R. Pitt
June 9, 2004

Module 1: Introduction to Erosion and Sediment Control, Problems and Regulations

Summary
Construction Site Regulations
- CWA 402(p)(6) Initial Phase II Rule (for small municipalities
- Permit Requirements for each Regulatory Agency
- Proposed Construction Site Regulations

Basic Control of Construction Site Runoff
- Basic Goals and Performance Standards for Erosion and Sediment Control
- Design Criteria
- Exemptions and Waivers
- Design Assistance and Guidance

Example Construction Site Erosion Control and Stormwater Management Requirements
- Rationale and Purpose
- Standards and Specifications for Construction Site Erosion Control
- Site Erosion Control Requirements
- Summary of Erosion Control Requirements

Need for Adequate Design and Inspection
- Inspection During Construction

Important Internet Links
References
Appendix 1A: Example Components of Local and State Construction Site Regulations

Summary

Problems associated with construction site runoff have been known for many years. More than 20 years ago, Willett (1980; Virginia 1980) estimated that approximately five billion tons of sediment reached U.S. surface waters annually, of which 30 percent was generated by natural processes and 70 percent by human activities. Half of this 70 percent is attributed to eroding croplands. Although urban construction accounted for only ten percent of this total, this amount equaled the combined contributions of forestry, mining, industrial, and commercial activities. While construction occurred on only about 0.007 percent of U.S. land in the 1970s, it accounted for about ten percent of the sediment load to U.S. surface waters (Willett 1980). Increased development in many areas of the US in recent years has only served to increase the significance of construction site erosion control. The EPA's Stormwater Permit Program includes regulations for the control of construction site erosion problems in response to the increased awareness of these problems, and the public's demand that they be reduced. This chapter summarizes these emerging regulations and contains an appendix describing example regulations specifications for many areas in the country.

Construction accounts for a much greater proportion of the sediment load in urban areas, sometimes more than 50 percent, than it does in the nation as a whole. Urban areas experience large sediment loads from construction site erosion because construction sites have extremely high erosion rates and because urban construction sites are efficiently drained by stormwater drainage systems. Construction sites have an erosion rate of approximately 20 to 200 tons per acre per year, a rate that is about 3 to 100 times that of croplands. Construction site erosion losses vary greatly depending on local rain, soil, topographic, and management conditions. As an example, the Birmingham, Alabama, area may have one of the highest erosion rates in the nation because of its combination of very high energy rains, moderately erosive soils and steep topography. The typically high erosion rates mean that even a small construction project may have a significant detrimental effect on local water bodies.

Extensive evaluations of urban construction site runoff problems have been conducted in Wisconsin for many years. Data from the highly urbanized Menomonee River watershed in southeastern Wisconsin illustrate the impact of construction on water quality. These data indicate that construction sites had much greater potentials for generating sediment and phosphorus than did areas in other land uses (Chesters, *et al*. 1979). For example, construction sites can generate approximately 8 times more sediment and 18 times more phosphorus than industrial sites, the land use that contributes the second highest amount of these pollutants, and 25 times more sediment and phosphorus than row crops. In fact, construction contributed more sediment and phosphorus to the river than any other land use. In 1979, construction comprised only 3.3 percent of the watershed's total land area, but it contributed about 50 percent of the suspended sediment and total phosphorus loading at the river mouth (Novotny, *et al*. 1979).

Similar conclusions were reported by the Southeastern Wisconsin Regional Planning Commission in a 1978 modeling study of the relative pollutant contributions of 17 categories of point and nonpoint pollution sources to 14 watersheds in the southeast Wisconsin regional planning area (SEWRPC 1978). This study revealed construction as the first or second largest contributor of sediment and phosphorus in 12 of the 14 watersheds. Although construction occupied only two percent of the region's total land area in 1978, it contributed approximately 36 percent of the sediment and 28 percent of the total phosphorus load to inland waters, making construction the region's second largest source of sediment and phosphorus. The largest source of sediment was estimated to be cropland; livestock operations were estimated to be the largest source of phosphorus. By comparison, cropland comprised 72 percent of the region's land area and contributed about 45 percent of the sediment and only 11 percent of the phosphorus to regional watersheds. This study again pointed out the high pollution-generating ability of construction sites and the significant water quality impact a small amount of construction may have on a watershed.

A monitoring study of construction site runoff water quality in the Village of Germantown (Washington County, Wisconsin) yielded similar results (Madison, *et al*. 1979). Several large subdivisions being developed with single and multi-family residences were selected for runoff monitoring. All utility construction, including the storm drainage system and streets, was completed before monitoring began. Analysis of the monitoring data showed that sediment leaving the developing subdivisions averaged about 25 to 30 tons per acre per year (Madison, *et al*. 1979). Construction practices identified as contributing to these high yields were: removing surface vegetation; stripping and stockpiling topsoil; placing large, highly erodible mounds of excavated soil on and near the streets; pumping water from flooded basement excavations; and tracking of mud in the streets by construction vehicles. If the amount of sediment leaving the sites during utility development had been added in, the total amount of eroded sediment leaving the site would have been substantially greater. Analysis of the Germantown data also showed that the amount of sediment leaving areas undergoing development was a function of the extent of development and was independent of the type of development. Almost all eroded sediment from the Germantown construction areas entered the receiving waters. The delivery of sediment to the receiving waters was found to be nearly 100 percent when ten percent or more of the watershed was experiencing development. The smallest delivery value obtained during the Germantown monitoring was 50 percent, observed when only five percent of the watershed was undergoing development. These high delivery values occurred (even during periods with small amounts of development) because storm drainage systems, which efficiently transport water and its sediment load, had been installed during an early stage of development.

Local Birmingham, AL, erosion rates from construction sites can be ten times the erosion rates from row crops and one hundred times the erosion rates from forests or pastures (Nelson 1996). The site specific factors affecting construction site erosion include:

- Rainfall Energy (Alabama has the highest in the nation)
- Soil Erodibility (northern part of the state has fine grained, highly erosive soils)
- Site Topography (northeastern part of the state has steep hills under development)
- Surface Cover (usually totally removed during initial site grading on hilly construction sites)

The rain energy is directly related to rainfall intensity, and the rainfall erosion index varies from 250 to 550+ for Alabama (most of state is about 350) which is the highest in the U.S. The months having the greatest erosion potential are February and March, while September through November have the lowest erosion potential. Nelson (1996) monitored sediment quantity and particle size from 70 construction site runoff samples from the Birmingham area. He measured suspended solids concentrations ranging from 100 to more than 25,000 mg/L (overall median about 4,000 mg/L), while the turbidity values ranged from about 300 to >50,000 NTU (average of about 4,000 NTU). About 90% of the particles (by mass) were smaller than about 20 µm (0.02 mm) in diameter, and the median size was about 5 µm (0.005 mm). The local construction site erosion discharges were estimated to about 100 tons/acre/year. Table 1-1 summarizes the measured suspended solids and median particle sizes as a function of rain intensity. High intensity rains were found to have the most severe erosion problems, as expected, with much greater suspended solids concentrations. Typical small particle sizes of erosion particulates make it very difficult to remove these particulates after they have been eroded from the site. The extreme turbidity values also cause very high in-stream turbidity conditions in local receiving waters for great distances downstream of eroding sites.

Table 1-1. Birmingham Construction Site Erosion Runoff Characteristics (Nelson 1996)

	Low intensity rains (<0.25 in/hr)	Moderate intensity rains (about 0.25 in/hr)	High intensity rains (>1 in/hr)
Suspended solids, mg/L	400	2,000	25,000
Particle size (median), µm	3.5	5	8.5

The rest of this introductory chapter outlines the phase I and phase II NPDES stormwater regulations affecting construction sites.

