Stormwater Management Manual for the Puget Sound Basin

(The Technical Manual)

Volume II - Erosion and Sediment Control
VOLUME II - EROSION AND SEDIMENT CONTROL

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FOREWORD

Purpose of this Volume

This volume of the manual provides technical information to help in controlling erosion and sedimentation from new construction activities in the Puget Sound basin. Detailed standards and specifications for BMPs as well as background information on the erosion process and how it may be controlled are included. These BMPs are to be used to develop a detailed Erosion and Sediment Control Plan, as set out in Minimum Requirement #1 (see Chapter I-2). For a general overview of the entire stormwater program, please refer to Chapter I-1 in Volume I.

The target audience includes both officials in local governments who are responsible for administering ordinances pertaining to construction activities, and the development community. In a broader sense, this volume is intended for both engineers and planners because minimization of erosion requires good planning as well as good engineering and, most importantly, close collaboration between the two disciplines.

Chapter Contents

Chapter II-1 provides a general overview of the erosion and sedimentation process and the basic principles by which it may be controlled.

Chapter II-2 explores the concept of BMPs. Seven major problem areas that are encountered during the construction process are discussed, and the various erosion and sedimentation control BMPs that can be applied to each of these areas are briefly described.

Chapter II-3 contains BMPs to deal with pollutants other than sediment. This chapter has been included because many pollutants are adsorbed by or otherwise associated with sediment. Many of these pollutants can be generated during the construction process as a result of the use of petroleum products, fertilizers, pesticides, and other construction chemicals. Some of these pollutants may be hazardous. This chapter outlines how the generation of these wastes can be minimized, and for those that are generated, how they should be handled and disposed of.

Information on NPDES stormwater construction permits and the preparation of an Erosion and Sediment Control (ESC) plan can be found in Chapter II-4.

Chapter II-5 presents the design standards for erosion and sediment control BMPs. BMPs are the means by which Minimum Requirement #1 can be satisfied. In some cases the standards and specifications of BMPs are more in the form of guidelines, such as seeding mixtures for cover practices. In most others the standards and specifications are the minimum technical requirements. Examples include the depth of sediment traps, length of construction entrances etc. Some of the BMPs are simple and easy to apply, such as mulching, but others such as sediment ponds require design by a professional engineer, using the standards set out in this manual. Best management practices for individual family lots and small sites may be found at the end of Chapter II-5.

Acknowledgements

This volume of the manual was compiled by adapting existing manuals with advice from a technical advisory group comprised of people representing local agencies and other interested parties within the Puget Sound basin. The major sources of material include:
(i) King County Surface Water Management Manual, January 1990.
(iii) Stormwater Management Manual (SNOMET/King Co. 208 Plan), prepared by URS, 1977.
(iv) Construction and Erosion Control, King County Conservation District, December 1981.
(vi) Erosion and Runoff Control, Clark County Conservation District, January, 1981.

Information was also drawn from the Maryland Erosion and Sedimentation Control Manual (1983) and the Water Quality Manual of the Association of General Contractors of Washington.

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In addition, we wish to thank Chris Tiffany and Jill Reymore of the King County Conservation District, staff of the Bellevue Stormwater Utility, and Mel Schaefer of Ecology for their helpful suggestions.

The time and expertise readily given by these people has been of considerable value when preparing this volume of the manual and is gratefully acknowledged.

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CHAPTER II-1
THE EROSION AND SEDIMENTATION PROCESS

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II-1.1 IMPACTS OF EROSION AND SEDIMENTATION

Erosion and sedimentation produced by land development damages the environment and is costly to society. Fisheries resources, recreational resources, and aesthetic qualities may be lost or severely degraded. Harbors, lakes, and rivers fill and must be dredged. Sediments become contaminated.

Contractors, consultants, regulators, and inspectors can significantly affect soil loss. When land is developed, erosion increases by 2-40,000 times (1,2). Such erosion is estimated to produce approximately 70 percent of all sediment produced in this country (7). However, using good erosion control practices can greatly reduce this. For example, a study in Lake Tahoe Basin compared practices at two similar construction sites (3). Without erosion control, estimated soil loss exceeded background levels by 100-1000 times. Using good erosion control practices, soil loss was only double background levels.

Everyone is affected by damages from increased erosion and sedimentation. There are a variety of ways.

- The soil loses nutrients as clays, silts, and fine organic matter wash away. Reestablishing vegetation is difficult. The contractor must either import costly topsoil or apply fertilizers.
- Sediment clogs culverts and storm sewers resulting in frequent and costly maintenance. Without maintenance culverts may wash out and storm sewers fail. Siltation also decreases flow capacities.
- Landslides cause damage on-site and off-site.
- Detention facilities fill rapidly with sediment increasing cleaning costs.
- Infiltration devices may become clogged. This has been cited as the major cause of their failure.
- As velocity decreases, streams deposit sediment requiring dredging of obstructed channels. Additionally, harbors must be dredged more often to keep them open for navigation.
- Lakes age more rapidly. As the sediment builds, shallow areas may become covered by waterlilies or weeds. Increased nutrients may cause algal blooms, which deplete oxygen and can lead to fish kills.
- We lose aesthetics. Many citizens value clean streams. An eroded, silt-clogged stream or lake is ugly.
- Turbidity (water cloudiness) and suspended sediment increases. This impairs the feeding ability of aquatic animals, clogs gill passages of fish, and reduces photosynthesis.
- Fish spawning is seriously impacted. Clean gravels provide a habitat for fish eggs and permit a free flow of well oxygenated water around the eggs and alevines (young with egg yolk still attached). Sediment-clogged gravel prevents successful spawning. Sedimentation following spawning can smother the eggs or alevines.
The costs associated with these damages vary. Some are easy to quantify, others more difficult. The loss of aesthetic values or of recreational values is hard to quantify. People prefer to canoe in clear streams. Others, who would prefer to water-ski close to home, are confronted with a lake clogged with sediment and weeds. The costs for restoration and management of a single lake can easily run into the millions of dollars.

Reductions in spawning habitat, and thus reduction in salmon and trout production, cause economic losses to sports fisheries and traditional Native American fisheries. When lost, natural production is replaced by hatchery production. The public incurs expenses for construction, operation, and maintenance of hatcheries, and loses the natural production which many people consider superior.

Most quantifiable are the maintenance costs of man-made structures and harbors. Increased maintenance is necessary for culverts, storm sewers, retention/detention facilities, dams, rivers, and harbors. Harbor maintenance, for example, is expensive. The Seattle District of the U.S. Army Corps of Engineers, which does about one-third of the maintenance dredging in Puget Sound, currently budgets about $706,000 yearly for direct costs of dredging. This does not include administrative and other associated costs. Total yearly costs for dredging and administration for the Corps, the Ports and others runs into several million dollars. As city, county, state, and federal taxpayers, we all pay for these costs.

Impact Prevention

The problems listed above make it imperative to minimize erosion on construction sites. This is achieved through control of runoff. Knowledge of the erosion and sedimentation process is helpful in understanding the role of BMPs in runoff control.

II-1.2 THE EROSION AND SEDIMENTATION PROCESS

Soil erosion is defined as the removal and loss of soil by the action of water, ice, gravity, or wind. This section deals principally with soil erosion caused by the force of falling and flowing water.

The erosion process includes the detachment and transport of soil particles. The force of raindrops falling on bare or sparsely vegetated soil detaches soil particles. Water running along the ground surface picks up these particles and carries them along. As runoff increases in velocity and concentration, it detaches more soil particles, cuts rills and gullies into the soil surface, and adds to its sediment load.

II-1.2.1 Types of Water Erosion

Types of erosion caused by falling and flowing water are illustrated in Figure II-1.1; they include raindrop, sheet, rill and gully, and stream and channel erosion.

1. Raindrop Erosion: Erosion resulting from the direct impact of falling drops of rain on soil particles. This impact dislodges soil particles so that they can then be easily transported by runoff.

2. Sheet Erosion: The removal of a layer of exposed surface soil by the action of raindrop splash and runoff. The water moves in broad sheets over the land and is not confined in small depressions.

3. Rill and Gully Erosion: As runoff flows it concentrates in rivulets, cutting grooves called rills into the soil surface. If the flow of water is sufficient, rills may develop into gullies.
4. Stream and Channel Erosion: Increased volume and velocity of runoff may cause erosion of the stream or channel banks and bottom.

II-1.2.2 Sedimentation

Sedimentation is defined as the settling out of soil particles transported by water (Figure II-1.2). Sedimentation occurs when the velocity of water in which soil particles are suspended is slowed for a sufficient time to allow particles to settle out. Heavier particles, such as sand and gravel, settle more rapidly than fine particles such as clay and silt.

II-1.3 FACTORS INFLUENCING EROSION

The inherent erosion potential of any area is determined by four interrelated, principal factors: soil characteristics, vegetative cover, topography, and climate (Figure II-1.3).

II-1.3.1 Soil Characteristics and the Geology of the Puget Sound Basin

Soil properties which influence erosion by rainfall and runoff are those factors 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 vulnerability of a soil to erosion is called erodibility. Some key factors which control erodibility are:

- particle size and gradation
- organic content
- soil structure
- soil permeability

Particle Size

Soils that contain high proportions of silt and very fine sand are generally the most erodible and are easily detached and carried away. The erodibility of these soils is decreased as the percentage of clay or organic matter increases. Clay acts as a binder and tends to limit erodibility. Most soils with a high clay content are relatively resistant to detachment by rainfall and runoff. Once eroded, however, clays are easily transported and settle out slowly.

Organic Content

Organic matter creates a favorable soil structure, improving its stability and permeability. This increases infiltration capacity, delays the start of erosion, and reduces the amount of runoff.

Soil Structure

Organic matter, particle size and gradation affect soil structure (the arrangement, orientation, and organization of particles). Well-drained and well-graded gravels and gravel mixtures with little or no silt are the least erodible soils. Their high permeability and infiltration capacity helps prevent or delay runoff.

Soil Permeability

Soil permeability refers to the ease by which water passes through a given soil. Clay soils have high water holding capacity relative to sands and gravels, but poor infiltration characteristics. Although clay particles are harder to detach, they are more vulnerable to erosion because they tend to increase runoff.
The Puget Lowland and Associated Watersheds

The landscape of Puget Sound is the product of a long history of mountain-building and subsidence, glaciation and volcanism, erosion and deposition. In addition, the makeup of surface soils is affected to varying degrees by landslide and slopewash activities. The fundamental geologic division in the Puget Sound region is between the Puget Lowland and the Cascade and Olympic mountain ranges. The terrain of the Puget Lowland is made up of a series of rolling plateaus (drift plains) cut by steep-sided valleys. The drift plains are built of unconsolidated sediment deposited during glacial and non-glacial periods during the past two million years. These deposits range from a thin veneer over bedrock hills to a depth of 3,600 feet in the deepest basin.

Two kinds of large valleys cross the lowlands. The longest and deepest of these (Hood Canal, Central Puget Sound, Lake Washington-Duwamish-Puyallup, Sammamish and Snoqualmie troughs) trend roughly north-south and were carved in their present form during the most recent glaciation. Their shapes reflect the direction of flow in ice streams and/or subglacial rivers in the bottom of the continental glaciers that filled the lowland. On the other hand, the canyons of the Nooksack, Skagit, Stillaguamish, Green, Puyallup, Nisqually and Olympic drainages were excavated by streams flowing off the retreating ice sheet and down the Cascade and Olympic mountains.

Although bedrock is not exposed extensively in the Puget Sound region, its underlying structure controls runoff and erosion. The properties of rocks, glacial
deposits and soils exposed at the ground surface determine their reactions to weathering and erosion, and their ability to absorb and transmit water.

Glacial Deposits

Glacial deposits can be divided into two broad categories: till and outwash. The till, and underlying sediments, have undergone one or more glaciations. The weight of up to 4,000 feet of ice has compacted these deposits and can greatly affect their mechanical and hydraulic properties, particularly if the deposit is fresh and undisturbed. Till deposits contain large amounts of silt or clay, often intermixed with large cobbles, and have low percolation rates. Only a small fraction of infiltrated precipitation reaches the regional ground water table through the till. The rest moves laterally through the thin surface soil above the till deposit (generally as shallow subsurface flow), often reemerging at the base of hillslopes. Soils may become saturated during large storms and produce significant amounts of surface runoff. The peak runoff rate from till areas is therefore generally quite high. The lateral flow of subsurface water may also make some types of soil more vulnerable to sloughing.

In most of the drift plains, the outwash sediment deposited by streams that flowed off the front of the ice sheet are common. For the most part these sediments are coarse-grained, well-bedded, porous and loose. Some of these deposits are now terraces along modern stream valleys. Most outwash soils have high percolation rates, and rainfall in these areas is quickly absorbed. Creeks draining outwash deposits often intersect the ground water table and receive most of their flow from ground water discharge. Even for the largest storms, stream flow response is slow, with peak flow often lagging several days behind the rainfall that produced it. Erosion associated with outwash soils is much less than that associated with till. In contrast, erosion of fine-grained sandy outwash can be particularly severe.(8)

II-1.3.2 Vegetative Cover

Vegetative cover (Figure II-1.4) plays an extremely important role in controlling erosion by:

- Shielding the soil surface from the impact of falling rain.
- Slowing the velocity of runoff, thereby permitting greater infiltration.
- Maintaining the soil's capacity to absorb water.
- Holding soil particles in place.

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

II-1.3.3 Topography

The size and shape of a watershed influences the amount and rate of runoff. Several control measures, described in Chapters II-2 and II-5, deal with protecting vulnerable areas from high concentrations of runoff.

Slope length and steepness are key elements in determining the volume and velocity of runoff. As slope length and/or steepness increase, the rate of runoff increases and the potential for erosion is magnified.
Slope orientation is also a factor in determining erosion potential (Figure II-1.5). For example, a slope that faces south and contains droughty soils may have such poor growing conditions that vegetative cover will be difficult to reestablish.

II-1.3.4 Climate

The frequency, intensity, and duration of rainfall and temperature are fundamental factors in determining the amounts of runoff produced. As the volume and/or the velocity of runoff increase, the capacity of runoff to detach and transport soil particles increases.

Where storms are frequent, intense, or of long duration, erosion risks are high (Figure II-1.6). Seasonal changes in temperature, as well as variations in rainfall, help to define the high erosion risk period of the year. If precipitation falls as snow, no erosion will take place. In the spring, however, melting snow adds to the runoff, and erosion potential will be high. Because the ground is still partially frozen, its infiltration capacity is reduced.

The Puget Sound basin and adjacent areas vary significantly in storm intensity and duration from most of the rest of the country. This area is characterized in fall, winter and spring by storms that are mild in intensity and long-lasting in duration. Rainfall in the summer is sporadic and mild. Statistical analysis of the rainfall patterns in this area indicate that storms occur, on the average, every two days in the fall, winter and early spring, and every 7 days in the late spring and summer. These climatic differences are significant because storms in this area require the use of different management tools than do storms in other parts of the country.

II-1.4 BASIC PRINCIPLES: A SUMMARY

From this brief discussion of the erosion process and the factors that influence erosion, seven major principles of erosion and sedimentation control can be summarized.

1. Plan the development to fit the site.
2. Minimize the extent of the disturbed area and duration of exposure.
3. Stabilize and protect disturbed areas as soon as possible.
5. Protect disturbed areas from runoff.
6. Retain sediment within the corridor or site area.
7. Implement a thorough maintenance and follow-up program.

Each of these principles is discussed below in more detail.

1. Plan the Development to Fit the Particular Topography, Soils, Drainage Patterns, and Natural Vegetation of the Site.

Detailed designing 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 overcoming the limitations.
Figure II-1.2 Cross-Section of Flowing Waterway

Small Colloidal Soil Particles
May Not Settle Out

Larger Particles May Settle To Bottom

Figure II-1.3 Characteristics Which Affect Erosion Losses
Figure II-1.4 Effect of Vegetation on Stormwater Runoff

1. Vegetation absorbs the energy of falling rain

2. Roots hold soil particles in place

3. Vegetation helps to maintain absorptive capacity

4. Vegetation slows the velocity of runoff and acts as a filter to catch sediment
through sound engineering practices. For instance, long steep slopes can be broken by benching, terracing, or constructing diversion structures (see Chapter II-2).

Erosion control, development, and maintenance costs can be minimized by selecting a site suitable by its nature for a specific proposed activity, rather than 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 the 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 areas 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. Then immediately after grading is complete, 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 period October-April reduces the risk of erosion.

3. Stabilize and Protect Disturbed Areas as Soon as Possible.

Two methods are available for stabilizing disturbed areas: mechanical (or structural) methods and vegetative methods. In some cases, these are combined in order to retard erosion. These control measures are discussed in Chapter II-2.

4. Keep Runoff Velocities Low.

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. Slope changes should be designed to keep slope length and gradient to a minimum. Short slopes, low gradients, and the preservation of natural vegetative cover can keep runoff velocities low. This will limit erosion hazards.

5. Protect Disturbed Areas from Stormwater Runoff.

Measures can be utilized to prevent off-site water from entering and running over the disturbed area. These protective measures are described in Chapter II-2.

6. Retain Sediment Within the Corridor or Site Area.

Sediment can be retained by two methods: (1) by filtering runoff as it flows and (2) by detaining sediment-laden runoff for a period of time so that soil particles settle out. The best way to control sediment, however, is to prevent erosion in the first place.

7. Implement a Thorough Maintenance and Follow-Up Program.

This last principle is vital to the success of the six other principles. A site cannot be effectively controlled without thorough, periodic checking of
Figure II-1.5 Slope Orientation Affects Erodibility

Slopes facing south tend to be drier and more difficult to establish vegetation on.

Figure II-1.6 Rainfall Characteristics Help to Determine Amounts of Runoff

FREQUENCY

INTENSITY

DURATION

SIZE OF AREA = RUNOFF
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.

II-1.5 REFERENCES


(4) Alex Sumari, Seattle District, U.S. Army Corps of Engineers, personal communication.


CHAPTER II-2
BEST MANAGEMENT PRACTICES FOR PROBLEM AREAS ON CONSTRUCTION SITES

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CHAPTER II-2

BEST MANAGEMENT PRACTICES FOR PROBLEM AREAS ON CONSTRUCTION SITES

II-2.1 BEST MANAGEMENT PRACTICES

Understanding the basic processes of erosion and sedimentation and the basic principles of control provides the foundation for developing and implementing a successful erosion and sedimentation control plan. This chapter will outline the types of erosion and sediment control measures (Best Management Practices) that can be applied before, during and after the development process. Best Management Practices (BMPs) are defined as physical, structural, and/or managerial practices, that when used singly or in combination, prevent or reduce pollution of water and have been approved by Ecology.

The purpose of this chapter is to provide guidelines and background information that will assist in choosing the most suitable BMPs to control erosion and sediment from construction sites. This is done by describing the major problem areas and the appropriate BMPs that could be implemented to manage the problem. Complete standards and specifications for each BMP are provided in Chapter II-5.

Best Management Practices are those practices that are currently believed to provide the most effective, practicable means of preventing or reducing pollution generated by non-point sources. They are used to implement the general principles presented in the previous chapter. Most importantly, they change with time, as we discover or become aware of other practices that better accomplish their purposes.

Most of the BMPs presented in this manual either minimize erosion or control sedimentation. In any construction project, it is most important to do everything feasible to prevent erosion first. Stabilizing slopes, creating natural vegetation buffers, diverting runoff from exposed areas, controlling the volume & velocity of runoff and conveying that runoff away from the development area all serve to decrease erosion. Silt fences, sediment traps and diversions all trap sediment before it leaves the site. Sedimentation control should only deal with the sediment produced from unavoidable erosion.

Best Management Practices fall into a number of categories. Frequently they are split into cover BMPs, including grasses, mulches or other materials used to stabilize soil surfaces, or structural BMPs including check dams, sediment ponds (basins)', diversions and other structural techniques. Most sites require the use of several types of BMPs to adequately control erosion and sedimentation, so vegetative BMPs and structural BMPs are often used together to address a single problem. BMPs may be temporary or permanent. Soil that is exposed for a lengthy time is a large contributor to erosion and it should be stabilized as soon as possible. Thus, a temporary control measure (vegetative or structural), may be used because more grading will be needed later in the project or because putting in a permanent control is not immediately feasible. Measures left in place for a year or less are generally considered temporary (Figure II-2.1). In some cases temporary BMPs can be planned into a development in such a way that they may become permanent as completion of various phases of the development occurs. For example, sediment ponds can, with modification, function as permanent detention ponds (Figure II-2.2).

Monitoring and Maintenance

No matter whether BMPs are temporary or permanent, structural or vegetative, monitoring and maintenance of BMPs is vital. The importance of maintenance has been supported by a survey of BMPs by the King County Conservation District (1).

1 The terms sediment pond and sediment basin are used interchangeably.

II-2-1 FEBRUARY, 1992
Table II-2.1  Categories, Examples and Effectiveness of BMPs  
(adapted from Reinelt, 1991)

Site Design and Construction Management:
  Preserving Natural Vegetation*  
  Buffer Zones*  
  Gradient Terraces*  
  Dust Control

Site and Drainage Way Stabilization
  Stabilized Construction Entrance*  
  Riprap  
  Construction Road Stabilization  
  Vegetative Streambank Stabilization  
  Bioengineering Protection of Very Steep Slopes  
  Bioengineering Methods of Streambank Protection  
  Structural Streambank Protection

Flow Diversion
  Interceptor Dike and Swale*  
  Level Spreader  
  Pipe Slope Drains  
  Subsurface Drains

Overland Flow Management
  Biofilters (see Chapter III-6)  
  Temporary Seeding of Stripped Areas**  
  Permanent Seeding**  
  Mulching and Matting**  
  Plastic Covering  
  Sodding**  
  Topsoiling  
  Inlet Protection  
  Outlet Protection  
  Check Dams**  
  Surface Roughening

Sediment Trapping
  Filter Fence**  
  Brush Barrier  
  Straw Bale Barrier***  
  Gravel Filter Berm  
  Sediment Trap***  
  Sediment Pond""

Effectiveness Ratings (from the King County Conservation District)
  Most Effective*  
  Moderately Effective**  
  Least Effective***

Note: Effectiveness ratings are not available for all BMPs listed.
Preliminary results indicate that the major reason for BMP failure is poor maintenance. BMPs should be inspected regularly, particularly before, during, and after a major storm. Specific maintenance requirements of individual BMPs are dealt with in Chapter II-5.

II-2.1.1 Problem Areas

The remainder of this chapter will examine particular problem areas of the construction site (such as slopes or surface drainageways) and will describe which BMPs best alleviate problems associated with each area. The areas are:

1. Slopes
2. Streams and Waterways
3. Surface Drainageways
4. Enclosed Drainage Inlets and Outfalls
5. Large, Flat Surface Areas
6. Borrow Areas
7. Adjacent Properties

A listing of the BMPs and the problem area, or areas, they are appropriate for, is presented as a uniform coding system in Table II-2.2 at the end of this chapter. This has been introduced to promote uniformity in the specification and presentation of BMPs on Erosion and Sedimentation Control (ESC) plans. Each BMP has been assigned a specific number, code and symbol.

Assigned numbers should be used to identify BMPs in the narrative or other written portions of the plan, while the practice symbol should be used to identify practices on the map or site plan. The BMP can be further defined to indicate whether it is proposed as a temporary or permanent measure by using the notation "t" or "p". For example SOP = permanent sodding; STT = temporary sediment trap. The practice symbols are based upon similar systems used in other states such as Virginia and Maryland. We hope that the system will become widely used so that ESC plans will become more uniform and understandable throughout the Puget Sound basin.

Note: The American Society of Agricultural Engineers (ASAE) is proposing to standardize mapping symbols for erosion and sediment control structures and practices. These symbols differ somewhat from those now in this manual, as they are based on another resource. Since those symbols are still in the discussion stage, we have chosen to continue to use the practice symbols found in the Virginia manual.

II-2.2 SLOPES

Slopes greatly increase the potential for erosion. As slope length and steepness increase, runoff velocity increases. This increases the capacity of water to detach and transport soil particles. Steeper slopes usually have faster runoff velocities, less infiltration and more erosion than less steep slopes.

Modifying a slope by clearing existing vegetative cover also increases its vulnerability to erosion. Vegetation slows down runoff velocity and root systems hold soil particles in place. Vegetation maintains the soil's capacity to absorb precipitation. The following conditions indicate a need for special care when modifying or creating a slope:
1. Extensive length.2

2. Moderate to extreme steepness. (greater than about 7%)

3. High soil erodibility.

4. Difficulty of reestablishing vegetative cover.

Vegetative stabilization, diversion measures, slope drains and slope stabilization measures may counteract problems created by modifying slopes.

II-2.2.1 Vegetative Stabilization Techniques (BMPs E1.10, E1.15, E1.30, E1.35, E1.40)

Vegetative Buffer Strips

Maintaining a natural vegetative buffer or filter strip at the base of a slope retains sediment on site and is the preferred method for control of erosion. If the natural vegetative cover is lost, other cover techniques such as mulch or plastic covering will not have to be used. Undisturbed vegetation is by far the best method to maintain unstable slopes. If the natural vegetative covering must be disturbed, methods such as placing sod strips at intervals along the face of the slope also help (Figure II-2.8). These measures help slow runoff, trap sediment, and reduce the volume of runoff.

Grass or grass and legumes are the most commonly used plant material for stabilizing slopes. Plants are usually established in one of three ways (Figure II-2.9):

1. Hydro-seeding: A mixture of seeds, fertilizer, and water is sprayed on the slope. A mulch and a mulch tacking agent can also be applied. This method is effective on large areas.

2. Standard seeding: Seed is drilled or broadcast either mechanically or by hand. A cultipacker or similar tool is used after seeding to make the seedbed firm and to provide seed covering. The proper timing of seeding, mulching, and watering is important for areas seeded in this manner.

3. Sodding: Sod strips are laid across the slope and in this way instant cover is provided. Sod should be placed on a prepared bed and pegged on steep slopes. Watering is important. This method is effective and is often used on steep slopes.

II-2.2.2 Diversion Measures Used to Control Erosion (BMP E2.55)

A dike, ditch or a combination dike/ditch can divert runoff from the face of an exposed slope. For short slopes, placing these diversion measures at the top works well. For longer slopes, placing the dikes or ditches across the slope at intervals effectively reduces slope length. Temporary diversions must remain in place until slopes have been permanently restabilized.

Diversion ditches can be bare channels, vegetatively stabilized channels, or channels lined with a hard surface material (Figure II-2.3). To determine what size and design is appropriate for each situation consider the following:

1. The amount of runoff to be diverted.

2. The velocity of runoff in the diversion.

---

2 As a general rule there will be a potential hazard if slope lengths exceed the following: 0-7% - 300 feet; 7-15% - 150 feet; >15% - 75 feet.
3. The erodibility of the soils on the slope.

4. The erodibility of the soils within the channel.

When properly constructed, diversions minimize runoff over disturbed slopes. They may also collect runoff and divert it to a sediment trap or pond.

Since diversions concentrate the volume of surface runoff, they increase its erosive force. The contractor should release runoff onto a stabilized area to reduce erosion potential. Gradually reducing the slope of the diversion channel is sometimes adequate. The contractor may also use level spreaders, or stormwater conveyance channels such as grassed waterways (Figure II-2.4).

II-2.2.3 Slope Drains (BMPs E2.25, E2.70)

Where disposing of runoff laterally is unsatisfactory, the contractor may drain it over the slope face. Slope drains can run down the surface of the slope as sectional downdrains, paved chutes, or pipes placed beneath the ground surface (Figure II-2.5).

On-surface sectional downdrains are usually pipes made of corrugated metal, bituminous fiber, or other material; these slope drains are temporary. Paved chutes covered with a surface of concrete or bituminous material are usually permanent. Subsurface pipes are also permanent.

The contractor should protect against erosion at the inlet; otherwise undercutting at the lip of the drain and piping under the drain frequently occur. Compacting the soil carefully at the mouth of the slope drain and anchoring it adequately can prevent this undercutting. Also, any areas cleared to construct the drain should be revegetated and stabilized.

Figure II-2.1 Temporary Control Measures Used During Construction
Figure II-2.2 Many temporary measures can be made permanent.
At the slope drain outlet, energy dissipators (such as riprap) are frequently necessary. Not using a dissipator can result in serious erosion problems at the outflow end of the drain. The dissipator slows the velocity of the runoff to a nonerosive level. Riprap is one effective energy dissipator.

II-2.2.4 Structural Slope Stabilization Measures (BMPs E2.35, E2.40, E2.45)

The most effective way to decrease erosion is to avoid modifying slopes. The angle of repose naturally achieved is the most stable for that soil type and situation. However, during construction it is often necessary to modify existing slopes or to create non-natural slopes. Cut and fill slopes are a good example.

One way to stabilize slopes is to reduce their steepness. To choose an appropriate slope ratio we consider the soil’s stability, drainage characteristics, and erodibility. The type of vegetative cover and the type of maintenance are also important.

To reduce extreme slope a developer may use retaining walls (Figure II-2.6). Retaining walls are often used when a slope is too steep to establish and maintain vegetation. They obviate disturbance of the upper parts of natural slopes when lower parts are disturbed. Thus, trees or other naturally stable vegetation can be maintained. The cost of building retaining walls is significant but many areas are difficult or impossible to stabilize otherwise. Another way to protect slopes against erosion is to reduce length by using diversions or benches, as previously mentioned.

When slopes are disturbed, leaving them rough reduces velocity and increases infiltration rates. Rough slopes hold water, seed, and mulch better than smooth slopes.2) Slope surfaces can be roughened by running wheeled construction equipment across the slope, or tracked equipment up and down the slope face. The grooves created by the construction equipment should run across the slope horizontally, and not up and down the slope. Slopes can also be scarified to produce the desired surface roughness (Figure II-2.7).

A suitable soil, good seedbed preparation, and adequate lime and fertilizer are required for all of these methods. However, special precautions need to be taken to avoid nutrients (especially phosphorus) from fertilizers being washed into waterways.

If final grading is delayed more than a few days, the contractor should stabilize exposed slopes immediately after completing rough grading. For short periods of protection either temporary mulching or temporary seeding and mulching together should be used.

When slopes are cut to final grade, permanent vegetative stabilization measures are implemented. Selecting appropriate plant materials depends on:

1. Soil and climate conditions.
2. Duration, quantity, and velocity of runoff.
3. Time required to establish cover.
4. Maintenance requirements.
5. Site use.
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2. Duration, quantity, and velocity of runoff.
3. Time required to establish cover.
4. Maintenance requirements.
5. Site use.
SECTION OF DIVERSION AT TOP OF SLOPE

**Diversion**: intercepts stormwater runoff

Newly seeded and mulched slope protected by diversion

Stable outlet

DIVERSION OF CONTROL MEASURES CAN INTERCEPT STORMWATER RUNOFF BEFORE IT REACHES SLOPES
Figure II-2.5 Slope Drains

SECTIONAL DOWNDRAIN

CHUTE SLOPE DRAIN

DOWNSPOUT SLOPE DRAIN

RETAINING WALLS USED TO RETAIN EXISTING VEGETATIVE COVER

Figure II-2.6 Use of Retaining Walls
Establishing grass successfully requires that contractors:

1. Select proper seeding mixture for the site.
2. Observe seeding dates.
3. Cover area to be seeded with topsoil.
4. Prepare seedbed and plant properly.
5. Apply the correct amount of fertilizer for the specific seed or plant type.
6. Protect slope from wind and water erosion during establishment.
7. Ensure that adequate water is available during establishment and in dry periods, if necessary (by natural or other means).

