollutants in sanitary sewer systems. The same principles that make sanitary sewer flushing effective can be used to flush storm drains. Flushing may be designed to hydraulically convey accumulated material to strategic locations, such as to an open channel, to another point where flushing will be initiated, or over to the sanitary sewer and on to the treatment facilities, thus preventing re-suspension and overflow of a portion of the solids during storm events. Flushing prevents "plug flow" discharges of concentrated pollutant loadings and sediments. The deposits can hinder the designed conveyance capacity of the storm drain system and potentially cause backwater conditions in severe cases of clogging.

Storm drain flushing usually takes place along segments of pipe with grades that are too flat to maintain adequate velocity to keep particles in suspension. An upstream manhole is selected to place an inflatable device that temporarily plugs the pipe. Further upstream, water is pumped into the line to create a flushing wave. When the upstream reach of pipe is sufficiently full to cause a flushing wave, the inflated device is rapidly deflated with the assistance of a vacuum pump, releasing the backed up water and resulting in the cleaning of the storm drain segment.

To further reduce the impacts of stormwater pollution, a second inflatable device, placed well downstream, may be used to re-collect the water after the force of the flushing wave has dissipated. A pump may then be used to transfer the water and accumulated material to the sanitary sewer for treatment. In some cases, an interceptor structure may be more practical or required to re-collect the flushed waters.

It has been found that cleansing efficiency of periodic flush waves is dependent upon flush volume, flush discharge rate, sewer slope, sewer length, sewer flow rate, sewer diameter, and population density. As a rule of thumb, the length of line to be flushed should not exceed 700 feet. At this maximum recommended length, the percent removal efficiency ranges between 65-75 percent for organics and 55-65 percent for dry weather grit/inorganic material. The percent removal efficiency drops rapidly beyond that. Water is commonly supplied by a water truck, but fire hydrants can also supply water. To make the best use of water, it is recommended that reclaimed water be used or that fire hydrant line flushing coincide with storm drain flushing.

Flow Management

Flow management has been one of the principal motivations for designing urban stream corridors in the past. Such needs may or may not be compatible with the stormwater quality goals in the stream corridor.

Downstream flood peaks can be suppressed by reducing through flow velocity. This can be accomplished by reducing gradient with grade control structures or increasing roughness with boulders, dense vegetation, or complex banks forms. Reducing velocity correspondingly increases flood height, so all such measures have a natural association with floodplain open space. Flood elevations laterally adjacent to the stream can be lowered by increasing through flow velocity.

However, increasing velocity increases flooding downstream and inherently conflicts with channel stability and human safety. Where topography permits, another way to lower flood elevation is to lower the level of the floodway with drop structures into a large but subtly excavated bowl where flood flows we allowed to spread out.

Stream Corridor Planning

Urban streams receive and convey stormwater flows from developed or developing watersheds. Planning of stream corridors thus interacts with urban stormwater management programs. If local programs are intended to control or protect downstream environments by managing flows delivered to the channels, then it is logical that such programs should be supplemented by management of the materials, forms, and uses of the downstream riparian corridor. Any proposal for steam alteration or management should be investigated for its potential flow and stability effects on upstream, downstream, and laterally adjacent areas. The timing and rate of flow from various tributaries can combine in complex ways to alter flood hazards. Each section of channel is unique, influenced by its own distribution of roughness elements, management activities, and stream responses.

Flexibility to adapt to stream features and behaviors as they evolve must be included in stream reclamation planning. The amenity and ecology of streams may be enhanced through the landscape design options of 1) corridor reservation, 2) bank treatment, 3) geomorphic restoration, and 4) grade control.

Corridor reservation - Reserving stream corridors and valleys to accommodate natural stream meandering, aggradation, degradation, and over bank flows allows streams to find their own form and generate less ongoing erosion. In California, open stream corridors in recent urban developments have produced recreational open space, irrigation of streamside plantings, and the aesthetic amenity of flowing water.

Bank treatment - The use of armoring, vegetative cover, and flow deflection may be used to influence a channel's form, stability, and biotic habitat. To prevent bank erosion, armoring can be done with rigid construction materials, such as concrete, masonry, wood planks and logs, riprap, and gabions. Concrete linings have been criticized because of their lack of provision of biotic habitat. In contrast, riprap and gabions make relatively porous and flexible linings. Boulders, placed in the bed reduce velocity and erosive power.

Riparian vegetation can stabilize the banks of streams that are at or near a condition of equilibrium. Binding networks of roots increase bank shear strength. During flood flows, resilient vegetation is forced into erosion-inhibiting mats. The roughness of vegetation leads to lower velocity, further reducing erosive effects. Structural flow deflection can protect banks from erosion or alter fish habitat. By concentrating flow, a deflector causes a pool to be scoured in the bed.

Geomorphic restoration – Restoration refers to alteration of disturbed streams so their form and behavior emulate those of undisturbed streams. Natural meanders are retained, with grading to gentle slopes on the inside of curves to allow point bars and riffle-pool sequences to develop. Trees are retained to provide scenic quality, biotic productivity, and roots for bank stabilization, supplemented by plantings where necessary.

A restorative approach can be successful where the stream is already approaching equilibrium. However, if upstream urbanization continues new flow regimes will be generated that could disrupt the equilibrium of the treated system.

Grade Control - A grade control structure is a level shelf of a permanent material, such as stone, masonry, or concrete, over which stream water flows. A grade control structure is called a sill, weir, or drop structure, depending on the relation of its invert elevation to upstream and downstream channels.

A sill is installed at the preexisting channel bed elevation to prevent upstream migration of nick points. It establishes a firm base level below which the upstream channel can not erode.

A weir or check dam is installed with invert above the preexisting bed elevation. A weir raises the local base level of the stream and causes aggradation upstream. The gradient, velocity, and erosive potential of the stream channel are reduced. A drop structure lowers the downstream invert below its preexisting elevation, reducing downstream gradient and velocity. Weirs and drop structure control erosion by dissipating energy and reducing slope velocity.

When carefully applied, grade control structures can be highly versatile in establishing human and environmental benefits in stabilized channels. To be successful, application of grade control structures should be guided by analysis of the stream system both upstream and downstream from the area to he reclaimed.

Examples

The California Department of Water Resources began the Urban Stream Restoration Program in 1985. The program provides grant funds to municipalities and community groups to implement stream restoration projects. The projects reduce damages from streambank aid watershed instability arid floods while restoring streams' aesthetic, recreational, and fish and wildlife values.

In Buena Vista Park, upper floodway slopes are gentle and grassed to achieve continuity of usable park land across the channel of small boulders at the base of the slopes.

The San Diego River is a large, vegetative lined channel, which was planted in a variety of species to support riparian wildlife while stabilizing the steep banks of the floodway.

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Waste Handling and Disposal SC-75

Objectives

- Cover
- Contain
- Educate
- Reduce/Reuse

Targeted Constituents

Sediment	✓
Nutrients	✓
Trash	✓
Metals	✓
Bacteria	✓
Oil and Grease	✓
Organics	✓
Oxygen Demanding	✓

Description

It is important to control litter to eliminate trash and other materials in stormwater runoff. Waste reduction is a major component of waste management and should be encouraged through training and public outreach. Management of waste once it is collected may involve reuse, recycling, or proper disposal.

Approach

Pollution Prevention

- Reuse products when possible.
- Encourage recycling programs with recycling bins, used oil collection, etc.

Suggested Protocols

Solid Waste Collection

- Implement procedures, where applicable, to collect, transport, and dispose of solid waste at appropriate disposal facilities in accordance with applicable federal, state, and local laws and regulations.
- Include properly designed trash storage areas. If feasible provide cover over trash storage areas.
- Regularly inspect solid waste containers for structural damage. Repair or replace damaged containers as necessary.

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- Secure solid waste containers; containers must be closed tightly when not in use.
- Do not fill waste containers with washout water or any other liquid.
- Ensure that only appropriate solid wastes are added to the solid waste container. Certain wastes such as hazardous wastes, appliances, fluorescent lamps, pesticides, etc. may not be disposed of in solid waste containers (see chemical/ hazardous waste collection section below).
- Do not mix wastes; this can cause chemical reactions, make recycling impossible, and complicate disposal.
- Refer to SC-34 Waste Handling and Disposal for more information regarding solid waste facilities.

Waste Reduction and Recycling

- Recycle wastes whenever possible. Many types of waste can be recycled, recycling options for each waste type are limited. All gasoline, antifreeze, waste oil, and lead-acid batteries can be recycled. Latex and oil-based paint can be reused, as well as recycled. Materials that cannot be reused or recycled should either be incinerated or disposed of at a properly permitted landfill.
- Recycling is always preferable to disposal of unwanted materials.
- Recycling bins for glass, metal, newspaper, plastic bottles and other recyclable household solid wastes should be provided at public facilities and/or for residential curbside collection.

Controlling Litter

- Post "No Littering" signs and enforce anti-litter laws.
- Provide litter receptacles in busy, high pedestrian traffic areas of the community, at recreational facilities, and at community events.
- Clean out and cover litter receptacles frequently to prevent spillage.

Illegal Dumping

Substances illegally dumped on streets and into the storm drain system and creeks include paints, used oil and other automotive fluids, construction debris, chemicals, fresh concrete, leaves, grass clipping, and pet wastes.

- Post "No Dumping" signs with a phone number for reporting dumping and disposal. Signs should also indicate fines and penalties for illegal dumping.
- Landscaping and beautification efforts of hot spots might also discourage future dumping.
- See SC-74 Drainage System Maintenance, and SC-10 Non-Stormwater Discharges.

Requirements

Costs

- The costs for a solid waste source control program vary depending on the type of method. The cost of a community education program or a plan to increase the number of trash receptacles can be very minimal. Costs for structural controls such as trash racks, bar screens, and silt traps can be quite costly ranging from $250,000 to $900,000.

- A collection facility or curbside collection for used oil may result in significant costs. Commercial locations (automobile service stations, quick oil change centers, etc.) as collection points eliminate hauling and recycling costs.

- Collection and disposal of hazardous waste can be very expensive and requires trained operators; laboratory and detection equipment; and extensive record keeping including dates, types, and quantities.

- Use of volunteer work forces can lower storm drain stenciling program costs. Stenciling kits require procurement of durable/disposable items. The stenciling program can aid in the cataloging of the storm drain system. One municipality from the state of Washington has estimated that stenciling kits cost approximately $50 each. Stencils may cost about $8 each including the die cost on an order of 1,000. Re-orders cost about $1/stencil. Stencil designs may be available from other communities. Stencil kits should be provided on a loan basis to volunteer groups free of charge with the understanding that kit remnants are to be returned.