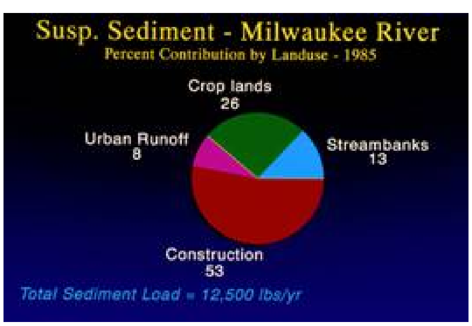
Bad Impression on Neighbors

Trying to Sell Badly Eroded Land

This home is actually being constructed in 12 feet of fill soil. The foundation footers are 14 feet below the groundline. Note the rills draining down to the drainage swale.

Erosion Threatening Homes


Damage from Erosion Requiring Repairs (IECA photo)

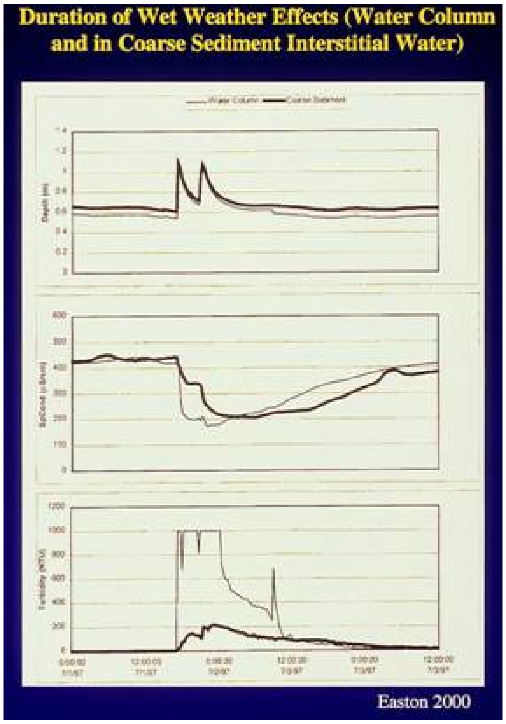


Sources of Sediment in Milwaukee River, WI (WI DNR)

Culverts can be haphazardly installed during construction operations. They can provide high energy super critical velocities at their outlets that need to be reduced to prevent scour.

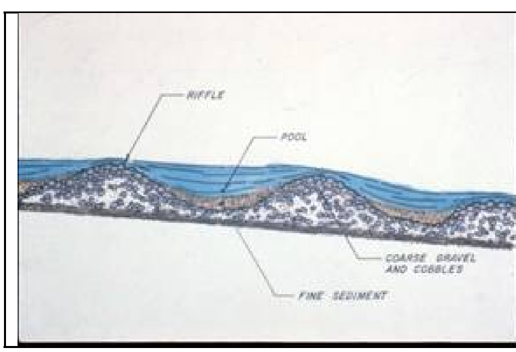
Receiving Water Problems Caused by Excessive Erosion

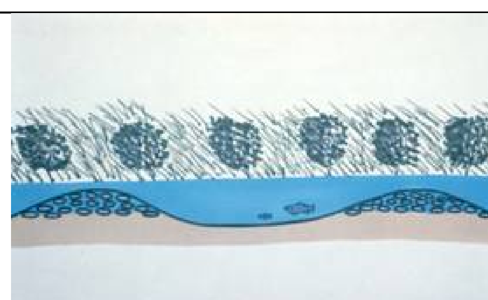
Secchi Disk used to Measure Water Turbidity

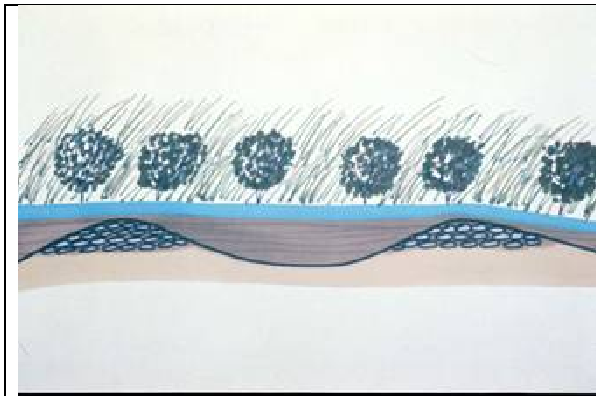


Very High Turbidity During Wet Weather

Typical Urban Stream Sediment



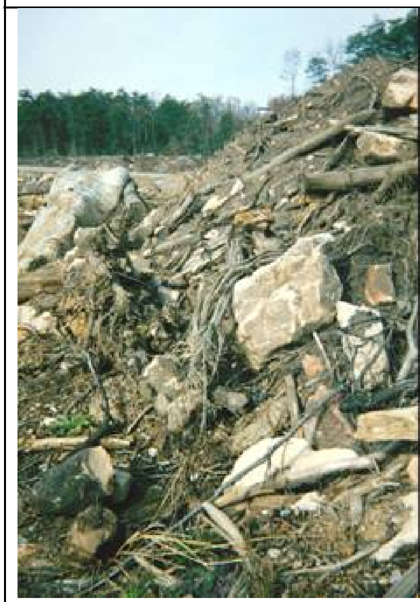





Sediment Problems (WI DNR)


Drainage Filled with Construction Sediment (J. Voorhees)

Eroded Streams and Channels (WI DNR)

Sidebar Story:
This site began, at least on paper, with all the promise of a well planned, phased, and properly design residential development. The consulting engineering firm had divided this 70 acre site into four construction phases, balancing the cuts and fills for each phase. They had incorporated appropriate erosion and sediment control practices in the stormwater pollution prevention plan that also contained an 8 acre pond for water quality and quantity control.

Unfortunately, once the project began construction in mid-August, the developer instructed the contractor to ignore the plan and build the entire site and infrastructure in one phase, 65 aces were disturbed at one time. In fact, the developer never signed nor submitted the Notice of Intent for the project as required under the state permit regulations. It began raining in mid-October and was still raining in late December. Unfortunately this site drainage outlets to a tributary only 3,800 feet from a high quality sport fishing recreational lake. It was later determined that the soils that washed off this site (whose gradation contained 75-98 percent smaller than .074 mm) destroyed two acres of walleye spawning area.

The site was shut down by state authorities after the sediment plume into the lake was noticed in late December. Remediation included seeding and mulching the entire site for spring thaw conditions, placing stone check dams in all drainage conveyances, installing a rock dam to create a large sediment basin, construction of five rock chutes for gradient control, and six sediment traps at various locations on the site. The cost for this work was approximately $ 35,000. In addition, the developer paid a $ 10,000 fine and was placed on a graduated fine scale for any additional water quality violations.

Even though this site was relatively flat, the high content of fines in the soil coupled with the total disregard for erosion control practices and lack of knowledge of the drainage area created this disaster.

	
This exposed site is under a state shutdown order for destroying 2 acres of walleye spawning area in a nearby lake. 65 acres of the 70 acre site was stripped exposing soil containing 75 – 98 percent fines that could not settle out on site.	


Control of runoff is critical at the beginning of construction. Here the stormwater infrastructure is in place but the 24 inch storm sewer is 75% plugged with sediment. Note the size of the material on the catch basin grate.