Clear plastic covering provides immediate protection to slopes that cannot be prepared and seeded during the seeding period and/or during initial establishment of seeded areas. However, plastic covering also increases the quantity and velocity of runoff, requiring safe disposal of it onto stabilized areas. Additionally, plastic becomes a disposal problem once it is removed from the slopes it is protecting. Generally, mulches are a better solution for covering exposed areas.

Mulches

Mulching after permanent seeding as well as before seeding protects exposed areas for short periods. Mulches decrease the impact of falling rain, slow runoff velocity and increase the capacity of the soil to absorb water. Mulches hold seeds in place, preserve soil moisture, and insulate germinating seeds from the extremes of heat and cold. Many mulches are available: these include straw and woodchips.

Figure II-2.7 Slope Roughening

Unvegetated Slopes Should Be Temporarily Scarified To Minimize Runoff Velocities
Most mulches must be anchored. Another alternative is to disc the mulch just enough to anchor it. While tacking agents can be used, they are only effective under the right conditions and cannot be used to try and solve problems with unsuitable soils or excessively steep slopes.

Special Problems

On fill slopes, compaction can be a major factor in erosion control. In addition to other compaction controls required by the nature of the project, the minimum criterion recommended for successful erosion control on fill slopes is to meet or exceed the standards described in WSDOT Standard Specifications Section 2-03.3(14)C "Compacting Earth Embankments."(3) Running heavy equipment over the fill usually compacts it adequately. Formal testing may not be required. On cut slopes, ground water seepage can cause erosion problems. Seepage causes piping and soil slippage.

Slope is an important factor in the success of vegetative reestablishment measures. On steep slopes (2:1 or steeper; 2 feet horizontal distance to 1 foot vertical rise) normal tillage equipment cannot be used to prepare a seedbed. Stormwater runoff will result in the loss of seeds, fertilizer, and soil. Sod can be used to stabilize steep slopes instead of seeding where grades are more than 2:1. Sod on steeper slopes must be anchored with pegs.

Sandy soils present a special problem for establishing vegetation, especially in areas where the sand is deep and droughty. American beach grass is one solution to this problem. This plant is established by hand planting live plants.

Steeply sloped areas such as lake shores and road banks involve three special considerations:

1. To ensure probability of successful stabilization, banks should consist of slopes that are 2:1 or flatter.

2. The toe of the slope must be protected from undercutting or other erosive forces by mechanical means where necessary.

3. Water seepage coming out on the face of the slope should be intercepted by a properly designed drainage system (Figure II-2.10).

II-2.2.5 Summary

This section reviewed a range of choices available for erosion control on slopes. These measures may protect other areas exposed during development. A summary follows:

1. Diversion measures: Diversions can intercept stormwater runoff before it reaches disturbed slopes or other exposed areas. They can also collect runoff and convey it to a sediment basin or other suitable location.

2. Vegetative buffer strips: Natural vegetative filters retain sediment on-site. The contractor can significantly reduce erosion on slopes through proper application of these control measures.

3. Slope stabilization control measures: Slopes can be stabilized both mechanically and vegetatively. A slope exposed for longer than a few days should be stabilized by using temporary mulching and seeding. Retaining walls reduce slope and stabilization problems.
Figure II-2.8  Natural Vegetative Filter Strips

NATURAL VEGETATIVE FILTER STRIPS HELP TO MINIMIZE SEDIMENTATION

Figure II-2.9  Seeding Methods
II-2.3 STREAMS AND WATERWAYS

Protecting streams and waterways on and near sites undergoing development and protecting areas downstream from development involves three goals:

1. The increased sediment loads carried by surface runoff from areas under construction must not be allowed to enter streams.

2. Stream banks must be protected from erosion hazards caused by increases in runoff volume and velocity.

3. The rates of release of increased volumes of runoff into streams and waterways and the velocity of flow in stream channels must be controlled.

There are several characteristics that serve to identify streams that are particularly vulnerable to erosion. Streams which have a small channel capacity and steep banks are very susceptible to erosion. Streams which flow through areas of erodible soil and streams with sharp meanders or bends in the channel alignment are also prone to erosion. Before development begins, nearby streams should be analyzed to identify potential problem areas.

II-2.3.1 Streambank Stabilization Measures (BMPs E2.75-2.90)

The maintenance of existing vegetation on stream banks is a fundamental principle of erosion and sedimentation control. Streambank vegetation serves to stabilize the soil, slow runoff and dissipate its erosive energy, and to filter sediment from runoff. To prevent the destruction of streambank vegetation, stream crossing and construction traffic along the banks must be controlled. Culverts or temporary bridges for vehicle crossings should be constructed only where necessary (Figure II-2.11).

(Note: federal, state and local permits may all be required before streambank (or near streambank) work can commence – see Chapter I-3.)

Vegetative Measures

Where stream banks must be disturbed or where existing cover is inadequate, grass or grass-legume mixtures may be established. Immediately after grading on stream banks has been completed, vegetative restabilization measures must be initiated. Willows and other natural vegetation, as well as grass and legumes, are recommended for the protection of stream banks. Woody vegetation is used where ice damage may occur.

Structural Measures

Stream banks can be protected from erosion by structural as well as vegetative measures. Where vegetation will not provide sufficient protection, banks can be protected with revetments and deflectors, as well as other mechanical measures. However, willows and other vegetation can also be used in conjunction with structural measures. This is a biomechanical approach. Biomechanical and vegetative methods are always preferred over purely structural measures, which only should be used when absolutely necessary.

Revetments, which cover the banks, are commonly used where sharp bends or constrictions in the stream channel (such as culverts, bridges, or grade control structures) occur. Riprap, gabions, sacked concrete, and concrete or asphalt paving are commonly used as revetment materials. Deflectors consist of jetties or pilings that angle outward from the bank in a downstream direction and deflect currents away from vulnerable bank areas (Figure II-2.12).
Figure II-2.10  Slope Drain

POTENTIAL SLIDE CONDITION

ONE SOLUTION

CONTROL STREAM CROSSING POINTS

Figure II-2.11  Stream Crossing
II-2.3.2 Sediment Control Measures (BMPs E2.60, E3.10 through 3.40)

The first essential step in preventing sediment from entering streams and waterways is to control erosion on construction sites. A second necessary step in sediment control is to trap sediment that is transported by runoff before it reaches streams and waterways or leaves the construction site.

To trap sediment, the runoff must be detained for a sufficient period of time (up to 40 hours or longer) to allow the suspended soil particles to settle out. The amount of sediment which is deposited will depend on the speed at which runoff flows through the sediment trap, the length of time that runoff is detained, and the size and weight of the soil particles which are in suspension.

Several techniques are available for controlling the amount of sediment which reaches streams and waterways. Vegetative filter strips (preferably strips left in their natural state) between streams and development areas serve to slow runoff and filter out sediment. Check dams can also be constructed in drainageways. Check dams placed at regular intervals within a drainage channel are a temporary sediment control measure that is easy and economical to construct (Figure II-2.13). Barriers are constructed of bags filled with peagravel or crushed rock and stacked in an interlocking manner which is designed to trap sediment and reduce the velocity of flow. Bags filled with peagravel tend to filter the water. They do not totally block the flow like sandfilled bags.

Piping, or undercutting, can be reduced by setting the bags at least 6 inches into the bottom of the drainageway and compacting excavated soil along the upstream side (Figure II-2.14).

Streams may also be protected from increased sediment loads by trapping runoff in sediment basins or ponds before it is released into stream channels. In addition to trapping sediment, these basins are designed to release runoff at nonerosive rates. Such sediment basins can be constructed by excavating a pit or by construction of an impoundment (Figure II-2.15).

Sediment basins often consist of an earthen dam, mechanical spillway (including a perforated riser pipe), and an emergency spillway. The construction of sediment basins should be completed before clearing and grading begin. They are generally located at or near the low point of the site. Points of discharge from sediment basins must be stabilized. In many developments these temporary sediment basins may be converted into permanent retention/detention basins (Figure II-2.16).

II-2.3.3 Summary

The two categories of BMPs used to protect streams and waterways from erosion and sedimentation are:

1. Streambank stabilization BMPs: Streambanks can be stabilized by using vegetative or mechanical control techniques. Deciding which method is appropriate includes factors such as the volume and velocity of water in the stream, the gradient and shape of the stream, and maintenance of control measures.

2. Sedimentation control BMPs: It is necessary to prevent sediment from entering streams and waterways and this can be done by using vegetative filters and sediment traps or basins and check dams. Sediment traps and basins can be either temporary or permanent. Sediment traps are usually temporary and are removed and filled in after construction. Permanent sediment ponds may become a part of the final development in the form of ponds or small lakes. These ponds can be attractive after development is completed.
II-2.4 SURFACE DRAINAGEWAYS

Surface runoff, and runoff intercepted by erosion control measures such as diversions, must be collected by drainageways and let out in stabilized areas, storm sewers, or sediment basins. The design of these drainageways ensures that runoff is transported without risk of erosion or flooding. Unless surface drainageways are adequately designed, constructed, and maintained, they can become a major source of sediment pollution.

Development should be planned to maintain and utilize the naturally stabilized drainageways that exist on a site. Increases in runoff volume and velocity because of changes in soil and surface conditions during and after construction must be anticipated and controlled to the maximum extent possible. Where the capacity of the natural site drainage channels is exceeded, additional capacity, stabilizing vegetation, and/or structural measures may be needed.

Allowable design velocities vary with soil conditions, the character of the channel lining, and anticipated runoff volume. Formulas and techniques for determining runoff flows, channel cross sections, slopes, stabilizing covers, and design velocity are discussed in Volume III, Chapter III-2 instead of this volume to avoid duplication in BMPs.

II-2.4.1 Grade Control Structures

To reduce the velocity of runoff in drainageways, a variety of grade control structures can be used. These structures can be either temporary or permanent depending on the long-range requirements for the site. Pipe drops and drop spillways can be used.

II-2.4.2 Summary

Erosion and sedimentation from surface runoff can be minimized through the use of the following:

1. Grassed waterways: These channels may be stabilized through seeding and mulching or with sod, and are the preferred form of conveyance.

2. Lined channels: Lined channels should be used where water velocities are high, but are an undesirable alternative to grassed waterways.

3. Grade control structures: In some cases, grade control structures are necessary to reduce runoff velocity to non-erosive levels. Care should be taken to ensure the protection of channel sides and bottoms.

II-2.5 ENCLOSED DRAINAGE: INLET AND OUTFALL CONTROL

The capacity of vegetated drainage channels may be exceeded by the increases in runoff caused by construction activities. As a result, vegetatively-lined channels may scour and erode. Enclosed storm sewers can safely convey runoff of high concentrations and velocities; they can also serve to decrease the velocity of runoff and release it at preferred rates of flow. The following factors should be considered in determining when to use a storm sewer:

1. Whether or not existing enclosed storm sewers are available within reasonable proximity to the site or if there is a natural outlet available.

2. What the actual size of paved areas is and what the ratio of paved areas is to vegetated areas.
The installation of storm sewers, grassy swales, and other runoff control systems before major building construction begins can aid in controlling site runoff and in avoiding erosion hazards. Volume III contains BMPs for runoff quality and quantity control.

Diversions and surface drainageways are needed to intercept runoff and to convey runoff to storm sewers.

II-2.5.1 Drain Inlet Sediment Filters (BMPs E3.30, E3.35)

The capacity of the storm sewer system itself can be severely impaired by sediment deposits within the system. Sediment should be prevented from entering the enclosed storm sewer by the use of small sediment traps or sumps and filters at system inlets. Filters made of crushed rock, gravel, or sod, can be placed at inlets where sediment traps cannot be constructed (Figures II-2.17 and II-2.18). It is essential to regularly check and clean out these sediment traps and filters to insure that they function properly.

II-2.5.2 Enclosed Drains and Sediment Basins (BMP E3.40)

Where enclosed drainage systems do not tie into existing storm drainage mains, consideration must be given to the location and design of the enclosed drainage system outlet. These outlets must be resistant to erosion. The rate of release must be controlled and the energy of flow must be dissipated. It is essential that sediment be removed from runoff before it is released from the site or corridor. Sediment basins are frequently used at storm sewer outlets during construction.

II-2.5.3 Summary

Enclosed storm sewer systems can safely convey high velocities and large volumes of runoff as well as aid in preventing erosion during and after construction. Sediment must be prevented from entering the storm sewer system and it must be removed from runoff. The following BMPs achieve these purposes:

1. Drain inlet sediment filters prevent sediment from entering the storm sewer system.
2. Enclosed drains and sediment basins must be carefully located and designed to:
   a. Trap sediment that may be in storm water before it is released off the site or downstream.
   b. Control the volume and velocity of runoff.

The use of temporary control measures can reduce the accumulation of sediment in an enclosed drainage system.

II-2.6 LARGE, FLAT SURFACE AREAS

II-2.6.1 Exposed Surfaces (BMPs E1.10, E1.15, E2.10, E2.15, E3.10, E3.40)

Although erosion rates on steep exposed slopes are higher than on flat or gently sloping areas, all areas of exposed soil are vulnerable to erosion. If erosion control is ignored on large areas of nearly flat or gently sloping land, it will be possible for significant amounts of soil to be eroded. Clearing, grading, and vegetative restabilization in these areas can be timed so that the extent of exposed area and the duration of exposure is minimized. These areas require prompt
Figure II-2.12 Riprap Revetment Can Help to Minimize Erosion

**Figure II-2.13** Check Dam

**Figure II-2.14** Proper Construction of Check Dam
Figure II-2.15
Profile Through Typical Embankment Sediment Basin

PROFILE THROUGH AN EXCAVATED SEDIMENT BASIN

PROFILE THROUGH TYPICAL EMBANKMENT SEDIMENT BASIN
PERMANENT RETENTION BASINS CAN BE INTEGRATED INTO A DEVELOPMENT
vegetative restabilization. Temporary seeding or mulching is required where large areas will not be permanently stabilized within recommended time limits. Diversions, sediment barriers, or traps constructed on the lower side of large disturbed areas should be used to intercept and collect sediment.

Rights-of-way and parking areas that are being prepared for paving must be protected from rainfall and runoff. Diversions should be constructed to protect these areas from runoff before clearing and grading begin.

Areas that are being prepared for paving should be properly compacted because compaction makes the exposed surface area less vulnerable to erosion. Cleared rights-of-way may be covered with crushed aggregate to reduce erosion. Where rights-of-way will not be used for construction traffic, they can be seeded with a temporary cover.

Gravel or stone filter berms should be used at intervals along the gradient right-of-way to intercept runoff and direct it to stabilized areas, drainageways, or enclosed drainage system inlets. Filter berms also serve to slow and filter runoff and collect sediment. These berms can be crossed by construction equipment.

II-2.6.2 Paved Surfaces (BMP E3.25)

An increase in paved or compacted surface area on a site greatly increases the rate of site runoff. For example, a 20 percent increase in paved area can cause runoff to more than double during a heavy rainfall (8). In addition, the velocity of runoff moving across a paved surface is higher than the velocity of runoff moving across an area of exposed earth or vegetation. Pavement provides very little resistance to flow and does not allow any infiltration. Runoff draining from a paved surface area is also often highly concentrated.

The concentration of runoff leaving paved areas is highly erosive. After construction is complete, the paved roadway itself can serve as a drainageway with curbs and gutters conducting runoff to enclosed drainage system inlets. Where it is not economically feasible to install curbs and gutters, paved surfaces should be designed so that runoff will travel the shortest possible distance across the paved areas. This will prevent large accumulations of runoff from leaving paved areas at high velocities in any one area.

Well-stabilized drainageways will be necessary to receive and convey the increased volumes and velocities of runoff from paved surfaces. Where concentrated flows of runoff leave paved surface areas, outlet points must be especially well stabilized.

II-2.6.3 Summary

The amount of erosion on flat and gently sloping surface areas can be significant. Erosion on these areas can be minimized by:

1. Scheduling development in phases: The extent of the exposed area and the duration of exposure should be kept to a minimum.

2. Vegetative restabilization: Prompt surface stabilization with either temporary or permanent vegetative cover minimizes erosion.

3. Sediment traps: These measures trap soil eroded from exposed surface areas before it is carried off the site or into waterways.

Areas being prepared for paving should be protected from erosion by the use of:

1. Gravel or stone filter berms: Filter berms slow and filter runoff and divert runoff from the exposed right-of-way.
2. Compaction: Compaction reduces the vulnerability of the exposed right-of-way to erosion, but increases the velocity and amount of runoff.

3. Aggregate cover: Aggregate cover stabilizes the soil surface while allowing the movement of construction equipment on the right-of-way.

By implementing the control measures listed above, soil erosion on exposed surface areas and areas adjacent to paved surfaces can be minimized.

II-2.7 BORROW AND STOCKPILE AREAS (BMPs E1.10, E1.20, E1.35, E1.50, E2.35, E2.55)

Borrow areas, especially those that are located off the development site, cannot be ignored in erosion and sedimentation control planning. Borrow areas, as well as stockpile and spoil areas, must be stabilized.

Borrow and stockpile areas present the same set of problems for the control of erosion and sedimentation as exposed cut and fill slopes. All areas are erodible. Runoff should be diverted from the face of the slopes which are exposed in the excavation process. The runoff must then be conveyed in stabilized channels to stable disposal points.

The BMPs used to control erosion on slopes, such as the top of dikes, diversions, slope drains, etc., should also be used in borrow areas. Only those sections of the borrow area which are currently needed to supply fill should be stripped. Immediately after the required fill has been taken, the exposed area should be stabilized. If practical, each phase of the borrow operation should be:

1. graded
2. covered with topsoil
3. seeded with permanent vegetation and mulched

If final grading is delayed for more than a few days, temporary seeding should be used. By properly timing the disturbance of the natural cover in the borrow area in carefully planned phases, the area of exposed soil and the duration of exposure are reduced and, therefore, erosion losses are reduced.

The topsoil from borrow areas is stripped and stockpiled for later redistribution on the disturbed area. These stockpiles should be located on the uphill side of the excavated area wherever possible so that they can act as diversions. Stockpiles should be shaped and seeded with temporary cover. They can also be covered with plastic and circled at the bottom with a ditch to catch the runoff.

Where borrow areas are off the development site, a separate system for trapping sediment from the borrow area is needed. After the excavation is complete, borrow areas must be restored. Regrading to ensure proper drainage and to blend the borrow area with the surrounding topography is required. Stockpiled topsoil is then redistributed and permanent vegetative cover established.

II-2.8 ADJACENT PROPERTIES

The protection of adjacent properties and waterways from accelerated erosion and sedimentation is an important concern. Relevant BMPs for protecting adjacent properties have already been discussed under the previous problem areas. The following list illustrates some of the BMPs which can be used:

1. Sediment traps
2. Diversions
Figure II-2.17 Inlet Sediment Trap

2:1 slope

1 - 2 foot deep sump

large particles settle out

stormwater w/ larger particles removed

sediment

drain inlet

Figure II-2.18 Sod Filter for Drain Inlet

drain inlet with sod filter to minimize sedimentation

disturbed areas
3. Grass waterways
4. Rock and washed gravel check dams
5. Vegetative filter strips
6. Filter fences

A more complete list of applicable BMPs is shown in The Unified Coding System in Table II-2.2.
Table II-2.1 Unified Coding System for Erosion and Sedimentation Control BMPs and Their Applicability to Control Various Problem Areas

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II-2.9 REFERENCES

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# CHAPTER II-3

GUIDELINES FOR CONTROLLING POLLUTANTS OTHER THAN SEDIMENT ON CONSTRUCTION SITES

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CHAPTER II-3
GUIDELINES FOR CONTROLLING POLLUTANTS OTHER THAN SEDIMENT ON CONSTRUCTION SITES

II-3.1 INTRODUCTION

Potential pollutants other than sediment associated with construction activity, include numerous hazardous wastes as well as other solid and liquid wastes. Hazardous wastes include pesticides (insecticides, fungicides, herbicides, rodenticides etc.), petrochemicals (oils, gasoline, asphalt degreaser etc.) and other construction chemicals such as concrete products, sealer, paints, and wash water associated with these products. Other wastes include paper, wood, garbage, sanitary wastes, and fertilizer.

Practices must be used that prevent these potential pollutants from leaving the construction site. Good erosion and sediment control, coupled with stormwater management, will deter the movement of large amounts of sediment off the site. [It must be recognized, however, that pollutants carried in solution in runoff water, or fixed with sediment crystalline structures (e.g., crystalline clays), will be carried through the erosion and sediment control defenses.] Pollutants such as oils, waxes, and water-insoluble pesticides, form surface films on water and on solid particles, and also, oil films serve as a medium for concentrating water-soluble insecticides. Other than by use of very costly water-treatment facilities, or long runoff water detention periods, these pollutants become nearly impossible to control once present in the runoff.

The most economical and effective controls for pollutants other than sediment generated on construction sites, are the exercise of good "housekeeping" practices, and an awareness by construction workers, planners, engineers, and developers of the need and purpose of compliance with federal, state, and local regulations. For example, most pesticides can kill forms of life other than their pest targets. Certain insecticides can persist for months or years in soil and water, and many toxic chemicals can be passed along plant and animal food chains. Similarly, high levels of nutrients (principally phosphorus and nitrogen) from fertilizers used to revegetate exposed subsoils in graded areas may enter waterways and ponds, and increase the growth of algae at the surface to such an extent that light penetration in the water column is decreased. The end result is over-enrichment (or eutrophication). In confined water bodies, over-enrichment can lead to complete deoxygenation of the water and consequent death of fish and other organisms.

Ways must be found to protect ponds, wetlands, lakes, streams, and coastal and estuarine water bodies from damage by sediment and other pollutants generated during construction activities.

The variety of pollutants and the severity of the damage they cause depend upon a number of factors. The most significant of these include:

1. The nature of the construction activity.
2. The physical characteristics of the construction site, including such factors as weather, time of year for construction, topography, soil condition, drainage systems, etc.
3. The proximity, quantity, and quality of the receiving waters (i.e., the amount and purity of the water receiving the contaminated runoff).

It is reasonable to expect, for example, that potential pollution resulting from fertilizers used during revegetation would be more severe on a highway or housing
development than for a shopping center development. This is because highways and housing developments usually have far greater landscaping requirements than shopping centers which are composed mostly of rooftops and pavement.

The physical characteristics of the construction site have a major bearing on the potential severity of pollution from construction activities. As in the case of sediment, the vast majority of all pollutants are carried into the receiving waters via runoff. The amount of runoff coming from a construction site is dependent upon hydrologic factors. These include the amount, intensity, and frequency of rainfall; the infiltration rate of the soil; surface roughness; and the length and steepness of the ground slope. Large areas denuded or stripped of vegetation, long slopes, steep slopes, tight soils, and high intensity rainfall are all factors conducive to heavy runoff.

Another physical factor influencing the severity of pollution is the proximity of the pollutant, or potential pollutant, to the receiving water. For example, fertilizers applied to a streambank are more apt to cause water pollution than fertilizers applied to a slope well upland of the waterway.

The following information deals with the nature and control of various construction-related pollutants, other than sediment.

II-3.2 BMP C1.10 PESTICIDE CONTROL

Although the word "pesticide" has come to mean only those chemicals which attack insect populations, here the word is used to include herbicides and rodenticides as well as chemicals commonly known as pesticides. Insecticides, rodenticides, and herbicides have historically been used on construction sites to increase health and safety, maintain a pleasant environment, and reduce maintenance and fire hazards. Often, rodents are attracted to construction sites and rodenticides are used.

Pesticides shall only be used in conjunction with Integrated Pest Management (IPM). IPM utilizes a needs assessment which determines which method to use and the necessity of controlling a pest population. Pesticides should be the tool of last resort; methods which are the least disruptive to the environment and to human health should be used first (1). IPM as a BMP is further discussed in Volume IV, Chapter IV-4, BMP S1.90.

If pesticides must be used, clearance for use of any of these chemicals is often required by restrictive federal and state regulations. All pesticides should be stored and applied in accordance with regulations of the State Department of Agriculture, WAC 16-228-185. EPA has produced a pamphlet "Suspension, Cancelled and Restricted Pesticides" (Jan. 1985), which includes information on many pesticides. As it is more than five years old, it is wise to check with EPA’s Region 10 Pesticides Branch, Seattle, if any questions regarding the use of pesticides arise. An awareness of the need to adhere to recommended dosages, type of application equipment, time of application, cleaning of application equipment, and safe disposal of these chemicals, will go far in limiting the pollution of waterways. Application rates should conform to registered label direction. Many of these compounds are considered "Dangerous Wastes" and must be disposed of properly. Disposal of excess pesticides and pesticide-related wastes should conform to registered label directions for the disposal and storage of pesticides and pesticide containers set forth in applicable federal, state and local regulations. General disposal procedures are:

- Dispose of through a licensed waste management firm or treatment, storage and disposal company (TSD).
- Use up, or give away to garden center, landscape service, etc.
Triples rinse containers before disposal, reuse rinse waters as product.

"Hazardous Waste Pesticides - Determining if Your Pesticide is a Hazardous Waste," booklet #89-14 provides guidance and is available from Ecology's Publications Office. For more information call Hazards Line (587-3292) or Hazardous Substance Information Hotline (1-800-633-7585).

Pesticide storage areas on the construction site should be protected from the elements, from vandals, and from the curious. Warning signals should be placed in areas recently sprayed or treated with the most dangerous pesticides. Persons involved in the mixing and application of these chemicals, to be in compliance with the law, must wear suitable protective clothing.

Other practices include:

- Set aside a locked, weather-resistant storage area.
- Lids should be tightly closed.
- Keep in a cool, dry place. Many pesticides rapidly lose their effectiveness if stored in areas exposed to heat.
- In case of a leak, put original container into a larger container and label it properly.
- Check containers periodically for leaks or deterioration.
- Keep a list of products in storage.
- Use plastic sheeting to line the area.
- The applicator must follow the notification requirements of the WDSA. Neighbors on properties adjacent to the one being sprayed should also be notified prior to spraying.
- All storage sheds, dumpsters or other storage facilities should be regularly monitored for leaks and repaired as necessary. Remind workers during subcontractor or safety meetings about proper storage and handling of materials.

II-3.3 BMP C1.20 HANDLING OF PETROLEUM PRODUCTS

Petroleum products are widely used during construction activities. They are used as fuels and lubricants for vehicular operations, power tools, and general equipment maintenance. These pollutants include oils, fuels such as gasoline, diesel oil, kerosene, lubricating oils, and grease. Asphalt paving can be a pollutant source as it continues to release various oils for a considerable length of time. Most of these pollutants adhere to soil particles and other surfaces easily.

One of the best modes of control is to retain sediments containing oil on the construction site. Soil erosion and sediment control practices can effectively accomplish this. Improved maintenance and safe storage facilities will reduce their chances of contaminating construction sites. One of the greatest concerns confronting uses of these petroleum products is the method for waste disposal. Oil and oily wastes such as crankcase oil, cans, rags, and paper dropped in oils and lubricants, can be best disposed of in proper receptacles or recycled (call 1-800-RECYCLE). Waste oil for recycling should not be mixed with degreasers, solvents, antifreeze, or brake fluid. The dumping of these wastes in sewers and other drainage channels is illegal and could result in fines or job shutdown. A further
source of these pollutants is leaky vehicles. Proper maintenance of equipment and installation of proper stream crossings will further reduce pollution of water by these sources. Stream crossings should be minimized through proper planning of access roads.

Guidelines for storing petroleum products are as follows:

- Store products in weather-resistant sheds where possible.
- Create shelter around area with cover and wind protection.
- Line the storage area with double layer of plastic sheeting or similar material.
- Create impervious berm around the perimeter.
- Capacity of berm area should be 110 percent of largest container.
- All products should be clearly labeled.
- Keep tanks off the ground.
- Keep lids securely fastened.
- Contact local fire marshall for more information.
- Post information for procedures in case of spills. Persons trained in handling spills should be on-site or on call at all times.
- Materials for cleaning up spills should be kept on-site and easily available. Spills should be cleaned up immediately and the contaminated material properly disposed of.
- Specify a staging area for all vehicle maintenance activities. This area should be located away from all drainage courses.
- All storage sheds, dumpsters or other storage facilities should be regularly monitored for leaks and repaired as necessary. Remind workers during subcontractor or safety meetings about proper storage and handling of materials.

II-3.4 BMP C1.30 NUTRIENT APPLICATION AND CONTROL

Inorganic nutrient pollution is most often caused by fertilizers used in revegetating graded areas. The use of proper soil-stabilization measures, sediment control, and stormwater detention structures can be effective means of keeping these materials out of waterways. Only small amounts of inorganic nutrients are beneficial to the productivity of waterways, while excess amounts result in over-enrichment (eutrophication).

Nutrient pollution can be minimized by working fertilizers and liming materials into the soil to depths of 4 to 6 inches, and by proper timing of the application. Hydro-seeding operations, in which seed, fertilizers and lime are applied to the ground surface in a one-step operation, are more conducive to nutrient pollution than are conventional seedbed-preparation operations, where the fertilizers and lime are tilled into the soil. In the case of surface dressings, control can be achieved by applying the required quantity of fertilizer in more than one operation. For example, an area requiring an application of 500 lbs. per acre of fertilizer could be dressed with about 125 lbs. per acre at four separate times over the growing season.
Use of fertilizers containing little or no phosphorus may be required by local authorities if the development is near sensitive water bodies. In any event great care should be taken to use only the minimum amount of phosphorus needed, as determined by soil tests, or advice from the local Conservation District or Soil Conservation Service.

Near sensitive surface waters, the addition of lime can affect the pH (or acidity) of runoff and receiving waters. Importation of topsoil is better than heavily liming and fertilizing exposed subsoil.

II-3.5  BMP C1.40 SOLID WASTE HANDLING AND DISPOSAL

Solid waste is one of the major pollutants caused by construction. Solid waste is generated from trees and shrubs removed during land clearing for construction of streets and parking facilities, and during the installation of structures. Other wastes include wood and paper from packaging and building materials, scrap metals, sanitary wastes, rubber, plastic and glass pieces, masonry products, and others. Food containers such as beverage cans, coffee cups, lunch-wrapping paper and plastic, cigarette packages, leftover food, and aluminum foil contribute a substantial amount of solid waste to the construction site.

The major control mechanism for these pollutants is to provide adequate disposal facilities. Collected solid waste should be removed and disposed of at authorized disposal areas. Frequent garbage removal helps maintain construction sites in a clean and attractive manner. Waste containers should be labelled and located in a covered area. Lids should be kept closed at all times. Any useful materials should be salvaged and recycled. For instance, masonry waste can be used for filling borrow pits; trees and brush from land-clearing operations can be converted into woodchips through mechanical chippers and then used as mulch in graded areas. Sanitary facilities must be convenient and well maintained to avoid indiscriminate soiling of adjacent areas. Selective (rather than wholesale) removal of trees is helpful in conservation of soil and reduction of wood wastes. Indiscriminate removal of trees and other beneficial vegetation should be avoided.

Soil erosion and sediment control structures capture much of the solid waste from construction sites. Constant removal of litter from these structures will reduce the amount of solid waste despoiling the landscape. The extension of local and state anti-litter ordinances to cover construction sites is also a viable control mechanism. Adherence to these regulations by construction personnel reduces unnecessary littering through carelessness and negligence.