Maintenance

- The primary staff demand for stenciling programs is for program setup to provide marketing and training. Ongoing/follow-up staff time is minimal because of volunteer services.

- Staffing requirements are minimal for oil recycling programs if collection/recycling is contracted out to a used oil hauler/recycler or required at commercial locations.

- Staff requirements for maintaining good housekeeping BMPs at waste handling sites is minimal.

Supplemental Information

Further Detail of the BMP

Waste Reduction

An approach to reduce stormwater pollution from waste handling and disposal is to assess activities and reduce waste generation. The assessment is designed to find situations where waste can be eliminated or reduced and emissions and environmental damage can be minimized. The assessment involves collecting process specific information, setting pollution prevention targets, and developing, screening and selecting waste reduction options for further study. Starting a waste reduction program is economically beneficial because of reduced raw material purchases and lower waste disposal fees.

References and Resources

Best Management Practices Program for Pollution Prevention, City and County of San Francisco, Uribe & Associates, Oakland, California, 1990.

Harvard University. 2002. Solid Waste Container Best Management Practices – Fact Sheet On-Line Resources – Environmental Health and Safety.

Model Urban Runoff Program: A How-To-Guide for Developing Urban Runoff Programs for Small Municipalities. Prepared by City of Monterey, City of Santa Cruz, California Coastal Commission, Monterey Bay National Marine Sanctuary, Association of Monterey Bay Area Governments, Woodward-Clyde, Central Coast Regional Water Quality Control Board. July 1998. (Revised February 2002 by the California Coastal Commission).

Orange County Stormwater Program
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Water & Sewer Utility Maintenance SC-76

Objectives

- Contain
- Educate
- Reduce/Minimize

Targeted Constituents

Sediment	✓
Nutrients	✓
Trash	
Metals	
Bacteria	✓
Oil and Grease	✓
Organics	✓
Oxygen Demanding	✓

Description

Although the operation and maintenance of public utilities are not considered chronic sources of stormwater pollution, some activities and accidents can result in the discharge of pollutants that can pose a threat to both human health and the quality of receiving waters if they enter the storm drain system. Sewage incident response and investigation may involve a coordinated effort between staff from a number of different departments/agencies. Cities that do not provide maintenance of water and sewer utilities must coordinate with the contracting agency responsible for these activities and ensure that these model procedures are followed.

Approach

Pollution Prevention

Inspect potential non-stormwater discharge flow paths and clear/cleanup any debris or pollutants found (i.e. remove trash, leaves, sediment, and wipe up liquids, including oil spills).

Suggested Protocols

Water Line Maintenance and Cleaning

Procedures can be employed to reduce pollutants from discharges associated with water utility operation and maintenance activities. Planned discharges may include fire hydrant testing, flushing water supply mains after new construction, flushing lines due to complaints of taste and odor, dewatering mains for maintenance work. Unplanned discharges from treated, recycled water, raw water, and groundwater systems operation and maintenance activities can occur from water main

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breaks, sheared fire hydrants, equipment malfunction, and operator error.

Planned discharges

- Identify a suitable discharge option in the following order of preference:
  - Apply to the land.
  - Reuse water for dust suppression, irrigation, or construction compaction.
  - Discharge to a sanitary sewer system with approval.
  - Discharge to the storm drain system using applicable pollution control measures. (Only available to clean water discharges such as water main/ water storage tank/water hydrant flushing).
- If water is discharged to a storm drain, control measures must be put in place to control potential pollutants (i.e. sediment, chlorine, etc.). Examples of some storm drain protection options include:
  - Silt fence – appropriate where the inlet drains a relatively flat area.
  - Gravel and wire mesh sediment filter – Appropriate where concentrated flows are expected.
  - Wooden weir and fabric – use at curb inlets where a compact installation is desired.
- Prior to discharge, inspect discharge flow path and clear/cleanup any debris or pollutants found (i.e. remove trash, leaves, sediment, and wipe up liquids, including oil spills).
- General Design considerations for inlet protection devices include the following:
  - The device should be constructed such that cleaning and disposal of trapped sediment is made easy, while minimizing interference with discharge activities.
  - Devices should be constructed so that any standing water resulting from the discharge will not cause excessive inconvenience or flooding/damage to adjacent land or structures.
- The effectiveness of control devices must be monitored during the discharge period and any necessary repairs or modifications made.

Unplanned Discharges

- Stop the discharge as quickly as possible.
- Inspect flow path of the discharged water:
  - Identify erodible areas which may need to be repaired or protected during subsequent repairs or corrective actions

- Identify the potential for pollutants to be washed into the waterway

- If repairs or corrective action will cause additional discharges of water, select the appropriate procedures for erosion control, chlorine residual, turbidity, and chemical additives. Prevent potential pollutants from entering the flow path.

Sanitary Sewer Maintenance

Applicable to municipalities who own and operated a sewage collection system. Facilities that are covered under this program include sanitary sewer pipes and pump stations owned and operated by a municipality. The owner of the sanitary sewer facilities is the entity responsible for carrying out this prevention and response program.

- Clean sewer lines on a regular basis to remove grease, grit, and other debris that may lead to sewer backups.

- Establish routine maintenance program. Cleaning should be conducted at an established minimum frequency and more frequently for problem areas such as restaurants that are identified

- Cleaning activities may require removal of tree roots and other identified obstructions.

- During routine maintenance and inspection note the condition of sanitary sewer structures and identify areas that need repair or maintenance. Items to note may include the following:

  - Cracked/deteriorating pipes

  - Leaking joints/seals at manhole

  - Frequent line plugs

  - Line generally flows at or near capacity

  - Suspected infiltration or exfiltration.

- Prioritize repairs based on the nature and severity of the problem. Immediate clearing of blockage or repair is required where an overflow is currently occurring or for urgent problems that may cause an imminent overflow (e.g. pump station failures, sewer line ruptures, sewer line blockages). These repairs may be temporary until scheduled or capital improvements can be completed.

- Review previous sewer maintenance records to help identify "hot spots" or areas with frequent maintenance problems and locations of potential system failure.

Spills and Overflows

- Identify and track sanitary sewer discharges. Identify dry weather infiltration and inflow first. Wet weather overflow connections are very difficult to locate.

- Locate wet weather overflows and leaking sanitary sewers using conventional source identification techniques such as monitoring and field screening. Techniques used to identify other illicit connection sources can also be used for sewer system evaluation surveys (see SC74 Drainage System Operation and Maintenance).

- Implement community awareness programs for monitoring sanitary sewer wet weather overflows. A citizen's hotline for reporting observed overflow conditions should be established to supplement field screening efforts.

- Establish lead department/agency responsible for spill response and containment. Provide coordination within departments.

- When a spill, leak, and/or overflow occurs and when disinfecting a sewage contaminated area, take every effort to ensure that the sewage, disinfectant and/or sewage treated with the disinfectant is not discharged to the storm drain system or receiving waters. Methods may include:

  - Blocking storm drain inlets and catch basins

  - Containing and diverting sewage and disinfectant away from open channels and other storm drain fixtures (using sandbags, inflatable dams, etc.)

  - Removing the material with vacuum equipment

- Record required information at the spill site.

- Perform field tests as necessary to determine the source of the spill.

- Develop notification procedures regarding spill reporting.

Septic Systems

- Ensure that homeowners, installers, and inspectors are educated in proper maintenance of septic systems. This may require coordination with staff from other departments. Outreach to homeowners should include inspection reminders informing then that inspection and perhaps maintenance is due for their systems. Recommend that the system be inspected annually and pumped-out regularly.

- Programs which seek to address failing septic systems should consider using field screening to pinpoint areas where more detailed onsite inspection surveys are warranted.

Training

- Conduct annual training of water utility personnel and service contractors. (field screening, sampling, smoke/dye testing, TV inspection).

- OSHA-required Health and Safety Training 29 CFR 1910.120 plus annual Refresher Training (as needed).

- OSHA Confined Space Entry training (Cal-OSHA Confined Space, Title 8 and federal OSHA 29 CFR 1910.146).

Spill Response and Prevention

- See previous section regarding spills and overflows.

- Refer to SC-11, Spill Prevention, Control & Cleanup.
- Have spill cleanup materials readily available and in a known location.
- Cleanup spills immediately and use dry methods if possible.
- Properly dispose of spill cleanup material.

Other Considerations

- Enact ordinance granting "right-of-entry" to locate potentially responsible parties for sewer overflows.
- Reliance on individual onsite inspection to detect failed septic systems can be a major limitation. The individual onsite inspection is very labor-intensive and requires access to private property to pinpoint the exact location of the failing system.
- A significant limitation to correcting failing septic systems is the lack of techniques available for detecting individual failed septic systems.

Requirements

Costs

- Departmental cooperation recommended for sharing or borrowing staff resources and equipment from municipal wastewater department.
- Infiltration, inflow, and wet weather overflows from sanitary sewers are very labor and equipment intensive to locate.
- The costs associated with detecting and correcting septic system failures are subject to a number of factors, including availability of trained personnel, cost of materials, and the level of follow-up required to fix the system problems.

Maintenance

- Minimum 2-person teams to perform field screening and associated sampling.
- Larger teams required for implementing other techniques (i.e. zinc chloride smoke testing, fluorometric dye testing, television camera inspection and physical inspection with confined space entry) to identify sewer system leaks.
- Program coordination required for handling emergencies, record keeping, etc.
- Many of the problems associated with improper use of septic systems may be attributed to lack of user knowledge on operation and maintenance. Educational materials for homeowners and training courses for installers and inspectors can reduce the incidence of pollution from these widespread and commonly used pollution control devices.

Supplemental Information

Further Detail of the BMP

Onsite Sewage Disposal Systems

New onsite sewage disposal systems should be designed, located, and installed away from open waterbodies and sensitive resources such as wetlands and floodplains. A protective separation between the OSDS and groundwater should also be established. OSDSs should be operated and maintained to prevent surface water discharges and reduce pollutant loadings to groundwater. Inspection of OSDSs should occur regularly and repairs made immediately. New or replacement plumbing fixtures should be of the high efficiency type.

