Construction Site Storm Water – Sediment Control

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This course was adapted from the Environmental Protection Agency (EPA) Best Management Practice relating to the "Sediment Control" section of the "Construction Site Storm Water Runoff Control", which is in the public domain.

Construction Site Storm Water Runoff Control

Regulatory Text

- You must develop, implement, and enforce a program to reduce pollutants in any storm water runoff to your small MS4 from construction activities that result in a land disturbance of greater than or equal to one acre. Reduction of storm water discharges from construction activity disturbing less than one acre must be included in your program if that construction activity is part of a larger common plan of development or sale that would disturb one acre or more. If the NPDES permitting authority waives requirements for storm water discharges associated with small construction activity in accordance with Sec. 122.26(b)(15)(i), you are not required to develop, implement, and/or enforce a program to reduce pollutant discharges from such sites.

- Your program must include the development and implementation of, at a minimum:

(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) Requirements for construction site operators to implement appropriate erosion and sediment control (ESC) best management practices;

(C) Requirements for construction site operators to control waste such as discarded building materials, concrete truck washout, chemicals, litter, and sanitary waste at the construction site that may cause adverse impacts to water quality;

(D) Procedures for site plan review which incorporate consideration of potential water quality impacts;

(E) Procedures for receipt and consideration of information submitted by the public, and

(F) Procedures for site inspection and enforcement of control measures.

Guidance

Examples of sanctions to ensure compliance include nonmonetary penalties, fines, bonding requirements, and/or permit denials for non-compliance. EPA recommends that procedures for site plan review include the review of individual pre-construction site plans to ensure consistency with local (ESC) requirements. Procedures for site inspections and enforcement of control measures could include steps to identify priority sites for inspection and enforcement based on the nature of the construction activity, topography, and the characteristics of soils and receiving water quality. You are encouraged to provide appropriate educational and training measures for construction site operators. You may wish to require a storm water pollution prevention plan for construction sites within your jurisdiction that discharge into your system. See Sec. 122.44(s) (NPDES permitting authorities' option to incorporate qualifying State, Tribal and local erosion and sediment control programs into NPDES permits for storm water discharges from construction sites). Also see Sec. 122.35(b) (The NPDES permitting authority may recognize that another government entity, including the permitting authority, may be responsible for implementing one or more of the minimum measures on your behalf).

BMP Fact Sheets

Runoff Control

Minimize clearing

Land grading

Permanent diversions

Preserving natural vegetation

Construction entrances

Stabilize drainage ways

Check dams

Filter berms

Grass-lined channels

Riprap

Erosion Control

Stabilize exposed soils

Chemical stabilization

Mulching

Permanent seeding

Sodding

Soil roughening

Protect steep slopes

Geotextiles

Gradient terraces

Soil retention

Temporary slope drain

Protect waterways

Temporary stream crossings

Vegetated buffer

Phase construction

Construction sequencing

Dust control

Sediment Control

Install perimeter controls

Temporary diversion dikes

Wind fences and sand fences

Brush barrier

Silt fence

Install sediment trapping devices

Sediment basins and rock dams

Sediment filters and sediment chambers

Sediment trap

Inlet protection

Storm drain inlet protection

Good Housekeeping

Other wastes

General construction site waste management

Spill prevention and control plan

Vehicle maintenance and washing areas

Education and awareness

Contractor certification and inspector training

Construction reviewer

BMP inspection and maintenance

Model ordinances

Additional Fact Sheets

Turf Reinforcement Mats

Vegetative Covers

Dust Control

Sediment Control

Install perimeter controls

Temporary Diversion Dikes, Earth Dikes, and Interceptor Dikes

Construction Site Storm Water Runoff Control

Description

Diversion dikes can be used to contain storm water onsite

Earthen perimeter controls usually consist of a dike or a combination dike and channel constructed along the perimeter of a disturbed site. Simply defined, an earthen perimeter control is a ridge of compacted soil, often accompanied by a ditch or swale with a vegetated lining, located at the top or base of a sloping disturbed area. Depending on their location and the topography of the landscape, earthen perimeter controls can achieve one of two main goals.

Located on the upslope side of a site, earthen perimeter controls help to prevent surface runoff from entering a disturbed construction site. An earthen structure located upslope can improve working conditions on a construction site by preventing an increase in the total amount of sheet flow runoff traveling across the disturbed area and thereby lessen erosion on the site.

Alternatively, earthen perimeter control structures can be located on the downslope side of a site to divert sediment-laden runoff created onsite to onsite sediment trapping devices, preventing soil loss from the disturbed area.

These control practices can be referred to by a number of terms, including temporary diversion dikes, earth dikes, or interceptor dikes. Generally speaking, however, all earthen perimeter controls are constructed in a similar fashion with a similar objective—to control the velocity and/or route of sediment-laden storm water runoff.

Applicability

Temporary diversion dikes are applicable where it is desirable to divert flows away from disturbed areas such as cut or fill slopes and to divert runoff to a stabilized outlet (EPA, 1992). The dikes can be erected at the top of a sloping area or in the middle of a slope to divert storm water runoff around a disturbed construction site. In this way, earth dikes can be used to reduce the length of the slope across which runoff will travel, thereby reducing the erosion potential of the flow. If placed at the bottom of a sloping disturbed area, diversion dikes can divert flow to a sediment trapping device. Temporary diversion dikes are usually appropriate for drainage basins smaller than 5 acres, but with modifications they can be capable of servicing areas as large as 10 acres. With regular maintenance, earthen diversion dikes have a useful life span of approximately 18 months.

To prevent storm water runoff from entering a site, earthen perimeter controls can be used to divert runoff from areas upslope around the disturbed construction site. This is accomplished by constructing a continuous, compacted earthen mound along the upslope perimeter of the site. As an additional control measure, a shallow ditch can accompany the earthen mound.

