Construction Site Storm Water Runoff Control

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3 PDH Credits

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Runoff Control

Minimize clearing

Land Grading

Construction Site Storm Water Runoff Control

Description

Soils exposed from land grading activities are very vulnerable to erosion

Land grading involves reshaping the ground surface to planned grades as determined by an engineering survey, evaluation, and layout. Land grading provides more suitable topography for buildings, facilities, and other land uses and helps to control surface runoff, soil erosion, and sedimentation during and after construction.

Applicability

Land grading is applicable to sites with uneven or steep topography or easily erodible soils, because it stabilizes slopes and decreases runoff velocity. Grading activities should maintain existing drainage patterns as much as possible.

Siting and Design Considerations

Before grading activities begin, decisions must be made regarding the steepness of cut-and-fill slopes and how the slopes will be

- Protected from runoff
- Stabilized
- Maintained.

A grading plan should be prepared that establishes which areas of the site will be graded, how drainage patterns will be directed, and how runoff velocities will affect receiving waters. The grading plan also includes information regarding when earthwork will start and stop, establishes the degree and length of finished slopes, and dictates where and how excess material will be disposed of (or where borrow materials will be obtained if needed). Berms, diversions, and other storm water practices that require excavation and filling also should be incorporated into the grading plan.

A low-impact development BMP that can be incorporated into a grading plan is *site fingerprinting*, which involves clearing and grading only those areas necessary for building activities and equipment traffic. Maintaining undisturbed temporary or permanent buffer zones in the grading operation provides a low-cost sediment control measure that will help reduce runoff and off-site sedimentation. The lowest elevation of the site should remain undisturbed to provide a protected storm water outlet before storm drains or other construction outlets are installed.

Limitations

Improper grading practices that disrupt natural storm water patterns might lead to poor drainage, high runoff velocities, and increased peak flows during storm events. Clearing and grading of the entire site without vegetated buffers promotes off-site transport of sediments and other pollutants. The grading plan must be designed with erosion and sediment control and storm water management goals in mind; grading crews must be carefully supervised to ensure that the plan is implemented as intended.

Maintenance Considerations

All graded areas and supporting erosion and sediment control practices should be periodically checked, especially after heavy rainfalls. All sediment should be removed from diversions or other storm water conveyances promptly. If washouts or breaks occur, they should be repaired immediately. Prompt maintenance of small-scale eroded areas is essential to prevent these areas from becoming significant gullies.

Effectiveness

Land grading is an effective means of reducing steep slopes and stabilizing highly erodible soils when properly implemented with storm water management and erosion and sediment control practices. Land grading is not effective when drainage patterns are altered or when vegetated areas on the perimeter of the site are destroyed.

Cost Considerations

Land grading is practiced at virtually all construction sites. Additional site planning to incorporate storm water and erosion and sediment controls in the grading plan can require several hours of planning by a certified engineer or landscape architect. Extra time might be required to excavate diversions and construct berms, and fill materials might be needed to build up low-lying areas or fill depressions.

References

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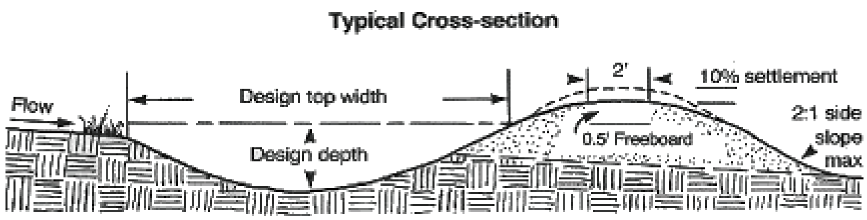
Permanent Diversions

Construction Site Storm Water Runoff Control

Description

Diversions can be constructed by creating channels across slopes with supporting earthen ridges on the bottom sides of the slopes. The ridges reduce slope length, collect storm water runoff, and deflect the runoff to acceptable outlets that convey it without erosion.



Site planners incorporate diversions into the overall grading plan to direct clean runoff away from exposed areas

Applicability

Diversions are used in areas where runoff from areas of higher elevation poses a threat of property damage or erosion. Diversions can also be used to promote the growth of vegetation in areas of lower elevations. Finally, diversions protect upland slopes that are being damaged by surface and/or shallow subsurface flow by reducing slope length, which minimizes soil loss.