Typical Sanitary Sewer Problems

- Old and deteriorated main and lateral pipes - Sewers range in age from 30 to 100 years with an average age of 50 years.
- Cracked sewer pipes - Existing sewers are mostly clay pipes which can crack as they deteriorate with age and also by earth movement.
- Misaligned and open pipe joints - Most of the mortar used to seal the joints between sections of clay pipe has deteriorated.
- Undersized sewer pipe - The existing sewer system is overloaded due to new sewer hook-ups, underground water infiltration, and illegal roof and/or yard drain connections.
- Defective manholes - Old manholes are made of bricks. Typical problems associated with brick manholes are loose bricks, missing bricks, and misaligned manholes.
- Missing and/or unrecorded sewer pipes and manholes - This problem is typical in the easement/backline sewer. Sewer pipe locations shown on the sewer record map are different from the actual sewer location.
- Sewer main under houses and other improvements - Complaints of sewer main alignment crossing the house and other improvements. A solution to this problem requires an agreement with the property owner for a new sewer easement at a relocated line.

Causes of Sanitary Sewer Backups

- Root infiltration - Tree roots are a major cause of backups.
- Water inflow/infiltration - Rain water entering the sewer pipe causes overflows.
- Solids - Typical solids that buildup in the pipe and cause backups are grease, dirt, bones, tampons, paper towels, diapers, broken dishware, garbage, concrete, and debris.
- Structural defects in pipes and manholes - Sags in the line, cracks, holes, protruding laterals, misaligned pipe, offset joints are all possible causes of backups.

Design Considerations

Sanitary sewer overflows can often be reduced or eliminated by a number of practices, in addition to sewer system cleaning and maintenance, including the following:

- Reducing infiltration and inflow through rehabilitation and repair of broken or leaking sewer lines.
- Enlarging or upgrading the capacity of sewer lines, pump stations, or sewage treatment plants.
- Constructing wet weather storage and treatment facilities to treat excess flows.
- Addressing SSOs during sewer system master planning and facilities planning.

Septic Systems

Two field screening techniques that have been used with success at identifying possible locations of failing septic systems are the brightener test and color infrared (CIR) aerial photography. The first involves the use of specific phosphorus-based elements found in many laundry products, often called brighteners, as an indicator of the presence of failing onsite wastewater systems. The second technique uses color infrared (CIR) aerial photography to characterize the performance of septic systems. This method has been found to be a quick and cost-effective method for assessing the potential impacts of failing systems and uses variations in vegetative growth or stress patterns over septic system field lines to identify those systems that may potentially be malfunctioning. Then a more detailed onsite visual and physical inspection will confirm whether the system has truly failed and the extent of the repairs needed. These inspections may be carried out by county health departments or other authorized personnel.

References and Resources

Alameda Countywide Clean Water Program on-line
http://www.ci.berkeley.ca.us/pw/Storm/stormala.html

Los Angeles County Stormwater Quality. Public Agency Activities Model Program. On-line: http://ladpw.org/wmd/npdes/public_TC.cfm

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United States Environmental Protection Agency (USEPA). 2001. Illicit Discharge Detection and Elimination. On-line: http://cfpub.epa.gov/npdes/stormwater/menuofbmps/illi_1.cfm

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Maintenance Concerns, Objectives, and Goals

- Accumulation of Metals
- Clogged Soil Outlet Structures
- Vegetation/Landscape Maintenance

General Description

An infiltration trench is a long, narrow, rock-filled trench with no outlet that receives stormwater runoff. Runoff is stored in the void space between the stones and infiltrates through the bottom and into the soil matrix. Infiltration trenches perform well for removal of fine sediment and associated pollutants. Pretreatment using buffer strips, swales, or detention basins is important for limiting amounts of coarse sediment entering the trench which can clog and render the trench ineffective.

Inspection/Maintenance Considerations

Frequency of clogging is dependant on effectiveness of pretreatment, such as vegetated buffer strips, at removing sediments. See appropriate maintenance factsheets for associated pretreatment. If the trench clogs, it may be necessary to remove and replace all or part of the filter fabric and possibly the coarse aggregate. Clogged infiltration trenches with surface standing water can become a nuisance due to mosquito breeding. Maintenance efforts associated with infiltration trenches should include frequent inspections to ensure that water infiltrates into the subsurface completely at a recommended infiltration rate of 72 hours or less to prevent creating mosquito and other vector habitats. Most of the maintenance should be concentrated on the pretreatment practices, such as buffer strips and swales upstream of the trench to ensure that sediment does not reach the infiltration trench. Regular inspection should determine if the sediment removal structures require routine maintenance. Infiltration trenches should not be put into operation until the upstream tributary area is stabilized.

Targeted Constituents

✓	Sediment	■
✓	Nutrients	■
✓	Trash	■
✓	Metals	■
✓	Bacteria	■
✓	Oil and Grease	■
✓	Organics	■
✓	Oxygen Demanding	■

Legend ***(Removal Effectiveness)***

- ● Low
- ■ High
- ▲ Medium

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Inspection Activities	Suggested Frequency
■ Inspect after every major storm for the first few months to ensure proper functioning. Drain times should be observed to confirm that designed drain times has been achieved.	After construction
■ Inspect facility for signs of wetness or damage to structures, signs of petroleum hydrocarbon contamination, standing water, trash and debris, sediment accumulation, slope stability, standing water, and material buildup. ■ Check for standing water or, if available, check observation wells following 3 days of dry weather to ensure proper drain time. ■ Inspect pretreatment devices and diversion structures for damage, sediment buildup, and structural damage.	Semi-annual and after extreme events
■ Trenches with filter fabric should be inspected for sediment deposits by removing a small section of the top layer. If inspection indicates that the trench is partially or completely clogged, it should be restored to its design condition.	Annual

Maintenance Activities	Suggested Frequency
■ Repair undercut and eroded areas at inflow and outflow structures. ■ Remove sediment, debris, and oil/grease from pretreatment devices and overflow structures.	Standard maintenance (as needed)
■ Remove trash, debris, grass clippings, trees, and other large vegetation from the trench perimeter and dispose of properly. ■ Mow and trim vegetation to prevent establishment of woody vegetation, and for aesthetic and vector reasons.	Semi-annual, more often as needed
■ Clean out sediment traps, forebays, inlet/outlet structures, overflow spillway, and trenches if necessary. ■ Remove grass clippings, leaves, and accumulated sediment from the surface of the trench. Replace first layer of aggregate and filter fabric if clogging appears only to be at the surface. ■ Clean trench when loss of infiltrative capacity is observed. If drawdown time is observed to have increased significantly over the design drawdown time, removal of sediment may be necessary. This is an expensive maintenance activity and the need for it can be minimized through prevention of upstream erosion.	Annual
■ If bypass capability is available, it may be possible to regain the infiltration rate in the short term by providing an extended dry period. ■ Seed or sod to restore ground cover.	5-year maintenance
■ Total rehabilitation of the trench should be conducted to maintain storage capacity within 2/3 of the design treatment volume and 72-hour exfiltration rate limit. ■ Trench walls should be excavated to expose clean soil. ■ All of the stone aggregate and filter fabric or media must be removed. Accumulated sediment should be stripped from the trench bottom. At this point the bottom may be scarified or tilled to help induce infiltration. New fabric and clean stone aggregate should be refilled.	Upon failure

Additional Information

Infiltration practices have historically had a high rate of failure compared to other stormwater management practices. One study conducted in Prince George's County, Maryland (Galli, 1992), revealed that less than half of the infiltration trenches investigated (of about 50) were still functioning properly, and less than one-third still functioned properly after 5 years. Many of these practices, however, did not incorporate advanced pretreatment. By carefully selecting the location and improving the design features of infiltration practices, their performance should improve.

It is absolutely critical that settleable particles and floatable organic materials be removed from runoff water before it enters the infiltration trench. The trench will clog and become nonfunctional if excessive particulate matter is allowed to enter the trench.

Cold climate considerations – see http://www.cwp.org/cold-climates.htm

References

EPA, Stormwater Technology Fact Sheet - Infiltration Trench. EPA 832-F-99-019. September, 1999.

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Michigan Department of Environmental Quality. Infiltration Trench Factsheet. Available at: http://www.deq.state.mi.us/documents/deq-swq-nps-it.pdf

Montgomery County Department of Environmental Protection. Maintaining Urban Stormwater Facilities - A Guidebook for Common Ownership Communities. Available at: http://www.montgomerycountymd.gov/mc/services/dep/Stormwater/maintain.htm

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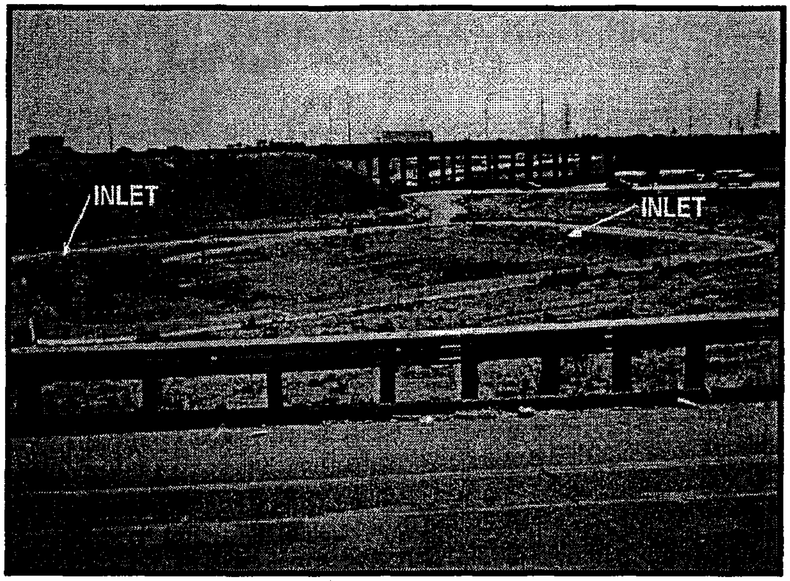
Stormwater Managers Resource Center. On-line: http://www.stormwatercenter.net

U.S. Department of Agriculture, Natural Resources Conservation Service. Illinois Urban Manual: A Technical Manual Designed for Urban Ecosystem Protection and Enhancement, 1995.

U.S. Environmental Protection Agency, Post-Construction Stormwater Management in New Development & Redevelopment BMP Factsheets. Available at: http://www.cfpub.epa.gov/npdes/stormwater/menuofbmps/bmp_files.cfm

Ventura Countywide Stormwater Quality Management Program, Technical Guidance Manual for Stormwater Quality Control Measures. July, 2002.

