CHAPTER 2

Erosion and Sediment Control Principles, Practices and Costs

INDEX

EROSION AND SEDIMENT CONTROL

PRINCIPLES, PRACTICES AND COSTS

CHAPTER 2

EROSION AND SEDIMENT CONTROL PRINCIPLES, PRACTICES AND COSTS

This chapter contains basic information on the principles, practices and costs of erosion and sediment control on urban land-disturbing projects. It is divided into three parts.

PART I - EROSION AND SEDIMENT CONTROL PRINCIPLES: Information on the causes and effects of erosion and sedimentation is presented along with a discussion of basic conservation principles for effectively controlling the problem.

PART II - OVERVIEW OF PRACTICES: The nature, purpose and distinguishing features of erosion and sediment control practices are briefly summarized to provide users with a quick reference and broad basis of comparison.

PART III - COSTS: Information on estimating the cost of implementing various vegetative and structural erosion and sediment control practices is provided.

WALL CHART: A large, folded wall chart is contained in a pocket at the end of this chapter to provide users with a single-sheet reference to all of the erosion and sediment control practices found within. This chart consolidates relevant information concerning the selection and application of the practices and presents a unified coding system for designers who will specify the practices on erosion and sediment control plans.

PART I

EROSION AND SEDIMENT CONTROL PRINCIPLES

THE EROSION PROCESS

Soil erosion is the process by which the land's surface is worn away by the action of wind, water, ice and gravity. Natural, or geologic erosion has been occurring at a relatively slow rate since the earth was formed, and is a tremendous factor in creating the earth as we know it today. The picturesque mountains of the west, the rolling farmlands of the Piedmont, and the productive estuaries of the Coastal Zone are all products of geologic erosion and sedimentation in Virginia. Except for some cases of shoreline and stream channel erosion, natural erosion occurs at a very slow and uniform rate and remains a vital factor in maintaining environmental balance.

Water-generated erosion is unquestionably the most severe type of erosion, particularly in developing areas; it is, therefore, the problem to which this handbook is primarily addressed. It is helpful to think of the erosive action of water as the effects of the energy developed by rain as it falls, or as the energy derived from its motion as it runs off the land surface. The force of falling raindrops is applied vertically, and force of flowing water is applied horizontally. Although the direction of the forces created is different, they both perform work in detaching and moving soil particles.

Water-generated erosion can be broken down into the following types:

Raindrop erosion is the first effect of a rainstorm on the soil. Raindrop impact dislodges soil particles and splashes them into the air (see picture below). These detached particles are then vulnerable to the next type of erosion.

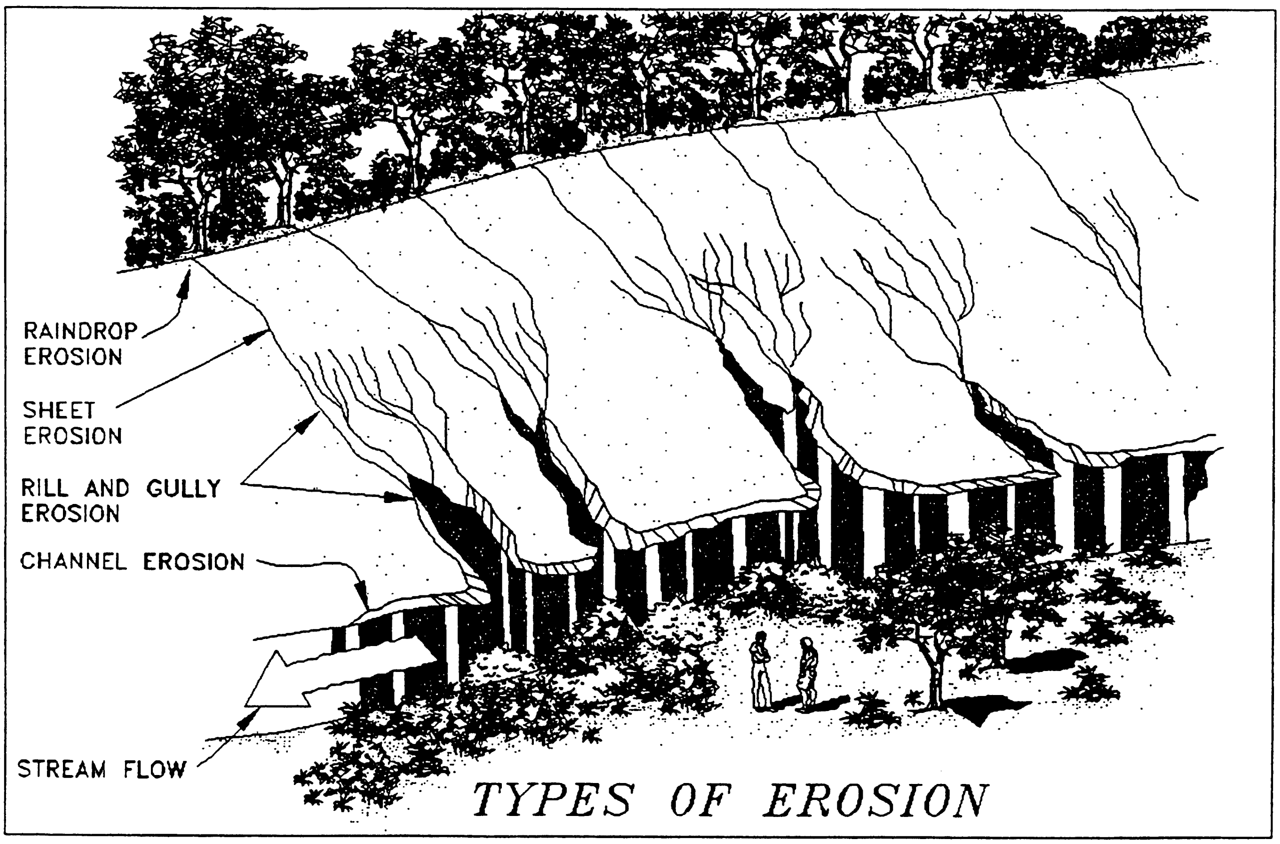
Source: Soil Conservation Society of America

<u>Sheet erosion</u> is the erosion caused by the shallow flow of water as it runs off the land. These very shallow moving sheets of water are seldom the detaching agent, but the flow transports soil particles which are detached by raindrop impact and splash. The shallow surface flow rarely moves as a uniform sheet for more than a few feet on land surfaces before concentrating in the surface irregularities.

<u>Rill erosion</u> is the erosion which develops as the shallow surface flow begins to concentrate in the low spots of the irregular contours of the surface. As the flow changes from the shallow sheet flow to deeper flow in these low areas, the velocity and turbulence of flow increase. The energy of this concentrated flow is able to both detach and transport soil materials. This action begins to cut small channels of its own. Rills are small but well-defined channels which are at most only a few inches in depth. They are easily obliterated by harrowing or other surface treatments.

<u>Gully erosion</u> occurs as the flow in rills comes together in larger and larger channels. The major difference between gully and rill erosion is a matter of magnitude. Gullies are too large to be repaired with conventional tillage equipment and usually require heavy equipment and special techniques for stabilization.

<u>Channel erosion</u> occurs as the volume and velocity of flow causes movement of the stream bed and bank materials. Plate 2-1 illustrates the five stages of erosion.