Siting and Design Considerations

The siting of earthen perimeter controls depends on the topography of the area surrounding a specific construction site and on whether the goal is to prevent sediment-laden runoff from entering the site or to keep storm water runoff from leaving the site. When determining the appropriate size and design of earthen perimeter controls, the shape of the surrounding landscape and drainage patterns should be considered. Also, the amount of runoff to be diverted, the velocity of runoff in the diversion, and the erodibility of soils on the slope and within the diversion channel or swale are essential design considerations (WSDE, 1992).

Diversion dikes should be constructed and fully stabilized prior to commencement of major land disturbance. This will maximize the effectiveness of the diversion measure as an erosion and sediment control device.

The top of earthen perimeter controls designed as temporary flow diversion measures should be at least 2 feet wide. Bottom width at ground level is typically 6 feet. The minimum height for earthen dikes should be 18 inches, with side slopes no steeper than 2:1. For points where vehicles will cross the dike, the slope should be no steeper than 3:1 and the mound should be constructed of gravel rather than soil. This will prolong the life of the dike and increase effectiveness at the point of vehicle crossing.

If a channel is excavated along the dike, its shape can be parabolic, trapezoidal, or V-shaped. Prior to excavation or mound building, all trees, brush, stumps and other objects in the path of the diversion structure should be removed and the base of the dike should be tilled before laying the fill. The maximum design flow velocity should range from 1.5 to 5.0 feet per second, depending on the vegetative cover and soil texture.

Most earthen perimeter structures are designed for short-term, temporary use. If the expected life span of the diversion structure is greater than 15 days, it is strongly recommended that both the earthen dike and the accompanying ditch be seeded with vegetation immediately after construction. This will increase the stability of the perimeter control and can decrease the need for frequent repairs and maintenance.

Limitations

Earth dikes are an effective means of diverting sediment-laden storm water runoff around a disturbed area. However, the concentrated runoff in the channel or ditch has increased erosion potential. To alleviate this erosion capability, diversion dikes must be directed to sediment trapping devices, where erosion sediment can settle out of the runoff before being discharged to surface waters. Examples of appropriate sediment trapping devices that might be used in conjunction with temporary diversion structures include a sediment basin, a sediment chamber/filter, or any other structure designed to allow sediment to be collected for proper disposal.

If a diversion dike crosses a vehicle roadway or entrance, its effectiveness can be reduced. Wherever possible, diversion dikes should be designed to avoid crossing vehicle pathways.

Maintenance Considerations

Earthen diversion dikes should be inspected after each rainfall to ensure continued effectiveness. The dike should be maintained at the original height, and any decrease in height due to settling or erosion should be repaired immediately. To remain effective, earth dikes must be compacted at all times. Regardless of rainfall frequency, dikes should be inspected at least once every 2 weeks for evidence of erosion or deterioration.

Effectiveness

When properly placed and maintained, earth dikes used as temporary diversions are effective for controlling the velocity and direction of storm water runoff. Used by themselves, they do not have any pollutant removal capability. Diversion dikes must be used in combination with an appropriate sediment trapping device at the outfall of the diversion channel.

Cost Considerations

The cost of constructing an earthen dike can be broken down into two components: (1) site preparation, including excavation, placement and compacting of fill, and grading, and (2) site development, including topsoiling and seeding for vegetative cover. The Southeastern Wisconsin Regional Planning Commission (1991) estimated the total cost of site preparation to be $46.33 to $124.81 for a 100-foot dike with 1.5-foot-deep, 3:1 side slopes. The cost of site development was estimated at $115.52 to $375.44. The total cost was between $162 and $500.

References

Smolen, M.D., D.W. Miller, L.C. Wyall, J. Lichthardt, and A.L. Lanier. 1988. *Erosion and Sediment Control Planning and Design Manual*. North Carolina Sedimentation Control Commission, North Carolina Department of Environment, Health, and Natural Resources, and Division of Land Resources Land Quality Section, Raleigh, NC.

USEPA. 1992. *Storm Water Management for Construction Activities: Developing Pollution Prevention Plans and Best Management Practices*. EPA 832-R-92-005. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

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Wind Fences and Sand Fences

Construction Site Storm Water Runoff Control

Description

A Sand fences are barriers of small, evenly spaced wooden slats or fabric erected to reduce wind velocity and to trap blowing sand. They can be used effectively as perimeter controls around open construction sites to reduce the off-site movement of fine sediments transported by wind. They also prevent off-site damage to roads, streams, and adjacent properties. The spaces between fence slats allow wind and sediment to pass through but reduces the wind velocity, which causes sediment deposition along the fence.

Sand fences are used to trap blowing sand and to reduce offsite movement of sand particles

Applicability

Wind fences are applicable to areas with a preponderance of loose, fine-textured soils that can be transported off-site by high winds. They are especially advantageous for construction sites with large areas of cleared land or in arid regions where blowing sand and dust are especially problematic. Shorefront development sites also benefit from using wind fences because they promote the formation of frontal dunes.

Siting and Design Considerations

Effective trapping of sediment and reduction of wind velocity occurs only when the fence is erected perpendicular to the prevailing wind. Although wind fences have been shown effective up to 22.5 degrees from perpendicular, they should be erected as close to perpendicular to the movement of wind as possible (Smolen et al., 1988). Multiple fences can be erected to increase sediment-trapping efficiency, depending on the degree of protection desired. Linear rows of fence 2 to 4 feet high and spaced 20 to 40 feet apart can be installed. When used on shoreline beaches, wind fences should be installed well away from the incoming tide.

Limitations

A wind fence does not control sediment carried in storm water runoff. Wind fences should be installed in conjunction with other sediment and erosion control measures that capture sediment from runoff.

Maintenance Considerations

Wind fences require periodic inspection to ensure that there are no breaks or gaps. Repairs should be made immediately. Sand and sediment should be cleaned from the fence area periodically to prevent their mobilization by storm water runoff.