Sediment Sources

Stock Pile Problems and Working Close to Roads



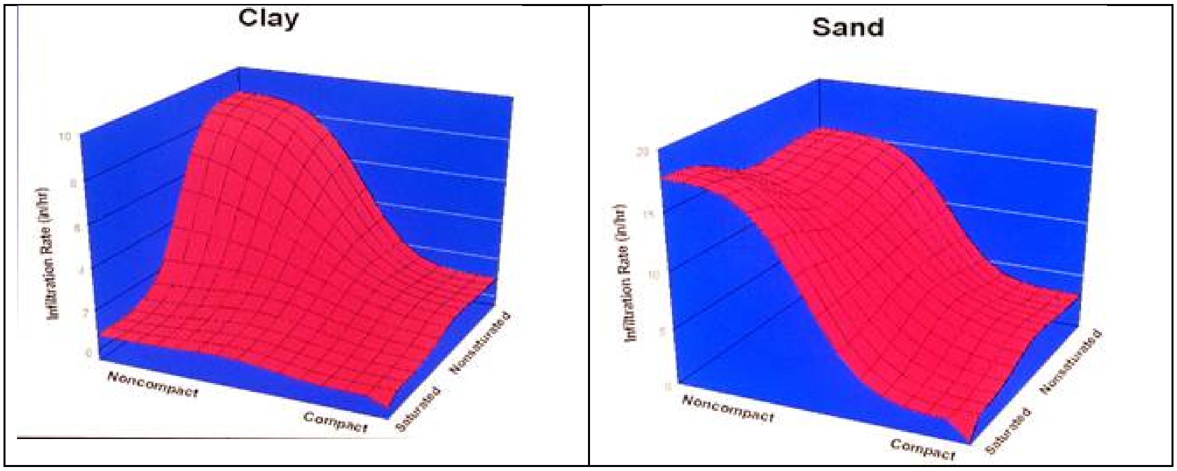
Improper Disposal of Construction Debris and Improper Equipment Maintenance


Poor Drainage Construction

<table>
<tr><td>
In this commercial mall re-habilitation project, dust became a problem even though much of the site area was impervious. Complaints were registered from homeowners beyond the work area. (in the direction of the prevailing winds).</td><td></td></tr>
<tr><td></td><td></td></tr>
</table>

Fugitive Dust Problems



Soil Structure Problems

Construction Site Regulations

The NPDES (National Pollutant Discharge Elimination System) was established as part of the Clean Water Act amendments of 1972. It was intended to control and regulate point sources of water pollution throughout the US, with the eventual objective of totally eliminating these discharges and ensuring all US receiving waters were "fishable" and "swimmable." Over the years, these lofty objectives have been scaled back, but these regulations have done much to improve the quality of US waters.

These initial regulations affected municipal sewage treatment plants (or "publicly owned treatment works," POTWs) and industrial discharges. Stormwater was initially considered an exempt point source and was not included in the initial regulations. The EPA finally established separate regulations for stormwater in 1987. The original Phase I regulations for stormwater (implemented in 1990) applied to large municipalities (generally >250,000 population) and certain industries. Medium-sized municipalities (100,000 to 250,000 in population, plus other industries) were regulated several years later. The recently implemented Phase II regulations are intended to be applied to all urban areas in the US. The phase I regulations included construction activity as an industry and were applied to all construction sites greater than 5 acres. The phase II regulations will generally apply to all construction sites larger than 1 acre.

Many municipalities and some states have had local regulations affecting construction sites for many years, independent of the federal regulations. Some features of these are included in Appendix 1A.

CWA 402(p)(6) Initial Phase II Rule (for small municipalities

The purpose of the initial Phase II regulations was to designate additional sources of stormwater, beyond Phase I, that needed to be regulated to protect receiving water quality. These regulations require that all unregulated sources of stormwater discharges apply for NPDES permits by March 10, 2003. According to the EPA, this regulation could apply to millions of industrial/commercial facilities and over 22,000 municipalities.

A Federal Advisory Committee (FACA) helped to develop the proposed Phase II rules. The membership in the FACA included a cross-section of interested stakeholders (private environmental groups, municipal representatives, trade associations, state regulators, and various other experts) from throughout the US. They held 14 meetings from 1995 – 1998 and prepared three preliminary drafts circulated for review and comment.

The proposed Phase II rule was published in the Jan. 9, 1998 edition of the *Federal Register* (40 CFR Parts 122 and 123, 63 FR 1563). There was a 90-day comment period and about 550 comments were received. The EPA held public hearings at six locations to explain the proposed Phase II rules and to obtain public comment. The final phase II rule was signed on December 8, 1999, after modifications based on these comments. Phase II NPDES permit applications will be due starting March 10, 2003, but the specific compliance dates are to be set by each state regulatory agency.

Two new classes of facilities were established for automatic coverage on a nationwide basis:

> 1) small municipal separate storm sewer systems located in urbanized areas (about 3,500 municipalities) [Phase I included medium and large municipalities]
> 2) construction activities that disturb less than 5 acres of land (about 110,000 sites a year) [Phase I included construction sites larger than 5 acres]

A “no exposure” incentive for Phase I sites was also proposed for industrial activities (will exclude about 70,000 facilities).

Permit Requirements for each Regulatory Agency

The following are the elements that will be required for each plan to be prepared by the local regulatory agencies:

- develop, implement, and enforce a program to reduce the discharge of pollutants and protect water quality to the “maximum extent practicable”
- must include six minimum control measures:
  - public education and outreach
  - public involvement and participation
  - illicit discharge detection and elimination
  - construction site stormwater runoff control
  - post-construction stormwater management in new development and redevelopment
  - pollution prevention and good housekeeping for municipal operations
- must submit a notice of intent (NOI) or permit application and identify for each minimum control measure:
  - best management practices
  - measurable goals
  - timeframe for implementation
  - responsible persons
- must evaluate program and submit reports

The objective is to include greater flexibility in the Phase II rule by encouraging the use of general permits, encourage municipalities to determine appropriate stormwater controls, not require extensive monitoring by permittees, and recognize and contemplate the use of existing programs, including existing structures and mechanisms for public participation.

Proposed Construction Site Regulations

The Phase II regulations will extend existing Phase I regulations for construction coverage to:

- all sites that result in the disturbance of 1 acre or more, but less than 5 acres (designated nationwide)
- sites that result in disturbance of less than 1 acre (potential designation by permitting authority).

The regulations will encourage the use of local regulations that control erosion and sediment to the “maximum extent practicable,” control other waste at construction sites, allow the granting of waivers by the permitting authority, and to qualifying local and state programs.

The EPA allows the local agencies to waive coverage for construction sites that meet the following criteria:

• rainfall erosivity factor (NRCS RUSLE rainfall factor "R") is less than 2 (during the period of construction) ("low rainfall")
• annual soil loss of less than 2 tons/acre/year ("low erosion potential")
• a watershed plan or TMDL assessment addresses the pollutants of concern

The rule would require:

1) ensure control of other wastes at construction sites (discarded building materials, concrete truck washout, sanitary wastes, etc.)
2) implement appropriate best management practices (such as silt fences, temporary detention ponds, etc.)
3) require pre-construction reviews of site management plans
4) receive and consider public information
5) require regular inspections during construction
6) have penalties to ensure compliance

If local regulations incorporate the following principles and elements into its stormwater program, then it would be considered as a "qualifying" program that meets Federal requirements:

• Five Principles
1) good site planning
2) minimize soil movement
3) capture sediment
4) good housekeeping practices
5) mitigation of post-construction stormwater discharges

• Eight Elements
1) program description
2) coordination mechanism
3) requirements for nonstructural and structural BMPs
4) priorities for site inspections
5) education and training
6) exemption of some activities due to limited impacts
7) incentives, awards, and streamlining mechanisms
8) description of staff and resources

Basic Control of Construction Site Runoff

One of the main problems associated with the control of construction site runoff is that the actual monitored field performance of most construction site erosion controls has been disappointedly low. Excellent filter fence installations (well maintained and well constructed) provide only about 50% control, maximum. Typical monitored performance has shown negligible benefits due to installation and maintenance problems. The use of rock berms in channels are more robust, but still provide less than about 25% suspended solids control. Sediment ponds can be designed to provide good control (>50%) of suspended solids, but they would have to be very large (about 2% of drainage area) to provide significant removal of fine sediment. The effluent turbidity from sediment control ponds at construction sites is still high.