II-3.6  BMP C1.50 USE OF CHEMICALS DURING CONSTRUCTION

Many types of chemicals may be used during construction activities. These chemical pollutants include paints, acids for cleaning masonry surfaces, cleaning solvents, asphalt products, soil additives used for stabilization and other purposes, concrete-curing compounds, and many others. These materials are carried by sediment and runoff from construction sites.

A large percentage of these pollutants can be effectively controlled through implementation of source control soil erosion and sedimentation control practices. By using only the recommended amounts of these materials and applying them in a proper manner, pollution can be further reduced. As in the case of other pollutants, good housekeeping is the most important means of controlling pollution.

The correct method of disposal of wastes varies with the material. Wash-up waters from water-based paints may go into a sanitary sewer, but wastes from oil-based paints, cleaning solvents, thinners, and mineral spirits must be disposed of through
a licensed waste management firm or TSD. Disposal of concrete products, additives, and curing compounds depends on the product. Information is available from the local health department or the Hazardous Substance Information Hotline (1-800-633-7585).

II-3.7 OTHER POLLUTANTS

Other pollutants include concrete wash water from concrete mixers, acid and alkaline solutions from exposed soil or rock units high in acid, and alkaline-forming natural elements.

The control of these pollutants involves good site planning and pre-construction geological surveys. Neutralization of these pollutants often provides the best treatment. Sealing of fractures in the bedrock with grout and bentonite will reduce the amount of acid or alkaline seepage from excavations. Adequate treatment and disposal of concrete further reduces pollution.

II-3.8 GENERAL GUIDELINES

General guidelines for managing or minimizing any of the above hazardous wastes are as follows:

II-3.8.1 BMP Cl.60 Managing Hazardous Products

- Buy and use only what is needed. Leftovers need to be stored, re-used, given away, recycled or disposed of safely.
- Read labels and follow directions on the label. Hazardous products may be labeled:
  - Danger
  - Combustible
  - Warning
  - Caution
  - Poisonous
  - Caustic
  - Corrosive
  - Volatile
  - Explosive
  - Flammable
- Try to keep products in original containers and always keep them well-labeled. If the product must be transferred to smaller containers, use the proper size funnel and avoid spills. Label all containers.
- Labels can fall off with weathering. To prevent, cover with transparent tape. To relabel, use a metal tag attached to the container or use a stencil and spray paint.
- Do not mix chemical substances unless recommended by the manufacturer.
- Use in well-ventilated areas. Protect skin, eyes, nose, and mouth when necessary by wearing gloves, respirator, or other protective clothing.
- Keep corrosive liquids away from flammable liquids.
- Look for nontoxic or less toxic options (check with the State Department of Ecology Office of Waste Reduction at 1-800-822-9933).
- Use all of the product before disposing of the container.
- There are private firms that specialize in the cleanup of spills.
II-3.8.2 BMP C1.70 Equipment Washing

Thinners or solvents should not be discharged into the sanitary or storm sewer systems when cleaning large machine parts where discharge of water is required. Use alternative methods for cleaning larger equipment parts such as high pressure, high temperature water washes, or steam cleaning.

Equipment washing detergents can be used and wash water discharged into the sanitary system if grit is removed from the solution first. The water discharged into the sewer must not exceed the discharge limits set by the Sewer Authority.

Small parts can be cleaned with degreasing solvents which are reused after filtering or recycled. These solvents should not be discharged into any sewer. Further information is available from the Department of Ecology.

II-3.8.3 BMP C1.80 Spill Control Planning and Cleanup

Construction site supervisors shall adopt a spill control plan and identify persons responsible for implementing the plan if a spill of a dangerous or hazardous waste should occur. Any spill that occurs, regardless of the size and/or type of spill, should be reported to the following agencies:

- If the spill of a hazardous substance could reach surface waters, the following agencies must be notified (there are fines for failing to notify):
  
  National Response Center 1-800-424-8802 (24-hour)

- Locally, notify the regional Department of Ecology offices:
  
  Northwest Region - Redmond 649-7000 (24-hour)
  Southwest Region - Olympia 753-2353 (24-hour)

- Within the City of Bellevue
  
  Storm & Surface Water Utility 455-7846 (24-hour)

- For spills within salt water
  
  U.S. Coast Guard 286-5440

There are fines for failing to notify the appropriate authority when a spill occurs.

Some of the important components of a spill control plan are:

- Establish who to notify in the event of a spill, particularly if it is hazardous.
- Provide specific clean-up instructions for different products handled on site.
- Assign a person to be in charge of clean-up assistance.
- Prepare spill containment and clean-up lists that are easy to find and use.
- Post a summary of the clean-up plan at appropriate locations.
- If a spill occurs, demobilize it as quickly as possible.
• If there is a change that the spill could enter a storm drain or sewer, plug the inlet and turn off or divert any incoming water.

• Cover the spill with absorbent material such as kitty litter or sawdust. Do not use straw. Dispose of the used absorbent per Ecology or manufacturer's instructions. If the spill is flammable, dispose of as directed by the local fire marshal.

• Keep the area well ventilated.

II-3.8.4 BMP C1.90 Treatment and Disposal of Contaminated Soils

Contaminated ground water or soil may be encountered during earthwork activities or by the spill or leak of a hazardous product. The contaminant may be known or unknown. Sampling and laboratory tests may be required to determine whether a landfill can accept the contaminated soil. In some cases it is possible to reduce the hazardous potential of the soil by aerating it, for example. Local health departments can supply the necessary procedures. Private firms can also be consulted for disposal.

The Model Toxics Control Act, Ch. 70.105 RCW, requires that Ecology's Toxic Cleanup Program be notified if contaminated soil or ground water is encountered during a project.

II-3.8.5 BMP C 2.00 Concrete Trucks/Spray Washing of Exposed Aggregate Driveways and Walkways

The washout from a concrete truck should be disposed of into:

• A designated area which will later be backfilled: a slurry pit.

• An area where the concrete wash can harden, be broken up, and then put in the dumpster.

• A location which is not subject to surface water runoff, and more than 50 feet away from a storm drain, open ditch, or receiving water.

Never Dump Into:

• Sanitary sewer

• Storm drain

• Soil or pavement which carries stormwater runoff.

When spray washing driveways or walkways to expose the aggregate, all wash water should be diverted or sprayed to the sides, not down the driveway. If water must run down the driveway towards the street or sidewalk, it should be diverted at the bottom to a sump or sediment trap.

II-3.8.6 BMP C2.10 Use of Sandblasting Grits

If used to clean old buildings where lead, cadmium, or chrome-based paints were applied, the sandblasting grits are a hazardous waste. They cannot be washed into any sewer system. Contact a licensed waste management firm or TSD facility.

II-3.8.7 BMP C2.20 Disposal of Asbestos and PCBs

Use and disposal of these potential pollutants are regulated by both state and federal agencies. For further information, contact:
For Asbestos:

    Puget Sound Air Pollution Control Agency: 296-7330
    U.S. EPA: 442-7369

For Wastes Containing PCBs:

    Washington Department of Ecology, Hazardous Waste Section: 449-6687
    U.S. EPA: 442-7369

II-3.9 REFERENCES


# CHAPTER II-4

NPDES STORMWATER PERMIT REQUIREMENTS AND THE DEVELOPMENT OF LARGE PARCEL EROSION AND SEDIMENT CONTROL PLANS

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CHAPTER II-4
NPDES STORMWATER PERMIT REQUIREMENTS
AND THE DEVELOPMENT OF LARGE PARCEL EROSION AND SEDIMENT CONTROL PLANS

INTRODUCTION

Two different types of requirements commonly must be satisfied for construction sites. Those sites larger than 5 acres must comply with the requirements that will be contained in the baseline General NPDES Stormwater Permit (now under development). All new development and redevelopment sites larger than 1 acre must comply with Erosion and Sediment Control Requirements 1 through 14 (see Chapter I-2). This compliance is demonstrated through the submittal of an Erosion and Sediment Control (ESC) Plan.

II-4.1 NPDES STORMWATER PERMITS

EPA's National Pollutant Discharge Elimination System Permit (NPDES) regulations for stormwater (40 CFR Parts 122, 123 and 124) became effective on November 16, 1990. Washington is a NPDES delegated state which requires Ecology to administer NPDES permits. Cities and counties with a population of 100,000 and greater that have separate storm sewer systems, most industries that discharge stormwater associated with industrial activities or storage of raw materials, and construction sites 5 acres in area and greater are required to apply for NPDES permits. Stormwater from industrial uses that does not come in contact with industrial activities or storage of raw materials or products, such as runoff from roofs and parking lots, generally does not require a NPDES permit.

The purpose of the new stormwater NPDES regulations is to:

- Prohibit non-stormwater discharges into storm sewers
- Reduce discharge of stormwater-borne pollutants to the maximum extent practicable
- Establish a permit system for stormwater discharges

The Stormwater Management Program that Ecology and the Puget Sound Water Quality Authority are preparing for the Puget Sound Basin will be as consistent as possible with NPDES requirements. The thrust of the Stormwater Program is to direct the 111 cities and counties in the Basin to adopt and implement programs to prevent water pollution and enhance water quality for themselves and privately owned facilities in their jurisdiction. NPDES is a statewide permit program that Ecology will administer directly to cities, counties and regulated industrial facilities including construction sites.

Construction activity including clearing, grading and excavation activities that result in the disturbance of five acres or more will require a permit. Parcels less than five acres in area that are part of a common plan of development or sale totaling five acres or more will also be required to obtain a permit. Ecology anticipates that at the point that a permit program is developed, that construction sites will be covered as part of the baseline general permit to be published in final form in August, 1992. Once the permit is finalized, the contractor will be required to send to Ecology a Notice of Intent to begin construction 30 days before construction is to begin. At this time, details are not finalized.

Applications for coverage under the baseline permit should be submitted after Ecology adopts the permit (targeted for August, 1992), but before the current federal deadline of October 1, 1992. Applications will consist of filing a NOTICE
OF INTENT (NOI). Ecology has not yet decided on the information requirements for a NOTICE OF INTENT. Proposed requirements for a Notice of Intent will be discussed at public workshops and hearings.

At this time there will be no charges associated with the filing of the NOI. Ecology charges a fee for permits as allowed under State regulation, Chapter 173-224 WAC. That regulation does not identify a fee for facilities which will be covered under the baseline permit for storm water. Ecology plans to seek an increased legislative appropriation for the next biennium (July 1, 1993–June 30, 1995) to administer storm water permits. Fees would be set by amending the fee rule. There will be opportunities for public comment on the fee proposals. Subject to the appropriation and adoption of the amended fee regulation, fees for storm water permits would become effective after July 1, 1993.

PROPOSED ECOLOGY INDUSTRIAL/CONSTRUCTION PERMIT DEADLINES

May, 1992

Ecology holds public workshops, hearing on baseline permit.

August, 1992

Projected adoption of Ecology's baseline permit (including construction activities). The permit is effective 30 days later.

After 10/31/92

New industries must submit a NOTICE OF INTENT (to Ecology), and develop a pollution prevention plan (to be retained by the industry), before commencement of construction of a storm water discharge. EPA has proposed that these be completed at least 30 days prior to commencement.

ECOLOGY CONTACTS

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<tr>
<td>Stan Ciuba</td>
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<td>(206) 438-7042</td>
<td>(206) 438-7529</td>
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<tr>
<td>(206) 438-7037</td>
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II-4.2 INTRODUCTION TO LARGE PARCEL EROSION AND SEDIMENT CONTROL PLANS

This section is designed to provide an overview of the important components and process for developing, reviewing and implementing Large Parcel Erosion and Sediment Control (ESC) plans for construction sites. A separate example LPESC plan will be provided in the Stormwater Program Guidance Manual for the Puget Sound Basin currently being developed as a companion document to this manual. Small Parcel ESC requirements can be found in Chapters I-3 and II-5.

Section II-4.3 contains basic information which all site planners and plan reviewers should become familiar with. It describes criteria for plan format and content, ideas for improved planning effectiveness and sources of technical assistance.

Section II-4.4 outlines and describes a recommended step-by-step procedure for developing an erosion and sediment control plan from data collection to finished product. This procedure is written in general terms to be applicable to all types of projects.

Site planners, as well as local plan approving authorities, are urged to become familiar with the contents of this chapter so that plans will eventually become more standardized and thus more meaningful throughout the Puget Sound basin.
II-4.3 GENERAL GUIDELINES

II-4.3.1 What is a Large Parcel Erosion and Sediment Control Plan?

A Large Parcel ESC plan is a document which describes the potential for erosion and sedimentation problems on a construction project over 1 acre in size and explains and illustrates the measures which are to be taken to control those problems. The plan has a written portion known as a narrative and an illustrative portion known as a map or site plan.

The LPESC plan should be an independent entity. While it is a good idea to include erosion and sediment control standards and specifications in contract documents, the erosion and sediment control plan itself should be a separate document which can stand alone.

A LPESC plan is required for all new development and redevelopment where greater than 1 acre of land disturbing activities occur. See Chapter I-2 for more specific information on which type of planning is appropriate.

II-4.3.2 What is an "Adequate" Plan?

An erosion and sediment control plan must contain sufficient information to satisfy the Plan Approval Authority of the local government that the problems of erosion and sedimentation have been adequately addressed for a proposed project. The length and complexity of the plan should be commensurate with the size of the project, the severity of site conditions, and the potential for off-site damage.

In general, plans for constructing a few homes in a small subdivision do not need to be as complex as a plan for a large shopping center development or a large subdivision. Also, plans for projects undertaken on flat terrain will generally be less complicated than plans for projects constructed on steep slopes where the erosion potential is higher. The greatest level of planning and detail should be evident on plans for projects which are large in size, directly adjacent to flowing streams, other sensitive areas, or high value properties where damage may be particularly costly or detrimental to the environment.

The primary requirements that determine the adequacy of a plan are the Erosion and Sediment Control standards found in Minimum Requirement #1, described in Chapter I-2. Each of these Erosion and Sediment Control Requirements applicable to a project should be satisfied in the LPESC Plan unless a specific variance is granted by the Plan Approval Authority. The design and implementation of the LPESC plan should specifically fulfill all the Erosion and Sediment Control Requirements contained within Minimum Requirement #1 unless an exemption has been granted by the local government. As a guide to format, the site planners and plan reviewers should use the checklist contained in Section II-4.4.6. The step-by-step procedure outlined in this section is recommended for the development of all plans.

II-4.3.3 A Narrative is Important

The narrative is a written statement which explains and justifies the erosion and sediment control decisions made for a particular project. The narrative is especially important to the Plan Approval Authority because it contains concise information concerning existing site conditions, construction schedules, and other pertinent items which are not contained in a typical site plan.

The narrative is also important to the construction superintendent and inspector who are responsible to see that the plan is implemented properly. It provides them with a single report which describes where and when the various erosion and sediment control BMPs should be installed.
II-4.3.4 BMP Standards and Specifications

Chapters II-3 and II-5 of this volume of the manual contain standards and specifications for BMPs. These standards apply within the Puget Sound drainage basin except where an adopted and implemented basin plan is in place (see Minimum Requirement #9 in Chapter I-2). Wherever any of these BMPs are to be employed on a site, the specific title and number of the BMP should be clearly referenced in the narrative and marked on the plan. By referencing this manual properly, (or, the locally adopted technical equivalent of this manual) the site planner can reduce the need for detailed drawings and lengthy descriptions of the practices in the plan.

Modifications to standard practices or new innovative conservation practices may also be employed, but such practices (Experimental BMPs) must be thoroughly described and detailed to the satisfaction of Ecology and the Plan Approval Authority of the local government before they may be used (see Section I-2.17).

II-4.3.5 General Principles in Selecting BMPs for a Large Parcel Erosion and Sediment Control Plan

- Prevention of pollutant release is superior to pollutant capture later. Select source control BMPs as a first step.
- Selection of BMPs must depend on site characteristics and the construction plan.
- The proper first step is a site drainage analysis. Determine where runoff will enter, cross and exit the site.
- Flowing water has a tendency to concentrate in channels instead of flowing as sheet flow.
- Determine whether subsurface water is a factor.
- Divert runoff from exposed areas wherever possible.
- Existing vegetation is the most effective erosion control.
- Limit and phase clearing.
- Use materials found on the site wherever possible.
- Incorporate natural drainage features whenever possible, using adequate buffers and protecting areas where flow enters the drainage system.
- Keep structures simple.
- Minimize slope length and steepness.
- Keep runoff velocities low.
- Reduce the tracking of sediment off-site.
- Select and install controls that can be maintained.
- Select appropriate BMPs from Chapter II-3 for the control of pollutants not associated with sediment.

II-4.3.6 Standard Practice Coding System

Site planners are urged to use the standard numbering and coding system for BMPs contained in this manual. Table II-2.2 in Chapter II-2 lists each practice with its
designated number, symbol, and code. Use of this coding system will result in increased uniformity of plans and increase their readability to plan reviewers, job superintendents, and inspectors Puget Sound-wide. Since the SMPs in Chapter II-3 are not site-specific, they have not been given codes or symbols.

II-4.3.7 Comprehensive Site Planning

Erosion and sediment control planning should be an integral part of the site planning process, not just an afterthought. The potential for soil erosion should be a significant consideration when deciding upon the layout of buildings, parking lots, roads, and other facilities. Adverse environmental impacts and costly erosion and sediment control measures can be minimized if the site design can be adapted to existing site conditions and good conservation principles are used. Additionally, if thought is given to the design of temporary erosion control devices, they may be able to be converted into permanent facilities as well.

II-4.3.8 Who is Responsible for Preparing a Plan?

The owner or lessee of the land being developed has the responsibility for plan preparation and submission. The owner or lessee may designate someone (i.e., an engineer, architect, contractor, etc.) to prepare the plan, but he/she retains the ultimate responsibility. It is important for the developer to comply with the requirements of the local government and Minimum Requirement #1 contained in Chapter I-2 of this manual.

II-4.3.9 Technical Assistance

Possible sources of erosion and sediment control planning assistance within the state include:

1. Conservation Districts: These districts have elected representatives (directors) from each locality. One of the primary functions of these districts is to provide assistance to landowners for soil conservation planning and implementation. The USDA-Soil Conservation Service provides conservation districts with technical assistance. Requests for assistance in preparing erosion and sediment control plans for a construction site can be made through a district.

2. USDA-Soil Conservation Service: The Soil Conservation Service (SCS) provides technical assistance or conservation planning and implementation to landowners throughout the country through local conservation districts. In addition, the SCS is involved in soil surveys within the state. Requests can be made through a Soil Conservation Service field office for a soil survey on a specific site. These requests will be acted upon according to local priorities.

II-4.4 STEP-BY-STEP PROCEDURE

The five basic steps in producing a LPESC plan are summarized below:

Step 1 - Data Collection

A. Topography
B. Drainage
C. Soils
D. Ground Cover
E. Adjacent Areas
F. Existing Development
G. On and Off-Site Utilities
STORMWATER MANAGEMENT MANUAL FOR THE PUGET SOUND BASIN

Step 2 - Data Analysis
A. Topography - Slope gradients, lengths
B. Drainage - Outline existing natural and manmade drainage patterns
C. Soils - Erodibility (K) factors, permeability
D. Ground Cover - Trees, grassy areas, sensitive or endangered vegetation
E. Adjacent Areas - Streams, roads, buildings, etc.

Step 3 - Site Plan Development
A. Fit development to terrain
B. Locate construction in the least critical areas
C. Utilize cluster development whenever possible
D. Minimize paved areas
E. Utilize the natural drainage system and natural drainage locations whenever possible

Step 4 - Plan for Erosion and Sediment Control
A. Determine limits of clearing and grading
B. Divide the site into drainage areas
   • Consider each area separately
C. Select erosion and sediment control BMPs, emphasizing source control and vegetative BMPs.
   • Vegetative, especially buffers, preservation of natural vegetation and flagging
   • Structural
   • Management measures
D. Plan for stormwater management

Step 5 - Include BMPs for the Control of Pollutants Other Than Sediment
A. Review Chapter II-3 in this volume
B. Select appropriate BMPs based on the practices which will be used on-site.

Step 6 - Plan Preparation
A. Narrative
B. Site Plan

Note: The LPESC plan may be a subset of the Stormwater Site Plan. Full details on how to prepare the Stormwater Site Plan and how the LPESC plan is integrated into it are provided in Chapter I-3. In particular, most of the work for steps 1 and 2 will have been done when preparing the Site Improvement Plan Base Map. The actual LPESC plan is part of the Site Improvement Plan. All the hydrologic and hydraulic information used to analyze and size the ESC facilities must be included in Section IX of the Technical Information Report.

II-4.4.1 Step 1 - Data Collection

Inventory the existing site conditions to gather information which will help develop the most effective erosion and sediment control plan. The information obtained should be plotted on a map and explained in the narrative portion of the plan.

A. Topography - A small-scale topographic map of the site should be prepared to show the existing contour elevations at intervals of from 1 to 5 feet depending upon the slope of the terrain.

B. Drainage Patterns - All existing drainage swales and patterns on the site should be located and clearly marked on the topographic map including all
existing underground storm drain pipe systems.

C. **Soils** - Major soil type(s) on the site should be determined and shown on the topographic map. Soils information can be obtained from a soil survey if one has been published for the county. If a soil survey is not available, a request can be made to a district Soil Conservation Service Office. Commercial soils evaluations are also available. Soils information should be plotted directly onto the map or an overlay of the same scale for ease of interpretation.

D. **Ground Cover** - The existing vegetation on the site should be shown. Such features as tree clusters, grassy areas, and unique or sensitive vegetation should be shown on the map. Unique vegetation may include existing trees above a given diameter. Local requirements regarding tree preservation should be investigated. In addition, existing denuded or exposed soil areas should be indicated.

E. **Adjacent Areas** - Areas adjacent to the site should be delineated on the topographic map. Such features as streams, roads, lakes, wetlands, and wooded areas, etc., should be shown. These features should receive special attention during the construction project because of the potential for off-site damage.

F. **Existing Development** - Existing buildings and facilities (if any) on-site or adjacent to the site should be shown on the topographic map.

G. **On and Off-Site Utilities** - Identify all utility corridor locations, roadways, associated clearing limits and BMPs for all on-site and off-site utility construction.

II-4.4.2 Step 2 - Data Analysis

When all of the data in Step 1 are considered together, a picture of the site potentials and limitations should begin to emerge. Determination should be made to determine those areas which have potential critical erosion hazards. The following are some important points to consider in site analysis:

A. **Topography** - The primary topographic considerations are slope steepness and slope length. Because of the effect of runoff, the longer and steeper the slope, the greater the erosion potential. When the percent of slope has been determined, areas of similar steepness should be outlined. Slope gradients can be grouped into three general ranges of soil erodibility:

- 0-7% - Low erosion hazard
- 7-15% - Moderate erosion hazard
- >15% - High erosion hazard

Within these slope gradient ranges, the greater the slope length, the greater the erosion hazard. Therefore, in determining potential critical areas the planner should be aware of excessively long slopes. As a general rule, the erosion hazard will become critical if slope lengths exceed the following values:

- 0-7% - 300 feet
- 7-15% - 150 feet
- >15% - 75 feet

These distances may be shorter in areas with highly erodible soils.

B. **Natural Drainage** - Natural drainage patterns which consist of overland flow, swales and depressions, and natural watercourses, should be identified in order to plan around critical areas where water will concentrate. Where it is
possible, natural drainageways and discharge locations should be used to convey runoff over and off the site to avoid the expense and problems of constructing an artificial drainage system. Man-made ditches and waterways will become part of the erosion problem if they are not properly stabilized. Care should also be taken to be sure that increased runoff from the site will not erode or flood the existing natural drainage system. Possible sites for stormwater retention and detention should also be located at this point.

The site should also be checked for areas of saturated soil and/or areas where ground water may be encountered during construction. Construction in these areas should be avoided where possible.

C. Soils - Such soils properties as flood hazard, natural drainage, depth to bedrock, depth to seasonal water table, permeability, shrink-swell potential, texture, and erodibility should exert a strong influence on land development decisions.

D. Ground Cover - Ground cover is the most important factor in terms of preventing erosion. Any existing vegetation which can be saved will prevent erosion better than any constructed BMP. Trees and other vegetation protect the soil and beautify the site after construction. If the existing vegetation cannot be saved, consider such practices as staging construction, temporary seeding, or temporary mulching. Staging of construction involves stabilizing one part of the site before disturbing another. In this way, the entire site is not disturbed at once and the time without ground cover is minimized. Temporary seeding and mulching involve seeding or mulching areas which would otherwise lie open.

Buffers around water bodies or other sensitive areas should be delineated and the clearing limits flagged.

E. Adjacent Areas - An analysis of adjacent properties should focus on areas downslope from the construction project. Water bodies which will receive direct runoff from the site are a major concern. The potential for sediment pollution and/or downstream channel erosion and deposition should be considered and addressed. The potential for sediment deposition on adjacent properties due to sheet and rill erosion should also be analyzed so that appropriate sediment trapping measures can be planned.

II-4.4.3 Step 3 - Site Plan Development

After analyzing the data and determining the site limitations, the planner can then develop a site plan. Locate the buildings, roads, and parking lots and develop landscaping plans to exploit the strengths and overcome the limitations of the site. The following are some points to consider when making these decisions:

A. Fit the development to the terrain. The development of an area should be tailored to the existing site conditions to avoid unnecessary land disturbance and minimize erosion hazards and costs and other environmental impacts.

B. Confine construction activities to the least critical areas. Any land disturbance in highly erodible areas will necessitate the installation of more costly control measures.

C. Cluster buildings together. This minimizes the amount of disturbed area, concentrates utility lines and connections in one area, and provides more open natural space. The cluster concept not only lessens the erodible area and the amount of impervious surface, it reduces runoff, and generally reduces development costs.
D. Minimize impervious areas. Keep paved areas such as parking lots and roads to a minimum. This goes hand in hand with cluster developments in eliminating the need for duplicating parking areas, access roads, etc.

E. Utilize the natural drainage system. The natural drainage system and natural drainage locations of a site should be preserved instead of replaced with storm drains or concrete channels. The potential for downstream damages due to increased runoff can thus be minimized.

II-4.4.4 Step 4 - Plan for Erosion and Sediment Control

When the layout of the site has been decided upon, a plan to control erosion and sedimentation from the disturbed areas must be formulated. The Erosion and Sediment Control Requirements listed in Minimum Requirement #1 in Chapter I-2 establish a minimum level of control required for all projects.

The following general procedure is recommended for ESC control planning:

A. Determine limits of clearing and grading. Decide exactly which areas must be disturbed in order to accommodate the proposed construction. Pay special attention to critical areas. Show all limits of clearing for flagging in the field.

B. Divide the site into drainage areas. Determine how runoff will travel over the site. Consider how erosion and sedimentation can be controlled in each small drainage area before looking at the entire site. Remember, it is easier to control erosion than to contend with sediment after it has been carried downstream.

C. Select erosion and sediment control BMPs. Erosion and sediment control BMPs can be divided into three broad categories: cover practices, structural practices, and management measures. Cover practices, such as leaving buffer strips, seeding and mulching are the preferred BMPs and should be used first. Structural practices, such as sediment ponds and inlet protection should be implemented only after cover practices are used as a first line of defense. Management measures are construction management techniques such as staging construction which, if properly utilized, can minimize the need for physical controls and possibly reduce costs.

1. Cover Practices - Keep in mind that the first line of defense is to prevent erosion. This is accomplished by protecting the soil surface from raindrop impact and overland flow of runoff using source control BMPs. The best way to protect the soil surface is to preserve the existing ground cover. Where land disturbance is necessary, temporary seeding or mulching can be used on areas which will be exposed.

Erosion and sediment control plans must contain provisions for permanent stabilization of disturbed areas. Selection of permanent vegetation should include the following considerations:

a. establishment requirements
b. adaptability to site conditions
c. aesthetics
d. maintenance requirements

2. Structural Practices - Structural practices are generally more costly and less efficient than are source controls. However, they are usually necessary since not all disturbed areas can be protected with vegetation. They are often used as a second or third line of defense in series with other vegetative or structural practices to capture sediment before it leaves the site.
It is very important that structural practices be selected, designed, and constructed according to the standards and specifications in Chapter II-5 of this volume. Improper use or inadequate installation can create problems which are greater than the structure was designed to solve.

3. **Management Measures** - Good construction management is as important as physical practices for erosion and sediment control, and there is generally little or no cost involved. Following are some management considerations which can be employed.

a. Sequence construction so that no area remains exposed for an unnecessarily long period of time.

b. Temporary seeding should be done immediately after grading.

c. When possible, avoid grading activities during November through March since these months have the highest potential for erosive rainfall.

d. On large projects, stage the construction so that one area can be stabilized before another is disturbed.

e. Develop and carry out a regular maintenance schedule for erosion and sediment control practices.

f. Physically mark off limits of land disturbance on the site with tape, signs or other methods, so the workers can see areas to be protected.

g. Make sure that all workers understand the major provisions of the erosion and sediment control plan.

h. Responsibility for implementing the erosion and sediment control plan should be designated to one individual (preferably the job superintendent or foreman).

D. **Properties and waterways downstream from the development site shall be protected from erosion due to increases in volume, velocity and peak flow rate of stormwater runoff.**

II-4.4.5 Step 5 - Include BMPs for the Control of Pollutants Other than Sediment

A. **Review Chapter II-3 in this volume** - This chapter provides information on common construction practices which cause pollution other than erosion and sedimentation. These range from nutrient and pesticide control to disposal of solid and/or dangerous wastes.

B. **Select appropriate BMPs based on the practices which will be used on-site** - Based on the type of work to be done on-site, select the appropriate BMPs and include their use in the narrative plan. Areas where equipment washing may occur or where contaminated soils may be located on the site also should be noted on the site plan.

II-4.4.6 Step 6 - Prepare the Plan

All of the necessary planning work has been done in steps 1 through 5. The final step consists of consolidating the collected information and developing it into a specific erosion and sediment control plan for the project.
The plan consists of two parts: a narrative and a site plan. The narrative verbally explains the problems and their solutions with all necessary documentation. Justification should be provided for all solutions. The site plan is a series of maps or drawings pictorially explaining information contained in the narrative.

Following is a checklist of items which should be included in a narrative and on a site plan. This checklist can be used by a site planner as a quick reference to determine if all the major items are included in the erosion and sediment control plan.

II-4.4.7 Checklist for Erosion and Sediment Control Plans

Narrative

☐ Project description - Briefly describe the nature and purpose of the land disturbing activity, and the amount of grading involved.

☐ Existing site conditions - A description of the existing topography, vegetation, and drainage.

☐ Adjacent areas - A description of neighboring areas such as streams, lakes, residential areas, roads, etc., which might be affected by the land disturbance. Provide perimeter control of runoff on all necessary property boundaries.

☐ Soils - A brief description of the soils on the site giving such information as soil names, mapping unit, erodibility, permeability, depth, texture, and soil structure.

☐ Critical areas - A description of areas on the site which have potential serious erosion problems.

☐ Erosion and sediment control BMPs - A description of the BMPs which will be used to control erosion and sedimentation on the site. Specify the construction sequence.

☐ Permanent stabilization - A brief description, including specifications, of how the site will be stabilized after construction is completed.