Effectiveness

Wind fences are very effective for promoting dune formation along shoreline areas, but are not adequate as a primary dust control or sediment-trapping measure for perimeters of construction sites. They should be used only in conjunction with other erosion and sediment control practices.

Cost Considerations

Wind and sand fences are relatively inexpensive to purchase, install, and maintain because they are small, easy to transport, lightweight, and constructed of low-cost materials.

References

Smolen, M.D., D.W. Miller, L.C. Wyatt, J. Lichthardt, and A.L. Lanier. 1988. *Erosion and Sediment Control Planning and Design Manual*. North Carolina Sedimentation Control Commission, North Carolina Department of Environment, Health, and Natural Resources, and Division of Land Resources Land Quality Section, Raleigh, NC.

Brush Barrier

Construction Site Storm Water Runoff Control

Description

Brush barriers trap sediment and remove pollutants from storm water

Brush barriers are perimeter sediment control structures used to prevent soil in storm water runoff from leaving a construction site. Brush barriers are constructed of material such as small tree branches, root mats, stone, or other debris left over from site clearing and grubbing. In some configurations, brush barriers are covered with a filter cloth to stabilize the structure and improve barrier efficiency.

Applicability

Brush barriers are applicable to sites where there is enough material from clearing and grubbing to form a sufficient mound of debris along the perimeter of an area. The drainage area for brush barriers must be no greater than 0.25 acre per 100 feet of barrier length. In addition, the drainage slope leading down to a brush barrier must be no greater than 2:1 and no longer than 100 feet. Brush barriers have limited usefulness because they are constructed of materials that decompose.

Siting and Design Considerations

A brush barrier can be constructed using only cleared material from a site, but it is recommended that the mound be covered with a filter fabric barrier to hold the material in place and increase sediment barrier efficiency. Whether a filter fabric cover is used or not, the barrier mound should be at least 3 feet high and 5 feet wide at its base. Material with a diameter larger than 6 inches should not be used, as this material may be too bulky and create void spaces where sediment and runoff will flow through the barrier.

The edge of the filter fabric cover should be buried in a trench 4 inches deep and 6 inches wide on the drainage side of the barrier. This is done to secure the fabric and create a barrier to sediment while allowing storm water to pass through the water-permeable filter fabric. The filter fabric should be extended just over the peak of the brush mound and secured on the down-slope edge of the fabric by fastening it to twine or small-diameter rope that is staked securely.

Limitations

Brush barriers are an effective storm water runoff control only when the contributing flow has a slow velocity. Brush barriers are therefore not appropriate for high-velocity flow areas. A large amount of material is needed to construct a useful brush barrier. For sites with little material from clearing, alternative perimeter controls such as a fabric silt fence may be more appropriate. Although brush barriers provide temporary storage for large amounts of cleared material from a site, this material will ultimately have to be removed from the site after construction activities have ceased and the area reaches final stabilization.

Maintenance Considerations

Brush barriers should be inspected after each significant rainfall event to ensure continued effectiveness. If channels form through void spaces in the barrier, the barrier should be reconstructed to eliminate the channels. Accumulated sediment should be removed from the uphill side of the barrier when sediment height reaches between 1/3 and 1/2 the height of the barrier. When the entire site has reached final stabilization, the brush barrier should be removed and disposed of properly.

Effectiveness

Brush barriers can be effective at reducing off-site sediment transport, and their effectiveness is greatly increased with the use of a fabric cover on the up-slope side of the brush barrier.

Cost Considerations

Creating brush barriers can range in cost from $390 to $620, depending upon the equipment used, vegetation type (heavy or light), fuel price, personnel, amount of filter fabric needed (if used), and the number of hours to perform the task. A common filter fabric, geotextile, can range in cost from $0.50 to $10.00/square yard, depending upon the type of geotextile used.

References

Casados, A., and Leyba, P. Forest Engineers, Santa Fe National Forest, personal communication, February 7, 2000.

Straw Wattles. 2000. *Photos: Mine1*. [http://www.strawwattles.com/photos/mine1.jpg]. Accessed January 2001.

VDCR. 1995. *Virginia Erosion & Sediment Control Field Manual*. Second Edition. Virginia Department of Conservation, Division of Soil and Water Conservation.

Silt Fence

Construction Site Storm Water Runoff Control

Description

Silt fences are used as temporary perimeter controls around sites where there will be soil disturbance due to construction activities. They consist of a length of filter fabric stretched between anchoring posts spaced at regular intervals along the site perimeter. The filter fabric should be entrenched in the ground between the support posts. When installed correctly and inspected frequently, silt fences can be an effective barrier to sediment leaving the site in storm water runoff.


Silt fences prevent the offsite transport of sediment

Applicability

Silt fences are generally applicable to construction sites with relatively small drainage areas. They are appropriate in areas where runoff will be occurring as low-level shallow flow, not exceeding 0.5 cfs. The drainage area for silt fences generally should not exceed 0.25 acre per 100-foot fence length. Slope length above the fence should not exceed 100 feet (NAHB, 1995).

Siting and Design Considerations

Material for silt fences should be a pervious sheet of synthetic fabric such as polypropylene, nylon, polyester, or polyethylene yarn, chosen based on minimum synthetic fabric requirements, as shown in Table 1.

Table 1. Minimum requirements for silt fence construction (Sources: USEPA, 1992; VDCR, 1995)

Physical Property	Requirements
Filtering Efficiency	75–85% (minimum): highly dependent on local conditions
Tensile Strength at 20% (maximum) Elongation	Standard Strength: 30 lbs/linear inch (minimum) Extra Strength: 50 lbs/linear inch (minimum)
Ultraviolet Radiation	90% (minimum)
Slurry Flow Rate	0.3 gal/ft2/min (minimum)

If a standard strength fabric is used, it can be reinforced with wire mesh behind the filter fabric. This can increase the effective life of the fence. In any case, the maximum life expectancy for synthetic fabric silt fences is approximately 6 months, depending on the amount of rainfall and runoff for a given area. Burlap fences have a much shorter useful life span, usually only up to 2 months.