Siting and Design Considerations

Ridge. A cross section of the earthen ridge must have side slopes no steeper than 2:1; a width at the design water elevation of at least 4 feet; a minimum freeboard of 0.3 feet; and a 10-percent settlement factor included in the design.

Outlet. Four acceptable outlets for the conveyance of runoff and their construction specifications include:

1. *Storm water conveyance channel*. A permanent designed waterway, containing appropriate vegetation, that is appropriately shaped and sized to carry storm water runoff away from developing areas without any damage from erosion. The following are general specifications that are required for channel construction:

    - All obstructions and unsuitable material, such as trees, roots, brush, and stumps, and any excess soil should be removed from the channel area and disposed of properly.
    - The channel must meet grade and cross-section specifications, and any fill that is used must be compacted to ensure equal settlement.
    - Parabolic and triangular-shaped, grass-lined channels should not have a top width of more than 30 feet.

- Trapezoidal, grass-lined channels may not have a bottom width of more than 15 feet unless there are multiple or divided waterways, they have a riprap center, or other methods of controlling the meandering of low flows are provided.
- If grass-lined channels have a base flow, a stone center or subsurface drain or another method for managing the base flow must be provided.
- All channels must have outlets that are protected from erosion.

2. *Level spreader*. A device used to prevent erosion and to improve infiltration by spreading storm water runoff evenly over the ground as shallow flow instead of through channels. It usually involves a depression in the soil surface that disperses flow onto a flatter area across a slight slope and then releases the flow onto level vegetated areas. This reduces flow speed and increases infiltration. Construction specifications for level spreaders include:

- Level spreaders should be constructed on natural soils and not on fill material or easily erodible soils.
- There should be a level entrance to the spreader to ensure the flow can be evenly distributed.
- Heavy equipment and traffic should not be allowed on the level spreader, as they can cause compaction of soil and disturbance of the slope grade.
- The spreader should be regraded if ponding or erosion channels develop.
- Dense vegetation should be sustained and damaged areas reseeded when necessary.

3. *Outlet protection*. This involves placing structurally lined aprons or other appropriate energy-dissipating devices at the outlets of pipes to reduce the velocity of storm water flows and thereby prevent scouring at storm water outlets, protect the outlet structure, and minimize potential for erosion downstream. Construction specifications for outlet protection practices require the following:

- No bends occur in the horizontal alignment.
- There is no slope along the length of the apron, and the invert elevations must be equal at the receiving channel and the apron's downstream end.
- No overfall at the end of the apron is allowed.
- If a pipe discharges into a well-defined channel, the channel's side slopes may not be steeper than 2:1.
- The apron is lined with riprap, grouted riprap, concrete, or gabion baskets, with all riprap conforming to standards and specifications, and the median-sized stone for riprap is specified in the plan
- Filter cloth, conforming to standards and specifications, must be placed between riprap and the underlying soil to prevent any soil movement through the riprap.

- All grout for grouted riprap must be one part Portland cement for every 3 parts sand, mixed thoroughly with water. Once stones are in place, the spaces between them are to be filled with grout to a minimum depth of 6 inches, with the deeper portions choked with fine material.
- All concrete aprons must be installed as specified in the plan.
- The end of the paved channel in a paved channel outlet must be smoothly joined with the receiving channel section, with no overfall at the end of the paved section.

4. *Paved flume. A* permanent paved channel that is constructed on a slope through which storm water runoff can be diverted down the face of the slope without causing erosion problems on or below the slope. Paved flumes are not recommended unless very high flows with excessive erosive power are expected, because increased runoff velocity might magnify erosion at the flume's outfall. Outfall protection must be provided to prevent damage from high-velocity flows. The paved flume also prevents infiltration of surface runoff, exacerbating offsite runoff problems. Where possible, vegetated channels should be used--additional stabilization can be provided with rip-rap, gabions, or turf reinforcement mats.