☐ Stormwater management considerations - Will the development of the site result in increased peak rates of runoff? Will this potentially result in channel degradation downstream? If so, consideration must be given to stormwater control structures on the site (see Minimum Requirement #5 in Chapter I-2).

☐ Maintenance - A schedule of regular inspections and repair of erosion and sediment control structures should be set forth.

☐ Calculations - Any calculations made for the design of such items as sediment ponds, diversions, waterways, and calculations for runoff and stormwater detention basin design (if applicable). All calculations must bear the signature and stamp of an engineer licensed in the State of Washington.

☐ Non-ESC BMPs Required - Indicate which BMPs from Chapter II-3 will be used on-site.

Site Plan

☐ Vicinity map - A small map locating the site in relation to the surrounding area.

☐ Existing contours - Existing contours of the site should be shown on a map.
□ Existing vegetation - The existing tree lines, grassy areas, or unique vegetation should be shown on a map.

□ Soils - The boundaries of the different soil types should be shown on a map.

□ Indicate north - The direction of north in relation to the site should be shown.

□ Critical erosion areas - Areas with potentially serious erosion problems should be shown on a map.

□ Existing drainage patterns - The dividing lines and the direction of flow for the different drainage areas should be shown on a map.

□ Final contours - Changes to the existing contours should be shown on a map. Use a bold dashed line showing developed condition drainage divides.

□ Limits of clearing and grading - Areas which are to be cleared and graded should be outlined on a map.

□ Cut and Fill Slopes - Show all cut and fill slopes, indicating top/bottom of slope catch lines.

□ Conveyance -

(1) Designate locations for grass-lined swales, interceptor trenches, or ditches.

(2) Show all drainage pipes, ditches, or cut-off trenches associated with erosion/sediment control.

(3) Provide all temporary pipe inverts or minimum slopes and cover.

(4) Show grades, dimensions, location, and direction of flow in all ditches and swales.

(5) Provide details of bypassing off-site runoff around clearing limits/disturbed areas and sediment pond/trap.

(6) Indicate locations and outlets of any possible dewatering systems.

□ Location of BMPs - The locations of the erosion and sediment control and stormwater management BMPs used on the site should be shown on a map. In particular, locate the construction entrance and detail. Specify length, width, thickness and rock size of the entrance.

□ Sediment Control Facilities -

(1) Show all the locations of sediment trap(s)/pond(s) (if required) and all associated pipes and structures.

(2) Dimension pond berm widths and all inside and outside pond slopes.

(3) Indicate the trap/pond storage required and the depth, length, and width dimensions.

(4) Provide typical section views throughout pond and outlet structure.

(5) Provide typical details of gravel cone and standpipe, and/or other filtering devices.
(6) Detail stabilization techniques for outlet/inlet.
(7) Detail control/restrictor device location and details.
(8) Specify mulch and/or recommended cover of berms and slopes.
(9) Provide rock specifications and detail for rock check dam, if used.
(10) Specify spacing for rock check dams as required for actual slopes on-site.
(11) Provide front and side sections of typical rock check dams.
(12) Indicate locations and provide details and specifications for silt fabric fence (include installation detail).

☐ Detailed drawings - Any structural practices used that are not referenced to this manual or other local manuals should be explained and illustrated with detailed drawings.

☐ Non-ESC BMPs - Indicate any equipment washdown areas, areas of contaminated soils or other BMPs used where there are site-specific requirements.
CHAPTER II-5
STANDARDS AND SPECIFICATIONS FOR
BEST MANAGEMENT PRACTICES FOR EROSION AND SEDIMENT CONTROL

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CHAPTER II-5

STANDARDS AND SPECIFICATIONS FOR
BEST MANAGEMENT PRACTICES FOR EROSION AND SEDIMENT CONTROL

II-5.1 INTRODUCTION

Best Management Practices (BMPs) are defined as physical, structural and/or managerial practices, that when used singly or in combination, prevent or reduce pollution of water and have been approved by Ecology. This chapter contains the standards and specifications for erosion and sediment control BMPs which form the backbone of any Erosion and Sediment Control Plan.

II-5.2 STANDARDS AND SPECIFICATIONS FOR COVER PRACTICES

Specifications and design criteria of BMPs for erosion and sedimentation control can be broadly divided into two categories: cover practices (such as seeding and mulching) and structural practices (such as sediment ponds, filter fences, etc.) which require engineering standards and specifications. Structural control BMPs are dealt with in the next section.

Vegetative cover is the most important form of erosion control possible because it prevents or reduces erosion rather than attempting to trap sediment after soil has already eroded. In addition, it adds to the aesthetic and functional value of a development.

Cover practices can be divided into temporary and permanent measures. Temporary measures are implemented to provide a quick cover to soils that are exposed for longer than 2-7 days, or if an erosion problem already exists on the site during the development phase. They include:

- seeding
- mulching and matting
- clear plastic covering

Permanent measures are implemented both during and on completion of construction activities. They include:

- preserving natural vegetation
- buffer zones
- permanent seeding and planting
- sodding

II-5-1

FEBRUARY, 1992
II-5.3 TEMPORARY COVER PRACTICES

II-5.3.1 BMP E1.10: Temporary Seeding of Stripped Areas

Code: TS
Symbol: "\n
Definition: The establishment of a temporary vegetative cover on disturbed areas by seeding with appropriate rapidly growing annual plants.

Purpose

To provide temporary soil stabilization by planting grasses and legumes to areas which would remain bare for more than 7 days where permanent cover is not necessary or appropriate.

Conditions Where Practice Applies

- Permanent structures are to be installed or extensive re-grading of the area will occur prior to the establishment of permanent vegetation.
- Areas which will not be subjected to heavy wear by construction traffic.
- Areas sloping up to 10% for 100 feet or less (where temporary seeding is the only BMP used).

Advantages

- This is a relatively inexpensive form of erosion control but should only be used on sites awaiting permanent planting or grading. Those sites should have permanent measures used (see BMP E1.35, Permanent Seeding and Planting).
- Vegetation will not only prevent erosion from occurring, but will also trap sediment in runoff from other parts of the site.
- Temporary seeding offers fairly rapid protection to exposed areas.

Disadvantages/Problems

- Temporary seeding is only viable when there is a sufficient window in time for plants to grow and establish cover. During the establishment period the bare soil should be protected with mulch (see BMP E1.15) and/or clear plastic covering (see BMP E1.20).
- If sown on subsoil, growth will be poor unless heavily fertilized and limed. Because over-fertilization can cause pollution of stormwater runoff, other practices such as mulching (BMP E1.15) alone may be more appropriate. The potential for over-fertilization is an even worse problem in or near aquatic systems.
- Once seeded, areas cannot be used for heavy traffic.
- May require regular irrigation to flourish. Regular irrigation is not encouraged because of the expense and the potential for erosion in areas that are not regularly inspected. The use of low maintenance native species should be encouraged, and planting should be timed to minimize the need for irrigation.

Planning Considerations

Sheet erosion, caused by the impact of rain on bare soil, is the source of most fine particles in sediment. To reduce this sediment load in runoff, the soil surface
itself should be protected. The most efficient and economical means of controlling sheet and rill erosion is to establish vegetative cover. Annual plants which sprout rapidly and survive for only one growing season are suitable for establishing temporary vegetative cover. Temporary seeding is effective when combined with construction phasing so bare areas of the site are minimized at all times.

Temporary seeding may prevent costly maintenance operations on other erosion control systems. For example, sediment basin clean-outs will be reduced if the drainage area of the basin is seeded where grading and construction are not taking place. Perimeter dikes will be more effective if not choked with sediment.

Temporary seeding is essential to preserve the integrity of earthen structures used to control sediment, such as dikes, diversions, and the banks and dams of sediment basins.

Proper seedbed preparation and the use of quality seed are important in this practice just as in permanent seeding. Failure to carefully follow sound agronomic recommendations will often result in an inadequate stand of vegetation that provides little or no erosion control.

Design Criteria

- Time of Planting - Planting should preferably be done between April 1 and June 30, and September 1 through October 31. If planting is done in the months of July and August, irrigation may be required. If planting is done between November 1 and March 31, mulching shall be required immediately after planting. If seeding is done during the summer months, irrigation of some sort will probably be necessary.

- Site Preparation - Before seeding, install needed surface runoff control measures such as gradient terraces, interceptor dike/swales, level spreaders, and sediment basins.

- Seedbed Preparation - The seedbed should be firm with a fairly fine surface. Perform all cultural operations across or at right angles to the slope. See BMP E1.45, Topsoiling, and BMP E2.35, Surface Roughening for more information on seedbed preparation. A minimum of 2-4 inches of tilled topsoil is required.

- Fertilization - as per suppliers and/or Soil Conservation Service recommendations. Developments adjacent to water bodies must use non-phosphorus fertilizer.

- Seeding - seeding mixtures will vary depending on the exact location, soil type, slope, etc. Information on mixes may be obtained from local suppliers, the Washington State Department of Transportation, or the Soil Conservation Service. However, approval to use any particular mix must be obtained from the local government. The following seed mix is supplied as guidance.

<table>
<thead>
<tr>
<th>Name</th>
<th>Proportions By Weight</th>
<th>Percent Purity</th>
<th>Percent Germination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Redtop (Agrostis alba)</td>
<td>10%</td>
<td>92</td>
<td>90</td>
</tr>
<tr>
<td>Annual Rye (Lolium multiflorum)</td>
<td>40%</td>
<td>98</td>
<td>90</td>
</tr>
<tr>
<td>Chewings Fescue</td>
<td>40%</td>
<td>97</td>
<td>80</td>
</tr>
<tr>
<td>(Festuca rubra commutata)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White Dutch Clover (Trifolium repens)</td>
<td>10%</td>
<td>96</td>
<td>90</td>
</tr>
</tbody>
</table>

- "Hydro-seeding" applications with approved seed-mulch-fertilizer mixtures may also be used.
Maintenance

- Seeding should be supplied with adequate moisture. Supply water as needed, especially in abnormally hot or dry weather or on adverse sites. Water application rates should be controlled to prevent runoff.

- Re-seeding - Areas which fail to establish vegetative cover adequate to prevent erosion shall be re-seeded as soon as such areas are identified.

- All temporary erosion and sediment control measures should be removed within 30 days after final site stabilization is achieved or after the temporary BMPs are no longer needed. Trapped sediment must be removed or stabilized on site. Disturbed soil areas resulting from removal should be permanently stabilized.
II-5.3.2 BMP E1.15: Mulching and Matting

Code: MU  Symbol:  

Definition Application of plant residues or other suitable materials to the soil surface.

Purpose

To provide immediate protection to exposed soils during the period of short construction delays, or over winter months through the application of plant residues, or other suitable materials, to exposed soil areas.

Mulches also enhance plant establishment by conserving moisture and moderating soil temperatures. Mulch helps hold fertilizer, seed, and topsoil in place in the presence of wind, rain, and runoff and maintains moisture near the soil surface.

Conditions Where Practice Applies

- In areas which have been seeded either for temporary or permanent cover, mulching should immediately follow seeding.
- Areas which cannot be seeded because of the season, or are otherwise unfavorable for plant growth.
- Areas which have been seeded as specified in Temporary Seeding (BMP E1.10).
- In an area of greater than 2:1 slope, mulching should immediately follow seeding.

Advantages

- Mulching offers instant protection to exposed areas.
- Mulches conserve moisture and reduce the need for irrigation.
- Neither mulching nor matting require removal; seeds can grow through them unlike plastic coverings.

Disadvantages/Problems

- Care must be taken to apply mulch at the specified thickness, and on steep slopes mulch must be supplemented with netting.
- Thick mulches can reduce the soil temperature, delaying seed germination.
- Mulches such as straw, which are often applied to areas after grading must then be removed and either composted or landfilled. Straw is hollow, so it can actually draw water into the ground below it if the straw is at an angle.

Planning Considerations

Mulches are applied to the soil surface to conserve a desirable soil property or to promote plant growth. A surface mulch is one of the most effective means of controlling runoff and erosion on disturbed land (see Figure II-5.1 for a comparison of pollutant loading reductions for various mulches).

Mulches can increase the infiltration rate of the soil, reduce soil moisture loss by evaporation, prevent crusting and sealing of the soil surface, modify soil temperatures, and provide a suitable microclimate for seed germination.

Organic mulch materials, such as straw, wood chips, bark, and wood fiber, have been
found to be the most effective.

A variety of nets and mats have been developed for erosion control in recent years, and these are also used as mulches, particularly in critical areas such as waterways. They may be used to hold other mulches to the soil surface.

The choice of materials for mulching will be based on the type of soil to be protected, site conditions, season, and economics. It is especially important to mulch liberally in mid-summer and prior to winter, and on cut slopes and southern slope exposures. Table II-5.1 gives a comparison of costs based on 1988 figures.

Organic Mulches

Straw - Straw is the mulch most commonly used in conjunction with seeding. Its use is recommended where immediate protection is desired and preferably where the need for protection will be less than 3 months. The straw should come from wheat or oats, and may be spread by hand or machine. If the straw is not clean, weed growth can occur. Straw can be windblown and must be anchored down. Common anchoring methods are:

1. Crimping, diskng, rolling or punching into the soil;
2. Covering with netting;
3. Spraying with a chemical or fiber binder (tackifier); and
4. Keeping moist. Natural precipitation can often provide sufficient moisture.(2)

Corn Stalks - These should be shredded into 4 to 6-inch lengths. Stalks decompose slowly and are resistant to windblow.

Wood Chips - Suitable for areas that will not be closely mowed, and around ornamental plantings. Chips decompose slowly and do not require tacking. They must be treated with 12 pounds nitrogen per ton to prevent nutrient deficiency in plants. Chips can be a very inexpensive mulch if they are obtained from trees cleared on the site. However, both wood and bark chips tend to wash down slopes of more than 6 percent and create problems by clogging inlet grates etc. and are therefore not preferred for use in those areas.

Bark Chips, Shredded Bark - By-products of timber processing. Used in landscaped plantings. Bark is also a suitable mulch for areas planted to grasses and not closely mowed; may be applied by hand or mechanically. Bark is not usually toxic to grasses or legumes, and additional nitrogen fertilizer is not required.

Wood Fiber - Used in hydro-seeding operations, applied as part of the slurry. These short cellulose fibers do not require tacking, although a tacking agent or soil binders are sometimes used with wood fiber. The longer the fiber length, the better the wood fiber will work in erosion control. This form of mulch does not provide sufficient protection to erodible soils to be used alone during the severe heat of summer or for late fall seedings. Wood fiber hydro-seed slurries may be used to tack straw mulch. This combination treatment is well suited for steep slopes and critical areas, and severe climate conditions.

There are other organic materials which make excellent mulches but are only available locally or seasonally. Creative use of these materials can reduce costs.

Manure Mulches - Manure mulches should be well-aged and are not recommended for use near waterbodies.

Chemical Mulches and Soil Binders

The use of synthetic, spray-on materials (except tacking agents used with hydro-seeding) is not recommended. A major problem with their use is the creation of impervious surfaces and, possibly, adverse effects on water quality. Research has
shown that they can cause more erosion when used than does bare exposed soil.

**Nets and Mats** - Used alone, netting does not retain soil moisture or modify soil temperature. It stabilizes the soil surface while grasses are being established, and is useful in grassed waterways and on slopes. Light netting may also be used to hold other mulches in place. Its relatively high cost makes it most suitable for small sites.

The most critical aspect of installing nets and mats is obtaining firm, continuous contact between the material and the soil. Without such contact, the material is useless and erosion occurs. It is important to use an adequate number of staples and to roll the material after laying it to ensure that the soil is protected.

Table II-5.1 Summary of Estimated Service Lives and Costs 1988 Base - Horner, January, 1990

<table>
<thead>
<tr>
<th>Technique</th>
<th>Estimated Service Life (months)</th>
<th>Estimated Cost ($/acre served) (6 months service)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Straw (4 T/ac)</td>
<td>3</td>
<td>3,200</td>
</tr>
<tr>
<td>Straw (1.25 T/ac)</td>
<td>3</td>
<td>2,500</td>
</tr>
<tr>
<td>Straw (4 T/ac) manure-mulched,</td>
<td>6</td>
<td>2,400</td>
</tr>
<tr>
<td>fertilized, seeded</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jute mat</td>
<td>6</td>
<td>3,700</td>
</tr>
<tr>
<td>Excelsior</td>
<td>6</td>
<td>3,600</td>
</tr>
<tr>
<td>Woven straw blanket</td>
<td>6</td>
<td>4,100</td>
</tr>
<tr>
<td>Synthetic fiber blanket</td>
<td>6</td>
<td>3,300</td>
</tr>
<tr>
<td>Wood fiber mulch (1.25 T/ac)</td>
<td>6</td>
<td>1,300</td>
</tr>
<tr>
<td>fertilized, seeded</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wood fiber mulch (1.25 T/ac)</td>
<td>6</td>
<td>1,900</td>
</tr>
<tr>
<td>with tackifier (50 gal/ac),</td>
<td></td>
<td></td>
</tr>
<tr>
<td>fertilized, seeded</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wood fiber mulch (1.25 T/ac)</td>
<td>6</td>
<td>2,100</td>
</tr>
<tr>
<td>with tackifier (90 gal/ac),</td>
<td></td>
<td></td>
</tr>
<tr>
<td>fertilized, seeded</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wood fiber mulch (1.25 T/ac)</td>
<td>6</td>
<td>2,300</td>
</tr>
<tr>
<td>with tackifier (120 gal/ac),</td>
<td></td>
<td></td>
</tr>
<tr>
<td>fertilized, seeded</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chemical agent</td>
<td>6</td>
<td>2,100</td>
</tr>
<tr>
<td>Plastic sheeting</td>
<td>6</td>
<td>2,300</td>
</tr>
<tr>
<td>Designed sedimentation pond</td>
<td>&gt; 6</td>
<td>&lt; 4,200</td>
</tr>
<tr>
<td>Non-designed pond</td>
<td>&gt; 6</td>
<td>&lt; 7,500</td>
</tr>
</tbody>
</table>

*The estimated cost of seeding when it was used is based on hydro-seeding (approximately $500/acre).*
Figure II-5.1 Mean TSS and Overall Pollutant Loading Reductions of Slope Treatments Relative to Controls from Horner, January, 1990

Figure 3. Mean TSS and Overall Pollutant Loading Reductions of Slope Treatments Relative to Controls
Design Criteria

- Site Preparation - Same as Temporary Seeding.

- Mulch Materials, Application Rates, and Specifications - See Table II-5.2.

- Erosion blankets (nets and mats) may be used on level areas, on slopes up to 50 percent, and in waterways. Where soil is highly erodible, nets shall only be used in connection with an organic mulch such as straw and wood fiber. Jute nets shall be heavy, uniform cloth woven of single jute yarn, which if 36 to 48 inches wide shall weigh an average of 1.2 lbs./linear yard. It must be so applied that it is in complete contact with the soil. If it is not, erosion will occur beneath it. Netting shall be securely anchored to the soil with No. 11 gauge wire staples at least 6 inches long, with an overlap of three inches.

- Excelsior blankets are considered protective mulches and may be used alone on erodible soils and during all times of year.

- See Figure II-5.2 for orientation of netting and matting.

Maintenance

- Mulched areas should be checked periodically, especially following severe storms, when damaged areas of mulch or tie-down material should be repaired.

- All temporary erosion and sediment control measures shall be removed within 30 days after final site stabilization is achieved or after the temporary BMPs are no longer needed. Trapped sediment shall be removed or stabilized on site. Disturbed soil areas resulting from removal shall be permanently stabilized.

References

<table>
<thead>
<tr>
<th>Mulch Material</th>
<th>Quality Standards</th>
<th>Application Rates /1000 ft² /acre</th>
<th>Depth of Application</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravel, slag or crushed stone</td>
<td>Washed, ¾ - 1¼” size</td>
<td>9 yd³</td>
<td>3 inches</td>
<td>Excellent mulch for short slopes and around woody plants &amp; ornamentals. Use where subject to foot traffic. Approx. 2000 lbs/ yd³</td>
</tr>
<tr>
<td>Hay or straw</td>
<td>Air dried, free from unwanted seeds &amp; coarse material</td>
<td>75-100 lbs. or 1½-2½ tons or 90-120 bales</td>
<td>Minimum of 2 inches</td>
<td>Use where the mulching effect is to be maintained for &gt;3 months. Is subject to wind blowing unless kept moist or tacked down. Most common &amp; widely used mulching material. Can be used in critical erosion areas.</td>
</tr>
<tr>
<td>Wood fiber cellulose</td>
<td>Dyed green should not contain growth inhibiting factors.</td>
<td>25 - 30 lbs. or 1000-1500 lbs.</td>
<td></td>
<td>If used on critical areas, double the normal application rate. Apply w/hydromulcher. No tie-down required. Packaged in 100 lb. bags.</td>
</tr>
</tbody>
</table>

1 All mulches will provide some degree of (1) erosion control, (2) moisture conservation, (3) weed control, and (4) reduction of soil crusting.
Figure II-5.2 Orientation of Netting and Matting

Shallow Slope

On shallow slopes, strips of netting may be applied across the slope.
(Slopes up to 1:1)

Where there is a berm at the top of the slope, bring the netting over the berm and anchor it behind the berm.

Steep Slope

On steep slopes, apply strips of netting parallel to the direction of flow and anchor securely.
(Slopes greater than 1:1)

Bring netting down to a level area before terminating the installation. Turn the end under 6" and staple at 12" intervals.

Ditch

In ditches, apply netting parallel to the direction of flow. Use check slots every 15 feet. Do not join strips in the center of the ditch.
II-5.3.3 BMP E1.20: Clear Plastic Covering

Code: CPC Symbol: ←→

Definition The covering with clear plastic sheeting of bare areas which need immediate protection from erosion.

Purpose
To provide immediate temporary erosion protection to slopes and disturbed areas that cannot be covered by mulching, in particular during the specified seeding periods or as otherwise required by the local government. Clear plastic is also used to protect disturbed areas which must be covered during short periods of inactivity to meet November 1-March 31 cover requirements. Because of many disadvantages clear plastic covering is the least preferred covering BMP.

Conditions Where Practice Applies
- Disturbed areas which require immediate erosion protection.
- Areas seeded during the time period from November 1 to March 1.
  (Note: Plantings at this time require clear plastic covering for germination and protection from heavy rains.)

Advantages
- Clear plastic covering is a good method of protecting bare areas which need immediate cover and for winter plantings.
- May be quickly and easily placed.

Disadvantages/Problems
- There can be problems with vandals and maintenance.
- The sheeting will result in rapid, 100% runoff which may cause serious erosion problems and/or flooding at the base of slopes unless the runoff is properly intercepted and safely conveyed by a collecting drain. This is strictly a temporary measure, so permanent stabilization is still required.
- It is relatively expensive.
- The plastic may blow away if it is not adequately overlapped and anchored.
- Ultraviolet and possibly visible light can cause some types of plastic to become brittle and easily torn.
- Plastic must be disposed of at a landfill; it is not easily degradable in the environment.
- If plastic is left on too long during the spring it can severely burn any vegetation that has grown under it during cooler periods.

Design Criteria
- Clear plastic sheeting shall have a minimum thickness of 6 mil and meet the requirements of WSDOT/APWA Section 9-14.5.
- Covering shall be installed and maintained tightly in place by using sandbags or tires on ropes with a maximum 10 foot grid spacing in all directions. All seams shall be taped or weighted down full length and there shall be at least a 1 to 2 foot overlap of all seams. Seams should then be rolled and staked or
tied.

- Covering shall be installed immediately on areas seeded between November 1 to March 1, and remain until vegetation is firmly established.

- When the covering is used on unseeded slopes, it shall be left in place until the next seeding period.

- Sheetimg should be toed in at the top of the slope to prevent surface flow beneath the plastic.

- Sheetimg should be removed as soon as is possible once vegetation is well grown to prevent burning the vegetation through the plastic sheeting, which acts as a greenhouse.

Maintenance

- Check regularly for rips and places where the plastic may be dislodged. Contact between the plastic and the ground should always be maintained. Any air bubbles found should be removed immediately or the plastic may rip during the next windy period. Re-anchor or replace the plastic as necessary.

All temporary erosion and sediment control measures shall be removed within 30 days after final site stabilization is achieved or after the temporary BMPs are no longer needed. Trapped sediment shall be removed or stabilized on site. Disturbed soil areas resulting from removal shall be permanently stabilized.
II-5.4 PERMANENT COVER PRACTICES

II-5.4.1 BMP E1.25: Preserving Natural Vegetation

Code: VEG Symbol:  

Definition Minimizing exposed soils and consequent erosion by clearing only where construction will occur.

Purpose
To reduce erosion by preserving natural vegetation wherever practicable.

Condition Where Practice Applies
- Natural vegetation should be preserved on steep slopes, near perennial and intermittent watercourses or swales, and on building sites in wooded areas.
- As required by local governments.

Advantages
Preserving natural vegetation will:
- Help reduce soil erosion.
- Beautify an area.
- Save money on landscaping costs.
- Provide areas for wildlife.
- Possibly increase the value of the land.
- Provide buffers and screens against noise.
- Moderate temperature changes and provide shade and cover habitat for surface waters and land. This is especially important where detention ponds drain to salmonid-bearing streams. Increases in water temperature tend to lower the dissolved oxygen available for aquatic life.

Disadvantages/Problems
- Saving individual trees can be difficult, and older trees may become a safety hazard. Cottonwood and alder trees are especially prone to blowdown.

Planning Considerations
New development often takes place on tracts of forested land. In fact, building sites are often selected because of the presence of mature trees. However, unless sufficient care is taken and planning done, in the interval between buying the property and completing construction much of this resource is likely to be destroyed. The property owner is ultimately responsible for protecting as many trees as possible, with their understory and groundcover. This responsibility is usually exercised by agents—the planners, designers and contractors. It takes 20 to 30 years for newly planted trees to provide the benefits for which we value trees so highly.

Design Criteria
Natural vegetation can be preserved in natural clumps or as individual trees, shrubs and vines.
The preservation of individual plants is more difficult because equipment is generally used to remove unwanted vegetation. The points to remember when attempting to save individual plants are:

- Is the plant worth saving? Consider the location, species, size, age, vigor, and the work involved. Local governments may also have ordinances to save natural vegetation and trees.

- Is the tree or shrub a desirable plant? Is it shallow-rooted, do the roots seek water, or are insects and disease a problem? Shallow-rooted plants can cause problems in the establishment of lawns or ornamental plants. Water-seeking roots can block sewer and tile lines. Insects and diseases can make the plant undesirable. This is especially true with aphid on alder and maple.

- Old and/or large plants do not generally adapt to changes in environment as readily as young plants of the same species. Usually, it is best to leave trees which are less than 40 years of age. Some of the hardwoods (Red alder, Cherry, etc.) mature at approximately 50 years of age. After maturity they rapidly decline in vigor. Conifers, after 40 years of age, may become a safety hazard due to the possibility of breakage or blowdown, especially where construction has left only a few scattered trees in an area that was formerly dense woods. While old large trees are sometimes desirable, the problem of later removal should be considered. Again, local governments may have requirements to preserve older, larger specimen trees. It is expensive to cut a large tree and to remove the tree and stump from a developed area. Thinning some branches from trees can provide avenues for wind and hence lessen the "sail" effect.

- Clearly flag or mark areas around trees that are to be saved. It is preferable to keep ground disturbance away from the trees at least as far out as the dripline.

Plants need protection from three kinds of injuries:

- Construction Equipment -- This injury can be above or below the ground level. Damage results from scarring, cutting of roots, and compaction of the soil. Such injuries can be prevented by roping or fencing a buffer zone around plants to be saved prior to construction (Figure II-5.3.).

- Grade Changes -- Changing the natural ground level will alter grades which affect the plant's ability to obtain the necessary air, water, and minerals. Minor fills usually do not cause problems although sensitivity between species does vary. Cedars are more sensitive. Trees can tolerate fill of 6 inches or less. For shrubs and other plants the fill should be less. When there are major changes in grade, it may become necessary to supply air to the roots of plants. This can be done by placing a layer of gravel and a tile system over the roots before the fill is made. A tile system protects a tree from a raised grade.

The tile system should be laid out on the original grade leading from a dry well around the tree trunk. The system should then be covered with small stones to allow air to circulate over the root area (see Figure II-5.3.).

Lowering the natural ground level can seriously damage trees and shrubs. The highest percentage of the plant roots are in the upper 12 inches of the soil and cuts of only 2-3 inches can cause serious injury. To protect the roots it may be necessary to terrace the immediate area around the plants to be saved. If roots are exposed, construction of retaining walls may be needed to keep the soil in place. Plants can also be preserved by leaving them on an undisturbed, gently sloping mound. To increase the chances for survival, it is best to limit grade changes and other soil disturbances to areas outside the dripline of the plant (Figure II-5.3.).
- **Excavations** -- Protect trees and other plants when excavating for tile, water, and sewer lines. Where possible, the trenches should be routed around trees and large shrubs. When this is not possible, it is best to tunnel under them. This can be done with hand tools or with power augers.

If it is not possible to route the trench around plants to be saved, then the following should be observed:

Cut as few roots as possible. When you have to cut -- cut clean. Paint cut root ends with a wood dressing like asphalt base paint.

Backfill the trench as soon as possible.

Tunnel beneath root systems as close to the center of the main trunk to preserve most of the important feeder roots.

Some problems that can be encountered with a few specific trees are:

- Maple, Dogwood, Red alder, Western hemlock, Western red cedar and Douglas fir do not readily adjust to changes in environment and special care should be taken to protect these trees.

- The tipover hazard of Pacific silver fir is high while that of Western hemlock is moderate. The danger of tipover increases where dense stands have been thinned. Other species (unless they are on shallow, wet soils under 20 inches deep) have a low tipover hazard.

- Cottonwoods, maples, and willows have water-seeking roots. These can cause trouble in sewer lines and filter fields. On the other hand, they thrive in high moisture conditions that other trees would succumb to.

- Thinning operations in pure or mixed stands of Grand fir, Pacific silver fir, Noble fir, Sitka spruce, Western red cedar, Western hemlock, Pacific dogwood, and Red alder can cause serious disease problems. Disease can become established through damaged limbs, trunks, roots, and freshly cut stumps. Diseased and weakened trees are also susceptible to insect attack.

**Maintenance**

- Inspect flagged areas regularly to make sure flagging has not been removed. If tree roots have been exposed or injured, re-cover and/or seal them.
Figure II-5.3 Preserving Natural Vegetation

- **Individual Plants**
  - Surface Cleared

- **Potential Problems**
  - Roots compete for water with lawns and shrubs.
  - Water-seeking roots may clog tile lines.

- **Loose stones**
  - Drain Tiles "Vertical tiles"

- **Dry Well Soil Fill**

- **Dripline**
  - Original grade
  - Retaining wall
  - New grade

- **Mixture of peat moss or leaf mold and soil**
II-5.4.2 BMP El.30: Buffer Zones

Code: BZ
Symbol: ↑↓

Definition and Purpose: An undisturbed area or strip of natural vegetation or an established suitable planting that will provide a living filter to reduce soil erosion and runoff velocities.

Conditions Where Practice Applies

- Natural buffer zones are used along streams and other bodies of water that need protection from erosion and sedimentation. Vegetative buffer zones can be used to protect natural swales and incorporated into natural landscaping of an area.

Advantages

- Buffer zones provide critical habitat adjacent to streams and wetlands, as well as assist in controlling erosion, especially on unstable steep slopes. Buffers along streams and other water bodies also provide wildlife corridors, a protected area where wildlife can move from one place to another.