Infiltration Basin TC-11



Maintenance Concerns, Objectives, and Goals

- Vector Control
- Clogged soil or outlet structures
- Vegetation/Landscape Maintenance
- Groundwater contamination
- Accumulation of metals
- Aesthetics

Targeted Constituents

✓	Sediment	■
✓	Nutrients	■
✓	Trash	■
✓	Metals	■
✓	Bacteria	■
✓	Oil and Grease	■
✓	Organics	■
✓	Oxygen Demanding	■

Legend *(Removal Effectiveness)*

- ● Low
- ■ High
- ▲ Medium

General Description

An infiltration basin is a shallow impoundment that is designed to infiltrate stormwater. Infiltration basins use the natural filtering ability of the soil to remove pollutants in stormwater runoff. Infiltration facilities store runoff until it gradually infiltrates into the soil and eventually into the water table. This practice has high pollutant removal efficiency and can also help recharge groundwater, thus helping to maintain low flows in stream systems. Infiltration basins can be challenging to apply on many sites, however, because of soils requirements. In addition, some studies have shown relatively high failure rates compared with other management practices.

Inspection/Maintenance Considerations

Infiltration basins perform better in well-drained permeable soils. Infiltration basins in areas of low permeability can clog within a couple years, and require more frequent inspections and maintenance. The use and regular maintenance of pretreatment BMPs will significantly minimize maintenance requirements for the basin. Spill response procedures and controls should be implemented to prevent spills from reaching the infiltration system.

Scarification or other disturbance should only be performed when there are actual signs of clogging or significant loss of infiltrative capacity, rather than on a routine basis. Always remove deposited sediments before scarification, and use a hand-guided rotary tiller, if possible, or a disc harrow pulled by a light tractor. This BMP may require groundwater monitoring. Basins cannot be put into operation until the upstream tributary area is stabilized.

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Clogged infiltration basins with surface standing water can become a breeding area for mosquitoes and midges. Maintenance efforts associated with infiltration basins should include frequent inspections to ensure that water infiltrates into the subsurface completely (recommended infiltration rate of 72 hours or less) and that vegetation is carefully managed to prevent creating mosquito and other vector habitats.

Inspection Activities	Suggested Frequency
■ Observe drain time for a storm after completion or modification of the facility to confirm that the desired drain time has been obtained. ■ Newly established vegetation should be inspected several times to determine if any landscape maintenance (reseeding, irrigation, etc.) is necessary.	Post construction
■ Inspect for the following issues: differential accumulation of sediment, signs of wetness or damage to structures, erosion of the basin floor, dead or dying grass on the bottom, condition of riprap, drain time, signs of petroleum hydrocarbon contamination, standing water, trash and debris, sediment accumulation, slope stability, pretreatment device condition	Semi-annual and after extreme events
Maintenance Activities	**Suggested Frequency**
■ Factors responsible for clogging should be repaired immediately. ■ Weed once monthly during the first two growing seasons.	Post construction
■ Stabilize eroded banks. ■ Repair undercut and eroded areas at inflow and outflow structures. ■ Maintain access to the basin for regular maintenance activities. ■ Mow as appropriate for vegetative cover species. ■ Monitor health of vegetation and replace as necessary. ■ Control mosquitoes as necessary. ■ Remove litter and debris from infiltration basin area as required.	Standard maintenance (as needed)
■ Mow and remove grass clippings, litter, and debris. ■ Trim vegetation at the beginning and end of the wet season to prevent establishment of woody vegetation and for aesthetic and vector reasons. ■ Replant eroded or barren spots to prevent erosion and accumulation of sediment.	Semi-annual
■ Scrape bottom and remove sediment when accumulated sediment reduces original infiltration rate by 25-50%. Restore original cross-section and infiltration rate. Properly dispose of sediment. ■ Seed or sod to restore ground cover. ■ Disc or otherwise aerate bottom. ■ Dethatch basin bottom.	3-5 year maintenance

Additional Information

In most cases, sediment from an infiltration basin does not contain toxins at levels posing a hazardous concern. Studies to date indicate that pond sediments are generally below toxicity limits and can be safely landfilled or disposed onsite. Onsite sediment disposal is always preferable (if local authorities permit) as long as the sediments are deposited away from the shoreline to prevent their reentry into the pond and away from recreation areas, where they could possibly be ingested by young children. Sediments should be tested for toxicants in compliance with current disposal requirements if land uses in the catchment include commercial or industrial zones, or if visual or olfactory indications of pollution are noticed. Sediments containing high levels of pollutants should be disposed of properly.

Light equipment, which will not compact the underlying soil, should be used to remove the top layer of sediment. The remaining soil should be tilled and revegetated as soon as possible.

Sediment removal within the basin should be performed when the sediment is dry enough so that it is cracked and readily separates from the basin floor. This also prevents smearing of the basin floor.

References

King County, Stormwater Pollution Control Manual – Best Management Practices for Businesses. July, 1995 Available at: ftp://dnr.metrokc.gov/wlr/dss/spcm/SPCM.HTM

Metropolitan Council, Urban Small Sites Best Management Practices Manual. Available at: http://www.metrocouncil.org/environment/Watershed/BMP/manual.htm

U.S. Environmental Protection Agency, Post-Construction Stormwater Management in New Development & Redevelopment BMP Factsheets. Available at: http://www.cfpub.epa.gov/npdes/stormwater/menuofbmps/bmp_files.cfm

Ventura Countywide Stormwater Quality Management Program, Technical Guidance Manual for Stormwater Quality Control Measures. July, 2002.

General Description

Retention/irrigation refers to the capture of stormwater runoff in a holding pond and subsequent use of the captured volume for irrigation of landscape or natural pervious areas. This technology is very effective as a stormwater quality practice in that, for the captured water quality volume, it provides virtually no discharge to receiving waters and high stormwater constituent removal efficiencies. This technology mimics natural undeveloped watershed conditions wherein the vast majority of the rainfall volume during smaller rainfall events is infiltrated through the soil profile. Their main advantage over other infiltration technologies is the use of an irrigation system to spread the runoff over a larger area for infiltration. This allows them to be used in areas with low permeability soils.

Capture of stormwater can be accomplished in almost any kind of runoff storage facility, ranging from dry, concrete-lined ponds to those with vegetated basins and permanent pools. The pump and wet well should be automated with a rainfall sensor to provide irrigation only during periods when required infiltration rates can be realized. Generally, a spray irrigation system is required to provide an adequate flow rate for distributing the water quality volume (LCRA, 1998). Collection of roof runoff for subsequent use (rainwater harvesting) also qualifies as a retention/irrigation practice.

Inspection/Maintenance Considerations

Pollutant removal rates are estimated to be nearly 100% for all pollutants in the captured and irrigated stormwater volume. However, relatively frequent inspection and maintenance is necessary to verify proper operation of these facilities.

Maintenance Concerns, Objectives, and Goals

- Sediment Accumulation
- Mechanical malfunction
- Vector Control

Targeted Constituents

✓	Sediment	■
✓	Nutrients	■
✓	Trash	■
✓	Metals	■
✓	Bacteria	■
✓	Oil and Grease	■
✓	Organics	■
✓	Oxygen Demanding	■

Legend ***(Removal Effectiveness)***

● Low ■ High

▲ Medium

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Inspection Activities	Suggested Frequency
■ The irrigation system should be inspected and tested (or observed while in operation) to verify proper operation multiple times annually. Two of these inspections should occur during or immediately following wet weather. Any leaks, broken spray heads, or other malfunctions with the irrigation system should be repaired immediately.	Frequently (3-6 times per year)

Maintenance Activities	Suggested Frequency
■ The upper stage, side slopes, and embankment of a retention basin must be mowed regularly to discourage woody growth and control weeds.	Frequently
■ Remove sediment from inlet structure/sediment forebay, and from around the sump area at least 2 times annually or when depth reaches 3 inches. When sediment in other areas of the basin fills the volume allocated for sediment accumulation, all sediment should be removed and disposed of properly. ■ Grass areas in and around basins must be mowed at least twice annually to limit vegetation height to 18 inches. More frequent mowing to maintain aesthetic appeal may be necessary in landscaped areas. When mowing is performed, a mulching mower should be used, or grass clippings should be caught and removed. ■ Debris and litter will accumulate near the basin pump and should be removed during regular mowing operations and inspections. Particular attention should be paid to floating debris that can eventually clog the irrigation system.	Semi-annual
■ The pond side slopes and embankment may periodically suffer from slumping and erosion, although this should not occur often if the soils are properly compacted during construction. Regrading and revegetation may be required to correct the problems.	Infrequently

Maintenance Concerns, Objectives, and Goals

- Vegetation/Landscape Maintenance
- Endangered Species Habitat Creation
- Pollutant Removal Efficiency
- Clogging of the Outlet
- Invasive/exotic Plant Species
- Vector Control

General Description

Wet ponds (a.k.a. stormwater ponds, retention ponds, wet extended detention ponds) are constructed basins that have a permanent pool of water throughout the year (or at least throughout the wet season) and differ from constructed wetlands primarily in having a greater average depth. Ponds treat incoming stormwater runoff by settling and biological uptake. The primary removal mechanism is settling as stormwater runoff resides in this pool, but pollutant uptake, particularly of nutrients, also occurs to some degree through biological activity in the pond. Wet ponds are among the most widely used stormwater practices. While there are several different versions of the wet pond design, the most common modification is the extended detention wet pond, where storage is provided above the permanent pool in order to detain stormwater runoff and promote settling. The schematic diagram is of an on-line pond that includes detention for larger events, but this is not required in all areas of the state.

Inspection/Maintenance Considerations

In order to maintain the pond's design capacity, sediment must be removed occasionally and adequate resources must be committed to properly maintain peripheral aquatic vegetation, control vector production, and to maintain effective pool volume. Wet ponds can become a nuisance due to mosquito and midge breeding unless carefully designed and maintained. A proactive and routine preventative maintenance plan (which can vary according to location) is crucial to minimizing vector habitat. A vegetated buffer should be preserved around the pond to protect the banks from erosion and provide some pollutant removal before runoff enters the pond by overland flow.