Construction specifications for paved flumes require that:

- The subgrade must be constructed to required elevations, with all soft portions and unsuitable material removed and replaced with suitable material, must be thoroughly compacted and smoothed to a uniform surface, and must be moist when the concrete is poured.
- The slope of the structure may be no more than 1.5:1.
- Curtain walls must be attached to the beginning and end of any paved flumes that are not adjoined to another structure, and the curtain walls should be the same width as the flume channel, at least 6 inches thick, and extend at least 18 inches into the soil under the channel.
- Anchor lugs must be spaced no more than 10 feet apart on center, continuous with the channel lining for the length of the flume; they must be the same width as the bottom of the flume channel, at least 6 inches thick, and extend at least 1 foot into the soil under the channel.
- There should be at least a 4-inch thickness of class A-3 concrete with welded wire fabric in the center of the flume channel for reinforcement.
- Traverse joints should be provided at approximately 20-foot intervals or when there are more than 45 minutes between consecutive concrete placements in order to control cracks.
- Expansion joints should be provided approximately every 90 feet.
- Outlets of the paved flumes should be protected from erosion through the use of an energy-dissipating device with outlet protection, as described previously.

Stabilization. Immediately after the ridge and channel are constructed, they must be seeded and mulched along with any disturbed areas that drain into the diversion. Sediment-trapping measures must remain in place in case the upslope area is not stabilized, to prevent soil from moving into the diversion. All obstructions and unsuitable material, such as trees, brush, and stumps, must be removed from the channel area and disposed of so the diversion may function properly. The channel must meet grade and cross-section specifications, and any fill that is used must be free from excessive organic debris, rocks, or other unsuitable material and must be compacted to ensure equal settlement. Disturbed areas should be permanently stabilized according to applicable local standards and specifications.

Limitations

The area around the channel that is disturbed by its construction must be stabilized so that it is not subject to similar erosion as the steep slope the channel is built to protect.

Maintenance Considerations

Diversions should be inspected after every rainfall and a minimum of once every 2 weeks before final stabilization. Channels should be cleared of sediment, repairs made when necessary, and seeded areas reseeded if a vegetative cover is not established.

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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Preserving Natural Vegetation

Construction Site Storm Water Runoff Control

Description

Natural vegetation is protected from heavy equipment with safety fencing

The principal advantage of preserving natural vegetation is the protection of desirable trees, vines, bushes, and grasses from damage during project development. Vegetation provides erosion control, storm water detention, biofiltration, and aesthetic values to a site during and after construction activities. Other benefits from preserving natural areas are because natural vegetation

- Can process higher quantities of storm water runoff than newly seeded areas
- Does not require time to establish
- Has a higher filtering capacity than newly planted vegetation because aboveground and root structures are typically denser
- Reduces storm water runoff by intercepting rainfall, promoting infiltration, and lowering the water table through transpiration
- Provides buffers and screens against noise and visual disturbance
- Provides a fully developed habitat for wildlife
- Usually requires less maintenance (e.g., irrigation, fertilizer) than planting new vegetation
- Enhances aesthetics.

Applicability

Preservation of natural vegetation is applicable to all construction sites where vegetation exists in the predevelopment condition. Areas where preserving vegetation can be particularly beneficial are floodplains, wetlands, stream banks, steep slopes, and other areas where erosion controls would be difficult to establish, install, or maintain. Only land needed for building activities and vehicle traffic needs to be cleared.

Siting and Design Considerations

Vegetation should be marked for preservation before clearing activities begin. A site map should be prepared with the locations of trees and boundaries of environmentally sensitive areas and buffer zones to be preserved. The location of roads, buildings, and other structures can be planned to avoid these areas. Preservation requires careful site management to minimize the impact of construction activities on existing vegetation. Large trees located near construction zones should be protected because damage during construction activities may result in reduced vigor or death after construction has ceased. The boundaries around contiguous natural areas and tree drip lines should be extended and marked to protect the root zone from damage. Although direct contact by equipment is an obvious means of damage to trees and other vegetation, compaction, filling, or excavation of land too close to the vegetation also can cause severe damage.