Prevention is the best and typically least expensive control solution. Typical preventative measures include:

1) divert flows around exposed soils
2) schedule site activities to minimize amount of exposed soil
3) use temporary mulch
4) use erosion control blankets in sensitive areas (concentrated flow channels, steep slopes)

Diversion of Flows

WI DNR photo

Minimize Exposed Soil

Temporary Mulch

Erosion Control Blankets

Basic Goals and Performance Standards for Erosion and Sediment Control

The most common goal of jurisdictions implementing an erosion and sediment control program is protection of public safety, water quality, or other aquatic related resources such as habitat or fisheries. A more realistic goal is minimization, "to the extent practical," of off-site impacts. That is because, even with the best designs, the process of site development with its associated earth disturbance can still create adverse downstream impacts because of the limited effectiveness of current erosion and sediment practices, especially when severe storm events exceed the design capacity for these practices. The intent of erosion and sediment control programs should be to minimize the potential for off-site impacts by reducing the aerial extent and time duration of impacts.

In defining how a program can minimize impacts, a dual strategy is recommended. The program should seek first to prevent erosion from occurring and also to seek to reduce the associated sedimentation. Prevention practices include sequencing construction to reduce areas of disturbance, conducting land disturbance during the dry season, establishing limits on areas of disturbance during the wet season, and timely stabilization (temporary or permanent) of disturbed areas. Reduction of impacts would follow using traditional erosion and sediment control practices such as stabilized construction entrances, silt fences, diversion dikes, sediment traps and basins. Reduction practices are most effective at removing coarser sediments, while preventive practices are more effective at controlling silt or clay particles by preventing their initial movement. In summary, a basic goal of erosion and sediment control programs should be to minimize off-site impacts by following a philosophy of first preventing erosion and then maximizing control of sedimentation on-site.

Once the program's goal is determined, it is necessary to establish an achievable performance standard which will form the basis for the development of design criteria for the various erosion and sediment control practices to be used. Performance standards can be either technology based or water quality based. Technology-based standards are the most common. They typically are related to a reduction in the level of suspended solids (e.g. 80%) leaving a site, or may be expressed in terms of retaining sediment on-site. The former standard is appropriate because there is a good understanding of the processes involved in the reduction of suspended solids. The latter performance standard addresses potential adverse impacts beyond water quality such as public safety concerns associated with tracking sediments onto public streets or sediment clogging of runoff conveyances which can increase flooding. Water quality based standards often are a "backstop" since most environmental laws prohibit violations of water quality standards. A common water quality based standard is that discharges may not increase turbidity, measured in NTU, above background conditions by more than a specified amount (such as 50 NTU).

Design Criteria

Once a performance standard has been established, then design criteria need to be developed for the individual erosion and sediment controls. By providing both performance standards and design criteria, site planners and engineers can select those practices which will work best on a given site because of its specific soils, topography, slopes, geology, and hydrology characteristics. Design criteria need to be specified for both prevention and reduction practices.

Specific design criteria should be included for at least two prevention practices. First, a maximum area of disturbance at any one time should be specified, with a variance provision for specific activities which cannot meet that limitation. Second, a maximum time frame for either temporary or permanent site stabilization upon cessation of grading needs to be set. As an example, Delaware's program limits site disturbance at any one time to a maximum of 20 acres and requires site stabilization within 14 days when an area is not being actively worked. The specific design criteria for prevention practices will depend largely on local rainfall patterns and associated runoff characteristics. If there is a defined seasonality to the rainfall, the criteria may be primarily directed towards activities conducted during the wetter seasons. This approach is used by the Puget Sound Water Quality Management Program which establishes seasonal limits on disturbed area.

Design criteria for reduction practices often are based on sizing criteria, either in terms of contributing drainage area or storage volume, or both. Most programs establish a minimum size for sediment traps and basins, such as 1,800 cubic feet per acre of drainage area. This volume figure was developed years ago by the Natural Resources Conservation Service (then the Soil Conservation Service) to achieve a 70% reduction in suspended solids on a Piedmont hydrologic soil group C soil. This volume was then used as a design criteria as a minimum standard for site design.

Exemptions and Waivers

If the erosion and sediment control program is integrated with the stormwater management program, the exemptions and waivers should be consistent, but not necessarily identical. There are activities which, due to their limited size, should not be required to provide permanent stormwater management, but which should be required to implement erosion and sediment control. An example is single family home construction that is not part of a larger development.

The most common and simplest approach for establishing exemptions and waivers is based on the amount of disturbed area. This approach is easily implemented since determining the amount of disturbed area is simple. The size of the disturbed area for an exempt activity will depend to some extent on local conditions such as rainfall patterns, soil types, and topography. It is recommended that the threshold size of disturbance be relatively small, such as 5,000 square feet. This emphasizes that erosion and sediment control are integral components of site development. It also helps to minimize potential cumulative impacts if many construction projects are on-going within a watershed.

There also has to be some flexibility for unforeseen types of activities for which pre-construction review and approval would be an undue hardship and not be in the best public interest. These activities typically are of an emergency nature, such as those required after an extreme storm event which creates situations needing an immediate response. Such activities must still implement erosion and sediment controls, but implementation should be based on requirements defined on-site. Alternatively, a special process can be established which calls for submission and review of plans within an appropriate time frame.

Design Assistance and Guidance

To maximize program effectiveness and the proper use, design, construction, and maintenance of erosion and sediment controls, it is essential to have a design guidance document available for designers, developers, and contractors. It is not difficult to develop such a document, as most areas of the country already have one in use. To a large extent, the manuals are very similar to one another. For each practice, the design manual should specify the purpose, applicability in different site situations, sizing, materials, construction standards, maintenance needs, and operational information. The manual must include both structural and vegetative practices. Many of the structural practices, except for storage volumes of sediment traps or basins, tend to have universal design criteria. Vegetative practices must include local considerations such as the types of plant materials and how they are best established and maintained. It is critical, however, that design manuals consider local conditions, especially rain characteristics and topography. This hinders the simple transfer of design manuals throughout the country.

Example Construction Site Erosion Control and Stormwater Management Requirements

Rationale and Purpose

The objective of an effective construction site erosion control and stormwater management ordinance is to protect the local water resources from water quality degradation from many potential sources and activities. Specific provisions of an ordinance may:

- control development and related activities which may increase pollution from these sources,
- provide for treatment practices which promote the public health, safety, and general welfare, and
- restrict or prohibit discharges which are dangerous to, or potentially may increase pollution of, the watershed and public water supply.