Stakes used to anchor the filter fabric should be either wooden or metal. Wooden stakes should be at least 5 feet long and have a minimum diameter of 2 inches if a hardwood such as oak is used. Softer woods such as pine should be at least 4 inches in diameter. When using metal post in place of wooden stakes, they should have a minimum weight of 1.00 to 1.33 lb/linear foot. If metal posts are used, attachment points are needed for fastening the filter fabric using wire ties.

A silt fence should be erected in a continuous fashion from a single roll of fabric to eliminate unwanted gaps in the fence. If a continuous roll of fabric is not available, the fabric should overlap from both directions only at stakes or posts with a minimum overlap of 6 inches. A trench should be excavated to bury the bottom of the fabric fence at least 6 inches below the ground surface. This will help prevent gaps from forming near the ground surface that would render the fencing useless as a sediment barrier.

The height of the fence posts should be between 16 and 34 inches above the original ground surface. If standard strength fabric is used in combination with wire mesh, the posts should be spaced no more than 10 feet apart. If extra-strength fabric is used without wire mesh reinforcement, the support posts should be spaced no more than 6 feet apart (VDCR, 1995).

The fence should be designed to withstand the runoff from a 10-year peak storm event, and once installed should remain in place until all areas up-slope have been permanently stabilized by vegetation or other means.

Limitations

Silt fences should not be installed along areas where rocks or other hard surfaces will prevent uniform anchoring of fence posts and entrenching of the filter fabric. This will greatly reduce the effectiveness of silt fencing and can create runoff channels leading off site. Silt fences are not suitable for areas where large amounts of concentrated runoff are likely. In addition, open areas where wind velocity is high may present a maintenance challenge, as high winds may accelerate deterioration of the filter fabric. Silt fences should not be installed across streams, ditches, or waterways (Smolen et al., 1988).

When the pores of the fence fabric become clogged with sediment, pools of water are likely to form on the uphill side of fence. Siting and design of the silt fence should account for this and care should be taken to avoid unnecessary diversion of storm water from these pools that might cause further erosion damage.

Maintenance Considerations

Silt fences should be inspected regularly and frequently as well as after each rainfall event to ensure that they are intact and that there are no gaps at the fence-ground interface or tears along the length of the fence. If gaps or tears are found, they should be repaired or the fabric should be replaced immediately. Accumulated sediments should be removed from the fence base when the sediment reaches one-third to one-half the height of the fence. Sediment removal should occur more frequently if accumulated sediment is creating noticeable strain on the fabric and there is the possibility of the fence failing from a sudden storm event. When the silt fence is removed, the accumulated sediment also should be removed.

Effectiveness

USEPA (1993) reports the following effectiveness ranges for silt fences constructed of filter fabric that are properly installed and well maintained: average total suspended solids removal of 70 percent, sand removal of 80 to 90 percent, silt-loam removal of 50 to 80 percent, and silt-clay-loam removal of 0 to 20 percent. Removal rates are highly dependent on local conditions and installation.

Cost Considerations

Installation costs for silt fences are approximately $6.00 per linear foot (USEPA, 1992). SWRPC estimates unit costs between $2.30 and $4.50 per linear foot (SWRPC, 1991).

References

NAHB. 1995. *Guide for Builders and Developers*. National Association of Homebuilders, Washington, DC.

Smolen, M.D., D.W. Miller, L.C. Wyatt, J. Lichthardt, and A.L. Lanier. 1988. *Erosion and Sediment Control Planning and Design Manual*. North Carolina Sedimentation Control Commission, North Carolina Department of Environment, Health, and Natural Resources, and Division of Land Resources Land Quality Section, Raleigh, NC.

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Install sediment trapping devices

Sediment Basins and Rock Dams

Construction Site Storm Water Runoff Control

Description

Sediment basins and rock dams are two ways to capture sediment from storm water runoff before it leaves a construction site. Both structures allow a shallow pool to form in an excavated or natural depression where sediment from storm water runoff can settle. Basin dewatering is achieved either through a single riser and drainage hole leading to a suitable outlet on the downstream side of the embankment or through the gravel of the rock dam. In both cases, water is released at a substantially slower rate than would be possible without the control structure.

Sediment basins are used to trap sediments and temporarily detain runoff on larger construction sites

A sediment basin can be constructed by excavation or by erecting an earthen embankment across a low area or drainage swale. The basin can be either a temporary (up to 3 years) structure or a permanent storm water control measure. Sediment basins can be designed to drain completely during dry periods, or they can be constructed so that a shallow, permanent pool of water remains between storm events. However, depending on the size of the basin constructed, the basin may be considered a wet pond and subject to additional regulation.

Rock dams are similar in design to sediment basins with earthen embankments. These damming structures are constructed of rock and gravel and release water from the settling pool gradually through the spaces between the rock aggregate.

Applicability

Sediment basins are usually used for drainage areas of 5 to 100 acres. They can be temporary or permanent structures. Generally, sediment basins designed to be used for up to 3 years are described as temporary, while those designed for longer service are said to be permanent. Temporary sediment basins can be converted into permanent storm water runoff management ponds, but they must meet all regulatory requirements for wet ponds.

Sediment basins are applicable in drainage areas where it is anticipated that other erosion controls, such as sediment traps, will not be sufficient to prevent off-site transport of sediment. Choosing to construct a sediment basin with either an earthen embankment or a stone/rock dam will depend on the materials available, location of the basin, and desired capacity for storm water runoff and settling of sediments.