When selecting trees for preservation, the following factors should be considered:

- *Tree vigor*. Preserving healthy trees that will be less susceptible to damage, disease, and insects. Indicators of poor vigor include dead tips of branches, stunted leaf growth, sparse foliage, and pale foliage color. Hollow, rotten, split, cracked, or leaning trees also have less chance of survival.
- *Tree age.* Older trees are more aesthetically pleasing as long as they are healthy.
- *Tree species.* Species well-suited to present and future site conditions should be chosen. Preserving a mixture of evergreens and hardwoods can help to conserve energy when evergreens are preserved on the northern side of the site to protect against cold winter winds and deciduous trees are preserved on the southern side to provide shade in the summer and sunshine in the winter.
- *Wildlife benefits.* Trees that are preferred by wildlife for food, cover, and nesting should be chosen.

Other considerations include following natural contours and maintaining preconstruction drainage patterns. Alteration of hydrology might result in dieoff of preserved vegetation because their environmental requirements are no longer met.

The following are basic considerations for preservation of natural vegetation:

- Boards should not be nailed to trees during building operations.
- Tree roots inside the tree drip line should not be cut.
- Barriers should be used to prevent the approach of equipment within protected areas.
- Equipment, construction materials, topsoil, and fill dirt should not be placed within the limit of preserved areas.
- If a tree or shrub that is marked for preservation is damaged, it should be removed and replaced with a tree of the same or similar species with a 2-inch or larger caliper width from balled and burlaped nursery stock when construction activity is complete.
- During final site cleanup, barriers around preserved areas and trees should be removed.

Limitations

Preservation of vegetation is limited by the extent of existing vegetation in preconstruction conditions. It requires planning to preserve and maintain the existing vegetation. It is also limited by the size of the site relative to the size of structures to be built. High land prices might prohibit preservation of natural areas. Additionally, equipment must have enough room to maneuver; in some cases preserved vegetation might block equipment traffic and may constrict the area available for construction activities. Finally, improper grading of a site might result in changes in environmental conditions that result in vegetation dieoff. Consideration should be given to the hydrology of natural or preserved areas when planning the site.

Maintenance Considerations

Even if precautions are taken, some damage to protected areas may occur. In such cases, damaged vegetation should be repaired or replaced immediately to maintain the integrity of the natural system. Continued maintenance is needed to ensure that protected areas are not adversely impacted by new structures. Newly planted vegetation should be planned to enhance the existing vegetation.

Effectiveness

Natural vegetation (existing trees, vines, brushes, and grasses) can provide water quality benefits by intercepting rainfall, filtering storm water runoff, and preventing off-site transport of sediments and other pollutants.

Cost Considerations

A potential cost associated with preservation of natural vegetation is increased labor that might be required to maneuver around trees or protected areas.

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.

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Construction Entrances

Construction Site Storm Water Runoff Control

Description

Stabilized construction entrances allow dirt to be removed from tire treads and collected as trucks leave construction sites

The purpose of stabilizing entrances to a construction site is to minimize the amount of sediment leaving the area as mud and sediment attached to motorized vehicles. Installing a pad of gravel over filter cloth where construction traffic leaves a site can help stabilize a construction entrance. As a vehicle drives over the gravel pad, mud and sediment are removed from the vehicle's wheels and offsite transport of soil is reduced. The gravel pad also reduces erosion and rutting on the soil beneath the stabilization structure. The filter fabric separates the gravel from the soil below, preventing the gravel from being ground into the soil. The fabric also reduces the amount of rutting caused by vehicle tires by spreading the vehicle's weight over a larger soil area than just the tire width.

In addition to removal of sediment by simple friction of vehicle tires on the gravel pad, a vehicle washing station can be established at the site entrance. Wash stations, if used on a routine basis, remove a substantial amount of sediment from vehicles before they leave the site. Diverting runoff from vehicle washing stations into a sediment trap helps ensure that sediment removed from vehicles is kept on-site and disposed of properly.

Applicability

Typically, stabilized construction entrances are installed at locations where construction traffic leaves or enters an existing paved road. However, the applicability of site entrance stabilization should be extended to any roadway or entrance where vehicles will access or leave the site. From a public relations point of view, stabilizing construction site entrances can be a worthwhile exercise. If the site entrance is the most publicly noticeable part of a construction site, stabilized entrances can improve the appearance to passersby and improve public perception of the construction project.