Source: <u>Michigan Soil Erosion and Sedimentation Guidebook</u> Plate 2-1

FACTORS INFLUENCING EROSION

The erosion potential of any area is determined by four principal factors: the characteristics of its soil, its vegetative cover, its topography and its climate. Although each of these factors is discussed separately herein, they are inter-related in determining erosion potential.

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

1. Soil texture (particle size and gradation)
2. Percentage of organic content
3. Soil structure
4. Soil permeability

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

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

1. Shields the soil surface from raindrop impact
2. Root systems hold soil particles in place
3. Maintains the soil's capacity to absorb water
4. Slows the velocity of runoff
5. Removes subsurface water between rainfalls through the process of evapo-transpiration

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

Topography. The size, shape, and slope characteristics of a watershed influence the amount and rate of runoff. As both slope length and gradient increase, the rate of runoff increases and the potential for erosion is magnified. Slope orientation can also be a factor in determining erosion potential. For example, a slope that faces south and contains droughty soils may have such poor growing conditions that vegetative cover will be difficult to re-establish.

Climate. The frequency, intensity, and duration of rainfall are fundamental factors in determining the amounts of runoff produced in a given area. As both the volume and velocity of runoff increases, the capacity of runoff to detach and transport soil particles also increases. Where storms are frequent, intense, or of long duration, erosion risks are high. Seasonal changes in temperature, as well as variations in rainfall, help to define the high erosion risk period of the year. When precipitation falls as snow, no erosion will take place. However, when the temperature rises, melting snow adds to runoff, and erosion hazards are high. Because the ground is still partially frozen, its absorptive capacity is reduced. Frozen soils are relatively erosion-resistant. However, soils with high moisture content are subject to uplift by freezing action and are usually very easily eroded upon thawing.

SEDIMENTATION

Normally, runoff builds up rapidly to a peak and then diminishes. Excessive quantities of sediment are derived by erosion, principally during the higher flows. During lower flows, as the velocity of runoff decreases, the transported materials are deposited to be picked up by later peak flows. In this way, sediments are carried downslope, or downstream, intermittently and progressively from their source or point of origin. A study of sedimentation due to highway construction and land development in Virginia, for instance, indicated that 99 percent of the sediment discharge occurred during periods of high flow which took place during only three percent of the period of measurement (77).

SEDIMENT POLLUTION AND DAMAGE

Sediment pollution is soil out of place. It is a product of the activities of man which lead to severe soil loss. When these large quantities of soil enter our waters, then sediment pollution occurs.

Over four billion tons of sediment are estimated to reach the ponds, rivers, and lakes of our country each year, and approximately one billion tons of this sediment is actually carried all the way to the ocean. Approximately 10 percent of this amount is contributed by erosion from land undergoing highway construction or land development (73). Although these latter quantities may appear to be small compared to the total, they could represent more than one-half of the sediment load carried by many streams draining small subwatersheds which are undergoing development (81).

Excessive quantities of sediment cause costly damage to waters and to private and public lands. Obstruction of stream channels and navigable rivers by masses of deposited sediment reduces their hydraulic capacity which, in turn, causes an increase in subsequent flood crests and a consequent increase in the frequency of damaging storm events.

Sediment fills drainage channels, especially along highways and railroads, and plugs culverts and storm drainage systems, thus necessitating frequent and costly maintenance. Municipal and industrial water supply reservoirs lose storage capacity, the usefulness of recreational impoundments is impaired or destroyed, navigable channels must be continually dredged and the cost of filtering muddy water preparatory to domestic or industrial use becomes excessive - and sometimes exorbitant. The added expense of water purification in the United States, because of sedimentation, amounts to millions of dollars each year.

In an aquatic environment, the general effect of fine-graded sediments such as clays, silts, and fine sands is to reduce drastically both the kinds and the amounts of organisms present. Sediments alter the existing aquatic environment by screening out sunlight and by changing the rate and the amount of heat radiation. Particles of silt settling on stream and lake bottoms form a blanket which creates a hostile environment for the organisms living there and literally smothers many of them and their eggs. The disastrous effect (upon commercially valuable finfish and shellfish populations) of excessive amounts of silt entering estuarine waters was widely publicized in the case of the Chesapeake Bay following flooding of its main tributary, the Susquehanna River, caused by Hurricane "Agnes" in 1972.

Coarser-grained materials also blanket bottom areas to suppress aquatic life found in these areas. Where currents are sufficiently strong to move the bedload, the abrasive action of these materials in motion accelerates channel scour and has an even more severely deleterious effect upon aquatic life. The aesthetic attraction of many steams, lakes, and reservoirs used for swimming, boating, fishing, and other water-related recreational activities has been seriously impaired or destroyed by bank cutting and channel scour - accelerated by a higher flood stages induced by sedimentation.

EROSION AND SEDIMENT HAZARDS ASSOCIATED WITH LAND DEVELOPMENT

The principal effect land development activities have on the natural or geologic erosion process consists of exposing disturbed soils to precipitation and to surface storm runoff. Shaping of land for construction or development purposes alters the soil cover and the soil in many ways, often detrimentally affecting on-site drainage and storm runoff patterns and eventually the off-site stream and streamflow characteristics. Protective vegetation is reduced or removed, excavations are made, topography is altered and the removed soil material is stockpiled - often without protective cover. In effect, the physical properties of the soil itself are changed. The development process is such that many citizens of a locality may be adversely affected even by development of areas of only limited size. Uncontrolled erosion and sediment from these areas often causes considerable economic damage to individuals and to society, in general. Surface water pollution, channel and reservoir siltation and damage to public facilities, as well as to private property, are some of many examples of problems caused by uncontrolled erosion and sedimentation.

Potential hazards associated with development include:

1. A large increase in areas exposed to storm runoff and soil erosion.

2. Increased volumes of storm runoff, accelerated soil erosion and sediment yield and higher peak flows caused by:

a. Removal of existing protective vegetative cover.
b. Exposure of underlying soil or geologic formations which are less pervious and/or more erodible than original soil surface.
c. Reduced capacity of exposed soils to absorb rainfall due to compaction caused by heavy equipment.
d. Enlarged drainage areas caused by grading operations, diversions, and street constructions.
e. Prolonged exposure of unprotected disturbed areas due to scheduling problems and/or delayed construction.
f. Shortened times of concentration of surface runoff caused by altering steepness, distance and surface roughness and through installation of "improved" storm drainage facilities.
g. Increased impervious surfaces associated with the construction of streets, buildings, sidewalks and paved driveways and parking lots.

3. Alteration of the groundwater regime that may adversely affect drainage systems, slope stability and survival of existing and/or newly established vegetation.

4. Creation of south and west directional exposure of property which may hinder plant growth due to adverse temperature and moisture conditions.

5. Exposure of subsurface materials that are rocky, acid, droughty or otherwise unfavorable to the establishment of vegetation.