Standards and Specifications for Construction Site Erosion Control

Actual monitoring of construction sites (especially research on the yields and delivery of construction site erosion material) has found that the type of development (i.e., final land use) has very little effect on erosion rates. Instead, construction site erosion losses vary with the amount of land disturbed, the duration of that disturbance, and the presence of effective erosion controls. A watershed protection ordinance, therefore, should require erosion controls for all types of development and exclude only small construction projects (such as those disturbing less than 2,000 square feet, or involving excavation and/or filling of less than 500 cubic yards of material). Thus, projects such as home additions or household gardening activities will generally be too small to require control, while construction of most individual homes and all larger types of development would require control.

Construction site monitoring has also revealed that sediment delivery (the amount of sediment leaving its source compared to the amount entering the receiving water) is very close to 100 percent for typical construction sites. Watershed monitoring has shown that almost all of the sediment from construction areas that disturb more than about ten percent of a watershed, and about one-half of that from construction areas that disturb less than ten percent, reach the receiving water. These very large delivery ratios probably result from the normal practice of installing the storm drainage system during the initial construction phase, because sediment travels much more efficiently in conventional storm drainage systems than in natural sheetflows or in small tributary streams. The early installation of storm drainage systems also apparently makes sediment yield and delivery insensitive to site slope. An erosion control ordinance, therefore, should not exempt construction projects on the basis of percentage disturbance of a watershed, or construction site slope.

Vague regulations and general criteria regarding erosion control sometimes found in many erosion control ordinances should be replaced by criteria that specify when and where specific control practices are to be used. Such guidance should help site engineers as well as site plan reviewers and inspectors. In addition, specific criteria should promote more uniform construction site erosion control throughout the watershed.

The main purpose of construction site erosion control requirements is to prevent sediment and other pollutants from leaving construction sites. The secondary purpose is to significantly reduce the quantity of any “escaped” material that reaches receiving waters. Past research projects that have characterized construction erosion discharges and transport processes have concluded that very large amounts of sediment, phosphorus, and other pollutants erode from most construction sites. Sediment yields from uncontrolled construction sites may, for example, be several hundred to several thousand times the annual sediment yields from most developed urban areas. Small areas of active construction may therefore contribute much more pollution to a receiving water than entire cities or surrounding agricultural lands. By requiring reasonable and effective construction site erosion controls for most developing areas, discharges of many pollutants to receiving waters can be greatly reduced.

Site Erosion Control Requirements

Site erosion control requires three elements to protect downslope property, the storm drainage system, and receiving waters. The first involves diverting water from upslope, undisturbed areas so that it does not flow across disturbed land. This preventive measure can reduce the volume of water and energy available to transport soil exposed by construction activity.

Lack of diversion

The second element requires mulching disturbed ground at time intervals that permit necessary grading but that also reduce erosion losses during intense rains. Site erosion control, on-site mulch or temporary vegetation is needed in order to control erosion from disturbed sites during periods of site inactivity or when the erosion potential is very high. In many areas of the country, storms having high erosion potential can occur at any time, so immediate on-site mulching is a very important aspect of effective construction site erosion control. A risk assessment of the erosion potential of Jefferson County, AL, rains showed that rains occur about every three days. Although about three rains could occur during any seven-day period, the probability of a rain with high erosion potential during any seven-day period is relatively low. The probability increases with longer periods of time, however. A time limit of 14 days of no activity before mulching is required on portions of the construction site is a compromise between potential erosion damage and construction scheduling problems. Unfortunately, many disturbed sites are left inactive for periods much longer than 14 days, resulting in very high probabilities of severely erosive rains occurring when sites are left disturbed and inactive. Stabilization of these inactive but disturbed areas is needed, therefore, to prevent site erosion, to eliminate the cost of regrading severely eroded areas, and to protect off-site areas from erosion products. In many cases, better timing of grading operations could also reduce the time an area is left disturbed.

Unattended severely eroded land

The third site erosion control element requires downslope controls to minimize the quantity of erosion products that leave the site. This element is necessary because significant exposed land will always occur at construction sites. Moreover, plantings can require several weeks to become established and capable of reducing erosion. For small sites (less than 10 acres) with no channelized flow, filter fences or other perimeter controls are probably adequate. These controls are fragile, however, and suitable only for sheetflows at low velocities. When larger flows can be expected, sedimentation basins are needed because high flow rates can quickly destroy filter fences.

Filter fencing for small drainage areas

Sediment ponds for larger areas

Downslope controls alone cannot offer adequate protection from severely erosive rains that may occur at any time during the construction season. Because such rains could completely and quickly wash out a filter fence or silt-in a sedimentation basin if a site had no other protection, downslope controls should be installed in conjunction with above-site flow diversions and site mulching or plantings. Together, these three erosion control elements can significantly reduce potential erosion damage, which can be very expensive, if not impossible, to remedy once it has occurred. Nevertheless, occasional severe rains occurring at the "wrong time" in relation to site protection requirements may still cause downstream damage. The intent of an erosion control ordinance is to give site planners and engineers as much flexibility as possible in applying required specifications and standards to proposed projects. Although construction site regulations may appear restrictive, they should allow many choices about matters such as location of storage piles, mulch types, timing of grading, etc.

Summary of Erosion Control Requirements

As included in many regulations, including the proposed EPA *Effluent Guidelines for the Construction and Development Industrial Category* (June 24, 2003 *Federal Register*, 40 CFR Parts 122 and 450), all erosion control efforts should consist of three basic elements:

1) divert upslope water around the disturbed site, or pass it through the site along a protected channel,

2) expose disturbed areas for the shortest possible time (allowing a maximum time limit of about 14 days

for disturbed land before required protection), either through improved construction phase scheduling, or through temporary or permanent mulching, and

3) treat any runoff water before it leaves the site (by perimeter filter fencing, or if a “large” site, with a sediment pond).

This triple approach is needed because of the potential failure of any one system due to random rains that may cause severe site and erosion damage. As an example, if a temporary seeding is not fully established, a moderate rain of greater than 0.5 inch (which may occur about every 10 days in the Birmingham, AL, area) can easily wash it away. In addition, special considerations are also necessary, such as the following examples:

- construction wastes (don’t allow their burial on the site),

- tracking restrictions (all main site roads, which have greater than about 25 vehicles per day traffic, and all site entranceways have to be graveled, and travel is restricted off these graveled areas),

- treat dewatering wastes before discharge,

- protect storm drain inlets (with straw bale or filter fence barriers),

- locate material storage piles away from storm drain inlets (by at least 50 feet), and if left for a long time (greater than 14 days), then they must be covered, mulched, or surrounded with a perimeter filter fence or straw bale barrier,

- direct all on-site concentrated runoff (especially down steep slopes) along protected channels, or in flexible down drains, and

- have contractor inspect all erosion controls on the site and make necessary repairs at least weekly and after large rains (greater than about 0.5 inch).

- construction vehicle maintenance must be accomplished in special protected areas.

Need for Adequate Design and Inspection

Adequate design specifications, especially those based on local experience, can minimize potential construction site erosion problems. Construction site erosion controls may fail for several reasons. Unusual rains that exceed the design capacities of even correctly constructed and maintained control facilities may cause their failure. Most construction erosion controls are relatively fragile and cannot survive large rains. However, a wet detention basin installed early during the construction period will act as a good sediment trap during a wide range of rains. In-stream detention facilities that receive large amounts of runoff from above a construction project can also be easily damaged during large rains. The basin must be cleaned (dredged) often during construction and after final landscaping, for the construction period can produce as much sediment as many years of “normal” urban runoff. Large rains can also damage filter fences and other barriers and can severely erode culverts and waterway diversions. Failed controls are not only unable to reduce expected large amounts of erosion materials during severe rains but also may discharge previously retained sediment.