- Act as a visibility and noise screen.

Disadvantages/Problems

- Extensive buffers will increase development costs.

Design Criteria

- Preserving natural vegetation or plantings in clumps, blocks, or strips is generally the easiest and most successful method.

- Leave all unstable steep slopes in natural vegetation.

- Fence or flag clearing limits and keep all equipment and construction debris out of the natural areas.

- Keep all excavations outside the dripline of trees and shrubs.

- Do not push debris or extra soil into the buffer zone area because it will cause damage from burying and smothering.

- Vegetative buffer zones for streams, lakes or other waterways should be a minimum of 100 feet wide on each side with increases subject to other on-site sensitive conditions, existing vegetative conditions and erosion hazard potential (see Table II-5.3 for setback guidelines).
Table II-5.3 Minimum Recommended Guidelines for Undisturbed Vegetative Setbacks From Wetlands, Streams, Lakes and Other Sensitive/Critical Areas: (Expressed in feet from "ordinary high water mark".)

<table>
<thead>
<tr>
<th>Wetlands</th>
<th>Category</th>
<th>High intensity</th>
<th>300 feet</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Category I</td>
<td>Low intensity</td>
<td>200 feet</td>
</tr>
<tr>
<td></td>
<td>Category II</td>
<td>High intensity</td>
<td>200 feet</td>
</tr>
<tr>
<td></td>
<td>Low intensity</td>
<td>100 feet</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Category III</td>
<td>High intensity</td>
<td>100 feet</td>
</tr>
<tr>
<td></td>
<td>Low intensity</td>
<td>50 feet</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Category IV</td>
<td>High intensity</td>
<td>50 feet</td>
</tr>
<tr>
<td></td>
<td>Low intensity</td>
<td>25 feet</td>
<td></td>
</tr>
</tbody>
</table>

Streams: To be completed at a later date.

Lakes: To be completed at a later date.

1 The term "ordinary high water mark" means the line on the shore established by the fluctuations of water and indicated by physical characteristics such as a clear, natural line impressed on the bank; shelving; changes in the character of soil destruction on terrestrial vegetation, or the presence of litter and debris; or other appropriate means that consider the characteristics of the surrounding area.

2 Source: Model Wetlands Protection Ordinance, Dept. of Ecology, September, 1990. Note: These buffer ranges have been established to reflect the impact of intense land uses on wetland functions and values. The ratings system (Categories I-IV) are based on the Puget Sound Wetlands Rating System as set out in the same document.

3 Poor, fair, good and excellent conditions refers to percent coverage and growing condition of vegetation.

4 Erosion hazard ratings are based on the percent slope and hydrologic soil group of bare ground, as defined by the SCS.

NOTE: If ground cover is improved through reseeding reduce recommendations to next level within the same category except for excellent rating which is minimum specification.

Maintenance

- Inspect the area frequently to make sure flagging remains in place and the area remains undisturbed.
II-5.4.3 BMP El.35: Permanent Seeding and Planting

Definition
The establishment of perennial vegetative cover on disturbed areas.

Purpose
To establish permanent vegetation (such as grasses, legumes and trees and shrubs) as rapidly as possible to prevent soil erosion by wind or water, and to improve wildlife habitat and site aesthetics.

To provide pollutant filtration (biofiltration) in vegetation-lined channels and to establish constructed wetlands as required (see BMP RW.10 in Chapter III-4 and RV.05 in Chapter III-6).

Conditions Where Practice Applies
- Graded, final graded or cleared areas where permanent vegetative cover is needed to stabilize the soil.
- Areas which will not be brought to final grade for a year or more.
- Vegetation-lined channels.
- Retention or detention ponds as required.

Advantages
- Well established grass and ground covers can give an aesthetically pleasing, finished look to a development.
- Once established, the vegetation will serve to prevent erosion and retard the velocity of runoff.

Disadvantages/Problems
- Vegetation and mulch cannot prevent soil slippage and erosion if soil is not inherently stable.
- Coarse, high grasses that are not mowed can create a fire hazard in some locales. Very short mowed grass, however, provides less stability and sediment filtering capacity.
- Grass planted to the edge of a watercourse may encourage fertilizing and mowing near the water's edge and increase nutrient and pesticide contamination.
- May require regular irrigation to establish and maintain.

Planning Considerations
Vegetation controls erosion by reducing the velocity and the volume of overland flow and protecting the bare soil surface from raindrop impact.

Areas which must be stabilized after the land has been disturbed require vegetative cover. The most common and economical means of establishing this cover is by seeding grasses and legumes.

Advantages of seeding over other means of establishing plants include the small initial establishment cost, the wide variety of grasses and legumes available, low labor requirement, and ease of establishment in difficult areas.
Consider the microclimate(s) within the development area. Low areas may be frost pockets and require harder vegetation since cold air tends to sink and flow towards low spots. South-facing slopes may be more difficult to re-vegetate because they tend to be sunnier and drier.

Disadvantages which must be dealt with are the potential for erosion during the establishment stage, a need to reseed areas that fail to establish, limited periods during the year suitable for seeding, and a need for water and appropriate climatic conditions during germination.

There are so many variables in plant growth that an end product cannot be guaranteed. Much can be done in the planning stages to increase the chances for successful seeding. Selection of the right plant materials for the site, good seedbed preparation, timing, and conscientious maintenance are important. Whenever possible, native species of plants should be used for landscaping. These plants are already adapted to the locale and survivability should be higher than with exotic species.

Native species are also less likely to require irrigation, which can be a large maintenance burden and is neither cost-effective nor ecologically sound.

If non-native plant species are used, they should be tolerant of a large range of growing conditions and as low-maintenance as possible.

Design Criteria

- Vegetation cannot be expected to supply an erosion control cover and prevent slippage on a soil that is not stable due to its texture, structure, water movement, or excessive slope.

- Seeding should be done immediately after final shaping, except during the period of November 1 through March 1, when the site should be protected by mulching or plastic covering until the next seeding period.

- Permanent vegetation may be in the form of grass-type growth by seeding or sodding, or it may be trees or shrubs, or a combination of these. Establishing this cover may require the use of supplemental materials, such as mulch or jute netting (see BMP E1.15).

- Site Preparation: Install needed surface runoff control measures such as gradient terraces, berms, dikes, level spreaders, waterways, and sediment basins prior to seeding or planting.

- Seeding Grasses and Legumes: Seedbed Preparation -- If infertile or coarse textured subsoil will be exposed during land shaping, it is best to stockpile topsoil and respread it over the finished slope at a minimum 2 to 6-inch depth and roll it to provide a firm seedbed. If construction fills have left soil exposed with a loose, rough, or irregular surface, smooth with blade and roll. If cuts or construction equipment have left a tightly compacted surface, break with chisel plow or other suitable implement. Perform all cultural operations across or at right angles to the slope (contoured), such as with cat tracks on the final pass. The seedbed should be firm with a fairly fine surface.

- Soil Amendments: Rates will depend on site characteristics and soil, but as a guide, apply lime at the rate of 100 pounds per 1,000 square feet. Apply actual nitrogen at the rate of 1-2 pounds per 1,000 sq. feet, phosphoric acid at the rate of 1.5 pounds per 1,000 sq. feet, and potassium at the rate of 1.5 pounds per 1,000 sq. feet. Work in lime and other nutrients to a depth of a minimum of 4 inches with suitable equipment. Scatter amendments uniformly and work into the soil during seedbed preparation.

- Seeding: Apply an appropriate mixture to the prepared seedbed at a rate of 120 lbs/acre. (Seed mixture may be varied by the local government to take account of local conditions).
STORMWATER MANAGEMENT MANUAL FOR THE PUGET SOUND BASIN

Urban Application:

<table>
<thead>
<tr>
<th>Name</th>
<th>Portions by Weight</th>
<th>Percent Purity</th>
<th>Germination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kentucky Bluegrass</td>
<td>30%</td>
<td>85</td>
<td>80</td>
</tr>
<tr>
<td>Creeping Red Fescue</td>
<td>40%</td>
<td>98</td>
<td>90</td>
</tr>
<tr>
<td>Perennial Rye</td>
<td>30%</td>
<td>95</td>
<td>90</td>
</tr>
</tbody>
</table>

Rural Application:

<table>
<thead>
<tr>
<th>Name</th>
<th>Portions by Weight</th>
<th>Percent Purity</th>
<th>Germination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kentucky Bluegrass (Poa pratensis)</td>
<td>15%</td>
<td>85</td>
<td>80</td>
</tr>
<tr>
<td>Tall Fescue (Festuca arundinacea)</td>
<td>40%</td>
<td>95</td>
<td>90</td>
</tr>
<tr>
<td>Perennial Rye (Lolium perenne)</td>
<td>30%</td>
<td>95</td>
<td>90</td>
</tr>
<tr>
<td>Chewings Fescue</td>
<td>15%</td>
<td>95</td>
<td>90</td>
</tr>
</tbody>
</table>

Cover the seed with topsoil or mulch no deeper than ½ inch. It is better to work topsoil into the upper soil layer rather than spread a layer of it directly onto the top of the native soil.

"Hydro-seeding" applications with approved seed-mulch-fertilizer mixtures may also be used.

Wetlands Seed Mixtures: For newly created wetlands, a wetlands specialist should design plantings to provide the best chance of success. As a guide apply the following mixture at a rate of 60 lbs/acre, and/or additional tubers for cattail, bulrush, slough sedge, as required by the local government. See Chapter III-4, Volume III for more information on constructed wetlands.

Do not under any circumstances use introduced, invasive plants like reed canarygrass (Phalaris arundinacea) or purple loosestrife (Lythrum salicaria). Using plants such as these will cause many more problems than they will ever solve.

<table>
<thead>
<tr>
<th>Name</th>
<th>Proportions by Weight</th>
<th>Percent Purity</th>
<th>Germination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red Top (Agrostis alba)</td>
<td>30%</td>
<td>92</td>
<td>80</td>
</tr>
<tr>
<td>Birdsfoot Trefoil (Lotus corniculatus)</td>
<td>30%</td>
<td>90</td>
<td>80</td>
</tr>
<tr>
<td>Creeping Red Fescue</td>
<td>40%</td>
<td>98</td>
<td>90</td>
</tr>
</tbody>
</table>

Tree and Shrub Planting

Besides their erosion and sediment control values, trees and shrubs also provide natural beauty and wildlife benefits. When used for the latter, they are usually more effective when planted in clumps or blocks. These procedures should be followed:

1. Trees and shrubs will do best in topsoil. If no topsoil is available, they can be established in subsoil with proper amendment. If trees and shrubs are to be planted in subsoil, particular attention should be paid to amending the soil with generous amounts of organic matter. Mulches should also be used.

2. Good quality planting stock should be used. Normally one or two-year old deciduous seedlings, and three or four-year old coniferous transplants, when properly produced and handled are adequate. Stock should be kept cool and moist from time of receipt and planted as soon as possible.

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3. Competing vegetation, if significant, should be pulled out of the area where the plant or plants are to be placed.

Maintenance

Inspect seeded areas for failure and make necessary repairs and reseed immediately. Conduct or follow-up survey after one year and replace failed plants where necessary.

- If vegetative cover is inadequate to prevent rill erosion, overseed and fertilize in accordance with soil test results.

- If a stand has less than 40% cover, reevaluate choice of plant materials and quantities of lime and fertilizer. Re-establish the stand following seedbed preparation and seeding recommendations, omitting lime and fertilizer in the absence of soil test results. If the season prevents resowing, mulch or jute netting is an effective temporary cover.
II-5.4.4 BMP E1.40: Sodding

Code: (SO) Symbol: ☐

**Definition**
Stabilizing fine-graded disturbed areas by establishing permanent grass stands with sod.

**Purpose**
To establish permanent turf for immediate erosion protection or to stabilize drainageways where concentrated overland flow will occur.

**Conditions Where Practice Applies**
- Disturbed areas which require immediate vegetative cover.
- Waterways carrying intermittent flow, where immediate stabilization or aesthetics are factors and other locations which are particularly suited to stabilization with sod.

**Advantages**
- Sod will give immediate protection.
- Sod gives an immediate vegetative cover, which is both effective in checking erosion and is aesthetically pleasing.
- Good sod has a high density of growth which is superior in protection to a recently seeded area.
- Sod can be placed at any time of the year provided that soil moisture is adequate and the ground is not frozen.

**Disadvantages/Problems**
- Sod is expensive.
- Sod is heavy and handling costs are high.
- Good quality sod, free from weed species, may be difficult to obtain.
- If laid in an unfavorable season, midsummer irrigation may be required. This also applies to very droughty sandy soils.
- Grass species in the sod may not be suitable for site conditions.
- If mowing is required, do not use grass sod on slopes steeper than 3:1 (use minimum maintenance ground covers).
- If not anchored or drained properly, sod will "roll up" in grassed waterways.

**Design Criteria**
- Shape and smooth the surface to final grade in accordance with the approved grading plan.
- Use of topsoil shall be in accordance with the requirements of Topsoiling (BMP E1.50).
- Add lime to reach a soil pH value of 6.5 (based on soil tests).
- Fertilize according to a soil test or in the absence of a test use available
nitrogen, phosphorus and potash as prescribed for permanent seeding. Use fertilizers that are not highly soluble.

- Work lime and fertilizer into the soil 1 to 2 inches deep and smooth the surface.

- Lay strips of sod beginning at the lowest area to be sodded and perpendicular to the direction of water flow. Wedge strips securely in place. Square the ends of each strip to provide for a close, tight fit. Stagger joints at least 12 inches. Staple if on steep slopes.

- Roll the sodded area and irrigate.

- When sodding is carried out in alternating strips, or other patterns, seed the areas between the sod immediately after sodding.

- Sod should be free of weeds and be of uniform thickness (Approx. 1 in.) and should have a dense root mat for mechanical strength.

**Maintenance**

- Inspect sodded areas regularly, especially after large storm events. Re-tack, re-sod, or re-seed as necessary.
II-5.4.5 BMP E1.45: Topsoiling

While not a permanent cover practice in itself, topsoiling has been included in this section because it is an integral component of preparing permanent cover to those areas where there is an unsuitable soil surface for plant growth. Use of in-situ or imported topsoil is always preferable to planting in subsoil.

Definition Preserving and using topsoil to enhance final site stabilization with vegetation.

Purpose
To provide a suitable growth medium for final site stabilization with vegetation.

Conditions Where Practice Applies
- Preservation or importation of topsoil is determined to be the most effective method of providing a suitable growth medium, and the slopes are less than 2:1.
- Applicable to those areas with highly dense or impermeable soils or areas where planting is to be done in subsoil, where mulch and fertilizer alone would not provide a suitable growth medium.

Advantages
- Topsoil stockpiling ensures that a good growth medium will be available for establishing plant cover on graded areas. It has a high organic matter content and friable consistency, water holding capacity and nutrient content.
- The stockpiles can be used as noise and view baffles during construction.

Disadvantages/Problems
- Stripping, stockpiling, and reapplying topsoil, or importing topsoil may not always be cost-effective. It may also create an erosion problem if improperly secured.
- Unless carefully located, storage banks of topsoil may also obstruct site operations and therefore require double handling.
- Topsoiling can delay seeding or sodding operations, increasing exposure time of denuded areas.
- Most topsoil contains some weed seeds.

Planning Considerations
Topsoil is the surface layer of the soil profile, generally characterized as being darker than the subsoil due to the presence of organic matter. It is the major zone of root development, carrying much of the nutrients available to plants, and supplying a large share of the water used by plants.

Topsoiling is strongly recommended where ornamental plants or high-maintenance turf will be grown. Topsoiling is a required procedure when establishing vegetation on shallow soils, and soils of critically low pH (high acid) levels.

If topsoiling is to be done, the following items should be considered:
1. Whether an adequate volume of topsoil exists on the site. Topsoil should be spread at a depth of 2-4 inches. More topsoil will be needed if the subsoil is
2. Location of the topsoil stockpile so that it meets specifications and does not interfere with work on the site.

3. Allow sufficient time in scheduling for topsoil to be spread and bonded prior to seeding, sodding, or planting.

4. Care must be taken not to apply to subsoil if the two soils have contrasting textures. Sandy topsoil over clayey subsoil is a particularly poor combination, as water creeps along the junction between the soil layers and causes the topsoil to slough.

5. If topsoil and subsoil are not properly bonded, water will not infiltrate the soil profile evenly and it will be difficult to establish vegetation. The best method to prevent a lack of bonding is to actually work the topsoil into the layer below for a depth of at least 6 inches.

Design Criteria

- Field exploration of the site shall be made to determine if there is surface soil of sufficient quantity and quality to justify stripping. Topsoil shall be friable and loamy (loam, sandy loam, silt loam, sandy clay loam, clay loam). Areas of natural ground water recharge should be avoided.

- Stripping shall be confined to the immediate construction area. A 4 to 6 inch stripping depth is common, but depth may vary depending on the particular soil. All surface runoff control structures shall be in place prior to stripping.

- Stockpiling of topsoil shall occur in the following manner:
  a. Side slopes of the stockpile shall not exceed 2:1.
  b. An interceptor dike with gravel outlet and silt fence shall surround all topsoil stockpiles.
  c. Erosion control seeding or covering with clear plastic or other mulching materials (see BMPs E1.10, E1.20) of stockpiles shall be completed within 7 days of the formation of the stockpile.

- Topsoil shall not be placed while in a frozen or muddy condition, when the subgrade is excessively wet, or when conditions exist that may otherwise be detrimental to proper grading or proposed sodding or seeding.

- Previously established grades on the areas to be topsoiled shall be maintained according to the approved plan.

Maintenance

- Cover piles with clear plastic covering until needed.
II-5.5 STANDARDS AND SPECIFICATIONS FOR STRUCTURAL AND BIOMECHANICAL PRACTICES

Structural and biomechanical control practices are used to either reduce erosion or retain sediment on the construction site. The BMPs in this section have been divided into two basic groups based on these characteristics. The standards and specifications of each BMP are presented in the same format used for nonstructural practices.

Structural erosion control BMPs include measures for site stabilization (such as stabilized construction entrances), slope protection (such as pipe slope drains) and drainageway protection (such as level spreaders). Sediment control BMPs include filter fences, berms, and sediment traps. Table II-2.2 in Chapter II-2 gives the coding for these and all other BMPs in the volume.

Structural control is more effective when combined with vegetative protection and appropriate grading practices as part of an Erosion and Sediment Control (ESC) Plan (see the supplemental guidelines on preparing an ESC plan). Control measures may be either permanent or temporary depending on whether they will remain in use after development is complete.

Although temporary structures are emphasized in this section, they may be combined with permanent control facilities to provide protection of downstream properties during construction. Temporary ESC facilities provide siltation control, but downstream erosion protection must also be provided. Accordingly, the allowable discharge from development sites shall not exceed 50% of the pre-development peak flow for the 2-year, 24-hour storm.

It is also important not to disturb areas of natural ground water discharge and/or retention. To accomplish this, a permanent detention pond may have to be constructed first with modifications allowing it to temporarily function as a sediment pond. Or, a control structure as specified in Chapter III-4 of the Runoff Control Volume may be required on the outlet of the sediment pond.

The design of structural measures for erosion and sedimentation control is accomplished by carefully predetermining appropriate factors. The design storm, maximum drainage area, slope and other restrictions are noted for each BMP. The design criteria and limitations are important; if they are not observed, the simplest measures will fail and erosion control will not be achieved.

In most ESC designs, especially for sites larger than 5 acres, several small structures will function more effectively than a single large structure. For example, a combination of BMPs, such as filter fences, temporary dikes/swales, and several small sediment traps/ponds (depending on subbasin configuration) may be used as opposed to a single large sediment pond.

Maintenance is also of critical importance for proper operation of structural BMPs and must be considered in their design. Maintenance requirements and frequency vary with each BMP and its performance criteria. At a minimum, the ESC plan shall require monthly maintenance, or following each runoff producing storm (whichever occurs more frequently), for silt removal and proper operation of all ESC facilities. ESC facilities may have to be replaced or relocated depending on their performance under field conditions.

The following factors should be considered when designing structural control measures:

- Use material available on-site whenever possible.
- Keep structures simple and take advantage of permanent facilities unless the permanent structures are for infiltration.
- Install the most important control structures first.
• Install BMPs correctly; visit the site during and after storms to be sure that all structures are properly located, constructed, and functioning as designed.

• Install control measures in sequences which minimize land disturbance. For example, install interceptor dikes/swales and drainage trenches before seeding to avoid disturbing the seedbed. Avoid disturbing or removing existing vegetation whenever possible.

• Do not block a natural drainageway. Make certain that all necessary permits have been obtained before starting any work in a wetland, stream, or other sensitive area.

• Place control measures out of the way of construction operations.

• Make field modifications where necessary with the approval of the local jurisdiction.

• Provide access for maintenance.

Although design and construction standards and specifications are presented in some detail, this section is not a substitute for training in hydraulic and construction engineering. The materials presented are guidelines to assist in the design of erosion control measures. The standards and specifications provided should not be considered rigid requirements except where statutory requirements are indicated. Where local experience has shown that an alternate design will work better, it may be used as long as it meets the requirements contained found in Chapter I-2 and is approved by the local government. Designers are encouraged to continuously seek out new, more reliable solutions for controlling erosion and sediment.
II-5.6 STRUCTURAL EROSION CONTROL BMPs.

II-5.6.1 BMP E2.10: Stabilized Construction Entrance and Tire Wash

Definition A temporary stone-stabilized pad located at points of vehicular ingress and egress on a construction site.

Purpose
To reduce the amount of mud, dirt, rocks, etc. transported onto public roads by motor vehicles or runoff by constructing a stabilized pad of rock spalls at entrances to construction sites and washing of tires during egress.

Conditions Where Practice Applies
- Whenever traffic will be leaving a construction site and moving directly onto a public road or other paved areas.

Advantages
- Mud on vehicle tires is significantly reduced which avoids hazards caused by depositing mud on the public roadway.
- Sediment, which is otherwise contained on the construction site, does not enter stormwater runoff elsewhere.

Planning Considerations
Construction entrances provide an area where mud can be removed from vehicle tires before they enter a public road. If the action of the vehicle traveling over the gravel pad is not sufficient to remove the majority of the mud, then the tires must be washed before the vehicle enters a public road. If washing is used, provisions must be made to intercept the wash water and trap the sediment before it is carried off-site. Construction entrances should be used in conjunction with the stabilization of construction roads to reduce the amount of mud picked up by vehicles.

It is important to note that this BMP will only be effective if sediment control is used throughout the rest of the construction site.

Design Criteria
- Material should be quarry spalls (where feasible), 4 inches to 8 inches size.
- The rock pad shall be at least 12 inches thick and 100 feet in length for sites more than 1 acre; and may be reduced to 50 feet in length for sites less than 1 acre.
- A filter fabric fence (see BMP E3.10) should be installed down-gradient from the construction entrance in order to contain any sediment-laden runoff from the entrance.
- Width shall be the full width of the vehicle ingress and egress area (minimum 20 feet).
- Additional rock should be added periodically to maintain proper function of the pad.
- See Figure II-5.4 for details.
• Tire washing should be done before the vehicle enters a paved street. Washing should be done on an area covered with crushed rock and the wash water should be drained to a sediment retention facility such as a sediment trap or basin.

• The volume of wash water produced by tire washing should be included when calculating the sediment trap or basin size.

Maintenance

• The entrance shall be maintained in a condition which will prevent tracking or flow of mud onto public rights-of-way. This may require periodic top dressing with 2-inch stone, as conditions demand, and repair and/or cleanout of any structures used to trap sediment. All materials spilled, dropped, washed, or tracked from vehicles onto roadways or into storm drains must be removed immediately.

• All temporary erosion and sediment control measures shall be removed within 30 days after final site stabilization is achieved or after the temporary BMPs are no longer needed. Trapped sediment shall be removed or stabilized on site. Disturbed soil areas resulting from removal shall be permanently stabilized.

Figure II-5.4 Stabilized Construction Entrance
II-5.6.2 BMP E2.15: Construction Road Stabilization

Definition: The temporary stabilization with stone of access roads, subdivision roads, parking areas, and other on-site vehicle transportation routes immediately after grading.

Purpose
- To reduce erosion of temporary road beds by construction traffic during wet weather.
- To reduce the erosion and therefore regrading of permanent road beds between the time of initial grading and final stabilization.

Conditions Where Practice Applies
- Wherever rock-base roads or parking areas are constructed, whether permanent or temporary, for use by construction traffic.
- Note: Exceptions may be granted in areas with gravelly soils, such as the Everett series, as approved by the local government.

Advantages
- Efficiently constructed road stabilization not only reduces on-site erosion but can significantly speed on-site work, avoid instances of immobilized machinery and delivery vehicles, and generally improve site efficiency and working conditions during adverse weather.

Disadvantages/Problems
- Measures on temporary roads must be cheap not only to install but also to demolish if they interfere with the eventual surface treatment of the area.
- Application of aggregate to construction roads may need to be made more than once during a construction period.

Planning Considerations

Areas which are graded for construction vehicle transport and parking purposes are especially susceptible to erosion. The exposed soil surface is continually disturbed, leaving no opportunity for vegetative stabilization. Such areas also tend to collect and transport runoff waters along their surfaces. During wet weather, they often become muddy quagmires which generate significant quantities of sediment that may pollute nearby streams or be transported off-site on the wheels of construction vehicles. Dirt roads can become so unstable during wet weather that they are virtually unusable.

Immediate stabilization of such areas with stone may cost money at the outset, but it may actually save money in the long run by increasing the usefulness of the road during wet weather.

Permanent roads and parking areas should be paved as soon as possible after grading. As an alternative, the early application of stone may solve potential erosion and stability problems and eliminate later regrading costs. Some of the stone will also probably remain in place for use as part of the final base course of the road.
Design Criteria

- A 6-inch course of 2 to 4-inch crushed rock, gravel base, or crushed surfacing base course shall be applied immediately after grading or the completion of utility installation within the right-of-way. A 4-inch course of asphalt treated base (ATB) may be used in lieu of the crushed rock, or as advised by the local government.

- Where feasible, alternative routes should be made for construction traffic; one for use in dry condition, the other for wet conditions which incorporate the measures listed below.

- Temporary roads should follow the contour of the natural terrain to the maximum extent possible. Slope should not exceed 15 percent. Roadways should be carefully graded to drain transversely. Provide drainage swales on each side of the roadway in the case of a crowned section, or one side in the case of a super-elevated section. Drainage swales shall be designed in accordance with the standards given in Chapter III-2.

- Installed inlets shall be protected to prevent sediment-laden water entering the drain sewer system (see Section II-5.8.5 on Storm Drain Inlet Protection BMP E3.30).

- Simple gravel berms without a trench can be used for less traveled roads.

- Undisturbed buffer areas should be maintained at all stream crossings.

- Areas adjacent to culvert crossings and steep slopes should be seeded and mulched and/or covered.

- Dust control should be used when necessary (see BMP E2.20).

Maintenance

- Inspect stabilized areas regularly, especially after large storm events. Add crushed rock if necessary and restabilize any areas found to be eroding.

- All temporary erosion and sediment control measures shall be removed within 30 days after final site stabilization is achieved or after the temporary BMPs are no longer needed. Trapped sediment shall be removed or stabilized on site. Disturbed soil areas resulting from removal shall be permanently stabilized.
II-5.6.3 BMP E2.20: Dust Control

Code: (DC) Symbol: ♂

**Definition** Reducing surface and air movement of dust during land disturbing, demolition, and construction activities.

**Purpose**

To prevent surface and air movement of dust from exposed soil surfaces.

**Conditions Where Practice Applies**

- In areas (including roadways) subject to surface and air movement of dust where on-site and off-site damage is likely to occur if preventive measures are not taken.

**Advantages**

- A decrease in the amount of dust in the air will decrease the potential for accidents and respiratory problems.

**Disadvantages/Problems**

- Use of water on-site to control dust emissions, particularly in areas where the soil is already compacted, can cause a runoff problem where there wasn’t one.

**Planning Considerations**

Construction activities inevitably result in the exposure and disturbance of soil. Fugitive dust is emitted both during the activities (i.e., excavation, demolition, vehicle traffic, human activity) and as a result of wind erosion over the exposed earth surfaces. Large quantities of dust are typically generated in “heavy” construction activities, such as road and street construction and subdivision, commercial and industrial development, which involve disturbance of significant areas of soil surface. Research at construction sites has established an average dust emission rate of 1.2 tons/acre/month for active construction. Earthmoving activities comprise the major source of construction dust emissions, but traffic and general disturbance of the soil also generate significant dust emissions.

In planning for dust control, remember that the less soil is exposed at any one time, the less potential there will be for dust generation. Therefore, phasing a project and utilizing temporary stabilization practices upon the completion of grading can significantly reduce dust emissions.

**Design Criteria**

- Minimize the period of soil exposure through use of temporary ground cover and other temporary stabilization practices (see Seeding and Mulching, BMPs E1.10 and E1.15).
- Sprinkle the site with water until surface is wet. Repeat as needed. To prevent carryout of mud onto street, refer to Stabilized Construction Entrance (BMP E2.10).
- Spray exposed soil areas with approved dust palliative. Oil should not be used for dust suppression. Check with the local government to see which other dust palliatives may be used in the area.

**Maintenance**

- Respray area as necessary to keep dust to a minimum.
II-5.7.4 BMP E2.25: Pipe Slope Drains

Definition
A pipe extending from the top to the bottom of a cut or fill slope and discharging into a stabilized water course or a sediment trapping device or onto a stabilization area.

Purpose
To carry concentrated runoff down steep slopes without causing gullies, channel erosion, or saturation of slide-prone soils.

Conditions Where Practice Applies
- Where a temporary (or permanent) measure is needed for conveying runoff down a slope without causing erosion.

Advantages
- Slope drains provide a potentially effective method of conveying water safely down steep slopes.

Disadvantages/Problems
- Care must be taken to correctly site drains and not underdesign them. Also, when clearing takes place prior to installing these drains, care must be taken to revegetate the entire easement area, otherwise erosion tends to occur beneath the pipeline, resulting in gully formation.

Planning Considerations
There is often a significant lag between the time a cut or fill slope is completed and the time a permanent drainage system can be installed. During this period, the slope is usually not stabilized and is particularly vulnerable to erosion. This situation also occurs on slope construction which is temporarily delayed before final grade is reached. Temporary slope drains can provide valuable protection of exposed slopes until permanent drainage structures can be installed. When used in conjunction with diversion dikes, temporary slope drains can be used to convey stormwater from the entire drainage area above a slope to the base of the slope without erosion. It is very important that these temporary structures be installed properly since their failure will often result in severe gully erosion. The entrance section must be securely entrenched, all connections must be watertight, and the conduit must be staked securely.

Design Criteria
- The capacity for temporary drains shall be sufficient to handle a 10-year, 24-hour peak flow. This may be computed using the conveyance design method in Chapter III-1 of the Runoff Control Volume. Permanent pipe slope drains shall be sized for the 25-year 24-hour peak flow.
- The maximum drainage area allowed per pipe^ is ten acres. For larger areas, a rock-lined channel or more than one pipe shall be installed (see Volume III Chapter III-2).
- The entrance shall consist of a standard flared end section for culverts 12 inches and larger with a minimum 6-inch metal toe plate to prevent runoff from undercutting the pipe inlet. The slope of the entrance shall be at least 3 percent (Figure II-5.5).
• The soil around and under the pipe and entrance section shall be thoroughly compacted to prevent undercutting.