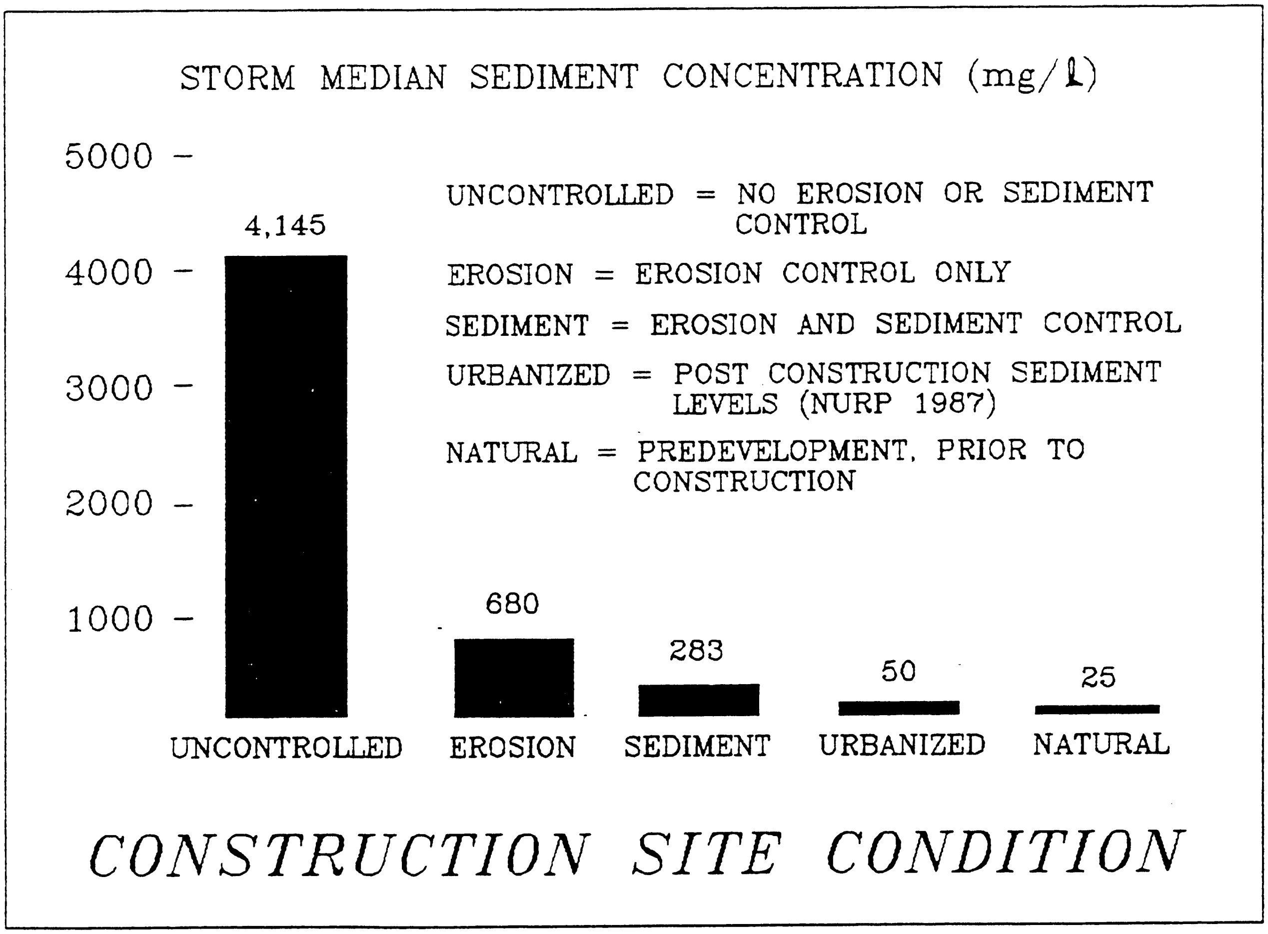
6. Adverse alteration of surface runoff patterns by construction and development.

Increases in sedimentation yield higher levels of nutrients and toxicants. The results of high sediment loading can have a profound effect on the environment. Sediment acts like a magnet to toxicants and trace metals. Additionally, the soil introduces nutrients into streams and groundwater. The net effect is to create a strata known as diagenesis. This activity decreases the oxygen available to support other aquatic life. Even more startling is the apparent ability of sediment to act as long term memory or storage media for toxicants. Studies show that pollutants such as DDT, DDE, PCBs and chlordane whose use has been banned or highly restricted, can still be found at detectable levels in sediment deposited years ago in the bottom of streams and rivers. It has been demonstrated that urbanization and associated sedimentation reduces the diversity of the fish populations in streams as well as the organisms that fish feed on.

The capacity of a stream to maintain its health can be related to the impervious areas within its watershed. Urbanization of a watershed increases the impervious surfaces and increases the pollutant load. One study suggests that once a watershed becomes 12% impervious, the quality of aquatic life has reached a critical threshold.

Responsible development requires that steps be taken to control erosion and sedimentation from construction sites. Plate 2-2 demonstrates the ability of good erosion and sediment controls, versus no controls, in minimizing the detrimental effects of sedimentation.

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



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

Plate 2-2

In the past, efforts have been made to quantify the damage caused by erosion and sedimentation in terms of dollars spent to dredge navigational channels, loss of reservoir capacity and so on. More recently, efforts have concentrated on the qualitative cost. It is very difficult to place a dollar figure on damage to the environment; however, we cannot escape the fact that human health and well-being is ultimately related to the environment in which we live.

DOLLARS AND SENSE

It is well known that urbanization has the following effects:

* Accelerated Rate of Soil Erosion
* Increase in the Peak Discharge and Total Volume of Stormwater
* Increased Potential for "Flash" Flooding
* Decreased Groundwater Recharge
* Increased Temperature in Natural Receiving Channels
* Increased Pollutant Loading to Receiving Waters

Each of these factors has an associated cost. The VESCL and the VESCR attempt to minimize these costs by regulating land-disturbing activities in the State of Virginia. All of the citizens of the Commonwealth stand to gain when local E&S programs are effective and developers follow responsible management procedures. The net results are dollars saved and a direct benefit to the environment.

COST TO THE DEVELOPER

The VESCL requires that land-disturbing activities have an approved E&S plan prior to commencement of work. The owner must provide the plan or pay someone else (i.e., engineer, architect, planner) to provide this plan. Once a plan is approved, generally a contractor places the controls. However, the owner is ultimately responsible and in fact must certify that the plan will be carried out. Once the project has moved through the bid process, the cost of implementation becomes the primary concern. Proper implementation of the E&S plan can save the developer and the contractor money in excavation costs. If denuded areas are stabilized initially, little or no additional work will be required later. This can speed up completion dates, and overall savings will be realized. This strategy requires that planning take on a more important role in the management of a project. Good management throughout the life of a project will lead to increased savings.

On the other hand, failure to implement an E&S plan or failure to maintain controls during construction of a project can mean additional costs to the developer and the contractor. These additional costs exist at three levels. The primary level is the cost of work being stopped for non-compliance with an approved plan; the secondary level is the cost of repairing damage to adjacent properties; the tertiary level would be the costs associated with missed deadlines, litigation with damaged parties and extra charges from the contractor for additional work. The perception of the public that the developer and the contractor were negligent in performing their responsibilities may also pose a negative cost -if not now, sometime in the future.