Rock dams are suitable where earthen embankments would be difficult to construct or where riprap is readily available. Rock structures are also desirable where the top of the dam structure is to be used as an overflow outlet. These riprap dams are best for drainage areas of less than 50 acres. Earthen damming structures are appropriate where failure of the dam will not result in substantial damage or loss of property or life. If properly constructed, sediment basins with earthen dams can handle storm water runoff from drainage basins as large as 100 acres.

Siting and Design Considerations

The potential sites for sediment basins should be investigated during the initial site evaluation. Basins should be constructed before any grading takes place within the drainage area. For structures that will be permanent, the design of the basin should be completed by a qualified professional engineer experienced in the design of dams.

Sediment basins with rock dams should be limited to a drainage area of 50 acres. Rock dam height should be limited to 8 feet with a minimum top width of 5 feet. Side slopes for rock dams should be no steeper than 2:1 on the basin side of the structure and 3:1 on the outlet side. The basin side of the rock dam should be covered with fine gravel from top to bottom for a minimum of 1 foot. This will slow the drainage rate from the pool that forms and allow time for sediments to settle. The detention time should be at least 8 hours.

Sediment basins with earthen embankments should be outfitted with a dewatering pipe and riser set just above the sediment removal cutoff level. The riser pipe should be located at the deepest point of the basin and extend no farther than 1 foot below the level of the earthen dam. A water-permeable cover should be placed over the primary dewatering riser pipe to prevent trash and debris from entering and clogging the spillway. To provide an additional path for water to enter the primary spillway, secondary dewatering holes can be drilled near the base of the riser pipe, provided the holes are protected with gravel to prevent sediment from entering the spillway piping.

To ensure adequate drainage, the following equation can be used to approximate the total area of dewatering holes for a particular basin (Smolen et al., 1988):

$$A_o = (A_s \text{ x } (2h) / (T \text{ x } C_d \text{ x } 20{,}428)$$

where

A_o = total surface area of dewatering holes, ft^2;

A_s = surface area of the basin, ft^2;

h = head of water above the hole, ft;

C_d = coefficient of contraction for an orifice, approximately 0.6; and

T = detention time or time needed to dewater the basin, hours.

In all cases, such structures should be designed by an appropriate professional based on local hydrologic, hydraulic, topographic, and sediment conditions.

Limitations

Neither a sediment basin with an earthen embankment nor a rock dam should be used in areas of continuously running water (live streams). The use of sediment basins is not intended for areas where failure of the earthen or rock dam will result in loss of life, or damage to homes or other buildings. In addition, sediment basins should not be used in areas where failure will prevent the use of public roads or utilities.

Maintenance Considerations

Routine inspection and maintenance of sediment basins is essential to their continued effectiveness. Basins should be inspected after each storm event to ensure proper drainage from the collection pool to determine the need for structural repairs. Erosion from the earthen embankment or stones moved from rock dams should be replaced immediately. Sediment basins must be located in an area that is easily accessible to maintenance crews for removal of accumulated sediment. Sediment should be removed from the basin when its storage capacity has reached approximately 50 percent. Trash and debris from around dewatering devices should be removed promptly after rainfall events.

Effectiveness

The effectiveness of a sediment basin depends primarily on the sediment particle size and the ratio of basin surface area to inflow rate (Smolen et al., 1988). Basins with a large surface area-to-volume ratio will be most effective. Studies have shown that the following equation relating surface area and peak inflow rate gives a trapping efficiency greater than 75 percent for most sediment in the Coastal Plain and Piedmont regions of the Southeastern United States (Barfield and Clar, in Smolen et al., 1988):

$$A = 0.01q$$

where A is the basin surface area in acres and q is the peak inflow rate in cubic feet per second.

USEPA (1993) estimates an average total suspended solids (TSS) removal rate for all sediment basins from 55 percent to 100 percent, with an average effectiveness of 70 percent.

Cost Considerations

If constructing a sediment basin with less than 50,000 ft^3 of storage space, the cost of installing the basin ranges from $0.20 to $1.30 per cubic foot of storage (about $1,100 per acre of drainage). The average cost for basins with less than 50,000 ft^3 of storage is approximately $0.60 per cubic foot of storage (USEPA, 1993). If constructing a sediment basin with more than 50,000 ft^3 of storage space, the cost range of installing the basin ranges from $0.10 to $0.40 per cubic foot of storage (about $550 per acre of drainage). The average cost for basins with greater than 50,000 ft^3 of storage is approximately $0.30 per cubic foot of storage (USEPA, 1993).

References

Smolen, M.D., D.W. Miller, L.C. Wyatt, J. Lichthardt, and A.L. Lanier. 1988. *Erosion and Sediment Control Planning and Design Manual*. North Carolina Sedimentation Control Commission, North Carolina Department of Environment, Health, and Natural Resources, and Division of Land Resources Land Quality Section, Raleigh, NC.

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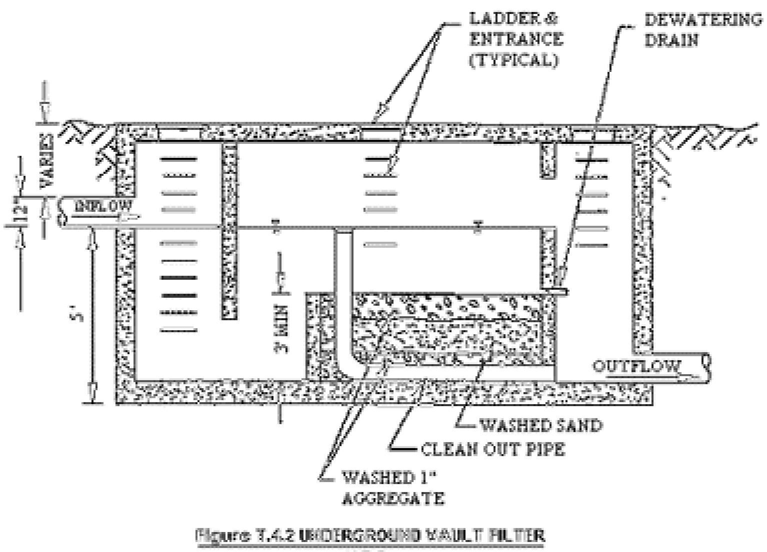
Sediment Filters and Sediment Chambers

Construction Site Storm Water Runoff Control

Description

Sediment filters are a class of sediment-trapping devices typically used to remove pollutants, primarily particulates, from storm water runoff. Generally speaking, sediment filters have four basic components: (1) inflow regulation, (2) pretreatment, (3) filter bed, and (4) outflow mechanism. Sediment chambers are merely one component of a sediment filter system.