Targeted Constituents

✓	Sediment	■
✓	Nutrients	▲
✓	Trash	■
✓	Metals	■
✓	Bacteria	■
✓	Oil and Grease	■
✓	Organics	■
✓	Oxygen Demanding	■

Legend ***(Removal Effectiveness)***

- ● Low ■ High
- ▲ Medium

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Inspection Activities	Suggested Frequency
■ Inspect after several storm events to confirm that the drainage system functions, and bank stability and vegetation growth are sufficient.	Post construction
■ Inspect for invasive vegetation, trash and debris, clogging of inlet/outlet structures, excessive erosion, sediment buildup in basin or outlet, cracking or settling of the dam, bank stability, tree growth on dam or embankment, vigor and density of the grass turf on the basin side slopes and floor, differential settlement, leakage, subsidence, damage to the emergency spillway, mechanical component condition, and graffiti.	Semi-annual, after significant storms, or more frequent as needed
■ Inspect condition of inlet and outlet structures, pipes, sediment forebays, basin, and upstream and downstream channel conditions. Monitor drain times, and check for algal growth, signs of pollution such as oil sheens, discolored water, or unpleasant odors, and signs of flooding.	Annual inspection
■ During inspections, note changes to the wet pond or the contributing watershed as these may affect basin performance.	
Maintenance Activities	**Suggested Frequency**
■ Introduce mosquito fish, *Gambusia* spp., (where permitted by the Department of Fish and Game or other agency regulations) to enhance natural mosquito and midge control and regularly maintain emergent and shoreline vegetation to provide access for vector inspectors and facilitate vector control if needed.	Post construction
■ Perform vector control, if necessary. ■ Remove sediment from outlet structure. Dispose of properly. ■ Remove accumulated trash and debris in the basin, inlet/outlet structures, side slopes, and collection system as required. ■ Repair undercut areas and erosion to banks and basin.	Semi annual, after significant storm events
■ Maintain protected vegetated buffer around pond. Mow side slopes and maintain vegetation in and around basin to prevent any erosion or aesthetic problems. Minimize use of fertilizers and pesticides. Reseed if necessary. ■ Manage and harvest wetland plants. ■ Structural repair or replacement, as needed.	Annual maintenance (if needed)
■ Remove sediment from the forebay and regrade when the accumulated sediment volume exceeds 10-20% of the forebay volume. Clean in early spring so vegetation damaged during cleaning has time to re-establish.	5- to 7-year maintenance
■ Remove sediment when the permanent pool volume has become reduced significantly (sediment accumulation exceeds 25% of design depth), resuspension is observed, or the pond becomes eutrophic.	>5 year maintenance

Additional Information

In most cases, sediment from wet ponds do not contain toxins at levels posing a hazardous concern. Studies to date indicate that pond sediments are generally below toxicity limits and can be safely landfilled or disposed onsite. Onsite sediment disposal is always preferable (if local authorities permit) as long as the sediments are deposited away from the shoreline to prevent their reentry into the pond and away from recreation areas, where they could possibly be ingested by young children.

Sediments should be tested for toxicants in compliance with current disposal requirements if land uses in the catchment include commercial or industrial zones, or if visual or olfactory indications of pollution are noticed. Sediments containing high levels of pollutants should be disposed of properly.

For the best water quality benefit, the pond should hold water for at least 24 hours. It should drain down to the permanent water level within 72 hours of a storm event to avoid conditions which might increase water temperatures, deplete oxygen, promote vector growth, and/or cause odors.

References

King County, Stormwater Pollution Control Manual – Best Management Practices for Businesses. July, 1995 Available at: ftp://dnr.metrokc.gov/wlr/dss/spcm/SPCM.HTM

Metropolitan Council, Urban Small Sites Best Management Practices Manual. Available at: http://www.metrocouncil.org/environment/Watershed/BMP/manual.htm

Model Urban Runoff Program: A How-To Guide for Developing Urban Runoff Programs for Small Municipalities. Prepared by City of Monterey, City of Santa Cruz, California Coastal Commission, Monterey Bay National Marine Sanctuary, Association of Monterey Bay Area Governments, Woodward-Clyde, Central Coast Regional Water Quality Control Board. July, 1998, revised February, 2002.

Montgomery County Department of Environmental Protection. Maintaining Urban Stormwater Facilities - A Guidebook for Common Ownership Communities. Available at: http://www.montgomerycountymd.gov/mc/services/dep/Stormwater/maintain.htm

North Carolina Department of Environment and Natural Resources, Division of Water Quality. Maintaining Wet Detention Ponds Factsheet. Available at: http://h2o.enr.state.nc.us/su/PDF_Files/Land_of_Sky_factsheets/FactSheet_7.pdf

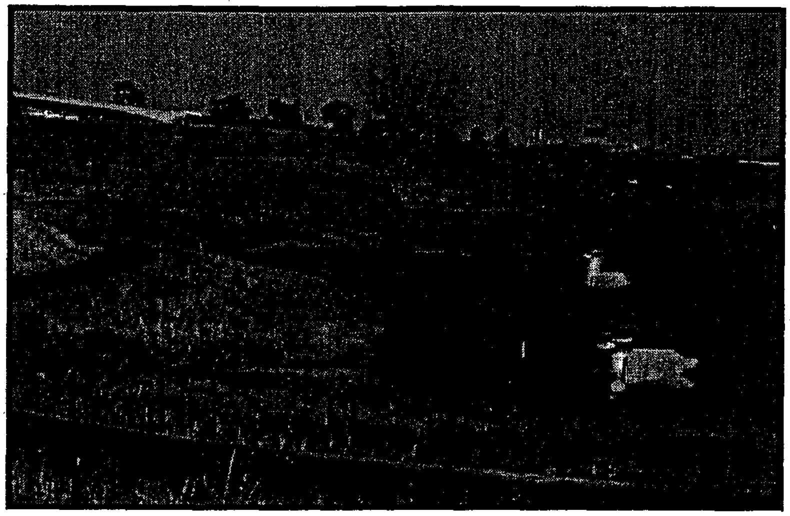
Oregon Association of Clean Water Agencies, Oregon Municipal Stormwater Toolbox for Maintenance Practices, June 1998. Available at: http://www.oracwa.org/Pages/toolbox.htm

Stormwater Managers Resource Center. On-line: http://www.stormwatercenter.net

U.S. Environmental Protection Agency, Post-Construction Stormwater Management in New Development & Redevelopment BMP Factsheets. Available at: cfpub.epa.gov/npdes/stormwater/menuofbmps/bmp_files.cfm

Ventura Countywide Stormwater Quality Management Program, Technical Guidance Manual for Stormwater Quality Control Measures. July, 2002.

Extended Detention Basin TC-22



Maintenance Concerns, Objectives, and Goals

- Vector/Pest Control
- Sediment and Trash Removal
- Vegetation/Landscape Maintenance
- Re-suspension of settled material
- Clogging of the Outlet

Targeted Constituents

✓	Sediment	▲
✓	Nutrients	●
✓	Trash	■
✓	Metals	▲
✓	Bacteria	▲
✓	Oil and Grease	▲
✓	Organics	▲
✓	Oxygen Demanding	▲

Legend ***(Removal Effectiveness)***

● Low ■ High

▲ Medium

General Description

Dry extended detention ponds (a.k.a. dry ponds, extended detention basins, detention ponds, extended detention ponds) are basins whose outlets have been designed to detain the stormwater runoff from a water quality design storm for some minimum time (e.g., 72 hours) to allow particles and associated pollutants to settle. Unlike wet ponds, these facilities do not have a large permanent pool. They can also be used to provide flood control by including additional flood detention storage.

Inspection/Maintenance Considerations

Inspections should be conducted semi-annually and after significant storm events to identify potential problems early. Most maintenance efforts will need to be directed toward vegetation management and vector control, which may focus on basic housekeeping practices such as removal of debris accumulations and vegetation management to ensure that the basin dewaters completely (recommended 72 hour residence time or less) to prevent creating mosquito and other vector habitats.

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Inspection Activities	Suggested Frequency
■ Inspect after several storm events for bank stability, vegetation growth, and to determine if the desired residence time has been achieved. ■ Inspect outlet structure for evidence of clogging or outflow release velocities that are greater than design flow.	Post construction
■ Inspect for the following issues: differential settlement, cracking; erosion of pond banks or bottom, leakage, or tree growth on the embankment; the condition of the riprap in the inlet, clogging of outlet and pilot channels; standing water, slope stability, presence of burrows; sediment accumulation in the basin, forebay, and outlet structures; trash and debris, and the vigor and density of the grass turf on the basin side slopes and floor.	Semi-annual, after significant storms, or more frequent
■ Inspect for the following issues: subsidence, damage to the emergency spillway; inadequacy of the inlet/outlet channel erosion control measures; changes in the condition of the pilot channel, accumulated sediment volume, and semi-annual inspection items.	Annual
■ During inspections, changes to the extended storage pond or the contributing watershed should be noted, as these may affect basin performance.	Annual inspection
Maintenance Activities	**Suggested Frequency**
■ If necessary, modify the outlet orifice to achieve design values if inspection indicates modifications are necessary. ■ Repair undercut or eroded areas. ■ Mow side slopes. ■ Manage pesticide and nutrients. ■ Remove litter and debris. ■ Control vectors as necessary.	As needed
■ Remove accumulated trash and debris from the basin, around the riser pipe, side slopes, embankment, emergency spillway, and outflow trash racks. The frequency of this activity may be altered to meet specific site conditions. ■ Trim vegetation at the beginning and end of the wet season to prevent establishment of woody vegetation and for aesthetic and vector reasons.	Semi-annual, or more frequent, as needed
■ Seed or sod to restore dead or damaged ground cover. ■ Repair erosion to banks and bottom as required.	Annual maintenance (as needed)
■ Supplement wetland plants if a significant portion have not been established (at least 50% of the surface area). ■ Remove nuisance plant species.	Annual maintenance (if needed)
■ Remove sediment from the forebay to reduce frequency of main basin cleaning.	3- to 5-year maintenance
■ Monitor sediment accumulation and remove accumulated sediment and regrade about every 10 years or when the accumulated sediment volume exceeds 10-20% of the basin volume, or when accumulation reaches 6 inches or if resuspension is observed. Clean in early spring so vegetation damaged during cleaning has time to re-establish.	Every 10-25 years

Additional Information

In most cases, sediment from extended detention basin does not contain toxins at levels posing a hazardous concern. Studies to date indicate that pond sediments are likely to meet toxicity limits and can be safely landfilled or disposed of onsite. Onsite sediment disposal is always preferable (if local authorities permit it) as long as the sediments are deposited away from the shoreline to prevent their re-entry into the pond.

Sediments should be tested for toxin in compliance with current disposal requirements if land uses in the catchment include commercial or industrial zones, or if visual or olfactory indications of pollution are noticed.

References

Metropolitan Council, Urban Small Sites Best Management Practices Manual. Available at: http://www.metrocouncil.org/environment/Watershed/BMP/manual.htm

U.S. Environmental Protection Agency, Post-Construction Stormwater Management in New Development & Redevelopment BMP Factsheets. Available at: cfpub.epa.gov/npdes/stormwater/menuofbmps/bmp_files.cfm

Ventura Countywide Stormwater Quality Management Program, Technical Guidance Manual for Stormwater Quality Control Measures. July, 2002.