At least one engineer has tried to relate these costs to the developer and contractor, based on his own experience and his year of practice. In a seminar on E&S, Mr. Jack Rinker of Rinker-Detwiler and Associates, P.C. presents a scenario called the "Hidden Cost to Down Time from Construction Stops by Government." The following is an abbreviated version of this scenario:

> Assume that a 50-house subdivision is underway. During construction, a rainstorm occurs. This storm can be either moderate or severe. Accordingly, erosion and sedimentation damage from the storm, because E&S measures were never placed, can be either moderate or severe. After the storm, neighbors call the local building official's office to complain. The building official visits the site, observes sedimentation damage and the potential for more, and immediately stops work on the project. This hypothetical situation assumes that the chief administrative officer of the locality has delegated the ability to "stop work" to the building official and that this was deemed an "emergency situation." At this time, all land-disturbing activity on the project is stopped. Three crews are affected by the work stoppage: the grading crew, curb and gutter crew and the utilities contractor. The job superintendent has to divert all of his attention to the immediate erosion problem and calls his office. His office in-turn calls the owner and then the owner calls the engineer and his attorney. The job has come to a virtual standstill because everyone's attention is focused on "putting out the fire." The neighbors are now calling the developer and voicing their disgust. Action must be taken. On the advice of his attorney, the developer makes the decision to have the contractor remove the sediment that has moved onto the neighbors' property. At the request of the owner, the engineer visits the site to assess the damage. The next day, the developer meets with his attorney, the engineer and local government officials to see what must be done to get this job "back on track." The adjacent property owners are still complaining even though work to remove the sediment has begun. The engineer determines that the controls shown on the original E&S plan should have been installed during the first stage of grading to prevent damage to adjacent property. These controls could have prevented the problem in the first place, if they had been installed! Much of the attorney's costly time is spent trying to calm the mood of the neighbors and local officials.

At this point, let us look at the potential damage:

* <u>Moderate Damage</u>: 12 cubic yards of sediment must be removed from one neighbor's property and the lawn must be repaired.

* <u>Severe Damage</u>: 12 cubic yards of sediment must be removed from the neighbor's property; however, the sediment has moved past the property owner's fence and a large section of fence must be removed to gain access to the property with equipment. In the process of getting equipment in and out of the property, six trees and 20 shrubs are damaged. The neighbor is even more angry now!

Possible Costs

Item:	**Moderate Damage**	**Severe Damage**
Clean-up crew mobilization	$ 288.00	$ 288.00
Silt removal and hauling	153.00	153.00
Dumping charge at landfill	60.00	60.00
Grading work	133.00	133.00
Fertilizer and seed	111.00	------
Mulch and tack	150.00	------
Sod and fertilizer	------	640.00
Replace 20 shrubs	------	1,680.00
Replace 6 trees	------	1,476.00
Replace 50 feet of fence	------	640.00
Totals:	**$ 895.00**	**$5,070.00**

These items are a secondary cost to the developer. The primary cost still needs to be considered.

Item:	
Developer's infrastructure (cost attributed to the five-day delay of construction): $1,200 per day	$ 6,000.00
Attorney costs: 21 hours @ $150 per hour	3,150.00
Engineer and staff cost: 31 hours @ $75 per hour	2,325.00
Curb and gutter crew start-up cost	1,500.00
Utilities crew start-up cost	2,000.00
Grading crew start-up cost	2,000.00
Total:	**$16,975.00**

During the ten-day period that it took to repair the damage and get the project back on schedule, the developer incurred these expenses:

	Moderate Damage	Severe Damage
	$16,975.00	$16,975.00
	895.00	5,070.00
Totals:	**$17,870.00**	**$22,045.00**

Not reflected in these costs are the tertiary cost such as ten days of additional interest on the construction loan, lost sales of homes and possible litigation costs.

In this case, the cost of the controls shown on the original E&S plan that would have prevented the problem are as follows:

Item:	Cost
Silt fence, 350 feet @ $4.50/linear ft.	$ 1,575.00
Diversion dike, 50 feet @ $2.00/linear ft.	100.00
Sediment trap, 1 @ $240.00 each	240.00
Total:	$ 1,915.00

It should be noted that variation in the magnitude of the storm event could make these numbers vary and pose some required clean-up costs - even for a properly controlled site. However, the use of properly installed control measures will still help to mitigate damage caused by less frequent, larger storms.

BASIC PRINCIPLES OF DESIGN AND CONTROL

For an erosion and sediment control program to be effective, it is imperative that provisions for sediment control measures be made in the planning stage. These planned measures, when conscientiously and expeditiously applied during construction, will result in orderly development, which minimizes environmental degradation. From the previous discussion about erosion and sediment processes and the factors affecting erosion, basic technical principles can be formulated to assist the project planner or designer in providing for effective sediment control. These principles should be utilized to the maximum extent possible on all projects.

1. Plan the development to fit the particular topography, soils, drainage patterns and natural vegetation of the site.

   Detailed planning should be employed to assure that roadways, buildings, and other permanent features of the development conform to the natural characteristics of the site. Large graded areas should be located on the most level portion of the site. Areas subject to flooding should be avoided, and floodplains should be kept free from filling and other development. Areas with steep slopes, erodible soils and soils with severe limitations for the intended uses should not be utilized without first overcoming the limitations through sound engineering practices. For instance, long steep slopes can be broken by benching, terracing, or construction diversion structures and thus will not become an erosion problem or transfer a problem down the grade.

Erosion control, development and maintenance costs can be minimized by selecting a site suitable by its nature for a specific proposed activity, rather than by attempting to modify a site to conform to a proposed activity. This kind of planning can be more easily accomplished where there is a general land-use plan based upon a comprehensive inventory of soils, water and other related resources.

2. Minimize the extent of the area exposed at one time and duration of exposure.

When earth changes are required and the natural vegetation is removed, keep the area and the duration of exposure to a minimum. Plan the phases or stages of development so that only the area which are actively being developed are exposed. All other areas should have a good cover of temporary or permanent vegetation or mulch. Grading should be completed as soon as possible after it is begun. Immediately after grading is completed, permanent vegetative cover should be established in the area. As cut slopes are made and as fill slopes are brought up to grade, these areas should be revegetated as the work progresses. This is known as staged seeding. Minimizing grading of large or critical areas during the seasons of maximum erosion potential - spring thaw in February and March and the thunderstorm season from May through September reduces the risk of erosion (60).

3. Apply erosion control practices to prevent excessive on-site damage.

This third principle relates to using practices that control erosion on a site to prevent excessive sediment from being produced. Keep soil covered as much as possible with temporary or permanent vegetation or with various mulch materials. Special grading methods such as roughening a slope on the contour or tracking with a cleated dozer may be used. Other practices include diversion structures to divert surface runoff from exposed soils and grade stabilization structures to control surface water.

"Gross" erosion in the form of gullies must be prevented by these water control devices. Lesser types of erosion such as sheet and rill erosion should be prevented but, often, scheduling or the large number of practices required makes this impractical. However, when erosion is not adequately controlled at the source, sediment control for the project as a whole is more difficult and expensive.

4. Apply perimeter control practices to protect the disturbed area from off-site runoff and to prevent sedimentation damage to areas below the development site.

This principle relates to using practices that effectively isolate the development site from surrounding properties and especially to controlling sediment once it is produced and preventing its transport for the site.

Diversions, dikes, sediment traps, vegetative filters and sediment basins are examples of practices which control sediment. Vegetative and structural sediment control measures can be classified as either temporary or permanent depending on whether or not they will remain in use after development is complete. Generally, sediment can be retained by two methods: a) filtering runoff as it flows through an area, and b) impounding the sediment-laden runoff for a period of time so that the soil particles settle out. Many practices are combinations of these two methods. The best way to control sediment, however, is to prevent erosion as discussed in the third principle.