Improperly located, designed, constructed, or maintained control devices produce little benefit. A common example of a poor location for a control device is the placement of filter fences in established waterways that drain large areas. Filter fences slow down water passing through them and create small detention areas. Particles then settle from the ponded water. They can be designed as small wet detention basins, based on their allowable water seepage rates (outfall velocities), and not as filtration devices. They are supposed to be used to control shallow sheetflows. When placed in channels draining areas that are too large, backed up water may topple the filter fence, or the stream may increase in elevation and collapse the fencing, or the water may flow around the filter fence edges. Similar problems exist when straw bales are placed in large waterways. These devices are best used to control sheetflows before they enter the drainage channels. If large drainage channels cannot be diverted and must pass through a project, filter fencing must be placed appropriately to control sheetflows entering the channel. Well designed wet detention (sediment) basins may also be needed below the site.

Probably the most common reason for failure of construction site erosion control devices is inadequate maintenance. These devices are often reluctantly installed and then ignored. If control devices are properly constructed, but not properly or frequently maintained, very little benefit may be expected. Newly installed devices will perform as initially expected until their “capacity” is exceeded. Filter fences, for example, should be maintained before the material that accumulates behind them becomes excessive. More importantly, the integrity of the fence also needs to be checked frequently. Many filter fences at construction sites are undermined or bypassed because of large flows or large sediment accumulations. Sedimentation basins, silt traps, catchbasins, etc., also need to be cleaned frequently. The cleaning frequency of these devices located in areas undergoing construction can be quite high because of the very large discharges of sediment from construction sites. Rill or gully erosion must be corrected immediately when first observed. Similarly, mulched or planted areas need frequent inspections and repairs before large amounts of material are lost. Proper plan reviews and adequate inspections by administrative officials can prevent many of the problems caused by improper location, construction, and maintenance of construction erosion and stormwater control devices.

Inspection During Construction

During construction, inspections need to be made of both erosion and sediment controls and stormwater management facilities. Erosion and sediment controls must be inspected periodically throughout the construction process, especially after storms. Stormwater management systems need to be inspected at critical times during construction of the individual practices.

Inspection frequency needs to be flexible, corresponding to shifts in the intensity of activity going on at the site. When active construction is occurring, erosion and sediment control inspections should be conducted on a specified, appropriate frequency. When work on the site stops temporarily, inspections should be done periodically to assure that erosion and sediment controls are being maintained and still working, and to ensure that work has not resumed. Ideally, inspections should be done at a specified regular time interval and after significant storm events. This allows any changes in site conditions to be observed, and ensure that erosion and sediment controls are still functioning as designed and approved. It is recommended that inspections be conducted by a public agency person at least once every two weeks.

Inspection staff resources typically are insufficient to visit all active construction sites. An implementation strategy decision must be made whether to visit fewer sites and completely follow the inspection procedures, or to conduct less comprehensive inspections at more sites. It is recommended that the inspection procedures be followed completely at sites which are inspected. Inspections need to be prioritized based on potential impacts, helping to assure compliance on tougher sites. Following the prescribed procedures also is important should legal enforcement action become necessary.

Inspectors should always attempt to contact an on-site individual who is responsible for the site grading activities. The contractor should be aware that the inspector is visiting the site even if the contractor does not accompany the inspector. This improves the dialogue that is important between the inspector and contractor. Highly visible inspections reinforce the commitment and importance a jurisdiction places on effective implementation of site controls. By knowing that the site will be inspected periodically, contractors are more likely to be aware of, and meet, site control responsibilities.

After completing the inspection, the inspector should leave an inspection report with the contractor, sending a copy to the developer and possibly the property owner. The report should serve as a site report card, clearly documenting proper installation and maintenance of site controls as well as any deficiencies in site control implementation. If there is a violation, the inspection report initiates a “paper trail” which is integral to successful enforcement actions.

It is unlikely that public agencies will ever have enough inspectors, simply do to the large number of active construction projects at any time and resource limitations of stormwater management programs. A creative, innovation to solve this problem is a partnership between the stormwater management program agency and the development community. This concept is being used in Delaware where the contractor or developer supplies their own inspectors. This person must attend and pass a State sponsored training course for inspectors. They are then responsible for inspecting the site at least once a week, completing an inspection form, and providing a copy of the form to the contractor, developer, and appropriate inspection agency. Having a “certified” private inspector on the site weekly can reduce the inspection frequency by the appropriate agency.

To improve the effectiveness of inspections, it is important to establish standard, well-documented inspection procedures. These procedures should specify in detail the actions an inspector conducts at a site, set out options and list steps to be taken when site compliance is inadequate, and establish an appeals process, should the inspector and developer disagree on matters. The procedures need to be developed in conjunction with available legal authorities and penalty provisions. Inspection of the stormwater management system during construction typically is not done on a regular schedule, but at certain stages of practice construction. For each type of construction site control, there are certain stages of construction where inspection is essential to assure proper construction and performance.


J. Voorhees photo


J. Voorhees photo

WI DNR photo

Maryland DNR (Earl Shaver) photo

Necessary Enforcement and Education

Important Internet Links

EPA. Office of Wastewater Management (OWM) information:
http://www.epa.gov/owm/

EPA Stormwater Program information, Final Phase II NPDES rule:
http://cfpub.epa.gov/npdes/home.cfm?program_id=6

EPA Fact Sheet Series:
http://cfpub.epa.gov/npdes/stormwater/swfinal.cfm

EPA stormwater regulations:
http://cfpub.epa.gov/npdes/regs.cfm?program_id=6

EPA information on discharges from construction activities:
http://cfpub.epa.gov/npdes/stormwater/const.cfm

References

Chesters, G., J. Konrad and G. Simsiman. "Menomonee River Pilot Watershed Study- Summary and Recommendations", EPA-905/4-79-029. U.S. Environmental Protection Agency, Chicago, Ill., 1979.

EPA. "Effluent guidelines for the construction and development industrial category." *Federal Register*, 40 CFR Parts 122 and 450. June 24, 2003

Madison, F., J. Arts, S. Berkowitz, E. Salmon, and B. Hagman. "Washington County Project". EPA 905/9-80-003, U.S. Environmental Protection Agency, Chicago, Ill., 1979.

Nelson, J. *Characterizing Erosion Processes and Sediment Yields on Construction Sites*. MSCE thesis. Dept. of Civil and Environmental Engineering, University of Alabama at Birmingham. 94 pgs. 1996.

Novotny, V. and G. Chesters. *Handbook of Nonpoint Pollution Sources and Management*. Van Norstrand Reinhold Company, New York, 1981.

Southeastern Wisconsin Planning Commission (SEWRPC). "Sources of Water Pollution in Southeastern Wisconsin: 1975". Technical Report No. 21. Waukesha, Wisconsin, 1978.

Virginia. Erosion and Sediment Control Handbook. Second Edition. Division of Soil and Water Conservation. Virginia Dept. of Conservation and Historic Resources. Richmond, Virginia. 1980.

Willett, G. Urban Erosion, in National Conference on Urban Erosion and Sediment Control; Institutions and Technology. EPA 905/9-80-002. U.S. Environmental Protection Agency, 1980.