Maintenance Concerns, Objectives, and Goals

- Channelization
- Vegetation/Landscape Maintenance
- Vector Control
- Aesthetics
- Hydraulic and Removal Efficacy

General Description

Vegetated swales are open, shallow channels with vegetation covering the side slopes and bottom that collect and slowly convey runoff flow to downstream discharge points. They are designed to treat runoff through filtering by the vegetation in the channel, filtering through a subsoil matrix, and/or infiltration into the underlying soils. Swales can be natural or manmade. They trap particulate pollutants (suspended solids and trace metals), promote infiltration, and reduce the flow velocity of stormwater runoff. Vegetated swales can serve as part of a stormwater drainage system and can replace curbs, gutters and storm sewer systems. Therefore, swales are best suited for residential, industrial, and commercial areas with low flow and smaller populations.

Inspection/Maintenance Considerations

It is important to consider that a thick vegetative cover is needed for vegetated swales to function properly. Usually, swales require little more than normal landscape maintenance activities such as irrigation and mowing to maintain pollutant removal efficiency. Swales can become a nuisance due to mosquito breeding in standing water if obstructions develop (e.g., debris accumulation, invasive vegetation) and/or if proper drainage slopes are not implemented and maintained. The application of fertilizers and pesticides should be minimized.

Targeted Constituents

✓	Sediment	▲
✓	Nutrients	●
✓	Trash	●
✓	Metals	▲
✓	Bacteria	●
✓	Oil and Grease	▲
✓	Organics	▲
✓	Oxygen Demanding	▲

Legend ***(Removal Effectiveness)***

● Low ■ High

▲ Medium

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Inspection Activities	Suggested Frequency
■ Inspect after seeding and after first major storms for any damages.	Post construction
■ Inspect for signs of erosion, damage to vegetation, channelization of flow, debris and litter, and areas of sediment accumulation. Perform inspections at the beginning and end of the wet season. Additional inspections after periods of heavy runoff are desirable.	Semi-annual
■ Inspect level spreader for clogging, grass along side slopes for erosion and formation of rills or gullies, and sand/soil bed for erosion problems.	Annual
Maintenance Activities	**Suggested Frequency**
■ Mow grass to maintain a height of 3–4 inches, for safety, aesthetic, or other purposes. Litter should always be removed prior to mowing. Clippings should be composted. ■ Irrigate swale during dry season (April through October) or when necessary to maintain the vegetation. ■ Provide weed control, if necessary to control invasive species.	As needed (frequent, seasonally)
■ Remove litter, branches, rocks blockages, and other debris and dispose of properly. ■ Maintain inlet flow spreader (if applicable). ■ Repair any damaged areas within a channel identified during inspections. Erosion rills or gullies should be corrected as needed. Bare areas should be replanted as necessary.	Semi-annual
■ Declog the pea gravel diaphragm, if necessary. ■ Correct erosion problems in the sand/soil bed of dry swales. ■ Plant an alternative grass species if the original grass cover has not been successfully established. Reseed and apply mulch to damaged areas.	Annual (as needed)
■ Remove all accumulated sediment that may obstruct flow through the swale. Sediment accumulating near culverts and in channels should be removed when it builds up to 3 in. at any spot, or covers vegetation, or once it has accumulated to 10% of the original design volume. Replace the grass areas damaged in the process. ■ Rototill or cultivate the surface of the sand/soil bed of dry swales if the swale does not draw down within 48 hours.	As needed (infrequent)

Additional Information

Recent research (Colwell et al., 2000) indicates that grass height and mowing frequency have little impact on pollutant removal. Consequently, mowing may only be necessary once or twice a year for safety or aesthetics or to suppress weeds and woody vegetation.

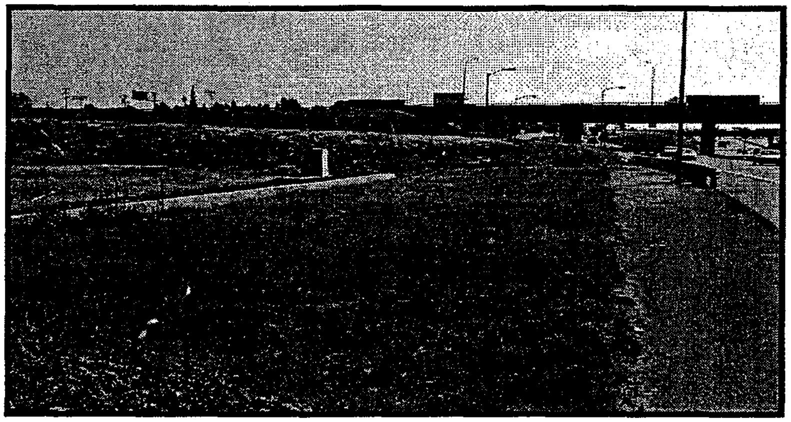
References

Metropolitan Council, Urban Small Sites Best Management Practices Manual. Available at: http://www.metrocouncil.org/environment/Watershed/BMP/manual.htm

U.S. Environmental Protection Agency, Post-Construction Stormwater Management in New Development & Redevelopment BMP Factsheets. Available at: cfpub.epa.gov/npdes/stormwater/menuofbmps/bmp_files.cfm

Ventura Countywide Stormwater Quality Management Program, Technical Guidance Manual for Stormwater Quality Control Measures. July, 2002.

Vegetated Buffer Strip



Maintenance Concerns, Objectives, and Goals

- Clogged Soil or Outlet Structures
- Invasive Species Management
- Vegetation/Landscape Maintenance
- Erosion
- Channelization of Flow
- Aesthetics

General Description

Grassed buffer strips (vegetated filter strips, filter strips, and grassed filters) are vegetated surfaces that are designed to treat sheet flow from adjacent surfaces. Filter strips function by slowing runoff velocities and allowing sediment and other pollutants to settle and by providing some infiltration into underlying soils. Filter strips were originally used as an agricultural treatment practice and have more recently evolved into an urban practice. With proper design and maintenance, filter strips can provide relatively high pollutant removal. In addition, the public views them as landscaped amenities and not as stormwater infrastructure. Consequently, there is little resistance to their use.

Inspection/Maintenance Considerations

Vegetated buffer strips require frequent landscape maintenance. In many cases, vegetated buffer strips initially require intense maintenance, but less maintenance is needed over time. In many cases, maintenance tasks can be completed by a landscaping contractor. Maintenance requirements typically include grass or shrub-growing activities such as irrigation, mowing, trimming, removal of invasive species, and replanting when necessary. Buffer strips require more tending as the volume of sediment increases. Vegetated buffer strips can become a nuisance due to mosquito breeding in level spreaders (unless designed to dewater completely in 72 hours or less) and/or if proper drainage slopes are not maintained.

Targeted Constituents

✓	Sediment	■
✓	Nutrients	●
✓	Trash	▲
✓	Metals	■
✓	Bacteria	●
✓	Oil and Grease	■
✓	Organics	▲
✓	Oxygen Demanding	▲

Legend ***(Removal Effectiveness)***

● Low ■ High

▲ Medium

CASQA California Stormwater Quality Association

Inspection Activities	Suggested Frequency
■ Once the vegetated buffer strip is established, inspect at least three times per year. Repair all damage immediately. ■ Inspect buffer strips after seeding and repair as needed.	Post construction
■ Inspect buffer strip and repair all damage immediately. ■ Inspect soil and repair eroded areas.	After major storms
■ Inspect for erosion or damage to vegetation, preferably at the end of the wet season to schedule summer maintenance and before major fall runoff to be sure the strips are ready for winter. However, additional inspection after periods of heavy runoff is desirable. ■ Inspect pea-gravel diaphragm/level spreader for clogging and effectiveness and remove built-up sediment. ■ Inspect for rolls and gullies. Immediately fill with topsoil, install erosion control blanket and seed or sod. ■ Inspect to ensure grass is well established. If not, either prepare soil and reseed or replace with alternative species. Install erosion control blanket. ■ Check for debris and litter, and areas of sediment accumulation.	Semi-annual

Maintenance Activities	Suggested Frequency
■ Water plants daily for 2 weeks after construction.	Post construction
■ Mow regularly to maintain vegetation height between 2 - 4 inches, and to promote thick, dense vegetative growth. Cut only when soil is dry to prevent tracking damage to vegetation, soil compaction and flow concentrations. Clippings are to be removed immediately after mowing. ■ Remove all litter, branches, rocks, or other debris. Damaged areas of the filter strip should be repaired immediately by reseeding and applying mulch. ■ Regularly maintain inlet flow spreader. ■ Irrigate during dry season (April through October) when necessary to maintain the vegetation.	Frequently, as needed
■ Remulch void areas. ■ Treat diseased trees and shrubs, remove dead vegetation.	Semi-annual
■ Remove sediment and replant in areas of buildup. Sediment accumulating near culverts and in channels should be removed when it builds up to 3 in. at any spot, or covers vegetation. ■ Limit fertilizer applications based on plant vigor and soil test results. ■ Rework or replant buffer strip if concentrated flow erodes a channel through the strip.	Annual

Additional Information

Recent research (Colwell et al., 2000) indicates that grass height and mowing frequency have little impact on pollutant removal. Consequently, mowing may only be necessary once or twice a year for safety or aesthetics or to suppress weeds and woody vegetation.

Trash tends to accumulate in swale areas, particularly along highways. The need for litter removal is determined through periodic inspection, but litter should always be removed prior to mowing.

References

Metropolitan Council, Urban Small Sites Best Management Practices Manual. Available at: http://www.metrocouncil.org/environment/Watershed/BMP/manual.htm

U.S. Environmental Protection Agency, Post-Construction Stormwater Management in New Development & Redevelopment BMP Factsheets. Available at: cfpub.epa.gov/npdes/stormwater/menuofbmps/bmp_files.cfm

Ventura Countywide Stormwater Quality Management Program, Technical Guidance Manual for Stormwater Quality Control Measures. July, 2002.

Maintenance Concerns, Objectives, and Goals

- Clogged Soil or Outlet Structures
- Invasive Species
- Vegetation/Landscape Maintenance
- Erosion
- Channelization of Flow
- Aesthetics

General Description

The bioretention best management practice (BMP) functions as a soil and plant-based filtration device that removes pollutants through a variety of physical, biological, and chemical treatment processes. These facilities normally consist of a grass buffer strip, sand bed, ponding area, organic layer or mulch layer, planting soil, and plants. The runoff's velocity is reduced by passing over or through a sand bed and is subsequently distributed evenly along a ponding area. Exfiltration of the stored water in the bioretention area planting soil into the underlying soils occurs over a period of days.