5. Keep runoff velocities low and retain runoff on the site.

The removal of existing vegetative cover and the resulting increase in impermeable surface area during development will increase both the volume and velocity of runoff. These increases must be taken into account when providing for erosion control. Keeping slope lengths short and gradients low and preserving natural vegetative cover can keep stormwater velocities low and limit erosion hazards. Runoff from the development should be safely conveyed to a stable outlet using storm drains, diversions, stable waterways, riprapped channels or similar measures. Consideration should be given to the installation of stormwater retention or detention structures when there is a potential for flooding and damage to downstream facilities resulting from increased runoff from the site. Conveyance systems should be designed to withstand the velocities of projected peak discharges. These facilities should be operational as soon as possible after the start of construction.

6. Stabilize disturbed areas immediately after final grade has been attained.

Permanent structures, temporary or permanent vegetation, and mulch, or a combination of these measures should be employed as quickly as possible after the land is disturbed. Temporary vegetation and mulches can be most effective where or when it is not practical to establish permanent vegetation. Such temporary measures should be employed immediately after rough grading is completed if a delay is anticipated in obtaining finished grade. The finished slope of a cut or fill should be stable, and ease of maintenance should be considered in the design. Stabilize roadways, parking areas, and paved areas with a gravel sub-base whenever possible.

7. Implement a thorough maintenance and follow-up program.

This last principle is vital to the success of the other six principles. A site cannot be effectively controlled without thorough, periodic checks of the erosion and sediment control practices.

These practices must be maintained just as construction equipment must be maintained and materials checked and inventoried. An example of applying this principle would be to start a routine "end of day check" to make sure that all control practices are working properly. Usually, these seven principles are integrated into a system of vegetative and structural measures along with management techniques and the "Minimum Standards" to develop a plan to prevent erosion and control sediment. In most cases, a combination of limited grading, limited time of exposure, and a judicious selection of erosion control practices and sediment trapping facilities will prove to be the most practical method of controlling erosion and the associated production and transport of sediment.

PART II

OVERVIEW OF PRACTICES

The following are summary overviews of the erosion and sediment control practices recommended for use in Virginia. Complete standards and specifications for these practices can be found in Chapter 3 of this handbook. The practices are numbered according to the following categories of use:

STRUCTURAL PRACTICES

- SAFETY (3.01)
- ROAD STABILIZATION (3.02 - 3.03)
- SEDIMENT BARRIERS (3.04 - 3.08)
- DIKES AND DIVERSIONS (3.09 - 3.12)
- SEDIMENT TRAPS AND BASINS (3.13 - 3.14)
- FLUMES (3.15 - 3.16)
- WATERWAY AND OUTLET PROTECTION (3.17 - 3.21)
- STREAM PROTECTION (3.22 - 3.27)
- SUBSURFACE DRAINAGE (3.28)

VEGETATIVE PRACTICES

- SITE PREPARATION FOR VEGETATION ESTABLISHMENT (3.29 - 3.30)
- GRASS ESTABLISHMENT (3.31 - 3.34)
- MULCHES (3.35 - 3.36)
- OTHER VEGETATIVE CONTROLS (3.37 - 3.38)
- DUST CONTROL (3.39)

3.01 SAFETY FENCE: A protective barrier installed to prohibit undesirable use of an erosion control measure.

3.02 TEMPORARY STONE CONSTRUCTION ENTRANCE: A stone pad, located at points of vehicular ingress and egress on a construction site, to reduce the soil transported onto public roads and other paved areas.

3.03 CONSTRUCTION ROAD STABILIZATION: Temporary stabilization with stone of access roads, subdivision streets, parking areas and other traffic areas immediately after grading to reduce erosion caused by vehicles during wet weather, and to prevent having to regrade permanent roadbeds between initial grading and final stabilization.

3.04 STRAW BALE BARRIER: A temporary sediment barrier composed of straw bales placed across or at the toe of a slope to intercept and detain sediment and decrease flow velocities from drainage areas of limited size; applicable where sheet and rill erosion may be a problem. Maximum effective life is 3 months.

3.05 SILT FENCE: A temporary sediment barrier constructed of posts, filter fabric and, in some cases, a wire support fence, placed across or at the toe of a slope or in a minor drainage way to intercept and detain sediment and decrease flow velocities from drainage areas of limited size; applicable where sheet and rill erosion or small concentrated flows may be a problem. Maximum effective life of 6 months.

3.06 BRUSH BARRIER: A temporary sediment barrier composed of limbs, weeds, vines, root mat, rock, and other cleared materials pushed together to form a berm; located across or at the toe of a slope to intercept and detain sediment and decrease flow velocities.

3.07 STORM DRAIN INLET PROTECTION: The installation of various kinds of sediment trapping measures around drop inlets or curb inlet structures prior to permanent stabilization of the disturbed area; limited to drainage areas not exceeding one acre, and not intended to control large, concentrated stormwater flows.

3.08 CULVERT INLET PROTECTION: A sediment filter located at the inlet to storm sewer culverts which prevents sediment from entering, accumulating in and being transferred by the culvert. It also provides erosion control at culverts during the phase of a project where elevations and drainage patterns are changing, causing original control measures to be ineffective.

3.09 TEMPORARY DIVERSION DIKE: A ridge of compacted soil constructed at the top or base of a sloping disturbed area which diverts off-site runoff away from unprotected slopes and to a stabilized outlet, or to divert sediment-laden runoff to a sediment trapping structure. Maximum effective life is 18 months.

3.10 TEMPORARY FILL DIVERSION: A channel with a supporting ridge on the lower side, constructed along the top of an active earth fill constructed in order to divert runoff away from the unprotected fill slope to a stabilized outlet or sediment trapping structure; applicable where the area at the top of the fill drains toward the exposed slope and continuous fill operations make the use of a TEMPORARY DIVERSION DIKE infeasible; maximum effective life is one week.

3.11 TEMPORARY RIGHT-OF-WAY DIVERSION: A ridge of compacted soil or loose gravel constructed across a disturbed right-of-way or similar sloping area to shorten the flow length within the disturbed strip and divert the runoff to a stabilized outlet. Earthen diversions are applicable where there will be little or no construction traffic within the right-of-way, and gravel structures are applicable where vehicular traffic must be accommodated.

3.12 DIVERSION: A permanent channel with a ridge on the lower side constructed across a slope to reduce slope length and intercept and divert stormwater runoff to a stabilized outlet at non-erosive velocities.

3.13 TEMPORARY SEDIMENT TRAP: A small ponding area, formed by constructing an earthen embankment with a stone outlet across a drainage swale, to detain sediment-laden runoff from small disturbed areas for enough time to allow most of the suspended solids to settle out. Maximum effective life is 18 months.

3.14 TEMPORARY SEDIMENT BASIN: A temporary barrier or dam with a controlled stormwater release structure which is formed by constructing an embankment of compacted soil across a drainageway. It is used to detain sediment-laden runoff from drainage areas 3 acres or greater for enough time to allow most of the suspended solids to settle out. It can be constructed only where there is sufficient space and appropriate topography. Maximum effective life is 18 months unless designed as a permanent pond by a qualified professional.