Appendix 1A: Example Components of Local and State Construction Site Regulations

Table 1A-1. Example Erosion and Sediment Control Exemptions and Waivers

Jurisdiction	Exemptions and Waivers
City of Alexandria, VA	<2,500 s.f.
City of Austin, TX	Agriculture; state facilities, projects disturbing < 1,000 s.f.
City of Bellevue, WA	None
City of Fort Collins, CO	Single family homes
City of Olympia, WA	Agriculture; forestry; public & private projects in right-of-way that add no impervious surface, grading projects that don't require grading permit
City of Orlando, FL	Single family homes not part of subdivision
City of Seattle, WA	Agriculture, forestry, WA DOT projects that comply with Puget Sound Highway Runoff Program, projects discharged directly to receiving water or piped storm drain (under certain conditions), < 750 s.f. new impervious surface or < 2,000 s.f. total impervious surface
District of Columbia	Agriculture, forestry, projects that disturb < 500 s.f. or total cost < $2,500.
City of Winter Park, FL	None
Baltimore County, MD	Agriculture, activities disturbing < 5,000 s.f.
Clark County, WA	Agriculture, forestry, projects disturbing < 2,000 s.f.
King County, WA	Agriculture; single family homes exempt from detailed ES control plan
Kitsap County, WA	Agriculture (Kitsap SWCD stormwater related activities funded by county stormwater program
Maricopa County, AZ	N/A because state NPDES program exempts projects disturbing < 5 acres

Montgomery County, MD	Agriculture, projects disturbing < 5,000 s.f.
Prince George's County, MD	Agriculture
Snohomish County, WA	Agriculture
Somerset County, NJ	See New Jersey State Soil Conservation Committee Program Summary.
Washington County, OR	None
Urban Drainage and Flood Control District (Denver)	State NPDES permit exempts activities disturbing < 5 acres; other requirements depend on regulations of 10 local government programs
Northeastern Illinois Planning Commission	Agriculture, forestry, activities disturbing < 5,000 s.f., activities disturbing < 500 s.f. if next to water
South Florida Water Management District	Agriculture using closed water management systems
Southwest Florida Water Management District	Agriculture (with site specific Conservation Plan with appropriate BMPs); forestry (complying with "Florida Silviculture BMP Manual"); single family homes not in subdivision
Suwannee River Water Management District	Agriculture (with site specific Conservation Plan with appropriate BMPs); forestry (complying with "Florida Silviculture BMP Manual"); single family homes not in subdivision
State of Delaware	Agriculture
Florida Department of Environmental Protection	Agriculture (if using approved Conservation Plan with appropriate BMPs); forestry (complying with "Florida Silviculture BMP Manual"); single family homes not in subdivision
Maryland Department of the Environment	Agriculture; activities disturbing < 5,000 s.f. or 100 cu. yds.
State of New Jersey	Agriculture, forestry, single family homes not part of larger development, activities disturbing < 5,000 s.f.
State of North Carolina	Construction sties < 5 acres and not located; within ½ mile of a water classified as a High Quality Water, in a coastal county and draining to a saltwater or other classified water, and located in a non-coastal county and draining to or within one mile of a water classified as a High Quality Water or an Outstanding Resource Water.
State of Pennsylvania	Timber harvesting disturbing < 25 acres; agricultural plowing & tilling pursuant to conservation plan; activities disturbing < 5 acres
State of South Carolina	Agriculture, forestry, single family homes not part of large development, utility operations with certificate of environmental compatibility
State of Virginia	Agriculture; forestry; activities disturbing < 10,000 s.f.; mining & gas exploration activities
Washington State Department of Ecology	Agriculture, forestry operation (except for forest conversions); activities disturbing < 1 acre; single family homes

Table 1A-2. Example Erosion and Sediment Control Preferred Practices

Jurisdiction	Preferred Practices
City of Alexandria, VA	Sediment basins & traps designed to capture 15 cu. yds/acre drainage area.
City of Austin, TX	Sediment basins & traps designed to capture 1,800 cu. yds/acre drainage area.
City of Bellevue, WA	Sediment basins & traps to contain runoff volume from: 10 yr storm for sites < 5 ac., or > 0.25 mi from waters; 20 yr storm for sites > 5 ac. or < 0.25 mi from waters
City of Fort Collins, CO	Sediment basins & traps designed for 100 cu. yds/acre
City of Olympia, WA	Sediment basins & traps to hold 2-yr (24 hr) storm volume.
City of Orlando, FL	Sediment basins & traps to capture 2.33 yr (6 hr) storm.
City of Seattle, WA	Sediment traps to retain runoff volume from 2 yr (24 hr) storm. Basins sized to settle medium silt soil particles (0.02 mm) during peak discharge from 10 yr (24 hr) storm.
District of Columbia	Sediment basins & traps to capture 1,800 cu. ft./acre drainage area.
City of Winter Park, FL	Sediment basins & traps to capture 67 cu. yds./acre drainage area.
Baltimore County, MD	Sediment basins & traps to contain 1,800 cu. yds runoff from drainage area.
Clark County, WA	Sediment traps to hold 2 yr (24 hr) storm runoff; basins to treat 10 yr (24 hr) storm.
King County, WA	Sediment traps to treat 2 yr (24 hr) storm runoff; basins sized for 10 yr (24 hr) storm.
Kitsap County, WA	Sediment traps & basins to treat runoff from 2 yr (24 hr) storm.
Maricopa County, AZ	None
Montgomery County, MD	Sediment basins & traps to capture 1,800 cu. ft/acre drainage area (to be changed to 3,600 cu. ft./ac.)
Prince George's County, MD	Sediment basins & traps to capture 1,800 cu. ft/acre drainage area (to be changed to 3,600 cu. ft./ac.)
Snohomish County, WA	Sediment basins & traps to capture runoff from 10 yr (24 hr) storm
Somerset County, NJ	See New Jersey State Soil Conservation Committee Program Summary.
Washington County, OR	Sediment basins & traps to capture runoff from 10 yr (24 hr) storm (RARELY USED)
Urban Drainage and Flood Control District (Denver)	Sediment basins & traps to retain 0.25 in of runoff from site.
Northeastern Illinois Planning Commission	Sediment basins & traps to capture runoff from 10 yr storm
South Florida Water Management District	None
Southwest Florida Water Management District	Sediment basins & traps to capture 67 cu. yds./acre drainage area
Suwannee River Water Management District	Sediment basins & traps to capture 67 cu. yds./acre
State of Delaware	Sediment traps & basins to retain 3,600 cu. ft./acre of contributing drainage area.