Inspection/Maintenance Considerations

Bioretention requires frequent landscaping maintenance, including measures to ensure that the area is functioning properly, as well as maintenance of the landscaping on the practice. In many cases, bioretention areas initially require intense maintenance, but less maintenance is needed over time. In many cases, maintenance tasks can be completed by a landscaping contractor, who may already be hired at the site. In cold climates the soil may freeze, preventing runoff from infiltrating into the planting soil.

Targeted Constituents

✓	Sediment	■
✓	Nutrients	▲
✓	Trash	■
✓	Metals	■
✓	Bacteria	■
✓	Oil and Grease	■
✓	Organics	■
✓	Oxygen Demanding	■

Legend *(Removal Effectiveness)*

● Low ■ High

▲ Medium

CASQA
California Stormwater Quality Association

Inspection Activities	Suggested Frequency
■ Inspect soil and repair eroded areas.	Monthly
■ Inspect for erosion or damage to vegetation, preferably at the end of the wet season to schedule summer maintenance and before major fall runoff to be sure the strips are ready for winter. However, additional inspection after periods of heavy runoff is desirable.	Semi-annual inspection
■ Inspect to ensure grass is well established. If not, either prepare soil and reseed or replace with alternative species. Install erosion control blanket. ■ Check for debris and litter, and areas of sediment accumulation. ■ Inspect health of trees and shrubs.	
Maintenance Activities	**Suggested Frequency**
■ Water plants daily for 2 weeks.	At project completion
■ Remove litter and debris.	Monthly
■ Remove sediment. ■ Remulch void areas. ■ Treat diseased trees and shrubs. ■ Mow turf areas. ■ Repair erosion at inflow points. ■ Repair outflow structures. ■ Unclog underdrain. ■ Regulate soil pH regulation.	As needed
■ Remove and replace dead and diseased vegetation.	Semi-annual
■ Add mulch. ■ Replace tree stakes and wires.	Annual
■ Mulch should be replaced every 2 to 3 years or when bare spots appear. Remulch prior to the wet season.	Every 2-3 years, or as needed

Additional Information

Landscaping is critical to the function and aesthetic value of bioretention areas. It is preferable to plant the area with native vegetation, or plants that provide habitat value, where possible. Another important design feature is to select species that can withstand the hydrologic regime they will experience. At the bottom of the bioretention facility, plants that tolerate both wet and dry conditions are preferable. At the edges, which will remain primarily dry, upland species will be the most resilient. It is best to select a combination of trees, shrubs, and herbaceous materials.

References

Metropolitan Council, Urban Small Sites Best Management Practices Manual. Available at: http://www.metrocouncil.org/environment/Watershed/BMP/manual.htm

Model Urban Runoff Program: A How-To Guide for Developing Urban Runoff Programs for Small Municipalities. Prepared by City of Monterey, City of Santa Cruz, California Coastal Commission, Monterey Bay National Marine Sanctuary, Association of Monterey Bay Area Governments, Woodward-Clyde, Central Coast Regional Water Quality Control Board. July, 1998, revised February, 2002.

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Ventura Countywide Stormwater Quality Management Program, Technical Guidance Manual for Stormwater Quality Control Measures. July, 2002.

Maintenance Concerns, Objectives, and Goals

- Pollutant Breakthrough
- Clogged of Sand Media
- Trash and Debris Accumulation

General Description

Stormwater media filters are usually two-chambered including a pretreatment settling basin and a filter bed filled with sand or other absorptive filtering media. As stormwater flows into the first chamber, large particles settle out, and then finer particles and other pollutants are removed as stormwater flows through the filtering media in the second chamber. There are a number of design variations including the Austin sand filter, Delaware sand filter, and multi-chambered treatment train (MCTT).

Inspection/Maintenance Considerations

Media filters may exhibit decreased effectiveness after a few years of operation, depending on the activities occurring in the drainage area. Media filters clog easily when subjected to high sediment loads. Sediment reducing pretreatment practices, such as vegetated buffer strips or vegetated swales, placed upstream of the filter should be maintained properly to reduce sediment loads into filter. Media filters can become a nuisance due to mosquito or midge breeding if not properly designed and maintained. Installations should dewater completely (recommended 72 hour or less residence time) to prevent creating mosquito and other vector habitats. Maintenance efforts will need to focus on basic housekeeping practices such as removal of debris accumulations and vegetation management (in filter media) to prevent clogs and/or pods of standing water. To minimize the potential for clogging, frequent maintenance and inspection practices are required. Waste sand, gravel, filter cloth, or filter media must be disposed of properly and in accordance with all applicable laws.

Targeted Constituents

✓	Sediment	■
✓	Nutrients	●
✓	Trash	■
✓	Metals	■
✓	Bacteria	▲
✓	Oil and Grease	■
✓	Organics	■
✓	Oxygen Demanding	■

Legend ***(Removal Effectiveness)***

● Low ■ High

▲ Medium

CASQA California Stormwater Quality Association

Inspection Activities	Suggested Frequency
■ During the first year of operation, inspect chambers quarterly to ensure that the system is functioning properly. ■ Inspect sand filters after every major storm in the first few months after construction to ensure that the system is functioning properly.	Post construction
■ Ensure that filter surface, inlets, and outlets are clear of debris. ■ Ensure that the contributing area is stabilized and mowed, with clippings removed. ■ Check to ensure that the filter surface is not clogging. ■ Ensure that activities in the drainage area minimize oil/grease and sediment entry to the system. ■ Inspect the facility once during the wet season after a large rain event to determine whether the facility is draining completely within 72 hr.	Quarterly, and after major storms
■ Inspect for standing water, sediment, trash and debris, structural damage, and to identify potential problems.	Semi-annual
■ Check to see that the filter bed is clean of sediments and the sediment chamber contains no more than six inches of sediment. ■ Make sure that there is no evidence of deterioration of concrete structures. ■ Inspect grates (if used). ■ Inspect inlets, outlets, and overflow spillway to ensure good condition and no evidence of erosion. ■ Ensure that flow is not bypassing the facility. ■ Ensure that no noticeable odors are detected outside the facility.	Annual
Maintenance Activities	**Suggested Frequency**
■ Remove trash and debris from the sedimentation basin (Austin design), the riser pipe, and the filter bed as needed. ■ Prevent grass clippings from washing into the filter. ■ Remove trash from inlet grates to maintain the inflow capacity of the media filter. ■ Upstream vegetation should be maintained as needed.	Frequently (as needed)
■ Clean filter surface semiannually; or more often if watershed is excessively erosive. ■ Replace sorbent pillows (Multi-Chamber Treatment Train only).	Semi-annual
■ Repair or replace any damaged structural parts. ■ Stabilize any eroded areas.	Annual
■ Remove accumulated sediment in the sedimentation chamber every 10 years or when the sediment occupies 10-20% of the basin volume or accumulates to a depth of six inches, whichever is less. ■ Remove top 2 in. of media filter and landfill if facility drain time exceeds 72 hr. Restore media depth to 18 in. when overall media depth drops to 12 in.).	As needed

References

Metropolitan Council, Urban Small Sites Best Management Practices Manual. Available at: http://www.metrocouncil.org/environment/Watershed/BMP/manual.htm

U.S. Environmental Protection Agency, Post-Construction Stormwater Management in New Development & Redevelopment BMP Factsheets. Available at: http://www.cfpub.epa.gov/npdes/stormwater/menuofbmps/bmp_files.cfm

Ventura Countywide Stormwater Quality Management Program, Technical Guidance Manual for Stormwater Quality Control Measures. July, 2002.

General Description

Water quality inlets (WQIs), also commonly called trapping catch basins, oil/grit separators or oil/water separators, consist of one or more chambers that promote sedimentation of coarse materials and separation of free oil (as opposed to emulsified or dissolved oil) from stormwater. Some WQIs also contain screens to help retain larger or floating debris, and many of the newer designs also include a coalescing unit that helps promote oil/water separation.

These devices are appropriate for capturing hydrocarbon spills, but provide very marginal sediment removal and are not very effective for treatment of stormwater runoff. WQIs typically capture only the first portion of runoff for treatment and are generally used for pretreatment before discharging to other best management practices (BMPs).

Inspection/Maintenance Considerations

High sediment loads can interfere with the ability of the WQI to effectively separate oil and grease from the runoff. During periods of high flow, sediment can be resuspended and released from the WQI into surface waters. Maintenance of WQIs can be easily neglected because they are underground. Establishment of a maintenance schedule is helpful for ensuring proper maintenance occurs. The required maintenance effort will be site-specific due to variations in sediment and hydrocarbon loading. Since WQI residuals contain hydrocarbon by-products, they may require disposal as hazardous waste. Many WQI owners coordinate with waste haulers to collect and dispose of these residuals.

Maintenance Concerns, Objectives, and Goals

- High Sediment Loads
- Hazardous Waste
- Vector Control

Targeted Constituents

✓	Sediment	●
✓	Nutrients	●
✓	Trash	▲
✓	Metals	●
✓	Bacteria	●
✓	Oil and Grease	▲
✓	Organics	●
✓	Oxygen Demanding	●

Legend ***(Removal Effectiveness)***

● Low ■ High

▲ Medium

CASQA
California Stormwater Quality Association

Inspection Activities	Suggested Frequency
■ Inspect after every storm event to determine if maintenance is required.	Monthly during the wet season, or after significant rain events

Maintenance Activities	Suggested Frequency
■ Clean out and dispose of accumulated oil, grease, and sediments. Remove accumulated trash and debris. The clean out and disposal techniques should be environmentally acceptable and in accordance with local regulations.	Annual, before the wet season, or more frequent as needed

Additional Information

Since WQIs can be relatively deep, they may be designated as confined spaces. Caution should be exercised to comply with confined space entry safety regulations if it is required.

References

http://www.co.pierce.wa.us/pc/services/home/environ/water/swm/sppman/bmpt1.htm

Wetland

MP-20

General Description

A manufactured wetland is similar to public domain stormwater wetlands. In a manufactured wetland, gravel substrate and subsurface flow of the stormwater through the root systems force the vegetation to remove nutrients and dissolved pollutants from the stormwater.

Only one company currently manufactures a pre-engineered wetland: It consists of a standard module, about 9.5 feet in diameter and 4 feet in height. The module is constructed of recycled polyethylene. The number of units is varied to meet the design volume of the site.