Inflow regulation refers to the diversion of storm water runoff into the sediment-trapping device. After runoff enters the filter system, it enters a pretreatment sedimentation chamber. This chamber, used as a preliminary settling area for large debris and sediments, usually consists of nothing more than a wet detention basin. As water reaches a predetermined level, it flows over a weir into a filter bed of some filter medium. The filter medium is typically sand, but it can consist of sand, soil, gravel, peat, compost, or a combination of these materials. The purpose of the filter bed is to remove smaller sediments and other pollutants from the storm water as it percolates through the filter medium. Finally, treated flow exits the sediment filter system via an outflow mechanism to return to the storm water conveyance system.



Schematic representation of a sediment filter

Sediment filter systems can be confined or unconfined, on-line or off-line, and aboveground or belowground. Confined sediment filters are constructed with the filter medium contained in a structure, often a concrete vault. Unconfined sediment filters are constructed without encasing the filter medium in a confining structure. As one example, sand might be placed on the banks of a permanent wet pond detention system to create an unconfined filter. On-line systems are designed to retain storm water in its original stream channel or storm drain system. Off-line systems are designed to divert storm water.

Applicability

Sediment filters may be a good alternative for smaller construction sites where the use of a wet pond is being considered as a sediment-trapping device. Their applicability is wide ranging, and they can be used in urban areas with large amounts of highly impervious area. Because confined sand filters are man-made soil systems, they can be applied to most development sites and have few constraining factors (MWCOG, 1992). However, for all sediment filter systems, the drainage area to be serviced should be no more than 10 acres.

The type of filter system chosen depends on the amount of land available and the desired location within the site. Examples of sediment filter systems include the "Delaware" sand filter and the "Austin" sand filter. The Austin sand filter, so named because it first came into widespread use in Austin, Texas, is a surface filter system that can be used in areas with space restrictions. If space is at a premium, an underground filter may be the most appropriate choice. For effective storm water sediment control at the perimeter of a site, the Delaware sand filter might be a good choice. This configuration consists of two parallel, trench-like chambers installed at a site's perimeter. The first trench (sediment chamber) provides pretreatment sediment settling before the runoff spills into the second trench (filter medium).

Siting and Design Considerations

Available space is likely to be the most important siting and design consideration when choosing an appropriate sediment-filtering system. As mentioned previously, the decision as to which configuration is implemented on a particular site is dependent on the amount of space on a site. Another important consideration when deciding to install sediment-filtering systems is the amount of available head. Head refers to the vertical distance available between the inflow of the filter system and the outflow point. Because most filtering systems depend on gravity as the driving force to move water through the system, if a certain amount of head is not available, the system will not be effective and might cause more harm than good. For surface and underground sand filters, a minimum head of 5 feet is suggested (Claytor and Schueler, 1996). Perimeter sand filters such as the two-chambered Delaware sand filter should have a minimum available head of 2 to 3 feet (Claytor and Schueler, 1996).

The depth of filter media will vary depending on media type, but for sand filters it is recommended that the sand (0.04-inch diameter or smaller) be at least 18 inches deep, with a minimum of 4 to 6 inches of gravel for the bed of the filter. Throughout the life of a sediment filter system, there will be a need for frequent access to assess continued effectiveness and perform routine maintenance and emergency repairs. Because most maintenance of sediment filters requires manual rather than mechanical removal of sediments and debris, filter systems should be located to allow easy access.

Limitations

Sediment filters are usually limited to the removal of pollutants from storm water runoff. They must be used in combination with other storm water management practices to provide flood protection. Sediment filters should not be used on fill sites or near steep slopes (Livingston, 1997). In addition, sediment filters are likely to lose effectiveness in cold regions because of freezing conditions.

Maintenance Considerations

Maintenance of storm water sediment filters can be relatively high compared to other sediment-trapping devices. Routine maintenance includes raking the filter medium and removal of surface sediment and trash. These maintenance chores will likely need to be accomplished by manual labor rather than mechanical means. Depending on the medium used in the structure, the filter material may have to be changed or replaced up to several times a year. This will depend, among other things, on rainfall intensity and the expected sediment load.

Sediment filters of all media types should be inspected monthly and after each significant rainfall event to ensure proper filtration. Trash and debris removal should be removed during inspections. Sediment should be removed from filter inlets and sediment chambers when 75 percent of the storage volume has been filled. Because filter media have the potential for high loadings of metals and petroleum hydrocarbons, the filter medium should be periodically analyzed to prevent it from reaching levels that would classify it as a hazardous waste. This is especially true on sites where solvents or other potentially hazardous chemicals will be used. Spill prevention measures should be implemented as necessary. The top 3 to 4 inches of the filter medium should be replaced on an annual basis, or more frequently if drawdown does not occur within 36 hours of a storm event.

Effectiveness

Treatment effectiveness will depend on a number of factors, including treatment volume; whether the filter is on-line or off-line, confined or unconfined; and the type of land use in the contributing drainage area. MWCOG (1992) state that sand filter removal rates are "high" for sediment and trace metals and "moderate" for nutrients, BOD, and fecal coliform. Removal rates can be increased slightly by using a peat/sand mixture as the filter medium due to the adsorptive properties of peat (MWCOG, 1992). Estimated pollutant removal capabilities for various storm water sediment filter systems is shown in Table 1.