• The flared inlet section shall be securely connected to the slope drain and have watertight connecting bands.

• Slope drain sections shall be securely fastened together and have gasketed watertight fittings, and be securely anchored into the soil.

• Interceptor dikes shall be used to direct runoff into a slope drain. The height of the dike shall be at least 1 foot higher at all points than the top of the inlet pipe.

• The area below the outlet must be stabilized with a riprap apron (see BMP E2.70, Outlet Protection, for the appropriate outlet material).

• If the pipe slope drain is conveying sediment-laden water, direct all flows into the sediment trapping facility.

• Materials specifications for the type of pipe used shall be set by the local government.

**Maintenance**

• Check inlet and outlet points regularly, especially after heavy storms. The inlet should be free of undercutting, and no water should be going around the point of entry. If there are problems, the headwall should be reinforced with compacted earth or sand bags. The outlet point should be free of erosion and installed with appropriate outlet protection (see BMP E2.70).

• All temporary erosion and sediment control measures shall be removed within 30 days after final site stabilization is achieved or after the temporary BMPs are no longer needed. Trapped sediment shall be removed or stabilized on site. Disturbed soil areas resulting from removal shall be permanently stabilized.
Figure II-5.5 Pipe Slope Drains

- Discharge into a stabilized watercourse or a sediment trapping device or onto a stabilized area
- Earth Dike
- Corrugated metal or CPEP pipe
- Slope = 2:1
- H = D + 12"
- Slope 3% or steeper
- 6" min Cutoff Wall
- Standard flared entrance section (for pipe ≥ 12"
- Diameter D
- 4" min. at least than 1% slope

Riprap per Table III-2.6
Depth of apron shall be equal to pipe diameter
II-5.6.5 BMP E2.30: Subsurface Drains

**Code:** SD  
**Symbol:** → →

**Definition**  
A perforated conduit such as a pipe, tubing, or tile installed beneath the ground to intercept and convey ground water.

**Purpose**  
To provide a dewatering mechanism for draining excessively wet, sloping soils—usually consisting of an underground perforated pipe that will intercept and convey ground water.

**Conditions When Practice Applies**

- Wherever excessive water must be removed from the soil. The soil must be deep and permeable enough to allow an effective system to be installed.

**Advantages**

- Subsurface drains often provide the only practical method of stabilizing excessively wet, sloping soils.

**Disadvantages/Problems**

- Problems may be encountered with tree roots (see Maintenance).
- Pipes cannot be located under heavy vehicle crossings.

**Planning Considerations**

Subsurface drainage systems are of two types; relief drains and interceptor drains. Relief drains are used either to lower the water table in order to improve the growth of vegetation, or to remove surface water. They are installed along a slope and drain in the direction of the slope. They can be installed in a gridiron pattern, a herringbone pattern, or a random pattern (Figure II-5.6).

Interceptor drains are used to remove water as it seeps down a slope to prevent the soil from becoming saturated and subject to slippage. They are installed across a slope and drain to the side of the slope. They usually consist of a single pipe or series of single pipes instead of a patterned layout (Figure II-5.7).

**Design Criteria**

- Subsurface drain shall be sized for the required capacity. The minimum diameter for a subsurface drain shall be four inches.
- The minimum velocity required to prevent silting is 1.4 ft./sec. The line shall be graded to achieve at least this velocity.
- Filter material and fabric shall be used around all drains for proper bedding and filtration of fine materials.
- The outlet of the subsurface drain shall empty into a sediment trap or pond. If free of sediment, it shall empty into a receiving channel, swale, or stable vegetated area adequately protected from erosion and undermining.
- The strength and durability of the pipe shall meet the requirements of the site in accordance with the manufacturer’s specifications.
Construction Specifications

- The trench shall be constructed on a continuous grade with no reverse grades or low spots.
- Soft or yielding soils under the drain shall be stabilized with gravel or other suitable material.
- Deformed, warped, or otherwise unsuitable pipe shall not be used.
- Filter material shall be placed as specified with at least 3 inches of material on all sides of the pipe.
- Backfilling shall be done immediately after placement of the pipe. No sections of pipe shall remain uncovered overnight or during a rainstorm. Backfill material shall be placed in the trench in such a manner that the drain pipe is not displaced or damaged.

Maintenance

- Subsurface drains shall be checked periodically to ensure that they are free-flowing and not clogged with sediment.
- The outlet shall be kept clean and free of debris.
- Surface inlets shall be kept open and free of sediment and other debris.
- Trees located too close to a subsurface drain often clog the system with their roots. If a drain becomes clogged, relocate the drain or remove the trees as a last resort. Drain placement should be planned to minimize this problem.
- Where drains are crossed by heavy vehicles, the line shall be checked to ensure that it is not crushed.
- All temporary erosion and sediment control measures shall be removed within 30 days after final site stabilization is achieved or after the temporary BMPs are no longer needed. Trapped sediment shall be removed or stabilized on site. Disturbed soil areas resulting from removal shall be permanently stabilized.
Figure II-5.6 Subsurface Drain Layout

Random Pattern

Herringbone Pattern

Parallel Pattern

Typical Section

Figure II-5.7 Effect of Subsurface Drain on Water Table
II-5.7.6 BMP E2.35: Surface Roughening

Code: [SR]  Symbol: →←

**Definition**  Provision of a rough soil surface with horizontal depressions created by operating a tiller or other suitable equipment on the contour or by leaving slopes in a roughened condition by not fine grading them.

**Purpose**
To aid in establishment of vegetative cover, reduce runoff velocity, increase infiltration, and provide for sediment trapping.

**Conditions Where Practice Applies**
- All slopes steeper than 3:1, and greater than 5 vertical feet, require surface roughening; either stair-step grading, grooving, furrowing, or tracking if they are to be stabilized with vegetation.

**Advantages**
- Surface roughening provides some instant erosion protection on bare soil while vegetative cover is being established.
- It is an inexpensive and simple erosion control measure.

**Disadvantages/Problems**
- While this is a cheap and simple method of erosion control, it is of limited effectiveness in anything more than a moderate storm.

**Planning Considerations**
Graded areas with smooth, hard surfaces give a false impression of “finished grading” and a job well done. It is difficult to establish vegetation on such surfaces due to reduced water infiltration and the potential for erosion. Rough slope surfaces with uneven soil and rocks left in place may appear unattractive or unfinished at first, but they encourage water infiltration, speed the establishment of vegetation, and decrease runoff velocity.

Rough, loose soil surfaces give lime, fertilizer, and seed some natural coverage. Niches in the surface provide microclimates which generally provide a cooler and more favorable moisture level than hard flat surfaces; this aids seed germination.

There are different methods for achieving a roughened soil surface on a slope, and the selection of an appropriate method depends upon the type of slope. Roughening methods include stair-step grading, grooving, and tracking. Factors to be considered in choosing a method are slope steepness, mowing requirements, and whether the slope is formed by cutting or filling.

1. Disturbed areas which will not require mowing may be stair-step graded, grooved, or left rough after filling.

2. Stair-step grading is particularly appropriate in soils containing large amounts of soft rock. Each "step" catches material which sloughs from above, and provides a level site where vegetation can become established. Stairs should be wide enough to work with standard earth moving equipment.

3. Areas which will be mowed (these areas should have slopes less steep than 3:1) may have small furrows left by disking, harrowing, raking, or seed-planting machinery operated on the contour.
4. It is important to avoid excessive compacting of the soil surface when scarifying. Tracking with bulldozer treads is preferable to not roughening at all, but is not as effective as other forms of roughening, as the soil surface is severely compacted and runoff is increased.

Design Criteria

Graded areas with slopes greater than 3:1 but less than 2:1 should be roughened before seeding (Figures II-5.8a,b). This can be accomplished in a variety of ways, including "track walking," or driving a crawler tractor up and down the slope, leaving a pattern of cleat imprints parallel to slope contours.

Graded areas steeper than 2:1 should be stair-stepped with benches as shown in Figure II-5.9. The stair-stepping will help vegetation become established and also trap soil eroded from the slopes above.

Maintenance

- Areas which are graded in this manner should be seeded as quickly as possible.
- Regular inspections should be made of the area. If rills appear, they should be re-graded and re-seeded immediately.
Figure II-5.8(a) Heavy Equipment Can Be Used To Mechanically Scarify Slopes

undisturbed area
tread grooves of track perpendicular to slope direction

undisturbed vegetation
diverison
dozer treads create grooves perpendicular to slope direction

Figure II-5.8(b) Unvegetated Slopes Should be Temporarily Scarified to Minimize Runoff Velocities
Debris from slope above is caught by steps.

Water, soil, and fertilizer are held by steps - plants can become established on the steps.

Stair Stepping Cut Slopes

Grooving is cutting furrows along the contour of a slope. Irregularities in the soil surface catch rainwater and provide some coverage of lime, fertilizer and seed.

Grooving Slopes
II-5.7.7 BMP E2.40: Gradient Terraces

Definition  An earth embankment or a ridge-and-channel constructed with suitable spacing and with an acceptable grade.

Purpose

To reduce erosion damage by intercepting surface runoff and conducting it to a stable outlet at a nonerosive velocity. (This standard covers the planning and design of gradient terraces and does not apply to diversions.)

Conditions Where Practice Applies

- Gradient terraces normally are limited to denuded land having a water erosion problem. They should not be constructed on deep sands or on soils that are too stony, steep, or shallow to permit practical and economical installation and maintenance. Gradient terraces may be used only where suitable outlets are or will be made available.

Advantages

- Gradient terraces lower the velocity of runoff, increase the distance of overland flow, and reduce effective hydraulic gradient. They also hold moisture and minimize sediment.

Disadvantages/Problems

- May significantly increase cut and fill costs and cause sloughing if excessive water infiltrates soils.

Design Criteria

- The maximum spacing of gradient terraces should be determined by the following method: V.I. = x s + y
  
  Where: V.I. = vertical interval in feet  
          x = 0.8 for Washington¹  
          s = land slope in feet per 100 feet  
          y = a soil and cover variable with values from 1.0 to 4.0²

- The minimum constructed cross-section should meet the design dimensions.

- The top of the constructed ridge should not be lower at any point than the design elevation plus the specified overfill for settlement. The opening at the outlet end of the terrace should have a cross section equal to that specified for the terrace channel.

¹ U.S. Soil Conservation Service, National Engineering Handbook

² Values of "y" are influenced by soil erodibility and cover practices. The lower values are applicable to erosive soils where little to no residue is left on the surface. The higher value is applicable only to erosion-resistant soils where a large amount of residue (1½ tons of straw/acre equivalent) is on the surface.
• **Channel Grade** - Channel grades may be either uniform or variable with a maximum grade of 0.6 feet per 100 feet length. For short distances, terrace grades may be increased to improve alignment. The channel velocity should not exceed that which is nonerosive for the soil type with the planned treatment.

• **Outlet** - All gradient terraces should have adequate outlets. Such an outlet may be a grassed waterway, vegetated area, or tile outlet. In all cases the outlet must convey runoff from the terrace or terrace system to a point where the outflow will not cause damage. Vegetative cover should be used in the outlet channel.

• The design elevation of the water surface of the terrace should not be lower than the design elevation of the water surface in the outlet at their junction, when both are operating at design flow.

**Specifications**

• Vertical spacing determined by the above methods may be increased as much as 0.5 feet or 10 percent, whichever is greater, to provide better alignment or location, to avoid obstacles, to adjust for equipment size, or to reach a satisfactory outlet (Figure II-5.10).

• The drainage area above the top should not exceed the area that would be drained by a terrace of equal length with normal spacing.

• **Capacity** - The terrace should have enough capacity to handle the peak runoff expected from a 2-year, 24-hour design storm without overtopping.

• **Cross-Section** - The terrace cross-section should be proportioned to fit the land slope. The ridge height should include a reasonable settlement factor. The ridge should have a minimum top width of 3 feet at the design height. The minimum cross-sectional area of the terrace channel should be 8 square feet for land slopes of 5 percent or less, 7 square feet for slopes from 5 to 8 percent, and 6 square feet for slopes steeper than 8 percent. The terrace can be constructed wide enough to be maintained using a small cat.

**Maintenance**

• Maintenance should be performed as needed. Terraces should be inspected regularly; at least once a year, and after large storm events.
Figure II-5.10 Gradient Terraces

slope to adequate outlet

10' min.

50' max.

50' max.

50' max.
II-5.7.8 BMP E2.45: Bioengineered Protection of Very Steep Slopes

Code: SSP  Symbol: ⇐(w)⇒

Definition  Steep slope protection using a combination of vegetative and mechanical measures.

Purpose  To stabilize steep banks.

Conditions Where Practice Applies

- Slopes of steep grade, cut and fill banks, and unstable soil conditions that cannot be stabilized using ordinary vegetative techniques.

Advantages

- Vegetation reduces sheet erosion on slopes and impedes sediment at the toe of the slope.
- Where soils are unstable and liable to slip due to wet conditions, utilization of soil moisture by vegetation can reduce the problem.
- Shrubs and trees shelter slopes against the impact of rainstorms, and the humus formed by decaying leaves further helps to impede runoff.
- Mechanical measures help to stabilize soil long enough to allow vegetation to become established.

Disadvantages/Problems

- The planting of non-seeded material such as live willow brush is a specialized operation and cannot be highly mechanized or installed by unskilled labor.
- The methods described are effective but require a complete knowledge of soil, hydrology, and other physical data to design measures that will adequately solve the problem.

Design Criteria

The following bioengineering methods can be used after slopes have been protected by diversion of runoff (covered in BMP E2.55) or through the terracing of slopes (BMP E2.40).

- Sod walls or retaining banks are used to stabilize terraces. Sod is piled by tilting it slightly toward the slope and should be backfilled with soil and compacted as they are built up. Sod walls can be as steep as 1:8 but should not be higher than 5 feet (Figure II-5.11a).

- Timber frame stabilization is effective on gradients up to 1:1 and involves the following steps in construction: 1) Lay soil retarding frames of 2 x 4 in. vertical members and 1 x 4 in. horizontal members on slopes. Frames on slopes over 15 feet in length need to be anchored to slope to prevent buckling. 2) Attach 14 gauge galvanized tire wires for anchoring wire mesh. 3) Fill frames with moist topsoil and compact the soil. 4) Spread straw 6 inches deep over slope. 5) Cover straw with 14 gauge 4-inch mesh galvanized reinforced wire. 6) Secure wire mesh at least 6 feet back of top slope. 7) Plant ground cover plants through straw into topsoil (Figure II-5.11b).

- Woven willow whips (Figure II-5.11c) may be used to form live barriers for immediate erosion control. Construction: 1) 3 foot poles are spaced at 5 foot
distances and driven into the slope to a depth of 2 feet. 2) 2 foot willow sticks are inserted between poles at one foot distances. 3) Live willow branches of 5 foot length are sunk to a depth of 1 inch and interwoven with poles and stocks. 4) Spaces between the woven 'fences' are filled with top-soil. Fences are generally arranged parallel to the slope or in a grid pattern diagonal to the direction of the slope.

- **Berm Planting.** 1) Excavate ditches from 3 to 5 feet apart along the slope and shape a berm on the downslope side. Construct ditches with 5 percent longitudinal slope. 2) Plant rooted cuttings on 3 foot centers and mulch. Suitable trees are willow, alder, birch, pine, and selected shrubs. In extremely dry situations, rooted cuttings can be planted in biodegradable plastic bags that are watered at the time of planting (Figure II-5.11d).

- **Brush Layers.** 1) Prepare 3 foot "niches" as shown. 2) Lay unrooted 5 foot live branches of willow or poplar at close spacing. 3) Starting at foot of slope, backfill lower ditch with excavated material from ditch above it. Operation should be carried out during dormant season (Figure II-5.11e).

**Maintenance**

- Regardless of the stabilization method used, inspections should be made on a regular basis to make sure the system is functioning correctly.

- **Note:** There are a number of manufacturers who provide prefabricated bioengineered devices for the protection of steep slopes.
1:2 maximum slope
sod usually 18" x 72"
well-drained fill tamped in - place in layers as sod is stacked

Figure II-5.11(a) Sod Retaining Bank

staked down 1"x 4" members
1"x 4" cross pieces with wire ties in place
extend netting into trench and bury
topsoil in framework
straw
netting secured in place by wire ties
timber, frame, straw & netting

Figure II-5.11(b) Timber Frame Stabilization

6" topsoil placed flush with top of "brush"
push willow whips into ground and then interweave between posts

Figure II-5.11(c) Woven Willow Whips

BERM PLANTING SECTION
mulch

BRUSH LAYERS SECTION

Figure II-5.11(d) Berm Planting

Figure II-5.11(e) Brush Layers
II-5.7.9 BMP E2.50: Level Spreader

Code: [LS] Symbol: [Diagram]

Definition: A temporary outlet for dikes and diversions consisting of an excavated depression constructed at zero grade across a slope.

Purpose

To convert concentrated runoff to sheet flow and release it onto areas stabilized by existing vegetation or an engineered filter strip.

Condition Where Practice Applies

- To be constructed on undisturbed areas that are stabilized by existing vegetation and where concentrated flows are anticipated to occur at 0 percent grade.

Advantages

- Level spreaders disperse the energy of concentrated flows, reducing erosion potential and encouraging sedimentation.

Disadvantages/Problems

- If the level spreader has any low points, flow tends to concentrate there. This concentrated flow can create channels and cause erosion. If the spreader serves as an entrance to a water quality treatment system, short-circuiting of the forebay may happen and the system will be less effective in removing sediment and particulate pollutants.

Planning Considerations

Interceptor dikes and swales (BMP E2.55) call for a stable outlet for concentrated stormwater flows. The level spreader can be used for this purpose provided the runoff is relatively free of sediment. If properly constructed, the level spreader will significantly reduce the velocity of concentrated stormwater and spread it uniformly over a stable undisturbed area.

Particular care must be taken during construction to ensure that the lower lip of the structure is level. If there are any depressions in the lip, flow will tend to concentrate at these points and erosion will occur, resulting in failure of the outlet. This problem may be avoided by using a grade board or a gravel lip over which the runoff must flow when exiting the spreader. Regular maintenance is essential for this practice.

Design Criteria

- The grade of the channel for the last 20 feet of the dike or interceptor entering the level spreader shall be less than or equal to 1 percent. The grade of the level spreader shall be 0 percent to ensure uniform spreading of storm runoff (Figure II-5.12).

- A 6-inch high gravel berm placed across the level lip shall consist of washed crushed rock, 2 to 4 inch or 3/4 inch to 1 inch size.

- The spreader length will be determined by estimating the flow expected from the 25-year, 24-hour design (Q₅), and selecting the appropriate length from the following table:
<table>
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<tr>
<th>$Q_v$, in CFS</th>
<th>Min. Length, in Feet</th>
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</thead>
<tbody>
<tr>
<td>0 - 0.1</td>
<td>15</td>
</tr>
<tr>
<td>0.1 - 0.2</td>
<td>20</td>
</tr>
<tr>
<td>0.2 - 0.3</td>
<td>30</td>
</tr>
<tr>
<td>0.3 - 0.4</td>
<td>40</td>
</tr>
</tbody>
</table>

- The width of the spreader should be at least 6 feet.
- The depth of the spreader as measured from the lip should be at least 6 inches and it should be uniform across the entire length.
- The slope of the undisturbed outlet should not exceed 6% percent.

**Maintenance**

- The spreader should be inspected after every runoff event to ensure that it is functioning correctly. The contractor should avoid the placement of any material on or prevent construction traffic across the structure. If the spreader is damaged by construction traffic, it shall be immediately repaired.
Figure II-5.12 Level Spreader

Interceptor Berm

Last 20' of Interceptor not to exceed 1% Grade

Flow

Channel Grade 0%

6" Gravel Berm Spreader

Stabilized Slope

Undisturbed Outlet

1' min

2:1 or flatter

3' min.
II-5.7.10 BMP E2.55: Interceptor Dike and Swale

Definition
A ridge of compacted soil or a swale with vegetative lining located at the top or base of a sloping disturbed area.

Purpose
To intercept storm runoff from drainage areas above unprotected slopes and direct it to a stabilized outlet.

Conditions Where Practice Applies

- Where the volume and velocity of runoff from exposed or disturbed slopes must be reduced. When an interceptor dike/swale is placed above a disturbed slope, it reduces the volume of water reaching the disturbed area by intercepting runoff from above (Figures II-5.13a,b). When it is placed horizontally across a disturbed slope, it reduces the velocity of runoff flowing down the slope by reducing the distance that the runoff can flow directly downhill.

Advantages
- This BMP provides a practical, inexpensive method to divert runoff from erosive situations.

Disadvantages/Problems
- None

Planning Considerations

A temporary diversion dike or swale is intended to divert overland sheet flow to a stabilized outlet or a sediment trapping facility during establishment of permanent stabilization on a sloping disturbed area. When used at the top of a slope, the structure protects exposed slopes by keeping upland runoff away. When used at the base of a slope, the structure protects adjacent and downstream areas by diverting sediment-laden runoff to a sediment trapping facility.

If the dike or swale is going to remain in place for longer than 15 days, it shall be stabilized with temporary or permanent vegetation. The slope behind the dike or swale is also an important consideration. The dike or swale must have a positive grade to assure drainage, but if the slope is too great, precautions must be taken to prevent erosion due to high velocity of flow.

This practice is considered an economical one because it uses material available on the site and can usually be constructed with equipment needed for site grading. The useful life of the practice can be extended by stabilizing the dike or swale with vegetation.

Design Criteria
- Interceptor dikes shall meet the following criteria:
  
  Top Width
  2 feet minimum.

  Height
  18 inches minimum. Measured from upslope toe and at a compaction of 90 percent ASTM D698 standard proctor.

  Side Slopes
  2:1 or flatter.
Grade

Topography dependent, except that dike shall be limited to grades between 0.5 and 1.0 percent.

Horizontal Spacing of Interceptor Dikes

<table>
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<td>200 feet</td>
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<td>5-10%</td>
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Stabilization

<table>
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<th>Slopes</th>
<th>=</th>
<th>5-40%</th>
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<td>&lt;5%</td>
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<td>Seed and mulch applied within 5 days of dike construction (see BMP E1.10).</td>
</tr>
<tr>
<td>5-40%</td>
<td></td>
<td>Dependent on runoff velocities and dike materials. Stabilization should be done immediately using either sod or riprap to avoid erosion.</td>
</tr>
</tbody>
</table>

Outlet

The upslope side of the dike shall provide positive drainage to the dike outlet. No erosion shall occur at the outlet. Provide energy dissipation measures as necessary. Sediment-laden runoff must be released through a sediment trapping facility.

Other

Minimize construction traffic over temporary dikes.

Interceptor swales shall meet the following criteria:

Bottom Width

2 feet minimum; the bottom shall be level.

Depth

1 foot minimum.

Side Slope

2:1 or flatter.

Grade

Maximum 5 percent, with positive drainage to a suitable outlet (such as a sediment trap).

Stabilization

Seed as per BMP E1.10
Temporary Seeding, or E2.75
Riprap 12 inches thick pressed into the bank and extending at least 8 inches vertical from the bottom.

Swale Spacing

<table>
<thead>
<tr>
<th>Slope of disturbed area</th>
<th>=</th>
<th>300 feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;5%</td>
<td></td>
<td>200 feet</td>
</tr>
<tr>
<td>5-10%</td>
<td></td>
<td>100 feet</td>
</tr>
</tbody>
</table>

Outlet

Level Spreader or Riprap to stabilized outlet/sedimentation pond.
Maintenance

- The measure should be inspected after every major storm and repairs made as necessary. Damage caused by construction traffic or other activity must be repaired before the end of each working day.

- All temporary erosion and sediment control measures shall be removed within 30 days after final site stabilization is achieved or after the temporary BMPs are no longer needed. Trapped sediment shall be removed or stabilized on site. Disturbed soil areas resulting from removal shall be permanently stabilized.
Figure II-5.13(a) Temporary Interceptor Dikes

Dike Material compacted
90% Standard Proctor

2 min.

8 min.

Interceptor dike spacing = 100', 200' or 300' depending on grade

Figure II-5.13(b) Interceptor Swale

ROW or Other Exposed Slope

1 ft min.

Level Bottom

Grass or Rock

2 ft min.

Spacing = 100', 200', or 300'
depending on Slope
II-5.7.11 BMP E2.60: Check Dams

Definition Small dams constructed across a swale or drainage ditch.

Purpose To reduce the velocity of concentrated flows, reducing erosion of the swale or ditch, and to slow water velocity to allow retention of sediments.

Conditions Where Practice Applies

- Where temporary channels or permanent channels are not yet vegetated, channel lining is infeasible and, therefore, velocity checks are required.
- In small open channels which drain 10 acres or less. No check dams may be placed in streams (unless approved by the State Departments of Fisheries or Wildlife as appropriate). Other permits may also be necessary.
- Check dams in association with sumps work more effectively at slowing flow and retaining sediment.

Advantages

- Check dams not only prevent gully erosion from occurring before vegetation is established, but also cause a high proportion of the sediment load in runoff to settle out.
- In some cases, if carefully located and designed, these check dams can remain as permanent installations with very minor regrading, etc. They may be left as either spillways, in which case accumulated sediment would be graded and seeded, or as check dams to precipitate further sediment coming off that site.

Disadvantages/Problems

- Because of their temporary nature, many of these measures are unsightly, and they should be removed or converted to permanent check dams before dwelling units are rented or sold.
- Removal may be a significant cost depending on the type of check dam installed.
- Temporary check dams are only suitable for a limited drainage area.
- Clogging by leaves in the fall may be a problem.

Planning Considerations

Check dams can be constructed of either stone, logs, or pea gravel filled sandbags. Log check dams may be more economical from the standpoint of material costs, since logs can often be salvaged from clearing operations. However, log check dams require more time and hand labor to install. Stone for check dams, on the other hand, must generally be purchased. However, this cost is offset somewhat by the ease of installation.

If stone check dams are used in grass-lined channels which will be mowed, care should be taken to remove all the stone from the channel when the dam is removed. This should include any stone which has washed downstream.

Since log check dams are embedded in the soil, their removal will result in more disturbance of the soil than will removal of stone check dams. Consequently, extra care should be taken to stabilize the area when log dams are used in permanent
ditches or swales.

Design Criteria

- Check dams can be constructed of either rock, pea-gravel filled bags or logs (Figures II-5.14a,b). Provide a deep sump immediately upstream (see Figure II-5.14c).

- The maximum spacing between the dams shall be such that the toe of the upstream dam is at the same elevation as the top of the downstream dam (Figure II-5.14c).

- Rock check dams shall be constructed of appropriately sized rock. The rock must be placed by hand or mechanical placement (no dumping of rock to form dam) to achieve complete coverage of the ditch or swale and to ensure that the center of the dam is lower than the edges. The rock used must be large enough to stay in place given the expected design flow through the channel.

- Log check dams shall be constructed of 4 to 6-inch diameter logs. The logs shall be embedded into the soil at least 18 inches (Figure II-5.14a).

- In the case of grass-lined ditches and swales, check dams shall be removed when the grass has matured sufficiently to protect the ditch or swale unless the slope of the swale is greater than 4 percent. The area beneath the check dams shall be seeded and mulched immediately after dam removal.

Maintenance

- Check dams shall be monitored for performance and sediment accumulation during and after each runoff producing rainfall. Sediment shall be removed when it reaches one half the sump depth.

- All temporary erosion and sediment control measures shall be removed within 30 days after final site stabilization is achieved or after the temporary BMPs are no longer needed. Trapped sediment shall be removed or stabilized on site. Disturbed soil areas resulting from removal shall be permanently stabilized.
Figure II-5.14 Check Dams

a. Log Check Dam

NO SCALE

b. Rock Check Dam

NO SCALE

$2^\circ$-4" Rock

Flow

2:1

24"

L = The distance such that points A & B are of equal elevation

$A - L - B$

1 Jump

c. Spacing Between Check Dams
STORMWATER MANAGEMENT MANUAL FOR THE PUGET SOUND BASIN

II-5.7.12 BMP E2.70: Outlet Protection

Code: OP
Symbol: 

Definition Structurally lined aprons or other acceptable energy dissipating devices placed at the outlets or pipes or paved channel sections.

Purpose

To prevent scour at stormwater outlets, and to minimize the potential for downstream erosion by reducing the velocity of concentrated stormwater flows.

Condition Where Practice Applies

• Applicable to the outlets of all pipes, interceptor swale outlets, and channel sections where the velocity of flow at the design capacity of the outlet will exceed the permissible velocity of the receiving channel or area.

Advantages

• Plunge pools which can develop without outlet protection may severely weaken the embankment and thus threaten its stability.

• Protection can prevent scouring at a culvert mouth and thus prevent gully erosion which may gradually extend upstream.

Disadvantages/Problems

• Some types of structures may be unsightly.

• Sediment removal may be difficult.

Planning Considerations

An outfall is defined as a concentrated discharge point which directs collected surface water flows into an open drainage feature, natural or manmade. These drainage features include ditches, channels, swales, closed depressions, wetlands, streams, rivers, ponds, lakes, or other open bodies of water. In nearly every case, the outfall will consist of a pipe discharging flows from a storm pipe system, a culvert, or a detention facility.

Design Criteria

See Sections III-2.3.4 and 2.3.5 in the Runoff Control Volume.

Maintenance

All temporary and permanent erosion and sediment control practices shall be maintained and repaired as needed to assure continued performance of their intended function. All maintenance and repair shall be conducted in accordance with an approved manual. Rock may need to be added if sediment builds up in the pore spaces of the outlet pad.
II-5.7.13 BMP E2.75: Riprap

Code: RR

Symbol: *

**Definition**
A permanent, erosion-resistant ground cover of large, loose, angular stone.

**Purpose**
To slow the velocity of concentrated runoff or to stabilize slopes with seepage problems and/or non-cohesive soils by placement of large, loose, angular stone.

**Conditions Where Practice Applies**
- Soil-water interfaces, where the soil conditions, water turbulence, water velocity, and expected vegetative cover, are such that the soil may erode under the design flow conditions.

**Advantages**
- Riprap offers an easy-to-use method for decreasing water velocity and protecting slopes from erosion. It is simple to install and maintain.
- Riprap provides some water quality benefits by increasing roughness and decreasing the velocity of the flow, inducing settling.

**Disadvantages/Problems**
- Riprap is more expensive than vegetated slopes.
- Riprap does not provide the habitat enhancement that other vegetative BMPs do.

**Planning Considerations**

**Graded vs. Uniform Riprap**
Riprap is classified as either graded or uniform. A sample of graded riprap would contain a mixture of stones which vary in size from small to large. A sample of uniform riprap would contain stones which are all fairly close in size.

For most applications, graded riprap is preferred to uniform riprap. Graded riprap forms a flexible self-healing cover, while uniform riprap is more rigid and cannot withstand movement of the stones. Graded riprap is cheaper to install, requiring only that the stones be dumped so that they remain in a well-graded mass. Hand or mechanical placement of individual stones is limited to that necessary to achieve the proper thickness and line. Uniform riprap requires placement in a more or less uniform pattern, requiring more hand or mechanical labor.