Inspection/Maintenance Considerations

To maximize wetland removal of pollutants, the vegetation must be harvested frequently. Harvesting is particularly important with respect to the removal of phosphorus and metals, less so nitrogen. Harvesting should occur by mid-summer before the plants begin to transfer phosphorus from the aboveground foliage to subsurface roots, or begin to lose metals that desorb during plant die off. While not stated by the manufacturer, it is also desirable that every few years the entire plant mass including roots be harvested. This is because the belowground biomass constitutes a significant reservoir (possibly half) of the nutrients and metals that are removed from the stormwater by plants (Minton, 2002).

If pretreatment is provided then maintenance consideration must be given to the build up of debris and floatables.

Inspection Activities	Suggested Frequency
■ Inspect during the dry season to determine if irrigation of plants is necessary.	As needed
■ Inspect to verify that invasive species of wetland plants is not occurring.	Annual
Maintenance Activities	**Suggested Frequency**
■ Clean the center well.	As needed
■ Remove vegetation near end of each growth season to capture the nutrients and pollutants removed by the wetland vegetation.	Annual

Maintenance Concerns, Objectives, and Goals

- Vegetation/Landscape Maintenance
- Endangered Species Habitat Creation
- Pollutant Removal Efficiency
- Clogging of the Outlet
- Invasive/exotic Plant Species
- Vector Control

Targeted Constituents

✓ Sediment
✓ Nutrients
✓ Trash
✓ Metals
✓ Bacteria
✓ Oil and Grease
✓ Organics
✓ Oxygen Demanding

Removal Effectiveness

See New Development and Redevelopment BMP Handbook-Section 5.

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Media Filter

General Description

Stormwater media filters are usually two-chambered including a pretreatment settling basin and a filter bed filled with sand or other absorptive filtering media. As stormwater flows into the first chamber, large particles settle out, and then finer particles and other pollutants are removed as stormwater flows through the filtering media in the second chamber.

There are currently three manufacturers of stormwater filter systems. Two are similar in that they use cartridges of a standard size. The cartridges are placed in vaults; the number of cartridges a function of the design flow rate. The water flows laterally (horizontally) into the cartridge to a centerwell, then downward to an underdrain system. The third product is a flatbed filter, similar in appearance to sand filters.

Inspection/Maintenance Considerations

Media filters may exhibit decreased effectiveness after a few years of operation, depending on the activities occurring in the drainage area. Media filters clog easily when subjected to high sediment loads. Sediment reducing pretreatment practices, such as vegetated buffer strips or vegetated swales, placed upstream of the filter should be maintained properly to reduce sediment loads into filter. Media filters can become a nuisance due to mosquito or midge breeding if not properly designed and maintained. Installations should dewater completely (recommended 72 hour or less residence time) to prevent creating mosquito and other vector habitats. Maintenance efforts will need to focus on basic housekeeping practices such as removal of debris accumulations and vegetation management (in filter media) to prevent clogs and/or pods of standing water. To minimize the potential for clogging, frequent maintenance and inspection practices are required. Waste sand, gravel, filter cloth, or filter media must be disposed of properly and in accordance with all applicable laws.

Maintenance Concerns, Objectives, and Goals

- Pollutant Breakthrough
- Clogged of Sand Media
- Trash and Debris Accumulation

Targeted Constituents

- ✓ Sediment
- ✓ Nutrients
- ✓ Trash
- ✓ Metals
- ✓ Bacteria
- ✓ Oil and Grease
- ✓ Organics
- ✓ Oxygen Demanding

Removal Effectiveness

See New Development and Redevelopment BMP Handbook-Section 5.

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Inspection Activities	Suggested Frequency
■ During the first year of operation, inspect chambers quarterly to ensure that the system is functioning properly. ■ Inspect sand filters after every major storm in the first few months after construction to ensure that the system is functioning properly.	Post construction
■ Ensure that filter surface, inlets, and outlets are clear of debris. ■ Ensure that the contributing area is stabilized and mowed, with clippings removed. ■ Check to ensure that the filter surface is not clogging. ■ Ensure that activities in the drainage area minimize oil/grease and sediment entry to the system. ■ Inspect the facility once during the wet season after a large rain event to determine whether the facility is draining completely within 72 hr.	Quarterly, and after major storms
■ Inspect for standing water, sediment, trash and debris, structural damage, and to identify potential problems.	Semi-annual
■ Check to see that the filter bed is clean of sediments and the sediment chamber contains no more than six inches of sediment. ■ Make sure that there is no evidence of deterioration of concrete structures. ■ Inspect grates (if used). ■ Inspect inlets, outlets, and overflow spillway to ensure good condition and no evidence of erosion. ■ Ensure that flow is not bypassing the facility. ■ Ensure that no noticeable odors are detected outside the facility.	Annual
Maintenance Activities	**Suggested Frequency**
■ Remove trash and debris from the sedimentation basin (Austin design), the riser pipe, and the filter bed as needed. ■ Prevent grass clippings from washing into the filter. ■ Remove trash from inlet grates to maintain the inflow capacity of the media filter. ■ Upstream vegetation should be maintained as needed.	Frequently (as needed)
■ Clean filter surface semiannually; or more often if watershed is excessively erosive. ■ Replace sorbent pillows (Multi-Chamber Treatment Train only).	Semi-annual
■ Repair or replace any damaged structural parts. ■ Stabilize any eroded areas.	Annual
■ Remove accumulated sediment in the sedimentation chamber every 10 years or when the sediment occupies 10-20% of the basin volume or accumulates to a depth of six inches, whichever is less. ■ Remove top 2 in. of media filter and landfill if facility drain time exceeds 72 hr. Restore media depth to 18 in. when overall media depth drops to 12 in.).	As needed

References

Metropolitan Council, Urban Small Sites Best Management Practices Manual. Available at: http://www.metrocouncil.org/environment/Watershed/BMP/manual.htm

U.S. Environmental Protection Agency, Post-Construction Stormwater Management in New Development & Redevelopment BMP Factsheets. Available at: http://www.cfpub.epa.gov/npdes/stormwater/menuofbmps/bmp_files.cfm

Ventura Countywide Stormwater Quality Management Program, Technical Guidance Manual for Stormwater Quality Control Measures. July, 2002.

Wet Vault

General Description

A wet vault is a vault with a permanent water pool, generally 3 to 5 feet deep. The vault may also have a constricted outlet that causes a temporary rise of the water level (i.e., extended detention) during each storm. This live volume generally drains within 12 to 48 hours after the end of each storm.

Inspection/Maintenance Considerations

Maintenance of wet vaults requires special equipment. Each manufacturer provides storage capacities with respect to sediments and floatables, with recommendations on the frequency of cleaning as a function of the percentage of the volume in the unit that has been filled by these materials. There is concern about mosquito breeding in standing water. A loss of dissolved pollutants may occur as accumulated organic matter (e.g., leaves) decomposes in the units. If regular maintenance is not performed, accumulated sediment may cause noxious gases to form.

It is important to recognize that as storage of accumulated sediment occurs directly in the operating area of the wet vault, treatment efficiency will decline over time given the reduction in treatment volume. Whether this is significant depends on the design capacity. Some manufactured wet vaults have relatively little sediment storage and therefore must be cleaned frequently (e.g., annually) while others have sufficient capacity to reduce cleaning frequency. Vault maintenance procedures must meet OSHA confined space entry requirements.

Sediment should be tested for toxicants in compliance with current disposal requirements if land uses in the catchment include commercial or industrial zones, or if visual or olfactory indications of pollution are noticed.

Maintenance Concerns, Objectives, and Goals

- Sediment Removal
- Vector Control

Targeted Constituents

- ✓ Sediment
- ✓ Nutrients
- ✓ Trash
- ✓ Metals
- Bacteria
- ✓ Oil and Grease
- ✓ Organics
- ✓ Oxygen Demanding

Removal Effectiveness

See New Development and Redevelopment BMP Handbook-Section 5.

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Inspection Activities	Suggested Frequency
■ Inspect the unit twice during the first wet season of operation, setting the cleaning frequency accordingly.	Post construction
■ Inspect for floating debris, sediment buildup, and accumulated petroleum products.	Annual
Maintenance Activities	**Suggested Frequency**
■ Remove sediment that has accumulated in the vault after construction in the drainage area is complete.	Post construction
■ The recommended frequency of cleaning differs with the manufacturer, ranging from one to two years. ■ Maintenance consists of the removal of accumulated material with an eductor truck. It may be necessary to remove and dispose the floatables separately due to the presence of petroleum product. Annual maintenance is typical.	Annual, or per manufacturers recommendations
■ Remove floating debris and accumulated petroleum products as needed. Floating oil should be removed from wet vaults that are used as oil/water separators when oil accumulation exceeds one inch.	Annual, or more frequent as needed

References

Metropolitan Council, Urban Small Sites Best Management Practices Manual. Available at: http://www.metrocouncil.org/environment/Watershed/BMP/manual.htm

Vortex Separator

General Description

Vortex separators: (alternatively, swirl concentrators) are gravity separators, and in principle are essentially wet vaults. The difference from wet vaults, however, is that the vortex separator is round, rather than rectangular, and the water moves in a centrifugal fashion before exiting. By having the water move in a circular fashion, rather than a straight line as is the case with a standard wet vault, it is possible to obtain significant removal of suspended sediments and attached pollutants with less space. Vortex separators were originally developed for combined sewer overflows (CSOs), where it is used primarily to remove coarse inorganic solids. Vortex separation has been adapted to stormwater treatment by several manufacturers.

Inspection/Maintenance Considerations

As some of the systems have standing water that remains between storms, there is concern about mosquito breeding. Also, a loss of dissolved pollutants may occur as accumulated organic matter (e.g., leaves) decomposes in the units.

Inspection Activities	Suggested Frequency
■ Inspect for accumulated sediment/debris.	As needed
Maintenance Activities	**Suggested Frequency**
■ Remove of accumulated material with an eductor truck. It may be necessary to remove and dispose the floatables separately due to the presence of petroleum product.	Annual, or more frequent as needed

Maintenance Concerns, Objectives, and Goals

- Sediment/Debris Removal
- Vector Control

Targeted Constituents

✓ Sediment
✓ Nutrients
✓ Trash
✓ Metals
Bacteria
✓ Oil and Grease
✓ Organics
✓ Oxygen Demanding

Removal Effectiveness

See New Development and Redevelopment BMP Handbook-Section 5.

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