Table 1. Pollutant removal efficiencies for sand filters.

Source	Filter System	TSS[a] (%)	TP[a] (%)	TN[a] (%)	Other Pollutants
Claytor and Schueler, 1996	Surface Sand Filter	85	55	35	Bacteria: 40-80% Metals: 35-90%
	Perimeter Sand Filter	80	65	45	Hydrocarbons: 80%
Livingston, 1997	Sand Filter (general)	60–85	30–75	30–60	Metals: 30–80%

[a]TSS=total suspended solids; TP=total phosphorus; TN=total nitrogen

Cost Considerations

MWCOG (1992) estimates cost of construction for sand filters to be between \$3.00 and \$10.00 per cubic foot of runoff treated. Annual costs are estimated to be approximately 5 percent of construction costs.

References

Claytor, R., and T. Schueler. 1996. *Design of Stormwater Filtering Systems*. Center for Watershed Protection, Silver Spring, MD.

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Sediment Trap

Construction Site Storm Water Runoff Control

Description

Sediment traps are used to collect sediment-laden runoff from disturbed areas on construction sites

Sediment traps are small impoundments that allow sediment to settle out of runoff water. They are usually installed in a drainageway or other point of discharge from a disturbed area. Temporary diversions can be used to direct runoff to the sediment trap (USEPA, 1993). Sediment traps are used to detain sediments in storm water runoff and trap the sediment to protect receiving streams, lakes, drainage systems, and the surrounding area.

Sediment traps are formed by excavating an area or by placing an earthen embankment across a low area or drainage swale. An outlet or spillway is often constructed using large stones or aggregate to slow the release of runoff (USEPA, 1992).

Applicability

Sediment traps are generally temporary control measures to slow concentrated runoff velocity and catch sediment, and they can be used with other temporary storm water control measures. They are commonly used at the outlets of storm water diversion structures, channels, slope drains, construction site entrance wash racks, or any other runoff conveyance that discharges waters containing erosion sediment and debris. Sediment traps can also be used as part of a storm water drop intake protection system when the inlet is located below a disturbed area and will receive runoff with large amounts of sediment.

Siting and Design Considerations

Sediment traps can simplify the storm water control plan design process by trapping sediment at specific spots at a construction site (USEPA, 1992). Therefore, they should be installed as early in the construction process as possible. Natural drainage patterns should be noted, and sites where runoff from potential erosion can be directed into the traps should be selected. Sediment traps should not be located in areas where their failure due to storm water runoff excess can lead to further erosive damage of the landscape. Alternative diversion pathways should be designed to accommodate these potential overflows.

A sediment trap should be designed to maximize surface area for infiltration and sediment settling. This will increase the effectiveness of the trap and decrease the likelihood of backup during and after periods of high runoff intensity. Although site conditions will dictate specific design criteria, the approximate storage capacity of each trap should be at least 1,800 ft^3 per acre of total drainage area

(Smolen et al., 1988). The volume of a natural sedimentation trap can be approximated by the following equation (Smolen et al., 1988):

$$\text{Volume (ft}^3\text{) = 0.4 x surface area (ft}^2\text{) x maximum pool depth (ft)}$$

Care should be taken in the siting and design phase to situate sediment traps for easy access by maintenance crews. This will allow for proper inspection and maintenance on a periodic basis. When excavating an area for sediment trap implementation, side slopes should not be steeper than 2:1 and embankment height should not exceed 5 feet from the original ground surface. All embankments should be machine compacted to ensure stability. To reduce flow rate from the trap, the outlet should be lined with well-graded stone.

The spillway weir for each temporary sediment trap should be at least 4 feet long for a 1-acre drainage area and increase by 2 feet for each additional drainage acre added, up to a maximum drainage area of 5 acres.

Limitations

Sediment traps should not be used for drainage areas greater than 5 acres (USEPA, 1993). The effective life span of these temporary structures is usually limited to 24 months (Smolen et al., 1988). Although sediment traps allow for settling of eroded soils, because of their short detention periods for storm water they typically do not remove fine particles such as silts and clays.

Maintenance Considerations

The primary maintenance consideration for temporary sediment traps is the removal of accumulated sediment from the basin. This must be done periodically to ensure the continued effectiveness of the sediment trap. Sediments should be removed when the basin reaches approximately 50 percent sediment capacity. A sediment trap should be inspected after each rainfall event to ensure that the trap is draining properly. Inspectors should also check the structure for damage from erosion. The depth of the spillway should be checked and maintained at a minimum of 1.5 feet below the low point of the trap embankment.

Effectiveness

Sediment trapping efficiency is a function of surface area, inflow rate, and the sediment properties (Smolen et al., 1988). Those traps that provide pools with large length-to-width ratios have a greater chance of success. Sediment traps have a useful life of approximately 18 to 24 months (USEPA, 1993), although ultimately effectiveness depends on the amount and intensity of rainfall and erosion, and proper maintenance. USEPA (1993) estimates an average total suspended solids removal rate of 60 percent. An efficiency rate of 75 percent can be obtained for most Coastal Plain and Piedmont soils by using the following equation (Barfield and Clar, in Smolen et al., 1988):

$$\text{Surface area at design flow (acres) = (0.01) peak inflow rate (cfs)}$$

Cost Considerations

The cost of installing temporary sediment traps ranges from \$0.20 to \$2.00 per cubic foot of storage (about \$1,100 per acre of drainage). The average cost is approximately \$0.60 per cubic foot of storage (USEPA, 1993).

References

Smolen, M.D., D.W. Miller, L.C. Wyatt, J. Lichthardt, and A.L. Lanier. 1988. *Erosion and Sediment Control Planning and Design Manual*. North Carolina Sedimentation Control Commission, North Carolina Department of Environment, Health, and Natural Resources, and Division of Land Resources Land Quality Section, Raleigh, NC.