3.15 TEMPORARY SLOPE DRAIN: A flexible tubing or conduit, used before permanent drainage structures are installed, intended to conduct concentrated runoff safely from the top to the bottom of a disturbed slope without causing erosion on or below the slope.

3.16 PAVED FLUME: A permanent concrete-lined channel constructed to conduct concentrated runoff from the top to the bottom of a slope without causing erosion on or below the slope.

3.17 STORMWATER CONVEYANCE CHANNEL: A permanent channel designed to carry concentrated flows without erosion. Applicable to man-made channels, including roadside ditches, and natural channels that are modified to accommodate increased flows generated by land development; not generally applicable to major, continuous-flowing natural streams.

3.18 OUTLET PROTECTION: The installation of riprap channel sections and/or stilling basins below storm drain outlets to reduce erosion and under-cutting from scouring at outlets and to reduce flow velocities before stormwater enters receiving channels below these outlets.

3.19 RIPRAP: A permanent, erosion-resistant ground cover of large, loose, angular stone installed wherever soil conditions, water turbulence and velocity, expected vegetative cover, etc., are such that soil may erode under design flow conditions.

3.20 ROCK CHECK DAMS: Small, temporary stone dams constructed across a drainage ditch to reduce the velocity of concentrated flows, reducing erosion of the swale or ditch. Limited to use in small open channels which drain 10 acres or less; should not be used in live streams.

3.21 LEVEL SPREADER: An outlet for dikes and diversions consisting of an excavated depression constructed at zero grade across a slope to convert concentrated, sediment-free runoff to sheet flow and release it onto areas of undisturbed soil which is stabilized by existing vegetation.

3.22 VEGETATIVE STREAMBANK STABILIZATION: The establishment of appropriate vegetation on streambanks to protect the banks from erosion.

3.23 STRUCTURAL STREAMBANK STABILIZATION: Stabilizing the banks of live streams with permanent structural measures to protect them from erosion. Particularly applicable to watercourses which must pass increased flows due to upstream development; not applicable to tidal streams.

3.24 TEMPORARY VEHICULAR STREAM CROSSING: A temporary structural span across a live stream to provide vehicular access to construction activity on either side of the stream while keeping sediment out of the stream and preventing damage to the channel bed and banks.

3.25 UTILITY STREAM CROSSING: A strategy for crossing small waterways when in-stream utility construction is involved. The strategy helps to prevent sediment from entering the affected watercourse and minimizes the amount of disturbance within the stream itself.

3.26 DEWATERING STRUCTURE: A temporary settling and filtering device for water which is discharged from dewatering activities.

3.27 TURBIDITY CURTAIN: A floating geotextile material which minimizes sediment transport from a disturbed area adjacent to or within a body of water. It provides sedimentation protection for a watercourse from upslope land disturbance or from dredging or filling within the watercourse.

3.28 SUBSURFACE DRAIN: A perforated conduit installed beneath the ground to intercept and convey groundwater. Prevents sloping soils from becoming excessively wet and subject to sloughing, and improves the quality of the vegetative growth medium in excessively wet areas by lowering the water table. Can also be used to drain detention structures.

3.29 SURFACE ROUGHENING: Grading practices such as stair-stepping or grooving slopes or leaving slopes in a roughened condition by not fine-grading them. Reduces runoff velocity, provides sediment trapping and increases infiltration, all of which facilitate establishment of vegetation on exposed slopes. Applicable to all slopes steeper than 3:1 or that have received final grading but will not be stabilized immediately. Also recommended for other exposed slopes with flatter grades.

3.30 TOPSOILING: Preserving and using topsoil to provide a suitable growth medium for vegetation used to stabilize disturbed areas. Applicable where preservation or importation of topsoil is most cost-effective method of providing a suitable growth medium; not recommended for slopes steeper than 2:1 unless additional measures are taken to prevent sloughing and erosion.

3.31 TEMPORARY SEEDING: Establishment of temporary vegetative cover on disturbed areas that will not be brought to final grade for periods of 30 days to one year by seeding with appropriate rapidly-growing plants.

3.32 PERMANENT SEEDING: Establishment of perennial vegetative cover by planting seed on rough-graded areas that will not be brought to final grade for a year or more or where permanent, long-lived vegetative cover is needed on fine-graded areas.

3.33 SODDING: Stabilizing fine-graded areas by establishing permanent grass stands with sod. Provides immediate protection against erosion, and is especially effective in grassed swales and water-ways or in areas where an immediate aesthetic effect is desirable.

3.34 BERMUDAGRASS AND ZOYSIAGRASS ESTABLISHMENT: Establishment of vegetative cover with hybrid bermudagrass or zoysiagrass by planting sprigs, stolons or plugs to stabilize fine-graded areas where establishment by sod is not preferred.

3.35 MULCHING: Application of plant residues or other suitable materials to disturbed surfaces to prevent erosion and reduce overland flow velocities. Fosters plant growth by increasing available moisture and providing insulation against extreme heat or cold. Should be applied to all seeding operations, other plant materials which do not provide adequate soil protection by themselves, and bare areas which cannot be seeded due to the season but which still need protection to prevent soil loss.

3.36 SOIL STABILIZATION BLANKETS AND MATTING: The installation of a protective blanket (Treatment 1) or a soil stabilization mat (Treatment 2) on a prepared planting of a steep slope, channel or shoreline.

3.37 TREES, SHRUBS, VINES AND GROUND COVERS: Stabilizing disturbed areas by planting trees, shrubs, vines and ground covers where turf is not preferred. These plant materials also provide food and shelter for wildlife as well as many other environmental benefits. Especially effective where ornamental plants are desirable and turf maintenance is difficult.

3.38 TREE PRESERVATION AND PROTECTION: Protecting existing trees from mechanical and other injury during land-disturbing and construction activity to ensure the survival of desirable trees where they will be effective for erosion and sediment control and provide other environmental and aesthetic benefits.

3.39 DUST CONTROL: Reducing surface and air movement of dust during land disturbance, demolition or construction activities in areas subject to dust problems in order to prevent soil loss and reduce the presence of potentially harmful airborne substance.

PART III

COSTS

DATA LIMITATIONS

The cost of implementing erosion and sediment control practices is highly variable and dependent upon many factors including regional cost trends, availability and proximity of materials, time of year, prevailing labor rates, etc. It is therefore very difficult to develop cost estimates which are applicable statewide and year-round. The cost data contained in this chapter are based upon a February, 1991 survey of contractors and suppliers in mostly urban areas of the state. The following cost figures reflect statewide, average costs.

The intended use of this cost information is to provide an example format for local officials who have to calculate performance bond amounts or other guarantees. It may also aid project planners who seek to estimate E&S costs for feasibility studies.

The actual "dollar amounts" are not recommended for use in estimating and bidding construction contracts. It is advisable to check with local suppliers and contractors for this purpose.

COST vs. EFFECTIVENESS

The person who prepares an erosion and sediment control plan must pay careful attention to the selection of each practice. The practice with the least expensive initial cost may require a great deal of maintenance over the length of a project. Accessibility for maintenance can often be a factor that determines effectiveness. Silt fence for instance, requires regular maintenance. If placed in an area that drains too much disturbed area and is difficult to reach, maintenance potential for failure becomes a problem. In such a case, a diversion dike leading to a sediment trap would most likely be a better selection. The dike and trap are more suitable to handle larger runoff volume and would require less day-to-day maintenance if installed properly.