Siting and Design Considerations

All entrances to a site should be stabilized before construction and further disturbance of the site area begins. The stabilized site entrances should be long and wide enough so that the largest construction vehicle that will enter the site will fit in the entrance with room to spare. If many vehicles are expected to use an entrance in any one day, the site entrance should be wide enough for the passage of two vehicles at the same time with room on either side of each vehicle. If a site entrance leads to a paved road, the end of the entrance should be "flared" (made wider as in the shape of a funnel) so that long vehicles do not leave the stabilized area when turning onto or off of the paved roadway. If a construction site entrance crosses a stream, swale, or other depression, a bridge or culvert should be provided to prevent erosion from unprotected banks. Stone and gravel used to stabilize the construction site entrance should be large enough so that they are not carried off site with vehicle traffic. In addition, sharp-edged stone should be avoided to reduce the possibility of puncturing vehicle tires. Stone or gravel should be installed at a depth of at least 6 inches for the entire length and width of the stabilized construction entrance.

Limitations

Although stabilizing a construction entrance is a good way to help reduce the amount of sediment leaving a site, some soil may still be deposited from vehicle tires onto paved surfaces. To further reduce the chance of these sediments polluting storm water runoff, sweeping of the paved area adjacent to the stabilized site entrance is recommended. For sites using wash stations, a reliable water source to wash vehicles before leaving the site might not be initially available. In this case, water may have to be trucked to the site at additional cost.

Maintenance Considerations

Stabilization of site entrances should be maintained until the remainder of the construction site has been fully stabilized. Stone and gravel might need to be periodically added to each stabilized construction site entrance to keep the entrance effective. Soil that is tracked offsite should be swept up immediately for proper disposal. For sites with wash racks at each site entrance, sediment traps will have to be constructed and maintained for the life of the project. Maintenance will entail the periodic removal of sediment from the traps to ensure their continued effectiveness.

Effectiveness

Stabilizing construction entrances to prevent sediment transport off-site is effective only if all entrances to the site are stabilized and maintained. Also, stabilization of construction site entrances may not be very effective unless a wash rack is installed and routinely used (Corish, 1995). This can be problematic for sites with multiple entrances and high vehicle traffic.

Cost Considerations

Without a wash rack, construction site entrance stabilization costs range from $1,000 to $4,000. On average, the initial construction cost is around $2,000 per entrance. Including maintenance costs for a 2-year period, the average total annual cost is approximately $1,500. If a wash rack is included in the construction site entrance stabilization, the initial construction costs range from $1,000 to $5,000, with an average initial cost of $3,000 per entrance. The total cost, including maintenance for an estimated 2-year life span, is approximately $2,200 per year (USEPA, 1993).

References

Corish, K. 1995. *Clearing and Grading Strategies for Urban Watersheds*. Metropolitan Washington Council of Governments, Washington, DC.

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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Stabilize drainage ways

Check Dams

Construction Site Storm Water Runoff Control

Description

Check dams are used to reduce the energy of storm water to prevent erosion

Check dams are small, temporary dams constructed across a swale or channel. Check dams can be constructed using gravel, rock, sandbags, logs, or straw bales and are used to slow the velocity of concentrated flow in a channel. By reducing the velocity of the water flowing through a swale or channel, check dams reduce the erosion in the swale or channel. As a secondary function, check dams can also be used to catch sediment from the channel itself or from the contributing drainage area as storm water runoff flows through the structure. However, the use of check dams in a channel should not be a substitute for the use of other sediment-trapping and erosion control measures. As with most other temporary structures, check dams are most effective when used in combination with other storm water and erosion and sediment control measures.

Applicability

Check dams should be used in swales or channels that will be used for a short period of time where it is not practical to line the channel or implement other flow control practices (USEPA, 1993). In addition, check dams are appropriate where temporary seeding has been recently implemented but has not had time to take root and fully develop. Check dams are usually used in small open channels with a contributing drainage area of 2 to 10 acres. For a given swale or channel, multiple check dams, spaced at appropriate intervals, can increase overall effectiveness. If dams are used in a series, they should be spaced such that the base of the upstream dam is at the same elevation as the top of the next downstream dam (VDCR, 1995).