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Inlet protection

Storm Drain Inlet Protection

Construction Site Storm Water Control

Description

Storm drain inlet protection measures are controls that help prevent soil and debris from site erosion from entering storm drain drop inlets. Typically, these measures are temporary controls that are implemented prior to large-scale disturbance of the surrounding site. These controls are advantageous because their implementation allows storm drains to be used during even the early stages of construction activities. The early use of storm drains during project development significantly reduces the occurrence of future erosion problems (Smolen et al., 1988).

Coarse gravel and cinder blocks are often used to keep sediment and other pollutants out of storm drains

Three temporary control measures to protect storm drain drop inlets are

- Excavation around the perimeter of the drop inlet
- Fabric barriers around inlet entrances
- Block and gravel protection.

Excavation around a storm drain inlet creates a settling pool to remove sediments. Weep holes protected by gravel are used to drain the shallow pool of water that accumulates around the inlet. A fabric barrier made of porous material erected around an inlet can create an effective shield to erosion sediment while allowing water flow into the storm drain. This type of barrier can slow runoff velocity while catching soil and other debris at the drain inlet. Block and gravel inlet protection uses standard concrete blocks and gravel to form a barrier to sediments while permitting water runoff through select blocks laid sideways. In addition to the materials listed above, limited temporary storm water drop inlet protection can also be achieved with the use of straw bales or sandbags to create barriers to sediment. For permanent storm drain drop inlet protection after the surrounding area has been stabilized, sod can be installed as a barrier to slow storm water entry to storm drain inlets and capture erosion sediments. This final inlet protection measure can be used as an aesthetically pleasing way to slow storm water velocity near drop inlet entrances and to remove sediments and other pollutants from runoff.

Applicability

All temporary controls should have a drainage area no greater than 1 acre per inlet. It is also important for temporary controls to be constructed prior to disturbance of the surrounding landscape. Excavated drop inlet protection and block and gravel inlet protection are applicable to areas of high flow where overflow is anticipated into the storm drain. Fabric barriers are recommended for smaller, relatively flat drainage areas (slopes less than 5 percent leading to the storm drain). Temporary drop inlet control measures are often used in combination with each other and other storm water control techniques.

Siting and Design Considerations

With the exception of sod drop inlet protection, these controls should be installed before any soil disturbance in the drainage area. Excavation around drop inlets should be dug a minimum of 1 foot deep (2 feet maximum) with a minimum excavated volume of 35 yd^3 per acre disturbed. Side slopes leading to the inlet should be no steeper than 2:1. The shape of the excavated area should be designed such that the dimensions fit the area from which storm water is anticipated to drain. For example, the longest side of an excavated area should be along the side of the inlet expected to drain the largest area.

Fabric inlet protection should be staked close to the inlet to prevent overflow on unprotected soils. Stakes should be used with a minimum length of 3 feet, spaced no more than 3 feet apart. A frame should be constructed for fabric support during overflow periods and should be buried at least 1 foot below the soil surface and rise to a height no greater than 1.5 feet above ground. The top of the frame and fabric should be below the down-slope ground elevation to prevent runoff bypassing the inlet.

Block and gravel inlet barrier height should be 1 foot minimum (2 feet maximum), and mortar should not be used. The bottom row of blocks should be laid at least 2 inches below the soil surface flush against the drain for stability. One block in the bottom row should be placed on each side of the inlet on its side to allow drainage. Wire mesh (1/2 inch) should be placed over all block openings to prevent gravel from entering the inlet, and gravel (3/4 to 1/2 inch in diameter) should be placed outside the block structure at a slope no greater than 2:1.

Sod inlet protection should not be considered until the entire surrounding drainage area is stabilized. The sod should be laid so that it extends at least 4 feet from the inlet in each direction to form a continuous mat the around inlet, laying sod strips perpendicular to the direction of flows. The sod strips should be staggered such that strip ends are not aligned, and the slope of the sodded area should not be steeper than 4:1 approaching the drop inlet.

Limitations

Storm water drop inlet protection measures should not be used as stand-alone sediment control measures. To increase inlet protection effectiveness, these practices should be used in combination with other measures, such as small impoundments or sediment traps (USEPA, 1992). Temporary storm drain inlet protection is not intended for use in drainage areas larger than 1 acre. Generally, storm water inlet protection measures are practical for relatively low-sediment, low-volume flows. Frequent maintenance of storm drain control structures is necessary to prevent clogging. If sediment and other debris clog the water intake, drop intake control measures can actually cause erosion in unprotected areas.

Maintenance Considerations

All temporary control measures must be checked after each storm event. To maintain the sediment capacity of the shallow settling pools created from these techniques, accumulated sediment should be removed from the area around the drop inlet (excavated area, around fabric barrier, or around block structure) when the sediment capacity is reduced by approximately 50 percent. Additional debris should be removed from the shallow pools on a periodic basis. Weep holes in excavated areas around inlets can become clogged and prevent water from draining out of shallow pools that form. Should this happen, unclogging the water intake may be difficult and costly.

Effectiveness

Excavated drop inlet protection may be used to improve the effectiveness and reliability of other sediment traps and barriers, such as fabric or block and gravel inlet protection. However, as a whole, the effectiveness of inlet protection is low for erosion and sediment control, long-term pollutant removal, and low for habitat and stream protection.

Cost Considerations

The cost of implementing storm drain drop inlet protection measures will vary depending on the control measure chosen. Generally, initial installation costs range from $50 to $150 per inlet, with an average cost of $100 (USEPA, 1993). Maintenance costs can be high (up to 100 percent of the initial construction cost annually) due to frequent inspection and repair needs. The Southeastern Wisconsin Regional Planning Commission has estimated that the cost of installation of inlet protection devices ranges from $106 to $154 per inlet (SEWRPC, 1991).

References

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