Florida Department of Environmental Protection	Sediment basins & traps to capture 67 cu. yds./acre
Maryland Department of the Environment	Sediment basins & traps to treat 1 in of runoff from disturbed area
State of New Jersey	Sediment basins & traps to retain 1 inch of runoff from disturbed area
State of North Carolina	Preventive Measures (nonstructural controls)
State of Pennsylvania	Sediment basins to treat 7,000 cfs/acre; sediment traps to treat 2,000 cfs/acre (max. 5 acres)
State of South Carolina	Sediment basins & traps to achieve 80% removal of average annual total suspended solids loading
State of Virginia	Sediment basins to capture 134 cu. yds/acre
Washington State Department of Ecology	Sediment basins & traps to detain 10 yr (24 hr) developed condition design storm

Table 1A-3. Example Erosion and Sediment Control Allowed Practices

Jurisdiction	Allowed Practices
City of Alexandria, VA	Silt fences, gravel const. entrance, slope protection, temp. & perm. veg. stabilization
City of Austin, TX	Construction sequencing, rock berms, filter dikes, diversion swales, temporary & permanent vegetation stabilization
City of Bellevue, WA	Seasonal limits on disturbed area, silt fence, gravel construction entrance, wheel washes; slope protection; temporary & permanent vegetation stabilization
City of Fort Collins, CO	Straw bales, surface roughening, diversions, gravel filters, filter fence, inlet barriers, terraces, temporary & permanent vegetation stabilization
City of Olympia, WA	Seasonal limits on disturbed area, silt fence, straw bales, gravel construction entrance, slope protection, inlet prot., temp. & permanent vegetation stabilization
City of Orlando, FL	Silt fences, gravel construction entrance, inlet protection, temporary & permanent vegetation stabilization, limited exposed areas
City of Seattle, WA	Silt fences, gravel construction entrance, wheel wash, slope protection, inlet protection, temporary & permanent vegetation stabilization
District of Columbia	Silt fences, vehicle wash area, straw bales, stabilized construction entrance, inlet protection, temporary & permanent vegetation stabilization
City of Winter Park, FL	Silt fences, straw bales, inlet & slope protection, temp. & perm. veg. stabilization.
Baltimore County, MD	Silt fences, straw bales, inlet & slope protection, temp. & perm. veg. stabilization.
Clark County, WA	Seasonal limits on disturbed area, stabilized construction entrance, wheel wash, slope drain, straw bales, silt fence, mulching, temp. & perm. vegetation stabilization.
King County, WA	Seasonal limits on disturbed area, mulching, silt fences, gravel construction entrance, slope drains, temporary & permanent vegetation cover.
Kitsap County, WA	Seasonal limits on land disturbance, gravel construction entrance, wheel wash, silt fences, straw bales, slope drains, mulching, temp. & perm. vegetative stabilization
Maricopa County, AZ	None
Montgomery County, MD	Mulching, sodding, staged clearing, silt fences, gravel construction entrances, temporary & permanent vegetation
Prince George's County, MD	Mulching, sodding, staged clearing, silt fences, gravel construction entrances, temporary & permanent vegetation
Snohomish County, WA	Mulching, seasonal limitation on disturbed area, silt fences, gravel construction entrance, slope drains, temporary & permanent vegetative stabilization
Somerset County, NJ	See New Jersey State Soil Conservation Committee Program Summary.
Washington County, OR	Silt fences, gravel construction entrances, diversions, bio-bags, straw, compost, temporary & permanent vegetation cover
Urban Drainage and Flood Control District (Denver)	Mulching, silt fences, temporary & permanent vegetation cover
Northeastern Illinois Planning Commission	Temporary & permanent vegetative cover; mulching; seeding; sodding; erosion blankets; silt fences; gravel construction entrances; outlet stabilization
South Florida Water Management District	None listed.
Southwest Florida Water Management District	Mulching; sodding, staged clearing, silt fences, gravel construction entrance, temporary & permanent vegetative cover
Suwannee River Water Management District	Mulching, sodding, staged clearing, silt fences, gravel construction entrances, temporary & permanent vegetation
State of Delaware	Silt fences, straw bales, gravel construction entrances, diversions, slope drains, temporary & permanent vegetation stabilization
Florida Department of Environmental Protection	Mulching, sodding, staged clearing, silt fences, gravel construction entrances, temporary & permanent vegetation
Maryland Department of the Environment	Mulching, sodding, staged clearing, silt fences, gravel construction entrances, temporary & permanent vegetation
State of New Jersey	Mulching, sodding, staged clearing, silt fences, gravel construction entrances, temporary & permanent vegetation
State of North Carolina	Preventative measures, detention and retention ponds and infiltration devices such as infiltration basins, trenches or underground trenches and dry wells
State of Pennsylvania	Silt fences, temp. & perm. vegetation, diversions, rock filters, riprap, inlet protection
State of South Carolina	Mulching, sodding, staged clearing, silt fences, gravel construction entrances, temporary & permanent vegetation
State of Virginia	Sediment traps, silt fences, temp. & perm. veg., diversions, daily street cleaning
Washington State Department of Ecology	Seasonal disturbed area limits, staged clearing, silt fences, gravel construction entrance, mulching, sodding, temporary & permanent vegetative cover, slope drains

Table 1A-4. Example Erosion and Sediment Control Design Criteria Publications

Jurisdiction	Design Criteria Publications
City of Alexandria, VA	Virginia Erosion and Sediment Control Handbook.
City of Austin, TX	City's Environmental Criteria Manual
City of Bellevue, WA	Bellevue Development Standards, Chapter 2 and Construction and Water Quality (King County Conservation District)
City of Fort Collins, CO	Fort Collins Storm Drainage Design Criteria and Construction Standards
City of Olympia, WA	Olympia Drainage Design and Erosion Control Manual; Stormwater Management Manual for the Puget Sound Basin, Volume II
City of Orlando, FL	Orlando Urban Stormwater Management Manual, Florida Development Manual: A Guide to Sound Land & Water Management
City of Seattle, WA	City of Seattle Pollution Control Guidelines for Construction Sites: Appendix A, Erosion and Sedimentation Control BMPs
District of Columbia	District of Columbia Erosion and Sediment Control Handbook
City of Winter Park, FL	Florida Development Manual: A Guide to Sound Land and Water Management
Baltimore County, MD	Maryland Standards and Specifications Handbook
Clark County, WA	Stormwater Management Manual for the Puget Sound Basin, Volume 2
King County, WA	Stormwater Management Manual for the Puget Sound Basin
Kitsap County, WA	Stormwater Management Manual for the Puget Sound Basin (Chapter II)
Maricopa County, AZ	None
Montgomery County, MD	Maryland Standards and Specifications Handbook
Prince George's County, MD	Maryland Standards and Specifications Handbook
Snohomish County, WA	Snohomish County Stormwater Management Manual (based on criteria in Puget Sound manual)
Somerset County, NJ	See New Jersey State Soil Conservation Committee Program Summary.
Washington County, OR	Erosion Control Plans Technical Guidance Handbook
Urban Drainage and Flood Control District (Denver)	Urban Storm Drainage Criteria Manual, Volume 3 - BMPs
Northeastern Illinois Planning Commission	Best Management Practices for Northeastern Illinois, NIPC
South Florida Water Management District	Florida Development Manual: A Guide to Sound Land and Water Management (Chapter 6)
Southwest Florida Water Management District	Florida Development Manual: A Guide to Sound Land and Water Management (Chapter 6)
Suwannee River Water Management District	Florida Development Manual: A Guide to Sound Land and Water Management (Chapter 6)
State of Delaware	Delaware Erosion and Sediment Control Handbook
Florida Department of Environmental Protection	Florida Development Manual: A Guide to Sound Land and Water Management (Chapter 6)
Maryland Department of the Environment	Maryland Erosion and Sediment Standards and Specifications Manual
State of New Jersey	Standards for Soil Erosion and Sediment Control in New Jersey
State of North Carolina	State of North Carolina: Stormwater Management Guidance Manual and Stormwater Management Site Planning
State of Pennsylvania	Discharge rate for temporary basins = 1.6 cfs/acre (2 yr storm); for permanent basins, discharge rate = 2.75 cfs/acre (25 yr storm);
State of South Carolina	A Guide to Site Development and Best Management Practices for Stormwater Management and Sediment Control; South Carolina Stormwater Management and Sediment Control Hand Book for Land Disturbing Activities
State of Virginia	Virginia Erosion and Sediment Control Handbook; Erosion and Sediment Control Field Manual
Washington State Department of Ecology	Stormwater Management Manual for Puget Sound Basin