Siting and Design Considerations

Check dams can be constructed from a number of different materials. Most commonly, they are made of rock, logs, sandbags, or straw bales. When using rock or stone, the material diameter should be 2 to 15 inches. Logs should have a diameter of 6 to 8 inches. Regardless of the material used, careful construction of a check dam is necessary to ensure its effectiveness. Dams should be installed with careful placement of the construction material. Mere dumping of the dam material into a channel is not appropriate and will reduce overall effectiveness.

All check dams should have a maximum height of 3 feet. The center of the dam should be at least 6 inches lower than the edges. This design creates a weir effect that helps to channel flows away from the banks and prevent further erosion. Additional stability can be achieved by implanting the dam material approximately 6 inches into the sides and bottom of the channel (VDCR, 1995). When installing more than one check dam in a channel, outlet stabilization measures should be installed below the final dam in the series. Because this area is likely to be vulnerable to further erosion, riprap, geotextile lining, or some other stabilization measure is highly recommended.

Limitations

Check dams should not be used in live, flowing streams unless approved by an appropriate regulatory agency (USEPA, 1992; VDCR, 1995). Because the primary function of check dams is to slow runoff in a channel, they should not be used as a stand-alone substitute for other sediment-trapping devices. Also, leaves have been shown to be a significant problem by clogging check dams in the fall. Therefore, they might necessitate increased inspection and maintenance.

Maintenance Considerations

Check dams should be inspected after each storm event to ensure continued effectiveness. During inspection, large debris, trash, and leaves should be removed. The center of a check dam should always be lower than its edges. If erosion or heavy flows cause the edges of a dam to fall to a height equal to or below the height of the center, repairs should be made immediately. Accumulated sediment should be removed from the upstream side of a check dam when the sediment has reached a height of approximately one-half the original height of the dam (measured at the center). In addition, all accumulated sediment should also be removed prior to removing a check dam. Removal of a check dam should be completed only after the contributing drainage area has been completely stabilized. Permanent vegetation should replace areas from which gravel, stone, logs, or other material have been removed. If the check dam is constructed of rock or gravel, maintenance crews should be sure to clear all small rock and gravel pieces from vegetated areas before attempting to mow the grass between check dams. Failure to remove stones and gravel can result in serious injury from flying debris.

Effectiveness

Field experience has shown that rock check dams are more effective than silt fences or straw bales to stabilize wet-weather ditches (VDCR, 1995). For long channels, check dams are most effective when used in a series, creating multiple barriers to sediment-laden runoff.

Cost Considerations

The cost of check dams varies based on the material used for construction and the width of the channel to be dammed. In general, it is estimated that check dams constructed of rock cost about $100 per dam (USEPA, 1992). Other materials, such as logs and sandbags, may be less expensive, but they might require higher maintenance costs.

References

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Washington State Department of Ecology. 1992. *Stormwater Management Manual for the Puget Sound Basin*. Technical manual. Washington State Department of Ecology, Olympia, WA.

Filter Berms

Construction Site Storm Water Runoff Control

Description

A gravel or stone filter berm is a temporary ridge made up of loose gravel, stone, or crushed rock that slows, filters, and diverts flow from an open traffic area and acts as an efficient form of sediment control. A specific type of filter berm is the continuous berm, a geosynthetic fabric that encapsulates sand, rock, or soil.

Applicability

Gravel or stone filter berms are most suitable in areas where vehicular traffic needs to be rerouted because roads are under construction, or in traffic areas within a construction site.

Siting and Design Considerations

The following construction guidelines should be considered when building the berm:

- Well-graded gravel or crushed rock should be used to build the berm.
- Berms should be spaced according to the steepness of the slope, with berms spaced closer together as the slope increases.
- Sediment that builds up should be removed and disposed of and the filter material should be replaced. Regular inspection should indicate the frequency of sediment removal needed.

Limitations

Berms are intended to be used only in gently sloping areas. They do not last very long, and they require maintenance due to clogging from mud and soil on vehicle tires.