Once installed, the costs associated with a particular control can be kept to a minimum when maintenance is performed on a regular basis. Once a practice fails, the replacement cost can be double the initial cost of the practice. Regular maintenance also decreases the likelihood that damage to down slope property would be caused.

STRUCTURAL PRACTICE COSTS (Table 2-1)

The structural cost table consists of a numerical listing of the structural conservation practices with associated cost ranges for various applications. The cost estimates include materials (see end of Table 2-1), labor (at $6.00 per hour), equipment, and contractor's profit and overhead (figured at 30%).

VEGETATIVE PRACTICE COSTS (Table 2-2)

The cost items associated with vegetation establishment may include any combination of sod, seed, lime, fertilizer, equipment rental or purchase, soil testing, mulch, labor and maintenance. Due to the high potential for variability in actual total cost, Table 2-2 is primarily oriented for materials costs. Only estimates for sodding include installation costs. Users of the vegetative cost tables must add in cost for labor, fuel, machinery and other appropriate items. Examples using the cost data from Table 2-2 are given immediately following the table.

TABLE 2-1

STRUCTURAL PRACTICE COSTS

3.01	Safety Fence	
	Plastic - $1.50 - $2.50/linear ft. (including post)	
	Chain-link - $8 - $12/linear ft. (8 ft. height incl. post)	
3.02	Temporary Stone Construction Entrance	
	* Stone Pad	$3 - $6/yd.^{2}
	** Wash Rack	$500 - $1,000/unit
3.03	Construction Road Stabilization	
	Stone only	$3 - $6/yd.^{2}
	Stone with filter fabric	$6 - $9/yd.^{2}
3.04	Straw Bale Barrier	
	* $3 - $6/linear foot	
3.05	Silt Fence	
	* $2 - $5/linear foot	
3.06	Brush Barrier	
	* $2 - $5/linear foot	

* price does not reflect maintenance for long-term use.
** price does not reflect cost for hose-bib or personnel to man station.
*** price assumes hand placement with underliner according to specification.
**** installation is too site specific to offer accurate cost figures.

TABLE 2-1 (Continued)

3.07	Storm Drain Inlet Protection		
	* $25 - $100/inlet		
3.08	****Culvert Inlet Protection		
3.09	Temporary Diversion Dike		
	$3 - $5/linear foot		
3.10	Temporary Fill Diversion		
	$0.50 - $1/linear foot		
3.11	Temporary Right-of-Way Diversion		
	Stone:	$2 - $2.50/linear foot	
	Earth:	$1.50 - $2.50/linear foot	
3.12	Diversion		
	$6.50 - $12/linear foot		
3.13	Temporary Sediment Trap		
	Drainage Area (acres)		
		* 1	$500 - $700/unit
		* 2	$1,200 - $1,400/unit
		* 3	$1,800 - $2,100/unit
3.14	****Temporary Sediment Basin		
3.15	Temporary Slope Drain		
	$10 - $20/linear foot		

* price does not reflect maintenance for long-term use.
** price does not reflect cost for hose-bib or personnel to man station.
*** price assumes hand placement with underliner according to specification.
**** installation of structure is too site specific to offer accurate cost figures.

TABLE 2-1 (Continued)

3.16	Paved Flume		$25 - $30/yd.^{2}
3.17	Stormwater Conveyance Channel		
		Grass-lined (seeded):	$ 3 - $ 7/yd.^{2}
		Grass-lined (sodded):	$ 8 - $12/yd.^{2}
	***	Riprap:	$35 - $50/yd.^{2}
3.18	Outlet Protection		
	***	Non-Grouted Riprap:	$35 - $50/yd.^{2}
	***	Grouted Riprap:	$45 - $65/yd.^{2}
		Concrete:	$25 - $30/yd.^{2}
3.19	Riprap		*** $35 - $50/yd.^{2}
3.20	Rock Check Dam		
	*	Log Check Dam:	$400 - $600/unit
	*	Rock Check Dam:	$13 - $20/yd.^{2}
3.21	Level Spreader:		$3 - $15/linear foot
3.23	Structural Streambank Protection		
		*** Non-Grouted Riprap:	$35 - $50/yd.^{2}
		*** Grouted Riprap:	$45 - 60/yd.^{2}
		Gabions:	$55 - $90/yd.^{3}
		Deflectors:	
		Timber and Pilings:	$25 - $50/linear foot
		Gabion or Rock:	$60 - $95/yd.^{3}
		Log Cribbing:	$60 - $95/yd.^{3}
		Grid Pavers:	$30 - $80/yd.^{2}

* price does not reflect maintenance for long-term use.
** price does not reflect cost for hose-bib or personnel to man station.
*** price assumes hand placement with underliner according to specification.
**** installation of structure is too site specific to offer accurate cost figures.

TABLE 2-1 (Continued)

3.24 Temporary Vehicular Stream Crossing

Pipe Diameter (inches)	Cost of Crossing (per linear foot)
12 - 24	\$20 - \$43
24 - 48	\$43 - \$86
48 - 72	\$86 - \$130
72 - 96	\$130 - \$172

3.25 **** Utility Stream Crossing

3.26 **** Dewatering Structure

3.27 **** Turbidity Curtain

3.28 Subsurface Drains: \$1 - \$3/linear foot

Maintenance Costs (General)

Sediment Removal:	\$5 - \$10/yd^3
Repair Cost (most often):	same as original cost
Replacement Cost:	1½ - 2 times original cost due to the necessity for removal of old measure

Material Costs (General)

VDOT #1 Coarse Aggregate:	\$ 2 - \$3/ton
Filter Fabric (Silt Fence):	\$0.20 - \$0.30/linear foot
Straw Bales:	\$2 - \$3.50/unit

* price does not reflect maintenance for long-term use.
** price does not reflect cost for hose-bib or personnel to man station.
*** price assumes hand placement with underliner according to specification.
**** installation of structure is too site specific to offer accurate cost figures.

TABLE 2-1 (Continued)

Material Costs (General)

Wire, Chicken Wire (4' x 150' roll):	
1-inch mesh	\$54 - \$66
2-inch mesh	\$30 - \$42
Welded Wire (4' x 100' roll):	
2-inch x 4-inch mesh	\$65 - \$84
Concrete Masonry Block:	
8-inch	\$0.75 - \$.85/unit
10-inch	\$0.95 - \$1.15/unit
Riprap: 50 - 150 lb.	\$4.50 - \$5/ton (excludes transportation to site)
Filter Cloth Used with Riprap:	\$0.50 - \$.75/yd.^{2}
Concrete:	\$40 - \$80/yd.^{3}
Bituminous Paving:	\$40 - \$80/yd.^{3}
Gabions (12"-3' X 3' basket):	\$55 - \$66/unit

Pipe (Corrugated Metal Pipe)

Diameter (inches)	Cost (per linear foot)
12"	\$ 6 - \$ 7
15"	\$ 7 - \$ 8
18"	\$ 8 - \$ 9
24"	\$10 - \$11
36"	\$13 - \$14
48"	\$21 - \$22
60"	\$43 - \$44
72"	\$63 - \$65
78"	\$74 - \$76
84"	\$79 - \$81
90"	\$85 - \$88
96"	\$91 - \$93