Riprap sizes can be designated by either the diameter or the weight of the stones. It is often misleading to think of riprap in terms of diameter, since the stones should be rectangular instead of spherical. However, it is simpler to specify the diameter of an equivalent size of spherical stone. Table II-5.4 below lists some typical stones by weight, spherical diameter and the corresponding rectangular dimensions. These stone sizes are based upon an assumed specific weight of 165 lbs./ft³

**Design Criteria**
Also see Table III-2.27, Rock Protection at Outfalls in the Runoff Control Volume.
Table II-5.4 Size of Riprap Stones

<table>
<thead>
<tr>
<th>Weight (lbs)</th>
<th>Mean Spherical Diameter (ft)</th>
<th>Rectangular Shape Length (ft)</th>
<th>Width, Height (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>0.8</td>
<td>1.4</td>
<td>0.5</td>
</tr>
<tr>
<td>100</td>
<td>1.1</td>
<td>1.75</td>
<td>0.6</td>
</tr>
<tr>
<td>150</td>
<td>1.3</td>
<td>2.0</td>
<td>0.67</td>
</tr>
<tr>
<td>300</td>
<td>1.6</td>
<td>2.6</td>
<td>0.9</td>
</tr>
<tr>
<td>500</td>
<td>1.9</td>
<td>3.0</td>
<td>1.0</td>
</tr>
<tr>
<td>1000</td>
<td>2.2</td>
<td>3.7</td>
<td>1.25</td>
</tr>
<tr>
<td>1500</td>
<td>2.6</td>
<td>4.7</td>
<td>1.5</td>
</tr>
<tr>
<td>2000</td>
<td>2.75</td>
<td>5.4</td>
<td>1.8</td>
</tr>
<tr>
<td>4000</td>
<td>3.6</td>
<td>6.0</td>
<td>2.0</td>
</tr>
<tr>
<td>6000</td>
<td>4.0</td>
<td>6.9</td>
<td>2.3</td>
</tr>
<tr>
<td>8000</td>
<td>4.5</td>
<td>7.6</td>
<td>2.5</td>
</tr>
<tr>
<td>20000</td>
<td>6.1</td>
<td>10.0</td>
<td>3.3</td>
</tr>
</tbody>
</table>

Since graded riprap consists of a variety of stone sizes, a method is needed to specify the size range of the mixture of stone. This is done by specifying a diameter of stone in mixture for which some percentage, by weight, will be smaller. For example, \( d_{50} \) refers to a mixture of stones in which 50 percent of the stone by weight would be smaller than the diameter specified. Most designs are based on \( d_{50} \). In other words, the design is based on the median size of stone in the mixture.

**Sequence of Construction**

Since riprap is used where erosion potential is high, construction must be sequenced so that the riprap is put in place with the minimum possible delay. Disturbance of areas where riprap is to be placed should be undertaken only when final preparation and placement of the riprap can follow immediately behind the initial disturbance. Where riprap is used for outlet protection, the riprap should be placed before or in conjunction with the construction of the pipe or channel so that it is in place when the pipe or channel begins to operate.

**Maintenance**

- Riprap coverings should be inspected on a regular basis and after every large storm event.

- All temporary and permanent erosion and sediment control practices shall be maintained and repaired as needed to assure continued performance of their intended function. All maintenance and repair shall be conducted in accordance with an approved manual.
II-5.7.14 BMP E2.80: Vegetative Streambank Stabilization

**Definition**
The use of vegetation to stabilize streambanks.

**Purpose**
To protect streambanks against erosion through vegetative means.

**Condition Where Practice Applies**
- Applicable to water areas and all land uses. To be used to stabilize banks in swales, creeks, streams, and rivers as well as man-made ditches, canals and impoundments, including ponds and storage basins.

**Advantages**
- Streambank vegetation can break wave action and the velocity of flood flows.
- Roots and rhizomes stabilize streambanks.
- The reduction of velocity can lead to the deposit of water-borne soil particles.
- Certain reeds and bulrushes have the capability of improving water quality by absorbing certain pollutants such as heavy metals, detergents, phenols, and indols (1).
- Plants regenerate themselves and adapt to changing natural situations, thus offering a distinct economic advantage over mechanical stabilization.
- Wildlife and fisheries habitat is improved.

**Disadvantages/Problems**
- Native plants may not be carried by regular nurseries and may need to be collected by hand, or obtained from specialty nurseries. Nurseries which carry these plants may require a long lead time for large orders.
- Flow retarding aspects of vegetated waterways need to be taken into account.

**Planning Considerations**
A primary cause of stream channel erosion is the increased frequency of bank-full flows which often results from upstream development. Most natural stream channels are formed with a bank-full capacity to pass the runoff from a storm with a 1.5 to 2-year recurrence interval. However, in a typical urbanizing watershed, stream channels may become subject to a 3 to 5-fold increase in the frequency of bank-full flows if stormwater runoff is not properly managed. As a result, stream channels that were once parabolic in shape and covered with vegetation may be transformed into wide rectangular channels with barren banks.

In recent years, a number of structural measures have evolved to strengthen and protect the banks of rivers and streams. These methods, when employed correctly, immediately ensure satisfactory protection of the banks. However, many such structures are expensive to build and to maintain. Without constant upkeep, they are exposed to progressive deterioration by natural agents. The materials used often prevent the reestablishment of native plants and animals, especially when the
design is executed according to standard cross-sections which ignore natural variations of the stream system. Very often these structural measures destroy the appearance of the site. Additionally, structural stabilization and channelization can alter the hydrodynamics of a stream and only serve to transfer erosion potential and associated problems downstream.

In contrast, the utilization of living plants instead of or in conjunction with structures has many advantages. The degree of protection, which may be low to start with, increases as the plants grow and spread. The repair and maintenance of structures is unnecessary where self-maintaining streambank plants are established. The protection provided by natural plant vegetation is more reliable and effective when the cover consists of natural plant communities adapted to their site.

Design Criteria

- Design must be prepared based on criteria and input/review by a qualified fisheries biologist.

- Streambanks can be divided into: 1) aquatic plant zones at the mean low-water level (MLW); 2) reed bank zones covered at bankfull stage (BF); 3) lower riparian zones or open floodway zones naturally covered with willows and shrubbery plants (OF); 4) upper riparian areas or flood fringe areas that would naturally be covered with canopy-forming trees (FF) (see Figure II-5.15a).

- Aquatic plants are often considered weeds and a nuisance though they do slow down streamflow and protect the streambed. Primary emphasis of streambank stabilization lies in the bankfull zone.

- The reed bank zone forms a permeable obstacle, slowing down current waves by friction. Suitable plants can be found by consulting the guidelines found in Chapter III-5. Their shoots, with a root clump, can be planted in pits at 1/2 to 1 foot depth below water, or in a reed roll as in Figure II-5.15b. A trench 1-1/2 feet wide and deep is dug behind a row of stakes; wire netting is then stretched from both sides of upright planks; coarse gravel is dumped on this and covered with reed clumps until the two edges of the netting can just be held together with wire. The upper edge of the roll should not be more than two inches above water level. Finally, the planks are taken out and gaps in the ditch are backfilled.

- The lower riparian zone in the Puget Sound region has a natural growth of willow, alder, cottonwood, small maples, and various berries. These vegetative types can be reintroduced on denuded floodplains to stabilize the soil with their roots. In periods of high water, their upper branches reduce the speed of the current and thereby the erosive force of water. The most commonly used vegetative stabilizer for this zone is willow because of its capability to develop secondary roots on cut trunks and to throw up suckers. Willows are planted either as individual cuttings bound together in various forms or wired together in "fascines."

- Fascines (Figure II-5.16a) have a diameter of 3 to 12 inches and contain brushwood and sticks and coarse gravel or rubble in the center tightly wound around. Packed fascine-work (Figure II-5.16b) can be employed on cut banks. It consists of 1 foot layers of branches covered with young, freshly cut shoots secured by stakes. The spaces between the shoots are filled with dirt and another layer is added on top. Another technique is the use of willow mattresses (Figure II-5.16c) made from 4 to 6 foot willow switches set into 6-inch trenches held down by stakes that are braided or wired together. The entire mattress is lightly covered with dirt. A variation of this method is the brush-mesh technique which is designed to stabilize breached cut banks and to encourage the deposition of sediment (Figure II-5.16d). It involves the following steps:
1. Placement of poles at 10 foot distance.
2. Placement of large branches and brush facing the stream.
3. Setting cuttings of live willow branches between the brush vertically, and
4. Securing vertical willows with cuttings set diagonally facing the streamflow.

- Slip banks of the lower riparian zone and tidal banks can be stabilized with grass (3). First the bank needs to be graded to a maximum slope of 3:1. Topsoil should be conserved for reuse; lime (2 tons/acre) and fertilizer (1,000 lbs/acre of 10:10:10) should be applied. Coarse grass and beach grass should be planted at the water’s edge to trap drift sand; and bermuda grass, suitable for periodic inundation, should occupy the face of the slope, followed by tall fescue on higher ground.

Maintenance

- Streambanks are always vulnerable to new damage. Repairs are needed periodically. Banks should be checked after every high-water event is over. Gaps in the vegetative cover should be fixed at once with new plants, and mulched if necessary. Fresh cuttings from other plants on the bank can be used, or they can be taken from mother-stock plantings if they are available.

- All temporary and permanent erosion and sediment control practices shall be maintained and repaired as needed to assure continued performance of their intended function. All maintenance and repair shall be conducted in accordance with an approved manual.

References


Figure II-5.15a
Streambank Vegetative Zones

Figure II-5.15b
Reed Roll

Figure II-5.16a
Fascines

Figure II-5.16b
Packed Fascine-Work

Figure II-5.16c
Willow Mattress

Figure II-5.16d
Brush-Mesh Protection

rolls of shoots similar to reed roll
alternate layers of branches and dirt

brazied shoots or wire securing mat to bank
down to refuse
II-5.7.15 BMP E2.85: Bioengineering Methods of Streambank Stabilization

Code: B55  Symbol: B55

Definition: Methods of stabilizing streambanks through a combination of vegetative and mechanical means.

Purpose:
To provide protection of critical sections of streambank where ordinary vegetative means of protection are not feasible or offer insufficient protection.

Conditions Where Practice Applies:
- To be used in streams with swift flow where the flow/soil conditions exceed the stabilizing effect of purely vegetative channel protection.

Advantages:
- Mechanical materials provide for interim and immediate stabilization until vegetation takes over.
- Once established, vegetation can outlast mechanical structures and requires little maintenance while regenerating itself.
- Aesthetic benefits and wildlife habitat.

Disadvantages/Problems:
- Slightly higher initial cost and need for professional advice. (It is recommended that the services of a qualified bioengineer be sought for this work).
- The methods described are effective but require a complete knowledge of soils, hydrology, and other physical data to design measures that will adequately solve the problem and stand up to the test of time.

Design Criteria:
Streams in urban settings may carry an increase in runoff of such great magnitude that they cannot be maintained in a natural state. In these cases bioengineering methods can provide for stabilization without complete visual degradation and they can provide higher effectiveness than purely mechanical techniques. This applies primarily to: 1) the reed bank zone (BF) and 2) the lower riparian zone (OF) (Figure II-5.17a). The following techniques apply to the reed bank zone:

Reed berms (Figure II-5.17b), consisting of a combination of reeds and riprap, break wave action, and erosion of banks by currents. Banks should not exceed a 2:1 slope. Riprap is placed to form a berm that extends beyond the surface at mean low-water level, separating the reed bed from the body of water.

Willow jetties (Figure II-5.17c) can be constructed at the water level to stabilize a cutbank by deflecting the current and by encouraging deposition of sediment. Steps:
1. Dig ditches diagonally to direction of flow, and place fill to form berm downstream from ditch.
2. Set 2-foot willow branches (4 feet may be needed) at 45° angle and 3-inch spacing facing downstream.

3. Weigh down branches with riprap extending beyond water level.

Willow gabions (Figure II-5.17d) can be used when a hard-edged effect is desired to deflect the eroding flow of water. Live willow branches, pointing downstream, are inserted through the wire mesh when the gabion is packed with stone and an addition of finer materials. Branches need to be long enough to extend through the gabion into the soil of the bank. They also should be placed at an angle back into the slope.

Piling revetment (Figure II-5.17e) with wire facings is especially suited for the stabilization of cutbanks with deep water. It involves the following steps:

1. Drive heavy timbers (8-12 inch diameter) on 6 to 8-foot centers along bank to be protected to point of refusal or one half length of pile below maximum scour.

2. Fasten heavy wire fencing to the posts and if the streambed is subject to scour, extend the fence horizontally on the streambed for a distance equal to the anticipated depth of scour and weight with concrete blocks. As scour occurs, this section will drop into place.

3. Pile brush on the bank side of the fence, and plant willow saplings on bank to encourage sediment deposits.

In the lower riparian zone (Figure II-5.17f) (open floodway) bank stabilization efforts should be concentrated on critical areas only. The stabilizing effect of riprap can be supplemented with willows which will bind soil through their roots and screen the bank. Banks can be paved with stone (set in sand). Willow cuttings in joints need to be long enough to extend to natural soil and should have 2 to 4 buds above surface. Willow branches in riprap should be installed simultaneously. Branches should extend 1 foot into the soil below stone and ½ feet above ground, pointing downstream.

Willow branch mat revetment (Figure II-5.17g) takes the following steps to install:

1. Grade slope to approximately 2:1 and excavate a 3 foot ditch at the toe of slope.

2. Lay live willow brush with butts upslope and anchor mat in the ditch below normal waterline by pushing with large stones.

3. Drive 3-foot willow stakes 2½ feet on center to hold down brush; connect stakes with No. 9 galvanized wire and cover brush slightly with dirt to encourage sprouting.

Maintenance

- Costs vary according to local availability of labor. However, there are practically no maintenance costs for the vegetation once it is established, since it holds the banks 'naturally' as compared to concrete 'improvement' that constantly needs repairs.

- All temporary and permanent erosion and sediment control practices shall be maintained and repaired as needed to assure continued performance of their intended function. All maintenance and repair shall be conducted in accordance with an approved manual.
References


(3) Schiectl, H. Bioengineering for Land Reclamation and Conservation, University of Alberta Press, 1980.

Figure II-5.17a
Reed Bank Zone (BF)
and Lower Riparian Zone (OF)

Figure II-5.17b
Dumped riprap berm

Figure II-5.17c
Willow Jetty

Figure II-5.17d
Willow Gabion

Figure II-5.17e
Piling Revetment

Figure II-5.17f
Willow Branches in Riprap

Figure II-5.17g
Willow Branch Mat Revetment
II-5.7.16 BMP E2.90: Structural Streambank Stabilization

Code: SSS  Symbol: SSS

Definition  Methods of stabilizing the banks and streams with permanent structures.

Purpose
To protect streambanks from the erosive forces of moving water, where vegetative or bioengineered methods are insufficient or infeasible.

Conditions Where Practice Applies
- Streambank sections, where excessive erosion is anticipated because of highly erodible soils.

Advantages
- Permanent structural measures are an effective method of preventing severe streambank erosion.

Disadvantages/Problems
- Most types of structural stabilization do not offer any water quality benefits except for the potential for reduced erosion and downstream siltation.

Planning Considerations

Stream channel erosion problems vary widely in type and scale and there are many different structural stabilization techniques which have been employed with varying degrees of effectiveness. The purpose of this specification is merely to point out some of the practices which are available and to establish some broad guidelines for their selection and design. Such structures should be planned and designed in advance by a professional engineer licensed in the state of Washington. Many of the practices referenced here involve the use of manufactured products and should be designed and installed in accordance with manufacturer's specifications.

Before selecting a structural stabilization technique, the designer should carefully evaluate the possibility of using vegetative stabilization (BMP E2.80) or bioengineering measures (BMP E2.85) to achieve the desired protection. Vegetative techniques are generally less costly and more compatible with natural stream characteristics, and, in most instances, HPAs from the state Departments of Fisheries and Wildlife may require this method.

Design Criteria
- Design must be prepared based on criteria and input/review from a qualified fisheries biologist.

- Since each reach of channel requiring protection is unique, measures for streambank protection shall be installed according to a plan and adapted to the specific site. Design shall be developed according to the following principles:
  a. Bottom scour shall be controlled, by either natural or structural means, before any permanent type of bank protection can be considered feasible. See Chapter III-2, Volume III for channel design.
b. Stream requirements must be met. These include, but are not necessarily limited to, development limitations imposed by the local government's Sensitive Area Ordinance (if applicable), the requirements of the Shoreline Management Act and permit requirements from State and Federal agencies such as a Hydraulic Project Approval (HPA, Washington Deps. of Fish and Wildlife), Dam Safety (Washington Dept. of Ecology), and Navigation, Shoreline and Section 101 and 404 permits for the Corps of Engineers.

c. Special attention shall be given to maintaining and improving habitat for fish and wildlife.

d. Structural measures must be effective for the design flow and be capable of withstanding greater flows without serious damage.

• The following structural streambank stabilization measures may be considered:

a. Riprap - heavy angular stone placed on the streambank to provide armor protection against erosion.

b. Gabion - rectangular, pervious, semi-flexible rock-filled wire baskets which can be used to armor streambanks.

c. Reinforced Concrete - retaining walls or bulkheads used to armor eroding sections of streambank.

d. Log Cribbing - retaining structure built of logs to protect streambanks from erosion. (Log cribbing can have vegetation inserted between logs.)

e. Grid Pavers - modular concrete units with interspersed void areas which can be used to armor the streambank while maintaining porosity and allowing the establishment of vegetation.

Maintenance

• Inspections should be made regularly and after each large storm event. Repairs should be made as quickly as possible after the problem occurs.

• All temporary and permanent erosion and sediment control practices shall be maintained and repaired as needed to assure continued performance of their intended function. All maintenance and repair shall be conducted in accordance with an approved manual.
II-5.8 SEDIMENT RETENTION

II-5.8.1 BMP E3.10: Filter Fence

Code: FF
Symbol: ✱✱✱

Definition: A temporary sediment barrier consisting of a filter fabric stretched across and attached to supporting posts and entrenched. The filter fence is constructed of stakes and synthetic filter fabric with a rigid wire fence backing where necessary for support.

Purpose

1. To intercept and detain small amounts of sediment under sheet flow conditions from disturbed areas during construction operations in order to prevent sediment from leaving the site.

2. To decrease the velocity of sheet flows.

Conditions Where Practice Applies

• Filter fences must be provided just upstream of the point(s) of discharge of runoff from a site, before the flow becomes concentrated. They may also be required:
  1. Below disturbed areas where runoff may occur in the form of sheet and rill erosion; wherever runoff has the potential to impact downstream resources.
  2. Perpendicular to minor swales or ditch lines for contributing drainage areas up to one acre in size.

Advantages

• Downstream riparian areas will not be damaged by sediment deposits originating from the development.

• Sediment will not cause damage to fish habitat.

Disadvantages/Problems

• Filter fences are not practical where large flows of water are involved, hence the need to restrict their use to drainage areas of one acre of less, and flow rates of less than 0.5 cfs. This flow should not be concentrated; it should be spread out over many linear feet of filter fabric fence.

• Problems may arise from incorrect selection of pore size and/or improper installation.

• Filter fences should not be constructed in streams or used in V-shaped ditches. They are not an adequate method of runoff control for anything deeper than sheet or overland flow.

Planning Considerations

Laboratory work at the Virginia Highway and Transportation Research Council has shown that silt fences can trap a much higher percentage of suspended sediments than can straw bales. Silt fences are preferable to straw barriers in many cases. However, while the failure rate of silt fences is lower than that of straw barriers, there are many instances locally in which silt fences have been improperly
installed. The installation methods outlined here can improve performance.

Fabric Types:

There are four types of material used for filter fabric fences; woven slit-film fabric, woven monofilament fabrics, woven composites (of differing materials) and non-woven heat-treated or needle punched fabrics. Slit-film fabrics are made from woven sheets of nonporous polymers. The sheets are very thin but are cut or slit in wider bands to form the threads which are then woven into the fabric. Since slit-film weaves use strands that are quite thin, the resulting woven fabric has little rigidity, and pore spaces are not uniform. Wire fencing must be used as a backing for this type of filter fabric fence. While this type of fabric is generally cheapest and the most widely used, the additional costs of the wire fence installation must be figured in.

Woven monofilament fabrics are made from uniform spun or extruded filaments which are then woven to form the fabric. They are usually thicker and thus more rigid than slit-film fabrics. The pores in monofilament fabrics are regularly spaced and the increased rigidity offers more resistance to pore distortion. The material has a very low flow-through rate. Woven composites are similar in structure but use more than one fiber type.

Non-woven fabrics are made by using either continuous filaments or short staple fibers. These fibers are then bonded together by various processes that can include a needling process that intertwines the fibers physically, or a thermal or chemical bonding operation that fuses adjacent fibers together. The resulting fabric has a random fiber orientation and may have a thickness that ranges from thick felt to a relatively thin fabric.

King County Conservation District recently completed tests on 18 different types of filter fabrics. Their results have been incorporated into the design criteria.

Design Criteria

- Drainage area of 1 acre or less or in combination with sediment basin in a larger site.
- Maximum slope steepness (normal (perpendicular) to fence line) 1:1.
- Maximum sheet or overland flow path length to the fence 100 feet.
- No concentrated flows greater than 0.5 cfs.
- Selection of a filter fabric is based on soil conditions at the construction site (which affect the apparent opening size (AOS) fabric specification) and characteristics of the support fence (which affect the choice of tensile strength). The designer shall specify a filter fabric that retains the soil found on the construction site yet will have openings large enough to permit drainage and prevent clogging. The larger the AOS number, the smaller the AOS size of the opening in the fabric.
- The material used in a filter fabric fence must have sufficient strength to withstand various stress conditions and it also must have the ability to allow passage of water while retaining soil particles. The ability to pass flow through must be balanced with the material's ability to trap sediments.

The following criteria are recommended for selection of the AOS:

1. Because of the properties of soils in the Puget Sound basin, field work must be done to determine the optimum AOS for filter fence installations. Because of glaciation, many soils in this area contain both cobbles and
fines. If an SCS standard soil description is used, (e.g. Alderwood gravelly sandy loam) the AOS specified will not be sufficient to trap the finer particles of soil. Including gravels and larger sizes skews the results towards an AOS which is too small to capture suspended settleable solids and reduce TSS. Monofilament and non-woven geotextiles must have a minimum AOS of 70 when used in glacial soils. Composites and slit film fabrics must be extra-strength to perform similarly; in their case the AOS range may be from 40-60. In areas where Mazama ash is plentiful in the soil profile, a larger AOS will be necessary, or, fabric with an AOS of 70 should be used for outwash soils.

2. For all other soil types, the AOS should be determined by first passing soil through a #10 sieve (2.0 mm). Based on the amount of the remaining soil, by weight, which passes through a U.S. standard sieve No. 200, select the AOS to retain 85 percent of the soil. Where direct discharge to a stream, lake, or wetland will occur, then the AOS shall be no larger than Standard Sieve No. 100.

Non-woven and regular strength slit film fabrics shall be supported with wire mesh. Filter fabric material shall contain ultraviolet ray inhibitors and stabilizers to provide a minimum of six months of expected usable construction life at a temperature range of 0°F. to 120°F.

Standard Notes

In addition to the Technical Information Report (see Chapter I-3) required by the local government when preparing an erosion and sediment control plan, add the following notes to the Filter Fabric Fence Detail (Figure II-5.18):

a. The filter fabric shall be purchased in a continuous roll cut to the length of the barrier to avoid use of joints. When joints are necessary, filter cloth shall be spliced together only at a support post, with a minimum 6 inch overlap, and both ends securely fastened to the post.

b. Posts shall be spaced a maximum of 6 feet apart and driven securely into the ground a minimum of 30 inches (where physically possible).

c. A trench shall be excavated approximately 8 inches wide and 12 inches deep along the line of posts and upslope from the barrier. The trench shall be constructed to follow the contour.

d. When slit film filter fabric is used, a wire mesh support fence shall be fastened securely to the upslope side of the posts using heavy-duty wire staples at least 1 inch long, tie wires or hog rings. The wire shall extend into the trench a minimum of 4 inches and shall not extend more than 36 inches above the original ground surface.

e. Slit film filter fabric shall be wired to the fence, and 20 inches of the fabric shall extend into the trench. The fabric shall not extend more than 36 inches above the original ground surface. Filter fabric shall not be stapled to existing trees. Other types of fabric may be stapled to the fence.

f. When extra-strength or monofilament fabric and closer post spacing are used, the wire mesh support fence may be eliminated. In such a case, the filter fabric is stapled or wired directly to the posts with all other provisions of Standard Note "e" applying. Extra care should be used when joining or overlapping these stiffer fabrics.

g. Local governments may specify the use of properly compacted native material. In many instances, this may be the preferred alternative because the soil forms a more continuous contact with the trench below, and use of native materials
cuts down on the number of trips that must be made on and off-site. If gravel is used instead, the trench shall be backfilled with ¾-inch minimum diameter washed gravel. Care must be taken when using gravel to ensure good contact between the fabric and the trench bottom to prevent undercutting.

h. Filter fabric fences shall be removed when they have served their useful purpose, but not before the upslope area has been permanently stabilized. Retained sediment must be removed and properly disposed of, or mulched and seeded.

Maintenance

- Inspect immediately after each rainfall, and at least daily during prolonged rainfall. Repair as necessary.

- Sediment must be removed when it reaches approximately one third the height of the fence, especially if heavy rains are expected.

- Any sediment deposits remaining in place after the filter fence is no longer required shall be dressed to conform with the existing grade, prepared and seeded.

- All temporary erosion and sediment control measures shall be removed within 30 days after final site stabilization is achieved or after the temporary BMPs are no longer needed. Trapped sediment shall be removed or stabilized on site. Disturbed soil areas resulting from removal shall be permanently stabilized.

References:


(2) Varney, Dick, An Evaluation of Geotextiles as Filter Fabric Fence Using Local Soils for Planning and Engineering, King County Conservation District, Sept., 1991.

Figure II-5.18 Filter Fabric Fence Detail

Filter fabric material in continuous rolls:
Use staples or wire rings to attach fabric to wire

Wire mesh support fence for slit film fabrics

Bury bottom of filter material in 8" by 12" trench

6' Max.

2" by 2" wood posts, standard or better or equivalent

Wire mesh support fence for slit film fabrics

Filter fabric material

Provide washed gravel backfill or compacted native soil as directed by local government

Bury bottom of filter material in 8" by 12" trench

2" by 2" wood posts, standard or better or equivalent
II-5.8.2 BMP E3.15 Straw Bale Barrier

Definition  A temporary sediment barrier consisting of a row of entrenched and anchored straw bales.

Purpose

1. To intercept and retain small amounts of sediment from disturbed areas of limited extent to prevent sediment from leaving the site.
2. To decrease the velocity of sheet flows and low-to-moderate level channel flows.

Conditions Where Practice Applies

- Below disturbed areas subject to sheet and rill erosion.
- Where the size of the drainage area is no greater than 1/4 acre per 100 feet of barrier length; the maximum slope length behind the barrier is 100 feet; and the maximum slope gradient behind the barrier is 50 percent (2:1).
- In minor swales or ditch lines where the maximum contributing drainage area is no greater than 2 acres.
- Where effectiveness is required for less than 3 months.
- Under no circumstances should straw bale barriers be constructed in live streams or in swales where there is the possibility of a washout.

Advantages

- When properly used, straw bale barriers are an inexpensive method of sediment control.

Disadvantages/Problems

- Straw bale barriers are easy to misuse and can become contributors to a sediment problem instead of a solution.
- It is difficult to tell if bales are securely seated and snug against each other.

Planning Considerations

Based on observations made locally and in Virginia, Pennsylvania, Maryland, and other parts of the nation, straw bale barriers have not been as effective as many users had hoped they would be. There are three major reasons for such ineffectiveness.

1. Improper use of straw bale barriers has been a major problem. Straw bale barriers have been used in streams and drainageways where high water velocities and volumes have destroyed or impaired their effectiveness.

2. Improper placement and installation of the barriers, such as staking the bales directly to the ground with no soil seal or entrenchment, has allowed undercutting and end flow. This has resulted in additions to, rather than removal of, sediment from runoff waters.
3. Inadequate maintenance lowers the effectiveness of these barriers. For example, trapping efficiencies of carefully installed straw bale barriers on one project in Virginia dropped from 57 percent to 16 percent in one month due to lack of maintenance.

There are serious questions about the continued use of straw bale barriers as they are presently installed and maintained. Averaging approximately $4.00 per linear foot, the thousands of straw bale barriers used annually represent sufficient expense that optimum installation procedures should be emphasized. If such procedures are carefully followed, straw bale barriers can be quite effective. Therefore, continued designation of straw bale barriers as a BMP will be contingent upon significant improvement in the installation and maintenance procedures applied to their use.

Design Criteria

- A formal design is not required.

- Sheet Flow Applications

  1. Bales shall be placed in a single row, lengthwise on the contour, with ends of adjacent bales tightly abutting one another.

  2. All bales shall be either wire-bound or string-tied. Straw bales shall be installed so that bindings are oriented around the sides rather than along the tops and bottoms of the bales in order to prevent deterioration of the bindings (Figure II-5.19).

  3. The barrier shall be entrenched and backfilled. A trench shall be excavated the width of a bale and the length of the proposed barrier to a minimum depth of 4 inches. The trench must be deep enough to remove all grass and other material which might allow underflow. After the bales are staked and chinked (filled by wedging), the excavated soil shall be backfilled against the barrier. Backfill soil shall conform to the ground level on the downhill side and shall be built up to 4 inches against the uphill side of the barrier (Figure II-5.19).

  4. Each bale shall be securely anchored by at least 2 stakes or re-bars driven through the bale. The first stake in each bale shall be driven toward the previously laid bale to force the bales together. Stakes or re-bars shall be driven deep enough into the ground to securely anchor the bales. Stakes should not extend above the bales but instead should be driven in flush with the top of the bale for safety reasons.

  5. The gaps between the bales shall be chinked (filled by wedging) with straw to prevent water from escaping between the bales. Loose straw scattered over the area immediately uphill from a straw bale barrier tends to increase barrier efficiency. Wedging must be done carefully in order not to separate the bales.

  6. Inspection shall be frequent and repair or replacement shall be made promptly as needed.

  7. Straw bale barriers shall be removed when they have served their usefulness, but not before the upslope areas have been permanently stabilized.

- Channel Flow Applications

  1. Bales shall be placed in a single row, lengthwise, oriented perpendicular to the contour, with ends of adjacent bales tightly abutting one another.
2. The remaining steps for installing a straw bale barrier for sheet flow applications apply here, with the following addition.

3. The barrier shall be extended to such a length that the bottoms of the end bales are higher in elevation than the top of the lowest middle bale (Figure II-5.20) to assure that sediment-laden runoff will flow either through or over the barrier but not around it.