Maintenance Considerations

The berm should be inspected after every rainfall to ensure that sediment has not built up and that no damage has been done by vehicles. It is important that repairs be performed at the first sign of deterioration to ensure that the berm is functioning properly.

Effectiveness

The effectiveness of a rock filter berm depends upon rock size, slope, soil, and rainfall amount. The continuous berm is not staked into the ground and no trenching is required. Effectiveness has been rated at up to 95 percent for sediment removal, but is highly dependent on local conditions including hydrologic, hydraulic, topographic, and sediment characteristics.

Cost Considerations

Construction materials for filter berms (mainly gravel) are relatively low cost, but installation and regular cleaning and maintenance can result in substantial labor costs. These maintenance costs are lower in areas of less traffic, gentler slopes, and low rainfall.

References

Fifield, S.J. 1997. *Field Manual for Effective Sediment and Erosion Control Methods*. Hydrodynamics, Inc., Parker, CO.

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.

Grass-Lined Channels

Construction Site Storm Water Runoff Control

Description

A grass-lined channel can be used to filter and convey runoff

Grass-lined channels convey storm water runoff through a stable conduit. Vegetation lining the channel reduces the flow velocity of concentrated runoff. Grassed channels usually are not designed to control peak runoff loads by themselves and are often used in combination with other BMPs, such as subsurface drains and riprap stabilization. Where moderately steep slopes require drainage, grassed channels can include excavated depressions or check dams to enhance runoff storage, decrease flow rates, and enhance pollutant removal. Peak discharges can be reduced through temporary detention in the channel. Pollutants can be removed from storm water by filtration through vegetation, by deposition, or in some cases by infiltration of soluble nutrients into the soil. The degree of pollutant removal in a channel depends on the residence time of water in the channel and the amount of contact with vegetation and the soil surface. As a result, removal efficiency is highly dependent on local conditions.

Applicability

Grassed channels should be used in areas where erosion-resistant conveyances are needed, including areas with highly erodible soils and moderately steep slopes (although less than 5 percent). They should only be installed where space is available for a relatively large cross section. Grassed channels have a limited ability to control runoff from large storms and should not be used in areas where flow rates exceed 5 feet per second.

Siting and Design Considerations

Grass-lined channels should be sited in accordance with the natural drainage system and should not cross ridges. The channel design should not have sharp curves or significant changes in slope. The channel should not receive direct sedimentation from disturbed areas and should be sited only on the perimeter of a construction site to convey relatively clean storm water runoff. Channels should be separated from disturbed areas by a vegetated buffer or other BMP to reduce sediment loads.

Basic design recommendations for grassed channels include the following:

- Construction and vegetation of the channel should occur before grading and paving activities begin.

- Design velocities should be less than 5 feet per second.

- Geotextiles can be used to stabilize vegetation until it is fully established.
- Covering the bare soil with sod, mulches with netting, or geotextiles can provide reinforced storm water conveyance immediately.
- Triangular-shaped channels are used with low velocities and small quantities of runoff; parabolic grass channels are used for larger flows and where space is available; trapezoidal channels are used with large flows of low velocity (low slope).
- Outlet stabilization structures should be installed if the runoff volume or velocity has the potential to exceed the capacity of the receiving area.
- Channels should be designed to convey runoff from a 10-year storm without erosion.
- The sides of the channel should be sloped less than 2:1, and triangular-shaped channels along roads should be sloped 2:1 or less for safety.
- All trees, brushes, stumps, and other debris should be removed during construction.

Effectiveness

Grass-lined channels can effectively transport storm water from construction areas if they are designed for expected flow rates and velocities and if they do not receive sediment directly from disturbed areas.

Limitations

Grassed channels, if improperly installed, can alter the natural flow of surface water and have adverse impacts on downstream waters. Additionally, if the design capacity is exceeded by a large storm event, the vegetation might not be sufficient to prevent erosion and the channel might be destroyed. Clogging with sediment and debris reduces the effectiveness of grass-lined channels for storm water conveyance.