TABLE 2-2

MATERIALS COSTS FOR VEGETATIVE EROSION CONTROLS

MATERIAL		UNIT COST	RATE	COST PER 1000 SQ. FT	COST PER ACRE
SOD	Kentucky Bluegrass blends	$.80 - $1.25/yd.^{2}, cut $2 - $3.50/yd.^{2}, installed	1 yd.^{2} = 9 ft.^{2}	$140 installed	$9,680 - $16,940
	Tall Fescue	$.80 - $1.25/yd.^{2}, cut $2 - $3.50 yd.^{2}, installed	1 yd.^{2} = 9 ft.^{2}	$140 installed	$9,680 - $16,940
	Bermudagrass	$1.05 - $1.30/yd.^{2}, cut $2.25 - $3.75/yd.^{2}, installed	1 yd.^{2} = 9 ft.^{2}	$180 installed	$10,890 - $18,150
MULCH	Small grain straw (see Chemical Mulches for tack coat)	Average $2/bale or $100/ton (using 40 lb. bale)	2 tons/acre	$5 (material cost only)	$215 (material cost only)
	Fiber Mulch (50 lb. bale)	Average $175/ton (plus shipping)	2000 lbs./acre	$4 (material cost only)	$175 plus shipping
NETS AND MATS	Jute Mesh	$55/100 yd.^{2} roll; staples: $7/100 yd.^{2}	100 yds.^{2} = .02 ac.	$69 with staples	$3000 w/ staples
	Excelsior blanket	$39/80 yd.^{2} roll; staples: $7/100 yd.^{2}	100 yds.^{2} = .02 ac.	$46 with staples	$2003 w/ staples
	Mulchnet (used over straw only)	$.02 ft.^{2}; staples: $7/100 yd.^{2}	100 yds.^{2} =.02 ac.	$27 with staples	$1200 w/ staples
	Plastic Soil Reinforcement Mat (light / heavy):	$3.50 yd.^{2} / $5 yd.^{2}	4840 yd.^{2}/acre	$390 / $556	$17,000 / $24,000

TABLE 2-2 (Continued)

MATERIALS COSTS FOR VEGETATIVE EROSION CONTROLS

MATERIAL		UNIT COST	RATE	COST PER 1000 FT.^{2}	COST PER ACRE
TACKIFIERS	Asphalt - average for all grades used (used as straw tack coat)	$0.80/gal. bulk $2/gal. applied	400 - 480 gal./acre	$8.80 bulk $22 applied	$384, bulk $960, applied
	Typical synthetic binders	$1.50 - $3/gal.	45 - 75 lbs. /acre	$1.50 - $2.50	$65 - $115
	Terra Tack (as used with wood fiber)	$123/acre package	1 pkg./acre	$2.80	$123
	Fiber mulch	$200/ton	750 lbs./ac.	$1.75	$75
SOIL AMENDMENTS	Lime - pulverized agricultural limestone or dolomite	$40 -$100/ton	2-3 tons/ac., or according to soil test results	$1.85 - $6.70	$80 - $300
	10-20-10	$200 - $250/ton	Dependent on type of seeding and soil test results	--	--
	10-10-10 Note: Many formulations may be used to provide the necessary nutrients	$150 - $200/ton			
SEED	Cereal Rye	$0.25/lb., $13.50/bushel	2 bu./acre (110 lbs.)	$0.63	$27.50
	Oats	$0.15/lb., $5/bushel	3 bu./acre (100 lbs.)	$0.34	$15
	Annual Ryegrass	$0.35 - $0.50/lb.	50 lbs./acre	$0.57	$25
	German Millet	$0.40 - $0.50/lb.	60 lbs./acre	$0.69	$30

EXAMPLES:

Temporary Seeding

Seed a one-acre site using a cereal and annual rye mixture and standard soil amendments. Assume the soil is already at rough grade and does not need further preparation. Standard agricultural machinery (drill) is used.

Item	Cost
50 lbs. Cereal Rye @ $0.27/lb.	$13.50
50 lbs. Annual Rye @ $0.35/lb.	$17.50
600 lbs. 10-20-10 fertilizer @ $200/ton	$60.00
1 ton lime @ $50/ton	$50.00
Straw mulch - 100 bales @ $2/unit	$200.00
Mulch anchoring using "Krimper" method	$25.00
Materials Cost Per Acre	**$366.00**
Total Cost Per Acre for Temporary Seeding (including labor, fuel, and machinery)	**$650 - $850**

Permanent Seeding - Lawn-Type (Low Maintenance)

Item	Cost
100% Kentucky 31 Fescue @ 200 lbs./acre @ $0.75/lb..	$150.00
Annual Rye @ 20 lbs./acre @ $.40/lb.	$8.00
1000 lbs. 10-20-10 fertilizer @ $200/ton	$100.00
2 tons lime @ $50/ton	$100.00
Straw mulch - 125 bales @ $2/unit	$250.00

Tack Coat - 750 lbs. @ $200/ton	$75.00
Materials Cost Per Acre	**$683.00**
Total Cost Per Acre for Permanent Seeding of Low-Maintenance Area (including labor, fuel, and machinery)	**$1000 - $1500**

Permanent Seeding - Lawn-Type (High Maintenance)

Item		Cost
90% Turf-type Tall Fescue	225 lbs. @ $1.25/lb.	$281.25
5% Kentucky Bluegrass	12.5 lbs. @ $2.50/lb.	$31.25
5% Turf-type Perennial Rye	12.5 lbs. @ $1/lb..	$12.50
	250 lbs.	$325.00
1000 lbs. 10-20-10 fertilizer @ $200/ton		$100.00
2 tons lime @ $50/ton		$100.00
1 ton fiber mulch @ $200/ton		$200.00
Materials Cost Per Acre		**$725.00**
Total Cost Per Acre for Permanent Seeding of High-Maintenance Area (including labor, fuel, and machinery)		**$1100 - $1700**

General Slope (Non-Legume)

Item		Cost
Kentucky 31 Fescue	128 lbs. @ $0.75/lb.	$96.00
Redtop	2 lbs. @ $3.50/lb.	$7.00
Annual Rye	20 lbs. @ $.40/lb.	$8.00
	150 lbs.	$111.00

1000 lbs. 10-20-10 fertilizer @ $200/ton	$100.00
2 tons lime @ $50/ton	$100.00
Mulch (fiber)	$200.00
Materials Cost Per Acre	**$511.00**
Total Cost Per Acre for Permanent Seeding of General Slope with Non-Legume Mixture (including labor, fuel, and machinery)	**$800 - $1000**

General Slope (Legume)

Item		Cost
Kentucky 31 Fescue	108 lbs. @ $0.75/lb.	$81.00
Redtop	2 lbs. @ $3.50/lb.	$7.00
Annual Rye	20 lbs. @ $.40/lb.	$8.00
Crownvetch	20 lbs. @ $12.50 lb.	$250.00
	150 lbs.	$346.00
1000 lbs. 10-20-10 fertilizer @ $200/ton		$100.00
2 tons lime @ $50/ton		$100.00
Straw mulch - 125 bales @ $2/unit		$250.00
Tack Coat - 750 lbs. @ $200/ton		$75.00
Materials Cost Per Acre		**$871.00**
Total Cost Per Acre for Permanent Seeding of General Slope with Legume Mixture (including labor, fuel, and machinery)		**$1200 - $1600**