Maintenance

- Straw bale barriers shall be inspected immediately after each runoff-producing rainfall and at least daily during prolonged rainfall.
- Close attention shall be paid to the repair of damaged bales, end runs, and undercutting beneath bales.
- Necessary repairs to barriers or replacement of bales shall be accomplished promptly.
- Sediment deposits should be removed after each runoff-producing rainfall. They must be removed when the level of deposition reaches approximately one-half the height of the barrier.
- Any sediment deposits remaining in place after the straw bale barrier is no longer required shall be dressed to conform to the existing grade, prepared and seeded.
- All temporary and permanent erosion and sediment control practices shall be maintained and repaired as needed to assure continued performance of their intended function. All maintenance and repair shall be conducted in accordance with an approved manual.
- All temporary erosion and sediment control measures shall be removed within 30 days after final site stabilization is achieved or after the temporary BMPs are no longer needed. Trapped sediment shall be removed or stabilized on site. Disturbed soil areas resulting from removal shall be permanently stabilized.
Figure II-5.20 Proper Installation of a Straw Bale Barrier

1. Excavate the trench.  
2. Place and stake straw bales.

3. Wedge loose straw between bales.  
4. Backfill and compact the excavated soil.

CONSTRUCTION OF A STRAW BALE BARRIER

Points A should be higher than point B

PROPER PLACEMENT OF STRAW BALE BARRIER IN DRAINAGE WAY
II-5.8.3 BMP E3.20: Brush Barrier

Definition: A temporary sediment barrier constructed at the perimeter of a disturbed area from residue materials available from cleaning and grubbing on-site.

Purpose
To intercept and retain sediment from limited disturbed areas.

Conditions Where Practice Applies
- Below disturbed areas of less than one quarter acre that are subject to sheet and rill erosion, where enough residue material is available for construction of such a barrier. Note: This does not replace a sediment trap or pond.

Advantages
- Brush barriers can often be constructed using materials found on-site.

Problems
- None

Planning Considerations
Organic litter and spoil material from site clearing operations is usually burned or hauled away to be dumped elsewhere. Much of this material can be used effectively on the construction site itself. During clearing and grubbing operations, equipment can push or dump the mixture of limbs, small vegetation, and root mat along with minor amounts of soil and rock into windrows along the toe of a slope where erosion and accelerated runoff are expected. Anchoring a filter fabric over the berm enhances the filtration ability of the barrier. Because brush barriers are fairly stable and composed of natural materials, maintenance requirements are small. Material containing large amounts of wood chips should not be used because of the potential for leaching from the chips.

Design Criteria
- Height 3 feet (minimum) to 5 feet (maximum).
- Width 5 feet at base (minimum) to 15 feet (maximum).
- Filter fence anchored over the berm will enhance its filtration capacity.
- Further design details are illustrated in Figure II-5.21.

Maintenance
- Brush barriers generally require little maintenance, unless there are very heavy deposits of sediment. Occasionally, tearing of the fabric may occur.
- When the barrier is no longer needed, the fabric can be removed to allow natural establishment of vegetation within the barrier. Over time the barrier will rot.
Figure II-5.21 Brush Barrier

- Filter fabric draped over brush pile and secured in trench w/ compacted backfill
- Anchor downhill edge of brush barrier w/ twine fastened to fabric & stakes
- Min. 3' high
- 6" x 6" (min.) trench along uphill edge of brush barrier
- Vegetative debris/brush piled uniformly in row to form barrier
II-5.8.4 BMP E3.25: Gravel Filter Berm

Code: [GB]  Symbol: [GB]

Definition  A gravel berm constructed on rights-of-way or traffic areas within a construction site.

Purpose
To retain sediment from traffic areas by using a filter berm of gravel or crushed rock.

Conditions Where Practice Applies

- Where a temporary measure is needed to retain sediment from rights-of-way or in traffic areas on construction sites.

Advantages
- This is a very efficient method of sediment removal.

Disadvantages/Problems
- This BMP is more expensive to install than are other BMPs which use materials found on-site.

Design Criteria

- Berm material shall be ½ to 3 inches in size, washed, well-graded gravel or crushed rock with less than 5 percent fines (Figure II-5.22).

- Spacing of berms:
  every 300 feet on slopes less than 5 percent
  every 200 feet on slopes between 5 and 10 percent
  every 100 feet on slopes greater than 10 percent

- Berm dimensions:
  1 foot high with 3:1 side slopes
  8 linear feet per 1 cfs runoff based on the 10-year, 24-hour design storm.

Maintenance

- Regular inspection is required; sediment shall be removed and filter material replaced as needed.

- All temporary and permanent erosion and sediment control practices shall be maintained and repaired as needed to assure continued performance of their intended function. All maintenance and repair shall be conducted in accordance with an approved manual.
Figure II-5.22 Gravel Filter Berm

\[ \frac{3}{4}" - 3" \text{ crushed rock} \]
II-5.8.5 BMP E3.30: Storm Drain Inlet Protection

**Code:** IP

**Symbol:** C

**Definition** A sediment filter or an excavated impounding area around a storm drain, drop inlet, or curb inlet.

**Purpose**

To prevent sediment from entering storm drainage systems prior to permanent stabilization of the disturbed area.

**Conditions Where Practice Applies**

- Where storm drain inlets are to be made operational before permanent stabilization of the disturbed drainage area. Different types of structures are applicable to different conditions:
  
  a. **Filter Fabric Fence** - applicable where the inlet drains a relatively small (less than 1 acre) flat area (less than 5 percent slope). (see Figure II-5.23). Do not place fabric under grate as the collected sediment may fall into the drain when the fabric is retrieved. This practice cannot easily be used where the area is paved because of the need for driving stakes to hold the material.

  b. **Block and Gravel Filter** - applicable where heavy flows (greater than 0.5 cfs) are expected (Figure II-5.24).

  c. **Gravel and Wire Mesh Filter** - applicable where flows greater than 0.5 cfs are expected and construction traffic may occur over the inlet (Figure II-5.25).

**Advantages**

- Inlet protection prevents sediment from entering the storm drain system and clogging it.

**Disadvantages/Problems**

- Sediment removal may be difficult, especially under high flow conditions.

**Planning Considerations**

Storm sewers which are made operational before their drainage area is stabilized can convey large amounts of sediment to natural drainageways. In cases of extreme sediment loading, the storm sewer itself may clog and lose a major portion of its capacity. To avoid these problems, it is necessary to prevent sediment from entering the system at the inlets.

There are several types of inlet filters and traps which have different applications dependent upon site conditions and type of inlet. Other innovative techniques for accomplishing the same purpose are encouraged, but only after specific plans and details are submitted to and approved by the Plan Approving Authority of the local government (see Design Criteria for the description of a new method currently under development by Emcon Northwest). Note that these various inlet protection devices are for drainage areas of less than one acre. Runoff from larger disturbed areas should be routed through a Temporary Sediment Trap or Pond (see BMPs E3.35, E3.40).

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The best way to prevent sediment from entering the storm sewer system is to stabilize the site as quickly as possible, preventing erosion and stopping sediment at its source.

Design Criteria

- Grates and spaces of all inlets should be secured to prevent seepage of sediment-laden water.
- All inlet protection measures should include sediment sumps of 1 to 2 feet in depth, with 2:1 side slopes (Figure II-5.23).
- Installation procedure for filter fabric fence:
  a. Place 2 inch by 2 inch wooden stakes around the perimeter of the inlet a maximum of 3 feet apart and drive them at least 8 inches into the ground. The stakes must be at least 3 feet long.
  b. Excavate a trench approximately 8 inches wide and 12 inches deep around the outside perimeter of the stakes.
  c. Staple the filter fabric (for materials and specifications, see BMP E3.10, Filter Fence) to wooden stakes so that 32 inches of the fabric extends out and can be formed into the trench. Use heavy-duty wire staples at least \( \frac{1}{2} \) inch in length.
  d. Backfill the trench with 3/4 inch or less washed gravel all the way around.
- Installation procedure for block and gravel filter:
  a. Place wire mesh over the drop inlet so that the wire extends a minimum of 1 foot beyond each side of the inlet structure. Use hardware cloth or comparable wire mesh with one-half inch openings. If more than one strip is necessary, overlap the strips. Place filter fabric over the wire mesh.
  b. Place concrete blocks lengthwise on their sides in a single row around the perimeter of the inlet, so that the open ends face outward, not upward. The ends of adjacent blocks should abut. The height of the barrier can be varied, depending on design needs, by stacking combinations of blocks that are 4 inches, 8 inches, and 12 inches wide. The row of blocks should be at least 12 inches but no greater than 24 inches high (Figure II-5.24).
  c. Place wire mesh over the outside vertical face (open end) of the concrete blocks to prevent stone from being washed through the blocks. Use hardware cloth or comparable wire mesh with one half inch openings.
  d. Pile washed stone against the wire mesh to the top of the blocks. Use 3/4 to 3 inch gravel.
- Installation procedure for gravel and wire mesh filter:
  a. Place wire mesh over the drop inlet so that the wire extends a minimum of 1 foot beyond each side of the inlet structure. Use hardware cloth or comparable wire mesh with 1/2 inch openings. If more than one strip of mesh is necessary, overlap the strips. Place filter fabric over wire mesh.
  b. Extend the filter fence/wire mesh beyond the inlet opening at least 18 inches on all sides. Place 3/4 to 3-inch gravel over the filter fabric/wire mesh. The depth of the gravel should be at least 12 inches.
over the entire inlet opening (see Figure II-5.25).

Experimental Inlet Protection BMP:

EMCON Northwest, Inc. has recently developed a catchbasin filter (patent pending) that prevents sediments and other contaminants from entering storm drainage systems. The catchbasin filter is inserted in the catchbasin just below the grating. The catchbasin filter is equipped with a sediment trap and up to three layers of a fiberglass filter material (see Figure II-5.26). This type of system may not be applicable in all catchbasins but would work well at construction sites, industrial facilities, service stations, marinas/boatyards, etc.

During research and development of the catchbasin filter, EMCON Northwest, Inc. has found that particulates as small as 15 microns are retained by the filter. Additionally, high levels of particulate heavy metals, oil and grease and TSS have been removed at both industrial facilities and construction sites. The catchbasin filter is equipped with an overflow mechanism which allows it to pass peak flows up to 240 gallons per minute. Effective filtration can be accomplished at flows as high as 40 gallons per minute.

For further information, contact John MacPherson at EMCON Northwest Inc., (206) 485-5000.

Please note that this information is presented for informational purposes only. While this technology appears to be an effective method of controlling some types of pollutants, Ecology is not in a position to confirm or deny its efficacy at this time.

Maintenance

- For systems using filter fabric: inspections should be made on a regular basis, especially after large storm events. If the fabric becomes clogged, it should be replaced. Sediment should be removed when it reaches approximately one-half the height of the fence. If a sump is used, sediment should be removed when it fills approximately one half the depth of the hole.

- For systems using stone filters: If the stone filter becomes clogged with sediment, the stones must be pulled away from the inlet and cleaned or replaced. Since cleaning of gravel at a construction site may be difficult, an alternative approach would be to use the clogged stone as fill and put fresh stone around the inlet.

- All temporary and permanent erosion and sediment control practices shall be maintained and repaired as needed to assure continued performance of their intended function. All maintenance and repair shall be conducted in accordance with an approved manual.

- All temporary erosion and sediment control measures shall be removed within 30 days after final site stabilization is achieved or after the temporary BMPs are no longer needed. Trapped sediment shall be removed or stabilized on site. Disturbed soil areas resulting from removal shall be permanently stabilized.
Figure II-5.23 Filter Fabric Fence Inlet Filter
Figure II-5.24  Block and Gravel Filter

Figure II-5.25  Gravel and Wire Mesh Filter
Figure II-5.26 Experimental Catchbasin Filter With Sediment Trap
II-5.8.6 BMP E3.35: Sediment Trap

Code: ST

Symbol:  

Editor's Note: Based on comments that were received during the technical review period of the manual, BMPs E3.35 (Sediment Trap) and E3.40 (Sediment Pond) were revised and the use of the Universal Soil Loss Equation to calculate the sediment storage volume was dropped. Instead, volume calculations are to be based on one of the methods found in Volume III, Runoff Control, and a constant depth for sediment storage.

It is important to understand that sizing is perhaps less important for these BMPs (because of their temporary nature) than is constant maintenance. Inspections must be made and sediment removed regularly for either of these BMPs to function well.

Definition A small temporary ponding area, with a gravel outlet, formed by excavation and/or by constructing an earthen embankment.

Purpose

To collect and store sediment from sites cleared and/or graded during construction. It is intended for use on relatively small building areas, with no unusual drainage features, and projected quick build-out time. It should help in reducing silt-laden runoff. This silt-laden runoff clogs off-site conveyance systems and destroys habitat, particularly in streams. The trap is a temporary measure (with a design life of approximately 6 months) and is to be maintained until the site area is permanently protected against erosion by vegetation and/or structures.

Conditions Where Practice Applies

- Proposed building sites where the tributary drainage area is less than 3 acres.

Advantages

- Downstream riparian properties will not be damaged by sediment deposits originating from that development.
- Sediment deposits downstream will not reduce the capacity of the stream channel.
- Sediment will not cause the clogging of downstream impoundments and other facilities.

Disadvantages/Problems

- Serves only limited areas.
- Sediment traps (and ponds, see BMP E3.40) are only practically effective in removing sediment down to about the medium silt size fraction. Runoff with sediment of finer grades (fine silt and clay) will pass through untreated, emphasizing the need to control erosion to the maximum extent first.

Planning Considerations

Sediment traps should be used only for small drainage areas. If the contributing drainage area is greater than 3 acres, refer to Sediment Ponds (see BMP E3.40), or subdivide the catchment area (see Figure II-5.27).

Sediment must be periodically removed from the trap. Plans shall detail how this
sediment is to be disposed of, such as by use in fill areas on-site, or removal to an approved off-site dump. Sediment traps, along with other perimeter controls, shall be installed before any land disturbance takes place in the drainage area.

Safety

See Section II-5.8.7, Sediment Ponds (BMP E3.40).

Design Criteria

The sediment trap may be formed completely by excavation or by construction of a compacted embankment. It shall have a 1.5 foot deep sump for sediment storage. The outlet shall be a weir/spillway section, with the area below the weir acting as a filter for sediment and the upper area as the overflow spillway depth.

- See Figures II-5.27 and II-5.28 for details.
- The temporary sediment trap volume can be found by computing the detention volume required for the 2-year, 24-hour design storm using one of the approved methods found in Volume III, Chapter 1. Side slopes should not exceed 3:1. After determining the necessary volume, size the trap by adding an additional 1½ feet for sediment accumulation to the volume computed using the 2-year, 24-hour design storm.
- To complete the design of the temporary sediment trap:
  - Figures II-5.28 and II-5.29 may be useful in designing the sediment trap.
  - A 3:1 aspect ratio between the trap length and width of the trap is desirable. Length is defined as the average distance from the inlet to the outlet of the trap. This ratio is included in the computations for Figure II-5.28 for the surface area at the interface between the settling zone and sediment storage volume.
  - Determine the bottom and top surface area of the sediment storage volume to be provided (see Figure II-5.29) using 1½ feet in depth for sediment storage and 3:1 side slope from the bottom of the trap. Note the trap bottom should be level.
  - Determine the total trap dimensions by adding the depth required for the 2-year, 24-hour design storm above the surface of the sediment storage volume, while not exceeding 3:1 side slopes (see Figure II-5.29).

Maintenance

- The key to having a functional sediment trap is continual monitoring and regular maintenance. The size of the trap is less important to its effectiveness than is regular sediment removal. Sediment should be removed from the trap when it reaches approximately one foot in depth (assuming a 1½ sediment accumulation depth). Regular inspections should be done and additional inspections made after each large runoff-producing storm.
- All temporary and permanent erosion and sediment control practices shall be maintained and repaired as needed to assure continued performance of their intended function. All maintenance and repair shall be conducted in accordance with an approved manual.
- All temporary erosion and sediment control measures shall be removed within 30 days after final site stabilization is achieved or after the temporary BMPs are no longer needed. Trapped sediment shall be removed or stabilized on site. Disturbed soil areas resulting from removal shall be permanently stabilized.
Figure II-5.28 Sediment Trap

CROSS SECTION
NO SCALE

Outflow channel is constructed by excavation.

1' depth of 2" - 4" rock
1' overflow depth
4' min.

1' depth
¾" - 1½" washed gravel

2' settling depth
1.5' sediment storage

filter fabric fencing

note: may be constructed by excavation or by building a berm

SEDIMENT TRAP OUTLET
NO SCALE

1.5' sediment storage
2' settling depth &
1' depth of 2" - 4" rock
1' depth of ¾" - 1½" washed gravel

overflow spillway
6' minimum width
II-5.8.7 BMP E3.40: Temporary Sediment Pond (or Basin)

Code: SB  Symbol:  

Editor's Note: Based on comments that were received during the technical review period of the manual, BMPs E3.35 (Sediment Trap) and E3.40 (Sediment Pond) were revised and the use of the Universal Soil Loss Equation to calculate the sediment storage volume was omitted. Instead, volume calculations are to be based on one of the methods found in Volume III, Runoff Control, and a constant depth for sediment storage.

It is important to understand that sizing is perhaps less important for these BMPs (because of their temporary nature) than is constant maintenance. Inspections must be made and sediment removed regularly for either of these BMPs to function well.

Definition  A temporary basin with a controlled stormwater release structure formed by constructing an embankment of compacted soil across a drainageway, or other suitable locations.

Purpose
To collect and store sediment from sites cleared and/or graded during construction or for extended periods of time before reestablishment of permanent vegetation and/or construction of structures. It is intended to help prevent erosion on the site which results in silt-laden runoff. The basin is a temporary measure (with a design life less than 1 year) and is to be maintained until the site area is permanently protected against erosion.

Conditions Where Practice Applies
- Proposed construction sites where the tributary drainage is less than 10 acres.

Safety
Sediment traps and ponds must be installed only on sites where failure of the structure would not result in loss of life, damage to homes or buildings, or interruption of use or service of public roads or utilities. Also, sediment traps and ponds are attractive to children and can be very dangerous. Local ordinances regarding health and safety must be adhered to. If fencing of the pond is required, the type of fence and its location shall be shown on the ESC plan.

Advantages
- Because of additional detention time, sediment ponds may be capable of trapping smaller sediment particles than traps. However, they are most effective when used in conjunction with other BMPs such as seeding or mulching.

Disadvantages/Problems
- Ponds may become an "attractive nuisance" and care must be taken to adhere to all safety practices.
- Sediment ponds are only practically effective in removing sediment down to about the medium silt size fraction. Sediment-laden runoff with smaller size fractions (fine silt and clay) will pass through untreated emphasizing the need to control erosion to the maximum extent first.
Planning Considerations

Effectiveness

Sediment basins are at best only 70-80 percent effective in trapping sediment which flows into them. Therefore, they should be used in conjunction with erosion control practices such as temporary seeding, mulching, diversion dikes, etc. to reduce the amount of sediment flowing into the basin. Sediment basins are most effective when designed with a series of chambers.

Location

To improve the effectiveness of the basin, it should be located so as to intercept the largest possible amount of runoff from the disturbed area. The best locations are generally low areas below disturbed areas. Drainage into the basin can be improved by the use of diversion dikes and ditches. The basin must not be located in a stream but should be located to trap sediment-laden runoff before it enters the stream. The basin should not be located where its failure would result in the loss of life or interruption of the use or service of public utilities or roads.

Multiple Use

Sediment basins may be designed as permanent structures to remain in place after construction is completed for use as stormwater detention ponds. Wherever these structures are to become permanent, or if they exceed the size limitations of the design criteria, they must be designed as permanent ponds by a professional engineer licensed in the State of Washington. Permanent ponds are dealt with in Volume III, Runoff Control.

Design Criteria

The sediment pond may be formed by partial excavation and/or by construction of a compacted embankment. It may have one or more inflow points carrying polluted runoff. Baffles to spread the flow throughout the basin should be included (Figure II-5.30). A securely anchored riser pipe is the principal discharge mechanism along with an emergency overflow spillway. The riser pipe shall be solid with two 1-inch diameter dewatering holes located at the top of the sediment storage volume on opposite sides of the riser pipe as shown in Figure II-5.30. Outlet protection is provided to reduce erosion at the pipe outlet.

• The sediment pond volume is the sum of the sediment storage volume (3 feet in depth) plus a settling volume of not less than 2 feet in depth. The sediment depth is computed based on the basin surface area required to settle out the design particle at the design inflow rate.

Computing the settling zone volume: The settling zone volume may be approximated by assuming a 2 foot depth above the sediment storage volume and extending the 3:1 side slopes as necessary, or by computing the precise volume as outlined below. The maximum settling zone depth shall be 4 feet.

a. Pond surface area

The settling zone volume is determined by the pond surface area which is computed using the following equation: (SA) = 1.2Q_{10} / V_{sed}

Where Q_{10} = design inflow based on the peak discharge from a 10-year, 24-hour duration design storm event from the tributary drainage area as computed using the methods described in Chapter III-1 of Volume III, Runoff Control.
\[ V_{sw} = \text{the settling velocity of the design soil particle.} \]

The design particle chosen is medium silt (0.02 mm) for most purposes. It has a settling velocity \((V_{sw})\) of 0.00096 ft/sec. Note that for the relatively common sandy loam soils found in the Puget Sound basin, approximately 80 percent of the soil particles are larger than 0.02 mm. Thus, choosing a design particle size of 0.02 mm gives a theoretical trapping efficiency of approximately 80 percent. In practice, and for more finely textured soils, the trapping efficiency would be less. However, as a general rule, it will not be necessary to design for a particle of size less than 0.02 mm, especially since the surface area requirement increases dramatically for smaller particle sizes. For example, a design particle of 0.01 mm requires about three times the surface area of 0.02 mm. However, for sites with very finely textured soils, the local government may require a smaller design particle size than 0.02 mm. Note also that choosing a \(V_{sw}\) of 0.00096 ft/sec equates to a surface area (SA) of 1250 sq. ft. per cfs of inflow.

b. Settling depth (SD) should not be less than 2 feet and is also governed by the sediment storage volume surface area and relationship to the basin length (L). The basin length is defined as the average distance from the inlet to the outlet of the pond.

The ratio of L/SD should be less than 200.

The settling volume is therefore the surface area (SA) times the required settling depth.

To complete the design of the sediment pond:

Total sediment pond volume and dimension are determined as outlined below:

a. Determine pond geometry for the sediment storage volume calculated above using 3 feet in depth and 3:1 side slopes from the bottom of the basin. Note, the basin bottom is level.

b. Extend the pond side slopes (at 3:1 max.) as necessary to obtain the settling zone volume at 2 foot depth minimum or as determined above, 4 foot maximum.
Figure II-5.29 Sedimentation Pond Baffles

\[ W_e = \frac{L_1 + L_2}{A} \]

- \( W_e \) = effective width of basin
- \( A \) = surface area of basin when filled to crest
- \( L_1 \) = shortest travel distances around the baffle from inlet to outlet

If riser is placed here no baffle is required.

Riser here is in very poor location, baffle is required.

In this case it is important to place baffle so that \( L_1 = L_2 \)

Sheets of plywood 4ft x 8ft x \( \frac{3}{8} \) in exterior plywood or equiv.

Depth of water in basin when full 3' Max.

Elevation of basin bottom

8 ft centers

Elevation of riser crest

Posts 4 in square or 5 in round minimum set at least 3 ft into ground.
Figure II-5.30 Sediment Pond

- pond length ≥ 3x pond width
- filter fabric fence
- emergency overflow spillway
- outlet pipe
- level bottom
- riser pipe* w/ weighted base
- perforated drain pipe* in gravel-filled trench
- 1' spillway depth
- 1' freeboard
- riser pipe, open at top (principal spillway)
- dewatering outlets
- max. 4"
- min. 2' settling depth
- sediment storage
- 3' maximum depth
- level grade
- perforated drain pipe in gravel-filled trench for silt dewatering; trench wrapped w/ filter fabric full length
- provide a rebar trash rack on riser pipes ≥ 18"
- 6' min.
- emergency overflow spillway crest
- filter fabric fence
- outlet pipe
- anti-seep collars
- weighted base to prevent floatation
- energy dissipating rock

*Note: Sediment dewatering may be accomplished with perforated pipe in trench as shown or with a perforated riser pipe covered with filter fabric and a gravel "cone". A control structure may also be required; see Conditions Where Practice Applies

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d. Adjust the geometry of the basin to effectively combine the settling zone volume and sediment storage volumes while preserving the depth and side slope criteria.

Provide baffles to prevent short-circuiting (see Figure II-5.30). A 6:1 aspect ratio between the basin length and width of the pond is desirable.

Maintenance

- Inspections should be made regularly, especially after large storm events. Sediment should be removed when it fills one half of the pond's total sediment storage area. The effectiveness of a sediment pond is based less on its size than on regular sediment removal.

- All temporary and permanent erosion and sediment control practices shall be maintained and repaired as needed to assure continued performance of their intended function. All maintenance and repair shall be conducted in accordance with an approved manual.

- All temporary erosion and sediment control measures shall be removed within 30 days after final site stabilization is achieved or after the temporary BMPs are no longer needed. Trapped sediment shall be removed or stabilized on site. Disturbed soil areas resulting from removal shall be permanently stabilized.
II-5.9 EROSION AND SEDIMENT CONTROL ON INDIVIDUAL HOMESITES AND SMALL PARCELS

Background

Construction of many small developments can cause large amounts of sediment to be transported to receiving waters. Many stormwater management professionals in the Puget Sound basin believe that construction of individual family residences and businesses on small parcels causes more than three-quarters of all erosion problems in the area.

The conclusion drawn by a Metro study of single family residential construction sites was that a minority of sites cause a majority of the problems. Only 26 percent of the sites had any BMPs in place and 10 percent of the total surveyed had water quality problems (mainly sedimentation). Fifteen of the 52 sites that had water quality problems were located within 50 feet of a water body (3).

The erosion-sedimentation process on smaller areas is similar to that on larger areas and is primarily influenced by four factors:

1. Climate - The frequency, intensity, and duration of precipitation influences the amount of runoff from a given area particularly when the ground surface is exposed or unprotected.

2. Soils - The texture, structure, and organic matter content (and thus the permeability and infiltration rate) of a soil largely determines its tendency to erode.

3. Topography - The size, shape, and slope characteristics (steepness, length, and profile) of a watershed or a small lot within the watershed influences the amount, duration, and intensity of runoff.

4. Vegetative Cover - The type, amount, and consistency of vegetation and ground litter are important in keeping erosion processes to a minimum. There are a number of characteristics of an effective vegetative cover:

   a. Vegetative cover absorbs the energy of raindrops. Raindrops detach soil particles and destroy soil structure, and the splash of rain hitting the ground can transport soil particles. On an erodible soil, a very heavy rainfall may splash as much as 100 tons of soil per acre of exposed land and move each particle 4 to 5 feet (4).

   b. Vegetative cover will reduce the volume and velocity of storm runoff. Vegetation absorbs water, and a thick mass of vegetation on the soil surface will also serve as a barrier to prevent high velocity surface runoff.

   c. Roots aid in binding soil particles together giving the soil resistance to erosion.

   d. Roots break up a heavy soil structure and increase its porosity. This increases the soils ability to absorb water. Undisturbed forest soils in the Pacific Northwest have only small amounts of surface runoff even during the largest storms.

   e. Vegetation aids in removing surface and subsurface water through evapotranspiration. In a coniferous forest, evapotranspiration will release back to the air up to 40 percent of all precipitation over a years time.

The following are some of the damaging activities and conditions that may occur during development:
- Often, exposed and unprotected soil is left throughout the development. When runoff occurs, sediment is transported into the nearest stormwater facility or stream, eventually clogging it.

- Vehicles and heavy equipment track soil from the development onto the street. Gullies formed by tire tracks become channels for runoff flow.

- Vegetation bordering streams or lakes is often removed during construction. This increases the water temperature by removing shade. An increase in water temperature can contribute to algae blooms and may change the species composition of the lake or stream. Because the vegetation has been removed, there is no barrier to prevent sediment from entering the stream. This can clog spawning grounds and fishes' gills.

These problems may occur during work performed by subcontractors who are on-site for a very short time. Cooperation and communication between buyers (or developers), builders, and subcontractors are essential to minimize erosion and damage to the environment.

Some important design principles for controlling erosion and sedimentation in developing areas are as follows:

1. Plan the development to fit the particular topography, soils, waterways, and natural vegetation of a site.
   a. Avoid wet areas. Wet areas can often be identified by the type of vegetation that grows there. Skunk cabbage, rushes, horsetail ferns, sedges, cattails, willows, and shrubby-looking stunted red alders may be found in moist or even saturated soil conditions. Check the area during the wet season, not in the middle of the summer.
   b. Consider the effect of changes in topography. Wet areas are often found at the base of hills. Other wet areas are found along streams, in depressions where water can collect, and in natural drainageways.
   c. Building on steep slopes without erosion BMPs can cause severe erosion problems because of uncontrolled, high velocity surface runoff.

2. Do not plan construction or other site disturbance activities during the rainy season.

3. Minimize the length and angles of graded slopes and fills.

4. Retain and/or properly manage runoff volume and velocity on areas subject to erosion. Divert runoff away from disturbed areas.

5. Save natural vegetation whenever possible to act as a buffer zone and help stabilize the soil.

6. Keep sediment on-site.

7. Stabilize disturbed areas immediately upon completion of earthmoving activities. Use temporary or permanent seeding, or mulches such as straw to provide immediate protection from erosion. The County Conservation District office or local Soil Conservation Service office can provide information on seeding mixtures and application rates.

8. Erosion and sediment control facilities must be maintained after they are installed. They must be inspected on a regular basis and repaired or replaced as necessary.
II-5.10 BMPs for Small Parcels

A Small Parcel Stormwater Management Plan must be developed which satisfies the Small Parcel Minimum Requirements found in Volume II, Chapter II-2. These in turn may be satisfied by employing a suitable selection from the following list of BMPs.

BMP ES.10 Planned Clearing and Grading.

Plan and implement proper clearing and grading of the site. It is most important only to clear the areas needed, thus keeping exposed areas to a minimum. Phase clearing so that only those areas that are actively being worked are uncovered.

Note: Clearing limits should be flagged in the lot or area prior to initiating clearing.

BMP ES.20 Excavated Basement Soil

Locate excavated basement soil a reasonable distance behind the curb, such as in the backyard or side yard area. This will increase the distance eroded soil must travel to reach the storm sewer system. Soil piles should be covered until the soil is either used or removed. Piles should be situated so that sediment does not run into the street or adjoining yards.

BMP ES.30 Backfilling

Backfill basement walls as soon as possible and rough grade the lot. This will eliminate large soil mounds which are highly erodible and prepares the lot for temporary cover which will further reduce erosion potential.

BMP ES.40 Removal of Excess Soil

Remove excess soil from the site as soon as possible after backfilling. This will eliminate any sediment loss from surplus fill.

BMP ES.50 Management of Soil Banks

If a lot has a soil bank higher than the curb, a trench or berm should be installed moving the bank several feet behind the curb. This will reduce the occurrence of gully and rill erosion while providing a storage and settling area for stormwater.

BMP ES.60 Construction Road Access

Apply gravel or crushed rock to the driveway area and restrict truck traffic to this one route. Driveway paving can be installed directly over the gravel. This measure will eliminate soil from adhering to tires and stops soil from washing into the street. This measure requires periodic inspection and maintenance including washing, top-dressing with additional stone, reworking and compaction. (For further details see BMP E2.10, Chapter II-5.7.1).

BMP ES.70 Soil Stabilization

Stabilize denuded areas of the site by mulching, seeding, planting, or sodding. For further details on standards and specifications, see BMPs No. E1.10, E1.15, E1.35, E1.40 in Chapter II-5.

BMP ES.80 Street Cleaning

Provide for periodic street cleaning to remove any sediment that may have been tracked out. Sediment should be removed by shovelling or sweeping and carefully removed to a suitable disposal area where it will not be re-eroded.
II-5.11 REFERENCES