Maintenance Considerations

Maintenance requirements for grass channels are relatively minimal. During the vegetation establishment period, the channels should be inspected after every rainfall. Other maintenance activities that should be carried out after vegetation is established are mowing, litter removal, and spot vegetation repair. The most important objective in the maintenance of grassed channels is the maintaining of a dense and vigorous growth of turf. Periodic cleaning of vegetation and soil buildup in curb cuts is required so that water flow into the channel is unobstructed. During the growing season, channel grass should be cut no shorter than the level of design flow.

Cost Considerations

Costs of grassed channels range according to depth, with a 1.5-foot-deep, 10-foot-wide grassed channel estimated between $6,395 and $17,075 per trench, while a 3.0-foot-deep, 21-foot-wide grassed channel is estimated at $12,909 to $33,404 per trench (SWRPC, 1991). Grassed channels can be left in place permanently after the construction site is stabilized to contribute to long-term storm water management. The channels, in combination with other practices that detain, filter, and infiltrate runoff, can substantially reduce the size of permanent detention facilities such as storm water ponds and wetlands, thereby reducing the overall cost of storm water management.

References

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Riprap

Construction Site Storm Water Runoff Control

Description

Riprap is a permanent, erosion-resistant layer made of stones. It is intended to protect soil from erosion in areas of concentrated runoff. Riprap may also be used to stabilize slopes that are unstable because of seepage problems.

Riprap can be used to stabilize drainageways and outlets to prevent erosion

Applicability

Riprap can be used to stabilize cut-and-fill slopes; channel side slopes and bottoms; inlets and outlets for culverts, bridges, slope drains, grade stabilization structures, and storm drains; and streambanks and grades.

Siting and Design Considerations

Riprap may be unstable on very steep slopes, especially when rounded rock is used. For slopes steeper than 2:1, consider using materials other than riprap for erosion protection. If riprap is being planned for the bottom of a permanently flowing channel, the bottom can be modified to enhance fish habitat. This can be done by constructing riffles and pools which simulate natural conditions. These riffles promote aeration and the pools provide deep waters for habitats.

The following are some design recommendations for riprap installation, (Smolen et al., 1988):

- *Gradation*. A well-graded mixture of rock sizes should be used instead of one uniform size.
- *Quality of stone*. Riprap must be durable so that freeze/thaw cycles do not decompose it in a short time; most igneous stones such as granite have suitable durability.
- *Riprap depth*. The thickness of riprap layers should be at least 2 times the maximum stone diameter.
- *Filter material*. Filter material is usually required between riprap and the underlying soil surface to prevent soil from moving through the riprap; a filter cloth material or a layer of gravel is usually used for the filter.
- *Leaching Protection*. Leaching can be controlled by installing a riprap gradation small enough to act as a filter against the channel base material, or a protective filter can be installed between the riprap and the base material.
- *Riprap Limits*. The riprap should extend for the maximum flow depth, or to a point where vegetation will be satisfactory to control erosion.

- *Curves*. Riprap should extend to five times the bottom width upstream and downstream of the beginning and ending of the curve as well as the entire curved section.
- *Riprap Size*. The size of riprap to be installed depends on site-specific conditions.

Limitations

Riprap is limited by steepness of slope, because slopes greater than 2:1 have potential riprap loss due to erosion and sliding. When working within flowing streams, measures should be taken to prevent excessive turbidity and erosion during construction. Bypassing base flows or temporarily blocking base flows are two possible methods.

Effectiveness

When properly designed and installed, riprap can prevent virtually all erosion from the protected area.

Maintenance Considerations

Riprap should be inspected annually and after major storms. If riprap has been damaged, repairs should be made promptly to prevent a progressive failure. If repairs are needed repeatedly at one location, the site should be evaluated to determine if the original design conditions have changed. Channel obstructions such as trees and sediment bars can change flow patterns and cause erosive forces that may damage riprap. Control of weed and brush growth may be needed in some locations.

Cost Considerations

The cost of riprap varies depending on location and the type of material selected. A cost of $35 to $50 per square yard of nongrouted riprap has been reported, while grouted riprap ranges from $45 to $60 per square yard (1993 dollars; Mayo et al., 1993). Alternatives to riprap channel lining include grass, sod, and concrete, which cost $3, $7, $8, $12, and $25 to $30 per square yard, respectively (1993 dollars, Mayo et al., 1993).

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